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Rudolf Schnee

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**THESE DE DOCTORAT DE L'ETABLISSEMENT UNIVERSITE BOURGOGNE FRANCHE-COMTE
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Par

Monsieur SCHNEE Rudolf

Towards a Conceptual Framework for Sustainable Business Models for Electromobility

Vers un cadre conceptuel de modèles d'affaires soutenables pour l'électromobilité

Thèse présentée et soutenue à Belfort, le 5 octobre 2021

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Abstract

The desire of the population for environmentally friendly mobility without burdening social fairness and human rights is constantly increasing and the achievements and conveniences in mobility that have been reached so far are to be safeguarded. A solution for this can be electromobility along with new business models to support it. The question is: what kind of business model is able to fully develop the potential of electromobility?

The aim of the thesis is to contribute to the literature on sustainable business models through the lens of the fast-growing market of electromobility. For this purpose, the concept of electromobility is analyzed and defined in a comprehensive manner. Also, the key elements of electromobility are revealed, underlining the basic principles of value proposition for customers.

Electromobility is based on new technologies. However, it is shown that technology alone is not sufficient and the business model is an essential vector of innovation. Conventional and sustainable business models are discussed. The latter have a special significance for electromobility, as they already consider the environmental and social aspects of business alongside the economic one.

A new framework in order to analyze and/or to design sustainable business models for electromobility is proposed. It allows to better support the specific key values of electromobility. The framework of sustainable business models for electromobility (SBMEM) has to be based on close cooperation between producers, suppliers, and providers. An ecosystem has to be formed in which the individual value chains of the involved companies in electromobility are interlinked; they contribute all together to the value proposition and the value creation and delivery. In the framework, the environmental, social and economic dimensions are transversal to the basic elements “value proposition”, “value creation and delivery” and “value capture”, considered on the basis of a comprehensive ecosystem.

The framework of SBMEM is then used to analyze different existing business models of electromobility. It is shown that the latter are not sufficient for the success of electromobility because they take too little or no account of all of the environmental, social and economic aspects of the innovation.

The theoretical framework developed in this study contributes to the architecture of electromobility business model and aims to broaden the understanding of the role and applicability of business models in sustainability-oriented innovations and services. This framework is intended to enable the design of new sustainable business models for electromobility or to review existing business models and draw conclusions on which measures will make them more sustainable.

This new framework enables companies to find a compromise between the different dimensions of the approach. In doing so, they can satisfy the growing needs of the population regarding mobility, the preservation of environment and social fairness while achieving their business objectives.

The proposed SMBEM was discussed based on five case studies. It reveals to be a valuable tool both to analyze existing business models and to structure business models for future businesses.

Résumé

Le désir de la population de bénéficier d'une mobilité respectueuse de l'environnement sans porter atteinte à l'équité sociale et aux droits de l'homme ne cesse de croître et il convient de préserver les acquis et les commodités en matière de mobilité qui ont été obtenus jusqu'à présent. L'électromobilité et les nouveaux modèles commerciaux qui la soutiennent peuvent constituer une solution à cet égard. La question est de savoir quel type de modèle commercial est capable de développer pleinement le potentiel de l'électromobilité.

L'objectif de cette thèse est de contribuer à la littérature sur les modèles d'affaires durables à travers le prisme du marché en pleine croissance de l'électromobilité. À cette fin, le concept d'électromobilité est analysé et défini de manière exhaustive. Les éléments clés de l'électromobilité sont également révélés, soulignant les principes de base de la proposition de valeur pour les clients.

L'électromobilité repose sur les nouvelles technologies. Cependant, il est démontré que la technologie seule n'est pas suffisante et que le modèle économique est un vecteur essentiel d'innovation." Les modèles commerciaux conventionnels et durables sont abordés. Ces derniers ont une importance particulière pour l'électromobilité, car ils prennent déjà en compte les aspects environnementaux et sociaux de l'entreprise en plus des aspects économiques.

Un nouveau cadre est proposé pour analyser et/ou concevoir des modèles commerciaux durables pour l'électromobilité. Il permet de mieux soutenir les valeurs clés spécifiques de l'électromobilité. Le cadre des modèles commerciaux durables pour l'électromobilité (SBMEM) doit être basé sur une coopération étroite entre les producteurs, les fournisseurs et les prestataires. Un écosystème doit être formé dans lequel les chaînes de valeur individuelles des entreprises impliquées dans l'électromobilité se développent en un réseau dans lequel les chaînes de valeur des entreprises impliquées dans l'électromobilité sont reliées entre elles et qui contribuent toutes ensemble à la proposition de valeur, à la création de valeur et à la livraison. Dans ce cadre, les dimensions environnementales, sociales et économiques sont transversales aux éléments de base "proposition de valeur", "création et fourniture de valeur" et "capture de valeur" considérés sur la base d'un écosystème complet.

Le cadre du SBMEM est ensuite utilisé pour analyser les différents modèles commerciaux existants de l'électromobilité. Il est démontré que ces derniers ne sont pas suffisants pour le succès de l'électromobilité car ils ne prennent pas ou trop peu en compte tous les aspects environnementaux, sociaux et économiques de l'innovation.

Le cadre théorique développé dans cette étude contribue à l'architecture du développement des modèles d'affaires de l'électromobilité et vise à élargir la compréhension du rôle et de l'applicabilité des modèles d'affaires dans les innovations et les services orientés vers la durabilité. Le cadre conçu est destiné à permettre la conception de nouveaux modèles commerciaux durables pour l'électromobilité ou à examiner les modèles commerciaux existants et à tirer des conclusions sur les mesures qui les rendront plus durables.

Ce nouveau cadre permet aux entreprises de trouver un compromis entre les différentes dimensions du cadre. Ce faisant, elles satisfont les besoins des clients tout en atteignant leurs objectifs commerciaux.

Le SMBEM proposé a été discuté sur la base de 5 études de cas. Il s'avère être un outil précieux à la fois pour analyser les modèles d'affaires existants et pour structurer les modèles d'affaires pour les entreprises futures.

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List of Abbreviations

#	Number
&	And
AC	Alternating Current
AG	Aktiengesellschaft
API	Application Programming Interface
App	Application
Approx.	Approximately
BEV	Battery Electrical Vehicle
BMI	Business Model Innovation
CC	Corporate Citizenship
CS	Corporate Sustainability
CR	Corporate Responsibility
CSR	Corporate Social Responsibility
CO ₂	Carbon Dioxide
DC	Direct Current
E.g.	for example
EU	European Union
FCEV	Fuel Cell Electrical Vehicle
GWh	Gigawatt hours
HEV	Hybrid Electrical Vehicle
HPC	High Power Charging
ICE	Internal Combustion Engine
ICT	Information and Communication Technology
Inc.	Incorporated
IoT	Internet of things
IT	Information Technology
KM	Kilometer
n/a	not applicable
km/h	Kilometer per Hour
kW	Kilowatt
kWh	Kilowatt per hour

NM	Newton meter
MaaS	Mobility as a Service
OEM	Original Equipment Manufacturer
%	Percent
PHEV	Plug-In-Hybrid Electrical Vehicle
PSS	Product-Service Systems
R&D	Research and Development
REEV	Range Extended Electric Vehicle
SBM	Sustainable Business Model
SBMEM	Sustainable Business Model for Electromobility
SUV	Sport utility Vehicles
TCO	Total Cost of Ownership
UN	United Nations
US	United States
USA	United States of America
V2G	Value to Grid
WLTP	Worldwide Harmonized Light-Duty Vehicles Test Procedure

1. Introduction

The desire for mobility is a basic human need (Zukunftsinstitut, 2017) and is being further pushed by megatrends such as urbanization and individual mobility (Stürmer & Kuhnert, 2017; Tschiesner, Möller, Kässer, Schaufuss, & Kley, 2018). The possibility of being able to travel at any time using different means of transport is part of everyday life in industrialized countries and greatly enhances the quality of life. It has become an important parameter for growth and prosperity (Horx & Kupetz, 2012; Victorero, 2015). However, transportation is a major contributor to environmental pollution. Road transport was responsible for 26 percent of all carbon dioxide (CO₂) emissions in Europe in 2018. In 1990, it was 16 percent by simultaneously decreasing total CO₂ emissions. Since 1990, total CO₂ emissions fell by 23 percent to 2018 while CO₂ emissions from road transport rose by 24 percent in the same period. The reasons are the increasing volume of traffic, which could not be compensated by improved technology with lower consumption (DESTATIS, 2020). Additionally, climate change and environmental catastrophes are making the population aware that there is only one earth and that it must be protected by environmentally friendly treatment. Based on public pressure and scientific knowledge, more and more governments are reacting and enacting stricter laws to avoid carbon dioxide (CO₂) emissions and to improve the working conditions of employees. They subsidize new technologies and services to achieve ambitious climate protection goals and to get a higher social standard for the population (European-Commission, 2020a). Although the population wants environmentally friendly mobility and governments support it through subsidy programs, demand for less polluting modes of transportation remains low.

A significant role in improving environmental friendliness in the transportation sector can be electromobility, playing a key role in shaping the future of passenger and freight transport. But what does electromobility include? At the core of it are the battery electric vehicles (BEV) which were already invented during the 19th century and were common in large capital cities worldwide. But the internal combustion engine (ICE) vehicles were increasingly displacing BEVs or other alternative forms of propulsion, such as gas-powered vehicles. In the 1990s, individual countries and states began to enact stricter regulations for transportation due to growing air pollution. So in 1990, the California legislature enacted the Clean Air Act, which

mandated that at least two percent of newly registered vehicles should be emission-free by 1998 and ten percent by 2003 (Popp, 2003; Portney, 1990). Nevertheless, BEVs could not replace ICE vehicles from the market because the disadvantages dominated. Shorter range, higher price, and the lack of infrastructure contributed to the fact that electric vehicles continued to be built and sold only in very small figures. It was 20 years later that the ongoing debate about air pollution gave the electric vehicles a new boost and they were seen as a key component in improving environmental sustainability, without having eliminated the disadvantages compared to ICE vehicles. Only the performance and range of the vehicles were improved by advanced technologies in the drive units and the battery. But are the technologies already maturing enough to start the transformation and implement it successfully? Is the population also willing to take this step and what further measures are necessary for this? Surveys among consumers show that there is a high level of interest in climate-friendly mobility. In 2019, 61 percent of the 4.000 respondents from 16 countries stated that they had a positive attitude to electrified vehicles and 33 percent were considering choosing a BEV over an ICE vehicle. The main reason is that BEVs have a better CO₂ emissions balance and burden the environment less compared to conventional drives (LeasePlan, 2019). At the same time, governments are imposing more rigorously laws to reduce greenhouse gas (GHG) emissions in passenger transport (Tietge, Mock, Lutsey, & Campestrini, 2016). Permissible emissions in Europe was reduced for passenger cars from 140 gram carbon dioxide per kilometer (g CO₂/km) in 2009 to 120 g CO₂/km in 2012 (European Parliament, 2009) and is reduced to 95 g CO₂/km, starting in January 2021 (European Commission, 2019). Additionally high penalties will be imposed for violations (European-Commission, 2020b).

Nevertheless, electromobility is still far from being successful. For example, the goal by the Federal Republic of Germany of having one million registered electric vehicles in 2020 has been missed by a wide range (BMU, 2010). Only 589.752 vehicles with electric drives (BEVs, hybrids and fuel cell vehicles) have been registered, despite high investments in development, advertising, and infrastructure of automotive companies, governments, and energy firms. But one-dimensional and short-term developments in technology alone are not enough to overcome the behavioral patterns of the population that have developed over decades. So, one of the biggest obstacles to BEVs success is the shorter range compared with ICE

vehicles which turns out to be groundless for many drivers. The average distance a driver travels per day is under 50 kilometers and can easily be achieved by BEVs. This shows very clearly that a focus on technology alone is not sufficient and that further measures are necessary. These include mobility concepts that must differ significantly from today's. The vision of sustainable mobility integrates the infrastructure, the changed handling of property, the environmentally friendly generation of energy and new services that simplify mobility and make it comfortable.

But the transformation to a more environmentally friendly and socially compatible mobility system affects not only the population, but companies have to adapt to these changes, too, which affect all parts of the organization. This includes not only the development department but also the purchasing of raw materials, the marketing of products and services, and in particular, the business models. Many economically successful operating companies primarily strive for profit and market share in the late 20th and early 21st century market economy and take too insufficient consideration of the impact on environmental and social aspects. The development of more corporate social responsibility (CSR) in the companies as an additional parameter in terms of sustainability is hardly reflected in products or working conditions of the employees (Mayer, 2017, pp. 115–117). Many companies are investing more money to develop sustainable products but they are not always a commercial success (Krüger & Bizer, 2009). What is still missing are suitable business models that make innovative products more attractive for the consumers. Although companies have recognized that business models are an essential part for their business, they are not always aware that business models must be permanently adapted with modified products and changing market conditions. Sustainable business models can make a decisive contribution to initiate and support this transformation. They can satisfy the needs of customers for more environmentally friendly mobility and social fairness. It can stimulate demand (Wells, 2013) and enable companies to achieve the necessary economic success (Shakeel, Mardani, Chofreh, Goni, & Klemeš, 2020) because people are willing to pay the price for it. By compensating for the possible disadvantages compared to today's technology, they increase acceptance and promote the transformation process from predominantly fossil fuel-powered means of transport to vehicles operated with sustainable energy.

The scientific community has recognized the necessity of sustainable business models (SBM) and has increased its efforts in research of regularities, structures, and characteristics. Although the number of publications has increased, the research on the topic is still not sufficient. Particularly in the area of electromobility, more research is needed as there are only a few publications on this subject. This thesis contributes to close some gaps in the literature on sustainable business models for electromobility (SBMEM) by conducting a literature review, identifying potential shortcomings and developing recommendations on how to address them.

Based on a comprehensive definition of the concept of electromobility, a focused context is given to consider products and services available today and in future. Characteristic elements of business models in relevant academic literature are extracted, evaluated, and examined in order to assess whether they are necessary or useful for further elaboration of a SBMEM. A special focus will be given on sustainable business models, as these already consider ecological and social components that are also to be found in electromobility. Based on a critical review of the literature on SBMEMs, a framework is developed which sufficiently satisfies the needs and requirements of customers and companies. It is a further development of existing business models that meets the demands for greater environmental friendliness and more social fairness. The new developed framework can be used to design innovative business models for electromobility or to examine existing ones for their sustainability and effectiveness. In case studies, existing business models for electromobility are analyzed based on the framework and existing gaps are identified. In addition, indications are given on the way the business models can be enhanced and improved to be more sustainable

The contribution of this thesis is twofold. First, it strengthens the literature on SBMs by developing a new framework dedicated to design SBMEMs. In particular, it reveals which components of a business model are crucial for electromobility and what significance sustainability has for successful commercialization. Second, it can help actors involved in the field of electromobility to design efficient business models.

1.1. Background

The automotive world is changing dramatically along with changes in technology and society and new technologies and customer requirements are forcing companies to adapt their strategies and operational business (Zingrebe, Stephan, & Lorenz, 2016, p. 44). In addition, there are considerable opportunities for new players to develop business fields that have not so far been needed for the success of mobility (Kley, Lerch, & Dallinger, 2011).

Business models in automotive sector are based on elements of ICE vehicles which have been developed for over 120 years (Bernhart & Zollenkop, 2011, p. 277) in which business models have changed only slightly (Jacobsson & Bergek, 2004; M. W. Johnson & Suskewicz, 2009). In the typical automotive business models, vehicles are developed and produced by original equipment manufacturers (OEMs) and suppliers and sold to customers with support of services such as financing, leasing or after-sales (Zingrebe et al., 2016, p. 48). Over decades, a high proportion of development and value-added share has shifted to upstream and downstream suppliers (Bernhart & Zollenkop, 2011, p. 278) and vehicle manufacturers have developed into highly professional integrators, whose expertise are in production, quality and distribution.

In order to be able to adapt to the changes resulting from electromobility, new business models are needed as a stimulation for all stakeholders. The question will be to what extent incumbents can break free from path-dependent behavior and generate new, creative business models. A complete replacement of existing business models is not conceivable in short term because revenues from electromobility are not sufficient to ensure profitability of the company (Sosna, Trevinyo-Rodríguez, & Velamuri, 2010, p. 403). Therefore, a parallel existence of new and old business models will be necessary. New companies and start-ups do not have these disadvantages, but they do not have buffers from existing branches of business and must show short-term success (Bohnsack, Pinkse, & Kolk, 2014).

In practice, there are examples that differ from the typical automotive business models. But are they successful? Seemingly profitable business models, such as from Tesla Motors, which are enjoying rising sales figures and growing popularity, have recorded deficits in value capture and high losses. As a result, the company

was only able to close a few quarters with profits (Magazin-Manager, 2020). Other innovative ventures, such as Better Place with its battery swapping product have gone insolvent due to lack of customers and negative economic success (Noel & Sovacool, 2016).

New business models have to consider changes in the overall context. In **ecological terms**, the sensitivity of population and governments to environment is growing. Customers do not longer want to satisfy their mobility needs at the expense of the environment and do not want to pollute the environment with CO₂ emissions. Vehicles are no longer selected exclusively on the basis of engine performance and attractive design, but more and more emphasis are being given to environmental balance in several aspects. First and foremost, there is the engine, which should have less or no CO₂ emissions. However, the demands on environment go beyond the drive of vehicles. The extraction of raw materials, production, and recycling of products become more and more important. Electricity generation for the use of electric vehicles receives only modest attention from the population, but this demand will also become more and more important in the future.

A significant driver for electromobility is **politics and the political willingness of governments**. Tighter legislation on emission levels is forcing companies to adapt their business models and develop new products. The target values vary in ambition from country to country, but they all are reduced significantly. As Figure 1 shows, the EU limit for 2020 has been reduced to 95 grams per kilometer, which is a 41 percent reduction compared to 2006 (European Parliament, 2009). The target value means an average consumption of about four liters of petrol or 3.6 liters of diesel.

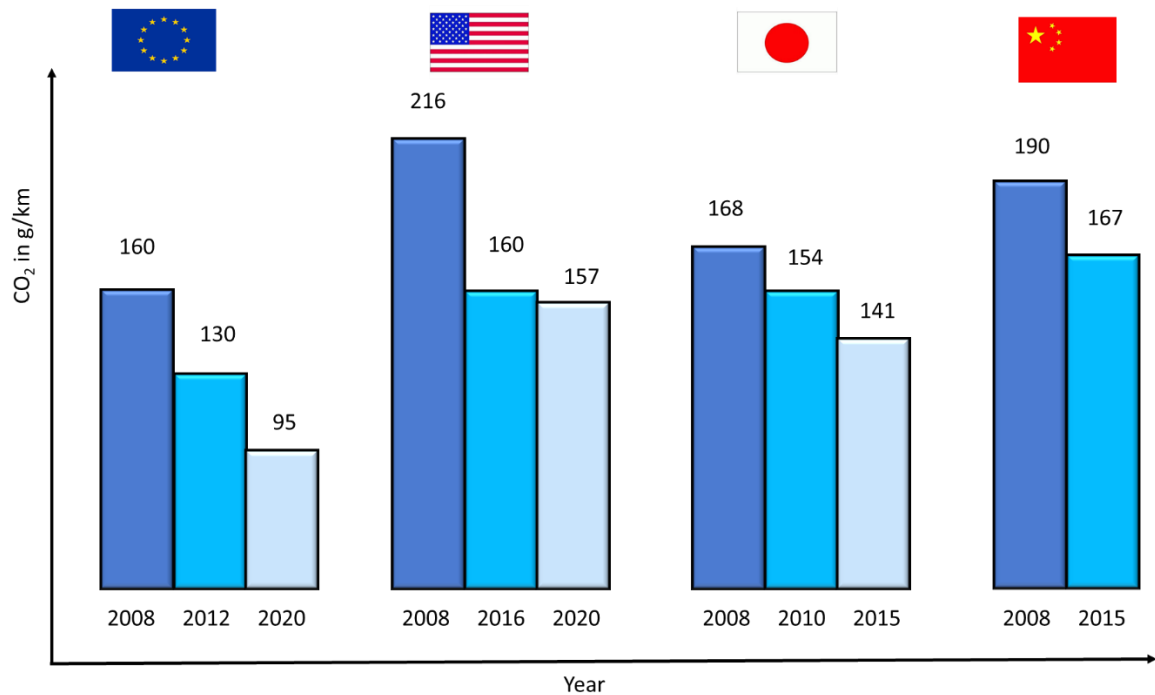


Figure 1: Reduction of CO₂ limits (own illustration based on (Bernhart & Zollenkop, 2011, p. 281))

To achieve these figures, OEMs have not only to develop new electro-mobile technologies, but also sell them in large volumes. Only then the CO₂ fleet consumption can be reduced.

The **socio-cultural** changes are challenging, as they address different needs for adapting through their diversity. The megatrend of urbanization is leading to a different mobility behavior among population. In 2014, 72.5 percent of inhabitants live in cities in the European countries and the number is constantly increasing (Figure 2). The European Commission expects 83.7 percent in 2050 (European-Commission, 2016; Eurostat, 2019).



Figure 2: The number of inhabitants in cities is increasing (Eurostat, 2019)

With increased interest in environmental friendliness, fewer polluting vehicles are needed and other mobility options such as public transport or e-car sharing are preferred. The switch from ICE vehicles to electric vehicles can only be a partial step in the solution, as electric vehicles also require parking spaces and long traffic jams can still be expected due to the densification of traffic.

The social aspects that are increasingly demanded from population and employees are not sufficiently anchored in business models today. Companies are making efforts to influence working conditions of supplier industry through contracts. They require better human conditions in form of remuneration, working conditions and protection against dismissal but the success is still limited. Especially in the mining of limited or price-sensitive goods and products (like lithium, cobalt, rare metals), measures are still not effective enough and need to be enhanced (Sabo-Wals, 2020). A fair-trade label, as already exists in food industry, would be a possible solution and incentive for the companies, as it would be directly recognizable by the customers and could support the transformation process to electromobility.

From an **economic** point of view, electromobility requires a better and stronger interaction between companies. Today, the business models of OEMs and their suppliers are predominantly focused on individual companies and have only little overlap. The need to offer comprehensive, beneficial mobility services,

infrastructure, power, information and communication services in addition to the vehicle makes it necessary for companies to cooperate more closely in order to offer new products.

A variety of technologies and mobile solutions are already being offered, but they are rarely economically successful. In 2018, the merge of car-share providers Car2Go from Daimler Aktiengesellschaft (AG) and Drive Now from BMW Group took place to achieve economic success. Goal was to reduce costs through a common organization and vehicle fleet and to increase occupancy rate of vehicles. As one of its first actions, the newly created association Share Now stopped its business activities in North America, as no economic success could be guaranteed in the future (Crawford, 2019).

Even massive subsidies and pressure from government could not persuade drivers of ICE vehicles to buy a more environmentally friendly BEV or to make more use of mobility-as-a-service (MaaS). History shows that even innovative and financially strong companies like Kodak, AEG or Quelle have failed due to insufficient reactions to new market situations. The main reason for the failure was that they did not manage to adapt their business models to the changing environmental conditions (Lüttgens & Diener, 2016). Innovative products and services are no longer the decisive elements in competition, but rather business models, in which customer's value proposition is in focus. Technological developments alone do not guarantee economic success and an appropriate business models does not develop by itself (Chesbrough, 2006b, p. 64). Another decisive factor will be the knowledge that car manufacturers can lose their leading position in the transportation sector because in the future, mobility can be more about overcoming a distance and less about the means of transport itself. The use of mobility services such as car-sharing or mobility offers indicates that the individual means of transport is becoming less important and for customers the complete range of services for overcoming the route of travel is gaining importance. This could lead that car manufacturers can become a co-supplier for the entire mobility service and loose the exceptional position of today. In addition, new competitors are entering the market with new mobile competencies that can replace existing automakers (Diez, 2018, p. 8). This means that new cooperations with other stakeholders will have to be established to ensure the attractiveness and easy access to electromobility.

With business model innovation (BMI), it is possible to generate new business models to support the technology of electric mobility (Burmeister, Luettgens, & Piller, 2015; Chesbrough, 2010; Laurischkat, Viertelhausen, & Jandt, 2016). Sustainable business models can make a decisive contribution to this. They create added value for the customer, mobilize demand (Bozem, Nagl and Rennhak 2013, pp. 119–123; Wells 2013) and provide companies with necessary profit. However, there is only a few scientific works on SBMEM, so further analysis is needed.

1.2. Motivation and Research Question

Although the demand for more environmentally friendly mobility is increasing, the demand is still very low and requires high subsidies from governments. One reason is that for mobility companies, the existing business models are not suitable for electromobility (Abdelkafi, Makhotin, & Posselt, 2013; Kley et al., 2011) because they are mainly based on conventional technology and services. The central point of the study is that the technology is not the decisive aspect, because electric drives have been on the market for many years and have not managed to establish themselves positively. For the success of new technologies, it is necessary to establish suitable business models that are specially designed for this purpose. Therefore, the questions addressed in this study are the following ones: how should business models be designed in order to fully develop the potential of electromobility? This first question can be elaborated. We can think that in order to implement electromobility, companies mostly use the business models which have been designed for the mobility of the 20th century. So, is it reasonable or even necessary to adopt elements from today's business models of mobility or are completely new approaches required? Moreover, considering the key values of electromobility, customer requirements are changing in mobility: they are getting more complex and looking for sustainability. So, what components are needed to achieve improvements in economic, ecological, and social aspects of today's business in response to the challenges of sustainable development and especially of electromobility?

Since electromobility is a broad term and is applied differently in the academic literature and in practice, it is necessary to narrow it down and define it for this thesis.

This provides the basis for a specific analysis of business models and the development of a suitable framework.

The central motivation for this study is to examine what business models can make electromobility successful and what significance the environmental and social aspects have in addition to the economic one in existing business models. Answering these questions is also relevant for other empirical areas of sustainability transitions based on technological innovations. The theoretical framework developed in this study intends to expand the understanding of the role and applicability of business models in sustainability-based innovations and services. In addition, the framework is expected to enable the creation of new sustainable business models for electromobility or to review existing business models and draw conclusions about which measures will make them more sustainable.

1.3. Research Methodology and Contribution of the Thesis

As regards the research methodology, there are basically two options: quantitative and qualitative research (Bryman, 2006; Celo et al., 2008). Quantitative research focuses on the gain of knowledge due to cause-effect relationship and there is the possibility to test in advance established hypotheses in order to substantiate causal structures. A sufficiently large statistical collection of data with a uniform scale level and the broadest possible data spectrum is used which can be collected through survey procedures, questionnaires, case studies, group discussions or test series (Bryman, 2006; Celo et al., 2008; Eisenhardt, 1989, S. 537). A prerequisite for the application of the quantitative research method is that the object of research is sufficiently known in order to be able to formulate robust hypotheses. Likewise, the population must enable a representative sample in order to verify the cause-effect principle and to be able to generalize the result (Bryman, 2006; Celo et al., 2008).

Qualitative research approaches focus on the identification of discovery contexts. The principle of openness is followed and the research steps allow a high variability. In the inductive method, an experiential reality is assumed as a starting point, which is then described and analyzed. A qualitative research method is particularly suitable when research area is insufficient studied and the phenomenon is still at the beginning of research (Mohajan, 2018). With qualitative research, a fact can be

made known and reach a higher level of abstraction by focusing on interpretation and understanding. Qualitative methods allow for classification and descriptiveness of an object of study and enable value judgments (Bryman, 2006; Celo et al., 2008).

Our approach is not a quantitative one and is rooted in the observation of actual business models and emerging business models for electromobility. This is a conceptualizing approach in order to deal with gaps in the academic literature since SBMEM are still not sufficiently researched and there is no defined frame of reference yet. Although electric vehicle and mobility services have been existing for a long time, it is only through recent evolutions in population and technology that they are gaining importance. As a result, an entire industry is being transformed, with a reshaping of companies and stakeholders. The close interrelationships between technologies and services are giving rise to new ecosystems in which the roles of companies have yet to be defined. Vehicle manufacturers are building the needed infrastructure to operate electric vehicles and are changing their development process to include parts that were previously only sourced from suppliers. The value chain is also evolving into new dimensions, with actors adopting the contact with the customer and established transport companies offering their products only in combination with other services. In the same way, research into sustainable business models has only recently begun and successful areas of application are not yet numerous.

For the development of a framework for SBMEM, a step-by-step approach is chosen (Figure 3). In the first step, business models and sustainable business models are comprehensively examined and understood in order to be able to identify suitable components for the framework. For the literature review, full-text databases of peer-reviewed scientific journals and google scholar search engine were used with the search terms “business model” and “sustainable business model” in German and English. The hits were selected according to the order of their occurrence, the frequency of the citations and the relevance of the products and services described therein for science and practice. The topic of electromobility was intentionally excluded to obtain a comprehensive record of the existing business model theories. The aim of the analysis was to identify and summarize the most important and formative patterns according to experts.

In the next step, the literature review on business models and sustainable business models were expanded with the terms "electromobility", "e-mobility" and "electric-mobility", in German and English. Scopus and google scholar were used as a database and the topics article, title, abstract and keywords were searched. The search is limited to the years between 2010 and 2021, since the research area has gained importance in recent years. The result gives a hit rate of 240 articles at google scholar and only one hit at Scopus. Then, titles and reference sections of the articles were read and 56 articles are not pursued further as they are not related to the research objective. These documents focus on business models in individual sectors such as the energy industry, tourism or the production of electrical products that are not related to mobility. They also cover the basics of the sharing economy and job profiles in electromobility with little reference to business models. The remaining academic literature was analyzed by reading the abstract and classified into different topics according to their content and objective. The remaining articles cover different topics with a strong application focus without providing further insight into the development of the framework. The remaining 36 articles are examined in more detail and form the basis for further elaboration.

In the third step, the key elements of electromobility are analyzed with the findings from the business models of step one and step two and the resulting gaps are extracted. This shows that existing business models for electromobility in science and practice cover only partial aspects and are incomplete. They focus strongly on the individual company and its capabilities and opportunities. Also, how the functions and roles of stakeholders are changing as a result of electromobility. Important elements that are necessary for successful transformation are missing, are insufficiently mapped or required relationships do not exist. It is also not sufficiently answered, how do the value chains within electromobility relate to one another. Ecological and social components are mainly anchored in the reviewed literature through the products and services and less in the business models itself. There is also a dominance of the environmental component and the social dimension is neglected.

The result is a framework for sustainable business models in electromobility that confirms existing scientific approaches to business models and adds new elements.

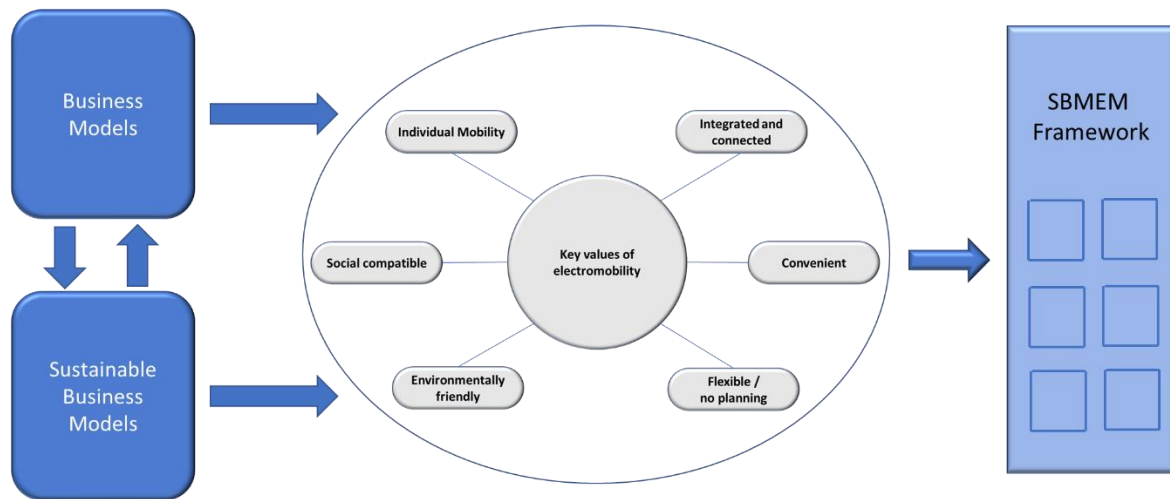


Figure 3: Step-by-step approach for designing the framework of SBMEM (own illustration)

The thesis aims to provide a theoretical contribution to the research field of business models and sustainable business models by helping to reduce the research gaps identified above and, to support the design of SBMEM in practice. In doing so, a systemic and interdisciplinary perspective is applied to electromobility as a possible solution to population's demands for sustainable mobility and the environmental challenges in the transport sector. It will be shown that the research on business models in electromobility is predominantly oriented on the basis of the different modes of transport. However, a systemic approach that includes several transport modes and the necessary conditions is still missing. Existing scientific foundations and elements, such as value proposition or required ecosystems, are not sufficient to successfully implement electromobility because important elements are missing or the interrelationships between the elements are not enough developed. Therefore, a framework is generated, which comprehensively addresses the key elements of electromobility and considers them in business models.

Secondly, the case studies provide an early assessment of the framework based on current developments in the field of electromobility. Due to a lack of knowledge from empirical research, they provide a valuable contribution for companies and government on the state of business models development in electromobility and give approaches and recommendations on how these can be further developed. These approaches are all the more relevant as political pressure makes the payment of penalties for exceeding CO₂ limits increasingly probable, or is already occurring in the case of individual companies (Reuters, 2021b).

1.4. Structure of the Thesis

The thesis is organized in six chapters and Figure 4 provides an overview about the procedure.

In **chapter 2**, the significance of electromobility for individual mobility is examined and it is shown that passenger transportation is responsible for a significant proportion of CO₂ pollution. Since electromobility does not yet have a uniform and relatively consensual definition, it will be defined extensively to provide an overarching and fundamental basis to sustainable business models in this field of activity. This comprehensive definition of electromobility leads to introduce significant changes in its value chains. These concern not only new collaboration models between incumbent actors in the form of a new ecosystem, but additional stakeholders are needed that previously played no role in the traditional means of transport. As a result, the structure of the value chain changes and forms a comprehensive network.

In **chapter 3**, the theoretical basis related to business models is reviewed. Starting with the definition and delimitation of technology, invention and innovation, the characteristics of business models will be explained and the interactions between technology and business models will be examined. In the next step, the business models are further developed into a sustainable business models based on the integration of corporate social responsibility in companies. The sustainable business models are analyzed, classified and their significance for technologies is worked out.

Chapter 4 defines the framework of SBMEMs on the basis of the theoretical approaches to electromobility and the literature review on business models, sustainable business models and sustainable business models in electromobility. Existing business model element groupings are modified so that they satisfy the key elements of electromobility. The relationships between the elements of the framework, which are significantly expanded by electromobility, will be addressed.

In **Chapter 5**, after the description of the methodology used for the case studies, a review of today's business models is conducted, which are implemented in the field of electromobility. The first step is to describe in different domains of electromobility (charging stations, propulsion batteries, electric vehicles, mobility services) typical

business models with the underlying technologies, products or services mentioning a leading company implementing each of them. In the second step, they are analyzed and assessed on the basis of the framework, developed in chapter 4. This is intended firstly to check the theoretical basis of the framework and secondly to provide starting points for expanding existing business models or for designing new business models in order to bring it closer to SBMEMs and thus increase the marketing opportunities, the environmental friendliness and the social fairness of electromobility.

In **Conclusion and outlook**, the answers to the research question are given and the theoretical and managerial contribution of the thesis is discussed and evaluated. Finally, the limitations of the study and future research suggestions are discussed.

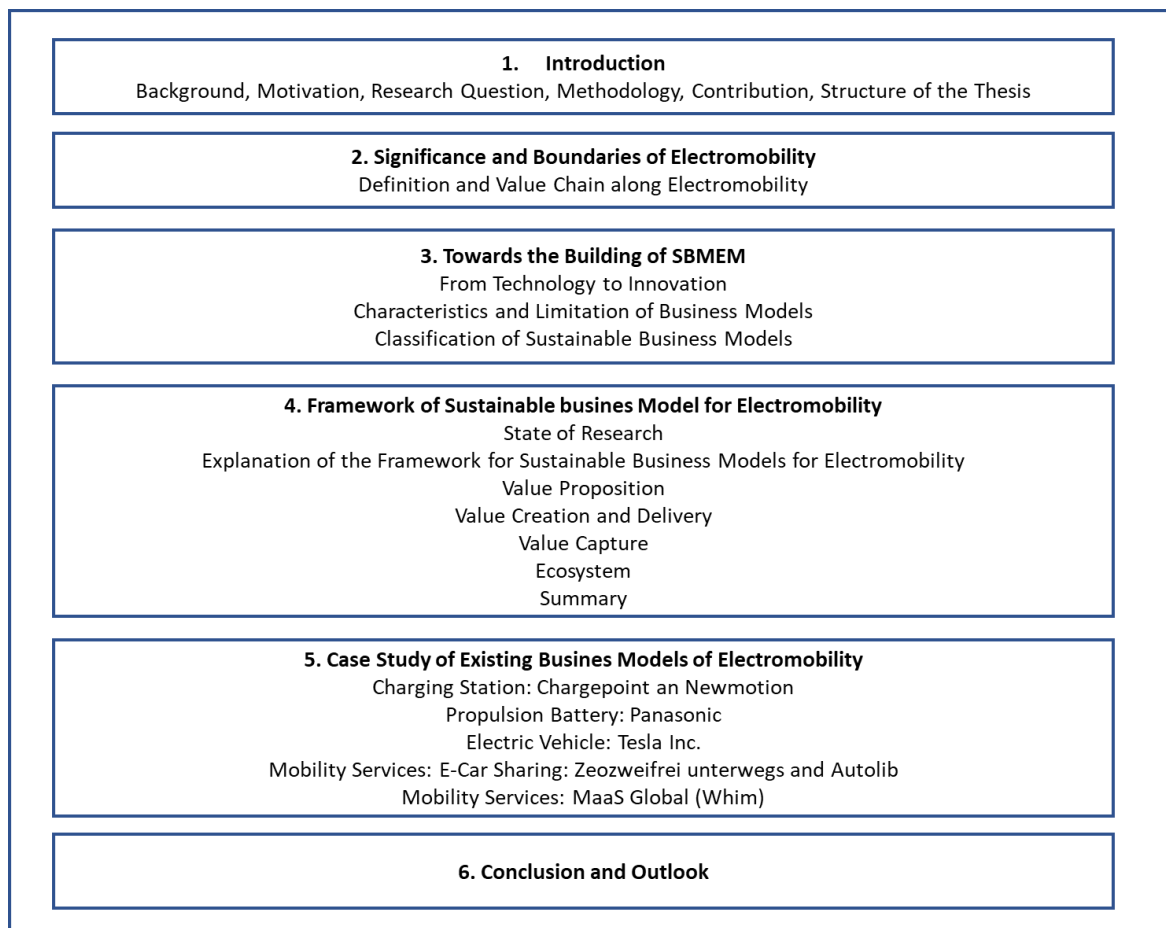


Figure 4: Structure of the thesis: main chapters and course of investigation

2. Significance and Boundaries of Electromobility

Although electromobility is addressed in the academic literature, there are different definitions and a generally accepted definition does not exist. In the next chapter, the term electromobility is examined and a comprehensive definition is created for the thesis so that the framework achieves a high coverage. Then, the impact of electromobility on the different value chains will be analyzed and important elements will be presented and described.

2.1. Several Definitions and Relevance of Electromobility

Megatrends¹ are long-term developments that have a strong influence on society and economy. They change the world for a long time and influence every single person. They are not predicted, but are already there, marking changes and shaping humanity. Popular megatrends in our time are urbanization, digitalization, individualization and neo-ecology (Zukunftsinsitut, 2020). A transformation based on these trends also affects mobility. Automated, comfortable and individual mobility at all times, that is the vision for the future which can lead to an increased volume of traffic and also to increased CO₂ emissions. At the same time, there is a wish of the population that mobility should not be at the expense of the environment (Zukunftsinsitut, 2017). This requires that the different elements of mobility ecosystem merge and that technologies, processes, industries, and consciousness adapt to humanity. Special attention is paid to (CO₂) consumption, of which traffic accounts for a considerable proportion.

Road traffic was responsible for 30 percent of all CO₂ emissions in Europe in 2019 (European_Parliament, 2019). According to studies by the European Commission, Figure 5 shows that passenger traffic in Europe will increase by approximately 40 percent between 2010 and 2050. 67 percent of this will be covered by cars in 2050 and will therefore remain the most important mode of transport in the nearer future (Capros, Höglund-Isaksson, Frank, & Witzke, 2016)

¹ "Megatrends are macroeconomic and geostrategic forces that are shaping the world. They are factual and often backed by verifiable data. By definition, they are big and include some of society's greatest challenges and opportunities" (Modly, Quinn, Alders, & Höhn, 2016).

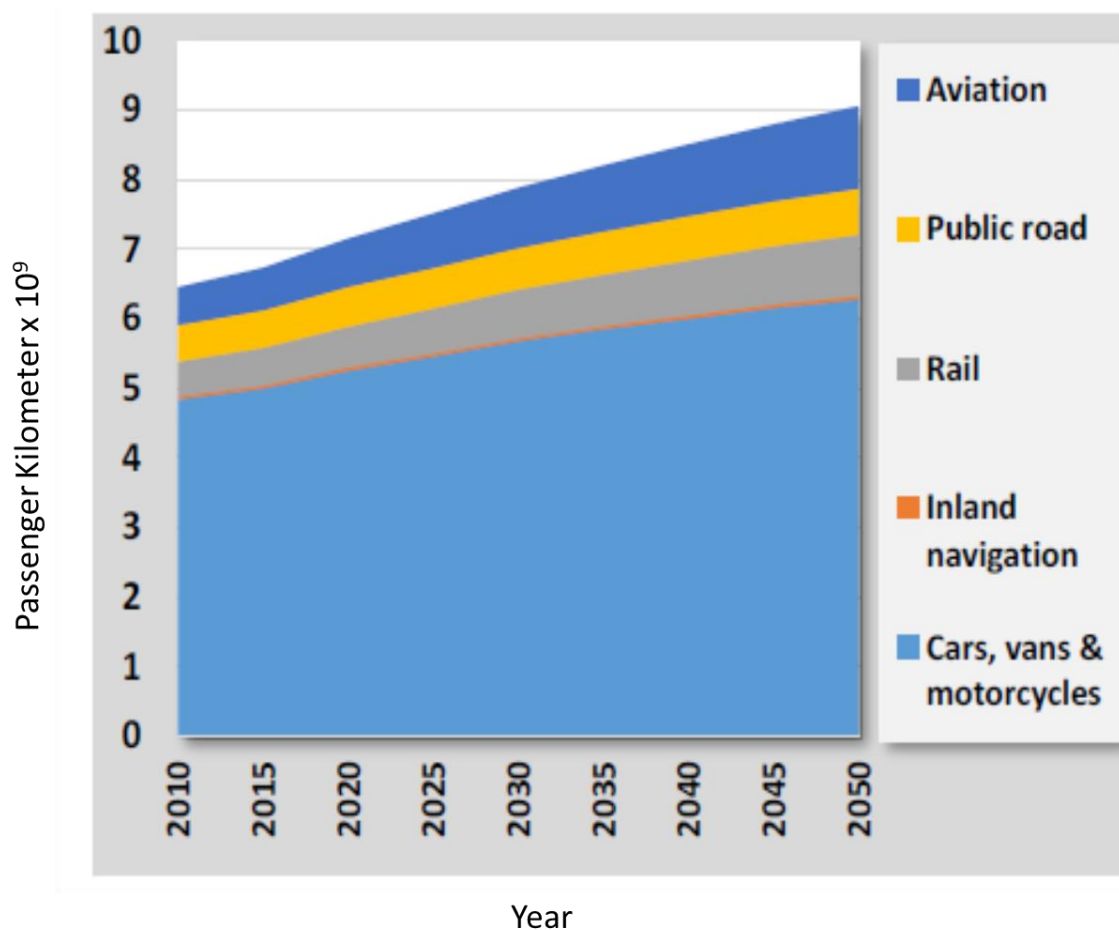


Figure 5: The demand for mobility will increase considerably in the coming years (Capros et al., 2016)

Also, governments are imposing more rigorously laws to reduce greenhouse gas (GHG) in passenger transport (Tietge et al., 2016). Every sold BEV are counted with 0-gram CO₂ in fleet consumption². This motivates OEMs to invest and sell BEVs because if they do not meet government targets, a penalty of 95 Euros per excess gram multiplied by the number of newly registered passenger cars will be imposed. The reduction requirements of the European Union (EU) are very high. Whereas in 2006 the limit was 159 g/km, in 2020 it was already 95 g/km and will be reduced to 59 g/km in 2030 (European Commission, 2019; European Parliament, 2009)(Figure 6). The situation of car manufacturers is further hampered, starting in 2021, vehicles will no longer be calculated with the NEDC-based³ emissions target, but with the

² Fleet consumption refers to the average fuel consumption of a vehicle fleet or its CO₂ emissions. With the “EU fleet-wide target, the average CO₂ emissions of all new passenger cars or all new light commercial vehicles [has] to be achieved in a given period” (European Commission, 2019).

³ New European Driving Cycle (NEDC) is a driving cycle defined in Europe (1992) for the measurement of fuel consumption and exhaust emission limits of motor vehicles for type approvals according to EC Directive 98/69 EC (Tsiakmakis et al., 2017, S. 5).

new worldwide harmonized light-duty vehicles test procedure (WLTP), which can lead to increases of over 20 percent for an identical vehicle. As a result, car manufacturers run a considerable risk of having to pay high penalties from 2021 on (Schiller, Mauries, Pottebaum, Neuhuber, & Bommer, 2020).

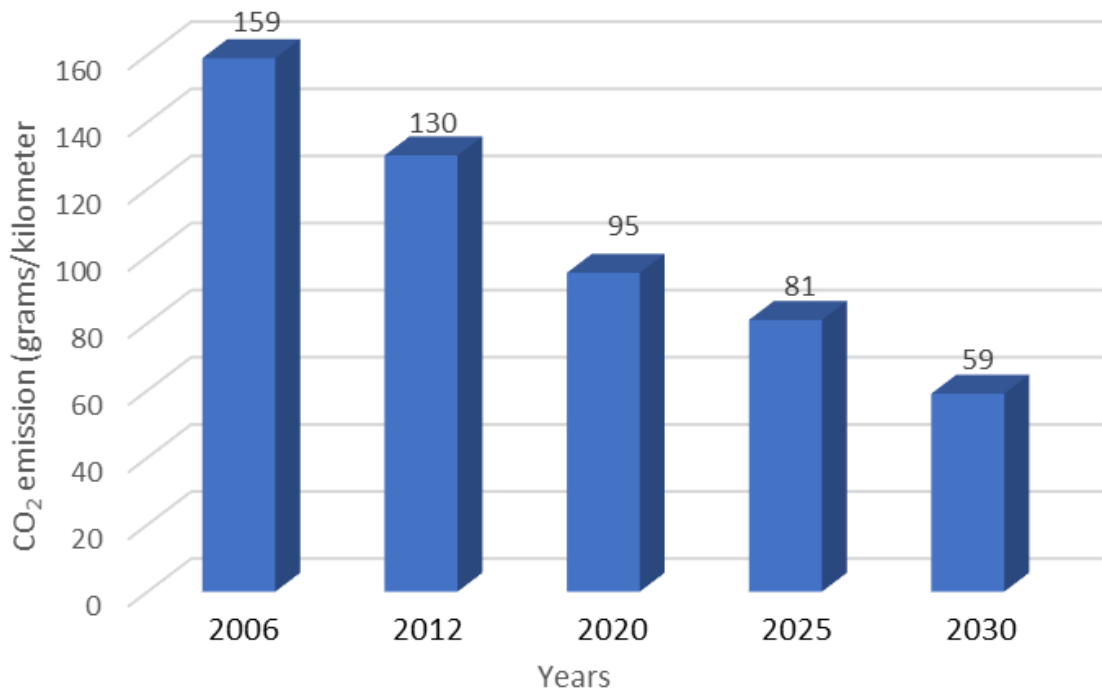


Figure 6: Development of decreasing European emission target from 2006 to 2030 (own illustration, based on (European Commission, 2019; European Parliament, 2009))

At the same time, the demand for environmentally friendly and individual mobility has grown rapidly in recent years and poses high expectations for research, development and industry (Golembiewski & Sick, 2015). Customer surveys show that interest in electric vehicles has increased considerably in the last years (Cordera, Dell’Olio, Ibeas, & Ortúzar, 2019). In 2019, 61 percent of the 4.000 respondents from 16 countries stated that they had a positive attitude to electrified vehicles and 33 percent were considering choosing BEVs over an ICE vehicle (LeasePlan, 2019).

With the buzzword “electromobility”, projects were initiated by governments and industry that should further accelerate the development of environmentally friendly mobility. Innovations to satisfy these requirements are radical and systematic and affect companies in different industries (Altenburg, Bhasin, & Fischer, 2012). Therefore, car manufacturers intensified their research activities in development of

low-emission drive systems and cities started to expand their public transportation systems with environmentally friendly means of transport. Electromobility has become a synonym for more environmentally friendly mobility, which will be fundamentally different from today's. But what is the definition and the relevance of electromobility? This question will be analyzed and different approaches and concepts of scientists will be examined. Their weaknesses will be highlighted. This analysis will lead to propose a new comprehensive definition of electromobility, which is the first step to design sustainable business models in this field.

Although the concept of electromobility has been increasingly treated with great interest and intensity in politics, science, industry and media in recent years, there were already several discussions in previous decades about electromobility. So the first electric vehicle was developed in the 19th century (Lixin, 2009). It was only a few years later that Carl Benz applied for a patent for the "Motorcycle # 1" in 1886, a vehicle with internal combustion engine (Daimler_AG, 2020). Interest increased again in the 1990s due to a law, introduced in California to reduce vehicle emissions and high overcapacity in automotive industry, which was accompanied by declining economic growth. The result was restructuring, plant closures and job cuts in this important industrial sector in many countries (Filho, Tahim, Serafim, & Moraes, 2017). At that time, the American car manufacturer, General Motors, developed a series-produced electric vehicle, called "EV1", which was leased to customers from 1996 to 1999. However, due to low interest, the vehicles were taken off the market in 2002 and largely scrapped (Lixin, 2009). Later, the start of the global economic crisis in 2008/2009 and the emerging discussions on environmental protection lead to higher interest for more environmentally friendly vehicles and more research efforts into alternative drive systems (Filho et al., 2017). In the EU, many research projects were launched and industries were subsidized with public funds. Governments increased their efforts to harmonize and promote the environment, mobility, and healthy economic growth.

Electromobility, e-mobility, electric-mobility or electric mobility is a word creation, which is written differently and does not allow a sufficient indication of its full meaning in science. The term is still so new that it is not yet considered and defined in well-known dictionaries such as Oxford Dictionary (Dictionary, 2021) or Cambridge Dictionary (Cambridge_Dictionary, 2021).

Bertram & Bongart (2014, p. 5) and Füßel (2017, p. 7) establish a close link between electromobility and individual transport. The word "mobility" has its origins in the Latin ("mobilis") and defines the possibility and ability to *"...achieve the desired destination by means of a temporal-spatial change of location"* (Bertram & Bongard, 2014, p. 5). It is necessary to be able to move between different locations to carry out essential activities of life such as working, caring, relaxing, and living. It also serves the individual development and is a basic demand of humanity. Mobility behavior changes depending on lifestyle, habit, age and political conditions (Zukunftsinstitut, 2017). Transport is the realized mobility in terms of the aggregated change of location of persons, goods or information that meet the mobility needs (Canzler, 2009, p. 313). A different Interpretation comes from Sauter-Servaes (2011) and Augenstein (2014). For them, electromobility is a word creation from the terms „electrified“ and „automobile“, where electricity is described as *„a form of energy from charged elementary particles, usually supplied as electric current through cables, wires, etc. for lighting, heating, driving machines, etc.“* (Oxford_Dictionary, 2020). Automobile is defined as a wheeled motor vehicle used for transportation. They run primarily on roads and have four tires (Grahame & Fowler, 1976).

The German Federal Republic (2009, p. 5) and the State Agency for New Mobility Solutions and Automotive Baden-Württemberg (2019) define electric vehicles as all types of vehicle concepts that allow battery-powered propulsion. A comprehensive definition based on vehicles is that a car is fully or partially electrically powered by an electric engine and primarily get their energy from the power grid and can be recharged externally (Gartner-Group, 2019; Grauers, Sarasini, & Karlström, 2013; Jochem, 2019; Paschotta, 2019; Spath, Bauer, Rothfuss, & Voigt, 2010; VDI/VDE, 2019). It includes BEVs and vehicles with a combination of two powertrain technologies. Hybrid electric vehicles (HEV) can be classified in series hybrid (ICE - drives the generator for the electric engine) and parallel hybrid vehicle (ICE - engine and electric engine are coupled to drive the vehicle) (Emadi, Lee, & Rajashekara, 2008). In addition, the plug-in hybrid (PHEV)⁴, the hydrogen fuel cell

⁴ PHEV is a motor vehicle with hybrid drive where the accumulator is charged both by the internal combustion engine or by the mains power supply (Emadi et al., 2008).

(FCV)⁵ vehicle, mild hybrid⁶ and the range extender electric vehicle (REEV)⁷ count also to the definition of electric vehicle (Emadi et al., 2008; Grauers et al., 2013; Jochem, 2019; Paschotta, 2019; Spath et al., 2010; VDI/VDE, 2019).

For Rammler and Weider (Rammler & Weider, 2011) is electromobility a battery electric vehicle with at least three wheels and exclude pedelecs and electric motorcycles. Koppel et al. (2013, p. 14) is integrating BEVs which have no additional drive.

Electric motorcycles, bicycles and Segways⁸ can also be powered by batteries and electric motors and are also included as means of transports.

There are different positions regarding the status of fuel cell vehicles and its belonging to the category of electric drives. The European Commission (2020) explicitly includes them while Kaiser (2012) and Bertram (2014) exclude them as they define e-mobility by the fact that the propulsion is mainly provided by an electric drive, which is primarily fed by an externally rechargeable battery.

An overview about electric vehicle can be seen in Figure 7.

⁵ A FCV or a fuel cell electric vehicle (FCEV) is an electric vehicle that uses a fuel cell instead of a battery or in combination with a battery to power its electric motor in the vehicle (Pistoia, 2009).

⁶ In a mild hybrid, the vehicle is powered by an internal combustion engine and assisted by an electric motor (Emadi, 2014, pp. 333–334).

⁷ In a REEV, the installed combustion engine drives a generator that supplies the battery in the vehicle with energy when required. For this function, the combustion engine can be designed smaller than in a pure combustion engine. The electric motor is responsible for propulsion (Spath et al., 2010).

⁸ Segways are two-wheeled electric scooters where the driver stands on a platform between the wheels.

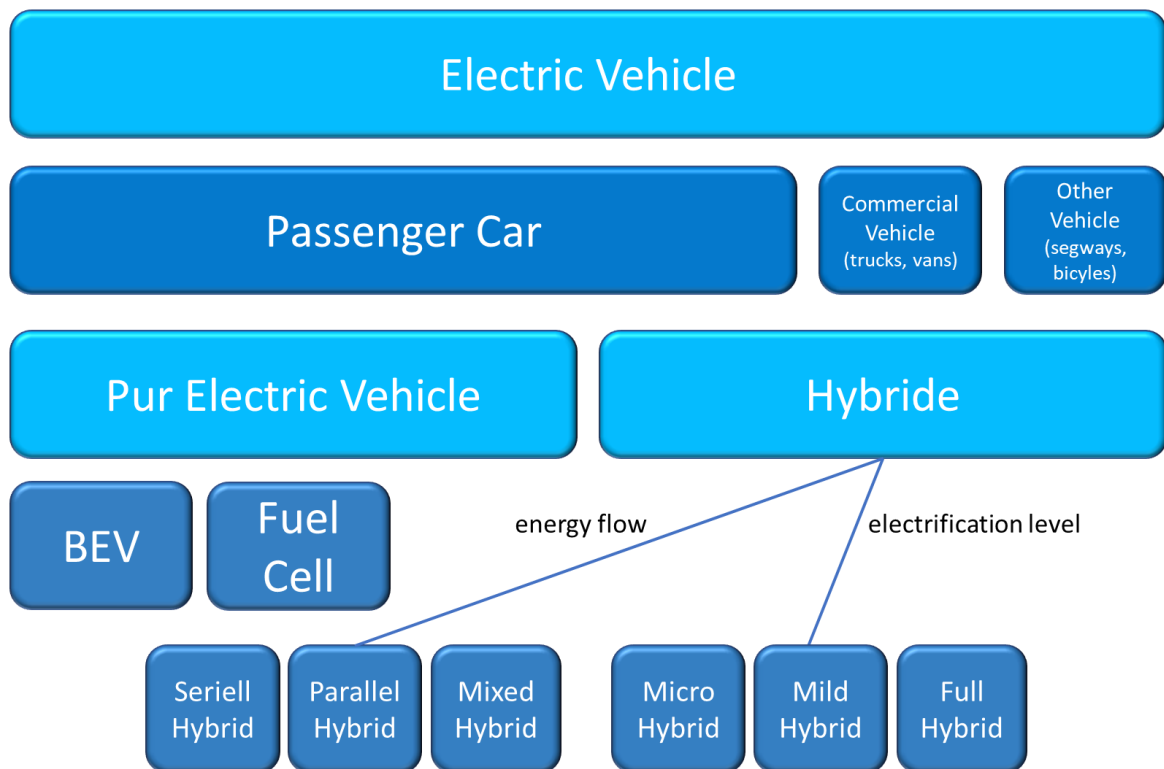


Figure 7: Overview of electric vehicle types (own illustration)

In case of trucks, three future-oriented technologies are currently being developed for electric mobility. First, the vehicles are supplied with electricity by means of overhead lines. However, it is not followed up by manufacturers and environmentalists because the electric railways already have a transport system with overhead contact lines and the extension of roads with overhead contact lines increases the danger of electro smog and causes a certain degree of environmental destruction (Doll, 2019). There is a second technology for trucks which consists in providing them externally charged batteries. In addition to their heavy weight, they are currently very expensive and allow a maximum range under 500 kilometers which is only interesting for short-distance transport. The fuel cell as the third approach appears to be the most future-oriented, as it achieves a longer range than battery, therefore companies are continuing to conduct research in this area (Hubik & Buchenau, 2020; Simon, 2020; Vichard et al., 2018). Although electrically powered vehicles have a high potential in commercial traffic among craftsmen and delivery services, these will not be considered further in the thesis because the business models follow different rules compared to individual mobility, which requires a specific study. Technologically, fuel cell vehicles are also powered by an

electric motor, but it is not supplied by a battery but by a fuel cell⁹. The low level of development of hydrogen vehicles, the very limited supply of vehicles and the very low number of fueling stations are reasons that it will not reach that level for the mass market in the foreseeable future (Siddiqui, 2020). Therefore, they are excluded in the closer examination of the thesis as well.

Recently, the concept of electromobility in academic literature and industry has been extended to upstream and downstream stages of production and operation (Bozem, Nagl, Rath, & Haubrock, 2013, p. 80). Reasons are an increasing concern about the environmentally harmful extraction of raw materials and bad social conditions of the employees at these stages of production. The European Commission (2020) therefore specifies the necessary conditions for operation and the introduction of intelligent electricity distribution networks and charging infrastructures. Bozem (2013, p. 2) and Hüttl (2010, p. 14) also see the charging infrastructure as a necessary component of electromobility, while Lee (2011) sees the basic supply of the electric vehicle not only with electricity for operation, but also with the supply of the batteries, the maintenance and repair work.

The term “autonomous driving” is also increasingly associated in the literature with electromobility, urbanization of cities and individual mobility (Attias & Mira-Bonnardel, 2019; Matthaei & Maurer, 2015). This refers to a self-driving vehicle that can transport passengers by using road maps, information and communication technology (ICT) and global localization using environmental- and self-awareness (Matthaei & Maurer, 2015). However, autonomous driving does not require direct electric vehicle propulsion and will therefore not be pursued further in this thesis.

A definition of electromobility reduced to the vehicle and its operation is too narrow to encompass the diversity of issues related to such a socio-technical phenomenon. Even introducing in this definition, the positive effects of electromobility associated with environment is not enough to support adequately research and development in

⁹ Within the fuel cell, a chemical reaction between hydrogen and oxygen produces electricity. This in turn is transferred to the engine and drives the vehicle. The big advantage: there are no emissions, only water vapor. This would make the hydrogen car the most environmentally friendly car in use. But the vehicle also has its downsides. How is hydrogen produced? Hydrogen does not occur in its pure form in nature. It would therefore have to be produced expensively from water and natural gas. Together with storage and transport, there is also a high energy consumption (Hertzke, et al., 2019; Tietge et al., 2016).

this area. Therefore, electromobility has to be given a broader view to create the basis for more environmentally friendly mobility. This can be achieved by integrating parameters related to electromobility as a system. A comprehensive description is provided by Bonnema (2015) and the „Electric Mobility in Norway“ project, which is supported by the Nordic research program BISEK¹⁰ (Figenbaum & Kolbenstvedt, 2013, p. 4). Electromobility will be extended to raw materials used for vehicles and batteries, the production of vehicles and environmentally friendly generated electricity, the applications for electric vehicles and the combination with other means of transport, especially public transport (Figure 8). In this new ecosystem for electromobility, technologies, stakeholders, and infrastructure will be linked and harmonized.

¹⁰ BISEK is a research program (The Social and Economic Significance of the Motor Car) which analyzed the consequences of electric vehicles to individuals and households (Figenbaum & Kolbenstvedt, 2013, p. 4).

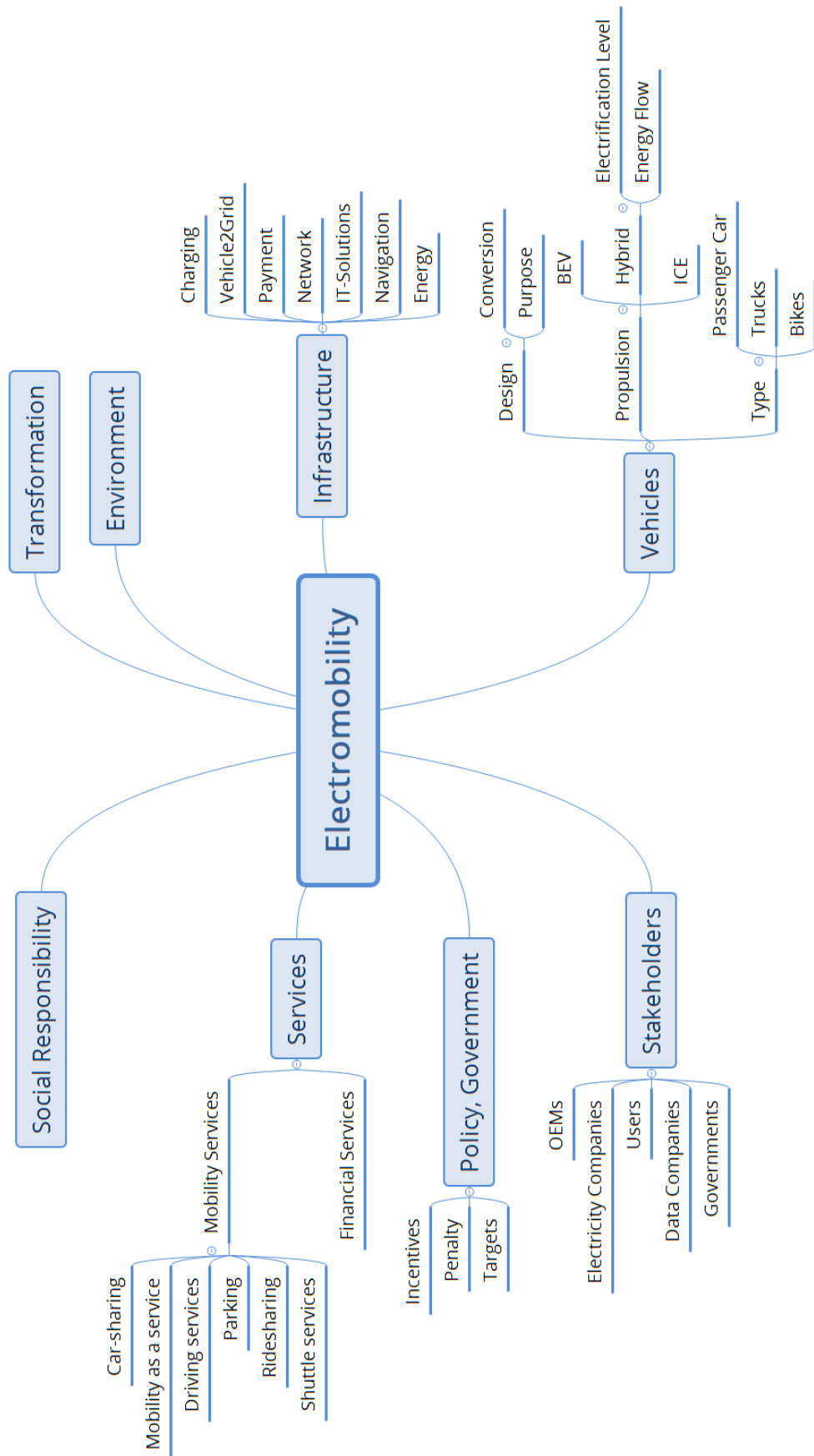


Figure 8: Elements of electromobility as a system (own illustration)

New technologies and ecosystems require an accompanying and long-term transformation process for their successful introduction and implementation. Today, the electric vehicles on the market have considerable disadvantages compared to the standards of ICE vehicles. Shorter ranges, insufficient number of charging stations, long charging times and a higher price than ICE vehicles (Brennan & Barder, 2016) hinder the sale of electric vehicles. Another reason is that the user cannot be sufficiently communicated the advantages and usefulness of electric vehicles. In 2019, only 387.808 BEVs, PHEVs, FCEVs and REVs were sold in Europe (without United Kingdom) (ACEA, 2021b), which represents 2.97 percent of the total new vehicle sales (13.028.948) (ACEA, 2021a). At the same time, the share of sport utility vehicles (SUV) with combustion engines was by 38.3 percent in 2019 (Workman & Munoz, 2020), although these are known to be more environmentally harmful than electric vehicles. The number of registrations increased significantly in Europe in 2020 and 2021. For example, 282,576 BEVs were already sold in Europe (excluding the UK) from January to June 2021 (ACEA, 2021b). However, this is predominantly due to high subsidies from the governments (Hubik, Menzel, Olk, & Rickens, 2021). Electric drives are predominantly considered to be environmentally friendly, so the acceptance of electromobility also depends on the environmental awareness of buyers and their willingness to accept disadvantages compared to vehicles with internal combustion engines. According to different studies, the acceptance of electric mobility depends also on age, gender, and individual attitude. For example, most younger people trust that the electric car will displace vehicles with combustion engines. There are also more men, aged between 35 and 55 with higher educational qualifications and higher incomes, who have a strong interest in electromobility (Jonuschat, Wölk, & Handke, 2012).

Considering electromobility, different transport modes and distance ranges must also be considered in order to obtain a holistic perspective. For bridging shorter distances, like in the city or suburbs, the use of BEVs or public transport is convenient. If longer distances need to be covered, rail or a hybrid vehicle can be used (Figure 9).

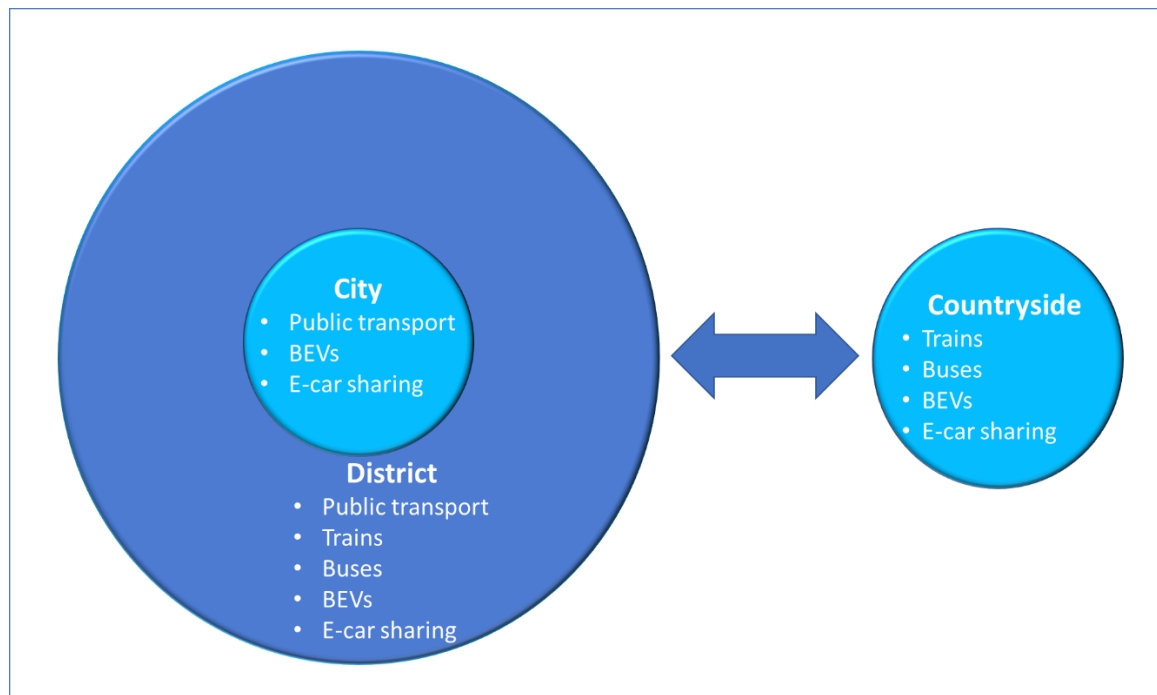


Figure 9: Depending on the distance to be covered and the geographical location, different means of transport can be used in electromobility (own illustration)

2.2. A Comprehensive Definition of Electromobility

The result of the review shows that there is no unified definition of electromobility in science. They differ considerably in content and topics of transport, infrastructure, and acceptance. For further development of the thesis, the term electromobility is defined in a new and comprehensive way.

Electromobility refers to mobile individual transport with reduced direct emissions of pollutants. Mining, production, use and recycling of products of electromobility (vehicles, infrastructure, development of services) must be environmentally friendly and socially responsible. Electromobility goes hand in hand with modernized networking of cities, municipalities, countries, and states as well as integration of smart technologies. The transformation process and the integration of stakeholders must be considered.

Electromobility supports the population's desire for individual mobility with no or reduced environmental impact. This does not mean that everyone has to own a car, but by adding other mobility concepts based on electromobility, the focus is on

transportation without ownership. The entire live cycle of the products must be considered and the consumption of raw materials must be minimized. The necessary connectivity can be achieved by integrating smart technology. The transformation process and the integration of stakeholders are also part of the definition.

Individual mobility and electromobility can be a contradiction in terms. Electrically powered vehicles have shorter ranges than vehicles with combustion engines. As a result, BEVs have to be charged more often than ICE vehicles need to be refueled and charging times are longer than refueling ICE vehicles. In addition, there are currently not enough charging stations, which can be occupied on highly frequented traffic routes due to longer standing times of BEVs. To overcome these, it is necessary to enhance technology of electromobility by more powerful batteries and economical electro engines. Also, the expansion of the charging infrastructure helps to increase charging opportunities and enable individual mobility.

From the previous contents and elements, the key values of electromobility are extracted and summarized: individual mobility, integrated and connected, convenient, flexible without planning, environmentally friendly, social compliant (Figure 10). They are the basic principles of electromobility and are the foundation on which they are built. They remain stable even when the surroundings change.

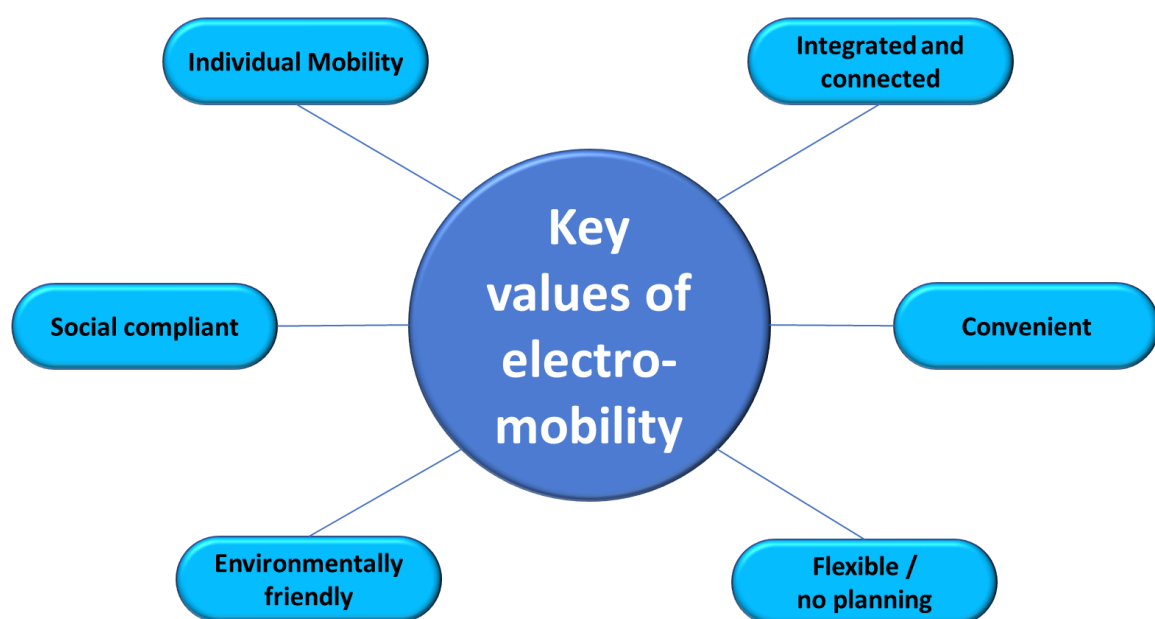


Figure 10: Key values of electromobility (own illustration)

Electromobility can be one option because it can reduce the burden of traffic on the environment with modern technologies and a functioning ecosystem. The pressure from population and politicians for sustainable mobility will increase. Electric mobility has the long-term potential to reduce and eliminate environmental problems such as noise and exhaust emissions. Industries, service companies, electricity companies and mobility services are called upon to offer solutions that are not only acceptable to the customer but are even strongly desired. But new incentives must be found in a variety of ways to support it. The governments of the countries will not find or propose directly implementable solutions and the users will need good arguments and solutions to want to leave the current, very familiar and well-worn path. Electromobility is currently the only way to offer sustainable mobility. However, electromobility has extensive impacts on companies. In addition to the products, this also affects the organization, production, sales and, in particular, the value chains.

2.3. Value Chain along Electromobility

Electromobility generates disruptive changes in the value chains. New technologies are implemented in globally networked supplier and marketing processes. Therefore, new competitors are arising and the competitive pressure on established participants is increasing. This generates new global value creation relationships. In addition, the pressure for cost savings and technology development is growing to make products and services competitive. As a result, the entire value-added chain must be restructured and improved to reduce costs significantly. However, electromobility involves not only high-tech products but also services that combine technologies and increase the benefits for the customer. The benefit of a charging station is significantly increased for the customer if the availability of an application (app) makes it easier to find and pay for charging station.

The value chain is a management concept and was first described by Porter (1985). It involves identifying general value-adding activities of an organization and determining costs and value drivers. It is used in strategic planning as a controlling management tool and aims to maximize value creation while minimizing costs. Porter (1985) shows that competitive advantages can be achieved with new technologies and their associated strategies. Value chains divide the activities into several categories. Primary activities include inbound logistics, production,

distribution, marketing and sales, and are required to create main products and services. The support activities assist primary processes. These include administrative infrastructure management, human resource management and procurement (Figure 11) (Porter, 1985).

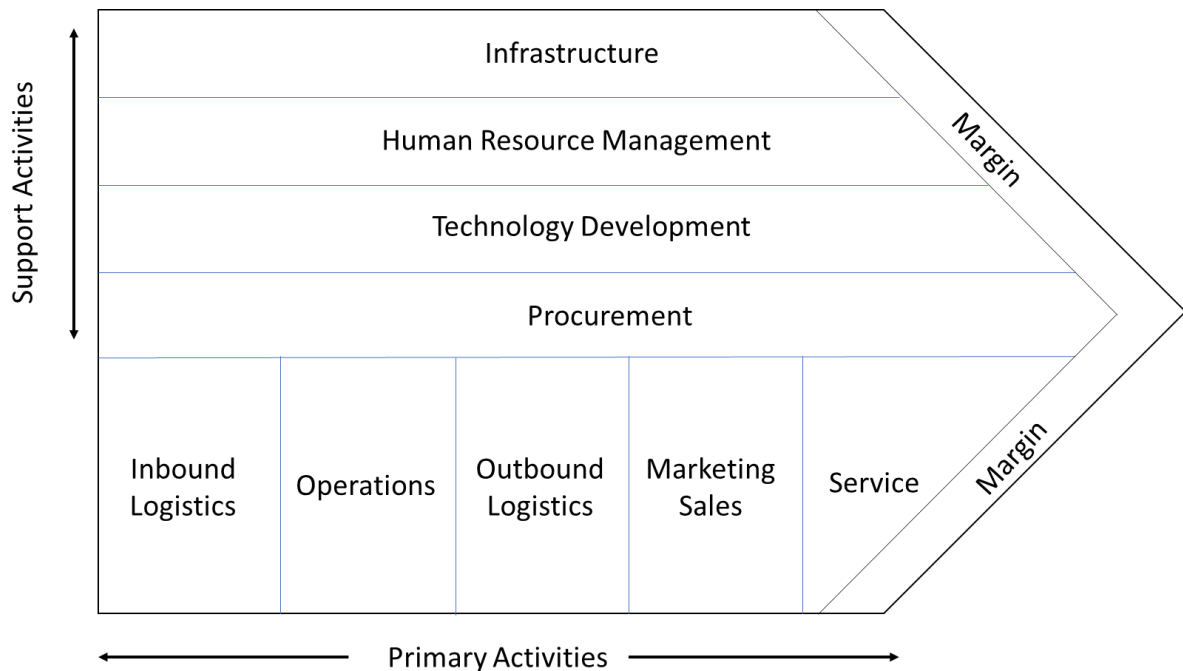


Figure 11: Value chain by Michael Porter (Porter, 1985)

Quite often, processes in companies are more complex and Porter's nine activities are supplemented and expanded by additional, industry-specific ones. The value chain has been discussed sufficiently in literature and is out of the scope of the thesis to discuss it further. The thesis concentrates on the effects of electromobility on the value chain of mobility, since there are still research gaps.

Kampker et al. (2018, pp. 42–53) analyze the change in the value chain following the introduction of the electric vehicle. They classify activities into up-stream (material, development, and production efforts) and down-stream (marketing, sales, financing). They show that new activities and business areas will change the scope of incumbents and new players will emerge. Also, technological and environmental changes lead to a higher number of collaborations. However, the predominant changes are expected to occur in the up-stream area with additional value-added components for the automotive industry. In their explanations, the authors refer primarily to the electric vehicle and do not consider other elements of electromobility.

Kasperk et al. (2018, pp. 133–154) show in their analysis the effects of changing business models on the value chain. Likewise, the need for cooperation due to new competencies is necessary and reasonable. Here, too, the basis of the analysis is the electric vehicle and the car manufacturers with their impact on other players and functions. Deuskens (2014, pp. 67–150) analyzes the value chain of the internal combustion engine and its changes with the introduction of the electric drive. He examines the differentiating features of the cost structures, the manufacturing competencies and the challenges of change. Strategic and organizational design elements of value creation as well as decision models are analyzed. Fournier et al. (2012) point out in their analysis of value chain in the automotive industry that this must be expanded to cover additional functions. These include new services for mobility, information, and communication applications. These expansions can represent a market potential for OEMs, but also risks if the adjustments are not made quickly enough. New competitors can displace the existing ones with new business models. In further elaborations, the starting points are the value chain of the automotive manufacturers and the changes resulting from the electrification of the vehicle. These include Freihaldenhoven and Wallentowitz (2011), Helbig, Sandau and Heinrich (2017), Wietschel et al. (2017), the project EVchain.NRW (2014) and the consulting company Deloitte (Helbig et al., 2017). Rath und Bozem (2013, pp. 103–114) indicate a close link between the value chain of the automotive manufacturers and the energy suppliers. They identify that different element of the value chain can be taken over by an actor displacing existing ones. In addition to developing, producing, and selling electric vehicles, OEMs can also offer customers power supply services. Other functions may include generating electricity or offering mobility services. However, the explanations do not take sufficient account of the potential that can result from a cross-sector ecosystem: the benefits for the customer could be further improved than through predatory competition. In different case studies in mobility in Japan, Beeton and Meyer (2014, pp. 208–213) show an extension of the value chain. The connection of electric vehicles with battery manufacturers and operators for the design of mobility designates the extension of the value chain beyond the vehicle. Communication and collaboration among multiple players in the value chain are necessary for successful implementation. In

addition, other value creation modules can be tapped, such as data and energy management (Figure 12).

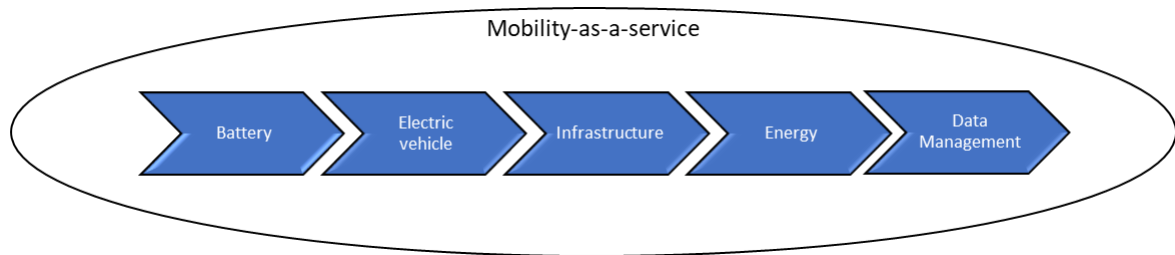


Figure 12: Linear value chain of electric vehicle and mobility as a service (own illustration based on (Beeton & Meyer, 2014, p. 211))

The Amsterdam Roundtables Foundation in cooperation with McKinsey (2014) indicate opportunities in the value chain of electromobility for incumbents and new entrants. For them, the introduction of electromobility as related to government regulations and the development of total costs. This has implications for OEMs and their suppliers, as well as for charging infrastructure and electric grid.

The report on potential analysis for electromobility at the City of Bremen (EuPD_DCTi, 2011) analyzes that the value chain of automotive industry needs to be extended with additional components from electrification. It consists of the elements of raw materials, vehicle components and electric vehicles. This vehicle-related value chain is supplemented by an energy-related value chain, which includes the generation of electricity, the infrastructure required for charging the vehicles and mobility services. A link is present between the vehicle-related and energy-related value chain in the components to infrastructure and electric vehicle to mobility services. As a result, the development of the vehicle battery component has to be coordinated with the infrastructure charging station. This leads to significant time and cost advantages. There is a common value chain in sales, maintenance, and recycling to offer the customers the highest possible benefit and reduce costs. The players are companies that are specialized in the respective elements of the value chain. The relationship of cooperation or possible forms of organization are not further elaborated in the report, which represents a weakness (Figure 13).

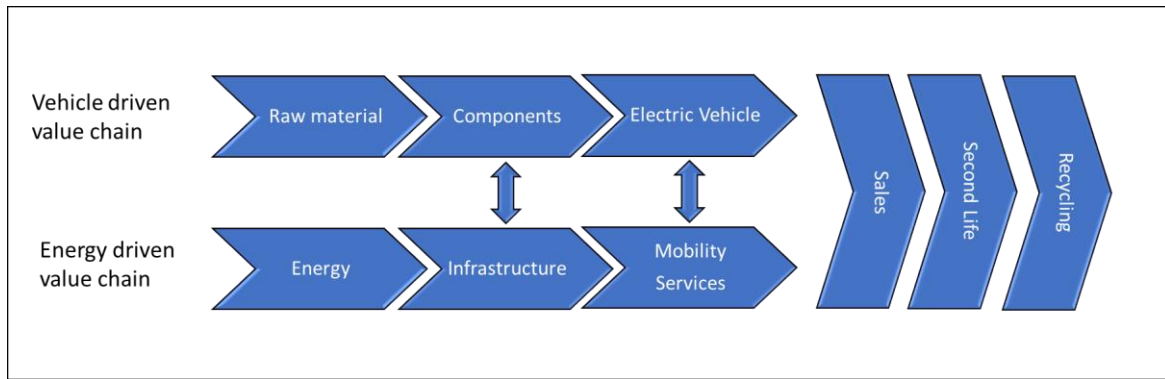


Figure 13: Combined value chains of electric vehicle and energy (own illustration based on (EuPD_DCTi, 2011))

The McKinsey Center for Future Mobility (Tschiesner et al., 2018) points out the further development of the value chain of automobile manufacturers due to government regulations into an electro mobile value chain. This not only avoids high penalty payments, but also opens up new potential in the field of mobility services. Also, the development of the value chain into an ecosystem is particularly important. Changes in the industrial environment due to electromobility make it necessary to enter into new cooperative ventures. For example, technology companies are increasingly entering the mobility market as mobility value chain expand to include areas in which they have a high level of expertise and where automotive industry products can be incorporated. Tschiesner et al. (2018) conclude that after a consolidation phase, there will be only a few ecosystems with different players, which can be divided into tech-oriented, OEM, investor-oriented and open platform ecosystems. The possibility of ecosystems for individual components or products of electromobility is not investigated.

Simpson et al. (2019) state in their report that in future there will be no longer one or more linear value chain in electromobility but this will develop into a complex web of interconnected value chains. In addition, the sources and contents of the different value chains will shift and lead to a new composition of market participants. This will have an impact on all branches and may even lead to the complete elimination of existing industries. From this, the authors derive five strategic directions for electromobility players: decoding and invest in disruptions, aggregate services and serve it to the customer, use of existing assets for new business ideas, monetizing data, use of agile methods to scale the commercialization of products and services.

They also expect that there will be two OEMs in future, the metalsmith and the grid masters which will provide platforms with mobility services.

Selected literature about value chains of electromobility is summarized in Table 1:

Table 1: Selected literature of value chain for electromobility, sorted according to the content of electromobility

Author	Main Contribution about the value chain of electromobility
(Kampker et al., 2018, pp. 42–53)	Shows changes for incumbents and new stakeholders in the value chain in the automotive industry.
(Kasperk et al., 2018, pp. 133–154)	New business models in electromobility lead to an expansion of the ecosystem with new stakeholders.
(Deutskens, 2014, pp. 67–150)	Electromobility is a disruptive innovation and focuses on strategic an organizational design elements of value creation.
(Fournier et al., 2012)	Address new services for automotive companies to enhance the value chain. This can also be a risk because new entrants can take over the business.
(EVchain.NRW, 2014; Helbig et al., 2017; Wallentowitz & Freialdenhoven, 2011; Wietschel et al., 2017)	Compare ICE and BEVs and the role of stakeholders on the value chain of electromobility and analyze changes for automotive industry. They describe automobile manufacturers threatened by electromobility and analyzes that the battery is one of the main changes in the value chain of car manufacturers.
(Bozem, Nagl and Rennhak 2013, pp. 103–114)	Demonstrate that special players can take over elements of value chain and displace incumbents.
(Beeton & Meyer, 2014, pp. 208–213)	Explain the expansion of the existing value chain by OEMs through new business areas like data and energy management.
(Amsterdam Roundtables Foundation and McKinsey, 2014)	See opportunities related to electromobility for incumbents and new entrants by new business models forced by government regulations.
(EuPD_DCTi, 2011)	Studies interactions between parallel value chains from OEMs and energy suppliers to reduce costs and increase value proposition.

(Tschiesner et al., 2018)	Deal with the creation of industry-specific ecosystem to avoid penalty due to CO ₂ emissions. After a consolidation phase, only a few ecosystems will survive.
(Simpson et al., 2019)	Show that end-to-end value chains are transformed to value networks and leads to the emergence of new market players.

In summary, it can be stated that today there is a small amount of literature dealing with the value chain changes due to electromobility. However, the attention still clearly focuses on the transformation of value creation and delivery in the automotive industry, illustrated by changes in the supply chain. Likewise, the authors address the fact that entrants will change the ecosystem composition and will also lead to incumbents or entire industries being eliminated. There are differences in the assessment of how the value chain will change. Kampker et al. (2018, pp. 42–53), Kasperk et al. (2018, pp. 133–154), Deutschens (2014, pp. 67–150), Beeton (2014, pp. 208–213) and The Amsterdam Roundtables Foundation (2014) show an extension of the existing value chain with additional elements, but stay with one linear string. Fournier et al. (2012), Rath and Bozem (2013, pp. 103–114), the report of the city of Bremen (EuPD_DCTi, 2011) show aggregated value creation stages in form of parallel value creation strings. Tschiesner et al. (2018) create independent ecosystems that are clustered by industry which interact with each other. Simpson et al. (2019) transform the value chain into a complex ecosystem net based on electromobility products and elements. There is also no consensus on how the players in the electromobility value chain interact. While Kampker et al. (2018, pp. 42–53) and Kasperk et al. (2018, pp. 133–154) discuss cooperations, Simpson et al. (2019) talk about an interconnected set of emerging value chains. However, no further research exists on how the value chain develops holistically due to the fact that electromobility consists of multiple products and services that are interdependent. In addition, it has not yet been sufficiently investigated how the various value chains within electromobility relate to another. Furthermore, it is not clear how the value chain relates to an ecosystem and how the ecosystem is composed and Simpson et al. (2019) concentrate on value chains and not on business models therefore environmental protection and social aspects are not considered. Is it still possible to form an end-to-end value chain in

electromobility or is electromobility as a complete system too complex which requires more flexible structures to be implemented?

It is widely agreed that the value chain in electromobility must be extended to include additional elements. It is still at the beginning of its development and more research has to be done so that a high level of benefit can be achieved for the customer. It can also be agreed that an interconnected set of specific value chains is more relevant for electromobility than traditional linear value chains. One reason is that electromobility aggregates products and services from different industries which can be seen in the automotive industry where BEVs are interlinked with charging stations and electricity.

Also, the complexity of interdependencies between different products (and services) prevents linear value chain with a single string for electromobility. A network of value chains emerges, some of which are closely related to each other (Figure 14). There will be also a shift in the elements between the value chain compared to today. Vehicles will be leased by the customer via MaaS and no longer purchased directly from the manufacturer. As a result, car manufacturers can lose the direct contact with the customer, who will only communicate with the MaaS operator. Even the downstream processes after the purchase are no longer demanded directly by the customer, but by the MaaS service providers.

Today's differentiated value creation in a single value chain can be transformed into a network of value chains so that information and data can flow freely between the various participants. A closer interaction between players in the value chain will play a key role, which is currently neither available among the parties nor with the necessary technology. Mechanical engineering and vehicle manufacturers are entering into new and/or closer cooperation with the energy industry and software companies to commercialize electric mobility. Therefore, in order to establish electric mobility, there will be a consolidation phase in which an ecosystem is built and is strengthened in order to reach the necessary efficiency to make electromobility successful without government subsidies. This can consist of a network of cross-sectoral value chains in which players cooperate across the board to generate high benefits for the customer. The various value chains will be self-contained but serve an overarching goal as a whole. The interconnections of the

value chains in the network will be so extensive that individual value chains will not make a sufficient contribution to the value proposition for the customer.

Environmental friendliness is not considered to the necessary extent in the discussions in academic literature. While second life use and recycling are partially, too little attention is paid to environmentally destructive mining methods in the extraction of raw materials. This can be cost effective but will disrupt the entire value chain and result in products and services no longer being demanded. The same is about social aspects, which are given far too little emphasis in academic literature. Equal access to jobs and products as well as respect for human rights should be elementary components in the value chain of electromobility. This can be done by extending CSR rules in existing companies or by adding new stakeholders. For incumbents in individual mobility, these transformations are a challenge for the entire company. Existing and optimized processes must be adapted to new products and services and existing sales markets can change or even disappear completely.

2. Significance and Boundaries of Electromobility



Figure 14: Ecosystem of interrelated value chains covers all levels of electromobility in a net (own illustration based on (Simpson et al., 2019, pp. 15–17))

In summary, most authors limit themselves to the changes in the value chain caused by new technologies. There are research gaps which can be closed in order to consider the whole ecosystem of electromobility and by considering the relationships between specific value chains. It is also necessary to go beyond the pure consideration of products and services and the relationships between individual companies and to include environmental and social aspects. For this

purpose, an overarching network of value chains has to be created which expands the linear value chain considerably. It includes sustainable production of electricity, which can be wind-, solar- or hydro-generated by private energy providers, municipalities, or even private photovoltaic plants. Distribution of the electricity to public or private charging stations is done by the power providers. High-performance batteries required to operate electric vehicles are produced by automobile manufacturers or, to a large extent, by a few specialized consumer electronics manufacturers. They are installed in electric vehicles, motorcycles or scooters by vehicle manufacturers, who also sell them to customers. The ICT required by electromobility and demanded by customers link products and services together in form of websites or apps. Operators run products and services for vehicles, billing, and route finding via various mobility services. To save raw materials and energy, it is necessary to leave the products and the batteries in the mobility cycle for as long as possible and then recycle it at the end of their life cycle through special companies. This means that the raw materials can be returned to the cycle.

Since the value chain of electromobility is fundamental important to the thesis, the elements are explained in the following paragraphs.

Raw Material

Electromobility requires various raw materials that are only available in limited quantities on earth. Some have to be extracted at high cost and under socially negative conditions (Valero, Valero, Calvo, & Ortego, 2018), which suggests that recycling has to be included in the value chain of metals for electromobility (Figure 15). These materials are needed especially for batteries. With the increase in demand for vehicles with propulsion batteries, demand for raw materials such as aluminum, cadmium, cobalt, lithium, nickel, and zinc has risen considerably and will continue to rise in coming years (Valero et al., 2018). As a result, prices are increasing and mining methods are being modified that larger quantities can be mined in a shorter period of time, which also can have negative impact on social aspects (Meyer, Buchert, Degreif, Dolega, & Franz, 2018, p. 3).

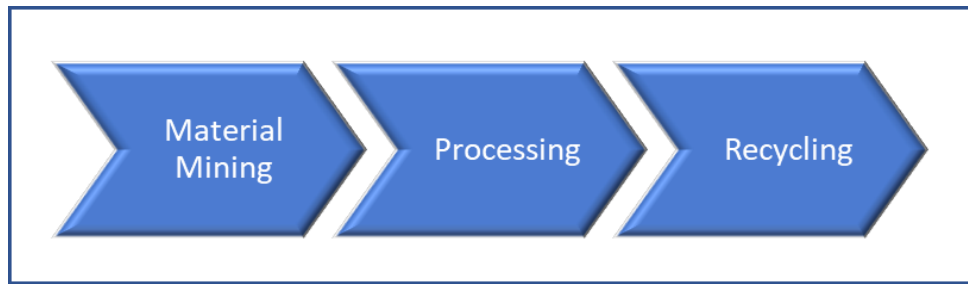


Figure 15: Linear value chain of raw material processing for electromobility (own illustration)

Electricity

In 28 European countries, net electricity production amounted to 3.03 million gigawatt per hours (GWh)¹¹. At 47.6 percent, production from solid fuels such as coal or oil is in first place, followed by nuclear power stations at 27.4 percent (Figure 16). 24.9 percent of the electricity is generated from renewable energy sources, where hydro has the highest share (Strandell & Wolff, 2017, pp. 174–186). Although the share of renewable energy sources in net electricity generation in the European Union rose from 13.5 percent to 24.9 percent (from 2004 – 2014) and fuel consumption declined from 55.9 percent to 47.6 percent (Strandell & Wolff, 2017), today's electricity demand is still predominantly generated from non-sustainable electricity generation.

¹¹ GWh = Gigawatt hours is a unit of energy representing one billion (1 000 000 000) watt hours and is equivalent to one million kilowatt hours. Gigawatt hours are often used as a measure of the output of large electricity power stations. A kilowatt hour is equivalent to a steady power of one kilowatt running for one hour and is equivalent to 3.6 million joules or 3.6 mega joules (Eurostat, 2013).

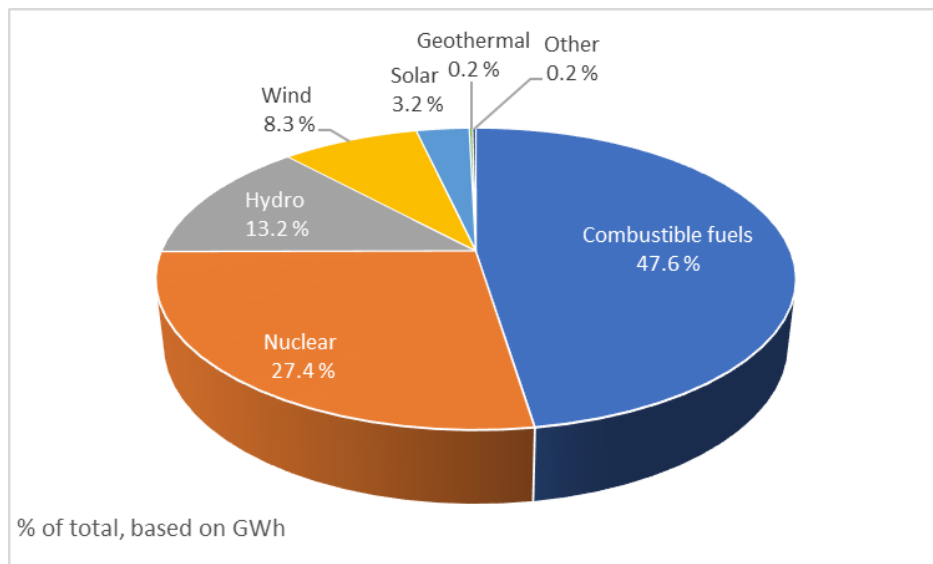


Figure 16: Net electricity generation in the EU-28 markets 2014 (own illustration, based on (Strandell & Wolff, 2017, pp. 174–186))

Based on the current electricity production mix, there is neither environmental nor social sustainability. The extraction of coal, oil and gas can cause considerable damage to environment. Operation of nuclear power plants generates a waste of radioactive materials with long half-lives. Some of the materials decompose in a short time (Beryllium-8 in $2 \cdot 10^{16}$ seconds), but some require thousands of years to be harmless (Tellur-128 in $7,2 \cdot 10^{24}$ years) (Koelzer, 2019). This waste, even if properly stored, will continue to affect human health for generations to come. Earthquakes or natural forces can damage repositories and release radioactive substances.

The liberalized energy markets are characterized by special competitive structures (Ridder, 2003, p. 19). Electricity producers mainly sell electricity products to end consumers via wholesalers (Figure 17), due to the physical nature of electricity, which makes storage difficult and economically not profitable (Erdmann & Zweifel, 2010, p. 295). Exceptions are large industrial companies, which have direct access via their own trading chains or when electricity producers sell directly to firms. In electromobility, the electricity value chain is connected to charging stations via wholesale or retail, depending on the charging station operator model. Generators, such as Shell or Energy Baden-Württemberg, produce electricity and distribute it through their own charging stations (ENBW, 2021; Shell, 2021a).

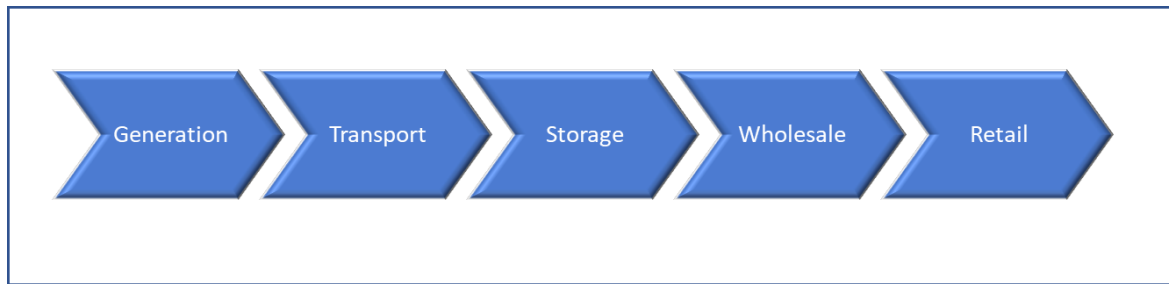


Figure 17: Linear value chain of the generation and distribution of electricity (own illustration)

Infrastructure

The value chain of charging infrastructure has evolved in recent years and the number of users will increase (Bonnema et al., 2015; Hardinghaus et al., 2016; Kley et al., 2011). Nevertheless, the number of charging stations is still too low for the sufficient supply of BEVs. Today's key stakeholders come from three areas: (a) energy supply, (b) infrastructure companies and (c) service companies (Capgemini, 2019, pp. 1–19). Energy suppliers and energy service companies are currently mainly responsible for the distribution of electricity and the installation of charging stations. To increase the number of charging stations and support the acceptance of BEVs, OEMs are additionally getting involved in the development and operation of the charging infrastructure. This kind of contribution is new in automotive business and only due to the fact that the build-up of charging stations is dependent on the sale of electric vehicles. This creates new opportunities for collaboration between different stakeholders in electromobility.

Electric vehicles with lithium-ion batteries¹² can store energy, but it takes a longer time for recharging than filling up the tank of a combustion-based motor with petrol (Kley, 2011). As a result, the issue of charging BEVs has a massive impact on using and route planning of electric vehicles (Bonnema et al., 2015; Hardinghaus, Blümel, & Seidel, 2016). The European Commission has defined the relationship of one charging station for ten BEVs for a satisfactory supply of electric vehicles (Sebastian, 2020). Although the number of charging stations is constantly increasing from 2,392 in 2011 to 188,881 in 2020 (Figure 18), the ratio of BEVs to charging points is only 1:7.

¹² Lithium-Ion batteries are currently the most powerful and economic batteries that are built into electric vehicles (Burke, 2007).

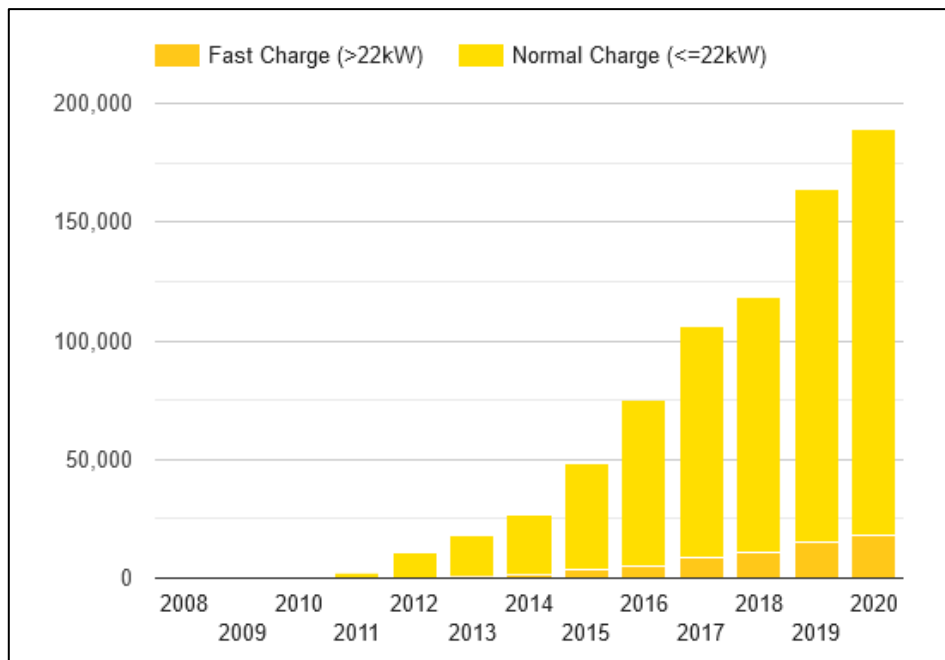


Figure 18: Charging points in Europe increase between 2008 and 2020 ((European Alternative Fuels Observatory (EAFO), 2020)

In Germany, there are expected to be up to 14.8 million BEVs registered in 2030. In 2020, there were 33,000 installed charging points and experts predict a demand of 440,000 to 843,000 public charging points in 2030 (Windt & Arnhold, 2020, pp. 56–65). This would mean that 181 public charging points would have to be installed every day to reach this figure (assuming 250 working days per year). A value that far exceeds the previous installation figures.

The value chain also includes data management and payment collection (Figure 19). For example, before charging, customers must register themselves with the operator company or use the roaming option. In this case, the operator company collects the payment and forwards it to the charging station company.

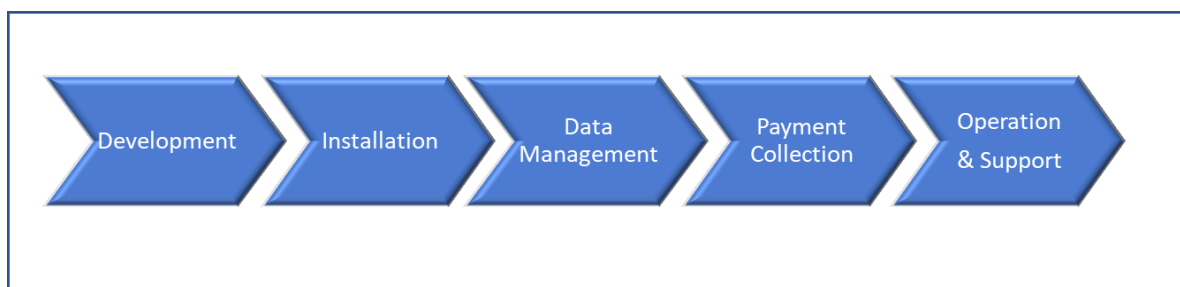


Figure 19: Linear value chain of charging infrastructure (own illustration)

Mobility Service

The MaaS value chain shows very clearly the changed roles and responsibilities in transportation of people with multiple means of transport (Figure 20). The first element is the collection of statistical data like timetables, departure and arrival times and dynamic data, such as traffic volumes and actual departure and arrival times of the different means of transport. The operator collects the data from all participants and makes it available to customers as transport offerings. The operator uses comfortable user interface that contains all information and combines the various functions, such as searching for offers, booking trips and billing. In doing so, it uses digital media like websites or smartphone apps. The mobility services can vary depending on companies involved. So, it takes over the payment process at the customer's and distributes the amounts to the transport companies according to agreements. For this, it receives a commission or a fee (König et al., 2016; Sarasini et al., 2017).

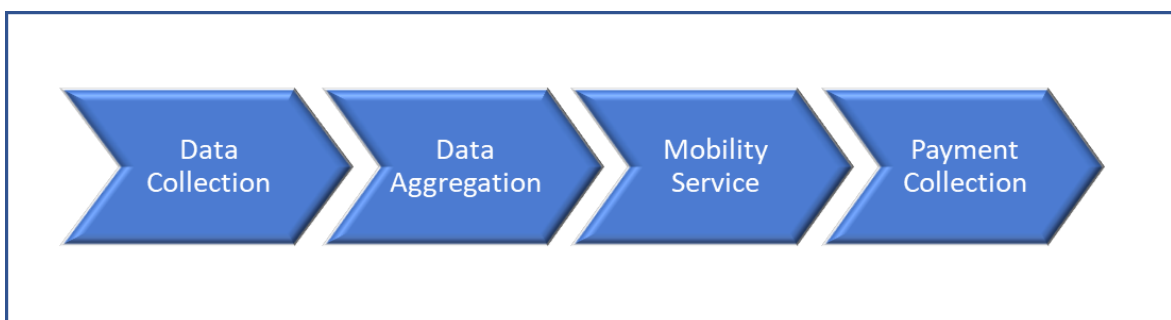


Figure 20: Linear value chain of mobility services (own illustration)

Information System

Information system support is important in electromobility, as it connects different products and services convenient for the customer. By developing and maintaining software, the user interface should be intuitive and enable the user to navigate through the applications without the need of training or reading user manuals, as this would prevent spontaneous use (Figure 21). Furthermore, the applications must be secure from cyber-attacks and consider the current data protection rules (Darejeh & Singh, 2013). For the data collection, data management and applications, extensive hardware and software is required that must be able to run 24 hours a day, 7 days a week, since mobility services are offered around the clock. Important program routines, such as backup or updates, must therefore be possible

in parallel. Data is stored in the cloud to enable access from any location (Dehlinger & Dixon, 2011).

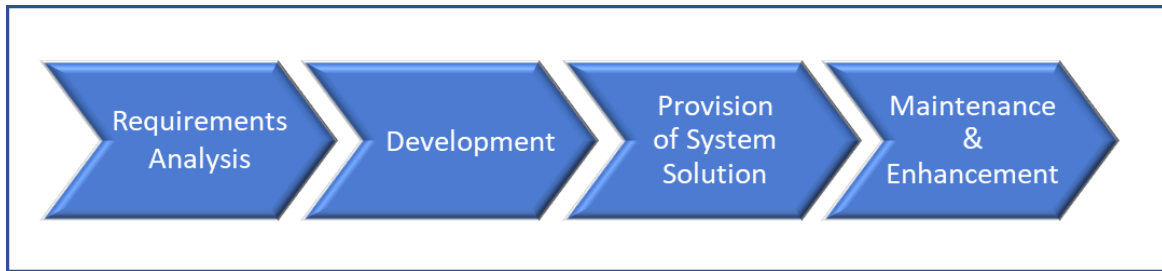


Figure 21: Linear value chain of information systems (own Illustration)

Another area of application for information technology (IT) solutions is the battery management system. The purpose is to make optimal use of battery performance under given conditions and to determine all important parameters of the battery such as temperature, state of charge and maintenance requirements (Figure 22). Sensors are used to measure and control voltages, temperatures of individual cells and the entire system. The battery management system uses the balancing function to optimize the usable capacity of the system and compensates for different capacities of the individual cells. This increases performance and extends the service life of the entire battery. Another important function of the battery management system is the control of the thermal management. Depending on the temperature, the cells are cooled or heated (Pistoia, 2018, p. 9). This information can also be passed to the user. This enables to check the condition of the battery, but also to select the possible drive in a hybrid vehicle (electric/petrol engine).

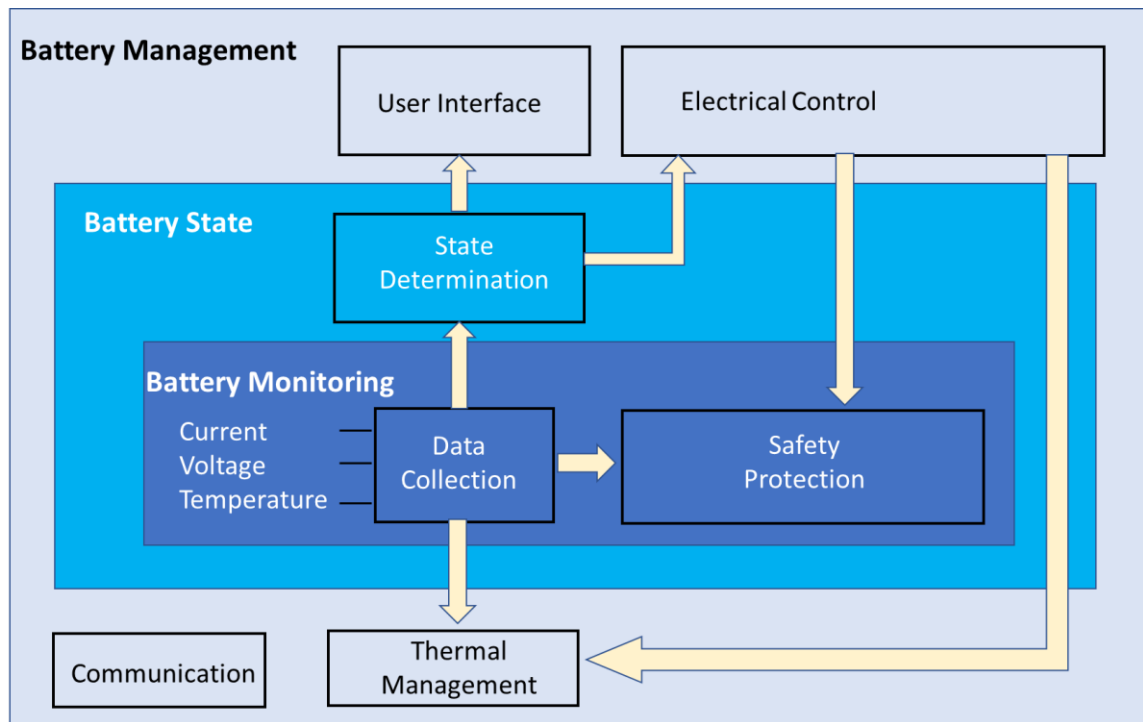


Figure 22: Structure of the battery management system and its main functions (own illustration based on (Xing, Ma, Tsui, & Pecht, 2011))

Electric Vehicles

For decades, the value chain of automobile manufacturers has been limited to the optimization of the supply chain for development, production, marketing and sales, and after-sales of vehicles. The traditional value chain can be divided into two areas (Figure 23):

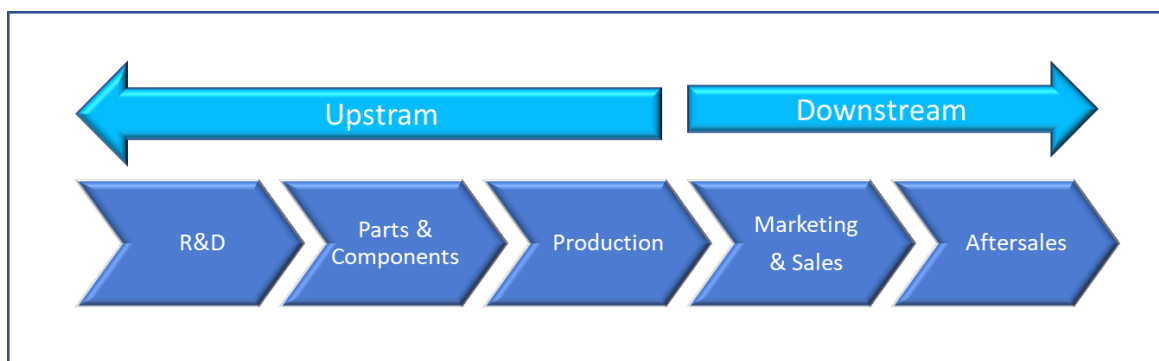


Figure 23: Linear value chain of ICE vehicles (own illustration)

Research and development (R&D) departments develop vehicle concepts and design the next model series. This work, originally in the complete responsibility of the OEM, has been outsourced to a large extent to module suppliers over the past

decades. The supply of parts and modules is to a high degree the responsibility of tier-x suppliers¹³ which deliver complete modules (for example: dashboards with all components or bumpers with already mounted lighting systems) or parts to the manufacturer just-in-time¹⁴ and just-in-sequence¹⁵ to the assembly line via optimized supply chains. The competence to assemble a vehicle from many individual parts and modules is the main task of the OEMs. Here, efficiency, quality and planning reliability are particularly important in order to supply the markets with the required quantities. Sales and aftersales take place over several stages, either independently or through independent dealers, with sales supported by the company's own financing and leasing companies.

The electrification of the powertrain has a significant impact on the value chain of automotive manufacturers, with shares of the value chain shifting to the upstream and downstream value chain elements. This is due to lower number of parts and reduced complexity of driving components.

E-car sharing

The value chain of e-car sharing (Figure 24) consists in the purchase / rent or lease of vehicles and offer it to the customer by operating maintenance and customer management. E-car sharing services are launched to provide the customers more environmentally friendly mobility (Fournier et al., 2015). Some providers reduce the usage fees by parking and charging at the same time (Firnborn & Müller, 2011). Especially for drivers who travel not too many kilometers a year, an electric vehicle from e-car sharing can save considerable costs compared to their own vehicle (Breitinger, 2014). Existing fear for electric vehicles, such as technological progress of batteries or uncertainty about lifetime (Nazari, Rahimi, & Mohammadian, 2019; Noel, Zarazua de Rubens, Sovacool, & Kester, 2019) can be avoided. Customer experience like finding, booking, opening the vehicle and paying the invoice should

¹³ Tier-x is the structure of the suppliers up to the producer of the final product.

¹⁴ Just-in-time in production management refers to a logistics-oriented, decentralized organization and control concept in which the parts are delivered and produced in the required quantity and at the appropriate time (Klug, 2006).

¹⁵ Just-in-sequence is the concept developed for inventory-free procurement logistics and production planning and control in the automotive industry. Due to the high diversity of the vehicles, the components are delivered in the required assembly sequence (Klug, 2006).

be easy and convenient via smartphone and app. Charging status of battery or the distance to the next charging station should always be transparent in order to avoid unnecessary ways to a vehicle (Briceno, Peters, Solli, & Hertwich, 2005; Hildebrandt et al., 2015).

Customers expect that they can charge the vehicle at many different stations or that they can find and park the vehicle within the convenient area boundaries. For this, cooperation with electricity suppliers and car park leaseholders are necessary and useful in order to avoid high initial investments with the e-car sharing company (J. Lee et al., 2011). Payment and billing should be possible by already establishing and well-known payment services.

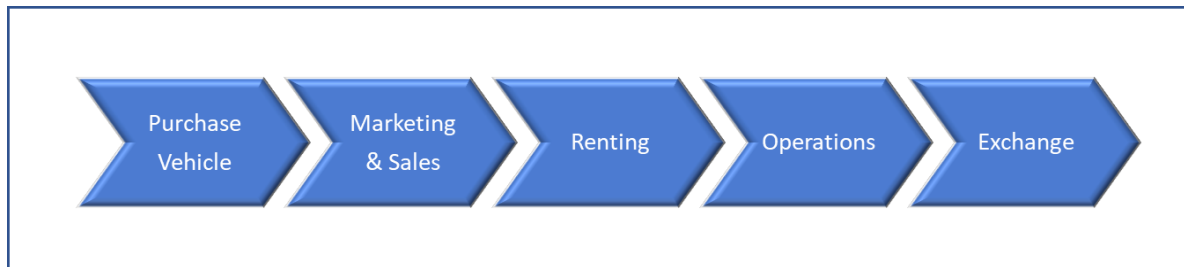


Figure 24: Linear value chain of e-car sharing (own illustration)

Battery

The value chain of propulsion batteries (Figure 25) begins with the cell production, which are assembled into battery packs (Dinger et al., 2020; Golembiewski & Sick, 2015). While production of the battery cells is currently reserved for a few specialized companies¹⁶, more and more car manufacturers are starting to produce battery packs in their own factories. This allows them to control an important part of the supply chain themselves, but they also acquire their own know-how in battery technology, which can be a competitive advantage over competitors. Especially the construction, size and weight of the battery packs are specific to vehicles and are an important criterion for performance and design of the vehicles. Over the lifespan of batteries and after a first life in electromobility, batteries can be used in second life applications.

¹⁶ The largest lithium-ion battery manufacturers for e-vehicles currently come from Asia. The Chinese battery specialist Contemporary Amperex Technology (CATL) is currently the world's largest producer of lithium-ion cells. Other companies are LG and Samsung. European companies are Gigaforce and Northvolt.

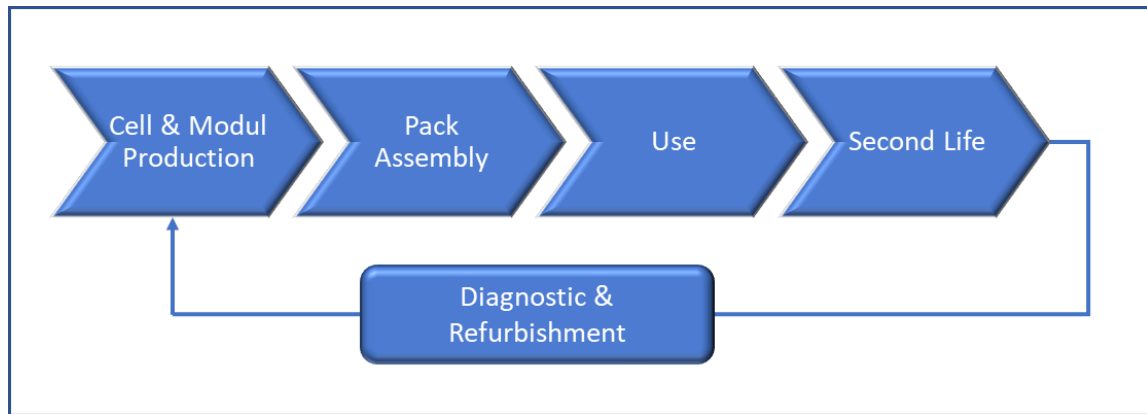


Figure 25: Value chain of electric propulsion battery (own illustration)

With second life there are different models, with which here the most important are specified (Jiao & Evans, 2016; G. Reid & Julve, 2016):

Home or building energy management system

Batteries are tested and, if necessary, reworked before further use so that their performance is fully restored. Then they can be used in households or small businesses as electricity storage devices. The user shifts the generation of electricity to a later point in time of electricity use. For saving costs, charging can be done by photovoltaic systems or over time periods when electricity costs are lower. In addition, the energy storage is a backup system, which can be used for important electrical devices in case of power failure.

Energy management system for commercial and industrial use

In addition to the possibility of using batteries as an energy-saving model, the criteria of safety and quality are of primary importance for industrial and commercial users. In addition to the electricity consumption, industrial companies pay high sums for peak loads, which can occur regularly or irregularly. The amount of the additional costs to be paid can be 30 to 40 percent above the normal tariff. Battery storage systems can absorb such peak loads and save costs and relieve the supply network and the energy supplier. Another

functionality concerns volatility peaks and frequency shifts that can affect production or damage sensitive machines.

Using as replacement part

Another way of reusing electric batteries is to use them as a replacement part. A battery that has still the full capacity can be removed in the case of accident and used as a replacement part on a vehicle of the same type where the battery is no longer powerful enough. However, propulsion batteries have a different design for each vehicle, replacement is only suitable for a vehicle of the same type without significant modification cost. Another use can be in electrical products that have a lower demand for electricity. Batteries that no longer have their full capacity can continue to be used without the need for extensive reprocessing. Batteries of electric vehicles have a battery capacity between 14.5 kilowatt (kW) and 100 kW. While e-scooters need less than five kW. A further application is possible for motorboats, pallet transporter or emergency call stations.

Recycling

The increasing number of electric vehicles and the resulting need for batteries significantly increases the importance of recycling and influences the value chain (Figure 26). Therefore, materials are separated from each other and returned to production. In terms of raw materials, there are very different priorities for recycling, depending on the amount of work involved in recycling and margins. Easily recoverable aluminum, steel and copper from cables and printed circuit boards account for the highest shares of recycling revenues. Cobalt and nickel follow due to the more complex separation processes. Lithium follows at last position (Thielmann, Wietschel, Funke, Grimm, & Hettesheimer, 2020a). However, an important indicator for companies are the costs incurred in relation to the extraction of the raw materials. Only if cost advantage of recycling is higher, the companies will do it (Mayyas, Steward, & Mann, 2018). A main focus in electromobility lies on the battery. At present, there are still few reliable figures available on cost and efficiency of battery recycling (Mayyas et al., 2018; Thielmann et al., 2020a). As an alternative, governments are now legislating and subsidizing recycling to minimize

environmental damage caused by mining. Within the European Union, recycling of lithium-ion batteries from end-of-life vehicles is regulated by the directives 2000 / 53 / EC (European Parliament and of the Council, 2000) and 2006 / 66 / EC (2006), which regulate the minimum collection rates, hazard potential and costs for collection, treatment and recycling system (Thielmann et al., 2020a). Recycling of batteries is generally considered technically feasible but is a complex and multi-stage process with high energy requirements and costs (Mayyas et al., 2018). The different recycling technologies will not be discussed in this thesis, but further literature will be referred to Mayyas, Davis and Hanisch (2018) and Zhang (2013). However, it is obvious that recycling as part of the life cycle assessment has an impact on costs and especially on environmental friendliness (Rodet-Kroichvili & Troussier, 2014). A high percentage of batteries are still used or stored in form of second live. From 2018 onwards, lithium-ion batteries from end-of-life vehicles will increasingly be on the markets and 120,000 to 170,000 tons per year are expected by 2020. Closed-loop recycling processes have the potential to conserve up to 51.3 percent of natural resources as opposed to production with mined raw materials. Likewise, up to 70 percent of energy and up to 70 percent of CO₂ can be saved (Mayyas et al., 2018).

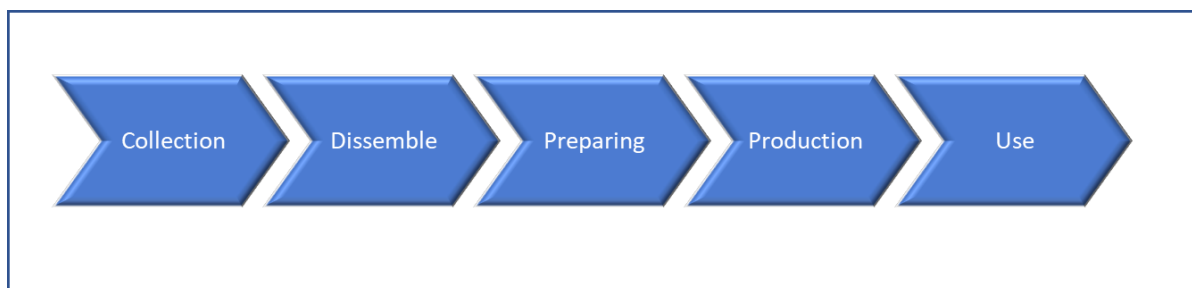


Figure 26: Linear value chain of recycling process (own illustration)

To provide the highest possible value proposition for the customer, it makes sense to create collaborations between raw material suppliers, production companies, energy companies, automobile manufacturers and service providers (Figure 27). These can share research and development costs and risks including the value added. There is a high number of variants how the collaborations between two or more participants can be arranged. Car manufacturers have a very high interest in cooperation or long-term supply contracts with battery cell producers in order to secure the currently insufficient capacities without having to make high investments

in their own development or production¹⁷ (Eckl-Dorna, 2019). Collaborations are formed not only to share R&D costs and risks, but also to accelerate the pace of technology development and participate in value-adding processes. Automobile manufacturers are increasingly cooperating with technology companies or outsourcing all research activities (Golembiewski & Sick, 2015; Pilkington & Dyerson, 2006).

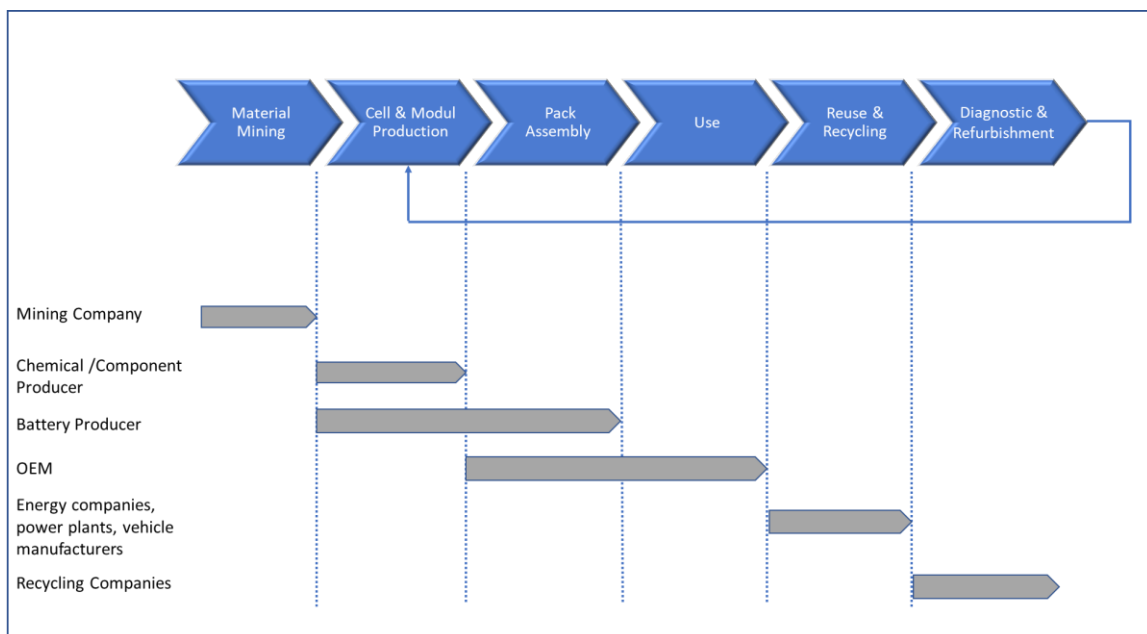


Figure 27: The battery business as an example of collaborations between different industries (own illustration based on (Dinger et al., 2020, p. 11))

For example, Daimler Aktiengesellschaft (AG) offers complement products, when selling an electric vehicle of its own model range. Also access to charging stations are provided setting up nationwide through cooperation with other manufacturers (Manager-Magazin, 2017). The propulsion batteries required for BEVs are produced in-house by Daimler AG subsidiary ACCUotive GmbH & Co. KG. In addition, the map material produced by card manufacturer HERE Global B.V. in cooperation with other manufacturers will receive accessible charging stations, which can be booked

¹⁷ Examples are joint ventures such as the Automotive Energy Supply Corporation between Nissan Motor Company and NEC (TOKIN) Corporation, Primearth EV Energy from Panasonic and Toyota, and Lithium Energy and Power from Bosch GmbH, GS Yuasa, and Mitsubishi Motors Corporation. Different competencies are bundled in the Lithium-Ion Battery Competence Network (KLiB) in Germany. This includes companies from the automotive, chemical, special battery, electronics, IT, and mechanical engineering sectors as well as partners from universities and research institutes.

via an additional software component (HERE, 2020). The battery returns are reused by The Mobility House GmbH and Getic Group in a second life as electrical storage and recycle it at the end. In the last step of the value chain, Daimler AG acts as a software supplier for the use of MaaS and enables users to use the app “Moovel” to travel from point A to point B by various means of transport.

The changes in value chains brought about by electromobility also have a high impact on companies' business models.

3. Towards the Building of Sustainable Business Models for Electromobility

The latest report by “Science and Policy for People and Nature” (IPCC, 2013; United Nations, 2019) shows that one million animal species are threatened with extinction if there are no fundamental changes in the use of land, environmental protection and mitigation of climate change. These and other reports on the worrying consequences of pollution have been a long part of political and social debate. A considerable part of environmental pollution is caused by the priority given to the economic dimension of companies’ activity and the urge for profits. These kinds of messages require a rethink in the relationship between economic, social, and environmental aspects of human activities. Business models, which are analyzed and outlined in this chapter, can be an effective way to develop and commercialize more sustainable products.

Firstly, the relationship between technology, invention and innovation will be explained and the link between business models and innovations is analyzed and clarified. Then, the characteristics and elements of business models and the features of sustainable business models are discussed and their significance for technologies will be explained.

3.1. Technology, Invention and Innovation

This section presents and discusses general principles of technology, invention and innovation as a basis for the study of business models in order to support innovation. First, terms are explained individually and then the relationship and differences are analyzed and presented. In the next step, different approaches to the development and commercialization of products and services are discussed and their advantages and disadvantages analyzed. Finally, the link between technology and business models is presented.

3.1.1. Technology

In the online version of Cambridge Dictionary (2016), the term “technology” is defined as “*the use of scientific knowledge or processes in business, industry, manufacturing, etc.*”. In other words, technology refers to man-made objects whose use is part of a purposeful action. It is invented in universities, technology institutes and research departments (R&D) of firms and mainly operated for a commercial success. “*Technology and technological development are constituent components in the progress of society: economic growth, industrial change, and social development*” (Hakanson & Lundgren, 1995, p. 291). Brian Arthur (2011, pp. 28, 51) presents the nature of technology in different key elements. So, technology is a phenomenon that is used for a human purpose and an aggregation of practices and components. It is also a “*collection of devices and engineering practices available to a culture*”. Christensen (1997) defines the process of creating a product or service as technology. This includes the organization with its manpower, capital, materials, and the necessary information to create value as a result. Therefore, every company can produce technology. Ford (1997) specifies technology as the ability to apply knowledge to solve a specific problem and generate profit. He classifies it into three types: product, process, and marketing technologies. It is unlikely that a firm possesses all of them because special knowledge and experience are necessary in every field. Therefore, multiple companies are necessary to invent, develop, produce, and bring the technology to the market. Emerging technology has a high potential to change existing industry, create a new one or change the structure of the economy (Arthur, 2009, p 191; Srinivasan, 2008, p 633). This change could happen as a “bit-by-bit” process until a discontinuity or a major advance interrupts it (Tushman & Anderson, 1986, p 441).

But what makes technology successful? There are different explanations for it. First, a new technology can be better than an existing one and has more functions, is easier to develop or smoother in operations (technology push). For example, a cheaper technology in overall cost can be a powerful stimulus for companies to change their current one whereby costs for development, production readiness, maintenance, and transformation must be included. Second, a new technology is developed to improve the satisfaction of existing or new customers which allow a new experience for the user or make things happen faster and has easier the chance

to be commercialized and to be successful (market pull). The third one is the regulatory push where governments want to introduce new technologies due to political will or popular demand, although they may have disadvantages compared to those used today (Beeton & Meyer, 2014, pp. 43–45). A well-known example is the electric vehicle which is supported by governments with tax subsidies and laws even if there are disadvantages compared to ICE vehicles.

Investment in technology should be accompanied with changes on how to earn money (Björkdahl, 2009). It is essential for companies to have the best and fitting resources to perform suitable processes and activities to be successful. They should be able to engage in technological opportunism (Srinivasan, Lilien, & Rangaswamy, 2002) and have to pursue the goal to be the technology leader, which brings it to a position having significant advantages on the market over competitors. However, a company must constantly ask itself the question whether the existing technology has still a promising future, even if it is successful today. Therefore, further developments are constantly necessary or even the change toward a new technology can become needed at an early stage. One example is the mobile phone supplier Nokia, whose products have become increasingly better in handling and battery performance through further development, but have been replaced by a completely new concept, the smartphone (Ciesielska, 2018). If the necessary technology change is recognized in time, the profits from the existing technology can be used for the development of the new one and thus gain a considerable advantage over new entrants. However, the change is not always easy to explain to employees, shareholders and customers and requires entrepreneurial skills and the willingness to take risks. A significant element will be the business models that supports technology development and will be handled later in the thesis.

3.1.2. Invention and Innovation

In academic literature, invention and innovation will be used in the same meaning but there are significant distinctions. **Invention** can be defined as “*the first occurrence of an idea for a new product or process*” (Fagerberg, 2003, p. 3). Therefore, the basic skills are creativity and scientific knowledge to design, create or to invent something new that has not existed before (Filho et al., 2017; Nelson, 2010). For Freeman (1991), invention is “*an iterative process initiated by the*

perception of a new market and/or new service opportunity for a technology-based invention which leads to development, production, and marketing tasks striving for the commercial success of the invention“. While invention is working in theory, **innovation** is the meeting of technology with the market (Fagerberg, 2003; Filho et al., 2017; Rosenbusch, Brinckmann, & Bausch, 2011; Schumpeter, 1939), illustrated in Figure 28.

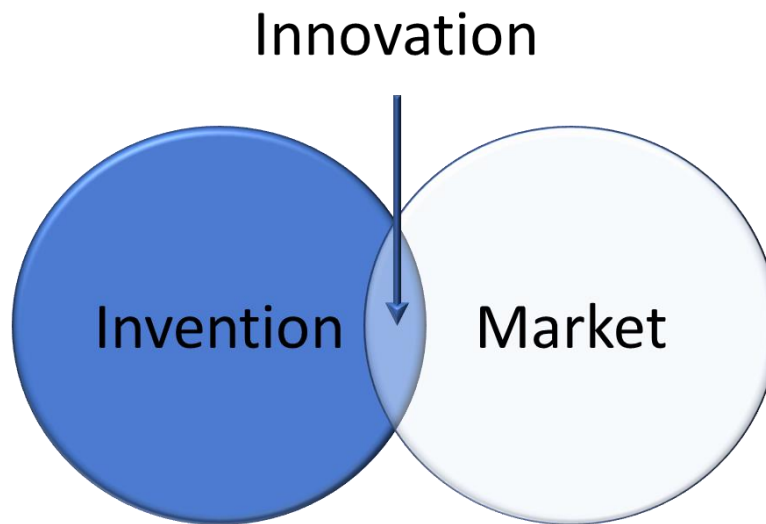


Figure 28: Invention becomes an innovation through commercialization (own illustration)

A technological innovation is for Schumpeter (1939) an important prerequisite for economic development and assumes that success of innovation is closely related to prevailing market structure and market dominance. He defines the entrepreneur as a person or institution that can impose an innovation. Successful innovation should have a competitive advantage and should provide a unique competitive position in the marketplace. A prerequisite for this is to know customers' needs so innovations can satisfy them and bring an additional value. Consequently, the success at market generates business value and generate profit for the organization (Balasubramanian, 2012; Chesbrough, 2003; Schumpeter, 1939). Innovation is not reduced to technology. Innovations can occur in different dimensions. In addition to technical innovations, there are also process oriented (new or changes in processes for optimization), organizational (changes and implementation in structure and operation of companies), institutional (new types of regulatory or quality systems) or social innovations (new lifestyles and consumption styles) (Albers, 2005; Fichter, 2011, pp. 26–27).

A special form of innovations are **disruptive innovations**. The theory, developed by Christensen (1997), states that existing and successful technologies, products or services are replaced by new ones and sometimes displace it completely. Disruptive innovations can be found in new markets where start-ups or new companies can enter with limited investments. Completely new features or enhancements of existing products may be not interesting for competitors but satisfy the needs of the customer even if they are not so powerful at the beginning as the current product. One example is the flash drive that had disadvantages in terms of capacity, reliability and price compared to the hard disk. However, because flash memories have small space requirements, are very fast and need less energy, they have replaced hard disk in some areas completely (Christensen, 1997, pp. 3–28). However, Christensen's theory is controversially discussed. Lepore (2014) argues that the theory is merely a shortened description of the long-term market development and that there are only a few justifiable examples of successful start-ups that have worked according to this theory. Her main criticism is that disruptive innovation merely describes why business fails. Moazed and Johnson (2016) raise another critical point: they confront Christensen's theory with real case studies, especially in the domain of business platforms. They criticize that business platforms do not have a linear supply chain (which is according to Christensen's theory, a prerequisite for a disruptive innovation), a platform creates and grows a network. Therefore, successes like Airbnb and Uber could not be explained by the disruptive innovation theory.

The transfer from invention to innovation is independent from any time schedule and can be cumbersome for the investor (Filho et al., 2017). It can take several decades or longer (Fagerberg, 2003; Rogers, 2002).

There are also different views in the academic literature when an innovation can be assumed. Are additional and continuous improvements to a product that change the value of the product already an innovation? The question is answered differently in academic literature. For Fichter (2011), the operationalization of the innovation process up to the introduction of the new product into the market is seen as routine. Thus, the integration of the diffusion of new solutions into the innovation makes the understanding less easy since a differentiation between innovation and routine action is no longer possible. Kline and Rosenberg (1986, p. 283) regard the delimitation of innovation as not clearly identifiable and assume gradual transitions:

“It is a serious mistake to treat an innovation as if it were a well-defined, homogenous thing that could be identified as entering the economy at a precise date – or becoming available at a precise point in time. [...] The fact is that most important innovations go through drastic changes in their lifetimes – changes that may, and often do, totally transform their economic significance. The subsequent improvements in an invention after its first introduction may be vastly more important, economically, than the initial availability of the invention in its original form”. These increments can be some additional functions or features on the product itself or it can be changes in marketing, pricing or innovations in business models (Chesbrough, 2010; Chesbrough & Rosenbloom, 2002; Teece, 2006).

A distinction between technology-based invention and innovation cannot always be precisely defined and should be closely linked. Both are a cross-sectional function in the companies and connect the R&D processes via marketing as a sales function and influence organization and financing. With the management of technology and innovation questions at strategic, operational, and normative level can be answered. Strategically, it is necessary to decide the perspectives of resources with the competencies of the employees and align them with future needs of the markets. With the transformation from seller's markets to buyer's markets in the 1970s (Albers, 2005, p. 5), the orientation and objectives of technology development also changed long-lasting. In operational terms, ideas and concepts are generated and evaluated ongoing and commercialized through an optimum value-added chain. While the normative area must clarify questions of the limits of technologies. However, how do companies come to inventions and innovations? In the 20th century, science was done predominantly in universities without any slope for commercialization. The focus was on exploring and analyzing problems without any practical goals. In addition, the government did not have the power and only provide limited funding to organize science. Therefore, industry took on the role of funding research for commercial use of science. Examples are Bell Labs, HP Labs or Xerox PARC. Innovations are predominantly driven by internal factors from these companies and can have different sources like R&D or employees (Penrose, 2009; Wernerfelt, 1995). Due to the company-internal orientation of the innovations, Chesbrough (2003, pp. 4–41) described it as closed innovation.

3.1.3. Closed Innovation

In the early twentieth century, United States (US) companies generated their innovations within the boundaries of the firm, which led to distinguished results and financial success (Chesbrough, 2003). The linear model of innovation (Figure 29) is based on a one after another sequence, starting with research for inventions, then developing a product, producing this product, distributing, and selling it to customer (Chesbrough, 2003, p. 2; Godin, 2006; Herzog, 2011, p. 1).

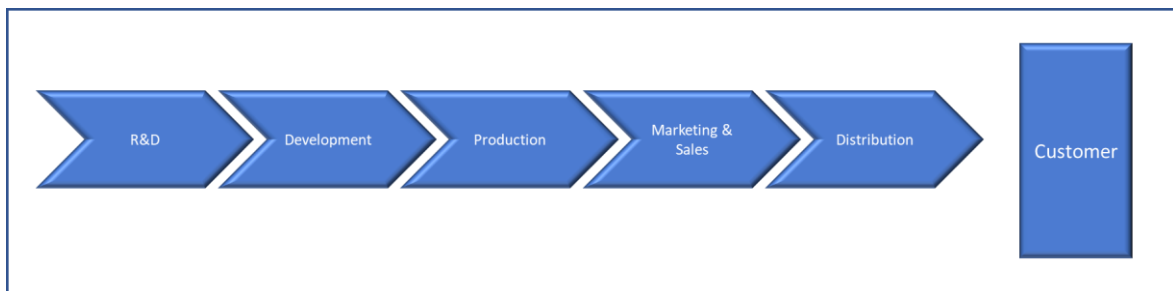


Figure 29: The customer is the beginning and the end of the linear model of innovation (own illustration)

In this sequential procedure, influences from outside were not supported, just as there were no feedbacks. R&D resorts create new ideas of its own personnel and equipment. External knowledge is only included in form of basic research by universities (Chesbrough, 2003, p. 24).

The R&D department works without restrictions to existing products or expectations of how an idea can be commercialized. Development then takes some of the ideas and examine if ideas can be used to develop a new product or enhance existing products with new features. They are restricted in their efforts because they have the requirement to earn money with their decisions. To minimize risk, they avoid new products and services, which are outside common product lines or processes of the company. The result is that good and promising ideas are not used or sold to other companies or partners (Kroichvili, Cabaret & Picard, 2014). Marketing and distribution take place via existing sales channels. New forms of distribution and business models are avoided. In addition, products are developed in a way that existing service modules of the company could be re-used. *"Companies must generate their own ideas and then develop them, build them, market them, distribute them, service them, finance them and support them on their own"* (Chesbrough,

2003, p. XX). This presumes that successful companies need professional and well-educated staff as well as state of the art research infrastructure. Closed innovation (Figure 30) implies that inventions must be protected against other companies. Unused patents or licenses, however, lead to high costs for development without the possibility of gaining profit (Chesbrough, 2006b; Vanhaverbeke & Chesbrough, 2014).

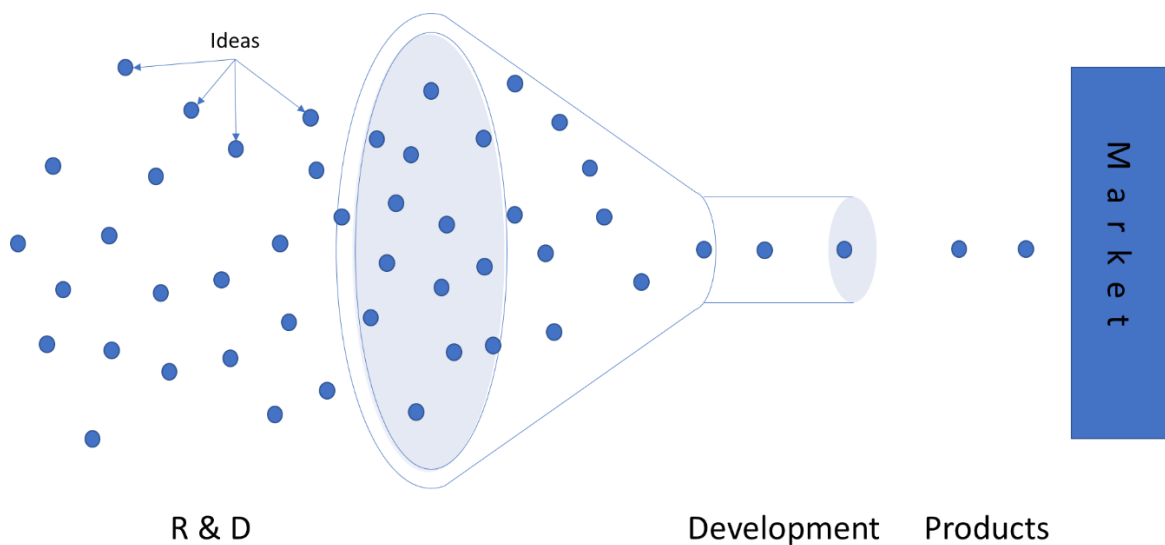


Figure 30: In case of closed innovation, companies develop their innovations themselves (own illustration)

Closed innovation requires a powerful and cost-intensive R&D and has a significant share in the total sum of investment of the company (Dahlander & Gann, 2010). It is not provided in the company's policy to accept achievements, methods, and innovations from outside the firm and integrate them into own research. Building on fundamental research conducted by universities, more advanced research activities are carried out with the company's own personnel. New business areas need a great deal of research with specialized researchers and high capital expenditure. If knowledge is not available in the firm, external staff has to be hired and so you compete with competitors and costs for salaries and placement increase (Chesbrough, 2003, p. XX).

Closed Innovation has been very successful and has brought many business success to companies (Chesbrough, 2003, p. 21). Using own R&D gives the local firm the opportunity to develop new products with the ideas and invention before

other companies has the chance to participate (Vanhaverbeke, Van de Vrande, & Chesbrough, 2008). These benefits, to be the first on the product development chain, could compensate the effort for infrastructure and staff. In addition, it could strengthen the market position and help to be leader not only in innovation but also in profit. Scholars emphasize that the model is still widespread in use in companies today and that technology is able to find a market and be successful in generating profit (Teece, 1986). But the evident boundary of infrastructure and professional staff limits the efficiency of the system. The investments require extensive research and development and must be earned on the market through successful and profitable products. In addition, not every idea or innovation of the large laboratories has been developed into a marketable product. Closed innovation also limits the possibility of early use of additional input from outside for further development. Thus, a product is first developed, before it comes on the market and the customer is offered for sale. Earlier feedback, which increases the marketing opportunities and can improve the product, are therefore only possible after the launch and can lead to lower sales or time-consuming rework. Koschatzky (2001, p. 6) underline the disadvantages of closed innovation by "*firms which do not cooperate and which do not exchange knowledge reduce their knowledge base on a long-term basis and lose the ability to enter into exchange relations with other firms and organizations*". Closed Innovation sorts out processes and products that did not fit into company's internal product family. The ability to generate development costs through profit is not or only to a limited extent possible. Chesbrough (2003, pp. 4–41) describes the limits of closed innovation model based on investigations in research-driven ventures (IBM, Intel). For example, companies that operate within their boundaries cannot make good use from outside like joint venture capital. In addition, participation and knowledge transfer to the emerging start-up companies are not possible and innovative processes and functions that are necessary for the marketing of a product must develop in-house and implemented operationally. Demands from the markets to reduce product cycles and to develop, produce and manage products faster, means that companies need to open in terms of knowledge transfer and marketing.

3.1.4. Chesbrough's Open Innovation

Companies realize that there are better methods to get more from ideas and innovations of their R&D (Kroichvili et al., 2014; Lichtenthaler, 2011). With the extension of borders beyond company boundaries, there is the opportunity to access external knowledge during R&D. It increases the options in the entire product development process and gives the company further chances to increase its profit (Chesbrough, 2003). Therefore, the focus in companies shifted from purely internal R&D activities to more open activities (Enkel, Gassmann, & Chesbrough, 2009). Chesbrough (2003, p. xxvi), emphasizes, "*Not all the smart people work for us. We need to work with smart people inside and outside our company*". He describes a new approach by opening the innovation process beyond the company's boundary and defines it as "*the use of purposive inflows and outflows of knowledge to accelerate internal innovation and to expand the markets for external use of innovation, respectively*" (Chesbrough, 2006b, p. 2). Due to professionalization of universities and the increase of start-up companies, knowledge was no longer generated and made available exclusively in large company laboratories. Increasing costs, shorter innovation cycles and lack of professional staff were further reasons for a change in the culture of organizations (Gassmann & Enkel, 2004). Involving its own employees, customers, suppliers, lead users, universities and competitors increases the company's innovation potential. Even if knowledge exchange and networking is typical for open innovation, it does not mean free access to knowledge and technology of a company. The term refers only to a collaborative networking (Figure 31).

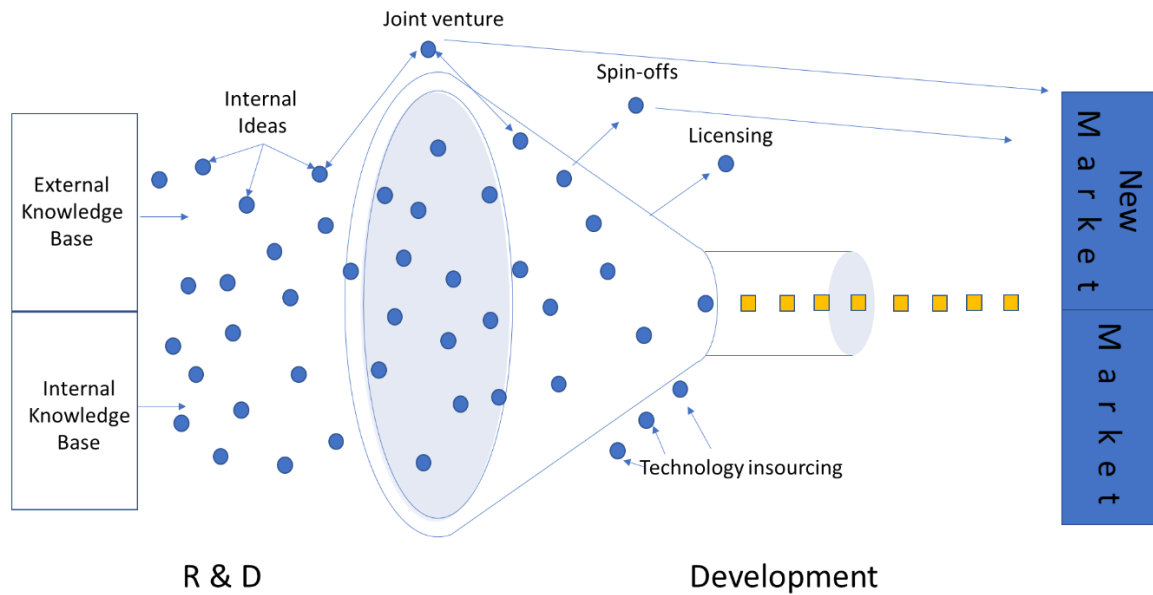


Figure 31: In open innovation, companies use external efforts to develop innovations (own illustration)

There are different types of open innovation: With the **outside-in process**, the local firm use external knowledge to add it to internal ideas and technologies. This increases the capability to be innovative (Laursen & Salter, 2006; Lettl, Herstatt, & Gemuenden, 2006; Piller & Walcher, 2006). Providing knowledge outside of the company (**inside-out process**) can be done in different ways. First, the aim is to generate profit by license and sell the knowledge or technology to other companies. Second, internal knowledge is given to the outside without receiving financial compensation for it. The reason for this may be to assist in the development of a product that is needed for the commercialization of the company's own product (Gassmann, 2006; Grindley & Teece, 1997). For Dalander & Gann (2010), it is reasonable to give parts of its own development to the outside world in a target manner. This can be the basis for further developments from other companies which can generate technologies and products that promote the sale of the company's own products. With the inside-out process, the internal R&D transfers knowledge to the outside of the company and sell it as Intellectual property to others. Enkel et al. (2009) differentiate a third process, the **coupled process**, in which further development of innovation or technology is done in participation with other companies in a joint venture or alliance (Enkel et al., 2009).

New technology and innovations, developed by smaller companies, start-ups or universities could be refined by R&D in other companies. Chesbrough (2003, p. 4,5,8,34) gives a special attention to technology start-ups. They often experiment with new technologies which were predesignate to capture new markets that are not yet attractive for a firm because they were not big enough. With open innovation, firms can establish their own start-ups using their own venture capital departments and invest in promising technology and innovations with restricted investments. The internal innovation process should be structured so that external ideas could be embedded in every stage and as a result, the internal R&D enhances its function and responsibility. It generates new ideas and technology with their own staff and infrastructure but integrate additional knowledge from outside (Grant & Baden-Fuller, 2004). They control and steer the internal architecture and link it to production and further company organization. This minimize the risk and new business models and markets can be proven.

Still open innovation also has its dangers. False positives¹⁸ can happen and are dependent on the skill and experience of staff and internal management. When ideas from R&D do not fit into the functionality of current products or business model, the idea is not commercialized and brought to market. Therefore, projects, which looked initially gainful, are stopped and the results are unused.¹⁹ So already made investment is lost which can be harmful for long-term projects in research (Chesbrough, 2006b).

3.1.4.1. Open Innovation and Open Source

Open Innovation is associated with the development and provision of open source. Various scientists discuss the development of software using open source software method in context of open innovation (Chesbrough, Vanhaverbeke, & West, 2006; Dahlander & Magnusson, 2008; Enkel et al., 2009; Lichtenthaler, 2011; von Hippel & von Krogh, 2009; West & Gallagher, 2006). In both concepts, knowledge outside the company is used to generate and develop ideas and create value (Chesbrough,

¹⁸ False positive: errors in which the projects were initially judged to be promising and later discontinued (Chesbrough, 2003).

¹⁹ On the contrary, there are also false negative: projects initially judged to lack promise, but which later turn out to be valuable (Chesbrough, 2003, p. 146).

2006b). In open source, software is developed by independent software developers in a cooperative model. The software code is made freely accessible and developers can add their own codes of lines and thus increase the usability of the program or add new functions. Therefore, the innovation also takes place outside the local firm (Figure 32). The product and the source code are freely available. In connection with open innovation paradigm, R&D boundaries are opened and the outstanding expertise of suppliers, customers or partners is used. While open innovation explicitly includes the business models as basis for value creation, the focus in open source is on shared use of value, created by all involved actors (Chesbrough, 2006b; Lichtenthaler, 2011).

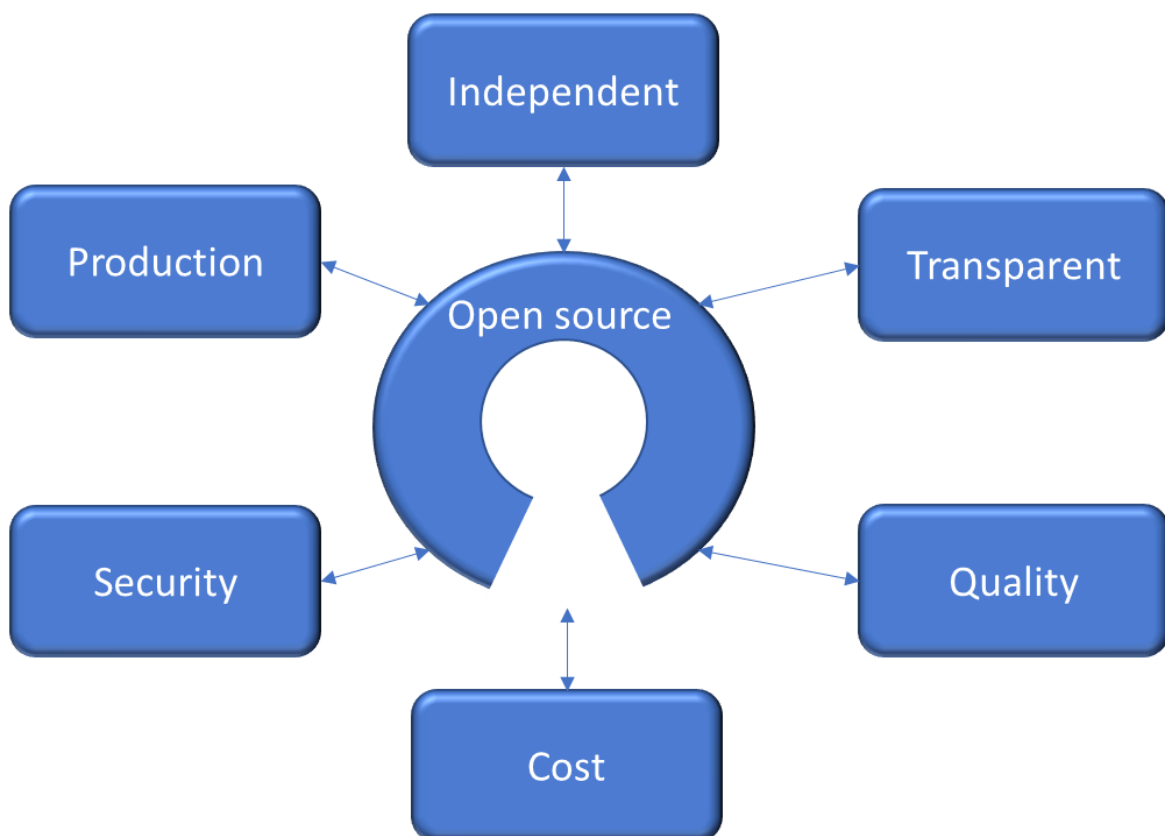


Figure 32: Elements of software development are externally shared and developed (own illustration)

3.1.4.2. Review of Chesbrough's Open Innovation

Chesbrough's approach is one of the most discussed topics in innovation management and gathered more than 1.800 citations and provides more than two

million hits by google scholar (Google Scholar, 2010; Huizingh, 2011). The open innovation framework includes new concepts and theoretical arguments; however it misses coherent new theories based on accepted standards (Bacharach, 1989; Van de Ven, 1989; Whetter, 1989). Scholars criticize Chesbrough's descriptions of the paradigm of open and closed innovation. Trott and Hartmann (2009) explain that the concept of open innovation has not brought new insights and has been described in literature of innovation management for the past 40 years. Pearson, Green and Ball (1979) have done basic work about it and emphasize the necessity of external knowledge consideration within the innovation process (Allen & Cohen, 1969). They also doubt that open innovation is the only possibility to integrate external knowledge to R&D and that companies are following this principle. Many companies have implemented the process of using external knowledge for their innovations for a long time just as selling internal knowledge to external companies (Huizingh, 2011). In addition, scholars consider that open innovation is "*old wine in new bottles*" (Trott & Hartmann, 2009, p. 715) because elements of open innovation paradigm can be found in industry in the 19th and 20th century in the United States (Mowery, 2009). Therefore, open innovation is a organically successor of closed (Hafkesbrink, Krause, & Westermaier, 2009). *„Innovation 2.0“ (also known as „Open Innovation“)* is not entirely new, but rather a more natural and logical continuation of "*new internet based innovation processes and business models*" that have been developed in the past decade, notably with *„open source“* (Hafkesbrink et al., 2009, p. 255). Open Innovation is more a framework, which characterizes approaches how to manage innovation (Chesbrough, 2006a). "*A framework is less rigorous than a model as it is sometimes agnostic about the particular form of theoretical relationships which may exist*" (Teece, 2006, p. 1138).

Although the criticism, Chesbrough's concept has developed into an established field of research (Gassmann, Enkel, & Chesbrough, 2010) and delivers new insights in the areas of technology and innovation. It is a very important process in the development of new products in companies.

3.1.4.3. Conclusion

The insights indicate that there is an evolution from closed to open innovation, based on the dynamics in the digital economy innovation system. The findings also reveal

that, especially in the digital economy, open innovation is not entirely new, but rather a more natural and logical continuation of “*new internet based innovation processes and business models*” (Hafkesbrink et al., 2009, p. 255) that have been developed in the past decade, notably with open source.

Open Innovation can also be a link between innovation and commercial success. By concentrating on one's own strengths and cooperating with other skills, innovations can be commercialized faster and more successfully. Additionally, necessary skills could be added by partners to save time and resources.

3.1.5. Interaction Between Technology and Business Model

The relationship between business models and technological innovation is very complex but authors support the idea that a business models are needed for value creation and capture (Baden-Fuller & Haefliger, 2013; Teece, 2010). It enables to identify customer needs, satisfy them in market and achieve the monetization of value (Baden-Fuller & Haefliger, 2013; Teece, 2010). Also Chesbrough (2003, p. 64) sees a close connection between technology and economic success. For him, technology alone has no objective value. Economic value creation is not automatically a result of new technology. Chesbrough and Rosenbloom (2002) stated that for successful innovations, the role of a business model is, to create “... *a heuristic logic that connects technical potential with the realization of economic value*”.

Embedded in regulations of state and market, new technologies with successful business models lead to a guiding position that can become standard (Figure 33). Although the business models are linked to new technologies, scientists agree that it is an essential vector of the innovation process (Baden-Fuller & Haefliger, 2013). In addition, novel technologies can drive new business models (S. Goel, Miesing, & Chandra, 2010).

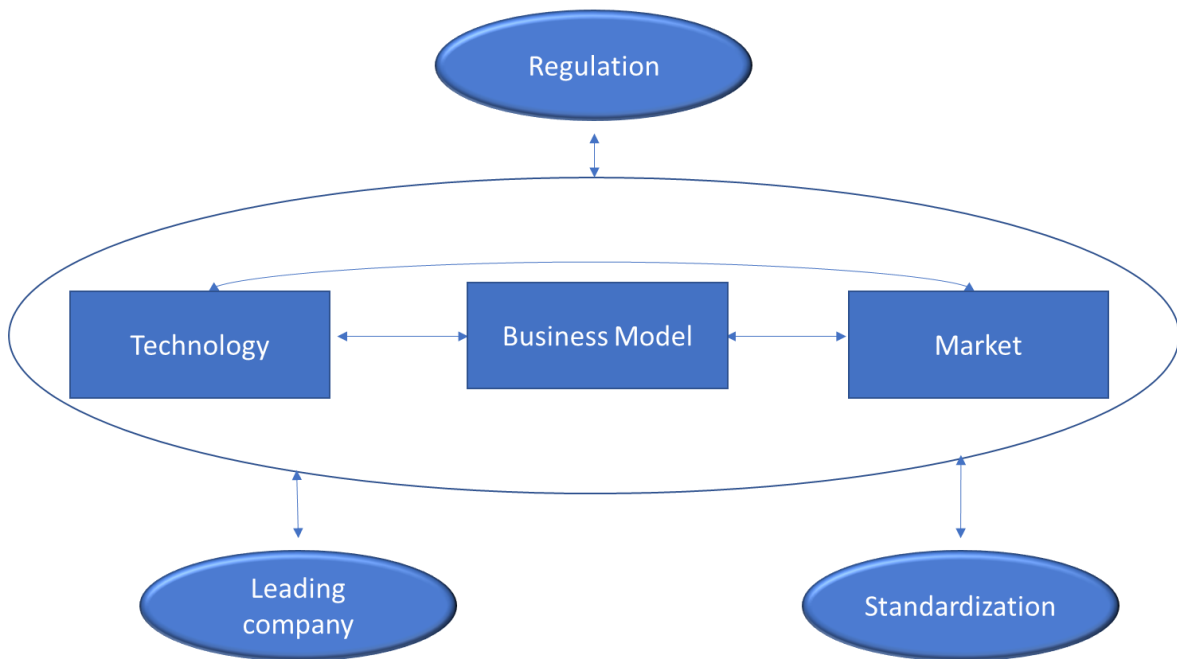


Figure 33: Technologies, business models and markets are interlinked based on government frameworks (own Illustration)

Having success with a new technology requires a transformation through a business model, because it does not lead to economic success automatically. Bjorkdahl (2009) explains that companies create more economic value by investing more in changes to their underlying business models than through the development of new technologies and Chesbrough (2003, p. 64) ranks the importance of business models even higher and argues that a “... *mediocre technology pursued within a great business model may be more valuable than a great technology in a mediocre business model*”. This gives the business model a significant new dimension as it has not only the role of bringing technology to the customer and making profit but also the business model is the cornerstone of innovation and enables the success of the product or service.

3.3. Business Models

Many scholars and practitioners use the term business model, although there is no final definition yet. This leads to a general lack of clarity about the concept itself. Based on a comprehensive overview of the scientific literature in this field, similarities and differences of business models are worked out. In the following, different business models are described, analyzed and differences to similar and

related theories are explained. In particular, differences between strategy and business models will be discussed. Finally, dimensions and characteristics of business models are described to identify known frameworks or canvas.

3.3.1. Contributions to the Definition of the Business Model Concepts

The term business model has been discussed more and more in academic literature without obtaining a clear definition (Chesbrough & Rosenbloom, 2002; Magretta, 2002). There are many agreements among scholars, but there are also many differences, although it is undisputed that business models are becoming increasingly important (Amit & Zott, 2001; DaSilva & Trkman, 2014). The concept of business models was introduced in academic literature in 1957 (Bellman, Clark, Malcolm, Craft, & Ricciardi, 1957) and studies increased dramatically at the beginning of the 1990's with the e-business hype when companies started to reduce transaction costs with the internet (Amit & Zott, 2001; DaSilva & Trkman, 2014; Zott, Amit, & Massa, 2011). The business model concept is used in practice and in academic research in a wide variety and fragmented way. Scholars from different domains (e-business, strategy, innovation, technology management) analyze and examine different definitions and concepts (Zott et al., 2011). A first overview and one of the most influential publication was provided by Amit and Zott (2001). Based on a discussion of different ways to create value (offering novelty, complementarities, efficiency and lock-in), they develop their theory within the framework of the (i) resource-based approach (Barney 1991, Penrose 1959), (ii) value chain analysis (Porter, 2001) and (iii) strategic networks (Dyer, Cho, & Chu, 1998) which are described below. The analyses and results of Amit and Zott (2001) are the starting point for the evaluation of business models. Based on different theories, they create the basis for obtaining value creation without prioritizing it. The findings have been confirmed in further research and are also guiding for this study. Penrose's (2009) **resource-based approach** is further developed by Barney (1991) and focuses on company's resources in its strategy management. Barney et al. (2010, p. 66) add control functions to the resources and defines resources "*as the tangible and intangible assets that a firm control that it can use to conceive and implement its strategies*". Tangible resources are in the meaning of firm's physical assets like machines or buildings (Garner-Stead & Stead, 2014, p. 101). The

objectives of the resource-based view are to use company's resources to create a lasting advantage over the competition to design a special benefit for the customer. It is important that resources are unique and cannot be easily imitated by competitors.

Following **Porter** (2001), a company acting according to the economic principles only enters into transactions that generate added value. This added value can be in the interest of the company or the customer and is based on processes within the company. When optimizing a company, critical processes within the strategic alignment are analyzed, products to be created are defined and value of individual value chains is determined. The final question is which activities a company takes up to add value. Porter distinguishes between primary processes that are necessary for the business purpose and secondary processes that support it.

Strategic networks are cooperations of independent companies in the form of strategic alliances, joint ventures, long-term buyer-supplier partnerships with the objective of realizing competitive advantages (Gulati, Nohria, & Zaheer, 2000; Jarillo, 1993, pp. 6, 7, 16, 97ff). They are used to bring benefits for the participating companies which can be the reduction of risks through jointly shared investments in development or production, creation of economies of scale or bundling of know-how and functions.

Burkhart et al. (2011) have conducted a detailed literature review on business model. Within this review, dedicated attention is paid to the selection of sources that have to meet several requirements. The sources should be of excellent quality, have a high reputation among researchers and cover several research areas. The ranking as well as the citation frequency of the literature is taken also into account. As a result, 17 evaluation criteria are developed, which are classified into five groups:

1. Classification of the underlying literature
2. Comprehension of business models
3. Usage of business models
4. Focus of business models
5. Representation and evaluation of business models

The analysis highlighted the assumption that business models are a high aggregation of the company business logic and that many aspects are addressed in business models that go beyond the boundaries of the company. In summary, the analysis of Burkhart et al. (2011) is very detailed and examines the components of

business models based on many different characteristics. It primarily underlines the unstructured nature of the topic but can only make a minor contribution to an understandable concept.

Other scholars used a framework to describe the business model. **Chesbrough and Rosenbloom** (Chesbrough & Rosenbloom, 2002) elaborates the components: value proposition, target markets, internal value chain structure, cost structure and profit model, value network, competitive strategy. For them, the commercialization of technologies is indispensably tied to the business model. Fulfilling value propositions for customers are not sufficient for innovations to succeed in the marketplace. Business models bring the innovations to market that can succeed there and thus create value for the company. The framework of **Richardson** (2008) classified business models in three main elements: value proposition, value creation and delivery, and value capture. With value proposition, the company delivers a product or service to the customer, so they will pay a price for it. Value creation and delivery integrates the value chain and the network of other firms that take part to the value creation and value capture refers to the way a firm gets revenue and makes money. The analysis of **Teece** (2010) indicates that a business model is more than doing business with customers and develops over time. It involves the relationships with customers, suppliers and business partners and should be difficult to be copied by the competitors to protect it and have a unique value proposition for the customer. **Amit and Zott** (2013, p. 409) anchor the concept of the business models in their research, calling it "*a robust, useful construct for strategic analysis*". For them, business models are a central level and unit of analysis for understanding value creation and capture. The focus is on the joint development and relationship between product market strategy, organizational design, and business model. For **Baden-Fuller and Mangematin** (2015), there is not one specific business model in a company, but many companies have a portfolio of business models. These depend on the diversification of products that meet different customer needs in different markets.

The Table 2 provides an overview of basic definitions by scientists who have made a significant contribution to the description, clarification, and definition of the concept. By combining the analysis of existing literature with examples from practice, they have created a terminology that is useful for research and practice.

3. Towards the Building of Sustainable Business Models for Electromobility

Table 2: Overview of basic business model definitions, sorted by years

Author	Definition
(Bellman et al., 1957, p. 474)	The business model represents the various aspects of economic and industrial interaction for training purposes. <i>“And many more problems arise to plague us in the construction of these business models than ever confronted an engineer”</i> . The importance of the business model is inextricably linked to a representation of reality, a simulation of the real world through a model.
(Amit & Zott, 2001, p. 511)	A business model depicts the content, structure, and governance of transactions designed to create value through the exploitation of business opportunities.
(Chesbrough & Rosenbloom, 2002)	The business model provides a coherent framework that takes technological characteristics and potentials as inputs and converts them through customers and markets into economic inputs. The business model is thus conceived as a focusing device that mediates between technology development and economic value creation. It <i>“spells out how a company makes money by specifying where it is positioned in the value chain”</i> .
(Chesbrough, 2007)	Every company has a business model, whether they articulate it or not. At its heart, a business model performs two important functions: value creation and value capture.
(Richardson, 2008, pp. 133–144)	<i>“The three major components of the framework: the value proposition, the value creation and delivery system, and value capture-reflect the logic of strategic thinking about value”</i> .
(Teece, 2010, p. 191)	“A business model describes the design or architecture of the value creation, delivery and capture mechanisms employed.”
(Osterwalder & Pigneur, 2010, p. 14)	A business model describes the rationale of how an organization creates, delivers, and captures value.
(Zott & Amit, 2013, pp. 403–411)	The relationship between business models, organization and product marketing strategy are dynamic and adapt to market and customer conditions.
(Baden-Fuller & Mangematin, 2015, pp. 11–22)	Companies have a portfolio of business models to satisfy the different needs of customers and markets.

3.3.2. Business Model Innovation

Technological and behavioral developments such as Web 2.0 (Wirtz, Schilke, & Ullrich, 2010), increasing globalization of business environment (Y. Lee, Shin, & Park, 2012), entry of new competitors, changing market requirements over the time, unfilled customer needs (M. W. Johnson & Christensen, 2010), environmental dynamics and changes are reasons why existing and even successful business models have to be enhanced and refined (S. Schneider & Spieth, 2013) to meet the new requirements (Chesbrough, 2007, 2010; Lindgardt, Reeves, Stalk Jr., & Deimler, 2015). Scholars have largely confirmed that business model innovation (BMI) is one of the key sources of competitive advantage (Baden-Fuller & Morgan, 2010; Björkdahl, 2009; Chesbrough, 2007; Chesbrough & Rosenbloom, 2002; Hamel, 2000; McGrath, 2010; D. Mitchell & Coles, 2003; Dan Pantaleo, 2008; Teece, 2010).

For Pohle and Chapman (2006), BMI is a promising reaction for firms about changes in sources of value creation in times of high environmental volatility. *“Business model innovation poses in addition questions about novelty in customer value proposition and about respective logical reframing and structural reconfigurations of firm”* (Spieth, Schneckenberg, & Ricart, 2014, p. 237). Markides (2006, p. 20) defines BMI as *“the discovery of a fundamentally different business model in an existing business”* and for Casadesus-Masanell & Zhu (2013, p. 464), BMI is: *“... the search for new business logics of the firm and new ways to create and capture value for its stakeholders”*.

For further use in the thesis, the following definition is proposed:

BMI is an enabler of creating and capturing value under the assumption of changing components of the existing business model (Amit & Zott, 2001; Chesbrough, 2010; Demil & Lecocq, 2010; D. Mitchell & Coles, 2003; Teece, 2010).

BMI is a decisive factor for the long-term competitiveness for companies. However, there are limited scientific approaches and methods for developing BMI and it is therefore a challenge for many incumbents. The development of business models

is complex and difficult because the structures of business models are not always clearly known and there are barely any suitable tools (S. Schneider & Spieth, 2013).

If companies fail to adjust the business model due to external and internal circumstances, they run the risk that the existing business models are no longer viable and consequences can be to lose market share and profit (Chesbrough, 2010). However, there are barriers, which make an adjustment difficult and prevent the management from dealing with these changes. Chesbrough (2010) analyzed barriers to BMIs based on prior studies of Amit and Zott (2010), Christensen and Raynor (2003), Christensen (1997) and Chesbrough and Rosenbloom (Chesbrough & Rosenbloom, 2002) and identified two categories of barriers: obstruction and confusion. To overcome these barriers, Chesbrough (2010) recommends to experiment with new business models and to try out potential new approaches in the market with limited use of resources.

Although the aim of BMI for all companies is to adapt their business models, there are different starting points, possibilities and limitations (Chesbrough, 2010; Sosna et al., 2010). Incumbents show a path-dependent behavior, which is determined by their historical background, the resource availability and the expectations of the customers, partners and suppliers (Garud, Kumaraswamy, & Karnøe, 2010; Sydow, Schreyögg, & Koch, 2009). Changes must be explained in detail and the procedure described, otherwise a resistance to the change may arise. Primarily efficiencies from cost reduction and economies of scope are identified and implemented. New revolutionary business model changes are prevented and can lead to an increased risk. However, incumbents can test new business models due to their resources. The cross-subsidization of established and profitable products enables them to use longer periods of testing to establish new business models. The size of the company also provides the opportunity to set new standards (Chesbrough & Rosenbloom, 2002).

Start-ups and younger companies are less handicapped by path dependencies as they do not have to consider business models that have been tried and tested over many years with the appropriate resources (Chesbrough & Rosenbloom, 2002). They are even expected by customers to translate innovation into changed value creation and to join forces with non-traditional partners in new stakeholder networks (Amit & Zott, 2001). As a result, they are more independent in their innovations and

can react more flexibly to changes in the general conditions. Due to novelty and lack of cross-subsidization of existing products, they are more dependent on the success of BMI, as they have fewer financial buffers.

The process how to come to BMIs is described only by few scholars. A high-level list of steps for a BMI is defined by Teece (2010). BMI is a continuous process (D. W. Mitchell & Bruckner Coles, 2004) and Osterwalder, Pigneur and Smith (2009) propose five steps to create new business models. Other approaches come from Laurischkat and Viertelhausen (2017) with a game-based methodology for BMI or from Täuscher and Abdelkafi (2017) with visual tools from a cognitive perspective. However, there is no universal method that addresses all the requirements for a BMI.

3.3.3. Open Business Models and Open Innovations

Open business models and open innovations have different meanings but can be closely related. The open business model can be seen as an example of BMI. Open business models often ensure higher benefits from innovations by adapting the business model (Chesbrough, 2007; Smith, Cavalcante, Kesting, & Ulhoi, 2010). While open innovation looks for ideas and knowledge outside the firm's boundary, an open business model uses partners and networks for value capturing and value creation. "(... -) *openness to innovations and openness of business models - needs to be adequately recognized, understood, and treated as separate phenomena ...*" (Holm, Günzel, & Ulhøi, 2013, p. 341). However, with open innovation, companies are able to make more use out of their innovations by linking it with the business model (Chesbrough, 2003, pp. 63–64). Researchers and practitioner have to estimate and rank if new ideas have the potential to enhance or generate profit or discard the process because any further investment will be lost.

Open business models extend the concept of open Innovation as open created technologies require appropriate business models to give them value. Following the principles of open innovation, an open business model goes beyond the boundary of a company. To capture more value of innovation, organization and tools outside the company can be used for distribution and marketing to commercialize the products (Chesbrough, 2006a, p. 2–3). This openness of the company's boundary

can improve the financial performance by reducing cost in R&D and other company's organization. In addition, it can increase the revenue by commercializing not used invention to other companies. Scholars highlight the importance of customer orientation as a key factor for open business models (Amit & Zott, 2001) and that multiple players can create value for the same customer (Storbacka, Frow, Nenonen, & Payne, 2012).

In summary, there is a link between open innovation and open business model. In Chesbrough's view, the open business model is closely related to the open innovation paradigm. However, there is no fixed conjunction between open innovation and open business models. Scholars agree that variable combinations are possible and exist (Sandulli & Chesbrough, 2009; Vanhaverbeke & Chesbrough, 2014).

3.3.4. Business Model versus Strategy

The terms "business models" and "strategy" are often mentioned in economic and in the scientific world and often they are used interchangeably (Magretta, 2002, p. 91–92). There is an overlap but there are also major differences, which can be seen in various dimensions.

As Porter (1996, 2001) defines it in his papers "What is strategy" and "Strategy and the Internet", the goal of strategy is to achieve a return on investment and to get a long term market position which differentiate you from competitors. In addition, it should create a unique and valuable position with continuity of direction. This means that strategy is long time oriented and gives companies the basis and direction for competitive advantage (Chandler, 1962, p 13).

Strategy focuses on competitors and the position you want to reach in the market (Zott et al., 2011). For Magretta (2002, p. 91), handling competitors is an important task of strategy "*Sooner or later – and it is usually sooner – every enterprise runs into competitors. Dealing with that reality is strategy's job*". Therefore, the process of reviewing and adjusting the strategy is a repetitive process (Figure 34).

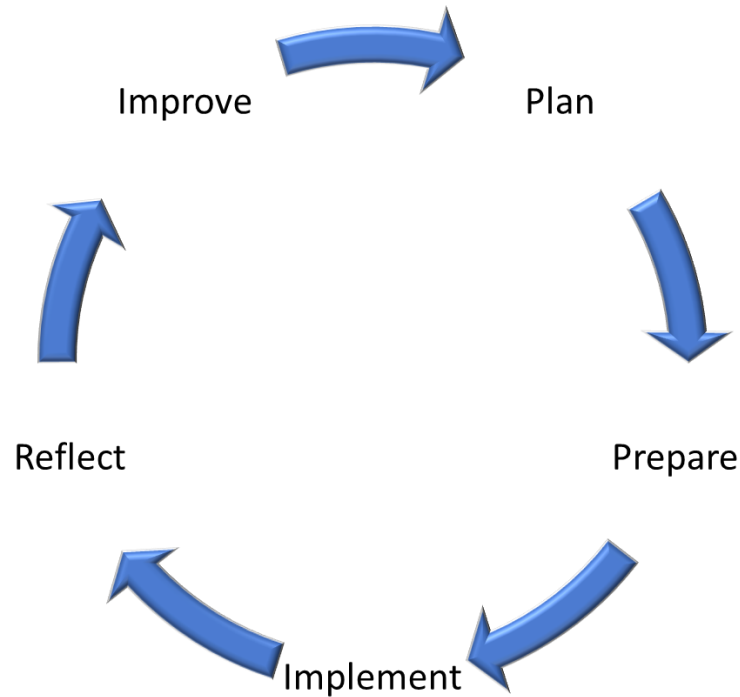


Figure 34: Cycle for reviewing and adjusting strategy (own illustration)

Related to business models they give an answer about the question regarding customer satisfaction, the architecture how products or services are provided and how the company gets money for it. It is adapted each time that general conditions are changing and the business model has to change (Bouwman, Haaker, Kijl, & de Reuver, 2008).

The implementation of the contents of a strategy is a function of the business model (Figure 35, option D). For this task, several business models can be created in the strategic phase to decide which one should be implemented in the market. Therefore, business models are the reflection of the strategy implemented and should be combined (Casadesus-Masanell & Ricart, 2010; Teece, 2010). Strategy is a precondition for development and selection of business models and are options how strategy can be implemented. Therefore, Figure 35, Option E, does not correspond to this procedure. Seddon and Freeman (Seddon & Freeman, 2004) have further developed this thesis and propose that the business model is an abstract representation of an aspect of the strategy of an enterprise. It outlines the substantial details, which one must know, to understand, how an enterprise can create successfully increase in value for its customers. Also, strategy is normally

based on reliable and sufficiently researched analyzes and information and is very specific and detailed. Business models can be based on assumptions and restricted information, which are so limited that business models must be tried out and then fine-tuned. The options A and B from Figure 35 are more theoretical because strategy and business models do not overlap but the business model reflects the strategy (Casadesus-Masanell & Ricart, 2010). Also, option C from Figure 35 can be excluded from further analysis, since, according to common view in the academic literature, a strategy does not represent the same as a business model (Casadesus-Masanell & Ricart, 2010; Chesbrough & Rosenbloom, 2002; Seddon & Freeman, 2004).

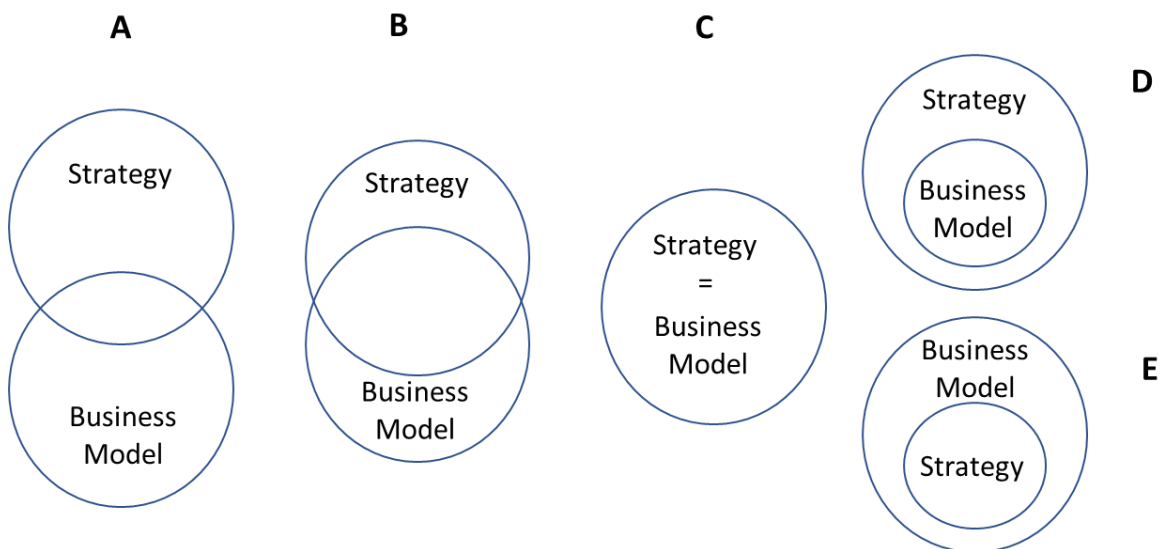


Figure 35: Possibilities of overlaps between the concepts of strategy and business models (own illustration, based on (Seddon & Freeman, 2004))

Zott et al. (2011) regard product market strategies and business models as complementary and not substitutive. Magretta (2002) and Weill and Vitale (2001) also consider business models to be important for the orientation of a company. Before new strategies emerge, business transactions must be thought through and tested on an abstract level before investments can be made. When defining a business model, the focus should be on stakeholders and customers and the competitive aspects of the strategy can be ignored.

3.3.5. Key Elements and Frameworks for Business Model Design

For the development of new business models, further examination of the elements of a business model is necessary and reasonable. For scholars, there is an unclear and over-arching view of which components are necessary for a successful business model (Gassmann, Frankenberger, & Csik, 2013; Lucassen, Brinkkemper, Jansen, & Handoyo, 2012). Elements are in academic literature also named as building blocks (Osterwalder & Pigneur, 2010), components (Pateli & Giaglis, 2004), (key) questions (Morris, Schindehutte, & Allen, 2005), categories (Burkhart et al., 2011) or functions (Chesbrough & Rosenbloom, Richard, 2002). The different descriptions vary in their composition but have also a lot in common.

Magretta (2002, p. 91) defines the elements of a business model in a specific scope: *“Business models describe, as a system, how the pieces of business fit together”*. She specifies a business model as different versions of a generic value chain. In part one, all activities like buying of raw material, designing and production are included. In the second part, the products find a customer and is distributed and delivered. Competition, product, market, customer segment and customer are part of strategy and not of the business model. For Amit and Zott (2001), business models are structured by three transactions. First, the content of transaction is based on goods, information, needed resources and capabilities. Second, the transaction structure describes which parties are involved and how the transactions go on. Third, the transaction of governance are the rules governing the control of transactions, legal aspects, and incentive systems for involved parties. The authors consider all transactions necessary for the use of a business opportunity. In a later article, the scientists supplement the design elements (content, structure, governance) with specific design themes (Zott & Amit, 2010). Chesbrough and Rosenbloom (Chesbrough & Rosenbloom, 2002) describe value proposition, market segment, structure of value chain, estimate of cost structure, profit potential, position of the company and their partners and the business strategy as elements of a business model. They start with the functional design and build the other components on it.

A framework of business models designates what a business model consists of (Fielt, 2013). For Abdelkafi et al. (2013) a framework of a business model is a value-

oriented concept with the elements value proposition, value communication, value creation and delivery and value capture, which enables a classification of design patterns.

From these different theoretical approaches regarding business models, key elements have emerged that are widely accepted by scholars and that shape and characterize business models (Amit & Zott, 2001; Chesbrough, 2002, 2010; Chesbrough & Rosenbloom, 2002; Magretta, 2002; Teece, 2010).

The first key element of a business model is the generation and provision of **value proposition** to the customer. This can take the form of products or services in any form, which are so attractive to a customer segment that they are willing to pay a price for it. A value is generated that solves problems for the customer or provides convenience. It does not matter whether it is a new product or just an improvement of an existing one. The basis for the success of a company is to have a value proposition that differentiates it from other companies.

Second, the **value creation and delivery** describe the company's sources and capabilities. *"It shows the logic of the firm's structure and how the organization is consistent with the firm's basic strategy"* (Richardson 2008, p. 89). By offering a product or service to the customer, the company's goal is to increase its value, so to create new value. The company makes use of its resources and of the value network in which it is integrated.

Third, with **value capture**, the value created by innovation is transformed into profit by selling it to customer. The value created provides the company with money, paid from the customer. For the generation and sale of products and services, several stakeholders are involved which are related to each other in different directions.

Business models are often too complex to represent them in a reasonable way. Therefore elements of the model are simplified (aggregation) or split (decomposition) and considered in isolation (Casadesus-Masanell & Ricart, 2010). Also, not all activities needed to be considered, but only those that exert a particularly strong influence on the structure of the business model.

For the objective of this thesis, it is meaningful to have a closer look on examples of business model frameworks in practice. They are intended to show different approaches to how business models can be structured. In addition, they show ways

in which these frameworks can be applied in practice. Relevant examples are the Business Model Canvas by Osterwalder and Pigneur (2010) and the St. Gallener Business Model Navigator (Gassmann & Frankenberger, 2014). The design thinking method (Brown, 2008; Johansson-Sköldberg, Woodilla, & Çetinkaya, 2013), also shown, goes beyond the business model framework. It enables the development of new ideas for fulfilling customer requirements while considering economic feasibility and profitability.

3.3.5.1. Business Model Canvas by Osterwalder & Pigneur

The work of Osterwalder, Pigneur and Tucci (2005) is probably the most famous and well known framework of business models (Joyce & Paquin, 2016). The framework describes and explains how a business model works in a firm. It is often used by start-ups and companies to structure and visualize their business ideas. It can help to represent the elements of a business model and their interrelationships and effects on each other. When applying the framework, a systemic perspective is adopted and it supports discussion about the underlying business model in terms of value creation - it is a tool that assists and drives BMIs with help of creative techniques.

The framework divides the business model in four areas, which is **product**, **customer interface**, **infrastructure management**, and **financial aspects**. A more detailed explanation is given in Table 3.

3. Towards the Building of Sustainable Business Models for Electromobility

Table 3: The four areas and nine building blocks of a business models (Osterwalder, 2004, p. 43)

Pillars	Building Block of Business Model	Description
Product	Value Proposition	Value Proposition is an overall view of a company's bundle of products and services that are of value to the customer.
Customer Interface	Target Customer	The Target Customer is a segment of customers a company wants to offer value.
	Distribution Channel	A Distribution Channel is a means of getting in touch with the customer.
Customer Interface	Relationship	The Relationship describes the kind of link a company establishes between itself and the customer.
Infrastructure Management	Value Configuration	The Value Configuration describes the arrangement of activities and resources that are necessary to create value for the customer.
	Capability	A capability is the ability to execute a repeatable pattern of actions that is necessary to create value for the customer.
	Partnership	A Partnership is a voluntarily initiated cooperative agreement between 2 or more companies to create value for the customer.
Financial Aspects	Cost Structure	The Cost Structure is the representation in money of all the means employed in the business model.
	Revenue Model	The Revenue Model describes the way a company makes money through a variety of revenue flows.

The Business Model Canvas is structured, straightforward and can lead to implementation successes in a short time. Due to the high number of clearly and understandable building blocks, it also leads to the consideration of many aspects that are elementary for a business model. The model also makes the relationship

between the individual elements clear and leads to a better overall understanding of the entire model as shown in Figure 36.

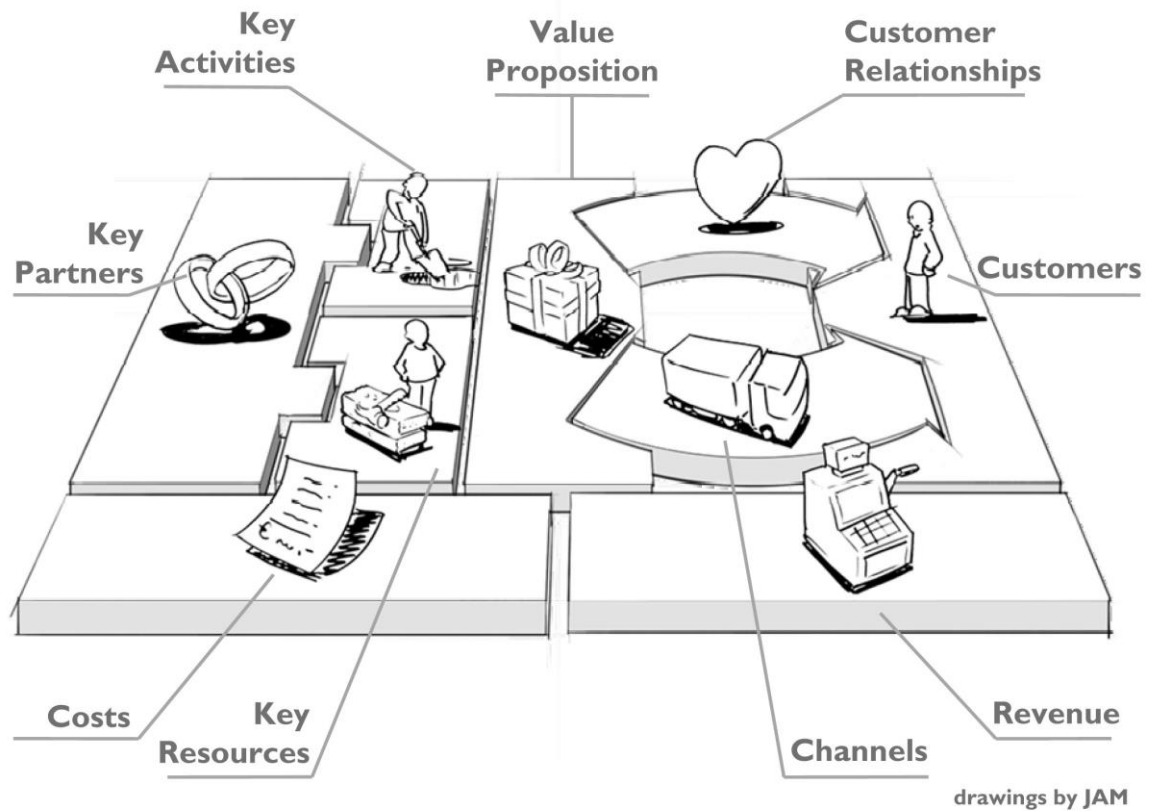


Figure 36: Business model canvas (illustrated by JAM, based on (Osterwalder et al., 2009, pp. 18–19))

The goal of the Business Model Canvas is to simplify the process. In addition, business goals have to be discussed and defined outside the framework and performance measurements like key performance indicators are missing. Nevertheless, the Canvas business model can be used for an initial assessment of business ideas.

3.3.5.2. St. Gallener Business Model Navigator

The Business Model Navigator (Gassmann & Frankenberger, 2014) is a process-oriented method for developing business models. This takes place in four phases (initiation, ideation, integration, and implementation) and is supported by special techniques. The core of this technology is developed by the University of St. Gallen

based on 55 different patterns for business models. The base is the imitation and recombination of existing patterns of business models. Therefore, a business model does not have to be reinvented, but can be created by rearranging elements of existing business models. As a result, the created business model can be new for the selected industry. Goal is not a simplified copy of components, but understanding and creative thinking about adapting the model to the need of the company that is targeted. This can be done by three strategies.

In strategy 1, an existing business model is transferred to another industrial sector. In strategy 2, two different business areas are linked and transferred to a new industry and in the strategy 3, an already existing business model is transferred to another product. For the end-to-end definition of a business model, the Business Model Navigator describes the triangle of value proposition, value creation and delivery, and revenue model (Figure 37).

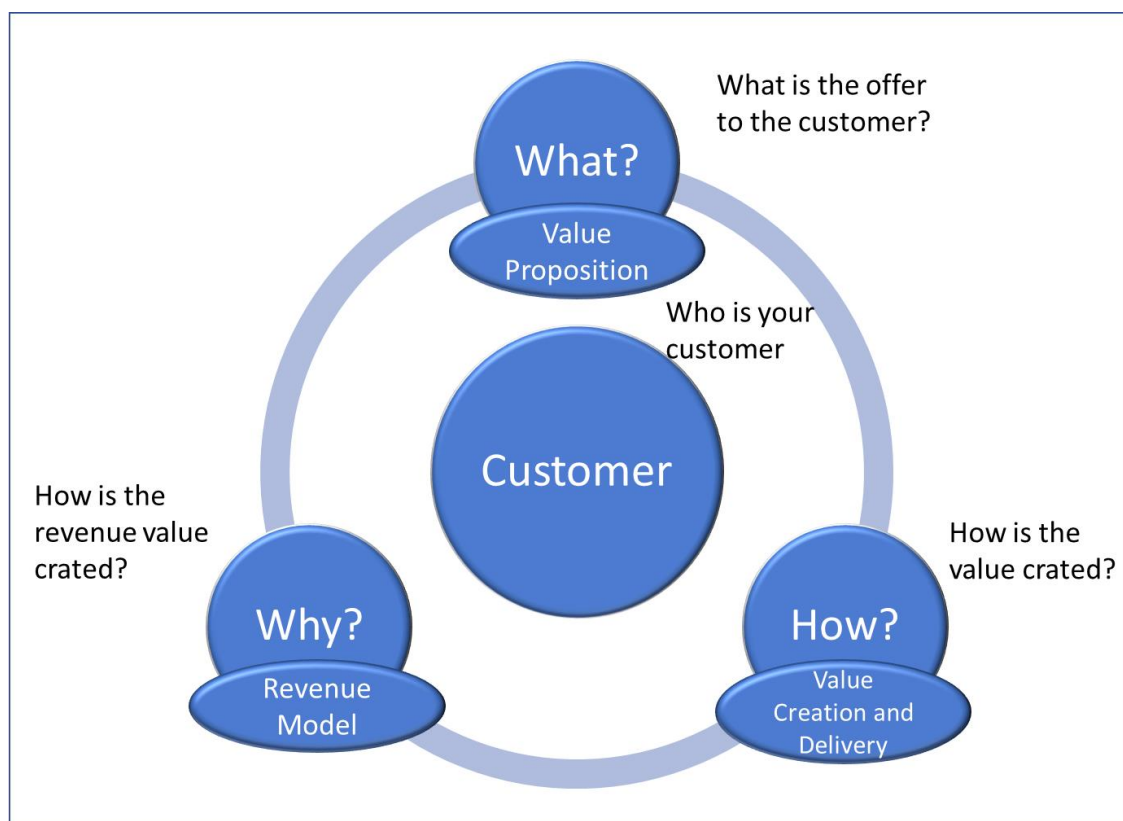


Figure 37: Three elements of the St. Gallener Business Model Navigator (own illustration)

3.3.5.3. Design Thinking

In comparison to the previous approaches of Osterwalder and Pigneur and the St. Gallener Business Model Navigator, design thinking focuses on the analysis and creation of the value proposition. There is a special focus on the needs of the customers. *“Thinking like a designer can transform the way you develop products, services, processes - and even strategy”* (Brown, 2008, p. 84). Design thinking is a collection of techniques from various disciplines which, when combined, can increase the likelihood and reliability of user-centered ideas. To ensure this, design thinking takes design-related approaches that are explicitly user-oriented. The design thinking method is based on six essential components (Breuer, Fichter, Lüdeke Freund, & Tiemann, 2018; Brown, 2008) to promote innovation (Figure 38).

1. **Understanding:** The first step is to understand the problem that defines the needs and challenges of the project. It is very important to understand which obstacle should be solved. Therefore, this phase is normally the most time consuming one and at the end of the phase, the problem should be clearly understood.
2. **Observing:** This is followed by intensive research and field observation to gain important insights and to define the framework conditions of the status quo.
3. **Point-of-View:** The observations made are then broken down into a single, prototypical user whose needs are condensed into a well-defined brainstorming question.
4. **Brainstorming:** This step is one of the core elements of design thinking and consists mainly of brainstorming, which serves the development and visualization of different concepts.
5. **Prototyping:** To test and illustrate the ideas, the first, low-effort prototypes are developed and tested on the target group.

6. **Refinement:** Based on insights gained through prototypes, the concept is further refined until an optimal, user-oriented product is created. This iteration step may refer to all previous steps.

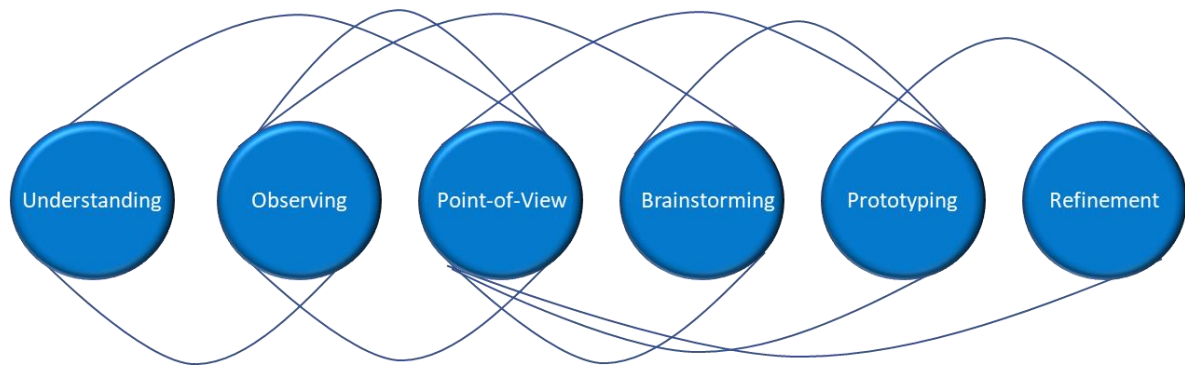


Figure 38: Recycling cycles of the process steps of design thinking (own illustration based on (Pacheco Pereira, 2018))

As a conclusion, there is no unique method of design thinking, but it is a successful way of promoting creative ideas. Scholars criticize that the method is pragmatic, that there is no scientific basis although there has been an increased number of scientific papers on design thinking (Johansson-Sköldberg et al., 2013) and design thinking is used widely in praxis.

3.4. Sustainable Business Models

The world is confronted with a constantly growing population, expanding consumption of resources, and changing climate. Furthermore, the number of people who are in favor of better working conditions, a more careful use of earth's resources and an ethical economy is increasing and the influence on existing and new enterprises is growing (Bocken, Short, Rana, & Evans, 2014; Ehrenfeld & Hoffman, 2017; Jackson, 2009). Companies are facing these challenges and questioning their previous business practices. They become aware that an exclusive concentration on shareholder value alone is no longer sufficient for long-term success (Hart, 2011). As a result of these changes, the management of companies is faced with a significant task. However, the consideration of environmental topics and social aspects is in many companies not yet anchored in operative business models or strategy. At present, economic growth and short-term profits are still the

most important goals in companies and thus influence their business behavior. To meet the new challenges, radical rethinking in companies is necessary. Existing business models, need to be adapted (Bocken et al., 2014) to overcome these challenges. Therefore, it is necessary to develop existing business model theory in the way that social, environmental, and economic aspects receive significant share. The transformation can succeed through new and innovative business models. Among others, companies in transport, automotive and energy industry are looking for new options how they can manage it. These efforts are remarkable, but they are only at the beginning and need further high efforts.

The following section examines the influence of social and environmental responsibility on companies and prepares the transition from business models to sustainable business models. Then a literature review provides an overview of the nature and characteristics of sustainable business models and highlights different interpretations. With the model of Clinton & Whisnant (2014) and the archetypes according to Bocken et al. (2014), two considerable approaches of SBMs are examined in detail. The following section summarizes the knowledge about SBM, as a basis to examine SBMEMs.

3.4.1. Sustainability and Corporate Social Responsibility

In recent years, sustainability has found an inflationary use in media, science, industry and economy and is used with different meanings (Koleva, Rodet-Kroichvili, David, & Marasova, 2010). Especially in marketing and business, sustainability is used as a symbol of environmentally friendly and social progress and is intended to give customers the good feeling that the purchased product or service does not harm the environment or disadvantage social groups. The question about the significance of sustainability often remains unanswered. The report of the Enquete Commission describes sustainability as "*A system that survives, survives in the long term and maintains its stability by keeping the rate of use of its resources below the rate of natural renewal*" (Petschow, Hübner, & Dröge, 1998, p. 22). This definition goes beyond the guiding principle of not polluting the environment more than is taken from it. Existing environmental damage can only be reduced by consuming resources below the earth's natural renewal rate.

Due to numerous interpretations of the term sustainability (Hasenmüller, 2012, p. 10), it is necessary to define it more precisely. At the beginning of the 21st century, companies began to use the term "Corporate Social Responsibility" to insist on the necessity for a company to be responsible for the work force, society, the environment and even the general economic conditions (European-Commission, 2001; Mayer, 2017, p. 20). In addition to CSR, other terms such as CS (Corporate Sustainability), CC (Corporate Citizenship) or CR (Corporate Responsibility) are used in practice and academic literature. Since these definitions are largely identical about sustainability, the term CSR will be used as a synonym. Although the term was already discussed in the United States of America (USA) in the 1950s (Loew, Ankele, Braun, & Clausen, 2004, p. 7), it has been established over the years as part of corporate governance in companies (Mayer, 2017, pp. 17–19).

Companies, especially multinationals, cannot ignore this development because they are not only involved in economic value chains, but they also have a public interest in society (Mayer, 2017, p. 22). Companies are in a field of tension between external influencing factors (like ecology and society) and legislation and internal effects like company value and corporate strategy (Figure 39). Then, companies are confronted with the question of whether the efforts to minimize costs, risks and increase sales on return are the only sensible and necessary driving force or whether other values need not be considered with sufficient attention. The number of managers, politicians and scientists who demand and want to implement a new economic paradigm is increasing (Schneider 2015, p. VII). Already existing components of competition and profit-making intention are not an end in themselves but are enhanced with environmental, social and cooperation elements. The addition of these elements requires a timeline and cannot be included on an ad hoc basis because the changes are too large. However, the transformation requires new business models that can win new customer groups, reorganize activities, and expand the value chain with additional sources of income.

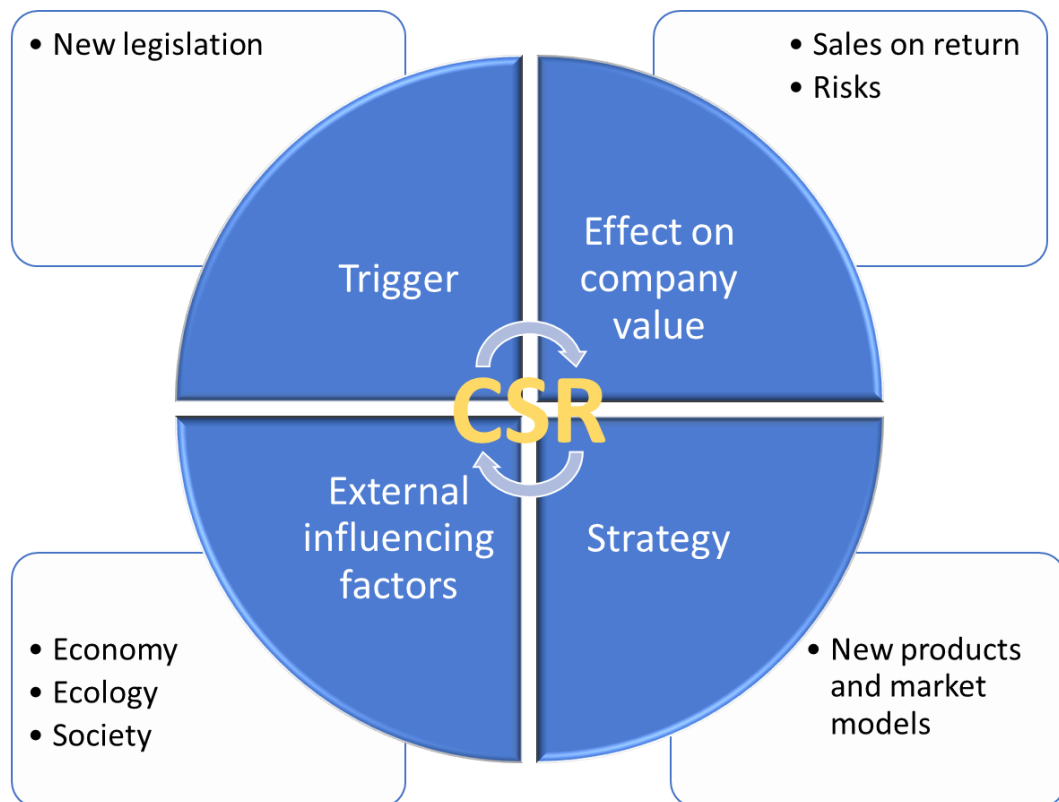


Figure 39: Interdependency between the company and its external environment in CSR (own illustration)

CSR is operationalized in companies by implementing the “Triple Bottom Line” (Elkington, 1998), which have become accepted from the mid-1990s onwards and has been established in companies (Kleine, 2009, p. 5). It describes the integrative approach, whereby economic (profit), ecological (planet) and social (people) objectives are pursued by the company as equally as possible and are considered in the company's development (Elkington, 1998), (Figure 40).

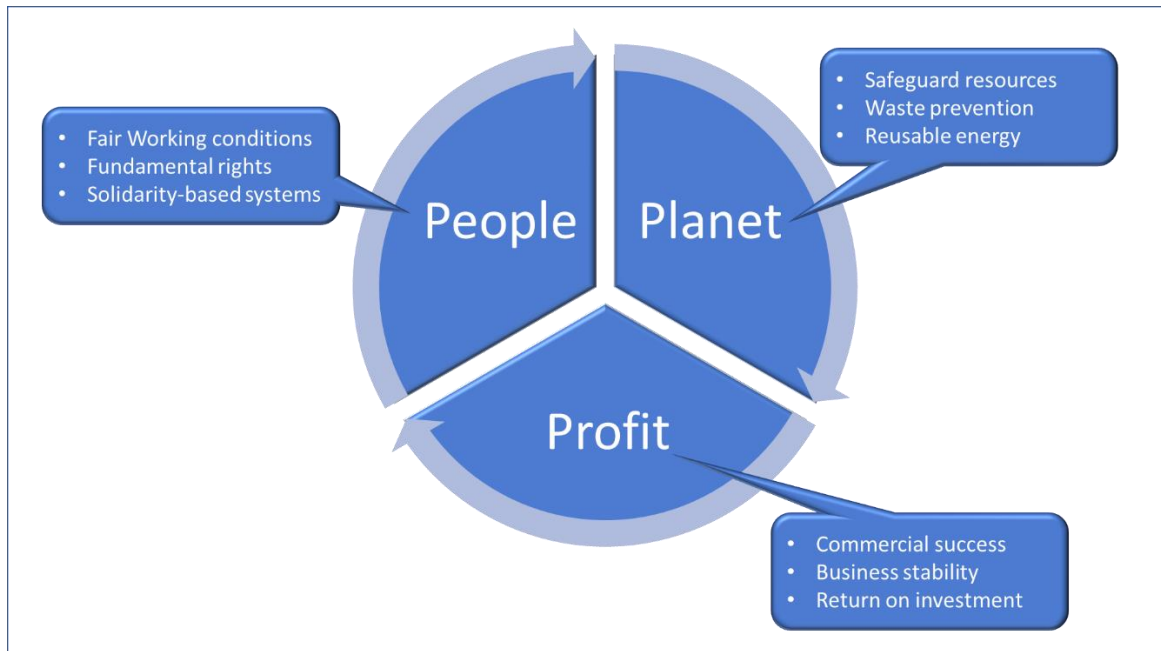


Figure 40: Three pillars of the triple bottom line combines economy and sustainability (own illustration)

For each pillar, different goals can be formed strategically and operationally and anchored in company branches. This enables targeted planning and progress control and helps to facilitate operational management. The goal of the management should be to bring all pillars in line and enables strategic sustainability of the entire company. But this can lead to conflicts, as corporate profitability can come at the expense of social and environmental measures and profits are reduced. In these conflicts, profitability, along with market growth and market dominance, have often a higher priority in the companies and rank lower the protection of the environment and the promotion of social aspects because it meets the requirements of the shareholders (Elkington, 2018). One reason for paying more attention to environmental and social issues can be the company's reputation among the population and the motivation of employees. Both can lead to economic disadvantages due to lower turnover or lower productivity because buyers avoid the products. So, companies include the adoption of sustainable aspects in their advertising and want to point out their changed corporate management. Examples of the integration of environmental aspects and social projects²⁰ in advertising can be seen in campaigns by Ørsted (2019) and CISCO Systems (Del Puerto, 2015)

²⁰ Ørsted Energy and CISCO Systems are under the top ten of the most sustainable companies of 2020 worldwide (Corporate_Knights, 2020; HausvonEden, 2020)

(Figure 41). However, it cannot be derived from these campaigns whether the prevention of environmental damage or the integration of social aspects are also included in corporate management.



Figure 41: Examples of sustainable campaigns from Ørsted and CISCO Systems (Del Puerto, 2015; Ørsted, 2019)

An example is the environmental disaster resulting from the activities of British Petrol, where the oil platform Deepwater Horizon caught fire and sank in 2010. This caused several weeks of flowing oil from the destroyed pipes, contaminating the US coast. The damage to the oil company's image was extensive and showed what dependencies can exist between ecological responsibility and economic success (Harlow, Brantley, & Harlow, 2011).

However, there is also criticism of the concept and especially of its implementation. In practice, concepts of ecology and social issues are often softened and replaced by goals that are more strongly oriented towards the economy. The intention of Elkington (2018) was not to introduce an accounting system in which profit, environment and social aspects are balanced against each other, but to make companies rethink the need to protect the environment and promote social aspects. In particular, the concept of sustainability is used to pursue economic goals that does not correspond to the original objectives of CSR. Examples are the expansion of sustainable transport routes, sustainable growth or sustainable securing of industrial locations (Vorschlag & Ott, 2009). Furthermore, the objectives are not always followed with equal priority and economic objectives are given preference in case of conflict. This is particularly problematic when it is done with arguments from the other pillars. For example, the extraction of raw materials that are harmful to environment can be justified by employment situation of the company with which jobs are to be secured. One potential solution can be the addition of a fourth

dimension, the operationalization of sustainability (Scholz, Pastoors, Becker, Hofmann, & van Dun, 2018, p. 14) (Figure 42).

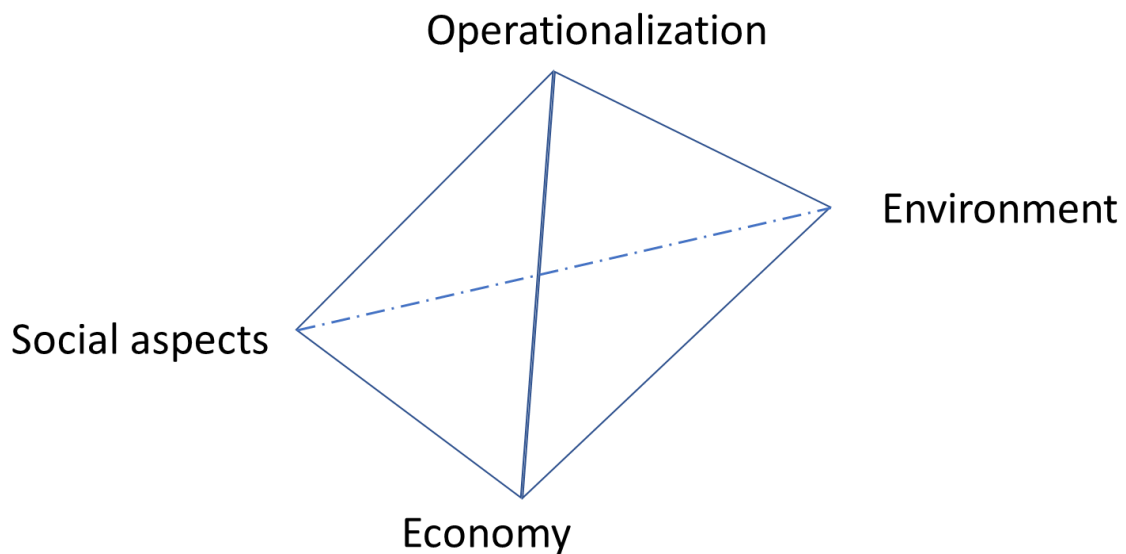


Figure 42 : The four dimensions of sustainability (own illustration based on (Scholz et al., 2018, p. 14))

Thereby the ecological, social, and economic goals are integrated into the structure and organization of the company and to create a value proposition for customer based on the three dimensions. This could lead to a situation in which the different goals are not only balanced out but are integrated into the genes of the companies and lead to a situation in which companies do not live off the earth's resources but with them (Elkington, 2018). This can only be successful when the principles of CSR are integrated into the business model. Therefore business models must be expanded and adapted (Slack, 2012).

3.4.2. State of Research on Sustainable Business Models

The growing interest of consumers in environmentally friendly and socially fair products and services lead companies to change their business model (Massa, Tucci, & Afuah, 2017) and represent the main vector of the development of sustainable business models (Boons & Lüdeke-Freund, 2013). The interest of scientists and practitioners in SBMs is relatively new but has already produced a larger number of publications (Bocken et al., 2014; Lüdeke-Freund & Dembek, 2017; Massa et al., 2017; Schaltegger, Hansen, & Lüdeke-Freund, 2016). SBMs

forces a systemic change in working methods and a changed value proposition for the customer (Jonker & Faber, 2019, p. 156) up to an expansion of the stakeholder landscape from individual actor to a multi-stakeholder concept (Breuer et al., 2018). Despite the increasing number of publications, there is a lack of common understanding of SBMs in scientific world and among practitioners (Schaltegger, Hansen, et al., 2016) and general design principles or practical guidance for the development of SBMs are not available (Breuer et al., 2018).

From a strategic management point of view, Lüdeke-Freund (2010, p. 23) analyzes the relationships between environmental sustainability, business activities and business model elements. The objective is to develop SBMs, which is defined as "*a business model that creates competitive advantage through superior customer value and contributes to a sustainable development of the company and society*". Garetti and Taischs (2012) focus more on sustainable production and they assume that SBMs protect the environment and improve people's quality of life at the same time. In Stubbs and Cocklin (2008), SBMs include an organizational and a systems perspective. SBMs are an expression of society and profits are a result of it. Companies take full account of their stakeholders, such as local communities, suppliers, partners, employees, customers, and nature. The aim is not to waste existing resources but to use renewable or man-made resources. Waste and environmental damage should be avoided. In the same way, the entire system must be adapted. Changes in the socio-economic system, both structural (such as the restructuring of transport and tax systems) and cultural (like attitudes to consumption and economic growth and well-being), are needed. Boons and Lüdeke-Freund (2013) present normative basic requirements for each constituent elements of SBM: the value proposition covers environmental, social and economic values, stakeholders are integrated into responsibility for sustainability and costs and benefits are to be shared fairly among the parties involved.

Upward and Jones (2013) also see a relationship between involved stakeholders in creation of value (especially customers and shareholders) and the social and environmental aspects. A sustainable business model requires the continuous development of the natural environment, society, and economy. A very comprehensive definition comes from Schaltegger et al. (2016, p. 6) "*A business model for sustainability helps describing, analyzing, managing, and communicating (i) a company's sustainable value proposition to its customers, and all other*

stakeholders, (ii) how it creates and delivers this value, (iii) and how it captures economic value while maintaining or regenerating natural, social, and economic capital beyond its organizational boundaries". It combines benefits to be generated for a company with value generated for other stakeholders. Economic benefit is combined with ecological and social value (Figure 43).

For Adams et al. (2012) several business aspects such as stakeholder relationships, knowledge management, leadership, networking and culture must be linked in SBMs.



Figure 43: In the sustainable business model, the elements "social aspects" and "environmental aspects" are added to the conventional business model (Schnee, 2020)

At the beginning of the development of sustainable business models, the primary aim was to transfer the upcoming responsibility of companies about environment and social performance into their structure and organization (Stubbs & Cocklin, 2008; Wells, 2013). This should not prevent existing goals of economic success or market presence. With changing customer demands, sustainable business models can help to gain a competitive advantage by addressing and satisfying customers' demands (Porter & Kramer, 2011).

3.4.3. Classification of Sustainable Business Models

Based on the definitions in the previously conducted literature review, the SBMs are categorized. This should provide further insight in order for generating new business models for electric mobility. Several scholars have already categorized SBMs on the basis of case studies (Bocken et al., 2014; M. W. Johnson & Suskewicz, 2009; Lüdeke-Freund, 2013; Stubbs & Cocklin, 2008). With this regard, fundamental mechanisms are analyzed and presented. In the first part, the SustainAbility approach is analyzed. The focus is on innovative SBMs. This is followed by the archetypes by Bocken et al. (2014), which are based on a literature review of scientific sources and practical examples.

3.4.3.1. Sustainable Business Models by Clinton & Whisnant

The researchers from SustainAbility²¹ identified 20 sustainable BMIs from 100 case studies, which was grouped into five dimensions: „Environmental Impact“, „Social Innovation“, „Financing Innovation“, „Base of the Pyramid“ and „Diverse Impact“ (Clinton & Whisnant, 2014) (Figure 44).

²¹ SustainAbility was founded by John Elkington and Julia Hailes in 1987 who are the authors of the book Green Consumer Guide, 1988.

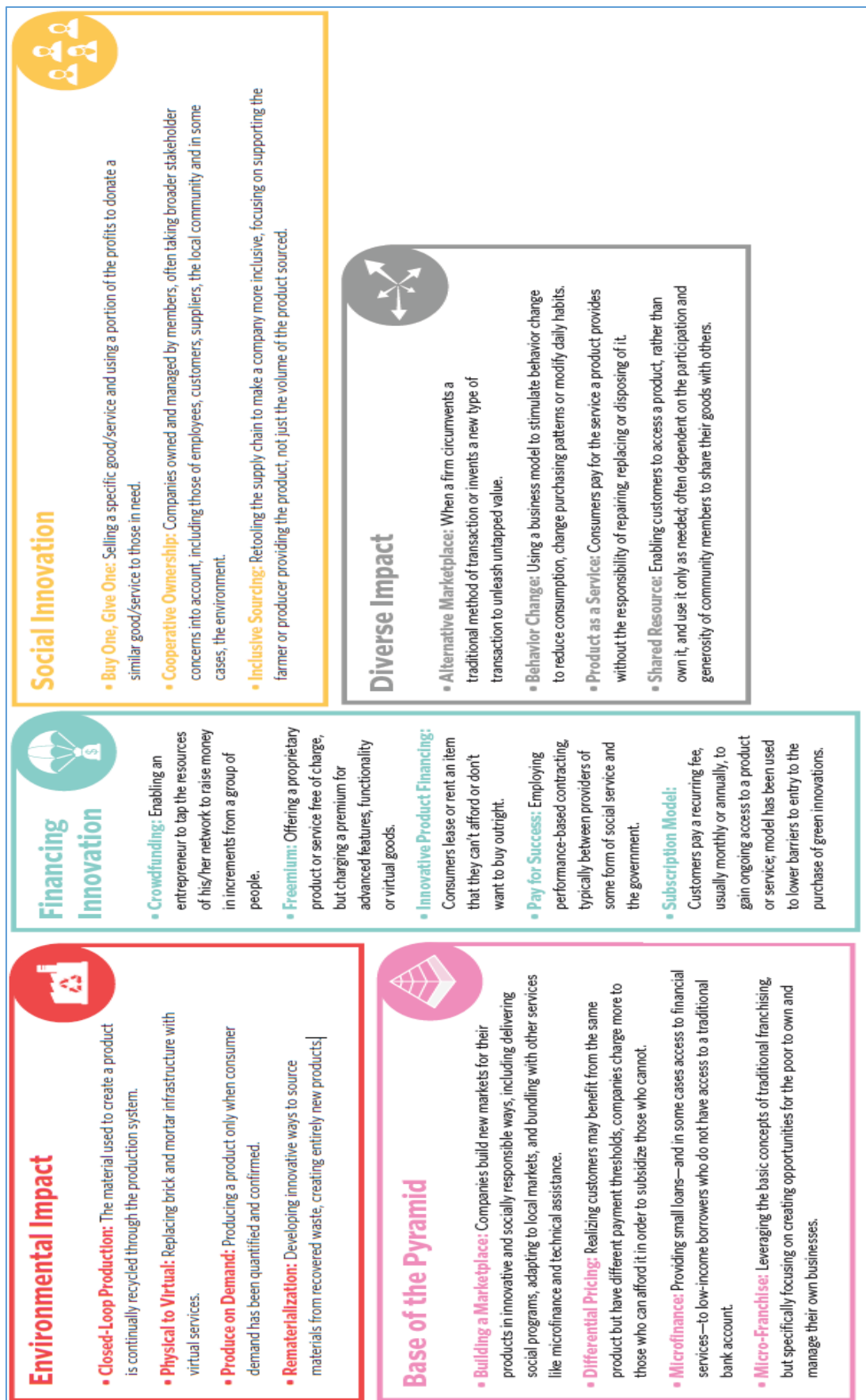


Figure 44: Five categories of SBMs from SustainAbility (Clinton & Whisnant, 2014)

In the first category, "**Environmental Impact**", business models are examined that intend to protect and preserve the environment. They concentrate on topics of recycling and waste management. The aim is to avoid raw materials in different forms. For example, recycled raw materials are reused, completely avoided through virtualization or products are only produced on demand.

In the second category, "**Social Innovation**", business models focus on creating more participation for people in special situations. They deal with cooperative ownership integration in supply chain using existing marketing measures and their redesign. For example, with "buy one, give one", the "buy one, get one free" sales method is reinterpreted. In this way, known customer behavior is used to donate goods or services to people who need it. While the popularity of this model is increasing, it has come under criticism because of its social impact. A lot of products are collected through the model, but donations alone cannot solve the complex social problems. By donating a product, buyers can have the feeling that they can solve all social problems related to poverty because it prevents the search for more global solutions and must be addressed at the root cause. Another option is to focus on strengthening your own business. By taking more responsibility from stakeholders or sourcing from local manufacturers will increase motivation among stakeholders and can lead to a higher social position.

In the category "**Financing Innovation**", established and new innovative forms of financing are presented (for example leasing or paying for premium functions). New approaches, which include public and private partnership are of particular interest. Governments or cities, as contractual partners, have a major concern in social subjects.

In "**Base of Pyramid**", tools for SBMs are presented in order to provide special opportunities for people who have lower incomes. For example, "Building a Marketplace" integrates additional programs that provide loans to individuals who do not have access to traditional bank accounts. Or, with "Micro-Franchise" the opportunity to operate one's own business is offered, with special discounted terms.

"**Diverse Impact**" is a collective category in which different objectives are addressed. Diverse Impact describes business models where companies can change conventional transaction methods or create a new type of transaction to

generate value. "Behavior Change" uses business models to change the habits of users in order to reduce consumption or change daily attitudes.

Clinton & Whisnant's (2014) business models are oriented strongly toward social subjects. They are designed to enable financially vulnerable groups of people to obtain products and services. They also describe different ways of financing through the business model, which is intended to make it easier to run one's own business. The environmental aspect is reflected in changes in consumer behavior, for example in form of reduced consumption. Although some of the business models described (15 out of 20) are already known and have been used for many years, the approaches of Clinton & Whisnant (2014) show concrete business models that can be applied in practice and consider especially socially disadvantaged groups on the provider and the demand side.

3.4.3.2. Classification of Archetypes by Bocken

Without evaluating the novelty of such business models, Bocken et al. (2014) classify SBMs differently. Based on an extensive literature search, they developed sustainable business model archetypes where archetypes are a higher order grouping describing the main type of business model innovation. The three main categories are "Technological", "Social" and "Organizational" and are based on the grouping of Boons and Lüdeke-Freund (2013) (Figure 45). The categories are divided into eight sub-categories and the concept is implemented as part of an online tool. It offers brief explanations of the respective archetypes as well as 100 case studies. In a next step, Bocken et al. (2014) assign the elements of each category into the elements of a sustainable business model that have been highlighted in the academic literature: value proposition, value creation and delivery, and value capture.

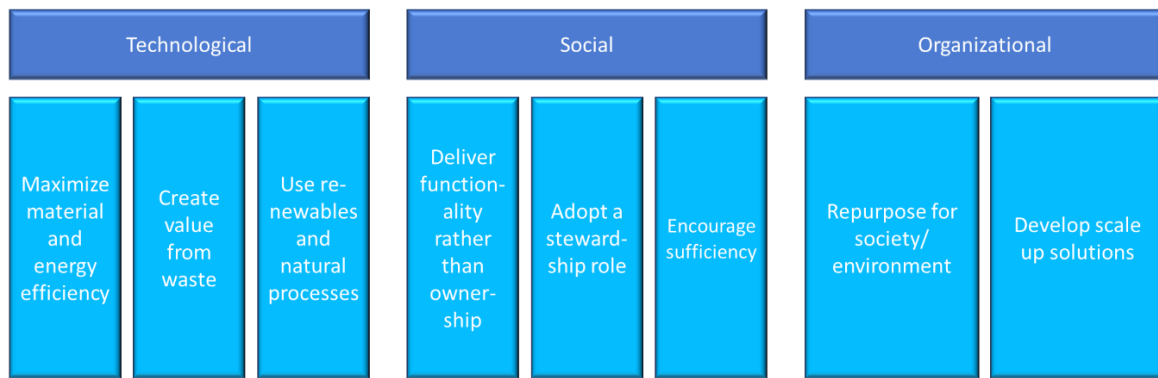


Figure 45: Main categories of SBMs (own illustration based on (Bocken et al., 2014))

a) Technological

In the technological category all measures are included, which handles raw material extraction, production, and recycling.

- Maximize material productivity and energy efficiency

The aim of SBMs is to reduce material usage, energy consumption and waste during production thus reducing costs and protecting the environment. However, this can lead to a rebound effect²² (Sorrell, 2009).

- Create value from 'waste'

In this element, waste should be used as a recyclable material and returned to the value chain. It saves costs and reduces material consumption. Many SBMs are created on this basis and are part of the recycling economy. It also includes the use of overcapacities and the compensation of low-capacity utilization through shared use.

- Use renewables and natural processes

Dependency on fossil raw materials and non-renewable resources is to be reduced using renewable energies, natural resources, and processes. Since they are not yet enough profitable, they could require government support.

²² With the rebound effect, the savings potential of increasing efficiency is not or only partially realized. Lower consumer spending increases their consumption.

b) Social

Social trading is the focus of this group, considering the employees.

- Deliver functionality, rather than ownership

In order to avoid idle- and downtimes, products and services are no longer purchased, but the availability of functionality is in the foreground which is based on Goedkoop et al. (1999) and Tukker (2004). The customer does not pay the right for the property but only for the use, connected with further services. This model can promote the development and availability of products with a long service life.

- Adopt a stewardship role

The focus of this element depends on the consideration and involvement of stakeholders. Productivity can be achieved through improved employee motivation and the reliability of the partnership is to be increased in a supplier relationship characterized by better cooperation. Customers can also be motivated for buying more expensive products by the companies' efforts to achieve sustainability.

- Encourage sufficiency

Long-life and stable products increase sustainability by reducing resources and energy consumption. In addition, the necessity and benefits of social and environmentally sustainability are to be communicated to customers. One example is the bottom or base-of-the-pyramid approach to simple belts in poor parts of the world (Prahalad & Hart, 2016; Yunus, Moingeon, & Lehmann-Ortega, 2010).

c) Organizational

In this group, measures for new sales channels and types of financing are proposed and explained.

- Repurpose for society/environment

This element gives high priority to environmental and social value, besides economic benefit. Profit maximization alone is not the primary aim, but aspects

of the environment and social fairness are also included. This can lead to greater business and stakeholder integration by changing the composition of stakeholders.

- Develop scale-up solutions

Achieving size to maximize the benefits to communities and the environment is one of the aims of SBMs. Scalable models are used, such as the franchising or licensing system, peer-to-peer models, or open innovation approaches. Combinations of the different approaches are possible, especially for multinational companies.

It has to be noticed that elements of a category partially overlap. The objectives of the elements "maximize material productivity and energy efficiency" and "create value from 'waste'" are almost identical. There is also no clear distinction between "substitutes with renewables and natural processes" and "maximize material productivity and energy efficiency". Further overlaps could be listed. For example, the sharing economy element occurs in several types and could thus be combined into one type.

3.4.4. Discussion

The importance of SBMs has increased significantly in the last years (Bocken et al., 2014; Bohnsack et al., 2014; Boons & Lüdeke-Freund, 2013; Cabaret, Kroichvili, & Picard, 2014; Evans et al., 2017; Schaltegger, Hansen, et al., 2016; Stubbs & Cocklin, 2008) in response to society pressure. Many companies meet the demands for more environmentally friendly products and improved social conditions by including these requirements in their corporate rules (Asswad, Hake, & Marx Gómez, 2016; Bocken et al., 2014; Giatrakou, Ntzimani, & Savvaidis, 2010; Schaltegger, Lüdeke-Freund, & Hansen, 2016). The practical implementation in the companies takes place mainly through the triple bottom line in the business models. The value proposition is extended by elements where the environment is to be protected and social conditions can be improved, while "value creation and delivery" and "value capture" continues to be pursued in SBM. The ever-growing academic

literature confirmed these core elements of SBMs and further explore them with the aspects of business model innovation. Through archetypes describing mechanisms and solutions, it is intended to accelerate the development of sustainable business models through a common language.

However, the rate of implementation in the companies or a transformation into sustainable business models have to increase. Many companies tend to give not the necessary priority to developments toward greater sustainability and persist with existing goals of profit maximization. They are discouraged by high investments in products, services, and corporate restructuring, or in some cases are technologically incapable of doing so (Fröndhoff, 2019).

For implementation of SBMs, it is necessary to make transparent the interrelationships between the individual elements of business models and to clarify their interdependencies. Only if these are understood, companies can adapt their business models according to customer requirements. A framework for SBMs that is aligned with the specific business activities is helpful in this regard. In the next chapter, a framework for sustainable business models will be presented for electromobility.

4. Framework for Sustainable Business Models for Electromobility

The development of a framework for SBMEMs is based on the theoretical concepts from the previous chapter created on future trends and a changed perception of the environmental and social aspects among the population, politicians and companies. The framework for SBMEM must fulfill the key values of electromobility (individual mobility, integrated and connected, convenient, flexible without planning, environmentally friendly and social compatible), only then customers will be willing to accept electromobility and buy environmentally friendly and social compliant products and services. For incumbents, SBMEM enables the transformation of their existing business model into electromobility, while for start-ups it provides the basis for implementing their business ideas. It should be clearly described and intuitive and its elements should be delimited, but not too detailed, in order to allow freedom for different products (Bocken et al., 2014). Furthermore, it should enable uniform and effective communication between the different stakeholders in the network of value chain (Osmani, Wagner, & Köster, 2018, p. 256). It serves researchers and practitioners to a better understanding and inspire them to create new business models for their products and services. The following chapter presents the state of research and the development of the framework for sustainable business models for electromobility.

4.1. State of Research

Electromobility is closely linked with the concept of sustainability (Burkert & Schmuelling, 2019). The literature review examines theoretical frameworks for sustainable business models in electromobility.

Schönfelder (2009) analyzed the increasing market penetration of electric mobility as one of the primary challenges of new, adapted business models in electric mobility. A core element is the integration of renewable energies into the electricity grids. In this way, peak loads in the evening hours are to be avoided by charging electric vehicles, as these are mostly covered with electricity from fossil fuels.

Wells (2013) addresses the economic, social and environmental elements in his study of automotive industry. By economic, Wells (2013) describes the relationship between production costs and the number of units to be produced, which influence

the distribution channel. Due to high fixed costs, small quantities should be sold through a direct sales channel to keep costs low. The first aspect regarding the social dimension is the improved access of customers to environmentally friendly products while the second aspect refers to interesting and more diversified jobs for employees with stable employment patterns. In the environmental dimension, Wells (2013) addresses the protection of resources through a longer service life and improved maintenance and repair options of the products and a changed product technology. His core question is, how can an unsustainable industry successfully produce sustainable products with a suitable business model. He addresses the business processes and operational environment of the automotive industry. With a sustainable product, the automotive industry will succeed in creating sustainable business models with the necessary structures and organizations.

Abdelkafi et al. (2013) introduce a framework with five value dimensions: value proposition, value communication, value creation, value delivery and value capture. While the elements value creation, value delivery and value capture are known from the business model research, Abdelkafi et al. (2013) add the element “value communication” as a new component, which is supposed to transport value to the stakeholders. This element, which has been little addressed in the academic literature so far, requires further research. It emphasizes the necessary differentiated communication to stakeholders to build an efficient ecosystem. The authors limit themselves to proven business models linked to the automotive industry, considering electric vehicles and vehicle-related services.

Kasperk et al. (2018, pp. 133–154) indicates a interaction between supply, demand and influencing factors in electromobility, which is linked by the business model. The demand of the different target groups must be analyzed to create a value-oriented offer. Politics must provide the necessary framework conditions in form of support systems, regulatory frameworks, and competitive structures. The providers, which are rigidly connected with each other today, should be arranged into innovative business.

Reinhardt et al. (2020) explore elements for a conceptual framework for electric vehicle battery second use based on sustainable business model archetypes. They propose a sustainable business model for the battery second use market in an emerging electric vehicle industry. Their findings include cross-sector stakeholder

collaboration that can succeed in medium term even if short-term success is low. The conceptual sustainable innovation business model framework includes the elements of environmental -, social -, and economic aspects, which are applied to this specific case.

Curtis (2020) investigates the gap between design and successful implementation of sustainable business models based on established business models. The aim is to identify patterns that enable successful implementation. As a result, regionally different patterns are identified, depending on context and business model attributes, which contribute only slightly to the design of a framework for electromobility.

A different approach is taken by Hamwi et al. (2021) in their framework with nine elements for a demand response business model as a tool for researchers and practitioners. The demand response business logic is used as a basis to achieve a more flexible and sustainable balance between energy production and demand. It is based on the following elements: flexibility product, flexibility market segment, service attributes, demand response resources, resource availability, demand response mechanism, communication channels, cost structures and revenue model. For a better visualization, the new elements can be represented in a demand response business model canvas, which is also suitable for electromobility, where electric vehicles generate an economic value through coordinated charging/discharging with grid technology. However, the implementation of the canvas in the context of electromobility has to be seen critically. Elements of the demand response framework are assigned characteristics that have a special focus on demand response energy and do not specifically address electromobility. This refers to the additional elements outside the traditional framework. Only the communication channel can be considered in a modified form.

Key findings regarding SBMEM are synthesized in Table 4.

4. Framework for Sustainable Business Models for Electromobility

Table 4: Selected contributions to sustainable business model frameworks , sorted by year of publication

Author	Contribution to the Framework	Application
(Wells, 2013)	Description of economic, social, and environmental elements. Narrowly confined to the automotive industry with effects of the transformation from ICE to BEVs in the value chain.	Automotive industry
(Abdelkafi et al., 2013)	Investigation of value proposition, value communication, value creation, value delivery and value capture and derives patterns from them. Value communication is intended to improve stakeholder's communication.	Automotive industry
(Künnecke, 2017)	Proposition of a framework that combine value proposition, value network and value capture with technological innovation systems, which result in an overall integration of business in technological innovations.	Charging infrastructure
(Breuer et al., 2018)	Establishing minimum requirements for designing a sustainable business model by defining four guiding (principles sustainability-orientation, extended value creation, systemic thinking, and stakeholder integration) and four process-related principles (reframing business model components, context-sensitive modeling, collaborative modeling, managing impacts and outcomes).	Life cycle thinking, product-service system
(Toma & Tohanean, 2019)	Case study on how German automakers concentrate their efforts in establishing green business models, focusing on connectivity (car-people-environment), electrification, autonomous driving, and shared mobility.	Automotive industry
(Bigerna, Micheli, & Polinori, 2019)	Research on the introduction of electric boats in Italy and what impact it has on tourists. Tourists are willing to pay for CO ₂ free mobility.	Tourism and electric boats
(Curtis, 2020)	Establishing sustainability in sharing economy: patterns can support general solution and support economic viability and improved sustainability with the attributes value capture, value delivery and value facilitation.	Sharing Economy
(Hamwi et al., 2021)	Proposition of a demand response business model with the following elements flexibility product, flexibility market segment, service attributes, demand response resources,	Energy demand

(Hamwi et al., 2021)	resource availability, demand response mechanism, communication channels, cost structures, and revenue model is presented. The elements are too specific for the use case and a derivation is therefore not meaningful.	
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The results of the literature review show that there is no consistent framework for SBMEMs although more and more researchers are turning to this research field. Their motivations are different, but mostly concern a closer examination of how to design sustainable business models. Also, closely related topics, such as circular economy or sharing economy are discussed in the papers, but without giving any further insight into a framework.

It can be stated that authors take the basic elements of business models, i.e. value proposition, value capture and delivery and value creation, as a basis and progress is done through business model innovation in order to design SBMEMs (Abdelkafi et al., 2013; Khan & Bohnsack, 2020; Reinhardt et al., 2020). Ecological and social components are mainly anchored in the reviewed literature through the products and services and less in the business models itself. Also, there is a dominance of the environmental component, and the social dimension is neglected. The need for a network of stakeholders is shown but remains predominantly at the level of individual companies.

There is still a gap in academic literature for a conceptual framework for SBMEMs. Thus, electromobility and its relationship to the elements of the business models are discussed. Since the academic literature describes electromobility as a product of a network of value chains, whose impact on individual dimensions of the sustainable business models has to be examined.

4.2. Building a New Framework for Sustainable Business Models for Electromobility

The framework of SBMEM satisfies the individual and contemporary mobility needs of customers. A compromise must be found between product offering with a significant improved ecological balance and increased social working conditions and an environmental stimulus for companies, with the possibility of making profit. The following framework for SBMEM is based on the elements of conventional business

models (value proposition, value creation and delivery, and value capture). The dimensions “environment”, “social” and “economic” are transversal due to their impact, as customers and companies need a system to find a compromise between economic, environmental and social aspects. Also, the importance of an ecosystem for electromobility is emphasized, which goes far beyond a network of stakeholders.

4.2.1. Value Proposition

The objective of electromobility is to satisfy individual mobility while preserving the regenerative and adaptive capacity of natural systems. In addition, the accumulation of problematic pollutants that endanger human health must be avoided (Kopfmüller et al., 2000) based on the key values of electromobility. The framework of SBMEM contributes to this in several ways which will be shown later in this chapter. For this purpose, the environmental footprint should not only be balanced but consumption of non-renewable resources should be compensated by a necessary increase in the amount of renewable resources (Hardtke, 2001, p. 58).

4.2.1.1. Environmental Dimension

An important element of the key values of electromobility is the possibility of moving around freely according to personal choice without having to consider other people, which contributes to a high value proposition among the population. According to the study "Mobility in Germany 2017" (2019), 90 percent of transportation trips are made individually. The main mode of individual transport is the private motorized transport with 57 percent. Walking is on second place with 22 percent and cycling with 10 percent. At 8.5 percent, local public transport is only at the fourth rank. Other means of transport such as airplanes and ships represent 2.5 percent of the total (BMVI, 2019, p. 5,46,55) (Figure 46).

4. Framework for Sustainable Business Models for Electromobility

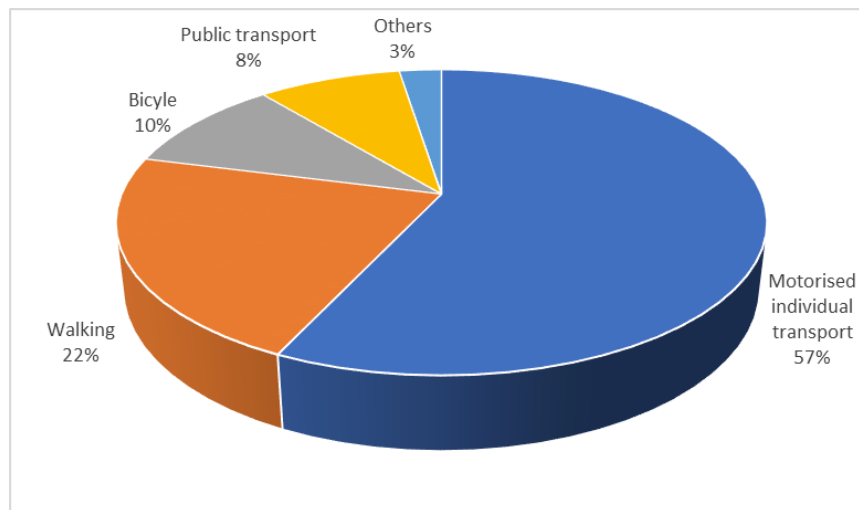


Figure 46: Modal split of transport routes shows a predominance of motorized individual transport (own illustration, based on (BMVI, 2019, p. 5,46,55))

However, transport is responsible for almost 30 percent of local CO₂ emissions in Europe. Road traffic accounts for 72 percent of these emissions, with a 60.7 percent share of passenger traffic, as can see in Figure 47 (European Parliament, 2016).

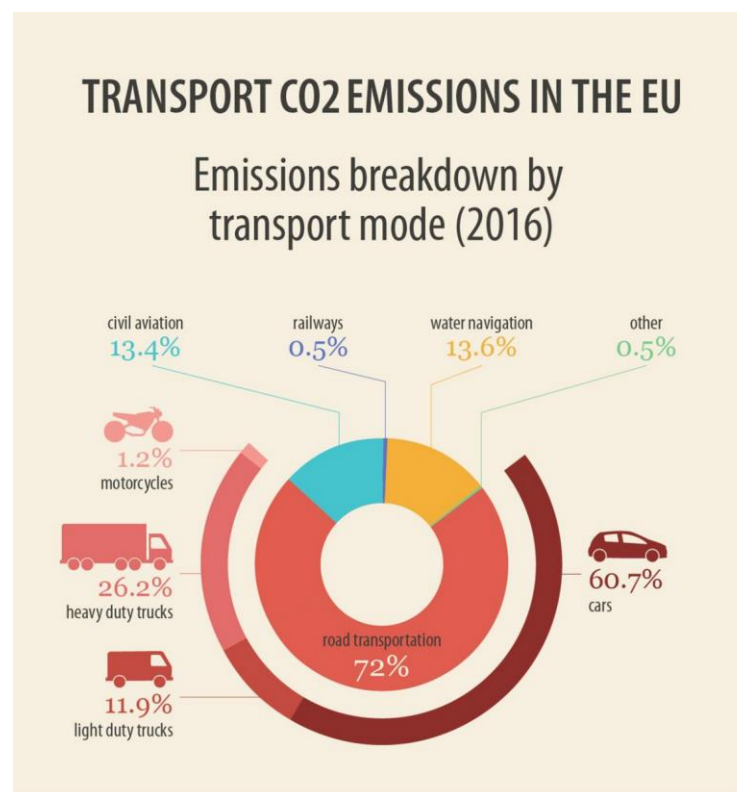


Figure 47: Passenger cars have the highest share of transport emissions in Europe (European Parliament, 2016)

With the conversion of ICE vehicles to BEVs, SBMEM supports the key values of electromobility for individual mobility. Electric vehicles avoid local CO₂ emissions and significantly reduce noise pollution. The conversion can take place in all areas of transport, such as private vehicle owners, company car fleets, car-sharing, and cab companies. Therefore, the reduction of environmental pollution leads to a higher motivation for the purchase of electric vehicles.

Today's mobility offerings are fragmented and have developed historically along very different lines. Services from different suppliers are not always transparent and confusing and it is not easy to choose the best suitable offer every time. Although the EU has been making efforts to improve travel between cities and countries, cross-border transport facilities are largely inefficient and have many bottlenecks (Caesar, Heilmann, Saalbach, & Schreiner, 2018). Even local transport in urban agglomerations of European cities does not meet the needs of users. A key value of electromobility is precisely the environmentally friendly travelling using integrated means of transport which can contribute to solve some existing problems regarding mobility. However, replacing existing technology with a new, sustainable one, cannot solve existing problems without a comprehensive overall concept (Jarass & Oostendorp, 2017). Information about available means of transport have to be present all the time and a common data platform where more detailed information can be viewed is necessary. Integration into digital tools makes sense but should not be the only choice. Multiple tickets when choosing multiple means of transport or payment to multiple service providers also do not correspond to the key values of electromobility and must be reduced to a single process. In case of cross-border traffic, language barriers can be difficulty which have to be solved with multi language ICT systems.

Another environmental dimension for reducing the burden on the environment in electromobility is the use of renewable energies. This relates in particular to the charging of electric vehicles. According to a survey by the FORSA Institute (2017), for 68 percent of the interviewees, a prerequisite for the spread of electric cars is operation with exclusively green electricity. This requirement is rated higher than the desire for a subsidy of over 4,000 euros per year from the government and shows that the generation of energy also contributes to a high value proposition among the population. Research reports with varying results create a great uncertainty among customers. For example, a study by the University of Karlsruhe with the authors

Koch and Bölke (2020) shows that results by the EU Commission on the emissions of BEVs are double the amount calculated because they are based on an inadequate determination during the generation of electricity. It assumes that the mix of environmentally friendly produced electricity or green electricity and electricity generated from fossil fuels does not correspond to reality. This strengthens the framework's approach that the provision of energy for electromobility must come from environmentally friendly generation. To satisfy the key values of electromobility, it is necessary for drivers of electric vehicles to recognize if charging stations are supplied with green electricity which is not always the case today. Therefore, operators of charging stations must ensure that they are always supplied with environmentally friendly produced electricity or label them adequately. This should be done at the charging station itself and in digital media such as apps or navigation systems.

Another approach is to use guarantee labels, such as the certified green electricity in Germany. It proves not only the generated electricity from 100 percent renewable sources, but the energy operator must also promote the expansion of renewable energy with a fixed amount per kilowatt per hour (kWh) sold. Another organization is the Renewable Energy Certificate System, which also supports the promotion of renewable energy. An overview of European measures is provided by the Intelligent Energy Europe Report within the project "Clean Energy network for Europe" (Bürger, Timpe, & Seebach, 2010).

The relationship between desired increase of electromobility and increasing mining of raw materials leads to a growing discussion in electromobility. Mining requires considerable amounts of water and energy (Meyer et al., 2018, p. 10) and burdens the environmental balance of BEVs. In order to increase the environmental friendliness of BEVs or even completely compensate for it, it is necessary to reduce or even eliminate the need for raw materials by expanding eco-conception, recycling and the circular economy in the field of electromobility. Moreover, a compromise must be found between the raw materials required and the range, since a long range is currently still often associated with large batteries and an increasing need of raw materials.

With the goal of achieving a common value proposition for the customer, it becomes possible to accelerate the implementation of electric mobility and to eliminate the

disadvantages compared to conventional products (Adner, 2016; Jacobides, Cennamo, & Gawer, 2018).

4.2.1.2. Social Dimension

For the acceptance of electromobility, it is important that it is not at the disadvantage of people (Reuter, Hendrich, Hengstler, Kupferschmid, & Schwenk, 2019). This can be described comprehensively as the fact that compliance with ethical principles is a mandatory requirement for the framework. In this context, ethics can be defined as "*moral principles that control or influence a person's behavior*" (Oxford_University_Press, 2020). Elements are the working conditions and the effects on health under which the working process is done. Adequate safety measures, sufficient rest periods, protective clothing and appropriate food and accommodation are necessary basic conditions that must be in place in production and distribution processes. The standards of working conditions, human rights, and health care systems of western world which are considered as decent (Kretsos & Livanos, 2016), do not apply in every country. For example, in the mining areas in Congo, Chile and Argentina, governments give priority to economic aspects, which is partly at the expense of the population (Sorge & Eckl-Dorna, 2016). Also, the environmental impacts caused by mining can have persistent effects on population living there. Contaminated water, deserted landscapes and poisoned soils can result in population no longer being able to live in their traditional homeland and using it for agriculture (Klein, 2020). The respect of basic rights is needed to be compatible with the responsible nature of electromobility. These include human rights, freedom of assembly and the right to health and education.

Another element of the social dimension is the influence of the business models on the employment rate. The changes in products and services caused by electromobility can lead to changes in employment rates in the industries. A lower number of components in the conversion from ICE vehicles to BEVs can lead to a reduction of employees needed in production. It is not yet clear whether this reduction can be compensated by the creation of new job profiles and the resulting need for employees for the new products. A decrease could lead to a lower acceptance of electromobility.

4.2.1.3. Economic Dimension

Costs are an important factor for the decision to convert ICE vehicles to BEVs. Although the purchase price of electric vehicles is higher than that of ICE vehicles, the running costs (fuel or electricity, insurance, tax and residual value losses) must also be considered. The consideration of the total cost of ownership (TCO) is a suitable and recognized procedure (Morrison, Stevens, & Joseck, 2018). Comparisons between BEVs and ICE vehicles show that electrically driven vehicles are cheaper in TCO over a longer period of observation than ICE vehicles (BUND, 2019; Helms et al., 2019). This figure will rise even further in the coming years, as technical progress will reduce consumption costs and vehicle prices.

Bocken et al. (2014) group “deliver functionality not ownership” into the social category of SBM. It has also an important and independent meaning in electromobility and should be preferably listed in the economic dimension of value proposition. More and more people want to satisfy their individual mobile needs without the disadvantages of ownership. They are becoming increasingly important in cities and metropolitan areas, where owning a vehicle can bring disadvantages like the search for parking spaces and the high costs caused not only by taxation and insurance but also by parking costs.. For them, the value of use is more important than ownership which can be a burden of them and is not necessary to fulfill their mobility needs. Rifkin (2001) examines the fundamental transformation of developed economies in terms of ownership.

One aspect of the economic dimension is for users that sharing means of transport also offers the possibility of reducing expenses for individual mobility and lowering the barrier to accessing electromobility. This can be the decisive element for the use of electromobility because when buying a vehicle, you are tied to it because you have made an investment to use the vehicle. If services in electromobility are higher than the benefits of ownership, the barrier is lowered and the transformation accelerated. Through services in the area of e-car sharing or MaaS, only the prices that are incurred through use have to be paid. There is no longer any need to invest in the purchase.

An extension of the sharing of property is provided by the implementation of a product service system (PSS) for electromobility, that combines products and

services and enables ownership-free use. Tukker (2004) has developed a classification of the different types and forms of product service system (PSS) and the relationship between the user and the company (Figure 48).

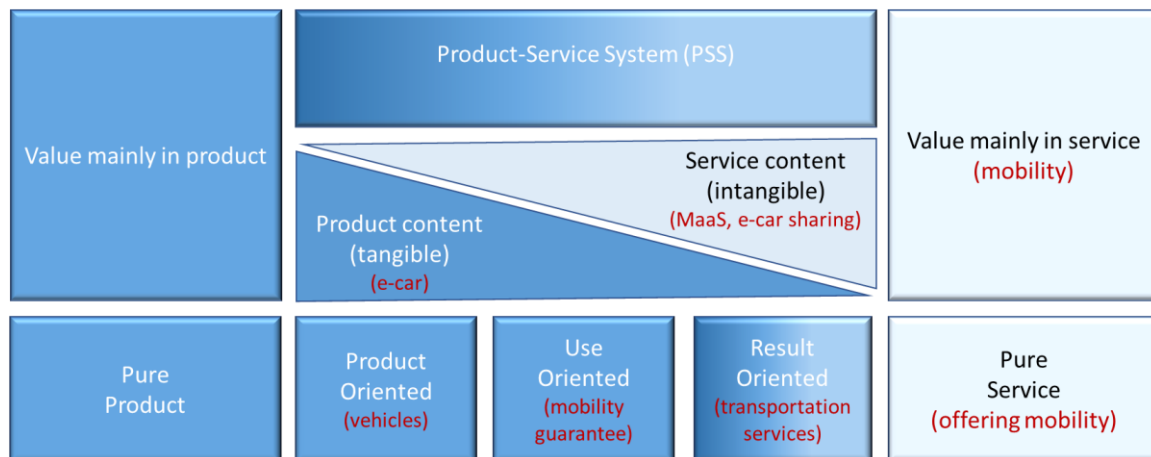


Figure 48: Typology of PSS adapted to electromobility (own illustration based on (Tukker, 2004))

Property rights are not transferred from manufacturer to user (transaction-based system), but single or multiple use of product is agreed upon, which represents a benefit-based relationship. This can also be seen as a network of actors where there is interaction between products with supporting infrastructure (Fazel, 2013, p. 47) in an ecosystem of value chains. The price is the compensation for use. The user has the possibility to use different means of transport and to connect them with each other by means of offered services.

A SBMEM has to make the convenient communication within all participants in transportation possible. But it is necessary to guide the user, which is more than information collection. It should be interactive, easy to understand and intuitive. With seamless interoperability it is possible to expand the environmentally friendly technology of electromobility and generate a value proposition for the customer. It explains and operationalizes the technology and stimulates emotional needs to buy. It is important to set meaningful touchpoints where customers can and should meet the products. The different channels are connected via customer journey and enable the customer to interact with products and services without interruption. It can also overcome the lack of information and an insufficient user experience for electric vehicles. Charging stations are often blocked for several hours due to longer

charging processes of BEVs and charging stations can also be misused as parking spaces. Therefore, it is important for drivers to know if charging stations are occupied and if the necessary authorization for the driver is available. This information can be provided by the vehicle itself which can communicate with route suggestions (Dammak et al., 2020).

4.2.2. Value Creation and Delivery

Electromobility can significantly changes the value chain in firms: it entails a complete reorientation of technology, organization, products, and processes. To be able to satisfy the key value of electromobility, the value chain must be analyzed and reviewed by adding, substituting or discontinuing value-added activities (Lopes de Sousa Jabbour, Vazquez-Brust, Chiappetta Jabbour, & Andriani Ribeiro, 2020).

4.2.2.1. Environmental Dimension

The generation of the required energy for electromobility is today mainly carried out in a mix between renewable and fossil fuels. For technical and economic reasons, companies avoid separating the two forms in terms of use. For example, the connection of charging infrastructures directly to an offshore wind farm would be desirable, but not economically feasible (Pehnt, Höpfner, & Merten, 2007). One solution can be, to connect electromobility providers with producer of green electricity or that all charging stations have to be supplied with green electricity. Another possibility is to generate environmentally friendly electricity by producing it oneself using block-type power plants or wind farms.

Also, energy is not only needed for driving, but for the extraction of raw materials, production, maintenance and recycling of products. For example, the battery production generates between 61 kilograms and 106 kilograms of local CO₂. Although the figure has fallen significantly since 2017 due to more stringent environmental conditions and improved manufacturing methods, a further reduction is necessary to further improve the environmental balance sheet (dpa, 2019).

Vehicle to Grid²³ (V2G) provides opportunities by storing renewable energy to bridge power fluctuations. In the majority of cases, these are bridged by power generation from fossil fuels. By connecting electric vehicles, they can be used to improve the quality of the grid or voltage stabilizing locally by connecting or disconnecting them as a sink or source when required. Therefore, the use of batteries in electric vehicles can compensate for fluctuations in electricity supply and thus better control electricity. However, V2G also has natural limitations. Electric cars can individually store only a small amount of energy in battery, which is additionally limited by the required residual amount for driving, the maximum permitted deep discharge and the approved number of recharging cycles. Calculated, about one million electric vehicles could provide three gigawatts of positive or negative balancing power at 10 kWh/vehicle (Pehnt et al., 2007). The use of V2G makes little sense from an economic point of view, since the marginal costs of participating in electricity market are too high and electricity prices, including those of renewable generation, are currently too low (Ianniciello, Biwole, Achard, & Henry Biwolé, 2017). This can evolve with the transition of electromobility when more BEVs are available for V2G.

Also, particular attention must be paid to the consumption of raw materials in the production process of electromobility which is an element of the key values of electromobility. It is also not clear yet whether the existing resources will be able to meet the necessary demand in future (Sorge & Eckl-Dorna, 2016). With rising sales figures for BEVs, bottlenecks may occur in materials such as silver, cadmium, cobalt, chromium, copper, gallium, indium, lithium, manganese, nickel, lead, platinum, tellurium and zinc (Valero et al., 2018).

A reduction in consumption can be achieved by using other materials and technologies and by eco-design. Regardless of existing reserves, it is necessary to use raw materials sparingly. Ekins and Hughes (2016) are convinced that world's consumption of resources can be reduced by 28 percent by 2050 and at the same time local CO₂ production can be reduced by 60 percent. Also, the global economy could grow by an additional one percent. However, this kind of eco-efficiency bears the risk of a rebound effect (Walnum, Aall, & Løkke, 2014). In case of a direct

²³ V2G = Vehicle to Grid. In the V2G business transaction, the service life of the electric vehicle and the integrated battery are used as energy storage devices. The V2G operators charge and discharge the battery during standby to compensate for current peaks (battery is used as an energy storage device) and charge the vehicle before the driver uses it. The driver receives a fee for using his battery. The power grid has advantages for the battery owner, the generator and the network operator (Weiller & Neely, 2014).

rebound, products or services are in greater demand because extraction and production has become more efficient and can therefore be offered at a lower price. At the end, production volume is not reduced, but even increased. In an indirect rebound, the funds freed up by lower price are used for other products and services, which in turn can increase demand for environmentally harmful resources.

The extraction of raw materials can also be reduced by reusing products and parts as long as possible in form of second life. Batteries from electric vehicles are particularly appropriate for this purpose. The use in the form of second life can expand the value chains of companies and can open up new business areas. Possibilities arise for second life applications including storage of solar or wind power, peak shaving, backup for energy or storage for power plants (Olsson, Fallahi, Schnurr, Diener, & van Loon, 2018)

A further reduction can be achieved by repair and appropriate recycling measures (Valero et al., 2018). Opportunities are the promotion of repair instead of new purchases for raw material-intensive products (Sorge & Eckl-Dorna, 2016) and the recycling of lithium batteries. In 2012, twenty of twenty-eight members of the EU have achieved the target of 25 percent. In 2016, only 14 member states have met the target of 45 percent (European_Commission, 2019, pp. 12–14). If the targets are met or tightened even further, it is feasible to recycle significant quantities of raw materials.

Companies have to decide whether to include the reuse of the product in second life, the repair and the recovery through recycling in their own value chain or to handle it through other companies in the ecosystem (Figure 49).

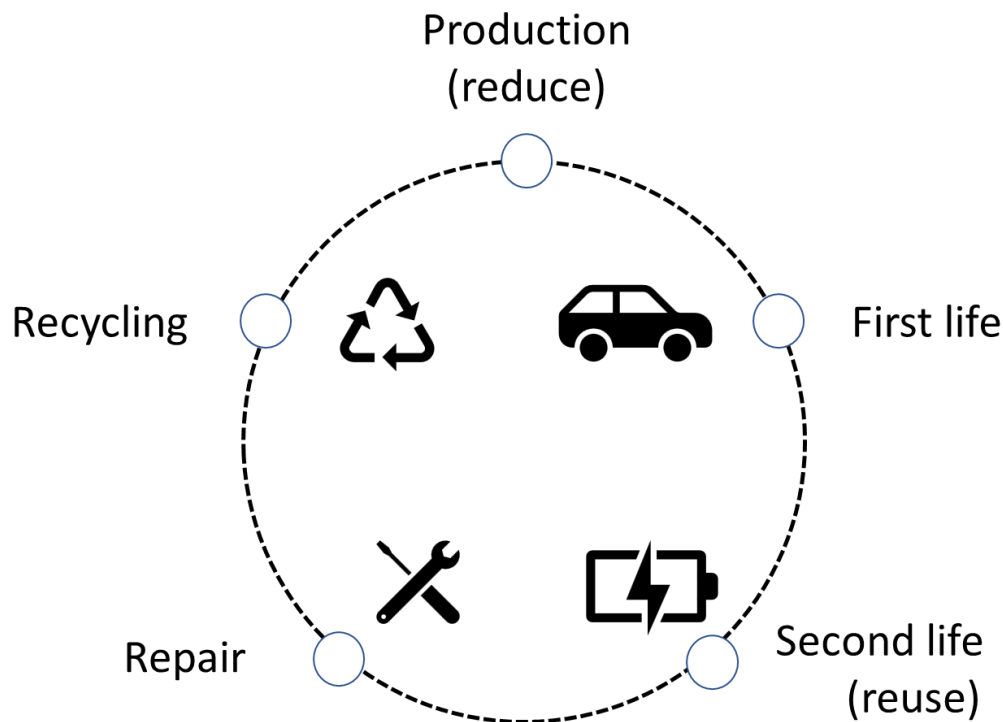


Figure 49: Avoid mining by reducing second life and recycling of raw materials (own illustration)

4.2.2.2. Social Dimension

In the value chain, social fairness and equity have to be considered in order to fulfill the key values of electromobility, which can lead to changes in existing supply chains. Value chains without consideration of social aspects are primarily focused on economic goals in order to achieve high productivity and profit. (Carter & Easton, 2011). Suppliers are selected on the basis of key performance indicators such as delivery reliability, flexibility in terms of quantity and time and price. The conditions under which the supplied parts and products are produced in the global supply chains are the responsibility of the supplier. The social responsibility and equity element makes companies responsible for examining their entire value chain and supply chain for human rights violations and for identifying, eliminating and preventing abuses (Brandenburg, Govindan, Sarkis, & Seuring, 2014). This strengthens the rights of employees who work in countries where inhumane working conditions predominate. The aim is to introduce a basic human rights standard since the products of these countries also ensure prosperity in the importing countries. In industrialized countries, it is reasonable and necessary to enable a good work-life balance for employees, which is becoming increasingly important for many people.

Equal pay between the genders and the possibility and necessity of promoting technology professions for women should also be considered. The due diligence created for companies in electromobility should extend from the raw material to the final sales product. This extended responsibility can lead to a change in value creation and form new chains. Existing suppliers or even entire countries can be excluded and new ones added. With the introduction of a social label in the sense of fair trade, compliance can be monitored and made credible to the customer.

The conversion from ICE vehicles to BEVs can also have a significant impact on the automotive industry. Depending on possible scenarios and framework conditions, this development has an impact on employment figures throughout the industry. In the scenario of Frieske et al. (2019, p. 7), the automotive cluster in Baden-Württemberg, Germany, will see an increase in employment of +1.9 percent and a decrease of -6.8 percent by 2030. However, this employment effect, can only be reached if the automotive cluster can maintain its previous leading innovative role, which cannot be assumed (Dyer & Gregersen, 2016). Mönning et al. (2018, p. 7) comes to a different conclusion. It calculates that the number of people employed in the electrification of powertrain will fall by 114,000 by 2035, with a vast majority of 83,000 employees in vehicle development being eliminated. In contrast, 124,000 employees can be expected to be created by new job profiles in other sectors. The basis is an electric car share of new registrations of 23 percent by 2035.

However, SBMEMs have the potential to generate additional jobs in the automotive industry through the key values of electromobility. For example, the development and production of batteries is creating a new supplier sector, which will have high growth rates due to the increasing number of registrations for BEVs.

Also, the new technologies will require changed job profiles throughout the automotive manufacturing organization. The further development of electric motors or battery systems requires specialized knowledge in electrical engineering. High-voltage systems will also create new job profiles in aftersales that were previously only needed to a very limited extent. In addition, the expansion of the product range will result in new activities in product management, marketing and sales. Moreover, other services or products can be offered that have not been available from automakers yet. A wall box or the placement of electricity contracts can be mentioned here as an example. Similarly, the expansion of the ecosystem due to

electromobility will create new collaborations and corporate relationships between companies that will require staff support. These go beyond the existing links between OEM and supplier and the linear value chains because other stakeholders are also added. It should be noted that job profiles and employment opportunities can change as a result of electromobility and are not always fungible. Employees from the production of vehicles are not immediately employable in the IT sector. Here, it is important to create a platform through comprehensive transparency of the job shifts and through training programs that counteracts a one-sided reduction of jobs through electromobility. The new ecosystem that has to be created can serve as a basis here. Missing employees in sectors that are to be built up can be filled by employees from other sectors who become redundant, which can lead to a transfer and transformation of electromobility. Moreover, it is important to note for a social balance in the place of residence and company headquarters. For example, the density of charging stations is higher in cities than in the countryside or in economically less developed areas (Initiative_Zukunftsmobilität, 2018, pp. 27–48). This can lead to the fact that only with higher investments of the population or the companies electromobility can be used adequately.

4.2.2.3. Economic Dimension

Converting ICE vehicles to BEVs can lead to the fact that existing suppliers, partners, and sales channels must be assessed and adapted. Also changes in distribution channels can be required for a better commercialization of the products. This can mean to sell products and services via sales platforms that are operated jointly with other companies. With an integrated offering, customers can have access to the services that satisfy the key values of electromobility (environmentally friendly). For example, it may make sense for the sale of electric vehicles to offer extra services for charging with a contract of an energy company which supplies green electricity or to propose services to install wall boxes. Cooperations and changes in the development of technologies are also conceivable. Existing knowledge in ICE vehicles can be supplemented by joint research in battery technology or electric motors since in-house knowledge is not available or cannot be built up fast enough (Reinhardt, Christodoulou, Gassó-domingo, & Amante, 2019).

Due to innovations and novelty, there are opportunities for new companies that can take a share of electric mobility. It is often easier for start-ups to make the transformation because they do not have to consider existing restrictions like corporate networks, company structure or processes (Wells, 2015, p. 212). Path depending behaviors can prevent incumbents to create new ways of value creation and delivery because they prefer to stay close to their familiar business models due to their past success (Chesbrough & Rosenbloom, 2002; Sosna et al., 2010). However, restructuring the company can lead to conflicts between electromobility stakeholders and the company's shareholders (Stubbs & Cocklin, 2008). As a result, a change in corporate objectives and strategy is necessary. However, this requires that the management of the companies support the adaptation of the value chains. Starting with electromobility products can indeed result in lower sales volumes and a flexible product offering can produce higher costs at the beginning, which can be reduced by optimizing the entire value chain including technical advances (Wells, 2015, p. 212).

The design of the vehicles can also be impacted by converting ICE vehicles to BEVs. When designing BEVs, OEMs can choose between two basic vehicle architectures: conversion design and purpose design. In conversion design, the components of the electric drive are integrated into the existing vehicle architecture with the advantage that existing models can be used as a basis and changes to the processes and vehicle concepts are not very high. The synergy effects reduce time and expense for new developments and allow a transition to purpose design. Therefore, it is predominantly used by incumbents. In purpose design, the vehicle architecture is designed with focus on the electric drive, which corresponds to a completely new development. In contrast to the conversion design, the effort is considerably higher, but it gives more freedom in design, operating elements and has a high novelty value, which can lead to an incentive for customers to buy. The consequence is that the existing processes and production facilities have to be converted and a higher investment is required. Also, the risk increase, as new technological developments are not always successful on the market. There are also organizational implications to consider. The more than 120-year history of the internal combustion engine and the experience gained are not directly transferable to electric vehicles and it means a considerable amount of retraining for employees. Persistence in implementation is to be expected and must be addressed through

change management and training measures (Wallentowitz & Freialdenhoven, 2011, pp. 117–118, 135–142). For the customer both designs can fulfill their wishes to electromobility. Using the conversion design, BEVs are faster available and in some cases cheaper than BEVs, created with purpose design. With purpose design, it is possible to integrate the modified technology better into the vehicle and provide a more pleasant feeling of space.

Regardless of the chosen design, the number of components in the electric vehicle compared to the ICE vehicle is significantly reduced (Table 5). In the powertrain itself from 1,400 to 210 (Kampker & Vallée, 2018, p. 17).

Table 5: Changes of components in powertrain from ICE vehicle to BEVs (Kampker & Vallée, 2018, p. 57)

Components no longer needed	Components strongly modified	Added components
Internal combustion engine	Gearbox	Electric motor
Tank system	Wheel suspension	Power electronics
Fuel injection system	Power transmission	Battery management
Clutch	Cooling water pump	Charger
Exhaust system		
Alternator, oil pump		

These effects influence incumbents in several ways. Electromobility means that fewer and different parts have to be purchased, which has an impact on the supply chain. For suppliers, this may lead to significant volumes of parts that are no longer produced and sold, resulting in an impact on profit. Also, it will be necessary for suppliers and OEMs to invest in electromobility in order to be able to develop and produce competitive parts and products. A persistence in the world of combustion engines can therefore also result in developments that may endanger the company.

The transformation to electromobility also influences the selection of suppliers and subcontractors. Suppliers firmly anchored in the supply chain will have to be reviewed as a result of the transition to electric vehicles and will in some cases no

longer be the right one (for example, parts for the combustion engine, exhaust systems or fuel tanks) or the suppliers will not be able to meet the new requirements in terms of environmentally friendly and social compliant production. Studies show that companies that produce in an environmentally friendly way must not have a disadvantage in sales or profits, but can even increase them (Danciu, 2013; S. B. Moore & Manring, 2009). One reason of this situation can be that consumers are paying more and more attention to the fact that suppliers behave ecologically when selecting products. This is also confirmed on the investor side, as the demand from institutional investors for environmentally friendly producing companies is also permanently increasing (Bundschuh, Dresch, & Emunds, 2018, p. 4).

Necessary high investments in development of innovations for environmentally friendly mobility could be shared between several parties and industries. Required skills would not have to be built up in one company but could be used and expanded in parallel through appropriate partnerships and cooperations. This would support the OEMs current corporate strategy of concentrating on core topics in automotive business. Delivering products and services can be improved by common platforms for sales, information exchange and networking of products and services.

Integrated and convenient travelling as key values of electromobility can offer operational functions. These include route planning, ticket purchase, reservation of seats or vehicles and payment for the entire journey. Other services are the hotline available 24 hours a day, 7 days a week. In addition to user-friendliness for customers and increased acceptance of electromobility, extensive service integration offers further economic potential. Operating various transport options or programming required ICT opens new opportunities for expansion for software companies. Increasing business activities can also lead to an expansion of the market shares of existing operators. New perspectives arise in the overall interoperability of electromobility if it is not limited to individual transport.

A change in the value chain can have an impact on companies' costs. Changing raw materials, new manufacturing processes and altered marketing strategies affect companies' profits and can be passed to customers in the form of higher prices. This is obvious in the case of electric vehicles. For other services such as MaaS, price reductions result when travel routes are booked through one service provider rather than separately by mode of transport with different ones.

4.2.3. Value Capture

Value capture is predominantly associated with the pricing model of the product. In electromobility, it is still under development and requires special consideration of the underlying ecosystem that is needed for the successful transformation.

4.2.3.1. Environmental Dimension

By the transition of the companies to more environmentally friendly products and services, there may be pricing implications. It can be necessary to make large investments in the development of more environmentally products which is particularly evident in the automotive sector. Also, existing value chains can change and increase costs through the use of modified raw materials and more environmentally friendly production or marketing. The adaptation of existing processes and manufacturing methods are cost-intensive not only for the transformation. Higher costs can also result in ongoing production due to the converted process. The question is whether these one-time transformation or operational costs will be honored by consumers and paid through higher prices. This transition particularly affects incumbents and they have to adjust their business model with BMI. New actors have the advantage to build value chains and production facilities under more environmentally friendly aspects and to develop the business model.

4.2.3.2. Social Dimension

The purchase of goods from fair trade enables the standards of social fairness and equity to be raised for the producers. It means that buyers and manufacturers negotiate the price of goods in a way that it is fair for the producer and is not mined or produced under inhumane conditions. In electromobility, this is particularly the case when purchasing raw materials that are mined in countries with little or no social legislation and sold to industrialized countries. For the key values of electromobility the significance of social aspects in production must be considered. This does not always mean that prices will rise, because by selecting or eliminating

intermediaries, the margins of the intermediary can be reduced and the return to the producers can be increased. Higher wages at the producers increase the purchasing power of the population, which enables the opening of new markets. The profits generated by higher sales can be passed on to the producers or used to cover their own costs, allowing them to capture a higher part of the economic value.

There are many ways for companies to invest in social aspects. These include not only appropriate wages and salaries but also supportive activities in form of health-promoting measures at the workplace, work safety, support of the working atmosphere and appropriate job security. This can refer to the employees in the companies but also to the people in the value chain. For buyers of the products, these measures can be important and decisive for the purchase itself in contrast to conventionally manufactured products. Also, they are willing to pay the appropriate price for it.

4.2.3.3. Economic Dimension

The conversion from ICE vehicles to BEVs results currently in price increases for products and services. Due to the high investment from companies in new technologies, seldom raw materials, new manufacturing processes and changed sales processes, the prices for the end customer will increase. In addition, the price structure of the vehicle may alter as new opportunities for bundling arise due the use of electricity instead of petrol. For example, one-off investments for the ICE vehicle can be split into reduced investments for the vehicle itself and additional services such as battery rental or access to electricity.

With the element "deliver functionality and avoid ownership", electromobility can be made accessible to a broad part of the population, as the need to purchase is not required. New value chains can be formed for the provision of products and services, which can also change the positions of companies in the market. In the case of mobility services, operational services such as customer management, hotline or authorization and payment services are required in addition to the means of transports and these services are in direct contact with the customer. The decision criteria for choosing a means of transport are no longer the vehicle itself, but availability, price, and pick-up and drop-off conditions. This can lead to

automotive manufacturers becoming only a supplier of the mobility service providers and integrating their value chain into the mobility service provider. However, in order to continue to maintain their existing position in the market as product manufacturers, OEMs may also switch to offer their own mobility services, retaining design sovereignty. However, this is accompanied by changes in terms of the company's business activities and orientation. Previous core competencies in production and sale of vehicles must be supplemented by services such as seamless operability.

Companies are increasingly adapting to customers' desire for more environmentally friendly products. Generally, customers are willing to pay a price premium for these types of products. Surveys in the consumer goods sector show that over 60 percent of all consumers are willing to pay a premium for products that demonstrably do no harm the environment (Ballas, 2020, p. 9; Gerhard, 2020). However, this behavior is less prominent in the case of electromobility, as the sales figures for electric vehicles show. Only high government subsidies make customers willing to switch to electric vehicles but will lead to an increase in sales only in short term. It will immediately end after the government support and sales fall back to a lower level (McKinsey & Company, 2019). Benefits in addition to direct financial participation, such as free parking, use of bus lanes and access to all low emission zones, like London, Paris or Grenoble, are not sufficient to convince people to buy an electric vehicle (Zulkarnain, Leviäkangas, Kinnunen, & Kess, 2014). It is therefore important to expand the business models in order to reduce the price for the consumer and to emphasize the consideration for the environment in order that people accept to pay more to protect the environment right now rather than supporting the economic cost of the climate change tomorrow.

4.2.4. Ecosystem

Mobility today is provided by many individual actors and most of them work together in a linear value chain. But electric mobility requires a more comprehensive cooperation in order to be able to fulfil the key values of electromobility. Therefore, a strong interaction between the stakeholders is needed and can only be solved by a new ecosystem of electromobility (Figure 50). This network includes companies from different industries that are focused on creating joint added value for the

customer. They are mutually dependent, so that market success cannot be guaranteed without this ecosystem. The individual company steps back in favor of companies collaborating within the entire value chain and increases its market share and profit through the generation of added value by all companies. The innovation performance can be increased considerably through common goals (Lingens & Gassmann, 2018; J. F. Moore, 1993).

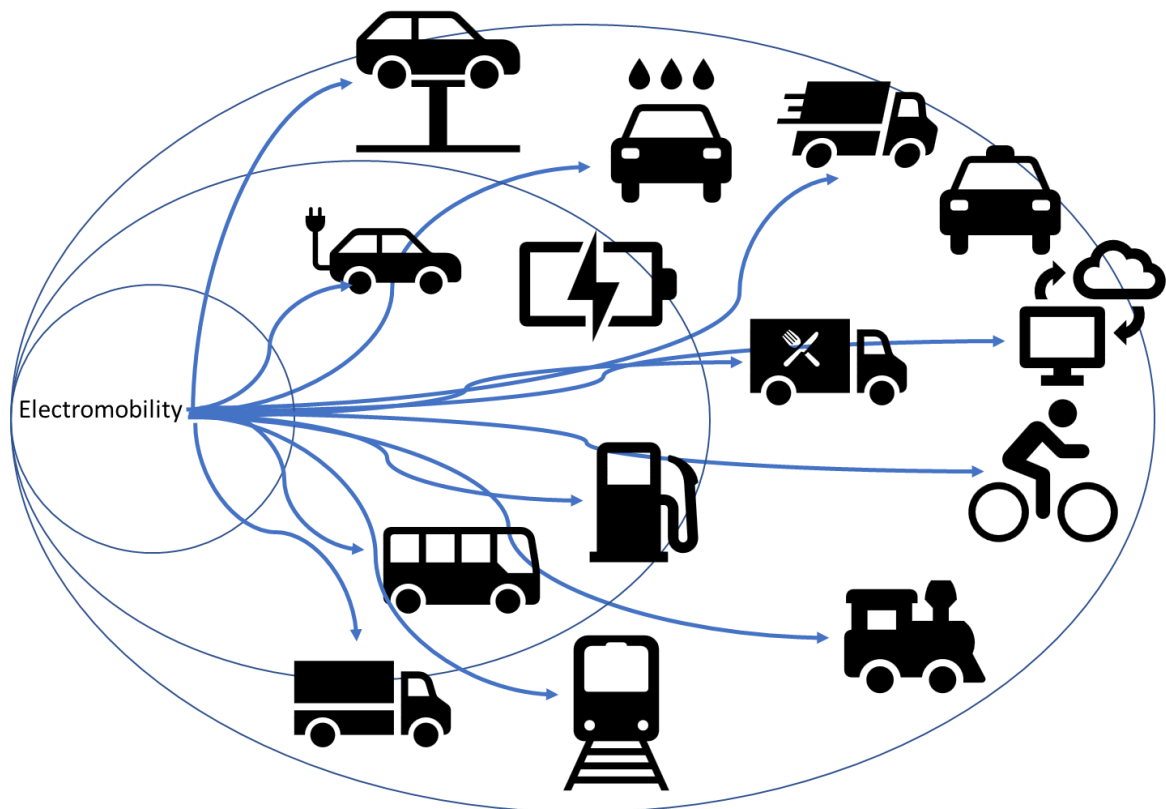


Figure 50: New ecosystem of electromobility includes stakeholders from different industries (own illustration)

Although there are a large number of possible cooperation models, the ecosystem approach has proven successful in industry (Attias & Mira-Bonnardel, 2019, p. 113; Donada & Perez, 2016). It is made up of the environment, stakeholders and their interactions and consists of institutional, cultural, social or economic stakeholders, such as automotive industry, energy suppliers, IT companies, charging infrastructure operators, local and national governments, end users, and complementary services (Fanti et al., 2017).

While there are already cooperations between automotive industry and IT suppliers, other relationships are still new like automotive industry and energy producers and

need more clarification. Several structure models are possible for the charging infrastructure: the necessary construction of charging infrastructure can be carried out by energy suppliers themselves, as they are producers and/or suppliers of electricity. However, it can also be carried out by the legislator, as there exist a strong interest in the implementation of electromobility. Ultimately, car manufacturers are also forced to provide charging infrastructures, otherwise the sales of electric vehicles will fall short of the necessary figures and CO₂ emission levels decided by governments will not be reached.

Depending on products, a higher-level coordinator can take over the management of the ecosystem. This is visible with MaaS. Seamless interoperability requires a close cooperation in the ecosystem, since otherwise a transition cannot be guaranteed due to different applications and systems. This goes far beyond the supplier relationship and cooperation model of today's mobility companies. Value creation becomes a collaborative effort that ideally benefits the focus company and all its stakeholders and corresponds to the approach of a multidirectional value flow (E. R. Freeman, 2010).

However, it is not enough just to change the technology to an environmentally friendly vehicle. Operating BEVs still requires the possibility of unrestricted operation and with sufficient opportunities of charging in various forms. This means that an adequate infrastructure of charging stations is needed, which must also be accessible to a high number of users. The products and services should also be integrated with each other in a useful way. This can only be achieved if companies do not operate singularly on the market, but in an ecosystem. The products and services to satisfy the customers' value proposition must be coordinated with each other, which requires an exchange of data and information. This type of cooperation between companies must first be learned and implemented and may be contrary to today's market situation, where suppliers are competitors rather than common participants in an ecosystem (Figure 51).

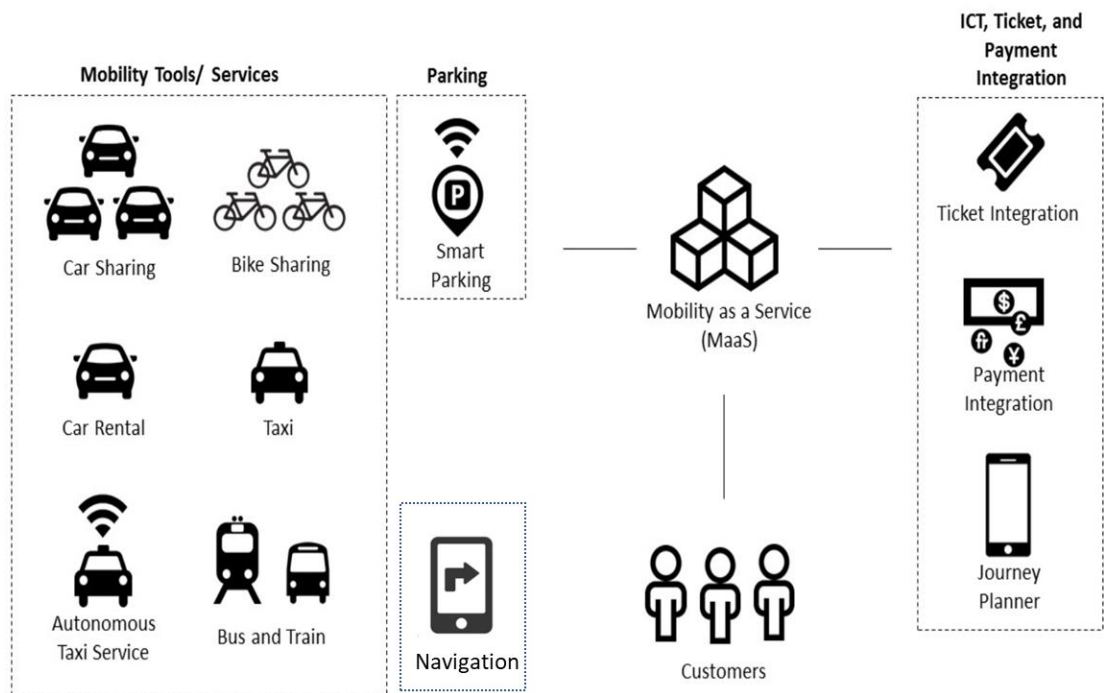


Figure 51: Interoperability connects means of transport of electromobility in different ways (own illustration based on (Guidon & Wicki, 2021))

Responsible for the legislation political actors have a special role as stakeholders, that comes along with electromobility development. Necessary balance must be achieved between competing objectives by responding to the public's desire to reduce air pollution, mitigate climate change and improve social working conditions, while strengthening key industries (Altenburg et al., 2012). The automotive industry is responsible for a significant share of Europe's economic output. However, stricter legislation to reduce CO₂ emissions could lead to a situation where high investments in sustainable products or new business models could reduce competitiveness of companies and endanger jobs or reduce economic well-being of the population. This can be avoided by transparent and forward-looking legislation, which provides a stable basis for corporate strategy. European states announce from which year on the registration of ICE vehicles will no longer be possible. British government is already announcing its phase-out of the ICE vehicles proposing to shorten the deadline already set by five years to 2035 and is even considering reducing it again to 2032. This would even affect hybrid vehicles (BBC, 2020). Also California plans to prohibit ICE vehicles from 2025 (Plumer & Cowan, 2020). To speed up the transformation of electromobility, a joined process can have the best prospects.

4.3. A Synthetic View of the Framework for Sustainable Business Models for Electromobility

Electromobility is a considerable challenge for companies. It can result in new business opportunities, which can have the chance to expand of the existing product portfolio or even to a complete replacement. But the consideration of environmentally friendly and social aspects in development, production and sales can also lead to an increase in costs in the companies and to a lower profit or have an increasing effect on the price of the products. It is up to them to assess what prospects they derive from it and they have to find a balance between the economic dimension and the environmental and social ones that underpin electromobility.

Based on the core elements of business models which are value proposition, value creation and delivery and value capture, the framework is developed at the level of the whole ecosystem and includes the new dimensions of environment and social in addition to the economic one. They are necessary for the satisfaction and fulfillment of the key values of electromobility and are arranged transversely to value proposition, value creation and delivery and value capture (Figure 52).

The environmental dimension in the field of electromobility could be refined by adding the following sub elements: "conversion of combustion engines vehicles to BEVs", "use of renewable energy" and "avoiding mining of raw materials" that contribute to the value proposition, value creation and delivery and value capture. In value creation and delivery, the changes in vehicle technologies and the extensions of services in mobility will change the value chains and lead to new criteria in the selection of suppliers. And in value capture, there are opportunities for new pricing models.

The social dimension can be further detailed by distinguishing the fair treatment of employees through minimum standards designed to improve human rights and increase working conditions. On the employment side, electromobility can lead to fewer employees being needed to manufacture the products and to changes in job profiles. SBMEM should pay attention to such bad consequences and more generally to enhance quality at work through value proposition, value creation and delivery and value capture. In the economic dimension, two elements that support electromobility can be underlined: „delivering functionality and avoiding ownership” that insists on the fact that the desire for mobility is no longer linked to the sole

vehicle ownership; “seamless interoperability” of electromobility that deals with the integration of transport modes that improves mobility. These features of electromobility change the value proposition as well as the value creation and delivery and the value capture.

A change in the network of stakeholders is also necessary, since only an ecosystem with a transformed value chain can provide the products and services that are essential for a SBMEM. This can be seen in the dependency of electric vehicles to charging stations or the link between green power generation and the transformation of ICT vehicles to BEVs.

All key values of electromobility have a direct relationship to at least one element in the framework. Also, multiple relationships exist since single key values cannot be fulfilled by only one element. For example, the elements “ecosystems” and “seamless interoperability” are needed to achieve the key value “integrated and connected”. This can be illustrated using the MaaS business model, where a cross-service platform for data and customer journey is required to offer customers various transport options with a single offer. This is not feasible for one provider only because, in addition to IT expertise, extensive transportation solutions such as electric vehicles, buses, and trains are needed to work together in an ecosystem. Due to the generic approach of the conceptual framework, it can be used to design different sustainable business models in electromobility, whereby the relationships between the key values of electromobility and the elements of the framework differ.

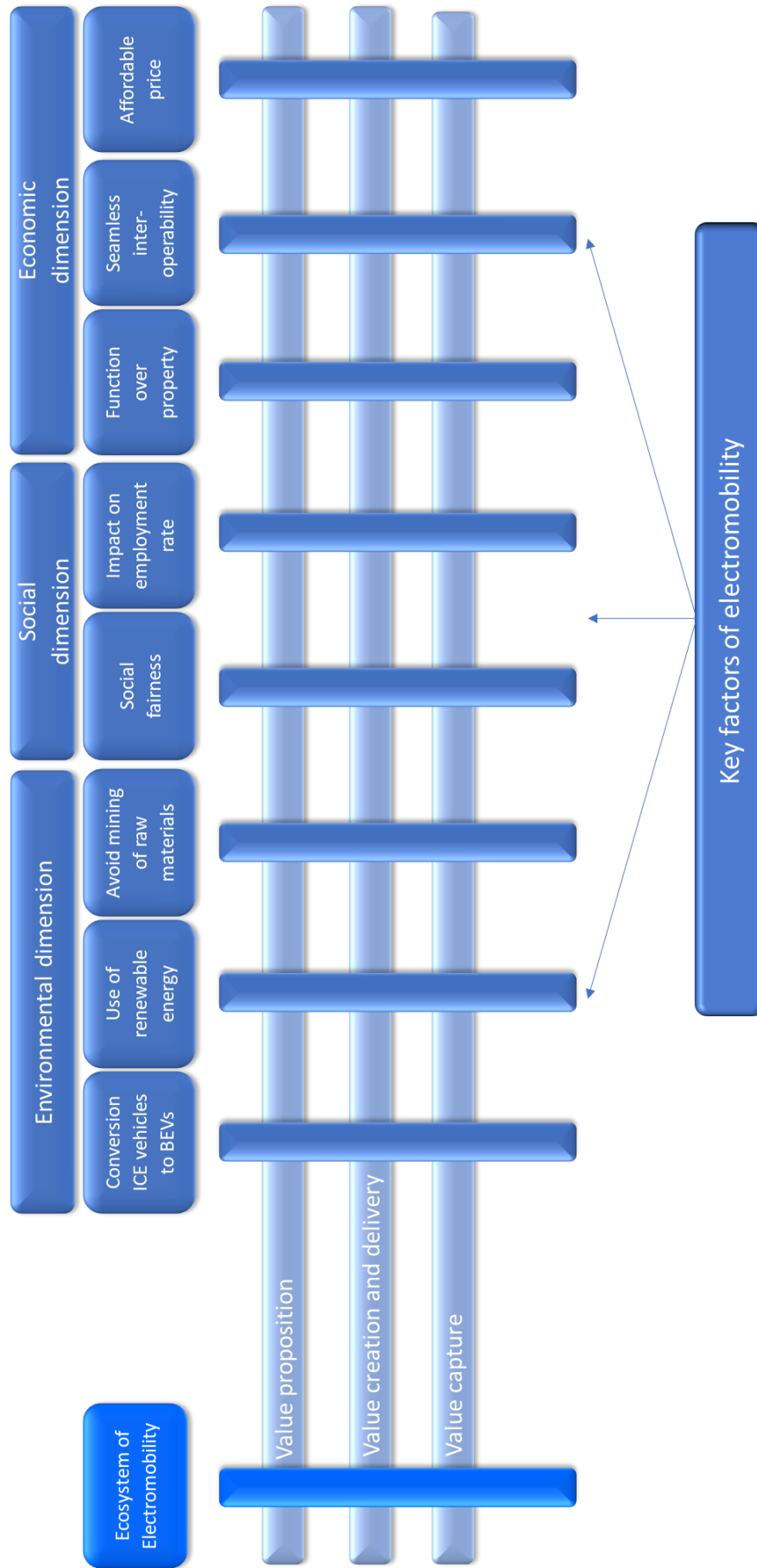


Figure 52: A synthetic view of the framework of SBMEM, with key factors of electromobility (own illustration)

The new framework for sustainable business models for electromobility provides new insights for the research on sustainable business models. It is necessary to enrich elements of business models described in the literature, to add new ones and reorganize the classification of the groups. This expands the approaches of traditional and sustainable business models and gives them a new perspective. This framework insists on the systematic compromise between economic, ecological, and social dimensions of a business model. It shows that the design of SBMEM has to be done at the level of the new ecosystem to be created, in which individual companies cannot be successful in isolation, but rather ensure the satisfaction of the customer's value proposition with a joint value creation and delivery and a sharing of value among stakeholders.

5. Applying the Framework for Sustainable Business Models for Electromobility to Screen Existing Business Models

In chapter 5 of the thesis, existing business models are examined through the lens of the framework of SBMEM. Goal is to analyze which elements of the framework for SBMEM are provided in these business models and which components can be added to get closer to SBMEM to increase attractiveness in the market. In addition, it will be examined whether it is possible and how elements that are missing can be integrated into the existing business model. For this purpose, typical business models from the electromobility ecosystem will be selected.

5.1. Methodology

The method by Bryman (2007) and Yin (2018) is used for the case studies. A case study is a part of the qualitative research method that examines a current phenomenon in detail (Yin, 2018, p. 17). In this approach, the case is considered in its reality in order to test the relevancy and the operability of the framework and to propose possible refinements (Bryman, 1989; Yin, 2018, p. 18).

Electromobility consists of different elements with different emphases. Therefore, case studies were selected that are currently seen as having great potential in the market. Existing business models in electromobility are analyzed through focused research (Denzin & Y.S., 2000, pp. 1–28), using multiple data sources. These are collected from primary and secondary literature review. When the available data are not enough relevant, interviews were carried out with experts from science and industry in order to complete the data.

Business models under study are selected from the ecosystem of interrelated value chains of electromobility (Figure 53).

1. **Charging stations: a crucial dimension of electromobility**

A comprehensive infrastructure with new functions and services is necessary for the successful transformation of electromobility. Without them, implementation would be impossible or very difficult. The infrastructure of charging stations is currently under expansion but is not available in sufficient

numbers. Based on two operators in the field of charging stations, the current business models will be examined through the SBMEM framework.

2. From ICE vehicles to BEV: electrification of transport

The innovations and technologies of electromobility are changing existing products and business models, due to different value propositions, value chains of stakeholders and concern for environmental and social aspects. Electric vehicles are more expensive compared to ICE vehicles and have a shorter range, so existing business models of the automotive industry need to be adapted significantly. Additionally, electric vehicles are a fundamental part in the transformation of electromobility because they do not emit local CO₂.

3. Mobility as a service: beyond BEVs

MaaS is becoming increasingly important due to rising urbanization and customers' demand for sustainable mobility. MaaS goes far beyond existing public transport and uses already vehicles with propulsion batteries in many areas. A comprehensive ecosystem is also needed to meet customer demands.

Recycling and second life for propulsion batteries is also becoming increasingly important because of electromobility. The mining of raw materials has a negative environmental impact and products like batteries should remain as long as possible in the material cycle before recycling which can prevent further mining through reuse.

The generation of electricity and information systems are not examined in the case studies because electricity has already been converted to more environmentally friendly generation for years and for other uses. Also, the creation and maintenance of IT solutions for other products is in place.

5. Applying the Framework for Sustainable Business Models for Electromobility to Screen Existing Business Models

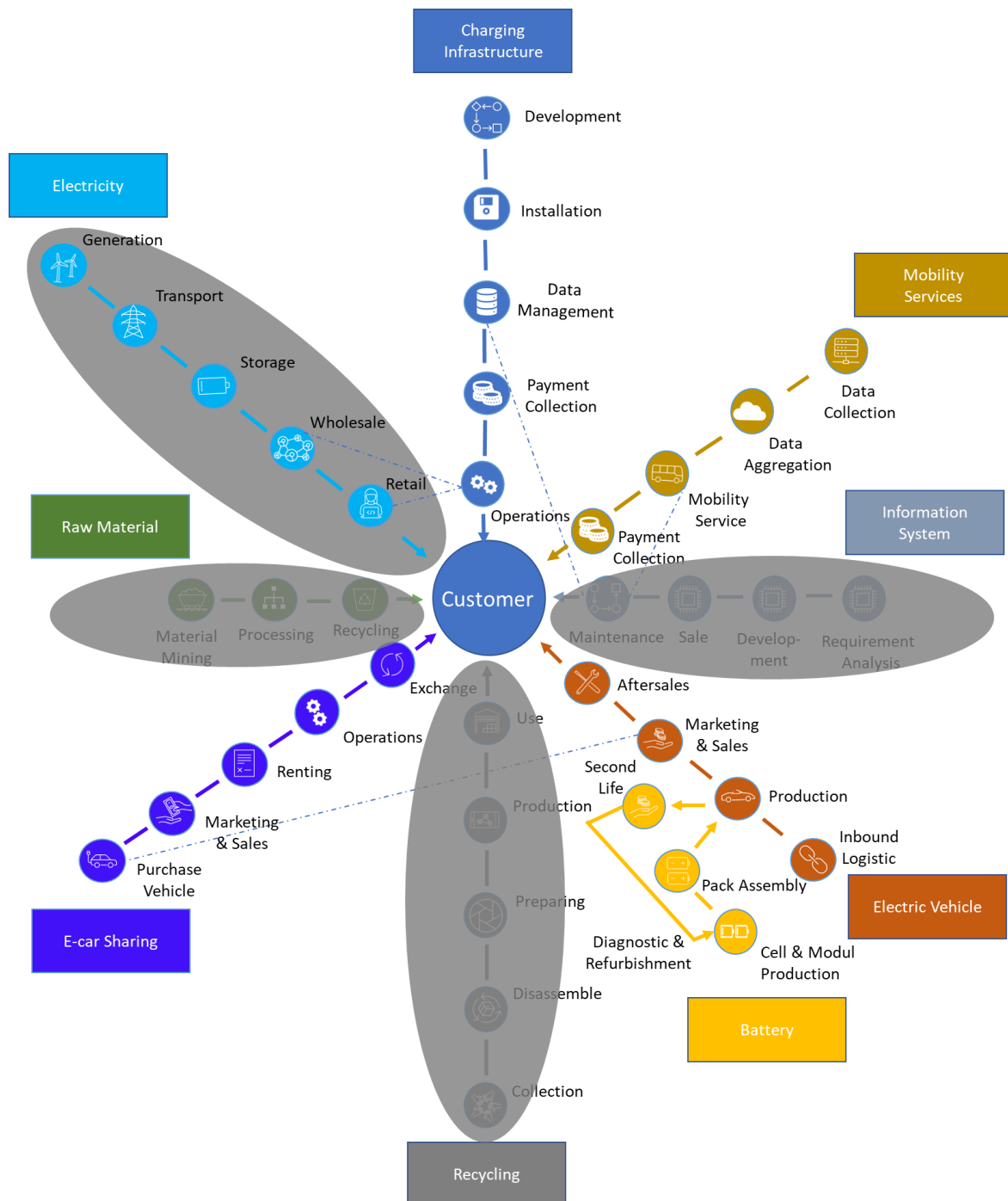


Figure 53: Selected value chains for case studies (own illustration based on (Simpson et al., 2019, pp. 15–17))

Different sources were used for data collection. Peer-reviewed journal articles and conference papers from google scholar und Scopus database are used. The first search was carried out in March 2020 with the keywords “charging station”, “propulsion battery”, “electric vehicle”, “e-car sharing” and “mobility-as-a-service” in German and English to gain the current state of science on the individual topics. It helps to understand the basic elements from the technical side and the position in

5. Applying the Framework for Sustainable Business Models for Electromobility to Screen Existing Business Models

the ecosystem. For the selection and analysis of appropriate companies for the case study at stake further literature was used like institutional reports, company reports, annual reports of companies with balance sheets and profit and loss accounts, corporate communications, book chapter, statistics, public media (reports from public broadcasters, daily newspapers, journals, business, environmental, automotive, mobility magazines) and publications and analyzes from environmental, automotive and mobility associations. Also, semi-structured interviews were conducted for the topics of electric vehicles and e-car sharing. Contact persons were chosen from the business field as well as from the scientific community to obtain a comprehensive perspective²⁴. The interviews were necessary to get internal information which are not available to the public. This form of interview was chosen because it is structured to correspond to the content of the case study but is flexible enough to allow to include the personal perspectives and experiences of the interviewees (Creswell, 2009, pp. 203–224) (Figure 54).

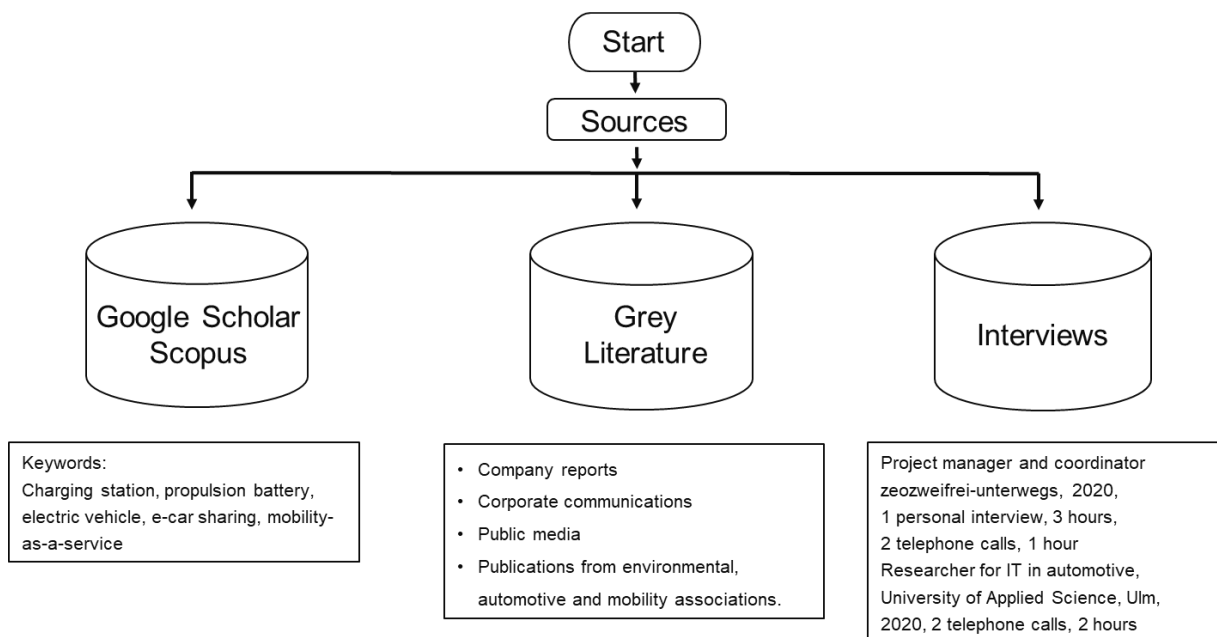


Figure 54: Methodology of case studies (own illustration)

In the first step, the companies are introduced to get a better insight into the company's purpose. In the analysis, elements and differences compared to the SBMEM framework are highlighted and discussed based on key values of

²⁴ Project manager and coordinator zeozweifrei-unterwegs, 2020, 1 personal interview, 3 hours, 2 telephone calls, 1 hour; researcher for IT in automotive, University of Applied Science Neu-Ulm, 2020, 2 telephone calls, 2 hours.

electromobility. Moreover, the findings allows conclusions to be drawn about the framework of SBMEM and are able to identify potential new variables for further research (Bryman, 1989). In the next step, there will be recommendations on the way to make business models more sustainable.

5.2. Charging Stations: Chargepoint and Newmotion

To support the transformation from ICE vehicles to BEVs, the availability of sufficient charging stations appears as a mandatory prerequisite. However, today, there are not enough charging stations and the expansion itself is progressing slowly. But what are the reasons why investors are not investing in the charging station business, even if forecasts for selling BEVs are very positive? One important reason is the business model, which is not lucrative enough for investors. Can a SBMEM be the solution?

5.2.1. Description of Charging Stations

In general, electric vehicles can be charged at any power socket but some technical features must be considered. There are different technical and operational options which can make charging complicated.

The most common solution for charging BEVs is wired charging (conductive), where a cable must be connected from charging station to the BEVs during each charging process. Much more convenient is wireless charging (inductive) were the vehicle is charged via electromagnetic waves (Kley, 2011). However, this innovative technology, which is preferred by users because of its simplicity, still has some technical and economic restrictions. The technology requires an on-board adapter in the vehicle, which is currently still very heavy and therefore reduces driving performance. It is also a cost factor that makes the already expensive BEVs even more expensive. In addition, location of battery in the various models of vehicles is different and not standardized, which can lead to loss of performance during charging. An innovative technology is dynamic charging, where the vehicle is charged while driving. This technology requires a great effort in infrastructure for implementing conductors by the road and have a complex billing system. However,

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it provides electric vehicles with a very long range, regardless of battery capacity (Chen, Liu, & Yin, 2017). In the stationary concept, the charging stations are equipped with inductive charging, but the maximum transferable power is limited. Connections of up to 11.1 kilowatt (kW) are currently possible and are therefore primarily useful for charging at home. In addition, this type of charging is more expensive than the conductive type due to the necessary infrastructure (Schraven, Kley, & Wietschel, 2010).

Different loading technologies (alternating current (AC) and direct current (DC)) influence the duration of the charging process, price and interface between vehicle and charging point (Kley, 2011). AC is mainly done at home (Specht, 2016) with the advantage that the vehicle can be loaded overnight if sufficient time is available. Price per kWh is on average the same as the price at a public AC charging station, but with the advantage that you can charge exactly at your own home (Kurz, 2019). Charging with DC can be significantly more expensive and is normally only available at public high power charging stations (HPC).

Due to user behavior and technical conditions of batteries, private charging and parking areas are due to user behavior and technical conditions of batteries the preferred locations for charging BEVs, because vehicles can stand longer, as illustrated in Figure 55 (Botsford, 2018). For shorter standing time when people are traveling, charging stations are needed at freeways and highways.

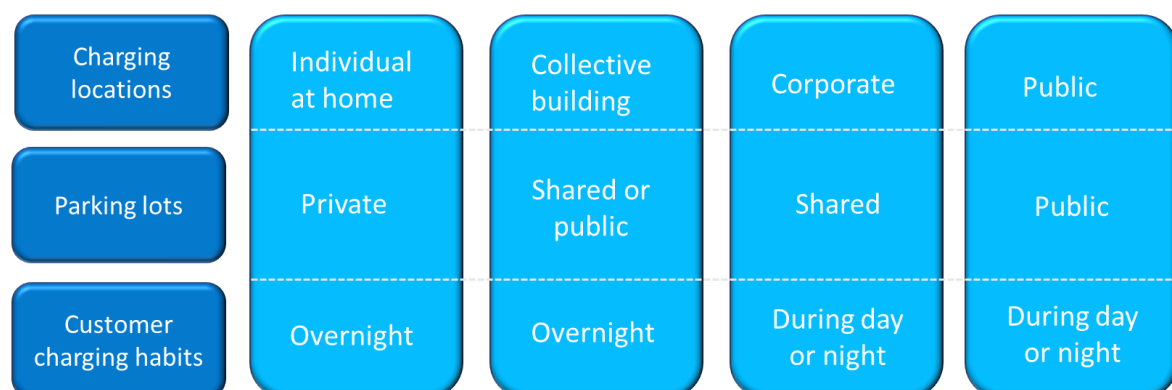


Figure 55: Market segment based on customer's charging location habit (own illustration based on (Capgemini, 2019, p. 11))

There are different variants in technical design of connection between vehicle and charging station plugs. These have been developed based on country versions or manufacturer-specific developments and exist in parallel, which can make handling

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of charging complicated, as they are not or only partially compatible. In addition, the appropriate plugs must be carried along when charging. In Europe there are at least five different types of plugs and two types of charging cable. There are also considerable differences in services and access to charging stations. ICT can be used to significantly improve service quality. Mobile applications for locating charging stations, information about prices, adapters or if the charging station is already used are comfortable services for users.


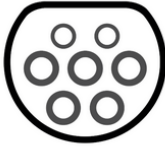
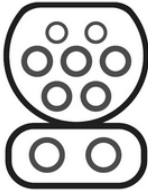

The authorization to use a charging station is also not yet standardized in contrast to refueling. Different electricity service providers have their own authorization regulations and can lead to multiple contracts with service providers to obtain a nationwide network supply of charging stations for drivers. Here, a universal access and billing modality is necessary and sensible.

The most important technical criteria for charging stations are summarized in Table 6:


Table 6: Technical criteria of charging stations

Criteria	Feature
Type of Power Supply (Kley, 2011)	<ul style="list-style-type: none"> • Conductive (wired) charging. • Inductive (wireless) charging.
Loading Technology (Kley, 2011; Specht, 2016)	<ul style="list-style-type: none"> • AC (alternating current) is done mostly at home • DC (direct current) is available at high power stations.
Place of Charging (Botsford, 2018)	<ul style="list-style-type: none"> • Resident charging (charger owns and operates). • workplace charging (BEVs are charged at working place and employer is owner). • public charging (using a publicity available charging station, owned by different companies like OEM, energy companies, public administrations, private enterprises).
Charging Technology (Langer, 2018)	<ul style="list-style-type: none"> • Slow socket (energy quantity up to 3.7 kW). • Normal charging station (up to 22 kW). • High Power Charger (HPC) quick charging station (till 350 kW).
Type of Connection (IEC, 2019)	<ul style="list-style-type: none"> • Mode1: Single-phase or three-phase alternating current up to 16 amperes. • Mode2: Device current up to 32 amps with single-phase and three-phase configuration.

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<p>Type of Connection (IEC, 2019)</p>	<ul style="list-style-type: none"> • Mode 3: Are designed for fast charging up to 250 A. • Mode 4: Fast charging with direct current up to 400 A possible. • Type 1 <p>Single-phase plug with charging capacities up to 7.4 kW (230 V, 32 A). The standard is mainly used in car models from the Asian region and is rather uncommon in Europe, which is the reason why there are hardly any charging stations with permanently attached type 1 charging cables.</p>  • Type 2 <p>The three-phase plug is the most widely used in Europe and has been set as the standard. Charging capacities of up to 22 kW (400 V, 32 A) are common in private homes, while charging capacities of up to 43 kW (400 V, 63 A) are possible at public charging points.</p>  • Combined Charging System (CCS) <p>The CCS connector supplements the type 2 connector with 2 additional power contacts to provide a quick charge function and supports AC and DC charging (alternating current and direct current charging) with up to 170 kW. In practice, the value is more likely to be 50 kW.</p>  • CHAdeMO-Plug <p>This fast-charging system was developed in Japan and allows charging up to 100 kW. However, most public charging stations only have a capacity of 50 kW.</p> 
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<p>Type of Connection (IEC, 2019)</p>	<ul style="list-style-type: none"> • Tesla Supercharger <p>Tesla uses a modified version of the Menakes Type 2 plug for its superchargers, which allow the Model S to be charged up to 80 percent in 30 minutes at a charge power of up to 250 kW.</p> 
<p>Communication (Bonnema et al., 2015)</p>	<p>The location of charging stations, the connection between charging station and vehicle and authentication of the user is carried out via suitable software from the various charging station providers. This requires the membership or the permission to use the charging station before charging.</p>
<p>Type of Billing (Mählmann, Groß, & Breitner, 2012)</p>	<p>Depending on the existing billing model, the purchased energy is paid to the provider free of charge, in advance, without cash or via a subsequent invoice. Particularly with municipalities it is still possible to charge electricity free of charge to increase the acceptance of BEV.</p>

For the expansion of charging stations, a competitive business field with new market entrants, start-ups, municipalities, private-sector companies, energy providers, oil companies, associations of automakers or individual automakers is arising (Bonnema et al., 2015; Foley, Tyther, Calnan, & Ó Gallachóir, 2013). In 2019, the Volkswagen Group founded its own charging station company, Elli Group (Elli stands for "Electric Life") which provides solutions for private and commercial users. The charging offer is not only dedicated towards Volkswagen drivers, but all BEV drivers can use it (Flauger & Witsch, 2019). Furthermore, there are cooperations between OEMs and providers of charging station services. Daimler AG, BMW Group, Volvo Car Corporation and Ford Motor Company have cooperations with providers like Ionity, Chargepoint or Newmotion (Manager-Magazin, 2017). The aim is to increase the penetration of charging stations to support the sales of electric vehicles.

In the field of charging stations, multiple business models exist. These are implemented by players individually or companies use multiple building blocks for an overarching business model. These can be grouped as follows:

1. Designing, producing and selling of charging hardware
2. Operating public charging stations through one's own business, other companies or private users
3. Charging-as-a-service where all charging functions are offered to companies or private users
4. Smart charging offering
5. V2G services

(Capgemini, 2019; Madina, Zamora, & Zabala, 2016).

Charging-as-a-service is a business model, where the service company offers charging stations to operators with full service. Therefore, investment for the operator for buying the hardware is not necessary replaced by a monthly fee. Operators like grocery stores, furniture stores, car dealers or car manufacturers select the location and rent the charging station from the service company. This model can be used to implement customer loyalty programs for operators or for company cars. Charging is free or credited against shopping invoice and the operator presents itself as an innovative company that protects environment and promotes electromobility without having high investments of its own. For car manufacturers, using charging-as-a-service can be used as sales promotion campaigns and customer binding program. Charging-as-a-service can be restricted and adjusted to certain groups of people. Employees can charge for free during business hours, while charging stations are available to public for a fee. It can be a motivation for employees or a way to reduce company's carbon footprint and become climate neutral. Fee from the charging-as-a-service company to the operator includes installing and setting up the charging station according to operator's specifications, as well as managing and controlling access and processing possible payment from the users. Charging stations are monitored by the service company which resolve possible faults via remote maintenance or on-site technicians. Furthermore, reports and analysis of the usage and performance of the charging station are provided to the operator (Lorentzen, Haugneland, Bu, & Hauge, 2017; Tamis, van den Hoed, & Thorsdottir, 2017).

5.2.2. Chargepoint and Newmotion: Successful Providers of Charging Stations

Chargepoint Holding (named Chargepoint) is based in Campbell, California, USA and was founded in 2007 as Coulomb Technologies by a group of entrepreneurs (Chargepoint, 2020b). It operates one of the largest independent charging station networks in Europe and North America with approximately 115,000 places to charge electric vehicles (Witsch, 2020a) and provides charging stations in 14 countries (Plugshare, 2020). The corporate functions include developing and producing charging stations, maintaining, and monitoring them, and creating and operating the app for using the charging station (Chargepoint, 2020a) (Figure 56).



Figure 56: Steps for implementing charging-as-a-service with Chargepoint (Chargepoint, 2016)

Chargepoint's main business model is charging-as-a-service and offering roaming²⁵ (Figure 57). The main revenue source is charging-as-a-service with business-to-business (Chargepoint, 2020a). The contract duration can be chosen between one, two or five years (Chargepoint, 2020a). Also, Chargepoint makes contracts with OEMs and navigation companies to show drivers available charging stations not

²⁵ Roaming is a term, known from the telecommunication sector and means that a charging station can be used from other providers. Payment will be forwarded from own provider to the roaming-partner. It significantly increases the number of available charging stations.

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only in their own app but also in in-car-solutions. The required capital for the business is raised through private investors. Chargepoint has received \$127 million through investors in mid of 2020 (Witsch, 2020b). \$82 million are from the lead investor Daimler AG. It has a revenue of 147 million US-Dollar in 2019 and its forecasted revenue will be more than two billion US-Dollar in 2026. Chargepoint is planning to merge with the U.S. based Switchback Energy through an initial public offering (Klayman, 2020).

ChargePoint Offerings

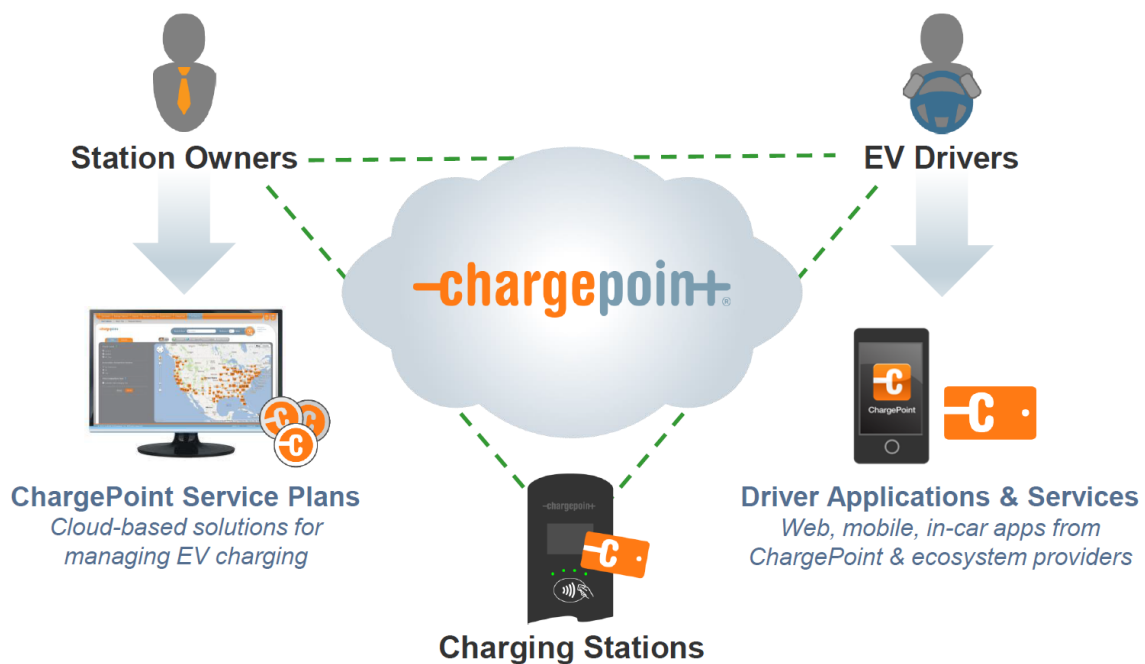


Figure 57: Charging-as-a-service business model offered by Chargepoint (Chargepoint, 2016)

Newmotion B.V. (named Newmotion) is a subsidiary of Royal Dutch Shell plc. which is based in London (United Kingdom). Royal Dutch Shell is an oil company with divisions of production of oil and gas, processing and distribution of mineral oil, transport and marketing of natural gas and electricity (Shell, 2021b). Due to debates of environmental protection and the environmental damage caused by CO₂ emissions, Shell enters the future market of environmentally friendly power generation and operation of charging stations (Shell, 2020). For faster growth, Shell acquired the Dutch charging station provider Newmotion in 2017 (Schaps, 2017).

Newmotion was founded in 2009 and had a portfolio of more than 30,000 charging stations for private homes or business users. In addition, it had further access to

over 50,000 public charging points in 25 countries. Newmotion is now a 100 percent subsidiary of Shell, but continues to operate independently with synergies in products and services (Ermisch, 2019). Newmotion also offers different products to private and commercial users. In the Home Line solution to private customers, different charging hardware is available with different charging power, plugs and connections. The home customer buys the hardware and pays a fee for maintenance, update of software, reporting and controlling of charging. It is also possible to share the charging point with other drivers and Newmotion takes over the billing. In Business Pro and Business Lite, companies can use Newmotion for their own employees, for customers or to sell charging to a wide range of drivers. Here, Newmotion offers a charging-as-a-service model with different additional services like customer management, plug and charge and remote-control-functions (Newmotion, 2018b).

A special feature is the range of metering and calibration-certified charging stations, which enable charging and billing in compliance with calibration regulations. This allows to calculate an exact price for the loaded energy while competitors calculate an interpolation between stand duration and potential loaded energy. Newmotion offers the access to more than 155,000 charging stations in 35 countries which are owned by Newmotion itself and roaming partners. Also, the access to the entire Shell portfolio with fuels and services at service stations, which is interesting for fleet operators with mixed fleets (ICE vehicles, BEVs, hybrids) (Newmotion, 2020a).

5.2.3. Business Modell Analysis of Chargepoint and Newmotion

For this case study, the companies Chargepoint and Newmotion are selected because they are two of the largest public operators of charging stations in the world. Additionally, they have a comprehensive product portfolio and offer their own app for finding, managing, and accounting of charging stations. Furthermore, the charging-as-a-service business model predominantly operated by the two companies appears as the most promising for the future. In the following developments, the sustainability of the business models of Chargepoint and Newmotion will be examined. Therefore, each element of the SBMEM framework is analyzed and evaluated.

In the dimension of value proposition, charging stations provide BEVs with energy in a convenient way and fulfill the key values of electromobility. This means that charging should be possible in different locations and countries, convenient to reach flexible without planning, with a competitive price. The network coverage of Chargepoint and Newmotion has increased significantly due to the expansion of both companies and the introduction of roaming services. Chargepoint and Newmotion provide a different charging portfolio for customized solutions. Depending on the type of clients to whom the operators want to provide energy (employees, customers of one's own business, free drivers), a service package is selected. The charging-as-a-service solution from Chargepoint and Newmotion is very convenient for operators because all activities like management of charging cards, support for the app, billing and reimbursement of electricity costs to operators or customers are managed (ChargePoint, 2016; Newmotion, 2020a). The service can individually be configured and depending on chosen service, operators pay a fee to Chargepoint or Newmotion. Selecting services from a catalogue and a pricelist is very convenient for operators because they do not need special know how or additional people for the management and maintenance. Similar options are offered from Chargepoint and Newmotion for private users and different packages are available where the customer can choose the most suitable ones. In this part of business, Newmotion offers more products and services for the private user than Chargepoint. Also, additional services like the installation of charging station signs to make it easier to find the stations can be ordered and installed in a package and therefore no additional work has to be done.

Although both companies offer easily accessible and convenient services, the number of charging stations in Europe from Chargepoint and Newmotion is still too low. Also, charging BEVs takes longer than refueling an ICE vehicle. Drivers of ICE vehicles are used to fill up their vehicles within a few minutes at a wide variety of service stations in a dense network. This is currently not possible at charging stations from Chargepoint and Newmotion, despite roaming and cooperation between charging station operators. Moreover, this hampers the model implemented in gas stations, which concept is a short stay and additional sales of consumer and nutritional goods. Additional services, like sale of lubricants are also no longer needed at charging stations. Charging stations from Chargepoint and Newmotion are often found in industrial areas that are outside of drivers' daily

routines. This hinders the ability to charge the vehicle without waiting because waiting time cannot be bridged with other activities like shopping. Also, it is not easy to get the current price for the electricity and it is difficult for customers to find the lowest-priced charging station. Chargepoint and Newmotion display the price of electricity in the app, but without guarantee, as only the operator defines the price and is not obliged to update it to Chargepoint or Newmotion. Similarly, access at charging stations does not have to be public and not all drivers can use it. The operator defines which drivers can use the charging station without having to show this at the charging station. A refusal is only apparent if the charging process fails during authorization.

Geographical location of the charging stations must also be taken into consideration in social aspects. While installation of a wall box in a single-family house with parking space is almost straightforward, residents of multi-family houses are dependent on the owner agreeing with. Although there are newer legal regulations in countries to simplify the installation, high costs and potential legal proceedings are necessary. If a suitable parking space is not available, electric drivers will be dependent on public charging stations, which will cause the problem of the last mile. Innovative solutions, such as charging at streetlamps, are currently not planned by Chargepoint or Newmotion and lead to discrimination against large groups of people. Chargepoint and Newmotion support flexible solutions for installation of wall boxes for private or business users which can be used by multiple customers with variable fixings and holders (ChargePoint, 2020b; Newmotion, 2018b) but they make no effort to improve them by influencing public policies and regulations.

Since charging takes more time in electromobility and considering the low number of charging stations, it is necessary and useful for seamless interoperability to find out the location and status in advance. Connector type, charging technology, billing variants, access or duration of stay must be considered before charging. The customer journey should be seamless and without media gaps. All necessary information must be available before selecting a charging station to avoid unnecessary distances and long waiting times. The aim is to be able to select charging stations spontaneously, without planning.

Chargepoint and Newmotion offer different options for seamless interoperability depending on user's option. Drivers can use the app to search for free charging

stations, check the status or start a charging process. If a charging point is occupied, a new one can be selected or the user can use the software to queue up in a sequence. Billing is done via Chargepoint or Newmotion, even if the charging station is from another provider and is integrated into the charging network via roaming (Loewenthal, 2020; Newmotion, 2020b). Chargepoint users have the additional possibility to use third-party apps like Apple CarPlay. When integrated into the in-car system, operation is also possible while driving (ChargePoint, 2020a). However, there are problems with the service with roaming partners and with operators. The latter they determine access and prices themselves and there is no verification for transferred data, this can lead to non-transparent prices or possible refusals to load. Seamless interoperability beyond the charging stations is also insufficient. There is no uninterrupted seamless interoperability with BEVs during purchase or operation. Only offers are made, which have to be activated via systems that are detached from one another. There is no end-to-end connection in the ecosystem with one application.

For operators, functions like charging management are offered, in which networked charging stations always reach full charging capacity by switching off unused charging points (Energy Saving Trust, 2017). With the buzzword 'smart charging', Newmotion enables services for drivers, such as searching and paying at the charging station.

Charging stations are an important enabler for electromobility as low capacity of the batteries forces drivers to charge more often than ICE to refuel and supports the SBMEM framework element conversion of ICE vehicles to BEVs. Therefore, one of the most important prerequisites for acceptance and expansion of electromobility is the number of charging stations (Codani, Petit, & Perez, 2015; Kempton, Perez, & Petit, 2014; Marrero, Perez, Petit, & Ramos-Real, 2015). It leads to a hen and egg dilemma: only few charging stations are needed if the number of BEVs does not increase massively. However, without a sufficient number of charging stations, no incentive is created for buyers of electric vehicles (Donada & Perez, 2016). A goal of both companies is to expand their business and install more charging stations. This increases the process of transformation which enables more environmentally friendly mobility. In 2020, Europcar and Newmotion concluded an agreement on the use of the Newmotion charging network when renting BEVs from Europcar. Europcar itself explicitly emphasizes the will to be more environmentally friendly in

their business (Business_Wire, 2020). Both companies are not aiming to accelerate the transformation but are acting for purely economic reasons to increase the number of charging stations.

The use of renewable energies is an important element of SBMEM, too and fulfill the key values of electromobility. The question of the environmental friendliness of charging infrastructure is primarily answered by the production and delivery of electricity. Charging BEVs with non-green produced electricity does not meet the environment dimension of SBMEM. The use of smart grids²⁶ in conjunction with intelligent charging management can lead to a better balance between the charging stations. This makes it possible to deliver green electricity to charging stations in a prioritized manner and avoid electricity that is not environmentally friendly (Hashmi, Hänninen, & Mäki, 2011). The prerequisite is that users of BEVs, energy suppliers, network operators and in some cases other parties such as billing service providers interact with each other. Newmotion supports the use of environmentally generated electricity. When using Newmotion services, the electricity can be purchased from the parent company Shell, which guarantees 100 percent electricity from renewable energy sources through its subsidiary Shell Energy which is certified by the RenewablePlus quality seal. In addition, investments are made in climate projects and the expansion of renewable energies. Since energy production differs from country to country, Newmotion can guarantee this service only country-specific (Shell-Energy, 2020b, 2020a). Newmotion also supports V2G technology and installed V2G in Amsterdam in 2018. V2G spots were also installed not only in public locations, but also at the private accounting company PricewaterhouseCoopers and a large sports facility (vehicle to office). The returned electricity can flow directly back to the connected companies (Newmotion, 2018a). A weak point for Chargepoint is that electricity is not produced by itself and operators choose electricity providers independently. Only the cooperation to a solar provider which supplies electricity generated by solar energy is possible with Chargepoint (ChargePoint, 2015). V2G installation of Chargepoint are currently in testing and not offered (Energy Saving Trust, 2017, p. 14).

²⁶ Smart Grid technology ensures bidirectional communication between distributed actors and resources in the power supply system (Soroudi & Keane, 2015, p. 1).

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The business model of both companies is based on a linear value chain (as shown in Figure 58) with the elements:

- Development of new models and updating of existing charging stations
- Production
- Sales in different sales channels
- Installation according to customer requirements
- Data Management of customers, cards, locations
- Maintenance and support with roaming and accounting of customer and supplier bills.



Figure 58: Linear value chain of charging stations for Chargepoint and Newmotion (own illustration)

Chargepoint and Newmotion are acting like an integrator and provide the customers with all functions from a single source. Development, design and production of hardware and software are mainly sourced from suppliers. In sales, the companies consider establishing cooperative ventures with electricity providers and use their sales channels. Other strategic cooperations are with car manufacturers, to offer the products directly with car sales (Wilfrid Eckl-Dorna, 2017). In the case of Newmotion, further opportunities arise from the parent company Shell through installation of charging stations at Shell service stations. It is planned that charging stations will also be installed at Shell service stations to test potential concepts (Hagedorn et al., 2019, p. 199).

As for the social concern that is a key value of SBMEM, it is necessary to involve stakeholders in decisions on energy production and not just for purely economic reasons to ensure social fairness and equity. Neither Chargepoint nor Newmotion emphasize social responsibility in their annual reports or in corporate advertising or have CSR clearly anchored in their strategies. Moreover, both are using materials which are mined under poor working conditions.

The influence of the expansion of charging stations to the employment rate is not researched. An increasing amount of charging stations will lead to a rise in the number of jobs in the business of charging stations. However, this development does not displace losses in service stations or jobs in the automotive industry per se, due to the conversion from ICE vehicles to BEVs. So far, service station operators have invested little in the expansion of charging stations in service stations, although governments would like to promote the expansion and even make it mandatory. The background to this is the currently still long-standing times, which would imply a change in the existing filling station concept. The gas station company "Total" has already equipped a small number of service stations with charging stations (Vieweg, 2017) while Shell is one of the first leading service station operators to declare its intention to equip its own service stations with charging stations in larger numbers (Witsch, 2019).

Chargepoint and Newmotion offer high customer benefits only in their comprehensive ecosystem. As service provider, they organize all necessary services and act as mediator for the customer. The task of Chargepoint and Newmotion is to select and manage the necessary suppliers so that all functions run smoothly. This includes agreeing terms and conditions, finalizing contracts, and resolving incidents. As soon as a component fails or is disrupted, this can lead to problems for the customer, for which Chargepoint and Newmotion are responsible. In addition to the operational running of the ecosystem, the systematic expansion along the needs of the customers is also part of the process. Innovations are to be integrated into the ecosystem without disturbing it. Competitive situations between the participants must be considered. Chargepoint's ecosystem includes different companies for paying, software developers, card suppliers and platform designers, as illustrated in Figure 59.

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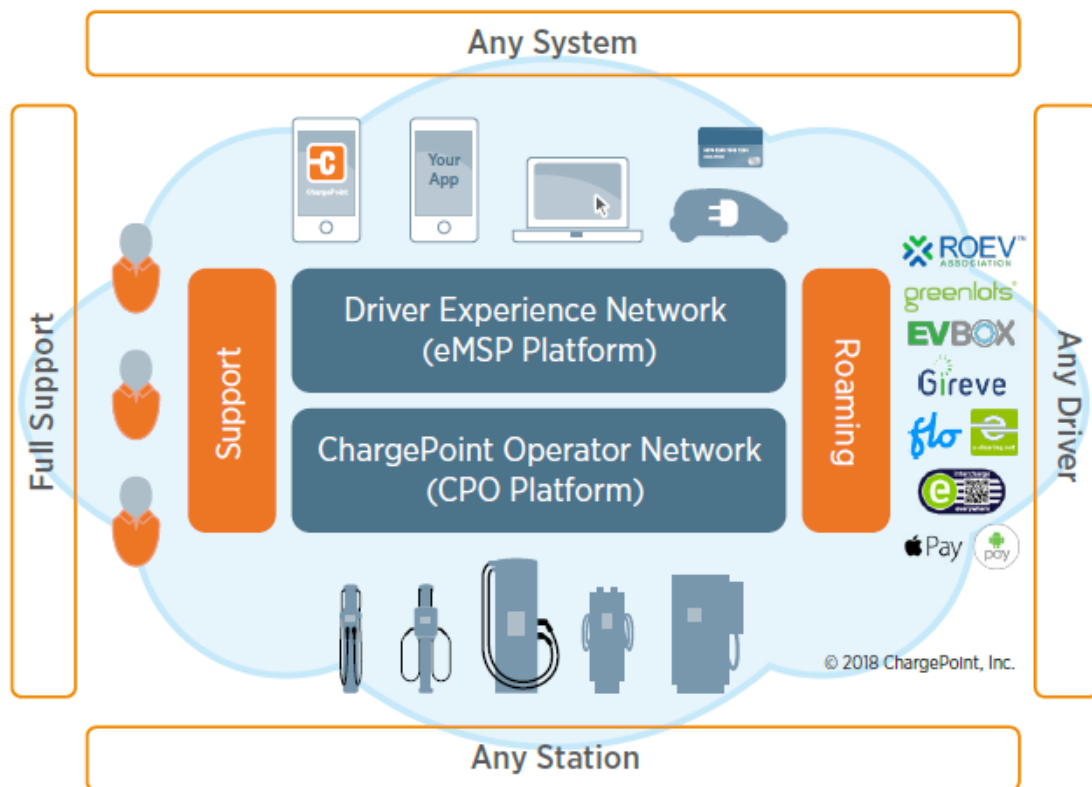


Figure 59: Ecosystem of Chargepoint with functions and suppliers (Chargepoint, 2018)

Chargepoint and Newmotion also use the available data, connected by business. “Personal data is the new oil of the internet and the new currency of the digital world”, according to a statement of the EU Commissioner for Consumer Protection, Melena Kunewa (2009): this describes possibilities of opening up new value creation chances with digitalization. Data such as e-mail addresses and names but especially frequency and locations of the use of charging stations from customers are processed further. A study estimates the total value of data economy in the European Union in 2016 at 300 billion euros with an increase to 740 billion euros in 2020 (Lenzen, 2018). They use the information collected to address people's needs in a targeted manner and enable effective advertising or sales. In addition to basic data, the data from the charging stations are used to draw conclusions about driving and travel habits. In combination with artificial intelligence, large amounts of data are evaluated in a very short time and new trends can be identified.

Chargepoint and Newmotion use different tariff models for the revenue model. It depends on service, location, time, and customer membership. Since the amount of

electricity costs per 100 kilometers should generally not exceed the amount for ICE vehicles (cheaper operating costs are an argument for buying BEVs, which currently have higher purchase prices than ICE vehicles), price is limited in its amount. Therefore, higher prices are not an alternative.

Chargepoint and Newmotion charge for selected services from operators. Customers pay for efforts and costs for development, design, installation, operation and marketing of the charging stations as well as for the management of the overall network. Multi-year contracts with fleet operators secure Chargepoint and Newmotion long-term customer loyalty with regular revenues. Selling hardware and services directly to operators or home-users is another business model of Chargepoint and Newmotion to make profit. This applies the business to customer business where charging stations and services like installation are sold directly to end users. Services like remote maintenance and reports are invoiced separately with minor fees. The third source of income are fees for roaming. Drivers who have a Chargepoint or Newmotion authorization can use charging stations from other suppliers as well. The paid fee contains a handling fee for the charging provider or operator to manage payment from driver to owner and managing the network in apps and networks.

For Chargepoint and Newmotion as a charging-as-a-service company, high investments are required for development, production, installation and operation of charging stations. These are provided by investors (Chargepoint) or in-house financing (Newmotion). A detailed estimate of the revenue that charging stations generate for providers is only possible to a limited extent. Chargepoint's loss in 2019 was \$133 million euros with a target of operating profit of \$86 million euros in 2024 (Schaps, 2017). Profit shall rise in 2026 to \$340 million euros (Klayman, 2020). In 2016, Newmotion made a net loss of 3.9 million euros with a net turnover of 12.9 million euros (Schaps, 2017).

With charging-as-a-service, Chargepoint and Newmotion provide the SBMEM element of "deliver functionality and avoid ownership". The operator does not own the charging station, but leases hardware, maintenance, management and reporting. Only the electricity consumption is paid directly to the energy supplier. But renting is not possible for every product of Chargepoint and Newmotion. When a private wall box is installed, the buyer becomes the owner.

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Another result of the analysis of Chargepoint and Newmotion business models is that not all elements of the framework can be evaluated. The reason for this is that the necessary information is not available (for example, social fairness and equity in the value creation and delivery element). The summary of the framework analysis can be seen in Table 7:

Table 7: Applying SBMEM framework to Chargepoint and Newmotion businesses models

Business Model Element	Dimension of Framework	Main Statements
Value proposition	Environment Convert ICEs to BEVs	<ul style="list-style-type: none"> + Increasing number of charging stations contributes to the acceptance of e-cars and individual mobility (Chargepoint, Newmotion). + Customized solution with less effort for operators (Chargepoint, Newmotion). – Hardware can be more powerful for faster loading (Chargepoint, Newmotion).
	Environment Use of renewable energies	<ul style="list-style-type: none"> + Environmentally friendly electricity generation is supported (Newmotion).
	Environment Avoid mining of raw materials	<ul style="list-style-type: none"> – More activities (second life, recycling) could be initiated to avoid the use of raw materials (Chargepoint, Newmotion).
	Social Social fairness and equity	<ul style="list-style-type: none"> – Full comparable access to public infrastructure is not always given (Chargepoint, Newmotion). – Cities are preferred in installation before countryside (Chargepoint, Newmotion).
	Social Impact on employment rate	<ul style="list-style-type: none"> – More jobs can be created by investing in environmental technology (Chargepoint, Newmotion).
	Economic Function over property	<ul style="list-style-type: none"> + Supports loading of BEVs with many locations so own wall box not needed (Chargepoint, Newmotion).

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Value proposition	Economic Seamless Interoperability	+ Using of digital tools to find and pay charging (Chargepoint, Newmotion).
	Economic Affordable Price	- Price transparency not always given (Chargepoint, Newmotion).
	Ecosystem of Electromobility	- More efficient use of the ecosystem desirable to increase the benefit for the customer (Chargepoint, Newmotion).
Value creation and delivery	Environment Convert ICEs to BEVs	- The selection of suppliers in the supply chain does not take place according to environmental considerations (Chargepoint, Newmotion). - No explicit CSR measures for supply chain (Chargepoint, Newmotion).
	Environment Use of renewable energies	- Promising future technologies like smart charge and V2G can still be expanded (Chargepoint, Newmotion). - Chargepoint supports only cooperations to electricity supplier and can therefore not guarantee for environmentally friendly generated energy.
	Environment Avoid mining of raw materials	± The consumption of raw materials in the supply chain could be further reduced (Chargepoint, Newmotion).
	Social Social fairness and equity	No data available (Chargepoint, Newmotion)
	Social Impact on employment rate	± There are no reliable findings on the elimination of gas stations and the construction of charging stations (Chargepoint, Newmotion).
	Economic Function over property	n/a (not applicable)
	Economic Seamless Interoperability	+ Additional services for seamless interoperability can extend the value chain (Chargepoint, Newmotion).

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Value creation and delivery	Economic Affordable Price	<ul style="list-style-type: none"> - Rooming increases the price of loading (Chargepoint, Newmotion).
	Ecosystem of Electromobility	<ul style="list-style-type: none"> + Different options of value creation are used (Chargepoint, Newmotion). + Offering smart charging services gives a broad variety of points of contacts (Chargepoint, Newmotion). - More availability of Charge-as-a-service for private wall boxes possible (Chargepoint, Newmotion). - Different levels of government support for local charging station operations (Chargepoint, Newmotion).
Value Capture	Environment Convert ICEs to BEVs	<ul style="list-style-type: none"> - More attractive prices can support conversion from ICE to BEVs.
	Environment Use of renewable energies	<ul style="list-style-type: none"> - Using of green electricity can increase price for the customer (Chargepoint, Newmotion).
	Environment Avoid mining of raw materials	<ul style="list-style-type: none"> + Second life and recycling can decrease price for the customer (Chargepoint, Newmotion).
	Social Social fairness and equity	n/a (not applicable)
	Social Impact on employment rate	n/a
	Economic Function over property	<ul style="list-style-type: none"> + Charge-as-a-service supports function and avoid ownership (Chargepoint, Newmotion). - Limited installation and use of private wall boxes if suitable properties are not available (Chargepoint, Newmotion).
	Economic Seamless Interoperability	<ul style="list-style-type: none"> + Supported seamless interoperability (Chargepoint, Newmotion).

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Value Capture	Economic Affordable Price	<ul style="list-style-type: none"> – Loading can be more expensive than refueling with petrol (Chargepoint, Newmotion).
	Ecosystem of Electromobility	<ul style="list-style-type: none"> – Revenue position could increase by higher integration of the ecosystem of the involved companies (Chargepoint, Newmotion). – Cost-covering operations not achieved yet (Chargepoint, Newmotion).

5.2.4. Recommendations to Design a more SBMEM

Some recommendations can be made in order that Chargepoint's and Newmotion's business models become more sustainable. A major criticism of electromobility is the use of electricity generated from coal, gas or nuclear power. To be more sustainable implies to use only electricity generated in an environmentally friendly way. To do so, both providers can make it mandatory to include electricity supply in their charging-as-a-service offer. An intermediate step would be to highlight charging stations with environmentally friendly electricity in the app and to give them priority in route planning for navigation systems. The use of environmentally friendly energy would also make sense for the roaming partners and participating companies could distinguish themselves by offering only green power at all their charging locations.

Additionally, both companies could emphasize the social component of sustainability. By including CSR principles in corporate strategy, this can be implemented and could attract additional buyer groups. The latter would pay attention to human rights and satisfactory working conditions when mining raw materials. Furthermore, rules for compliance in form of equal rights principles and minimum wages would also be helpful. It would satisfy the need of customers not to practice their mobility at the expense of other people's human rights. This is not limited to own production, but human treatment must also be observed throughout the entire supply chain and can help to ensure that the resulting higher prices are better accepted.

Moreover, the installation and use of wall boxes are currently difficult for residents of apartment buildings and tenants. Chargepoint and Newmotion could work through associations to make these regulations much easier, allowing more people to install private wall-boxes. This would encourage sales of BEVs, as currently most of the charging is done at home.

Optimizations in value chain are also necessary to be able to generate a positive return on investment. A major issue is the lack of profitability of Chargepoint and Newmotion. Currently, business models of both companies are not able to provide a positive return on investment. A greater emphasis on sustainability could lead to electric vehicles becoming more environmentally friendly and thus can lead to higher sales. Therefore, more charging stations are needed and the charging station business expands. With higher number of charging stations, it would be possible to reduce costs, dividing fix costs through more charging stations. In addition, it would be possible to apply a higher price for charging itself. It is known that environmentally friendly users are willing to pay a higher price per kilometer for mobility if the environment is better protected. However, in the long term, it will be necessary to generate a profitable return on investment. Since detailed figures and evaluations are not available from either company, a more detailed analysis cannot be made. Nevertheless, it can be observed that they can increase efficiency by optimizing costs in processes and with the ecosystem. The better the processes and business models of the involved partners are aligned, the more cost-effectively the products and services can be generated. Further cooperation with roaming partners leads to an increase in the power network and increases the potential customer base.

Chargepoint and Newmotion partially meet the SBMEM requirements but can be improved. It can be acknowledged that their business models significantly reduce the barrier for the implementation and the further development of electromobility. The successful seamless interoperability motivates drivers to use electric vehicles and contributes avoiding local CO₂. However, a deficit is the missing of more powerful hardware that can shorten charging time so that BEVs can be charged as fast as ICE vehicles need to refuel. The non-transparent prices and billing must also be viewed critically. Additionally, only Chargepoint offers billing according to the calibrated amount of electricity consumed, while at Newmotion the price is calculated by standing times. When charging with roaming, this becomes even more non-transparent for consumers because these charging stations are not fully

integrated in the network. Moreover, further developments in V2G and smart charging are necessary to balance the power fluctuations. Intelligent linking of charging stations with electric vehicles can reduce electricity production that are currently still produced with conventional and environmentally harmful types of power generation, like coal or nuclear. The social component is not explicitly anchored in the corporate strategy of neither Chargepoint nor Newmotion. Social abuses must also be addressed and remedied.

5.3. Propulsion Battery: Panasonic

Electric vehicles are an important component in electromobility, as they enable emission-free driving and reduce local CO₂ pollution. This requires powerful propulsion batteries to store and provide necessary energy (Madhusudan, Agarwal, & Seetharama, 2018). However, the successes in technological development are accompanied by burdens in raw material extraction, energy density, and steadiness (Faria, Moura, Delgado, & De Almeida, 2012). Additionally, the manufacturing process is very energy intensive and expensive (Dehghani-Sanij, Tharumalingam, Dusseault, & Fraser, 2019). This makes the battery the most expensive single component in an electric vehicle (Thielmann, Wietschel, Funke, Grimm, & Hettesheimer, 2020b).

5.3.1. Description of Propulsion Batteries

The battery is a central element in acceptance, economic success and spread of electromobility. While the electric motor is at a high level of development, the battery still has some catching up to do in all technical areas.

Different accumulator technologies are in use in electric vehicles. In addition to tried and tested lead-acid batteries there are nickel-cadmium (NiCd) and nickel-metal-hydride (NiMH) batteries, lead as well as a wide range of lithium-ion (Li-ion) accumulators and newer developments, such as lithium-titanate, lithium-iron-phosphate, lithium-nickel-cobalt-aluminum (NCA), lithium-iron phosphate (LFP), lithium-polymer and lithium-air batteries. The use of batteries depends on the

comparative key figures of the systems. The most important is the **energy density** (kWh/kg or kWh/l). It describes the amount of energy per weight or per volume stored in battery and is an important factor for the weight of the vehicle. The higher the energy density, the lower the weight for the same capacity. The **power density** (W/l per volume or (W/kg mass) indicates how much power can be taken from battery. The **cycle stability** is decisive for the steadiness. Modern batteries guarantee 1.000 to 2.000 charging and discharging processes until the battery capacity is significantly reduced. Closely linked to this is the **lifetime** of battery which should be at least equivalent to the vehicle's lifetime and it should be considered that batteries age. The **self-discharge rate** indicates the loss that the battery has without being used or charged. The lower the percentage, the lower the power loss. This is important when vehicles are not moved or charged, when transporting new vehicles from factory to customer. Another parameter is the **fast-charging time**, which indicates the time in which the battery can be charged. The shorter this time, the faster it can be charged and the shorter the time spent at the charging station. The **price per kilowatt per hour** is the parameter for economic efficiency in order to keep the purchase price of BEVs as low as possible (Chrenko et al., 2013; Komarnicki, Haubrock, & Styczynski, 2018, pp. 1–8; Kurzweil & Dietlmeier, 2015, pp. 255–336; Leuthner, 2018, pp. 13–17; Moeller, 2018, pp. 3–8).

An overview with different battery types can be seen in Table 8.

Table 8: Performance parameters in comparison of battery types (Kurzweil & Dietlmeier, 2015, pp. 157–363; Pistoia, 2018, pp. 9–21)

Performance parameters	Lead	NiCd	NiMH	Li-Ion
Energy density (Wh/kg)	20-45	25-40	55-85	90-160
Power density (W/kg)	100	600	750	1.350
Cycle stability (cycles)	500-1.500	Up to 2.000	300-1.000	>1.000
Self-discharge per month	5 percent (%)	5-20 %	30 %	5-10 %
Fast charging time in hours	8-16	1	2-4	2-4
Costs in Euro/kWh	150	600	750	750-1000

The different technologies have different specifications in terms of power, comfort, safety, environmental compatibility and economic terms (Table 9) and none of the current technologies has best values in all dimensions. The usability of NCA - batteries with a high power density is mitigated by a lower safety rating while the LFP, which is considered safe, has a low power density (Dinger et al., 2020). In addition, considerable improvements in service life and cycle stability are still necessary to be convincing in everyday operation and in the ecological and economic dimension.

Many manufacturers install batteries with a shorter life span of five to seven years with the advantage that these batteries are smaller and lighter. This means that they can be better integrated into existing construction of vehicles and total weight of vehicle is lower than with a larger and more powerful battery. It also reduces the total price of the vehicle or the leasing/rental rate for the battery. The shorter life span can be supported by a battery exchange program. If performance is less than 80 percent, the battery is replaced as part of the maintenance and leasing or rental agreement which completely decouples the life of the vehicle from the life of the battery (Dinger et al., 2020). It should be possible to carry out these tests as easily

as possible without removing the battery, although research results are already available (Schlasza, Ostertag, Chrenko, Kriesten, & Bouquain, 2014).

The currently on the market available BEVs use mainly lithium-ion batteries (Scrosati & Garche, 2010) because of their high energy density (more than 160 Wh/kg), high efficiency, low self-discharge rate and high specific energy (1,800 W/kg). At the same capacity, lithium-ion batteries are about 30 percent smaller and about 50 percent lighter than NiMH batteries. Due to required materials and the complex production process, however, it is expensive and some of the used materials are only available in small quantities on earth (Golembiewski & Sick, 2015; Notter et al., 2010). The current high costs can be reduced through better manufacturing processes and higher volumes (Sullivan & Gaines, 2012). Only the property of losing power at high temperatures and the necessary high safety precautions (Väyrynen & Salminen, 2012) are deficits that still need to be improved. In addition, intensive research is still being conducted on power density and battery capacity. The lithium-ion battery can be recharged at technically different stations (AC / three-phase / DC, power output, normal / fast charging) and at conventional power connections, for example installed at home.

The lithium-ion battery is currently treated as a hazardous material. It requires special handling, special production-technical processes (due to high-voltage properties) with the necessary protective measures and there is still little experience at BEVs in accidents how to extinguish possible battery fires (Weinkopf, Scholz, Mayr, & Hochmuth, 2021).

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Table 9: Selection of power parameters for batteries (Kurzweil & Dietlmeier, 2015, pp. 157–262; Pistoia, 2018, pp. 9–21; Writer, 2019, pp. 1–42)

Dimension	Performance Parameters
Power	Energy density
	Power density
	Lifetime
	Weight
	Capacity
	Energy density
Safety	Cycle stability
	Self-discharge
	Operating temperature
Environmental compatibility	Mining of raw materials
	Environmentally friendly production
	Recyclability
	Operating Effort
Economic efficiency	Investment costs
	Production costs
	Maintenance and operating costs
	Recycling costs

There is considerable research with different materials for the electrodes, electrolytes and battery management system with the aim of increasing performance, durability, environmental compatibility and reducing costs.

The battery is an integral part of BEVs, whereby economic and legal affiliation can be different. The following legal constellations are offered in descending order of frequency (Reuß, 2020; Siethoff, 2019):

1. Car is sold to customer, battery is rented/leased to customer
2. Car is leased/rented to customers, battery is rented to customers
3. Car is sold to customer; battery is sold to the customer (vehicle and battery form a legal unit)

With the "battery-as-a-service" model, the battery is not offered to customer as a product, but the customer pays for the energy performance. The lessor or rental company remains as owner of the battery, maintains the battery via battery management system and can check maintenance condition of the battery. The customer receives the guarantee that if the battery falls below a predefined performance level, it will be replaced. The service provider bears the full risk of damage of the battery. This model contributes significantly to increasing customer acceptance of BEVs, as batteries has a negative image among customers from experience with other battery devices, like mobile phones. For the owner of the vehicle and/or the battery there are further business model possibilities like V2G applications (Tabusse et al., 2021).

5.3.2. Panasonic: A Major Provider of Batteries

Panasonic Corporation is a public traded diversified company with headquarters in Kaoma, Japan. Among its various products, it is one of the leading manufacturers of propulsion batteries for electric vehicles (Yang & Jin, 2019). In 2016 and 2017, Panasonic was the global market leader, selling 14.9 gigawatt hours of lithium-ion cells. A large share went to the American electric car manufacturer Tesla (Manager-Magazin, 2018). In 2011, both companies agreed on a supply agreement for automotive-grade lithium-ion battery cells for the Tesla Model S. The agreement included battery cells to produce 80,000 vehicles in the four following years and a \$30 million investment by Panasonic in Tesla (Panasonic_Corporation, 2011). Based on a long-standing business relationship, both companies agreed on a joint construction of the Tesla Gigafactory in 2015 in Nevada with a \$1.6 billion investment by Panasonic (Ramsey, 2016). This business relationship helped Panasonic to become one of the leading lithium-ion manufacturers for automotive propulsion batteries. Due to problems in battery production and high scrap rate, only 24 GWh of the planned 35 GWh could be produced in 2019 and 54 GWh in 2020. As a result, the jointly further planned expansion of the Gigafactory in Nevada is not being pursued and Tesla is building its own competencies in battery development (Inagaki, 2019). Nevertheless, an extension of the business relationship for another three years between Panasonic and Tesla took place in 2020 (Ajmera, 2020).

Panasonic entered into another cooperation with Toyota in 2019, establishing the joint venture "Prime Planet Energy and Solutions" for the production of propulsion batteries not only for Toyota, but for all automakers (Gardener, 2020). This reduces Panasonic's risk, which it has with its strategic partner Tesla (Eckl-Dorna, 2020).

5.3.3. Business Model Analysis of Panasonic

There are only a few large manufacturers of batteries that supply the automotive industry due to the specific know-how (Yang & Jin, 2019). The three companies Panasonic from Japan (26.9 percent) CATL from China (26,0 percent) and BYD also from China (15.1 percent) have a market share of 68 percent of batteries for electric cars by sales worldwide in the first quarter 2018 (SNE_Research, IEA, & Reuters, 2019). Panasonic Corporation develops high-performance batteries and is the market leader of powerful batteries. For these reasons, Panasonic is examined in the case studies and the business model is examined of sustainability. After that, recommendations for a more sustainable business model are proposed.

Panasonic supports a high value proposition to customers in regard to the key values of electromobility. Already in 2012, the powerful propulsion batteries enable a range of 480 kilometers with the Model S of Tesla. The energy density of the 2170 nickel-cobalt-aluminum battery is expected to increase by 20 percent over the next five years. The battery type is installed in Tesla Model 3, has a high energy density of 700 Wh/L and a range of 580 km based on the standard of Worldwide harmonized Light vehicles Test Procedure (WLTP)²⁷. The battery can be charged at superchargers in 15 minutes for 275 km²⁸ (Tesla, 2021a). The batteries are also reliable and stable and continuous advancements enable the reduction of heavy metals with increasing ranges. Panasonic is researching solid-state batteries that have the potential to meet the increasing demand of growth markets, with faster charging times and absorption of larger amounts of energy (Langenbucher, 2018).

²⁷ WLTP is a measurement method for determining exhaust emissions (pollutant and CO₂ emissions) and fuel/electricity consumption of motor vehicles. The test procedure has been introduced in the European Union since 1 September 2017 and applies to passenger cars and light commercial vehicles.

²⁸ The number of fast charges with direct current is limited by Tesla in order not to reduce the life of the battery (TESLAMAG, 2017).

In its "Panasonic Environment Vision 2050", Panasonic formulates the goal of generating more renewable energy than it consumes in 2050. This is to be achieved through photovoltaic power generation systems, storage batteries and energy solutions in its own production. Further measures are the implementation of circular economy, reduction of water consumption, protection of biotopes and collaborations with suppliers and transport partners for the reduction of CO₂ and increase of recycling rates (Panasonic, 2021).

Provisions that support the goal of avoiding mining of raw materials and utilizing recycling are also anchored in the purchasing conditions. For example, there are further plans to purchase raw materials for the production of batteries directly from the producer in order to have more influence on the avoidance of environmental violations (Hotter, 2019). Panasonic batteries contain a lower amount of cobalt than batteries from other propulsion battery manufacturers. This is only 2.8 percent while 8 percent is common in the industry. The aim is to reduce the cobalt content to zero (Reiche, 2018). On the negative side, Panasonic does not have a second life for batteries or its own recycling program.

Regarding social compliance in mining or transport of raw materials, Panasonic refrains purchasing cobalt from the Democratic Republic of Congo to protect against child labor or armed conflict. Panasonic promotes the elimination of social injustice in mining of raw materials by communicating its own policies to suppliers but avoids conducting audits to monitor compliance and only uses common documentation tools (Panasonic, n.d.).

Panasonic's value chain to produce propulsion batteries includes the steps of raw material preparation, component production, and battery cell production (Figure 60). Further processing into modules and battery packs is handled by Tesla (Linette Lopez, 2019). This sharing of work is also expected to be the basis for the joint venture with Toyota (Gardener, 2020). Materials and equipment costs represent the highest share of costs in the value chain at 70 to 80 percent. Access to low-cost battery raw materials is a key competitive component. Electricity costs account for about 3 percent and labor costs for about 5 to 10 percent of production costs, so manufacturing location has low priority (Thielmann et al., 2020b, pp. 14–15).

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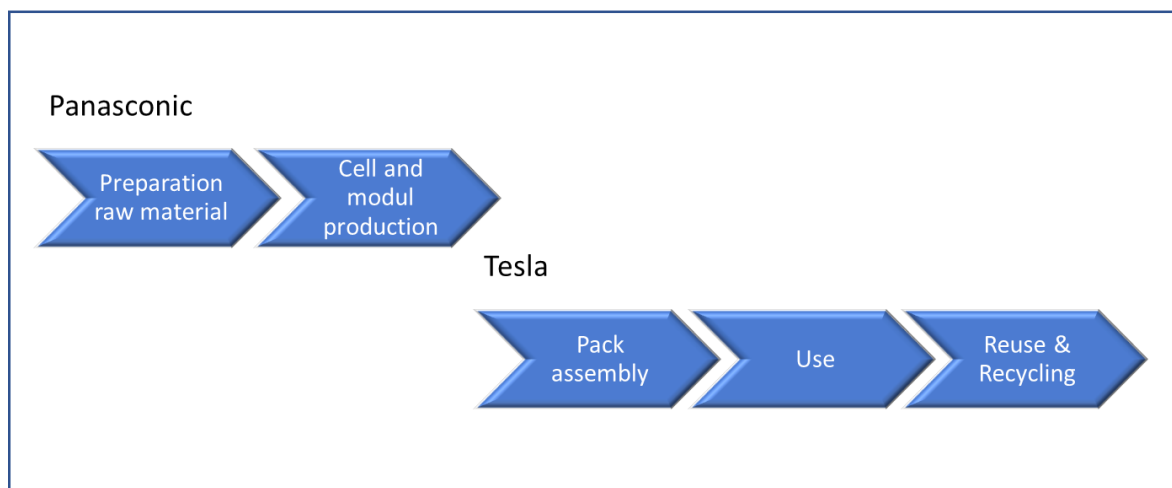


Figure 60: In the Tesla value chain, Panasonic prepares raw material and produces cells and modules (own illustration)

Due to Panasonic's company reporting, it is not possible to obtain detailed figures on value capture for propulsion batteries. However, it is known from the cooperation with Tesla that Panasonic finished a profitable quarter for the first time in 2019 and expects further profits in 2021 (Inagaki, 2020).

Deliver functionality and avoid ownership is not directly supported by Panasonic, as Panasonic is currently only a supplier to OEMs and does not do its own battery leasing or rental.

Regarding seamless interoperability of electromobility, Panasonic develops battery management systems for monitoring propulsion batteries in BEVs. This increases the performance and lifetime of the batteries and enables customers to obtain information about the charge level and the kilometers still to be driven. Depending on the type of cooperation, the battery management system will be supplied by Panasonic or provided by the OEM.

As a diversified company with many products, Panasonic has an extensive ecosystem. The largest collaboration is with Tesla to develop and produce lithium-ion batteries, but Panasonic has also other plants in Dalian, China and Himeji, Japan. Battery cells are made in Japan and manufactured into modules and complete batteries at Tesla Gigafactory in Nevada (Coffin & Horowitz, 2018). The cooperation with Toyota creates additional development opportunities. The summary of the framework analysis can be seen in Table 10:

Table 10: Applying SBMEM framework to Panasonic business model

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Business Model Element	Dimension of Framework	Main Statements
Value proposition	Environment Convert ICEs to BEVs	<ul style="list-style-type: none"> + High power density of lithium-ion battery from Panasonic supports conversion from ICE vehicle to BEVs. + Batteries from Panasonic are reliable and stable. – Production problems by Panasonic and Tesla prevent faster transformation due to shortage of batteries.
	Environment Use of renewable energies	<ul style="list-style-type: none"> + Panasonic’s protection goals to reduce energy are anchored in the company guidelines as a buying incentive for customers.
	Environment Avoid mining of raw materials	<ul style="list-style-type: none"> + Panasonic’s efforts in research lead to reduction of cobalt in batteries.
	Social Social fairness and equity	<ul style="list-style-type: none"> + Panasonic enact guideline for the avoidance of raw materials in context with the Democratic Republic of Congo.
	Social Impact on employment rate	n/a
	Economic Function over property	<ul style="list-style-type: none"> – No own activities in other forms of battery use (leasing, renting).
	Economic Seamless interoperability	Informative battery management system in place
	Economic Affordable price	<ul style="list-style-type: none"> – Batteries are the most expensive part in BEVs.
	Ecosystem of electromobility	<ul style="list-style-type: none"> + Eco-system of Panasonic and Tesla leads to well-matched product for the customers. – Cooperation with eco-system can be extended.
Value creation and delivery	Environment Convert ICEs to BEVs	<ul style="list-style-type: none"> + Environmentally production with Tesla supports transformation to BEVs.

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Value creation and delivery	Environment Use of renewable energies	– No own second life or recycling activities (only via Tesla).
	Environment Avoid mining of raw materials	– No explicit tracking of environmentally friendly extraction of raw materials.
	Social Social fairness and equity	– No explicit tracking of raw material extraction for socially responsible mining.
	Social Impact on employment rate	+ Panasonic is a major employer and creates jobs.
	Economic Function over property	n/a
	Economic Seamless interoperability	n/a
	Economic Affordable price	+ Effective joint venture with Tesla leads to competitive prices for batteries in BEVs.
	Ecosystem of electromobility	+ Stable production of batteries – Close cooperation with Tesla Motors leads to shortage in the value chain of batteries. – Untrained personnel from Panasonic and Tesla lead to production problems and shortage in battery availability.
Value Capture	Environment Convert ICEs to BEVs	+ Panasonic benefits from rising sales of BEVs.
	Environment Use of renewable energies	– Panasonic avoids green power due to higher electricity costs.
	Environment Avoid mining of raw materials	– Panasonic has only a small number of cooperations with suppliers with fair trade agreements.
	Social Social fairness and equity	No data available

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Value Capture	Social Impact on employment rate	No data available
	Economic Function over property	n/a
	Economic Seamless interoperability	n/a
	Economic Affordable price	– Costs of batteries still very high.
	Ecosystem of electromobility	<ul style="list-style-type: none"> + Profit margin achieved for the first time in 2019 with Tesla. – High economic dependence on Tesla. – No revenue due to outsourced second life products and recycling program. – Close relationship with Tesla Motors in value chain may lead to low value revenue for Panasonic. – Panasonic's expansion was linked to a cooperation partner Tesla for a long time.

5.3.4. Recommendations to Design a more SBMEM

Panasonic lithium-ion batteries have a high-power density and are stable in operations which leads to a high value proposition and supports the transfer from ICE vehicles to BEVs. Improvements can be made, however, in the far too low quantities and the high waste. The demand for BEVs and electric batteries exceeds the production figures to a high degree, which leads to delivery problems to customers and to negative customer feedback. This could have been avoided by an early adjusted planning, as the pre-orders of the Tesla Motors Model 3 confirmed the high demand. In addition, it became known that Panasonic was using inadequately trained personnel at Gigafactory 1 in Nevada, resulting in high waste and defect batteries. This can be avoided by trained staff and improved quality controls in the different steps of the production process.

In 2019, Panasonic launched another joint venture with the OEM Toyota, enabling Panasonic to pursue further developments independently of Tesla. Due to the early development stage of battery technology, it is necessary to adopt different concepts, as no technology yet meets all requirements in terms of environmental friendliness, economic efficiency, and safety. The financial participation brought in by Toyota would enable further expansions and a better supply of batteries for the transformation of electromobility.

Panasonic integrates social and environmental aspects into company policy but does not consistently drive and implement them which can improve the SBMEM. For example, suppliers could be required to produce in a more environmentally friendly manner and prevent social injustices. This is particularly important at Panasonic, as they source significant amounts of raw materials for battery production from countries that have a proven record of violating these regulations. Panasonic could use its market power and capital to agree binding mining targets. These include transportation with CO₂ reductions or the use of renewable energies. Avoiding involvement with the Democratic Republic of Congo is not enough to achieve this, as other countries also mine raw materials without considering the environmental and social aspects. Panasonic could also advocate for fairly produced batteries to be labeled with a seal. The initiative, established in 2017, aims to promote environmentally friendly produced propulsion batteries, especially with the growing demand from the automotive industry. This will allow manufacturers to prevent companies from exploiting raw material mining countries without regard to the environmental aspects and social justice (dpa, 2020; Handelsblatt, 2020) and would bring them closer to SBMEM.

Panasonic is currently only involved in second life or recycling of batteries to a very small extent and not according to its own program. The implementation of the reuse of propulsion batteries is currently handled by Tesla which uses batteries in its own Giga Factory. Panasonic could use batteries to further extend and also promote recycling of damaged or no longer efficient batteries. As a battery manufacturer, Panasonic has the know-how about the structure and production technology required for disassembly. In addition, production processes could be applied that enable disassembly into smaller, still functional blocks or that could significantly facilitate recycling.

5.4. Electric Vehicle: Tesla Inc.

The sales figures for electric vehicles have increased considerably in recent years but customers buy more ICE vehicles in percentage and absolute figures than BEVs. OEMs motivation to develop and produce BEVs can be predominantly attributed to pressure of penalties from governments rather than profitable business models. Specially incumbents have problems in transforming their business models that has been successful for many years. However, BEVs are an elementary component in electromobility, as they are very efficient and run without local emissions. If the electricity is used from renewable energy, it is to a high degree climate neutral and provides an important contribution to environmental protection.

5.4.1. Description of Electric Vehicles

The greatest benefit of BEVs is the local CO₂-free emission driving. No environmentally unfriendly fossil fuel is required for operation. BEVs also drive silently and reduce road traffic noise, especially in the city or on through roads where noise is a major problem for population. At least 20 percent of citizens in European states are exposed to harmful noise above 55 decibels in their environment with an increasing tendency due to growing urban populations and growing demand for mobility (Zeit-online, 2020). Electric vehicles can make a significant contribution to noise reduction in urban traffic at low speeds²⁹.

Another great advantage of BEVs over ICE vehicles is the driving performance of the BEVs, especially in urban traffic. Due to not delaying gear changes, maximum torque is reached immediately and is therefore ideal for stop and go traffic. Vehicles with transmissions require medium to high-speed range for optimum torque and therefore consume more energy. The electric engine has an efficiency of up to 90 percent, while conventional drives have a considerably low efficiency of 40 percent

²⁹ From an average speed of over 30 km/h, the tire/road noise of a car with an internal combustion engine predominates (Umwelt-Bundesamt, 2019). However, this effect is mitigated by the EU regulation on pedestrian protection. The Acoustic Vehicle Alerting Systems, regulated by the European Parliament and of the Council No. 540/2014 (Union, 2014), stipulates that electric and hybrid vehicle must emit a warning noise up to a speed of 20 km/h from July 1, 2019, whereby the noise can be defined by the manufacturers themselves. This regulation is intended to help ensure that pedestrians of noiseless electric vehicles are warned by noise, but again increases the basic noise level in cities.

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(diesel engine) or 35 percent (gasoline engine). Depending on the type of drive, other performance parameters also differ, as shown in the following Table 11:

Table 11: Selected performance parameters for ICE vehicles and BEVs (Farwer, 2018; Füßel, 2017; Statista, 2014; Volkswagen, 2015)

Criteria	ICE Vehicle³⁰	BEV³¹
	VW Golf (VII), 1.6 TDI BlueMotion trendline DPF	VW eGolf
Range	1.315 km	130 – 190 km ³²
Reduction of the range in winter	10 percent more of diesel	Up to 50 percent reduction of battery power
Duration of refueling/charging	2 – 3 minutes	30 - 780 minutes Depending on charging power of power source
Maximum speed	200 kilometer per hour (km/h)	140 km/h
Maximum weight	576 kg	440 kg
Lifetime	18 years	8 years (battery lifetime)
Acceleration (0 to 100 km/h)	10,5 seconds	10,4 seconds
CO ₂ emission (100 km)	< 100 g CO ₂	0
Price	Approx. 22.900 euros (2015)	34.900 euros (2014)

The varying performance data are linked to different vehicle concepts. While the ICE vehicles require additional complex units such as a transmission, gear ratio and exhaust system, the electric engines just need only power electronics and a propulsion battery.

³⁰ Reference vehicle is a Volkswagen Golf (VII), 1.6 TDI BlueMotion trendline DPF with an output of 81 kW and a maximum torque of 250 newton meter (Nm) (ADAC, 2013).

As there are only minor differences between diesel and gasoline engines in the properties investigated, only one vehicle type is examined (Füßel, 2017, pp. 15–33).

³¹ Reference vehicle is a Volkswagen eGolf, which has been in production since 2014 with an output of 85 kW and a torque of 270 (ADAC, 2014).

³² In more recent BEVs, the ranges are getting closer to reach the 400 kilometer range (The_Redaction, 2021)

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BEVs can bring further benefits to the driver. For example, in specific countries they can use the bus lane to avoid traffic jams in city centers or they can park in city centers free of charge (Lu, Yao, Jin, & Pan, 2020). The calculation of whether a model with ICE or BEV is more economical depends on several factors. In terms of purchase costs, BEVs are predominantly more expensive than the same model with a conventional engine. However, if government subsidies are considered, the difference is sometimes reduced considerably. In addition, there are discounts given by OEMs to increase sales of electric vehicles to meet the strict EU emission standards. The motor vehicle tax is also subsidized by individual governments and is almost cheaper or free of charge for BEVs compared to ICE vehicles. Also, maintenance costs are lower than for comparable ICE vehicles due to the smaller number of parts and less complicated electric motor. The consumption costs of BEVs depend largely on where the vehicle is charged. Low or sometimes free of charge for the employee or more expensive at home or at quick charging stations on the freeway. However, sample calculations show that electric vehicles are already cheaper on average in a TCO calculation than ICE vehicles (Bollmann, Neuhausen, Stürmer, Andre, & Kluschke, 2017; Redelbach, Propfe, & Friedrich, 2012) as it can be seen in Figure 61.

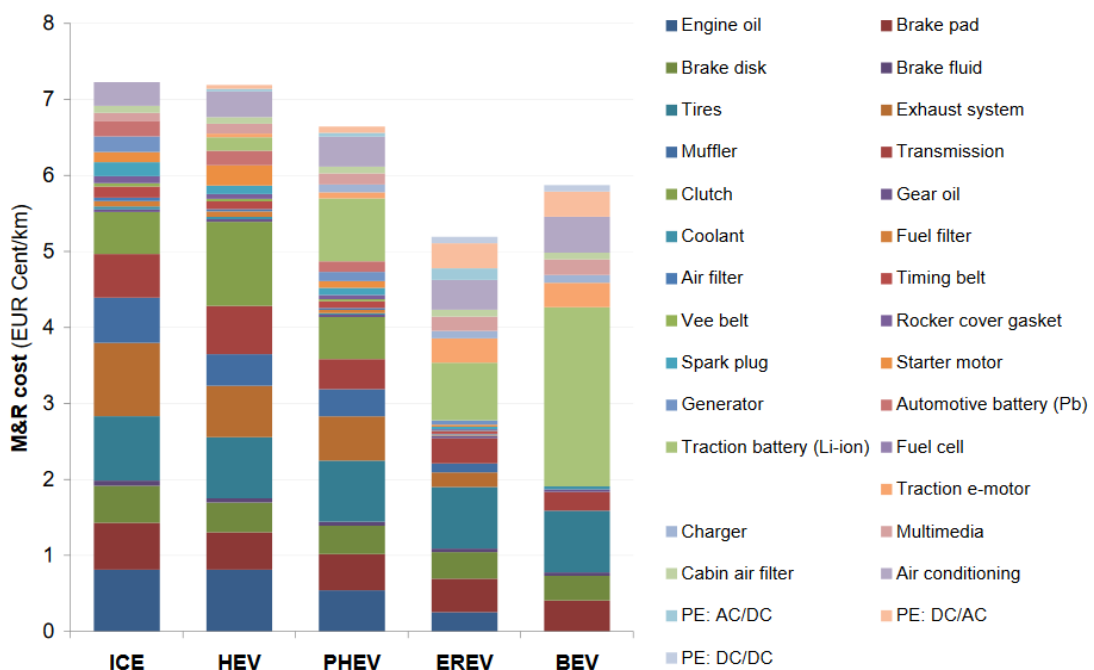


Figure 61: BEVs are in a TCO comparison cheaper than ICE vehicles (Redelbach et al., 2012)

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The growth rates of electric vehicles in the world are indifferent. The number of electric vehicles worldwide has increased from about 5.6 million in 2018 to about 7.9 million in 2019 (Figure 62), but growth has slowed down (Del Regno, 2020) because of recent decreasing registration figures in the two largest sales markets, China and United States of America (USA). The largest market is China with stock that has increased to 3.8 million BEVs since 2014. New registrations of BEVs (incl. commercial vehicles) in 2019 fell by four percent to 1.2 million vehicles, while in USA a decline of ten percent to 324,000 vehicles was recorded (Bratzel, 2020). One of the reasons is the elimination of subsidies, which clearly shows the sensitivity of electric vehicles to subsidies (Del Regno, 2020).

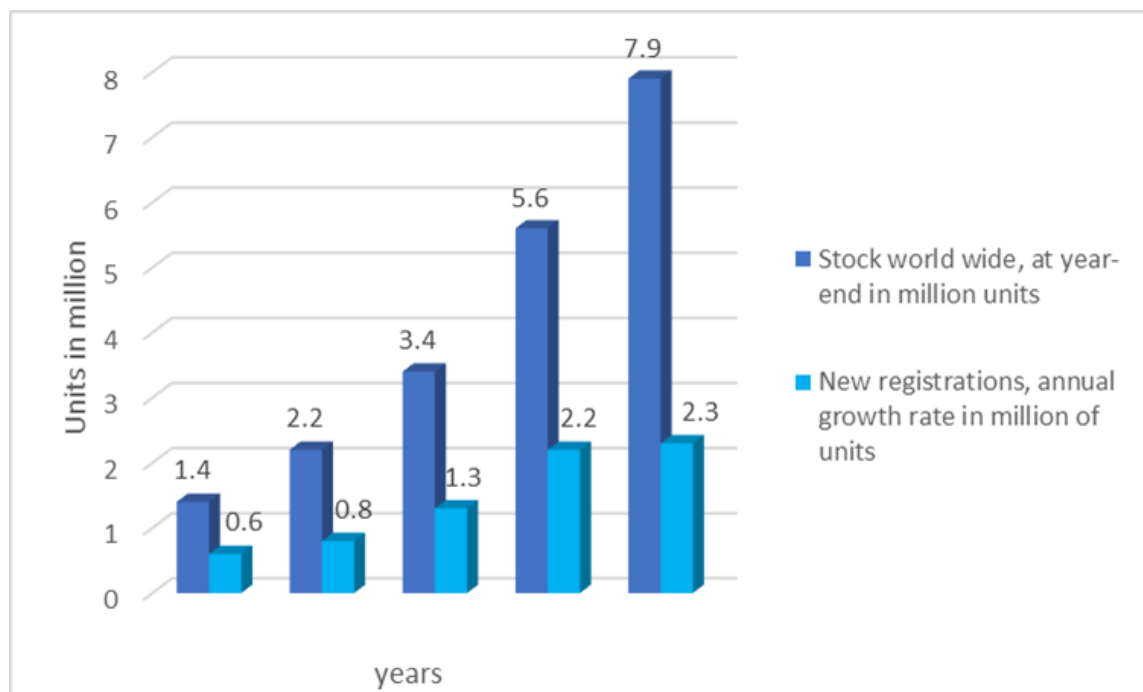


Figure 62: Increasing growth rates of BEVs in the world but growth has slowed down (own illustration based on (Del Regno, 2020))

In Europe, the situation is more differentiated. Depending on the degree of electrification, Germany leads in the absolute number of new registrations in 2019 with 108,839 cars, followed by Norway with 79,640 cars, France (61,356), Great Britain (72,834) and the Netherlands with 72,596 vehicles (all figures contain BEVs and PHVs) (Figure 63).

Subsidies also play a major role because in 24 out of 28 countries, the purchase of electric cars is supported by government. In 12 states a direct premium on the

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purchase price is given. Romania paid the highest amount in 2019, with a premium of 10,000 euros for the purchase of BEVs. France subsidized with up to 8,500 euros, Slovenia with 7,500 euros. Therefore, a direct connection between the subsidy and the registration figures can be observed. Countries that do not fund BEVs have the lowest registration numbers (Estonia, Croatia, Latvia, Poland) (Richarz, 2019). This leads to the conclusion that there is still no suitable and efficient business model for electrically powered vehicles.

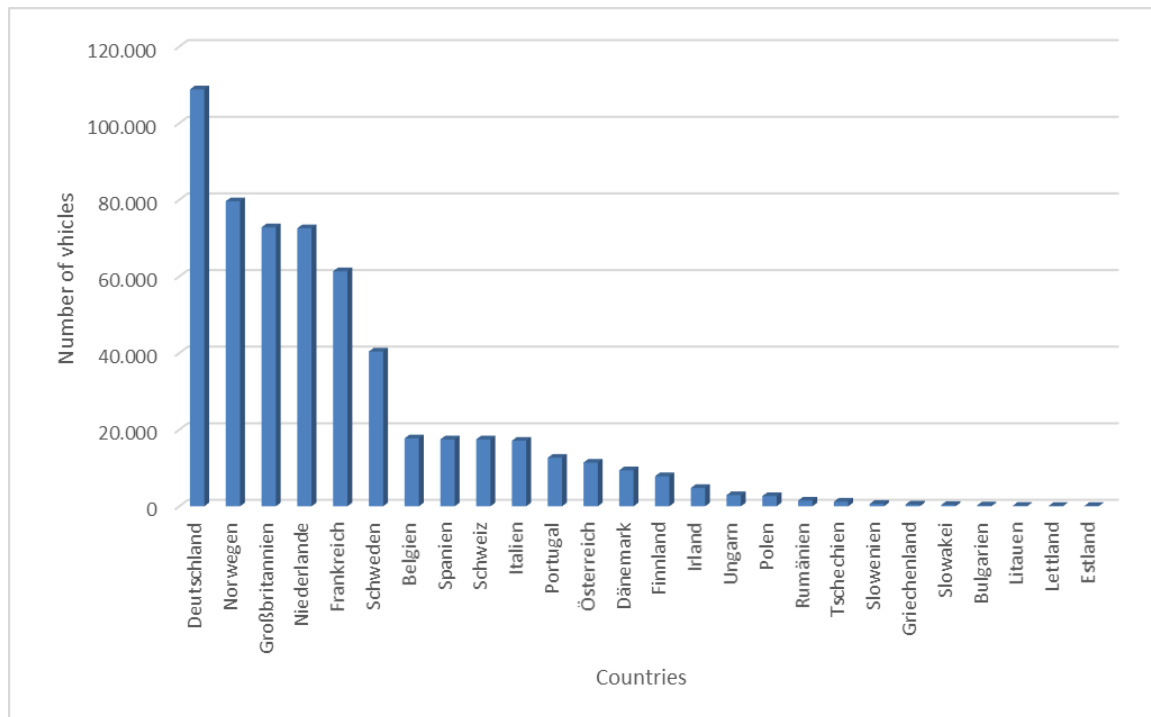
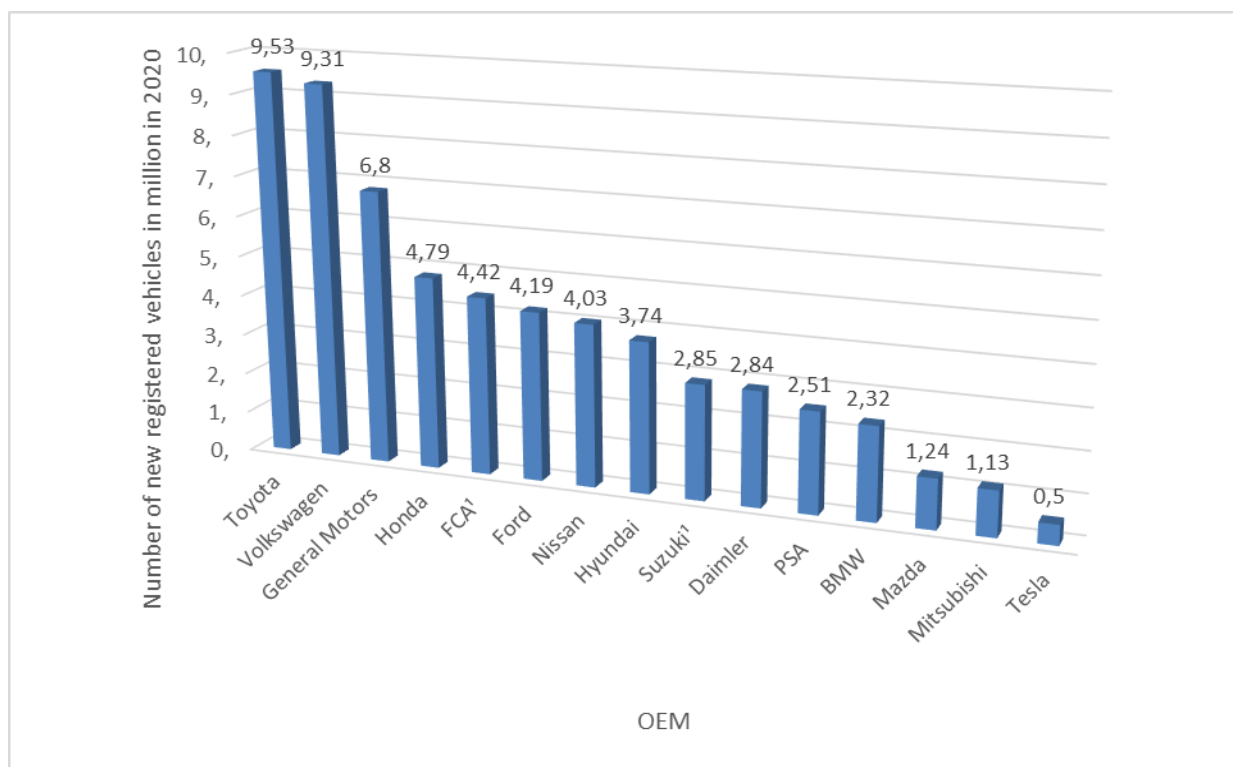


Figure 63: New registrations of BEVs in 2019 in Europe (own illustration based on (ACEA, 2019))

5.4.2. Tesla: A pioneer of Electric Vehicles

Tesla was founded in 2003 by Martin Eberhard and Marc Tarpenning in San Carlos, Silicon Valley, California, USA. Elon Musk and Jeffrey Brin Straubel joined the company later as investors because the founders wanted to build a sportscar with less emissions (Hüfner, 2019). Today, the purpose of the company is the production and sale of electric cars as well as power storages and photovoltaic systems (Greiner, Shermann, Baker, Schmitz, & Tse, 2019) with the goal of "... accelerating the transition to sustainable energy" (Musk, 2013). Tesla's best-known face is Elon

Musk, an American entrepreneur who develops and markets innovative ideas³³. He is Chief Operating Officer and in charge of the supervision of product development, engineering and production of electric vehicles, battery products, and solar roofs of the company. Tesla's famous and most successful product are electric vehicles, which are now produced and sold in several models. Tesla's first car was the Tesla Roadster, which was a high-performance vehicle built in small series. The chassis and body design were sourced from Lotus Cars³⁴ and the cars were also built in the factories of Lotus Cars. In 2009, the first Tesla developed vehicle followed, the Model S, which is a luxurious sports car that overcame the previous disadvantages of electric vehicles with a range of 480 kilometers (according to WLTP). It can be recharged in a short time using Tesla's own Supercharger charging stations. The vehicle had remarkable performance characteristics and accelerated from 0 to 100 km/h in 5.6 seconds. In the same year, Daimler AG invested 50 million euros which was a ten percent stake in Tesla, which provided the company with the necessary investment and technology to continue development and production of BEVs (Greiner et al., 2019). Compared to other OEMs, Tesla has a small market share in vehicles (Figure 64).



³³ PayPal is a company which provides easy and quick money transfer online. SpaceX develops, manufactures, and launches rockets and spacecrafts.

³⁴ Lotus Cars is a sports car automotive company in Hethel, Norwich, Great Britain.

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Figure 64: Comparison of Tesla with other competitors in the year 2020 (own illustration, based on corporate information)

With Model S, Tesla produces a vehicle with the unique selling proposition of electric drive in a market segment where innovation and individuality are highly valued (Bratzel, 2016). In addition, Tesla invested in key elements of the value chain, such as battery factories, to increase his expertise in electromobility and make itself independent of other suppliers with Tesla's own superchargers. With Model 3, Tesla is trying to penetrate the mass market and in a very short time, Tesla has taken a leading position compared to the established manufacturers, although Tesla is struggling with major problems in production and distribution (Eckl-Dorna, 2018).

The success of Tesla's vehicles is primarily based on the performance of the battery by Panasonic. Due to permanent further development, the new 4680 modules of the battery in Model 3 can store five times more energy than the 18650 modules installed in Model S. This is due to the expansion of the round cells and their higher efficiency. The technical advancement reduces the electrical resistance in the power lines and the generation of heat is lower. As a result, the number of round cells per battery and vehicle can be reduced (Knecht, Stegmaier, & Gregor, 2020).

Tesla customers also get a high benefit from technological innovations. Tesla vehicles are the first ones to have an operating system compared to the distributed Can-Bus architecture. It enables Tesla to update the vehicle with wireless over-the-air updates. This eliminates the need for workshop visits, as it is the case with other manufacturers. As a further technical development, Tesla vehicles are operated via a screen for most of the functions. Switches and buttons are no longer needed and gives the vehicles a futuristic and modern design that fits well with the new technology of electric mobility.

Tesla has repeatedly come under criticism for its autopilot, a semi-automatic driver assistant that performs automatic braking, steering and acceleration maneuvers according to traffic situations. The use of Autopilot sometimes results in serious accidents with deaths. Drivers trust Tesla's advertising claims that Autopilot can move the vehicle almost independently and are not paying attention to the traffic. In July 2020, a German court banned the use of the term "autopilot" in advertising because it can be misleading (Laris, 2020; Tagesschau, 2020).

5.4.3. Business Model Analysis of Tesla Inc.

Tesla develops, produces, and sells BEVs and has therefore the opportunity to create innovative business models without being constrained by transformation like incumbents. Its increasing successes shows that its products and business model are competitive. Through its innovative vehicles with a comprehensive ecosystem, it is seen as a pioneer in electric mobility and is therefore selected for the case study.

Tesla has a great technological lead due to its long range and novel vehicle software architecture. However, an innovative product is not enough to be successful if the appropriate business model is not available. When analyzing Tesla's business model, it appears that its products and services generates a high value proposition and satisfies the key values of electromobility. Tesla has the most loyal customers in the automotive industry, with a satisfaction factor of 90 percent and 80 percent of customers say their next vehicle will also be a Tesla (Morgan, 2019). Tesla's purpose is not only to develop and sell cars, but to preserve the environment. This is a great motivation for an increasing number of car buyers, as they no longer want to harm the environment by driving a car. In addition, people have the feeling that they are members of the community of Tesla drivers. Elon Musk, who is considered as a visionary for electric driving, acts as a guiding figure. He can inspire and motivate his employees and stakeholders to continue working and investing for Tesla. He persuades with an ambitious strategy that convinces through innovations. On the other hand, his persona can also make him a liability for Tesla. Tesla missed production and quality targets several times during the ramp-up of the Model 3 which damaged Tesla's reputation as a professional automaker. His public statement on Twitter about the privatization of Tesla was also disputed: "*@elonmusk: Am considering taking Tesla private at \$420. Funding secured*". The Securities and Exchange Commission (SEC)³⁵ proceedings resulted in fines of \$20 million for Tesla and the same amount for Elon Musk. As a result, he has to resign from his position as chairman at Tesla (Sage, 2019; Salinas, 2018).

Tesla focuses in particular on environmentally friendly products. The Model 3, launched in 2016 has brought electric vehicles into the mid-range and is becoming a mass manufacturer (Tesla, 2021b). With access to Tesla's own Superchargers,

³⁵ SEC is an independent federal government regulatory agency and is responsible to protect investors.

improved vehicle quality and more powerful propulsion batteries, the disadvantages compared to ICE vehicles are narrowing in technical terms and increase the conversion from ICE vehicles to BEVs. But high prices compared to ICE vehicle and accidents due to the autopilot or burning batteries reduce the conversion rate.

Tesla recognized early the need for the necessary infrastructure to sell electric vehicles and therefore began to set up its own charging stations worldwide with the delivery of the Model S. As early as 2013, it was possible to cover the distance from Munich to Amsterdam in one day due to the network coverage of Superchargers (Eckl-Dorna & Sorge, 2013). Therefore, only a minimum of planning is necessary and supports individual mobility. The number of charging stations has grown to 2,181 Supercharger stations in 2020. In Los Angeles, 56 charging points were implemented and is now the largest fast charging park in the world (Manager-Magazin, 2020).

Tesla's goal is that all Superchargers are able to be powered by environmentally friendly energy. In 2017, Musk (2017) announced in a tweet that *„all Superchargers are being converted to solar/battery power. Over time, almost all will disconnect from the electricity grid“* (Musk, 2017). So, Tesla plans to supply all Superchargers via solar panels or mobile mega packs rather than via the power grid which supports the SBMEM element of use of renewable energy (T3n, 2019).

Tesla fulfills another key value of electromobility with its efforts to protect the environment. Tesla is committed to reduce electricity and water consumption and in 2019, Tesla was able to reduce water consumption by 45 percent to 2.9 cubic meters per vehicle (Tesla Inc., 2020a, p. 17). At the new Gigafactory in Brandenburg, Germany, Elon Musk significantly reduced predicted water consumption after complaints from environmentalists. He radically changes the already decided factory concept and water consumption is expected to drop from a planned 3.3 million cubic meters to 1.4 million cubic meters (Freitag & Rest, 2021).

Moreover, the value chain of Tesla BEVs is different from that of traditional OEMs (Figure 65) and Tesla has no long experience with mass production of vehicles like incumbents. Gigafactories are less equipped with sophisticated supply chain mechanisms such as just-in-time or just-in-sequence and do not place development orders for essential components with suppliers, as traditional OEMs do. This applies to parts, components and vehicle software. Two Gigafactories are in the USA, one

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in China and one is being built in Germany. In inbound logistics, the Gigafactories are not only supplied directly via suppliers, but also via Tesla own large warehouses, which gives a high degree of independence from their upstream suppliers. However, the expansion of production due to high demand for the Model 3 has led to significant problems in Tesla's value chain, resulting in low production output, delivery delays and lost revenues. One bottleneck is the sourcing of raw materials like cobalt for batteries.

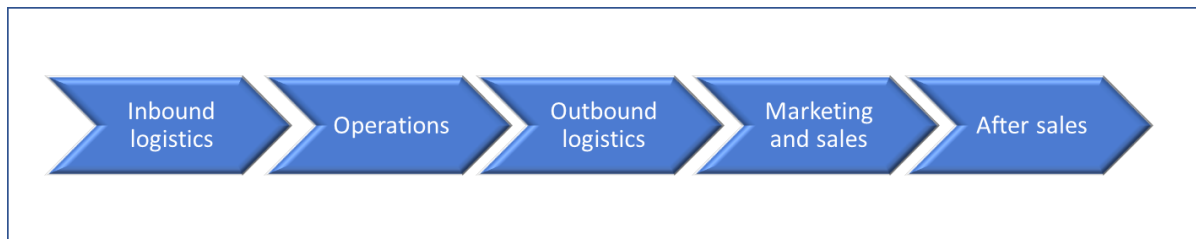


Figure 65: Value chain of Tesla (own illustration)

The main production site is the Gigafactory in Nevada. However, there were significant problems with the launch of Model 3, which is to be produced in far higher numbers than its predecessor, Model S. Due to the high sales figures, the demand of Model 3 is very high, so Tesla had to increase its capacities in a short period of time (Boudette, 2019).

Tesla also differentiates itself from incumbent OEMs in outbound logistics, sales and marketing. Tesla sells its vehicles via direct sales channel without dealers and vehicles are delivered via own stores. Sales take place exclusively online and vehicles can also be returned for a certain time after purchase. This method of selling cars in volume is unique in the auto world and is a model for OEMs to enable and accelerate online sales. Depending on country, financing and leasing can also be handled via Tesla's own financial service company or via cooperating financing institutions (Tesla, 2021b). Tesla also differs in marketing from other car manufacturers and does not use classic advertising budgets, but predominantly uses viral marketing³⁶. Through Elon Musk's direct communication in social media

³⁶ Viral marketing is based on the basic principle of word-of-mouth, which refers primarily to the personal transfer of information from consumers to each other about a company's services and products. The digital messages should spread efficiently and rapidly like a "virus" over modern communication network. The content of the message is of great importance, which must be emotionally appealing or beneficial for both sender and recipient (Kollmann & Esch, 2020)

or via his own events, product news is announced rather than in representative car exhibitions. This emphasizes and promotes Tesla's corporate culture of addressing customers directly in their language. Service is also fundamentally different at Tesla. Vehicles do not have fixed maintenance intervals and do not require an annual visit for servicing and changing fluids. The majority of maintenance is carried out via over-the-air software updates (Tesla, 2020). Tesla loses the lucrative aftersales business but does not have to build and maintain a dealer network.

A special feature of Tesla is that the value chain does not only consist of the electric vehicle, but other products are added. This includes the development and production of propulsion batteries and charging stations. As already mentioned, since 2017, Panasonic has been manufacturing exclusive lithium-ion battery cells for the Tesla battery factory in Nevada as a joint venture partner. Tesla processes the cells to battery packs. Tesla has established supply relationships with Chinese battery maker CATL³⁷ in order to deliver battery cells for its Chinese plant in Singapore (Eckl-Dorna, 2020). Tesla supports another value chain of electromobility by providing charging stations, which in the early years could even be used free of charge by Tesla drivers. However, the fast growth of business leads to problems in service. In Norway, the country with the highest density of electric vehicles, there was already an increased volume of complaints in 2018 due to failed Supercharger stations and poorly accessible support.

Currently, Tesla does not rely significantly on further use of the propulsion batteries in the form of second life, as the cathodes are not sufficiently suitable for most stationary storage requirements (Köllner, 2019; Niese, et al., 2020, S. 13). Therefore, Tesla is pushing recycling to reduce the mining of further raw materials. A separate recycling circuit is planned in which the batteries will be disassembled into its individual parts and rare metals such as cobalt and lithium will be reprocessed for new batteries. The remaining materials such as aluminum, steel or copper will be fed into a general recycling circuit (Tesla Inc., 2020a, pp. 14–15). Tesla normally recycles its batteries, thus reducing the mining of raw materials but there are still gaps where Tesla refuses to take back batteries. In November 2020, the German Federal Environment Agency imposed a fine of 12 million euros on

³⁷ CATL (Contemporary Amperex Technology Co. Limited) is a Chinese battery manufacturer which is specialized in lithium-ion batteries for BEVs and the battery management system.

Tesla for not complying with laws. The decision was motivated by the fact that Tesla refused to take back batteries from electric vehicles at the end of their life cycle for their recycling. Manufacturer must take back the batteries themselves or appoint a disposal partner. This latter case, concerns batteries after accidents where the battery is damaged and requires extensive treatment. The vehicle cannot simply be scrapped, but certified specialist companies must recycle the battery (Spiegel_Mobilität, 2020).

Tesla's corporate policy commits the company to strict requirements for the extraction and processing of raw materials. In addition to complying with legal requirements, suppliers are obligated by contract to extract raw materials in an environmentally friendly manner (Tesla Inc., 2020a, pp. 34–36) and submitted to the Conflict Mineral Policy. This sets comparable standards to the US Conflict Mineral Law³⁸.

As for the social dimension, Tesla forces all suppliers and partners to sign the “Tesla Supplier Code of Conduct”, the “Human Rights” and “Conflict Minerals Policy” to ensure humane mining conditions in the value chain. It must be documented by a corresponding management system (Tesla Inc., 2020a, p. 34). In order to be able to monitor compliance, Tesla has set up a process in which a due diligence procedure is used to check it (Tesla Inc., 2018, p. 3). Tesla also promises its own employees a crisis-proof job with good payment in addition to further training and education. However, there are repeated statements from employees that working conditions are not good due to long working hours with overtime. Especially during the start-up of the Model 3, there were considerable public complaints against Tesla's antisocial behavior, which was even supported by Elon Musk himself. He himself works sometimes up to 120 hours per week, but also demands up to 12 hours per day from his employees in the USA (Carrie Wong, 2018; E. Johnson, 2018). Tesla is also accused of labor law violations in the U.S. in connection with the formation of a union at Tesla. The U.S. National Labor Relations Board classified the dismissal of an employee as illegal (Siddiqui, 2021). By expanding its electric vehicle business, Tesla has become a large employer with increasing employees

³⁸ The section 1502 of US Dodd Frank Act is intended to prevent the mining of raw materials by rebels or militias in violation of human rights and international law (Global_Witness, 2010).

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(Figure 66). The building of the Gigafactory in Brandenburg (Germany) is expected to add another 7000 employees (Riering, 2020).

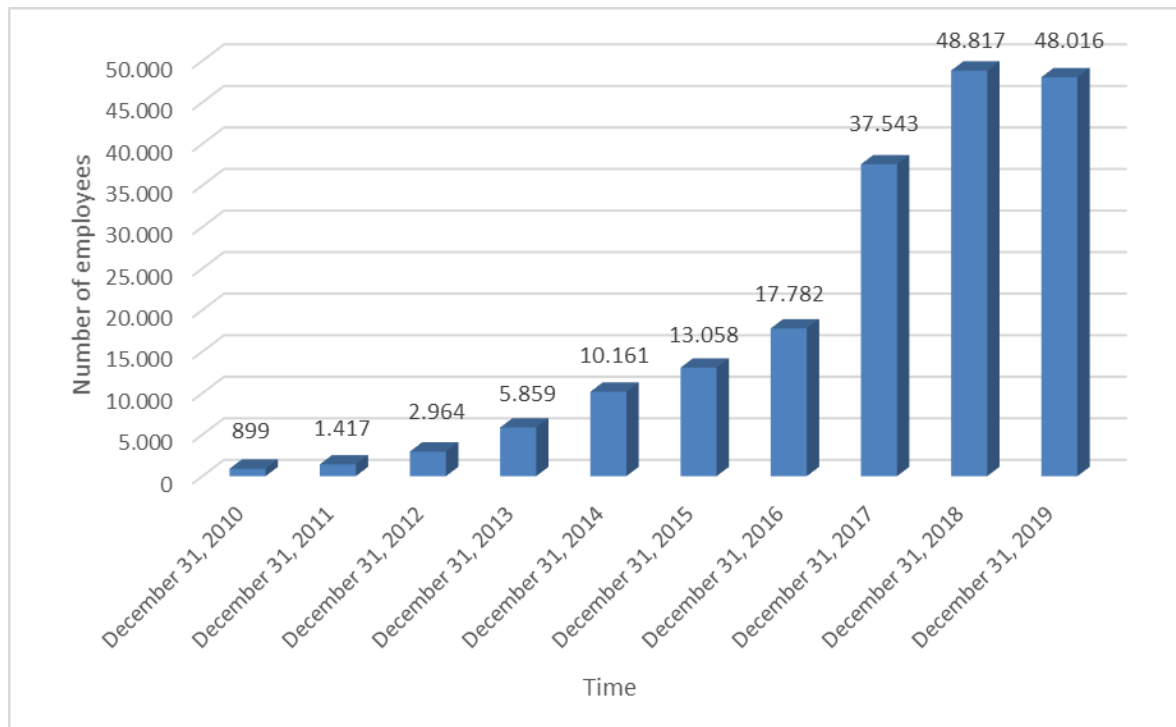


Figure 66: High increase in the number of employees at Tesla due to growing vehicle sales (own illustration based on (Tesla Inc., 2020b))

However, Tesla has considerable difficulties in making profit and earning interest on capital invested and has hardly been able to make any significant profits so far. 17 years after its foundation, Tesla still depends on investors and needs additional capital due to upcoming investments in further production facilities and for R&D, which it cannot generate through its own business activities. Tesla has now been able to report quarterly profit since 2018 (Magazin-Manager, 2020). In the third quarters of 2020, Tesla posted \$809 million operating income³⁹ and a 9.2 percent operating margin. Also, the cash flow Tesla generated over 1.9 billion of free cash flow over the past four quarters (Tesla Inc, 2020, p. 3). However it also includes the revenues that Tesla earns from the sale of U.S. emission rights⁴⁰ to other car manufacturers (Trefis_Team, 2020). These were amounted to \$1.6 billion in 2019 and were the reason for the positive result in 2020 as well (Automobilwoche, 2021).

³⁹ US Generally Accepted Accounting Principles is the generally accepted accounting principles in the USA.

⁴⁰ Emission rights are needed by manufacturers who have too little electrification of their vehicle fleets to avoid penalty payments from government.

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Another high source of income for Tesla is the subsidies, tax breaks and favorable credits from governments and states. In 2009, Tesla was able to acquire former General Motors factories for a favorable purchase price and a concessionary loan. Tesla received tax breaks of \$1.3 billion from the state of Nevada when it decided to locate the Gigafactory in Reno, Nevada, USA. Also, Tesla receives subsidies from the EU for the development of propulsion batteries (Lamparter, 2020; Reuters, 2021a).

Tesla's largest revenue is generated by vehicle sales, followed by energy generation and storage. R&D expenses are low at \$1.343 million (6.45 percent) of total revenue (Tesla_Inc, 2019, p. 21) for electric vehicles. In comparison, Daimler AG spent 8 percent of its revenue on R&D for the passenger car division (ICE vehicles and BEVs) in the same period (Daimler AG, 2019). This shows the technical advantage of Tesla in the field of electromobility.

Tesla's share price is far above the results of the business indicators and makes it one of the most valuable automotive companies in the world (Figure 71).

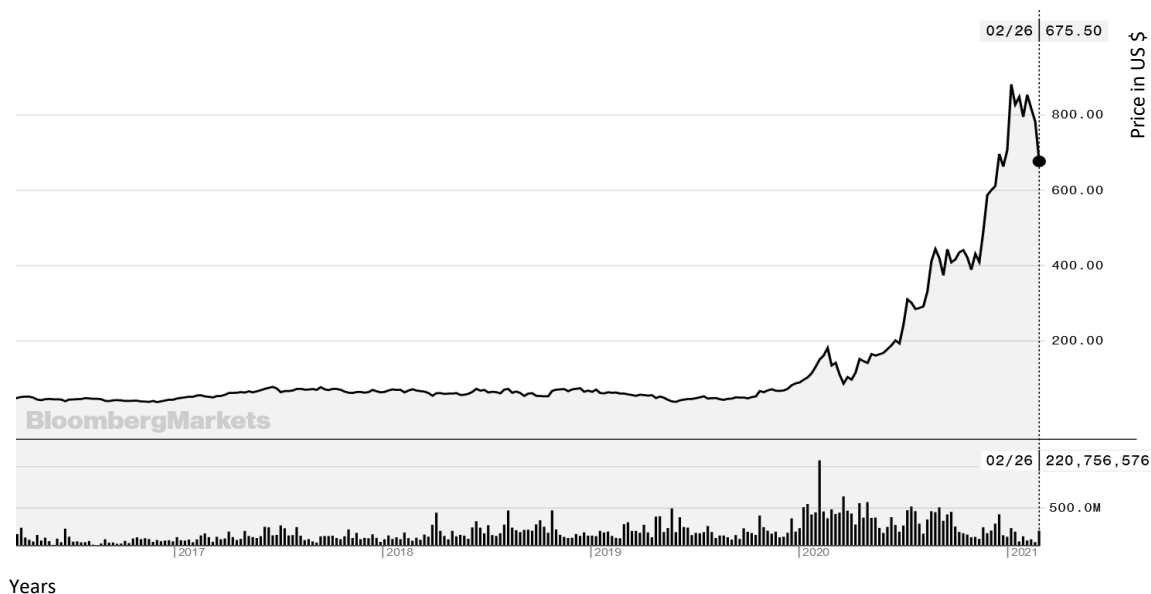


Figure 67: Enormous increase of Tesla market capitalization in the last years (Bloomberg Markets, 2021)

Investment analysts justify this by Tesla's future technology, which is superior to other car manufacturers. However, the share price not only reflects the current

situation of the company, but also the potential in the following years and the stock market follows its own laws.

With its strategy of using Tesla vehicles as robot-taxis when they are not being used by their owners, Tesla comes very close to the "deliver functionality and avoid ownership" element of SBMEM. It is creating its own business model in which car buyers make the investment for the vehicle and get some of it back through cab fees. Tesla assumes a return of 70 to 75 percent per year, which would mean a positive return after just one year. The vehicles are already being equipped with advanced hardware for autonomous driving. The necessary software can be supplied in due course by means of update over-the-air. Even without robot-taxis, Tesla intends to support the use of a vehicle by multiple drivers. For example, a network of private car sharing is to be set up in the USA, where up to five drivers can share a Model 3. To do this, access is granted to another driver via an app and the smartphone serves as the key for opening and driving the vehicle (Stahl, 2020).

One of the reasons for Tesla's successful business model is the seamless interoperability of electromobility. The core of this is Tesla's independently developed and controlled digital user experience of its customers. This starts with customer contact, which primarily takes place via digital media and Tesla manages to maintain permanent customer contact. While conventional OEMs on average lose the vehicle and owner in favor of another garage after four years, Tesla maintains contact via over-the-air update to correct bugs in the vehicle or unlock new features. Integration and connection are one of Tesla's basic rules and support the key values of electromobility. Additionally, Tesla keeps in touch with customers using its own Superchargers. A connection is established every time the vehicle is charged, giving the company the opportunity to contact the customer. Communication with customers is also characterized by transparency and openness. Customers sometimes receive a personal message from Elon Musk which happens during the delivery delay of Model 3. However, this direct approach has also led to customers dissatisfaction, finding it difficult to contact Tesla and receiving no or very delayed feedback. This can quickly leak out through digital communication and can damage Tesla's image (Morgan, 2019).

In Tesla's strategy, the ecosystem is one of the elementary building blocks that have made Tesla's success possible. Tesla identified the obstacles to the success of

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electric vehicles at an early stage and eliminated them with its own ecosystem. Tesla invested a significant amount in the development of high-performance batteries right at the start of its business activities. Tesla also solved the lack of infrastructure. While there were discussions in Europe about which actor should be responsible for the implementation of such an infrastructure, Tesla expanded its own infrastructure and thus enabled uninterrupted driving through its own network. This made Tesla the first electric car manufacturer to sell vehicles with a high charging capacity and a comprehensive network, which made it possible to overlook the high price of the Model S and the low level of optional equipment (Dyer & Furr, 2020). However, the company's own ecosystem hinders innovations that can come from outside and reduces the ability to innovate. The high level of investment in the company's own ecosystem reduces improvements in the supply chain or the possibilities of providing better financial support for the company's own staff. The summary of the framework analysis can be seen in Table 12:

Table 12: Applying SBMEM framework to Tesla Inc. businesses model

Business Model Element	Dimension of Framework	Main Statements
Value proposition	Environment Convert ICEs to BEVs	<ul style="list-style-type: none"> + Tesla transfers the vision of an environmentally friendly vehicle and company to the users. + Various models and technical variants support transfer from ICE vehicles to BEVs. + Tesla's experience world is like a philosophy, which is very attractive for customers to buy a Tesla car. + The charismatic person of Elon Musk. - The great dependence on Elon Musk.
	Environment Use of renewable energies	+ Activities for continuous reduction of electricity consumption during driving.
	Environment Avoid mining of raw materials	+ Low amount of cobalt in batteries.
	Social Social fairness and equity	- Unfavorable working conditions in the plants lead to a negative public image.

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Value proposition	Social Impact on employment rate	+ Tesla is an attractive employer
	Economic Function over property	+ Tesla supports private e-car sharing
	Economic Seamless interoperability	+ Direct sales and high use of viral marketing. + Tesla supports very successful and innovative customer experience and sales channel. – Problems of users to contact Tesla services.
	Economic Affordable price	– Tesla sells cars with a price premium.
	Ecosystem of electromobility	+ Close cooperation on environmental issues with Panasonic leads to a positive image among the population. + Tesla also has environmentally friendly solutions outside the vehicle (solar-powered charging stations, electricity storages).
Value creation and delivery	Environment Convert ICEs to BEVs	+ Tesla's own infrastructure enables use of electric vehicles even over long distances.
	Environment Use of renewable energies	+ Activities for continuous reduction of electricity consumption during production. + Goal to a faster migration to solar power for charging batteries and using renewable energy.
	Environment Avoid mining of raw materials	+ Low amount of cobalt in batteries due to technology. + Tesla forces "Code of Conduct" to suppliers and partners. – Second life usage of batteries can be increased.
	Social Social fairness and equity	– Challenging working conditions with below average wages.
	Social Impact on employment rate	+ Tesla is a major employer and creates additional jobs.

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Value creation and delivery	Economic Function over property	+ Tesla supports e-car sharing
	Economic Seamless interoperability	+ Additional services can increase the depth of added value
	Economic Affordable price	– Tesla products could be more affordable with a more efficient supply chain.
	Ecosystem of electromobility	– Missing parts due to high in-house production quota.
Value Capture	Environment Convert ICEs to BEVs	n/a
	Environment Use of renewable energies	No data available
	Environment Avoid mining of raw materials	<ul style="list-style-type: none"> – Tesla supports no full take-back obligation of batteries. – Tesla plans recycling of batteries but does not have it yet.
	Social Social fairness and equity	No data available
	Social Impact on employment rate	No data available
	Economic Function over property	<ul style="list-style-type: none"> + Tesla plans to introduce self-driving robot taxi service. + E-car sharing within the network of Tesla drivers.
	Economic Seamless interoperability	+ Convenient customer journey makes car shopping easy and an experience.
	Economic Affordable price	+ Price premium increases profitability of Tesla.
	Ecosystem of electromobility	<ul style="list-style-type: none"> + Investor's support and tolerate losses for years. – Low turnover with aftersales and services associated with the vehicle. – Profit for only a few quarters.

5.4.4. Recommendations to Design a more SBMEM

Tesla is a notable company that has taken electric mobility far ahead in the areas of vehicles, charging infrastructures, customer journeys and ecosystems and can continue to play an important role in the future. Tesla is characterized by a high level of innovation. Batteries with a long range, a new operating concept that is not based on switches but on intuitive menu navigation via screen and with software as a basis that can be updated over-the-air are just a few examples. All these contribute to implement a sustainable business model but there are some improvements possible.

One key element is the optimization of production, organization and logistics. Although Tesla wants to establish a high level of automation in its plants, there are still too many manual activities that cause high costs. Also, the ramp-up of Model 3 has shown that the increase in production numbers has pushed the entire production system to its limits. In addition, there were also significant quality issues that Tesla needs to get handled. To do this, expanding the ecosystem is necessary. While Tesla creates a large part of the value chain on its own, adding specialized suppliers could provide cost reductions and improved quality in factories. This would also allow Tesla to scale with further increasing volumes and generate a profit over many years. Also, innovation from suppliers can enhance the Tesla R&D work. In addition, it would be better to switch from make-to-order⁴¹ production to make-to-stock⁴² system. This would significantly increase the flexibility of the entire value chain and Tesla would be able to respond better and more cost-effectively to fluctuations in sales. Furthermore, it would reduce the large capital investment required by Tesla under its current corporate structure.

In the environmental area, Tesla should drive the expansion of second life batteries in addition to battery recycling. While this would require adapting the successful architecture of the propulsion batteries, it could result in a reduction in effort to recycle and keep products longer in the life cycle. As an intermediate step to recycling, this would reduce the environmental impact of mining raw materials,

⁴¹ Make-to-order is a contract manufacturing principle in which products are not manufactured until a specific customer order is received.

⁴² Make-to-stock focusses on production before a concrete customer order is available.

generating electricity and using water. Batteries could be easily integrated into other Tesla products like Powerwall and would support Tesla's own strategy of mobile electricity supply.

About the social components of sustainability, Tesla pays its employees only minimum wages, although the demands on working hours and performance in production facilities are high. Here, Tesla could pay more attention to the well-being of its workforce and reduce working hours and pay an appropriate wage. Although this would mean an increase in costs, it would raise the company's image as an employer. This is important for Tesla, as it attracts its customer to be part of a successful and well doing community. Additionally, the leadership style should be changed to be a role model. Elon Musk requires from employees to behave as he himself does, but this is not appropriate for a company with nearly 50.000 employees in the year 2019 which is no more a start-up company where such behaviors from employees can be observed. A leadership and management culture should be adopted that is appropriate to industry and number of employees. To reduce workload for the employees, a higher automation or an increase in number of employees would lead to higher employee satisfaction, which would be beneficial for Tesla's image. Additionally, more delegation of leadership and technology decision could take the pressure off Elon Musk himself and could increase the speed of implementation. In addition, this could already be used to develop skills of possible successors who could secure the continuation of the company in the case that Elon Musk has to be replaced (due to an accident or death). Elon Musk's behavior and decisions would then no longer be the focus of the company.

In the field of electromobility, Tesla is currently focusing on the electric car and its infrastructure. This cannot be sufficient for individual mobility. For this reason, the existing approaches to holistic electromobility should be expanded further and more strongly. Tesla should not only rely on technological components such as the use of Tesla models as robot-taxis or e-car sharing, but also cooperate with partners in order to further develop electromobility services. Models such as operating at MaaS would be one way of using the company's own ecosystem and expanding it via other stakeholders.

5.5. Mobility Services

The mobility behavior of the population has changed considerably in recent years. The requirement for convenient and sustainable mobility is growing and the desire to own a car is not as strong among younger people (Johansson, 2017). Different means of transport can be used depending on distances, number of people to be transported, availability of transport, price and available time. The offer for mobility services is constantly growing and conventional means of transport, such as public transport, are being supplemented by innovative ones, such as the e-scooter, Uber or ride sharing.

For the review of SBMEM in Mobility Services, e-car sharing and MaaS will be analyzed, as both services have been very popular in recent years and the forecasts predict that they will continue to grow. Also, mobility services support to a great extent the key values of electromobility. Vehicles stand predominantly unused during their life cycle at workplace, at home or in parking lots. With e-car sharing, this time can be shared by several people, which reduces the stock of vehicles and contributes to environmentally friendly transportation due to less produced and used vehicles. In addition, the offer can arouse interest in BEVs and encourage purchase if the trial with e-car sharing has been successful. With e-car sharing, a larger population group is enabled to use electric vehicles for individual mobility without having to pay high purchase costs. The use of MaaS enables the population to avoid owning their own vehicles and still be mobile. Fewer vehicles reduce environmental impact by mining fewer raw materials, local CO₂ consumption, less noise, and the need for dedicated parking space. In addition, the transport medium can be chosen that suit to the type of trip.

5.5.1. E-Car Sharing: zeozweifrei-unterwegs and Autolib

For the case study, one representative each from station-based and free-floating model is selected to analyze and elaborate the different business models. **Zeozweifrei-unterwegs** involves municipalities and fleet vehicles which vehicles were not used outside of business hours and had high idle times. To use the idle time, vehicles can be rented to other users. Due to the high number of vehicles in

fleets and municipalities and the shared usage possibilities, the business model can be considered as a showcase model. **Autolib** as a representative of the free-floating approach is selected because Autolib was one of the pioneers in the free-floating e-car sharing business and had a high own proportion of its value chain. By ending the business operation, many details are known that allow conclusions to be drawn about the business model, which is not always possible for e-car sharing companies that are still in operation. Known representatives like SHARENOW are affiliated companies to OEMs and no dedicated figures are published.

5.5.1.1. Description of E-Car Sharing

E-Car sharing has the potential to environmental friendly and social compliant mobility, as resources are used more than once (Georgi et al., 2019, p 1) and with the used BEVs, the local CO₂ emission will be reduced. E-car sharing is a further development of classic car sharing with BEVs, which has its origin in Switzerland and Germany (Rid, Parzinger, Grausam, & Müller, 2018, p 2). It combines a new mobility technology with the organizational model of car sharing (Fournier, Seign, Goehlic, & Bogenberger, 2015).

E-car sharing has also several variants (Millard-Ball, Murray, Ter Schure, Fox, & Burkhardt, 2005, pp. 2–18), which differ according type of booking, location and payment method, which have impact on sustainability (Münzel, Boon, Frenken, & Vaskelainen, 2018). With **station-dependent** e-car sharing (Figure 68), customers rent a vehicle for a predefined period, pick up and park the car at a specified location.

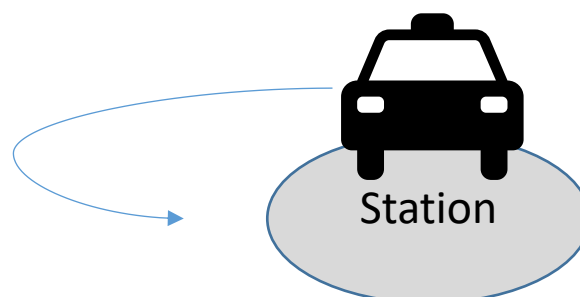


Figure 68: Station-dependent e-car sharing: pick up and return in the same station (own illustration)

The second model is the **free floating** service (Figure 69) which uses the free-floating principle to use the vehicle within a defined area (Firnkorner & Müller, 2011). BEVs are localized and activated via app and billing takes place predominantly every minute or by distance.

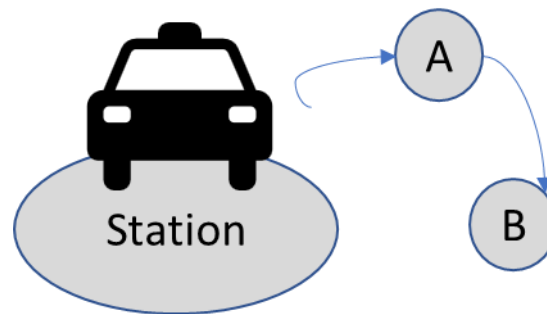


Figure 69: Free floating e-car sharing: vehicles are parked where the last customer placed it (own illustration)

With the third model, **private vehicle owner** makes his own car available to other private users for a fee. Communication between involved parties is made by web platform (Millard-Ball et al., 2005, pp 2-18). Because there are only a limited number of BEVs in countryside, which is the traditional area, this type of car sharing plays a subordinate role.

E-car sharing services are launched to provide the customers more environmentally benefit and to create a value proposition (Fournier et al., 2015). With some providers, the usage fees are reduced by parking and charging at the same time (Firnkorner & Müller, 2011). Especially for drivers who travel not too many kilometers a year, an electric vehicle from e-car-sharing pool can save considerable costs compared to own vehicle (Breitinger, 2014). Existing fear of BEVs, like technological progress of batteries or uncertainty about lifetime (Nazari, Rahimi, & Mohammadian, 2019; Noel, Zarazua de Rubens, Sovacool, & Kester, 2019), can be avoided.

However, if e-car sharing lead to less environmental impact is not clear among scientists and depends on the use of e-vehicles. In case of station-based car sharing models, both positive and negative effects are highlighted in literature (Becker, 2019; Shaheen & Cohen, 2012). Shaheen et al. (2009) show an individual reduction in kilometers driven and Haefeli et al. (2006) a decrease in total CO₂ emissions. The average number of vehicles per household is also reduced (Martin et al. 2010) and Martin et al. (2010) highlight a reduction of the number of car parked and circulating

in cities. This leads to a lower number of vehicles to be produced and contributes to the avoidance of raw materials, energy and waste when scrapping the cars (Firnborn & Müller, 2011). It is also undisputed, as already mentioned, that BEVs lead to lower local CO₂ emission compared to ICE vehicles, reduce noise levels and promote the expansion of infrastructure in the form of charging stations (Stresing, 2015), all dimensions that e-car sharing contributes to strengthen. This also explains why in many cities, e-car sharing services are included in the air pollution control plan and promote the environment (Agapitou, Deftou, Frantzi, Stamatopoulou, & Georgakellos, 2014; Landeshauptstadt München, Kreisverwaltungsreferat, 2019).

E-car sharing can often be found in the metropolitan areas of large, urban and high-density cities, since a high frequency of use for many destinations can be expected there. Peripheral areas are often excluded, even when the density of inhabitants per square kilometer is sometimes even higher there. This puts e-car sharing services in direct competition with local public transport, which is also better developed in city centers than in peripheral areas and has a better environmental balance (Tack, Nefzger, & Stotz, 2021).

5.5.1.2. Zeozweifrei-unterwegs and Autolib: Two Representatives of the e-car sharing business

Zeozweifrei-unterwegs is an e-car sharing provider in rural areas and a joint project of the Regional Economic Development in Bruchsal, the Environment and Energy Agency in Karlsruhe and the energy and water supply company in Bruchsal. The project was created with funding of the European Fond for Regional Development with the system subsidy program of the EU and the state of Baden-Württemberg. Currently 13 cities and municipalities and 14 companies from the Bruchsal area are participating. The goal of the project is to contribute to the implementation of the climate protection concept with new mobility models and to make e-car sharing known in rural areas (F. Schmidt, personal communication, May 11, 2020).

In about 40 stations in the Bruchsal region (Figure 70) it is possible for drivers from the region to rent and use electric vehicles. In doing so, a municipality company uses BEVs, which are normally used as a professional fleet car. During idle hours, in the evenings or weekends, the vehicles are available for e-car sharing.

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Operational management like booking, ICT, customer administration and support are handled by the professional car sharing operator Flinkster⁴³. The zeozweifrei-
unterwegs fleet includes several types of vehicles for different uses. In addition to a compact type with five seats, there are also vehicles with seven seats for larger groups and a van for transport of goods or moving. The vehicles are distributed throughout the Bruchsal district and zeozweifrei-unterwegs is one of the station-based e-car-sharing companies (F. Schmidt, personal communication, May 11, 2020).

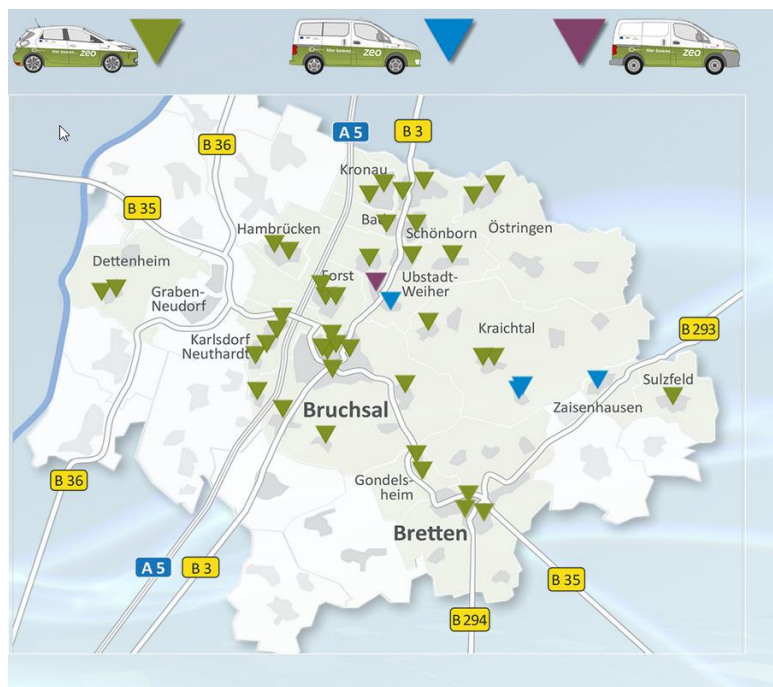


Figure 70: zeozweifrei-unterwegs locations are limited to the area of Bruchsal (Holland-Cunz, 2020a)

Autolib was one of the first e-car sharing pioneers and launched its e-car fleet in Paris in October 2011 (Geron, 2015). On the initiative of the City of Paris, the aim was to reduce environmental pollution and the increasingly dense of passenger traffic in the city with alternative transport options. This could be achieved by expanding public transport, increasing parking fees and using sharing services. The e-car sharing project Autolib was created by the merger of the bike sharing project "Velib", which has been in operation since 2009 and the electric car fleet brought in by the Bolloré Group (Vervaeke & Calabrese, 2015). Starting with 66 BEVs and 33 car rental stations, a vehicle stock of approx. 4,000 BEVs, the "Bluecars" (Figure

⁴³ Flinkster is the car-sharing provider of the German Railway company and was founded 2001.

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71), was reached in 2016, which could be charged at 6,200 own charging stations. It was possible to rent the Bluecars in Paris and in 89 suburbs in the Paris region (Industrial_Innovation_for_Competitiveness, 2016).



Figure 71: Bluecars in Paris at Autolib parking lot with charging stations (McPartland & AFP, 2018)

The vehicles could be rented and returned at 700 parking points within Paris and 700 stations in the surrounding area (Figure 72). It was possible to borrow and return vehicles at different stations. In order to use a vehicle, a one-time registration was necessary, which could be done at 70 subscription kiosks or digital via smartphone or website (Geron, 2015; Huré, 2012; Kouwenhoven, Kroes, Gazave, & Tardivel, 2011).

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Figure 72: Area of Autolib in Paris center and surrounding (Albert, 2014)

Autolib's concept was transferred to other cities under different names, but with different financing concepts. An e-car sharing service opened in Lyon in October 2013 and in Bordeaux in January 2014. It was followed by Indianapolis (USA) in 2015 and Singapore in December 2017. The company has also invested in the electromobility value chain with other services. For example, electric vehicle owners were offered special parking spaces and vehicles from other manufacturers were allowed to charge electricity at Autolib charging stations (Geron, 2015).

5.5.1.3. Business Model Analysis of zeozweifrei-unterwegs und Autolib

The value proposition of the e-car sharing service of zeozweifrei-unterwegs and Autolib is the satisfaction of individual, comfortable and environmentally friendly mobility. With zeozweifrei-unterwegs, a great flexibility is given by the possibility to choose different types of vehicles. Since zeozweifrei-unterwegs is one of the station-based operators, it is necessary to pick up the vehicle at a station and drop it off there. However, the radius of use is unlimited. Using Autolib's e-car sharing fleet

was limited to Paris and the surrounding area because it was an initiative to promote CO₂-free individual mobility in Paris. The vehicles could be rented and parked within the area. For this purpose, dedicated parking lots with charging stations were made available to Autolib. The offer of both companies is lucrative for users due to their own charging station infrastructure which can be used free of charge, as charging is already included in the rental fees. Autolib had a very dense network with 6,200 charging stations and zeozweifrei-unterwegs founded its own charging network "e-laden" for this purpose (Holland-Cunz, 2020b). The advantage for the user of zeozweifrei-unterwegs is that the vehicles are fully charged when they are picked up, since the operator charges and maintains the vehicles when they are returned. Also, the vehicles of zeozweifrei-unterwegs are well maintained by the owner of the company car fleet.

The advantage of e-car sharing is that many people have been granted uncomplicated and inexpensive access to the new technology of electric vehicles, which can have a positive effect on the attractiveness of BEVs and supports the key values of electromobility. The use of zeozweifrei-unterwegs vehicles can support the "deliver functionality and avoid ownership" goal and is especially useful for occasional drives. The purchase of an own vehicle as a second or third car, which is used only slightly, can be avoided.

Seamless interoperability of electromobility is only partially given with zeozweifrei-unterwegs. Registration takes place via a web application at Flinkster and is free of charge for citizens of participating communities. The locations of the zeozweifrei-unterwegs fleet can be viewed via web portal. Before the trip, the desired period must be booked and reduces the element of spontaneity of the key value of electromobility. Changes in rental period must be scheduled via app or by phone. The vehicle is opened using customer cards and keys are located inside the car (Schmidt, 2020). A negative point is that before the first use, it is necessary to appear in person at the municipalities or at citizens' offices where registration data are checked and a customer card is handed over. It is also necessary to return the vehicle to the place where it is rented. This is a disadvantage compared to private location-based e-car sharing operators, where vehicles can also be returned to other outlets of the company. As regards Autolib, it did pioneered work in customer journey and seamless interoperability. It included subscription, reservation, use of the Bluecar, modern on-board computer, client's experience in the car, contact with

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the support and the financial transactions of Autolib. Registration and communication with participants were possible via multi-channel media. For a spontaneous trip, it was even possible to identify oneself with a provisional registration or a weekly Metro ticket. There were 70 subscription kiosks (Figure 73) or access via smartphone and website is also possible. The legitimacy of the subscription was realized via videoconferencing, even from street (Désavie, 2015; Vous, 2016).



Figure 73: Simulation of comfortable subscription kiosk from Autolib (Picture_Allianz_dpa, 2011)

Payment was cashless via credit card and the access authorization to vehicles via RFID (Radio Frequency Identification) badge could be printed out with a special printer, sent by mail, or picked up from a subscription kiosk. The RFID card was used to open the vehicle or start the charging process. Order could be placed via stationary terminals or via web. Vehicles could be reserved for 30 minutes and function to reserve parking places in target area was already integrated. The vehicle had a permanent online connection to the control center, so that drivers known in the system were welcomed by name from a loudspeaker. The radio station that was selected during the last trip was set. This early form of personalization gave the driver the feeling that he was using his own car. If the vehicle left the allowed area of Autolib, the driver was called, because the car was located by GPS as can be seen in Figure 74 (Geron, 2015). Reserved vehicle could be picked up from all

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available rental stations and returned to any free one. The on-board computer of the Bluecar already displayed all necessary information, such as battery charge status or next Autolib parking spaces and appropriate directions.



Figure 74: Professional Autolib control center for monitoring Bluecars (McPartland & AFP, 2018)

The access conditions for registration with *zeozweifrei-unterwegs* correspond to the usual restrictions of e-car sharing operators. Therefore, a valid driver's license for the vehicle class and fitness to drive must be guaranteed. It is not possible to transfer the usage rights to other drivers. However, another driver can use the car if the *zeozweifrei-unterwegs* authorized person is in the vehicle. The use of Autolib was bound to legal requirements such as minimum age of 18, a valid vehicle license and prohibition of alcohol while driving and was therefore non-discriminatory.

Due to the guaranteed use of renewable electricity at charging stations of *zeozweifrei-unterwegs*, the operation of the BEVs is environmentally friendly and contributes to the key values of electromobility. Additionally, the number of charging stations increases, which can also be used by non-*zeozweifrei-unterwegs* drivers. In the case of Autolib, the electricity was obtained from the existing electricity suppliers and special attention to environmentally friendly production of electricity was not present in the project. It can therefore be assumed that this was produced in France and therefore largely with nuclear power which leaves a low carbon footprint but radioactive waste with inherited consequences for future generations. Bluecars and batteries were produced by the Bolloré Group and there is no evidence that any attention was paid to environmentally friendly electricity generation during production.

Data on extraction of raw materials are not available from either zeozweifrei-unterwegs or Autolib. Zeozweifrei-unterwegs uses commercially available models from Renault and Nissan (Holland-Cunz, 2020b) and Autolib used Bluecars produced in-house. It can therefore be assumed that neither company has any notable efforts in this regard, as there are also no project assumptions.

The used vehicles at zeozweifrei-unterwegs belong to the professional fleet operators, so it is their responsibility to give the batteries or vehicles a second life or recycling at the end of life. After Autolib's bankruptcy, the Bluecars were sold via wholesalers to private people, used by other e-car sharing companies of the Bolloré Group or scrapped (Werwitzke, 2018).

Charging at charging stations not owned by zeozweifrei-unterwegs is possible but must be paid by the drivers himself. A negative point of Autolib was that charging stations were often occupied by long-term parkers and continuous charging was therefore not possible. Additionally, there were complaints about the poor condition of the vehicles at Autolib. Some of these were littered, dirty, not loaded or parked in undesignated parking areas. This resulted in an increased expense for repair of the vehicles. Furthermore, Bluecars' own parking areas in highly frequented places were often occupied by other Bluecars and it was not possible for drivers to find an adequate parking space in the difficult traffic situation. Vehicles were therefore parked in more distant locations or in no-parking zones (Local, 2018). A negative aspect of zeozweifrei-unterwegs is the very limited period in which the vehicles can be used. The use as professional fleet car has the highest priority and the vehicles can only be rented at off-peak times such as evenings or weekends. With Autolib, bottlenecks occurred only occasionally due to high number of vehicles and a limited usage area. Moreover, the different regional uses patterns were problematic. In peripheral areas with low usage, vehicles were parked but not driven and had to be returned to the city center by Autolib. This reduced the number of trips per vehicle and increased the costs due to return transport. Another restriction with Autolib was the limited radius in which the vehicles could be moved. Driving outside the zone was prevented by a call from the hotline.

However, free-floating offers must be viewed critically, as they satisfy mobility needs within a small radius (Wilke and Bongard, 2005, Wilke 2009). People can be persuaded to substitute public transport due to convenient use of BEVs from a e-

car fleet (Brünglinghaus, 2013; Stüber, 2019). Autolib's goal of reducing the number of passenger cars in Paris could not be substantiated, although there is some evidence of a reduction of vehicles (Hildermeier, 2013; Sommer et al., 2016). Just as other car sharing projects, a cannibalization effect has occurred with public transport or pedestrian mobility, as people generally switch to a more comfortable vehicle for short distances. The lack of integration of Autolib into the public transport network has also contributed to this (Hildermeier, 2013). Autolib was an isolated mobility system that had no relationship to other means of transport: stops and parking spaces were not coordinated so that continuous travel was not good supported. As a result, the two transport systems did not complement each other.

Value creation and delivery of zeozweifrei-unterwegs and Autolib are very different due specific to business models. Zeozweifrei-unterwegs is an association of municipalities and companies coordinated by an umbrella company. The value chain, encompassing the provision of electric vehicles, charging infrastructure as well as the management of cards are distributed among different companies in the ecosystem of zeozweifrei-unterwegs (Figure 75). The umbrella company is the contact for admission of new members or for clarifications between partners. It also handles the allocation of centrally generated costs to the participants and distributes any profits. The value chain is extended when the customer pays at charging stations outside the project network. For Autolib, the Bolloré group and the Municipalities took over a large part of the value chain themselves. The Bolloré Group already had experience in the development of batteries. Since no car manufacturer wanted to develop an electric vehicle with the Bolloré Group, it developed its own electric vehicle and Autolib was the first major customer. Likewise, the Bolloré Group took over the development of the software for the monitoring and management of the vehicle fleet and charging stations. Hotline and support were also provided. Parking spaces were made available by local authorities. Only the electricity was sourced from external suppliers (Albert, 2014; Geron, 2015).

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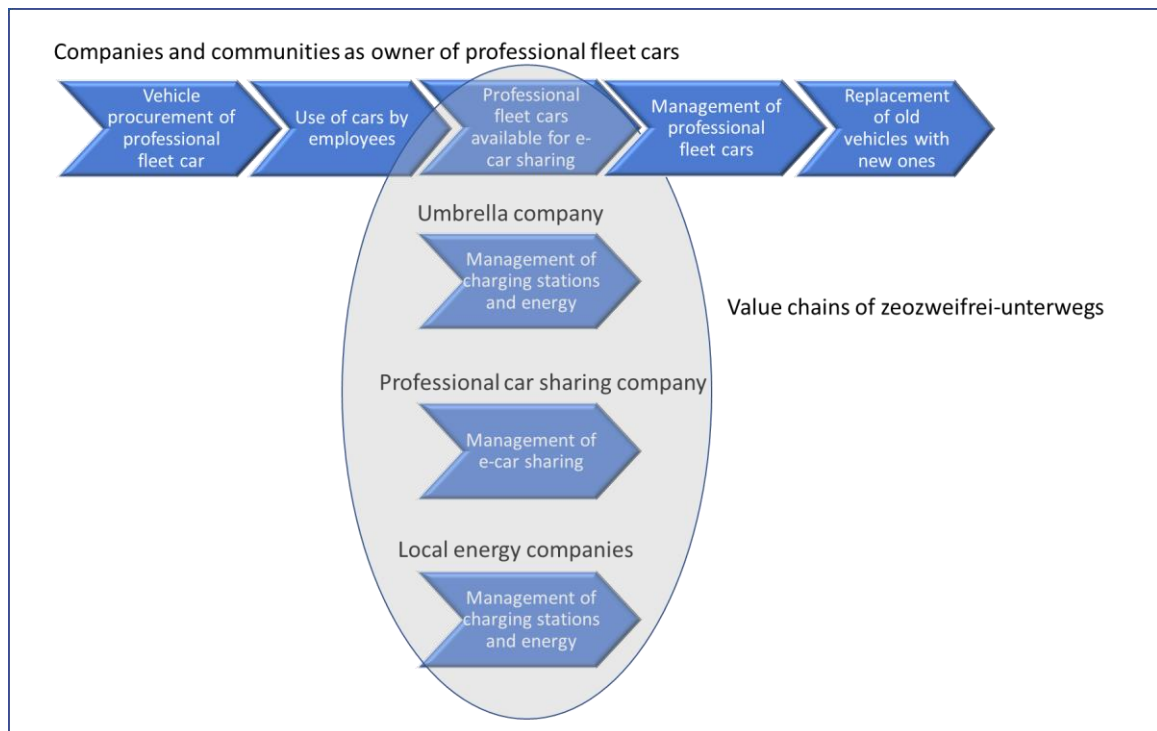


Figure 75: Multiple companies are participants in the value chain of zeozweifrei-unterwegs (own illustration)

With regard to the SBMEM framework element “social fairness and equity”, no statement can be found in the project premises or in company reports with regard to social concerns in the extraction of raw materials or in the production process, neither for zeozweifrei-unterwegs nor for Autolib. It can therefore also be assumed here that neither company is making any significant efforts in this respect.

Autolib has a positive impact on employment rate, due to required staff to manage and maintain the vehicles and operate the e-car sharing business even the figure of employment rate is low.

By taking over many functions in the value chain, Autolib was able to offer its customers a comprehensive service (Figure 76). The coordination of the individual value chain could also be realized efficiently due to the joint company network and it was possible to create necessary analyzes with a centralized database. However, the nearly closed ecosystem led to less innovation in the technology and business model, due to the lack of stimulus from outside. Efficiencies could not be implemented due to not enough involvement of professional companies in the supply chain. Moreover, communication and cooperation between the municipalities and the Boloré Group proved to be difficult due to the different interests involved.

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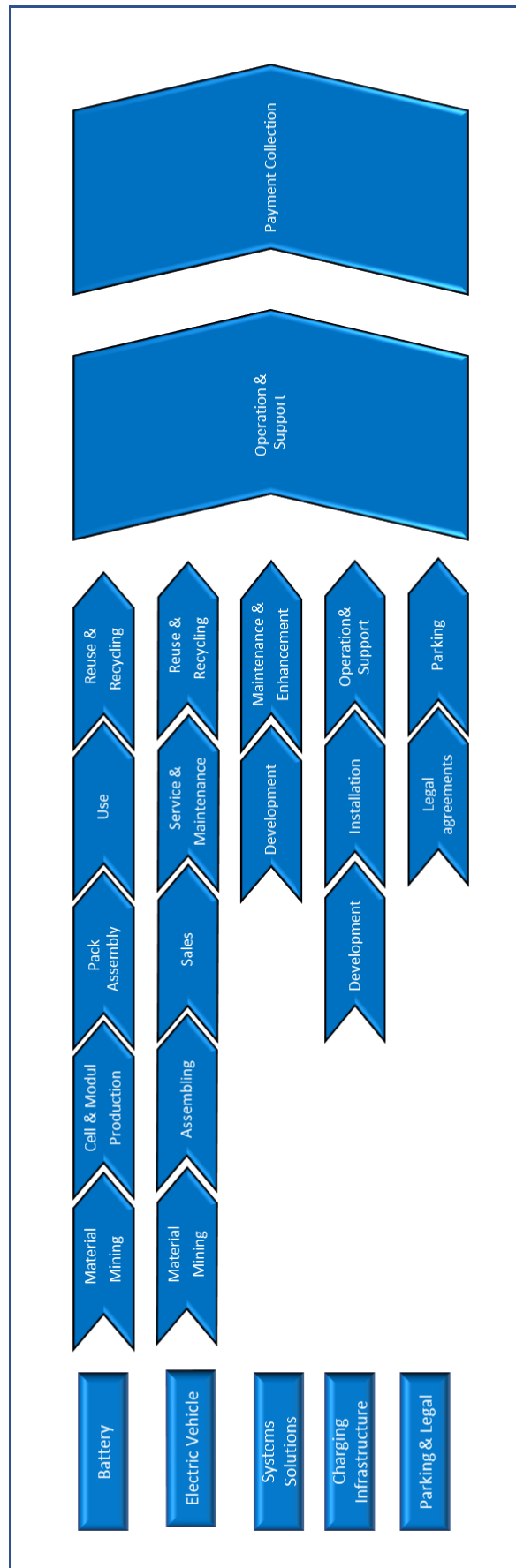


Figure 76: Combined value chains of Autolib (own illustration)

While the Bolloré Group had primarily economic motivations for the project, the municipalities wanted to solve the traffic problem and demonstrate a showcase project in electromobility.

The revenue model needs to be analyzed more deeply. Electric vehicles are considerably more expensive to purchase than ICE vehicles (Offer, Howey, Contestabile, Clague, & Brandon, 2010; Robinson, Brase, Griswold, Jackson, & Erickson, 2014; Wu, Inderbitzin, & Bening, 2015). Lower consumption and maintenance costs (Laurischkat et al., 2016; Wu et al., 2015) cannot compensate this financial disadvantage. So buying and operating an BEV can cost about \$400 more per month and per vehicle than a comparable ICE vehicle (Fairley, 2013).

Autolib's revenue was based on an annual membership and a fee for time usage of the vehicle. In addition, there was a revenue from drivers who used the charging stations even they did not drive a Bluecar. However, these profits were very small and did not play a decisive role in Autolib's revenue model and are therefore neglected. The annual subscription fee ensured a basic income (Figure 77) while the payments per kilometer should cover the operational costs.

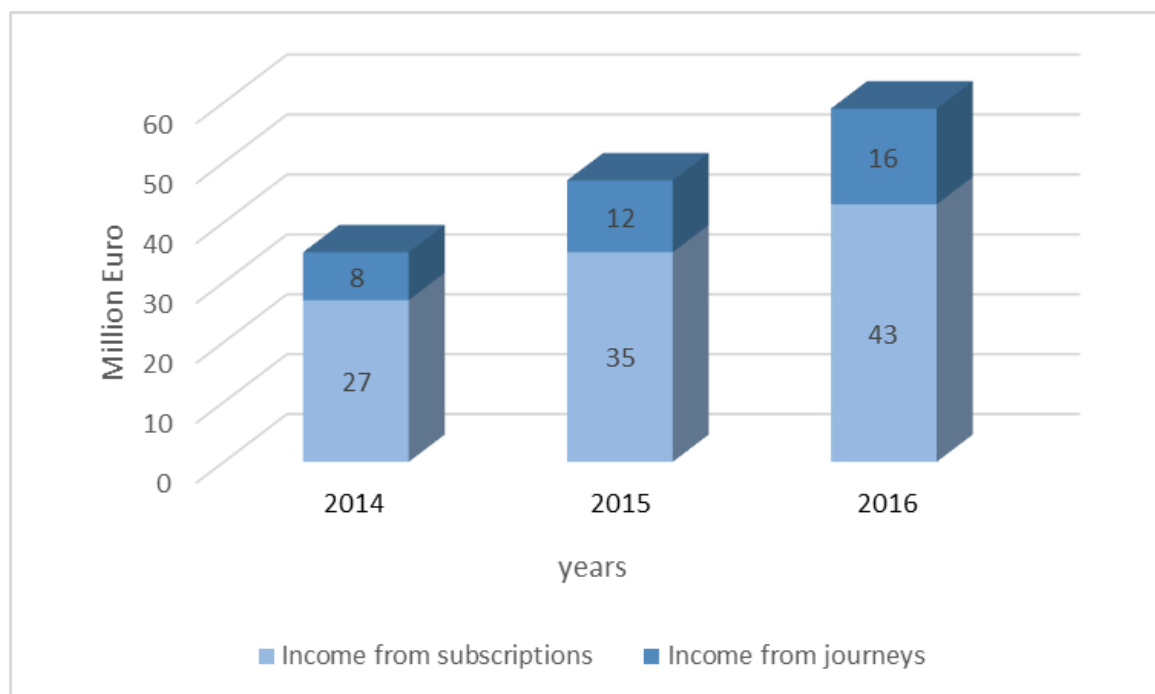


Figure 77: Increasing annual revenue from Autolib service (own illustration based on (Louvet, 2017))

The break-even point for Autolib's profitability was calculated at 50,000 subscribers by Bolloré Group in November 2013 (Albert, 2014). However, these number was

increased up to 82,000 subscribers at the beginning of 2015 (Désavie, 2015). As of November 2016, Autolib already had 131,328 subscribers without reaching the break-even point (Paris_ile-de-france, 2016).

An analysis of the data from Autolib's Métropole association (Hache & Fierling, 2014, 2015, 2016, 2017) and calculations by Louvet (2017) shows that service revenue for trips decreased by 33 percent between 2014 and 2015 and by 25 percent of total revenue between 2015 and 2016. Subscription revenue increased from 23 percent in 2014 to 26 percent in 2015 and to 27 percent in 2016 as a percentage of total revenue (Figure 78). This indicates that service revenue as a percentage of total revenue was shrinking while subscribers became more numerous. However, the rise in subscribers did not provide the necessary growth in revenue, as Autolib offered price reductions for first-time subscribers as well as price reductions for renewals, thus reducing the potential revenue. At the same time, the number of vehicles expanded from 2,645 in 2014 to 3,923 in 2016, leading more operating costs even though the number of trips per vehicle declined by 5.6 percent between 2015 and 2016. Bolloré justifies this situation with a structural threshold effect. The availability of vehicles was reduced due to the strong increase in subscribers, which led to less use of individual vehicles and a switch to alternative means of transportation. This cause is confirmed by a survey conducted by Autolib in 2013 and 2014 which stated that the success of Autolib was primarily due to the density and availability of the vehicles („Autolib reflex“) (Louvet, 2017).

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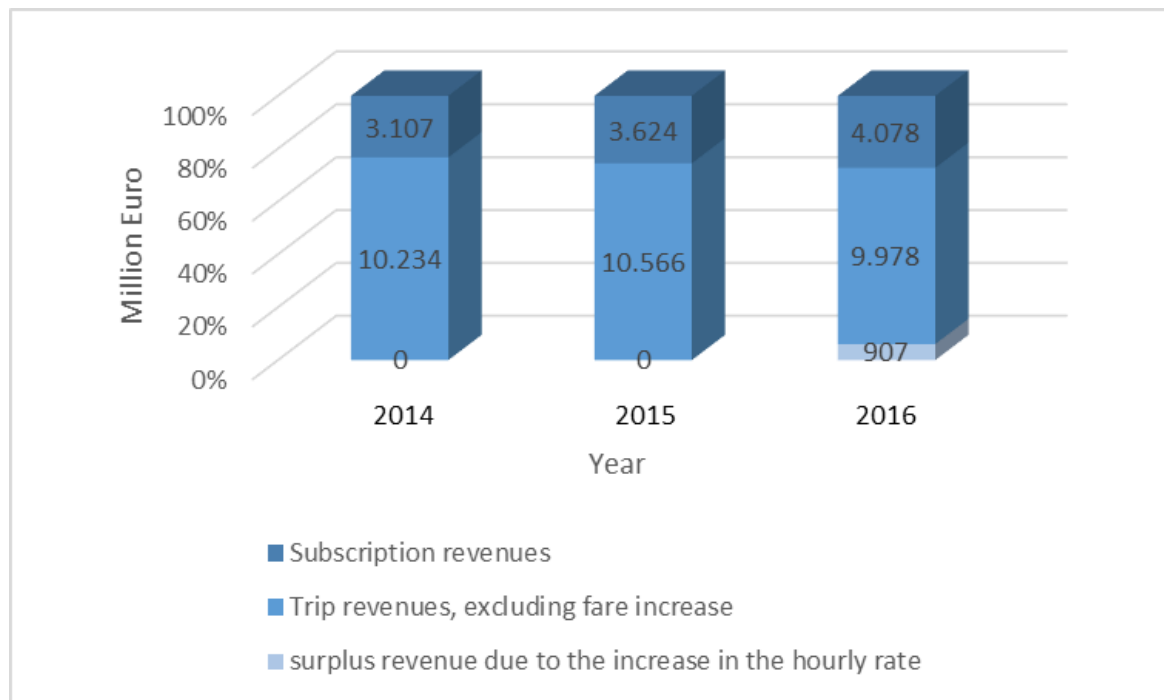


Figure 78: Annual revenue of Autolib between 2014 and 2016 (own illustration based on (Hache & Fierling, 2014, 2015, 2016, 2017))

As a consequence, the rental price was increased by 9 percent in 2016 (Louvet, 2017). In addition, the municipal contract partners were required to pay the accumulated debts and an annual subsidy of 46 million euros. As the municipalities refused to pay, business operations of Autolib were stopped on 31.07.2018 (Hanke, 2018). Vehicles were sold in several auctions at low prices to wholesalers while the charging stations were left unused, due to the legal disputes between the project parties. Today the charging stations are largely useless due to their low power of 3.7 kW and only one type of plug (type 3). So, they could hardly be used by other types of vehicles. The attempt to modernize the charging stations by an external company failed (Werwitzke, 2019).

The revenue model of *zeozweifrei-unterwegs* is more stable and robust than of Autolib due to its primary and secondary use of the vehicles. Municipalities and companies involved in *zeozweifrei-unterwegs* do not have the primary aim of renting BEVs, but rather make existing company vehicles available to users outside the municipality or company. BEVs can be purchased in Germany with subsidies of up to 9,000 euros and have the purpose of being made available to employees as company and fleet vehicles. Renting them to people outside the primary purpose can generate further income in form of rental fees. In addition, further subsidies are possible via the government and the EU to the project partners. Especially for local

authorities, the purchase of an electric vehicle together with the associated charging station is a marketing instrument that shows residents that they support electromobility. In addition, experience with electromobility can be gained, which can be integrated into further mobility project planning of the municipality or company. Since the administration is handled by the professional car sharing company Flinkster, no further investment is incurred in form of ICT, hotline or customer/vehicle administration and the entry barrier is drastically reduced due to proven processes. However, the motivation of shareholders to expand business activities is limited, as generating profit through car sharing is not the primary goal. Further investments in new electric vehicles are dependent on the need for new professional fleet vehicles. Also, the expansion of the infrastructure is only seen from the point of view of the needs for own employees.

The zeozweifrei-unterwegs project has different stakeholders in the ecosystem (Figure 79), organized and coordinated by the regional economic development agency of Bruchsal, which started the project with competence and necessary know-how in electromobility. The communication and marketing will be taken over by the environment and energy agency Karlsruhe and the energy and water supply Bruchsal will install and maintain the technology of the charging stations while the power supply will be taken over by regional energy companies. Professional car handling is done by Flinkster which maintains its own car sharing vehicles as well. Municipalities and companies as partner use the ecosystem to operate their electric vehicles or smaller fleets without having to build up know-how or personnel at great expense (Holland-Cunz, 2020b).

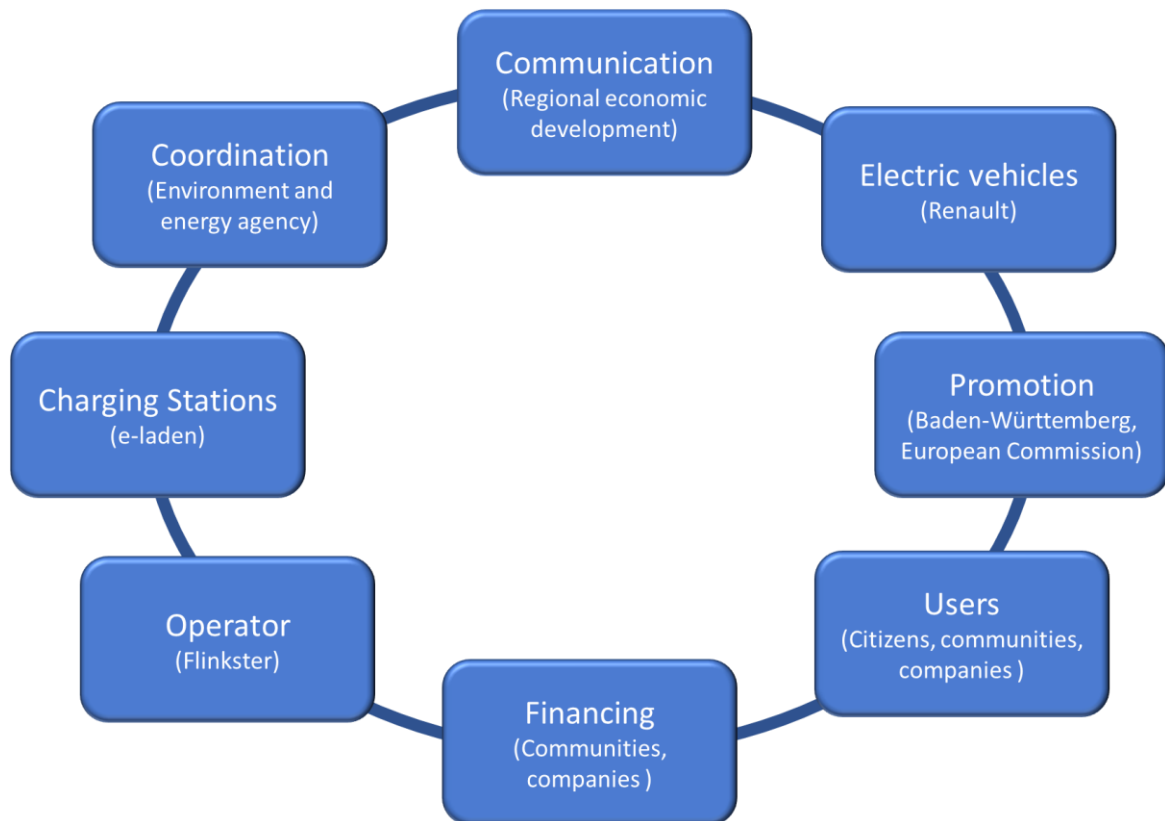


Figure 79: Different stakeholders of zeozweifrei-unterwegs (own illustration)

Stakeholders of zeozweifrei-unterwegs are not in competition with each other, which enables the disclosure of customer data, the business model and the internal structure. This provides the basis for constructive and transparent cooperation. The professionalism of the participants, like Flinkster, has enabled a quick and successful project start. However, the number of stakeholders is significantly reduced due to the necessity to be able to provide professional fleet vehicles for second use. Organizations without company vehicles have only a limited motivation.

Autolib had a highly closed ecosystem. Based on a corporate group, batteries, electric vehicles, software for the charging stations and management and support were provided by the Bolloré Group. The city of Paris and the municipalities provided the parking spaces in the city and suburbs and the necessary permits and investment. Autolib required a high level of integration among all participants, which was not easy given due to the high number of municipalities. Autolib Métropole was created as a coordinator for municipalities and the city of Paris with the task of coordinating and bundling the different concerns of the municipalities to present

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them to the Autolib company. This had the advantage that individual municipalities were not favored and, above all, that efficient decisions were possible (Figure 80).

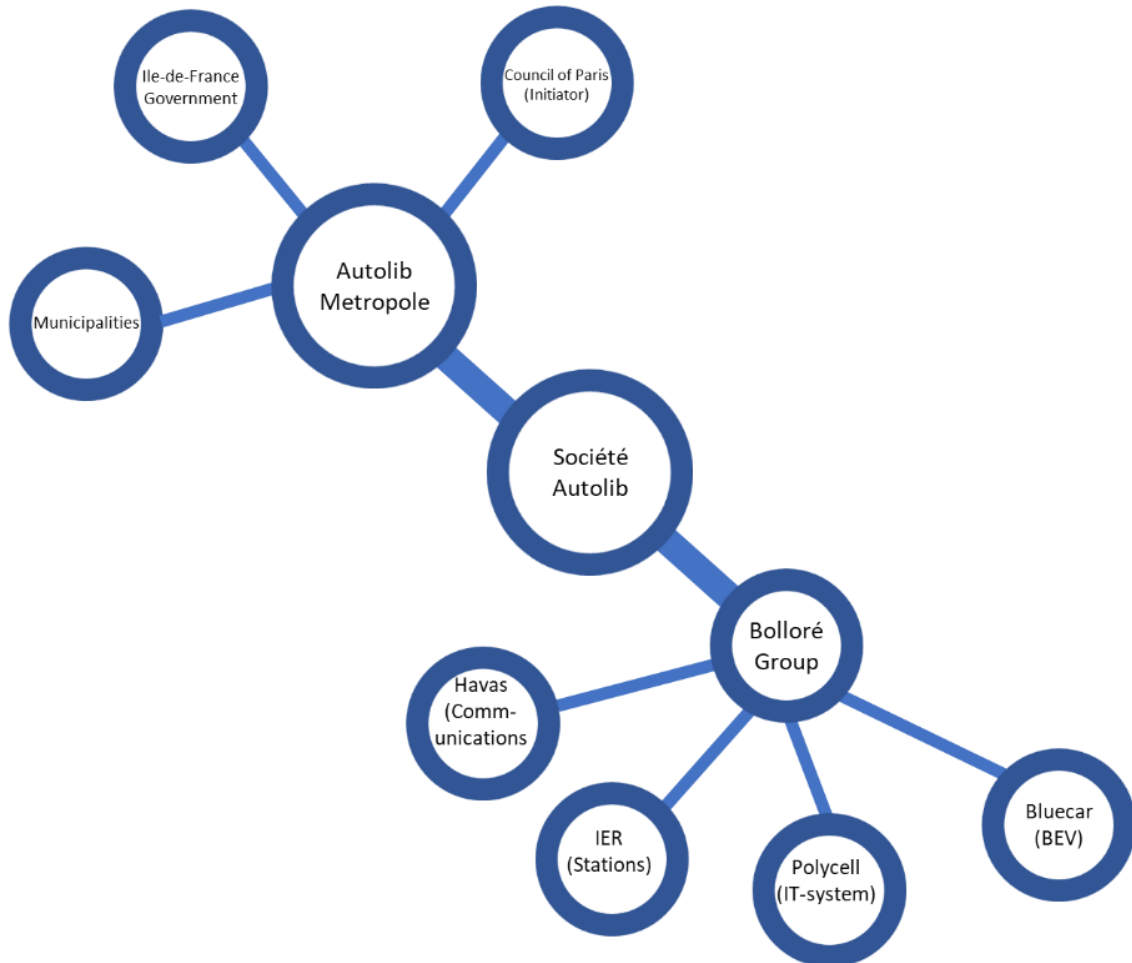


Figure 80: Comprehensive ecosystem from Autolib (own illustration based on (Industrial_Innovation_for_Competitiveness, 2016))

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The summary of the framework analysis can be seen in Table 13:

Table 13: Applying SBMEM framework to zeozweifrei-unterwegs and Autolib businesses models

Business Model Element	Dimension of Framework	Main Statements
Value proposition	Environment Convert ICEs to BEVs	<ul style="list-style-type: none"> + Several types of cars are available (compact/5 seats, family/7 seats, transport to fulfill customers transportation needs (zeozweifrei-unterwegs). + Easy way to try and test BEVs (zeozweifrei-unterwegs, Autolib). + All charging stations can be used and own stations are free (zeozweifrei-unterwegs). + Many charging stations were available for Bluecars (Autolib). – Vehicles are only available when they are not needed by primary users (zeozweifrei-unterwegs). – Bluecars were often in bad conditions (Autolib) – Parking spaces are often occupied at destination (Autolib). – Radius for Bluecars was limited to Paris and suburbs (Autolib). – Personal appearance necessary to use e-car sharing services (zeozweifrei-unterwegs). – Reserve before driving necessary (zeozweifrei-unterwegs). – Call Center was overloaded with long waiting times (Autolib).
	Environment Use of renewable energies	<ul style="list-style-type: none"> + Supply with green electricity within own network (zeozweifrei-unterwegs). – No green electricity charging (Autolib).
	Environment Avoid mining of raw materials	<ul style="list-style-type: none"> – Raw materials were purchased in normal process without detailed environmentally friendly or social friendly precautions (zeozweifrei-unterwegs, Autolib).

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Value proposition	Social Social fairness and equity	No data available
	Social Impact on employment rate	+ Approx. 200 employees (Autolib)
	Economic Function over property	+ Mobility without ownership
	Economic Seamless interoperability	+ Multichannel using of services (zeozweifrei-unterwegs, Autolib). + Personalization available (Autolib).
	Economic Affordable price	+ Transparent and favorable pricing
	Ecosystem of electromobility	– More cooperation with ecosystem possible to increase value proposition for users (zeozweifrei-unterwegs, Autolib).
Value creation and delivery	Environment Convert ICEs to BEVs	+ Supports replacing of ICE vehicles by BEVs due to easy testing of BEVs (zeozweifrei-unterwegs, Autolib).
	Environment Use of renewable energies	– No preference for suppliers who use renewable energies (zeozweifrei-unterwegs, Autolib).
	Environment Avoid mining of raw materials	– No preference for suppliers who avoid raw material extraction through appropriate measures (zeozweifrei-unterwegs, Autolib).
	Social Social fairness and equity	– No data available (zeozweifrei-unterwegs, Autolib).
	Social Impact on employment rate	+ Positive effect on employment rate (Autolib).
	Economic Function over property	n/a
	Economic Seamless interoperability	n/a

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Value creation and delivery	Economic Affordable price	<ul style="list-style-type: none"> – Reduction of competition through the dependence of municipalities (zeozweifrei-unterwegs).
	Ecosystem of electromobility	<ul style="list-style-type: none"> + Good coordination of the partners belonging to the ecosystem (zeozweifrei-unterwegs). + Comprehensive offer for users through well-functioning ecosystem BEVs (zeozweifrei-unterwegs, Autolib). – Closed ecosystem that prevented innovations (Autolib). – Different objectives of stakeholders that led to problems in communication and cooperation (Autolib). – Companies and communities share their strengths in the cooperation by joint motivation (zeozweifrei-unterwegs). – Stakeholders beyond services are excluded (zeozweifrei-unterwegs).
Value Capture	Environment Convert ICEs to BEVs	<ul style="list-style-type: none"> – Less competition leads to higher costs (Autolib).
	Environment Use of renewable energies	n/a
	Environment Avoid mining of raw materials	n/a
	Social Social fairness and equity	No data available
	Social Impact on employment rate	No data available
	Economic Function over property	<ul style="list-style-type: none"> – Integration into public transport was not planned (Autolib).
	Economic Seamless interoperability	No data available

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<p>Value Capture</p>	<p>Economic Affordable price</p>	<ul style="list-style-type: none"> + Low prices comparable to other means of transports (zeozweifrei-unterwegs, Autolib). – Number of trips per vehicle decreased over the years (Autolib). – Rising fixed costs and falling service fees could not be offset by the increasing number of subscriptions (Autolib).
	<p>Ecosystem of electromobility</p>	<ul style="list-style-type: none"> + Revenue model does not need to generate revenue, as vehicles are already financed by first users (zeozweifrei-unterwegs). + Additional revenue sources through EU subsidies (zeozweifrei-unterwegs). – Stakeholders were not willing to subsidize Autolib over a longer period (Autolib).

5.5.1.4. Recommendations to Design a more SBMEM

To increase the contribution to SBMEM, Zeozweifrei-unterwegs could expand the user group to include users who do not live in the region and increase the use of CO₂ free vehicles. This would enhance the value proposition through an extended offer, reduce the fixed costs due to more frequent use of the vehicles and increase the environmental friendliness to a higher conversion rate to BEVs. It would also be possible to expand the business model and purchase additional vehicles just for e-car sharing: even if the usage rate of the service trips would decrease, this could be offset by an increase in the value capture due to an additional e-car sharing revenue. In terms of seamless interoperability, it would be possible to replace the need for users to appear in person by a document workflow and video recognition system. The process, which is already established at banks, would be applicable without high costs, as there are already several systems on the market. In addition, the inhibition threshold of potential users who shy away from the effort of going to the authorities would be reduced.

Autolib could have increased availability at critical locations through various measures. For example, return trips from the outer districts to the inner districts

could have been made cheaper and one-way trips in the opposite direction could have been made more expensive. Also, vehicles could have been moved faster by involving students or Autolib employees who could have used the Bluecars for free when driving the vehicles to needed areas. The bad condition of vehicles or littering could have been monitored with cameras and violations could have been punished more easily. Furthermore, a bonus program could have been set up to encourage cleaning of the vehicles and thus earn free rides.

However, the biggest shortcoming of Autolib was the company's loss-making situation throughout the period. The low cost of rides for Paris could have been increased without much loss of customers. Using a car as opposed to crowded subways was very appealing to commuters from the suburbs and they would have been willing to pay a reasonable price as compared to the metro. In addition to increasing revenue, this would have entailed those vehicles were no longer being used for celebrating parties or overnight stays. The Bolloré Group, Paris city council and local authorities could subsidize the project. Indeed, with Autolib, the Bolloré Group was able to test its own products on the market in real terms and presented its capabilities to the public. This was valuable in the emerging market of electric mobility. For the Bolloré Group, Autolib provided valuable experience in use of electric vehicles and there was an opportunity for further vehicle development or e-car sharing projects. Moreover, even if it were a financial charge for them, Paris and the municipalities would have continued to be pioneers in environmentally friendly mobility and the model could have been further expanded. Also, a possibility would have been a subsidy from the French government, which could have used Autolib's experience to deploy the model in other cities.

Another aspect for the environmental friendliness of the SBMEM would be to exclusively use an environmentally friendly generated electricity. Both projects were already focused on CO₂ free mobility at the beginning, which could have been expanded. Using green electricity would have attracted more users. In addition, further measures would have been possible in terms of extraction, avoidance and recycling of raw materials. These measures would have made the e-car sharing experience even more environmentally friendly. A further upgrade would have been an integration into the public transport system. Autolib was awarded to the Bolloré Group without any requirements for connection to other means of transport. Rather than complementing each other, they were competing modes of transportation. For

users and environment, a coordinated schedule with appropriate fares would have been more effective for mobility and environmental friendliness. For example, commuters could have taken the Bluecar to get from their home to the Metro and then used the Metro to Paris. The vehicles that would have been needed less in the city center could have been placed in suburbs. This would have been closer to the aim of the project, a CO₂ free and car reduced traffic in Paris.

5.5.2. Mobility as a Service: MaaS Global (Whim)

With mobility services different means of transport can be used and there is no need to own a vehicle. The mobility services can be provided by different providers and include route planning for the individual journeys as well as joint billing.

5.5.2.1. Description of Mobility as a Service

The mobility sector is facing major challenges. In urban areas, the demand for mobility is increasing while at the same time traffic and environmental problems are growing (Kamargianni & Matyas, 2017; Sela, 2018). Scientists expect that population residing in urban areas will increase from 55 percent in 1918 to 68 percent in 2050 based on a study of 233 cities with 300,000 inhabitants or more, worldwide (Nations, of Economic, Affairs, & Division, 2019). However, cities are not prepared for an increase in population because infrastructures of transport systems were developed over the last 20th century (Störmer et al., 2009). Forecasts predict that in 2050, inhabitants will have to spend an average of 106 hours a year in traffic jams, which is three times more than today (Lerner & Van Audenhove, 2012). Technological progress in the area of individual transport has provided a certain amount of support, but this is often only temporary and limited to partial aspects (Economides, Han, Orowitsch, Scoullou, & Nuttall, 2012; Van Den Bergh, Truffer, & Kallis, 2011). Especially since individual mobility is seen as an important social function, new and environmentally friendly mobility solutions are required that modernize the limited urban mobility systems for an ecological and economic expansion of the transport systems.

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Already in 1995, the European Commissioner for Transport, Neil Kinnock (1995), demanded a strategy to solve transport problems and launched a political program. He announced: “*Whereas, in the past, we have tended to think about specific modes of transport – road, rail, air and waterborne – there is now growing recognition that sustainable mobility is about inter-connecting transport systems which have to provide door-to-door-service. This is what I call “intermodality”*” (Kinnock, 1995).

MaaS is part of intermodality and an innovative and emerging mobility concept (Figure 81). A core element of intermodality is the use of multiple carriers for a single journey. So defines Jones et al. (2000) intermodal transportation as “*the shipment of cargo and the movement of people involving more than one mode of transportation during a single, seamless journey*”. Intermodality includes the transport of goods, freight and people. However, in this thesis, we will focus on the transport of people. Passenger intermodality is a planning principle with the goal to provide passengers with different modes of transport in a combined and seamless journey from door-to-door (Müller & Bührmann, 2004, pp. 80–108).



Figure 81: Different means of transports are necessary and possible in urban cities (Harteneck, 2020)

Using means of transport with different carriers and owners is very complex and confusing without a comprehensive and seamless interoperability. Therefore, platforms were created that bundle different services (Arias-Molinares & García-Palomares, 2020), which is also the characteristic feature of MaaS. The term is used very differently in academic literature (Arias-Molinares & García-Palomares, 2020; Jittrapirom et al., 2017). It is a concept of conceiving mobility, a phenomenon with the emergence of new behaviors and technologies or as a new transport solution which merges different possible and available mobility services solution (Jittrapirom et al., 2017). Hietanen (2014) specifies the service as the one that arranges various transport options on a single interface of a service provider and in addition to booking, also uses other services such as billing. An early definition comes from Heikkilä (2014, p. 8), who describes MaaS as "*A system in which a comprehensive range of mobility services are provided to customers by mobility operators*". It combines different transport options into an individual transport subscription. The integration and use of the Internet with MaaS is mentioned by Finger et al. (2015). With the emergence of electronic and mobile devices like cell phones, access, management, and payment have been combined with the use of a single app (smart mobility). After planning the journey, booking and paying are available, coordinated by a MaaS operator (Holmberg, Collado, Sarasini, & Williander, 2016; Li & Voegelé, 2017), as illustrated in Figure 82. With additional personalization it is possible to store and use preferences of travelers and make the usage even more convenient and faster because already behavior is known (Atasoy, Ikeda, Song, & Ben-Akiva, 2015). The study "The 2019 Strategy & Digital Auto Report" (Weber, Krings, Seyfferth, GÜthner, & Neuhausen, 2019) from the strategy department of PricewaterhouseCoopers forecasts a market volume of \$1.2 trillion in Europe, USA and China. Therefore, in addition to the environmental and social aspects, it also has an economic significance.

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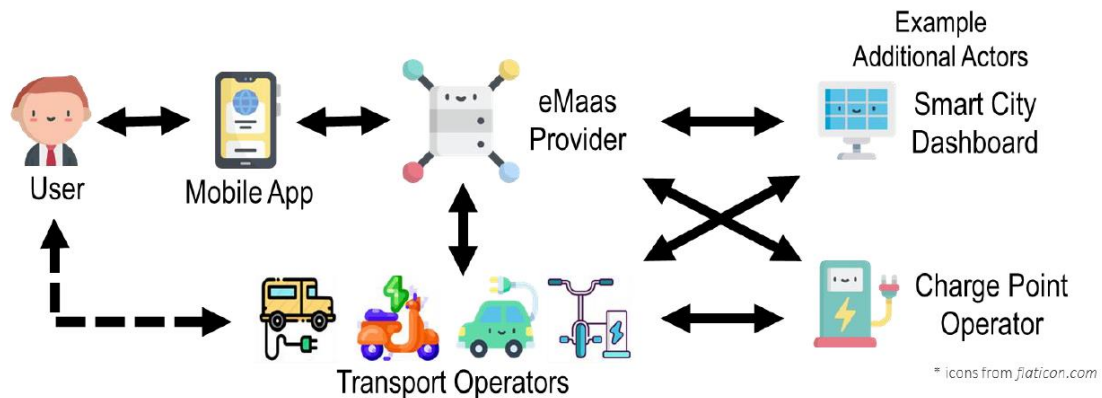


Figure 82: Procedure of MaaS from a user point of view (Havemann, Schloo, Bongers, Nordenfelt, & Lenz, 2020)

All definitions include the basic elements of a single platform with the customer interface via app or website, real-time information about different modes (public or private), bundling of transport services, cooperation of stakeholders, and intermodal planning (Christopher, Cox, Ben-Akiva, & Turner, 2015; Jittrapirom et al., 2017; Sarasini, Sochor, & Arby, 2017). But additional functionality is needed like "benefit without thought": this means that transport should be capable of "on-way" and a "pay-as-you-go" scheme, where only the actual use of a means of transport has to be paid for and a spontaneous start of the journey is possible.

Recent developments such as the Internet of Things (IoT)⁴⁴ combine the vision of intelligent traffic management with smart city (Sherly & Somasundareswari, 2015). Data streams such as traffic data, data infrastructure and physical transport infrastructure will be connected and used to provide additional services (Hietanen, 2014). Melis et al. (2016) interpret IoT as an enabler for the integration of private and public transport. IoT with on-board sensors can act like a connector to provide real-time information to the MaaS services. Equipped trains or buses send their location to the MaaS operator so that delays can be included in route planning. MaaS includes collective and shared means of transport (Beutler, 2004). In collective means of transport, there is no direct influence on the use by other road users. This includes buses, trains, and streetcars. In the case of shared means of transport, these are made available to the users and are moved by the user

⁴⁴ IoT is a term that describes a network of physical objects which can be connected using embedded sensors and software. For the needed exchange of data, the internet as connection platform is used.

themselves. These can be bicycles, rental vehicles or car sharing offers. Other forms of transport services are ride-hailing⁴⁵, ridesharing⁴⁶ or ride-pooling⁴⁷.

MaaS is a concept and not a prefabricated scheme with rigid structures. It can consist of different concepts and ideas based on an ecosystem of value chains of different transport modes. The goal is to make traffic more efficient, primarily in urban areas. The concept of MaaS can also be applied to electromobility, using environmentally friendly means of transport that do not create social disadvantages. In the thesis this case is to be examined.

5.5.2.2. MaaS Global (Whim): The Pioneer of MaaS

In Helsinki, the road network was expanded due to the lack of infrastructure, resulting in denser traffic. In addition, it exceeded the European limits for air pollution. The aim is, to reduce greenhouse gas emissions of 30 percent by 2030 and climate neutrality should be achieved by 2050. In 2015, Sampo Hietanen founded the start-up company MaaS Global. The aim of the mobility provider and the local municipality is to reduce the number of passenger cars in Helsinki and surrounding area and to become the "Netflix of transportation"⁴⁸ (Figure 83) (Zipper, 2018).

⁴⁵ With Ride-Hailing, the customer calls a vehicle with driver via phone or app, which takes him to the desired location. Examples are Taxi or Uber (Sela, 2018).

⁴⁶ Ride sharing is the joint transport of several people. The request is made via smartphone or app and people come together who have a common departure point and destination. Ridesharing is used in the private as well as the commercial sector. An example would be BlaBlaCar (Sela, 2018).

⁴⁷ Ride-pooling is like ride sharing, but here all requests are collected, and an algorithm is used to calculate the best possible route for the users. The entry and exit should be as close as possible to the customer's request. Ride-pooling always has a commercial basis. Examples are CleverShuttle, Moia and BerlKönig (Sela, 2018).

⁴⁸ Netflix is an American streaming service provider where you can watch movies and series online.

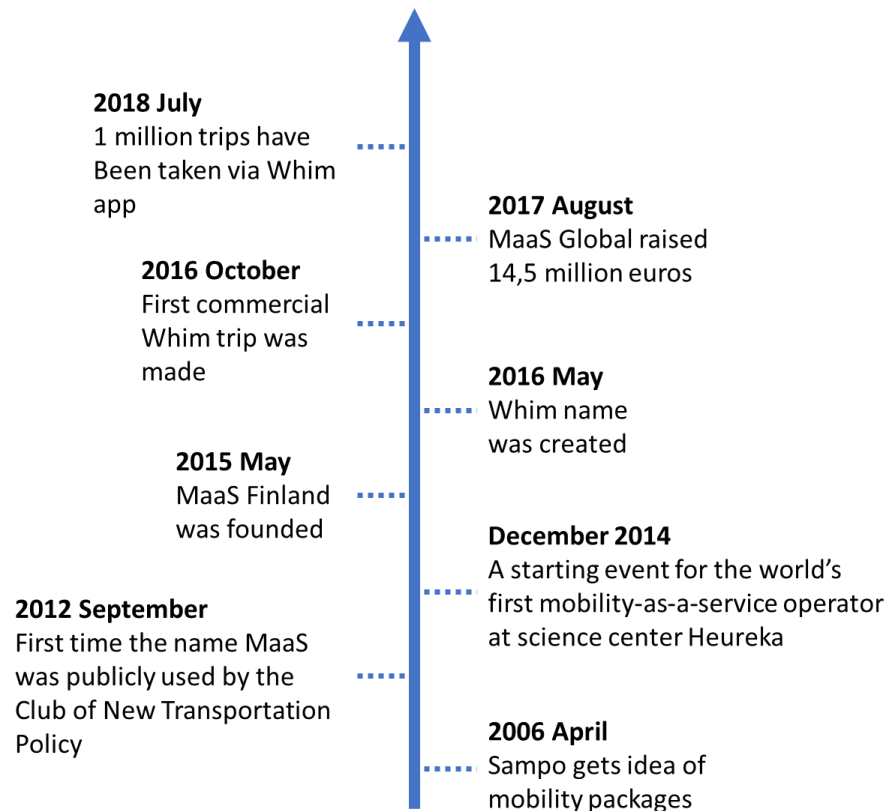


Figure 83: History of MaaS Global (Hietanen, 2019)

With an app called "Whim"⁴⁹ it is possible to plan, search, book, and pay for all types of public and private transportation in Helsinki (Oy, 2020) like taxis, car sharing, rental cars, local transports, trains, rental bikes or planes (Breitinger, 2016). As of March 2019, Whim has 70,000 registered users and 10,000 regular active users (C. Reid, 2019). The app can be used for spontaneously travel and pay per booked ride and different subscriptions can be used (Figure 84). There are several types of consumptions: Urban 30, Student, Weekend, and Unlimited. For an amount of 62.70 euros per month, it is possible to use unlimited public transport in Helsinki. In addition, there are discounts on cabs and rental cars. A flat rate is also offered for 699 euros per month, with additional unlimited use of rental cars and discounted use of rental bikes and cabs (MaaS_Global, 2021). For an additional amount of 50 euros, the area of use can be extended into the Helsinki area (Breitinger, 2016; Heller, 2018; Kühne & Adler, 2018; Li & Voegelé, 2017).

⁴⁹ Whim comes from the English language and means "on a whim".

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	Whim Urban 30 €62,70 / 30 days	Whim Student 30 €34,40 / 30 days	Whim Weekend €399 / 30 days, price valid from 16. Nov	Whim Unlimited €699 / month, price valid from 16. Nov
Public transport	HSL 30-day ticket	HSL 30-day student ticket	HSL 30-day ticket	Unlimited HSL single tickets
City bikes	Affordable season pass	Affordable season pass	Included (max. 30 min per ride)	Included (max. 30 min per ride)
Taxis	Trips under 3km for €12,5 (TaksiHelsinki only)	Pay as you go	-15%	80 rides (max 3 km), other rides normal price
Rental car	€55/day	Pay as you go	Weekends	Unlimited
E-scooter	TIER Standard pricing	TIER Standard pricing	TIER Standard pricing	TIER Standard pricing
	Read more	Read more	Read more	Read more

Figure 84: Different offers of Whim Helsinki depending on service and price (MaaS_Global, 2021)

MaaS Global is a private company with a total funding of 53,700 million euros. The largest shareholders are BP Ventures, Mitsui Fudosan, Mitsubishi Corporation, Nordic Ninja (29.5 million euros), Toyota Financial Services, and Aioi Nissay Dowa Insurance Company (14.2 million euros) (MaaS Global, 2017, 2019). Automotive companies have a great interest in MaaS because they want to pay more attention to mobility services due to the growing demand for environmentally and individual mobility and want to gain experience with participations in mobility service providers. They fear that the changes in individual mobility will turn them into nothing more than a mass manufacturer of vehicles whose service is sold to customers by mobility service providers and they lose their contacts with the customers and their supremacy in mobility (Zipper, 2018).

5.5.2.3. Business Model Analysis of MaaS Global (Whim)

For MaaS, the Finnish mobility operator MaaS Global will be analyzed because with Whim it offers a comprehensive range of different means of transport in Helsinki, which is operated via a smartphone app. Whim is a pioneer of multimodal traveling,

is very innovative and successful and has therefore been selected for the case study.

The value proposition of MaaS Global is to aggregate individual transport services and make them available to customers via an interface (smartphone app). The app helps in planning and selecting trips and suggests a route with the most suitable means of transport. The shortest, cheapest or most environmentally friendly connection can be chosen and used immediately. Going to a ticket office or using a separate app of the different service provider is not necessary. The great advantage of Whim is that due to the latest technology, real-time data of buses and streetcars are available, which leads to very punctual and comfortable routes.

By launching Whim in Helsinki, MaaS Global compensated global carbon emissions of 2,948 tons of CO₂ in high-quality carbon projects in 2019 (MaaS_Global, n.d.) and unburden the environment (MaaS_Global, n.d.). Furthermore, the target of MaaS Global is to eliminate one million private vehicles through the usage of Whim. This can be achieved by offering alternative transportation options that emits no or only low local CO₂. These include bicycles as well as public transportation. For example, 95.2 percent of Whim passengers use public transit and 1.02 percent use bicycles. 42 percent of bicycle users book another trip on public transport. This enables to overcome last-mile travel, which helps to increase public transit use. The low usage of car rental at 0.03 percent results from the absence of large operators, such as Uber and DriveNow, which are not included in the Whim network.

Whim includes the use of car sharing, which is especially useful for trips outside the city. However, Whim does not influence the vehicle type of the operators, so it is up to the car sharing companies themselves to exchange BEVs into ICE vehicles, which would have a positive impact on the local CO₂ balance of the vehicle fleet in Helsinki. MaaS Global also makes no effort to promote renewable energy. This element from the SBMEM is insufficiently fulfilled by Global MaaS.

The usage of public transport reduces the used vehicles in Helsinki and therefore the extraction of raw materials also. It also lowers the traffic density in Helsinki, which has a positive impact on noise and local CO₂ emissions.

On negative side, the percentage using taxis is high: while typical Helsinki resident takes taxis 1 percent of the time, Whim users take 2.1 percent (Ramboell, 2019).

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This can be explained by the pricing policy of Whim, which includes cab rides with a radius of five kilometers for a low price. So, it is obvious that instead of walking, people take the more convenient taxis, contributing to an increase in pollution of CO₂ and noise.

The value chain of Whim is more than just a digital marketplace that collects information from different suppliers and makes it available to customers, but rather provides the service in a binding offer. For this purpose, services of transport providers, like arrival and departure times, routes, or ticket prices, are aggregated and made available to the customer via the Whim app. The underlying algorithm can determine routes according to different criteria. One of the most important functions is the addition of the different amounts and tickets to one payment with only one ticket (Figure 85). MaaS Global depends on transportation companies being willing to share their data about their services so that they can be offered through Whim. As a result, companies can lose the important contact to the customers and the brand image that has been built up over years could be lost as the customer is only in contact with Whim (Zipper, 2020). MaaS Global obtains business critical data from suppliers and at the same time from customers that will be used for further business activities. For example, MaaS Global has contacts with manufacturers of navigation systems and uses data to improve its own offering without involving suppliers (Lindholm, 2017).

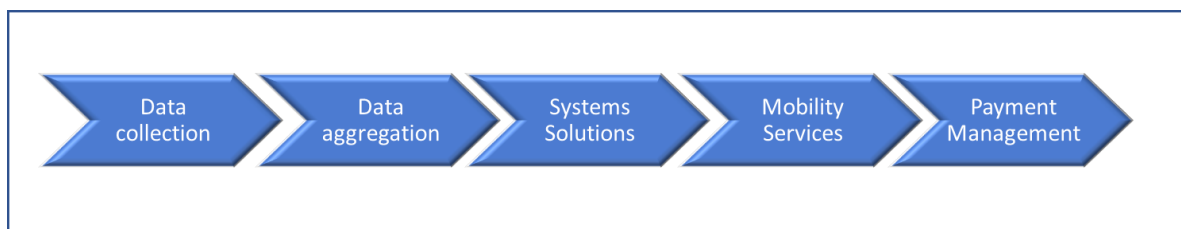


Figure 85: Linear value chain of MaaS Global (own illustration)

MaaS Global develops and operates the Whim app for smartphones, which is free of charge for customers. As a value capture, MaaS Global receives a commission from the transport companies participating in the ecosystem for registrations of new customers and bookings of trips. Commissions can range from 10 percent to 20 percent for a transport booking (Zipper, 2020). However, the revenue generated is low. For example, a booking with a bicycle with an average price of 4.00 euros and 10,000 trips per month, only generates a revenue of 208,000 euros annually.

MaaS Global's goal is to become profitable between 2021 and 2023 (Reid, 2019). The low-income potential is further hampered by the hostile attitude of the transportation companies. In order not to have to pay commissions to MaaS Global, they try to agree different commission rates with the agencies to give preference to other brokers than MaaS Global. So, Helsingin Seudun Liikenne (Helsinki regional transport) stopped all commission payments to agents because no payments should be made to MaaS Global. This affected Whim as well as other operators like kiosk owners which is accepted as collateral damage by Helsingin Seudun Liikenne. Also, transport service providers sell their service cheaper to the end user if they buy it directly and not through the Whim app.

Whim highly supports the SBMEM element "deliver functionality and avoid ownership" by offering different transport options, which are promoted by an efficient ecosystem. By offering car sharing, users can make further trips without having to own a vehicle. The use of bicycles and electric scooters is also conducive to cover the first and last mile.

The Whim app strongly supports seamless interoperability, where the smartphone becomes the user's digital control and command center. Whim enables a door-to-door journey experience where electronic or paper tickets from individual service companies are no longer needed. System connections to different companies are enabled using a standardized application programming interface (API). This makes it very easy for other companies to integrate into the ecosystem without having to impose additional interfaces to the user in the form of apps or different user navigation systems (Barrow, 2018) (Figure 86).

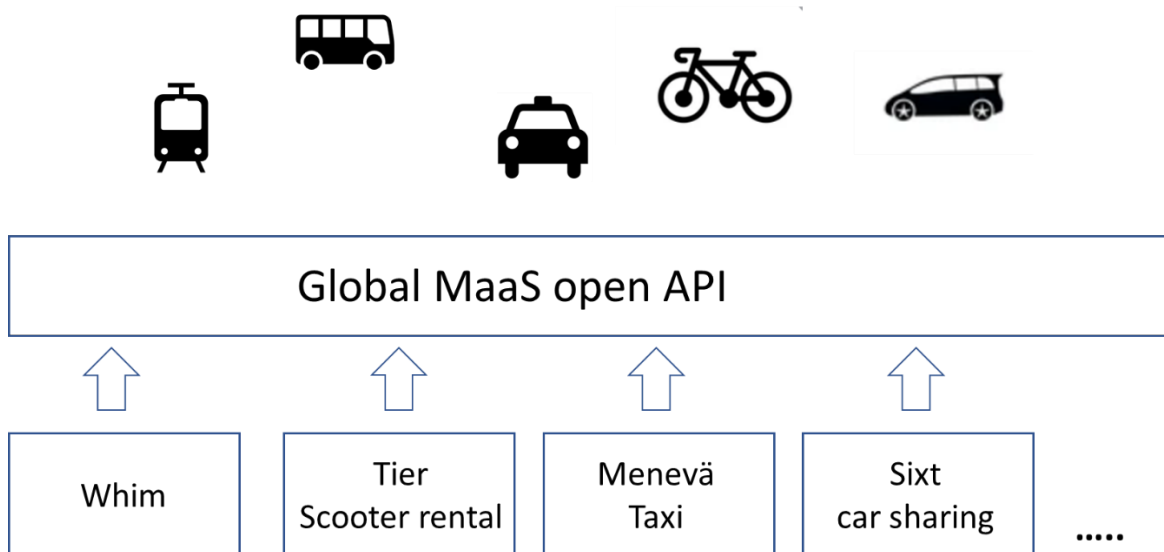


Figure 86: MaaS Global open API architecture enables easy connection to suppliers (own illustration)

Whim's ecosystem involves the car rental companies Sixt, Toyota and Hertz, as well as the bicycle rental company GO, the scooter rental companies Tier and Voi, and the taxi companies Lähitaksi, Menevä, and Taksi (MaaS_Global, 2019). However, the most important one is public transport. Since this is mostly in the hands of municipalities, an indispensable requirement is cooperation with local governments or legislation. In Helsinki, Whim is supported by the Act on Transport Services, locally called the transport code, which requires Finnish transport companies to open their transport services fully to third parties. However, this approach leads to resistance from transport companies. The public transport operator, Helsingin Seudun Liikenne, has already announced its intention to circumvent this law and establish an own competing mobility system (Zipper, 2018). If successful, this has significant disadvantages for Whim because Helsingin Seudun Liikenne made 375 million transport journeys in 2017 while Whim made less than 0.5 percent of all non-vehicle journeys (Lindholm, 2017). MaaS Global does not describe itself as a data owner, but as an open platform that can be more useful when the data of all participants are made available (Sampo Hietanen, 2018). *It's ecosystem, not egosystem,* " (Maas_Global, 2020). With this approach, Maas Global is trying to convince local and regional transport companies to join MaaS Global ecosystem.

The summary of the framework analysis can be seen in Table 14:

Table 14: Applying SBMEM framework for Maas Global (Whim) business model

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Business Model Element	Dimension of Framework	Main Statements
Value proposition	Environment Convert ICEs to BEVs	<ul style="list-style-type: none"> + Possibility to overcome first and last mile. - Whim does not influence enough the conversion of ICE to BEVs at taxi companies or car sharing operators.
	Environment Use of renewable energies	<ul style="list-style-type: none"> - Too little effort to support renewable energies for means of transport.
	Environment Avoid mining of raw materials	<ul style="list-style-type: none"> + Reducing individual transportation saves resources and lowers the burden on environment due to lower number of vehicles.
	Social Social fairness and equity	No data available
	Social Impact on employment rate	No data available
	Economic Function over property	<ul style="list-style-type: none"> + MaaS Global supports with means of transports the aim of ownerless transport. + Supports individual mobility and spontaneous begin of traveling.
	Economic Seamless interoperability	<ul style="list-style-type: none"> + Easy access and accounting via Whim app - Integration in other applications not available.
	Economic Affordable price	<ul style="list-style-type: none"> + Transparent pricing - Prices of single means of transport can be lower than MaaS price.
	Ecosystem of electromobility	<ul style="list-style-type: none"> - Stakeholders' common goal for environmentally friendly transport not in place.
Value creation and delivery	Environment Convert ICEs to BEVs	<ul style="list-style-type: none"> - Services with BEVs routes can be more offered.

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Value creation and delivery	Environment Use of renewable energies	– Low agreements with green energy providers.
	Environment Avoid mining of raw materials	– Low agreements with green energy providers
	Social Social fairness and equity	– Influence of MaaS Global on compliance with fair working conditions among stakeholders is low.
	Social Impact on employment rate	+ Positive effect on employment rate and creating new job profiles due to MaaS Global.
	Economic Function over property	– Additional services can extend value chain.
	Economic Seamless interoperability	+ Contact option to end customers preferred by Whim.
	Economic Affordable price	– Different steps in the value chain make the price more expensive.
	Ecosystem of electromobility	<ul style="list-style-type: none"> + Data from operations are used for other businesses. – High dependence of MaaS Global on goodwill of transport companies and municipalities. – Acceptance of MaaS Global from transport companies is low. – Strong competition among transport companies
Value Capture	Environment Convert ICEs to BEVs	– No preferred offers of BEVs instead of ICE vehicles.
	Environment Use of renewable energies	No data available
Value Capture	Environment Avoid mining of raw materials	No data available
	Social Social fairness and equity	No data available

5. Applying the Framework for Sustainable Business Models for Electromobility to Screen Existing Business Models

Value Capture	Social Impact on employment rate	No data available
	Economic Function over property	+ Use of MaaS can be less than the cost of owned transportation. + Using Whim can avoid ownership
	Economic Seamless interoperability	+ Continuous customer journey increases willingness to use.
	Economic Affordable price	+ Offers for different groups of people reduce standard price. – Often, no reduction in ticket price for customers.
	Ecosystem of electromobility	– Break-even not to be reached until 2021 – 2023. – Low fees and provisions from transport suppliers for MaaS Global.

5.5.2.4. Recommendations to Design a more SBMEM

The objective of Whim is the convenient use of suitable transportation services in Helsinki and surrounding area without passenger vehicles. However, MaaS Global does not explicitly emphasize the use of environmentally friendly transportation options. Although the most commonly used public transports are partly powered by electricity (streetcar, metro, suburban railroad), the majority of buses still run on internal combustion engines (Wagner, 2019). Drivers for a conversion of ICE vehicles to BEVs are the bus manufacturers themselves and not MaaS Global. MaaS Global could use its potential to influence more environmentally friendly transportation by offering reduced ticket prices or convenient routes with electric vehicles in route planning. Moreover, electricity generation in Finland comes predominantly from fossil sources. 37 percent of electricity generation in 2018 was from renewable sources. The main sources are fossil fuels and nuclear energy. Whim offers a sustainable route alternative, but this specifically considers cycling and walking. An additional option may be the use of environmentally friendly transportation based on electric taxis, electric bicycles or BEVs from e-car sharing. For car sharing companies, the lower operational costs and subsidized purchase of the electric vehicles could lead to lower total costs of ownerships in comparison to

ICE vehicles and be an additional motivation besides being environmentally friendly. The ecosystem would need to be expanded to include green energy producers and charging station operators to further increase environmental friendliness. Extending time of use and recycling could also be enforced by Global MaaS. Some vehicles in the ecosystem such as taxis or car sharing cars are used up more quickly due to the increased benefits.

MaaS is favored by the fact that younger road users no longer insist on owning an own vehicle. This is particularly true in the millennials and generation Z where permanent and short-term access to mobile transport services has a higher value proposition than owning a vehicle (Cohen & Kietzmann, 2014). This should also be extended to other generations.

Also, to be attractive, the basic problems of public transport must be solved. These include delays, dirty means of transport, high prices and the possibility of 7-day operation 24 hours a day. These problems already prevent the greater usage of public transport.

Another way to increase the profitability of MaaS Global is to focus more on business to business. Whim focuses on individual passengers, ignoring the option of corporate customers and can offer transportation services for employees without using a company car. Passengers would increase, leading to a better utilization of transportation and increased profitability. Special offers have to be prepared within the ecosystem and supported by the stakeholders so no cannibalization of existing company tickets from individual providers can occur.

The use of the data obtained via the Whim app is another way to generate profit, expand business activities and strengthen the ecosystem. In cooperation with the stakeholders, it is possible to evaluate customers' transport habits for further improvement of the customer journey. Likewise, city planners and municipalities could benefit from the evaluations in order to better planned infrastructure, parking spaces or leisure facilities (Motta, Sacco, Ma, You, & Liu, 2015; Willing, Brandt, & Neumann, 2017). However, a prerequisite is the trust of the stakeholders in the ecosystem so that no company is favored. No company should lose passengers because data can be used by other companies as well. Also, the use and sharing of data with MaaS Global is one of the biggest criticisms of companies in the ecosystem and has yet to be resolved by MaaS Global. Inadequate data protection

regulations or barely understandable data protection provisions in general terms and conditions make customers feel insecure about using the full potential of MaaS Global. It is easy to track travelers and their routes and their movements online. From this, it is possible to identify easily other personal data and practices that not everyone wants to disclose. Therefore, it is necessary that MaaS Global protects user data through a transparent and comprehensive privacy policy and thus promotes trust.

6. Conclusion and Outlook

The desire of the population for environmentally friendly mobility without burdening social fairness and human rights is constantly increasing. This includes the possibilities to start journeys and trips spontaneously and without planning, to change travel routes flexibly and to organize them individually. One possible answer to this is electromobility. Technologies have made great progress in recent years. The ranges of vehicles are increasing, the still insufficient charging infrastructure is being expanded and innovative and environmentally friendly mobility concepts are being offered. Nevertheless, the transformation from fossil-based means of transportation to electromobility is still in its beginning and great efforts by governments in the form of subsidies are needed to make electromobility products and services attractive for the population. However, what is still missing are the appropriate and necessary business models that are lucrative for companies while satisfying the value proposition of the customers.

Some business models are described in academic literature and researchers offer several frameworks in order to support the design of SBMEMs. However, the question, which has not yet been answered sufficiently is: what kind of business model is able to fully develop the potential of electromobility? How does a framework which supports companies in the field of electromobility look like to achieve benefits for the environment and society while generating economic value? The developed framework for SBMEM helps to close gaps in research on sustainable business models and shows to business leaders how sustainable business models in electromobility can be designed.

For this purpose, the concept of electromobility is analyzed and defined in a comprehensive manner. It goes beyond electric vehicles although they have a large share in electromobility. There are also other significant aspects like technologies and services that are needed to offer a broad range of electromobility services. Moreover, the key elements of electromobility are brought to light because they are the basic principles to fulfill the value proposition of the customers. In the next step, the relationships between technologies, innovations and business models are examined. This is followed by a more in-depth analysis of the concept of business model with a differentiation from closely related notions. Furthermore, their key

elements and components as well as business model reference frameworks are analyzed. Conventional and sustainable business models are discussed and especially the latter have a special significance for electromobility, as they already consider the environmental and social aspects. These findings form the basis for answering the questions whether the existing business models are sufficient for electromobility and give recommendations in order to design sustainable business models to support electromobility and its key values.

The literature review shows that academic literature focusses strongly on the individual company and its capacities and opportunities. However, it has been highlighted that a successful development of electromobility requires a whole ecosystem. To satisfy the key values of electromobility, products and services are needed which are difficult to generate by singular companies. Providers of mobility services, such as MaaS, can hardly own all means of transport, which is also not necessary for this purpose. It would also be difficult to make the necessary investments and to bundle the various job profiles in one company.

Another result of the literature research is that there are only few references on how the value chains of companies will change due to electromobility. Changed production processes and modified components mean that the value chains and the relationships between suppliers and manufacturers can change. Furthermore, high investments in research and development are still necessary to increase the range of the vehicle or the safety in case of accidents. Automobile manufacturers can avoid having to incur high expenses in their own companies by entering into new cooperations or supply commitments.

The results of the thesis which can be added to the academic literature show that the value chains of the companies change not only within the organization by the electromobility but relationships are formed to a newly emerging ecosystem of electromobility. Due to the complex requirements of customers in electromobility, companies would have to significantly expand their value chains both horizontally and vertically or they enter into an electromobility ecosystem where different products and services are available. The ecosystem of electromobility consists of different value chains that have the customer in focus. It can also be seen that the individual value chains are related to each other, as in the connection between electricity and charging stations. It shows that the performance of the entire ecosystem exceeds the sum of the individual contributions of all participants and

that the ecosystem includes companies from different industries. The success of the individual company depends on the success of the entire ecosystem: it increases its market share and profit through the added value provided together by the companies in the ecosystem. It means that the full sustainability is unlikely to be reached at the company level but can be expected at the ecosystem level, what questions the position of each actor and make the balance of power evolve.

The complexity of electromobility can modify the organization and structure of the stakeholders, which is not adequately analyzed in science yet. The need for an ecosystem for electromobility requires the adaptation of relevant stakeholders and can go beyond the boundaries of the company. This can have an impact on the product range, investors and workforce. It can also lead to possible cooperation and new relationships between the companies.

An additional outcome of the thesis is the necessity to companies to develop their business models to satisfy the key values of electromobility. New customer wishes and the key values of electromobility mean that not only products but also business models should be adapted for an environmental and social satisfying commercialization. Also, the dominance on the environmental component should be overcome because the social component is also needed and is elementary for SBMEMs and there should be no one-sided preference.

Another result of the thesis is the design of a refined framework for sustainable business models of electromobility, compared to the ones proposed so far in order to fully develop the dimensions of sustainable development. Three main elements come from the business model literature which are value proposition, value creation and delivery, and value capture as well as the environmental, social and economic dimensions from the sustainable business model literature. In order to satisfy the key values of electromobility, they are considered as transversal dimensions as they have to be kept in mind at each step of the process. This leads to interfaces between the different elements. An additional dimension to consider is the ecosystem of electromobility as a business model of electromobility has to be designed and assessed at this level. Also, further sub-columns are added. They correspond to the refinement of the environmental, social and economic dimensions in the field of electromobility, considering the need to satisfy its key values.

The Framework of SBMEM contributes to identify the significance and necessity of an ecosystem for electromobility and to define the perimeter of it. It is essential for

companies to contribute to the ecosystem in order to transform electromobility. In doing so, they must determine and adjust their contribution. This can change over time, depending on their own performance and the overall environment. When changing the contribution of the individual companies, it must always be considered that the ecosystem remains balanced and efficient or that the efficiency is increased in order not to jeopardize the overall implementation of electromobility.

As a further theoretical contribution of the thesis, it can be observed that the elements of traditional business models are valid but are not sufficient for electromobility to develop properly. To fulfill the potential of electromobility, environmental and social aspects have to be added to the economic one in sustainable business models. Therefore, the thesis shows that the traditional frameworks of business models are not sufficient for the success of electromobility. Also, relationships between the elements of the business models have to be changed in order to be able to satisfy the key values of electromobility at the level of a comprehensive ecosystem rather than at a company level. Moreover, when applying sustainable business models to the key values of electromobility, conflicting goals can arise that are difficult to resolve due to their direct assignability and cannot do adequate justice to the complexity of electromobility. As an example, the use of electric vehicles can be mentioned here. For environmentally friendly use, it is reasonable to charge the vehicles with green electricity, which is not available at all charging stations and the drivers are forced to drive detours for charging it. Another example is the higher purchase price of electric vehicles versus ICE vehicles for environmentally friendly transportation. In both cases, it is necessary to find compromises between the desire to drive environmentally friendly and economic in terms of affordable price. The interfaces between the basic elements of business models and the transversal dimensions enable the essential values of electromobility to be incorporated into the business model in the necessary detail. They provide guidance on how existing solutions and aspects can be modified or supplemented with the new dimensions.

The theoretical approach is tested with case studies and provides important insights by pointing out gaps and recommendations to close them. As a result, the theoretical approach of the SBMEM framework is confirmed and shows its applicability in practice. The case studies show that the strategies of companies are different in the fields of application of electromobility. For example, car manufacturers are trying to

satisfy the key values of electromobility through new technologies, but they are only succeeding to a limited extent due to the business models they have used so far which are aligned to the ones applied to produce ICE vehicles. Mobility service providers, such as MaaS, also have only a limited success because they cannot communicate the need for an overarching ecosystem to their transportation service providers and are more in competition than able to provide an environmentally friendly and socially compliant service. It is evident from all the case studies that the development and use of green products alone is not sufficient to achieve sustainable performance. It is necessary to adapt and redesign the business model as well.

As a further outcome, the thesis shows that missing business models can lead to the fact that today successful mobility companies in Europe, such as the car manufacturers, can lose their existing leading position and other companies and countries can expand by exploiting the opportunities provided by electromobility. This would result in a decline of a very successful industry so far with the risk of a loss of jobs and tax revenues in the affected countries. It should also be considered how long governments will subsidize electromobility. This may depend on the will of the voters as well as the funds needed for the subsidies. It is therefore necessary to make electromobility lucrative for companies and affordable for the population in the short term by further developing business models.

Also, in practice, existing business models are too limiting and may prevent long-term business success. Tesla, which is currently successful as a manufacturer of electric vehicles, limits itself to the development and production of vehicles in the same way that car manufacturers of ICE vehicles do today. Therefore, existing potentials are only insufficiently exploited. Tesla might find itself in the future in the same situation as manufacturers of ICE vehicles are in today. The solution could be to expand from an electric vehicle manufacturer to a mobility company that combines several products and services. Another example is zeozweifrei-unterwegs with its restriction to professional fleet cars or the still customer-unfriendly registration process with the need to appear in person at an authority.

Subsidies granted by governments give companies a time buffer to create and implement new business models. During this time, newly founded companies have the opportunity to develop technologies and products and establish them on the market with the framework of SBMEM. For this, they have the advantage that they

do not have to consider existing structures of suppliers, customers or their own workforce. However, a disadvantage is that new companies need to establish themselves in the market and require large amounts of investment capital. This can be an advantage of incumbents, as they still have revenues from the sale of ICE vehicles. However, barriers to restructuring due to electromobility are very high and will lead to traditional companies disappearing from the market because they cannot realize the transformation. One exception may be the public transport, which is traditionally subsidized by local authorities. For example, the state government of Baden-Württemberg, Germany, is currently considering setting up a mandatory tax on the population to subsidize local public transport (Schwarz, 2021). However, by sticking to existing business models, an elementary opportunity to turn loss-making public transport into an economically successful member of an ecosystem is being missed.

Due to the complexity of the topic, this thesis cannot address the exploration of the conditions and modalities of the transition to a sustainable business model. Also, the conditions for the ecosystem to fulfill more efficiently its goals should be more analyzed and possible adjustments to the framework should be examined based on lessons learned from additional case studies.

In other words, future research should further explore the conditions and modalities of the necessary transition from traditional mobility into electromobility. There is sufficient proof in academic literature that business models are to be considered as drivers for the development and commercialization of new technologies, but the process of transition are still poorly researched. The successful implementation of electromobility depends on whether companies succeed in expanding or replacing existing business models. In particular, research is needed into the interdependencies between value proposition and strategy, which can have a large discrepancy over time.

Another point of investigation is to explore the flexibility of SBMEMs, which are based on fundamental elements and are time-consuming and economically expensive to adapt. The goal is to design a method that allows for more flexible action at low cost and risk (Adams et al., 2012).

Climate change and unfair social working conditions are one of the greatest challenges of population in this century and must be overcome. One of the most promising options is the commercialization of environmentally friendly technologies considering social fairness and human working conditions. To avoid further state intervention that can prevent fair competition, designing new sustainable business models appears as one of the most relevant means in order to combine enough profit for companies to develop themselves and the satisfaction of the growing needs of the population as regards individual mobility, the preservation of environment and social fairness.

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Annex

A.1. Historical context of Sustainable Business Models

The world population is growing year by year and global development continues to accelerate also as economic growth increases. The consequences are increasing resource consumption and negative environmental impacts, which are becoming increasingly apparent. The result is that we are currently using the equivalent of 1.5 planets to satisfy our growth (World Wildlife Fund (WWF), 2018). These figures have led to a rethinking in the population, politics, and companies about the excessive use of the planet's resources. Today's sustainability debate grounded on the study "The Limits to Growth", published by the Club of Rome (Meadows, Meadows, Randers, & Behrens III, 1972), which is based on computer-simulated world model analyzing the interactions of key trends in scenarios: industrialization, population density, food resources, exploitation of raw material reserves and destruction of habitats and energy requirements. The United Nations Conference on the Environment in Stockholm in the same year and the establishment of an independent UN (United Nation) Commission ("World Commission on Environment and Development" ten years later have led to a sustainable change of thinking in the world. On basis of the Report: "Our Common Future" (Keeble, 1988), the new mission statement for sustainable development was pronounced. The content was a process that meets the needs of today's generations without risking that future generations will not be able to satisfy their own needs.

In 1972 the UN Conference "The Earth Summit" (UNCED, 1992) took place in Rio de Janeiro. It was the beginning of sustainability in the sense of a triad between economic, social, and environmentally friendly development. It entered politics and business and laid the foundation for the UN Climate Change Conferences that are still taking place today. The Kyoto Protocol to the United Nations Framework Convention on Climate Change ('the Kyoto Protocol') is a United Nations Additional Protocol adopted on 11 December 1997 with the objective of combating climate change. The agreement, which became effective on 16. February 2005 lays down for the first time internationally binding target values for greenhouse gas emissions in industrialized countries, which are the main cause of global warming. Almost all countries have ratified the protocol and thus committed themselves pursuing the

objectives of the Agreement. But one of the biggest economical powerful company, USA, has not ratified the agreement till today, and Canada announced its withdrawal from the agreement in 2011 (United Nations Framework Convention on Climate Change (UNFCCC), 2015).

In 2008 the initiative "Global Green New Deal" has started, which aims to promote sustainability as a driver of growth, whether qualitative or quantitative. „In a green economy, growth in income and employment are driven by public and private investments that reduce carbon emissions and pollution, enhance energy and resource efficiency, and prevent the loss of biodiversity and ecosystem services” (Yoon & Fang, 2009).

In social aspects, the Restriction of hazardous substances directive from European council and parliament has the aim, to restrict the use of ten hazardous materials in production of types of electronic (European_Parliament_and_Council, 2003) and is linked to the United Nation guiding principles on business and human rights that countries have the obligation to “respect, protect, and fulfill human rights and fundamental freedoms” (United_Nations, 2011)

The importance of sustainability is emphasized to the extent that it also affects developing countries. “Green growth is relevant to both developed and developing countries. For the majority of developing countries providing basic education, ensuring food security, and delivering essential services such as water supply and sanitation will remain overarching“ (OECD, 2010, p 13).

A.2. Sustainability from perspective of entrepreneurs

The basis of a systematic sustainability approach is a clear understanding of the benefit the company creates for the economy and society and where the actual value creation takes place. Therefore, the task of entrepreneur in the company is, to start a comprehensive analysis of the company's activities - including the entire supply chain and the entire life cycle of its products and services (Boons & Lüdeke-Freund, 2013). This holistic approach and a full picture of the value chain enable the entrepreneur to identify where it has a negative and positive impact, manage this accordingly and initiate targeted measures in the interests of sustainable overall development. With this approach, management can usually reduce costs in a short term, but an enormous innovation potential can also be unfolded, and risks identified

and reassessed. The fact that there is only one planet must be resolved and economic growth should be no longer the sole goal and the only objective for the entrepreneur. It is necessary for them to change the entire system, which today is based on an essentially linear value chain, in such a way that an optimal recycling economy is created.

Sustainable business models create not only opportunities but also risks for companies. Violating environmental regulations on exhaust emissions in 2015 (A. Goel, 2015) has led by mismanagement of the managers to one of the biggest scandals in the automotive industry, with disastrous consequences. Legal conflicts, litigation, reputational, market and social risks occurred. The full impact for the entrepreneur concerned and the economy cannot be assessed at present. The vision of the companies should be a waste-free economy, not using any materials that are harmful to health or the environment, and all materials being permanent nutrients for natural cycles or closed technical cycles.

The Entrepreneur has a significant competitive advantage if they also start an innovation process and address new services and products, change business models, or invent new ones that have environmental, social, and commercial objectives. A holistic approach to corporate management thus strengthens future viability in a radically changing world and creates intangible assets such as image and brand that are of great benefit, for example, in recruiting and retaining employees.

This situation can be explained using the example of mobility. Transport and mobility are responsible for about 25 percent of the world's human-induced emissions of greenhouse gases (WHO, 2016). This has catastrophic consequences not only for the environment but also for human health. According to an estimate from 2014 (WHO, 2016), about 1.3 million Chinese die annually from the effects of air pollution and micro pollution (e.g. diesel particles), which means additional health expenditure of about 1.4 billion US dollars. This indicates that car manufacturers and other mobility providers should make a significant contribution to find an overall solution for the problem. This, of course, cannot be done by the companies only, but requires politicians, government, and other organizations to cooperate. The study 'The Global Climate Legislation Study' by London School of Economics in 2015 (Nachmany et al., 2015) identified that the number of climate protection laws and

regulations has doubled every five years since 1997, forcing companies to adapt them to their business processes.

Sustainable entrepreneurs identify opportunities and take risks to make a real difference. They try to harmonize economic, ecological and social dimensions as far as possible and thus create additional benefit at the corporate, environmental and