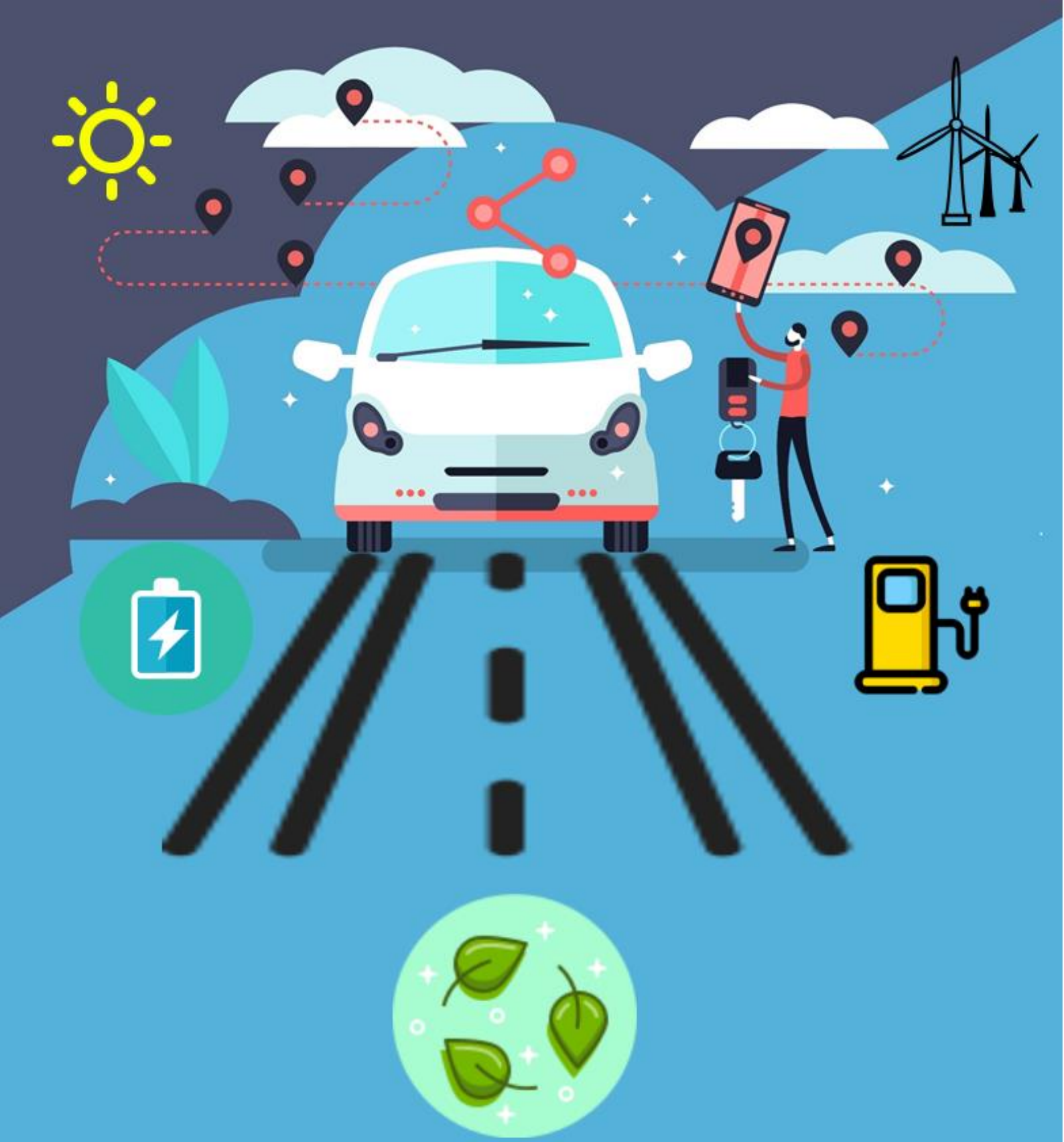

Free-Floating Electric Car Sharing as a Product-Service System Concept and Its Environmental Impacts

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Master Thesis of

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Abstract

The current system for passenger's road transportation cause environmental problems that are related to climate change, and this system is not the ideal option for a long-term use for the sake of the environment. The Paris Agreement, that aims to keep the increase of the global rise of temperature at 1.5 degrees Celsius, brings governments, companies and citizens together to find out new approaches for new systems that do not harm the environment. Therefore, car transportation based on owning cars – that brings unnecessary car per capita – needs to be re-evaluated by these actors. It emerges the question of functional use of cars, rather than owning. The free-floating car sharing system could be an ideal alternative to change the ownership, through the approach of Product-Service System. In addition, electrified cars emit zero air pollutants, while the conventional cars emit a lot, hence increase the cities air quality that harms people health and reduces the per capita CO_2 emission, hence contributing to the Paris Agreements and Sustainable Developments Goals' targets. That is why the aim of this master thesis has chosen to be the free-floating electric car sharing system and its environmental impacts.

While there are many challenges and opportunities from customers, governments and business perspectives for implementing the system efficiently around the world, there are good examples of this system in many cities, especially in developed countries. Even though companies and governments try for implementing the new mobility concept, the real challenge is changing the mind-set of people, which is about the car ownership' image among the society and not wanting to leave the comfort zone that private cars bring. In addition, a shared car can replace 7 to 11 cars depending on the cities, hence lower the environmental pressure of the transportation system, while around 95 percent of cars around the world are idle in average.

The new system also needs a strong relationship between the customers, the customer service and car manufacturer to ensure the ideal working mechanism that needs to be controlled by the governments. For the implementation of a new system, every actor has a responsibility by contributing his or her bests to achieve more sustainable transportation. From customer's complaints and compliments to more research and design processes by car companies, better customer service and more inclusive governments are the key elements for this implementation of Product-Service System.

Lastly, the Covid19 pandemic's impacts on trusting the sharing services also affected the study's direction for analysis and discussion, since people started to avoid common practices in order not to face with a dangerous virus that may come from using these sharing services.

Preface

This report has been conducted during the period of 15.06.2020 – 15.10.2020, as a product of master thesis of The Urban Energy and Environmental Planning Programme - department of Environmental Management and Sustainability Science at Aalborg University. It represents thirty ECTS of the study program.

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Mesut Yunal

15.10.2020

Abbreviations

BEV: Battery electric car

CO_2: Carbon dioxide

CO_2-eq: CO_2 equivalent

GHG: Greenhouse gas

ICE: Internal combustion engine

LCA: Life cycle assessment

NOx: Nitrogen oxides

PM: Particulate matter

PSS: Product-Service System

RD: Research & design

SDG(s): Sustainable Development Goal(s)

Keywords

Free-floating Electric Car Sharing

Product-Service System

Social Practice Perspective

Sustainable Mobility

Sustainable Development Goals

Contents

"There is nothing permanent except change."

(Heraclitus 535 BC - 475 BC)

1. Introduction

The popularity and the sales of electric cars are getting increasing around the world (Statista 2020). By definition, electric vehicles consist of the electric-based motor rather than an internal combustion engine and acquire their power from charging outlets to run, unlike oil-based cars (U.S. Department of Energy n.d.).

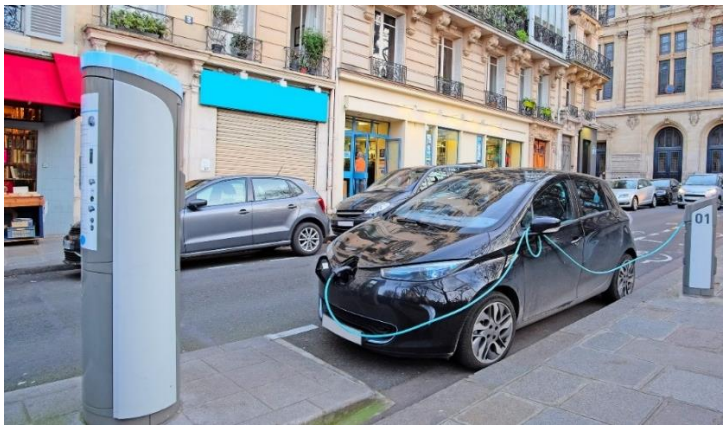

Figure 1 A Charging Electric Car on a Street in Paris (Colourbox#1354 2016)

The market share of electric vehicles is also increasing day by day in the biggest regions of the world. According to the U.S. Department of Energy, in the last 5 years, the market share of electric cars has changed in China from 1 percent to 5, in Europe from 1.3 percent to 3, and in the United States from 0.7 percent to 2 percent (U.S. Department of Energy 2020). The numbers are shown in the figure below:

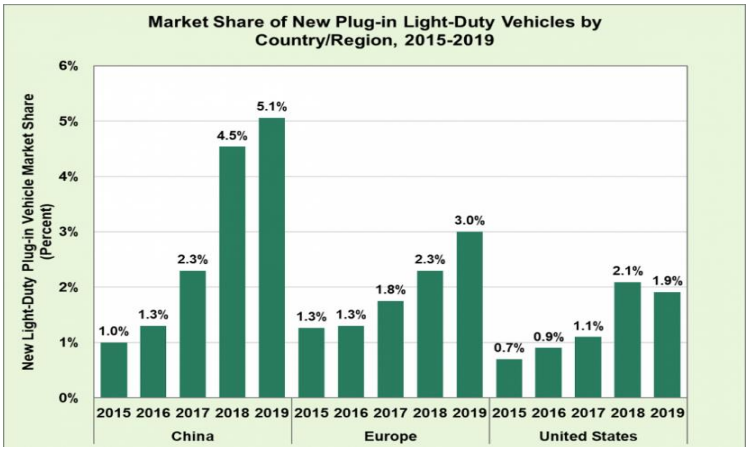

Figure 2 Plug-in Light Electric Vehicles' Market Share Statistics (U.S. Department of Energy 2020)

On the other hand, European countries have mostly taken the lead for the total electric vehicle sales, especially Norway leads this ranking with almost 50 percent of total sales within the

country, which means the sum of the following 7 countries' percentages that are Iceland (19.1), Sweden (8.0) Netherlands (6.7), Finland (4.7), China (4.4) Portugal (3.4) and Switzerland (3.2) (Routley 2019).

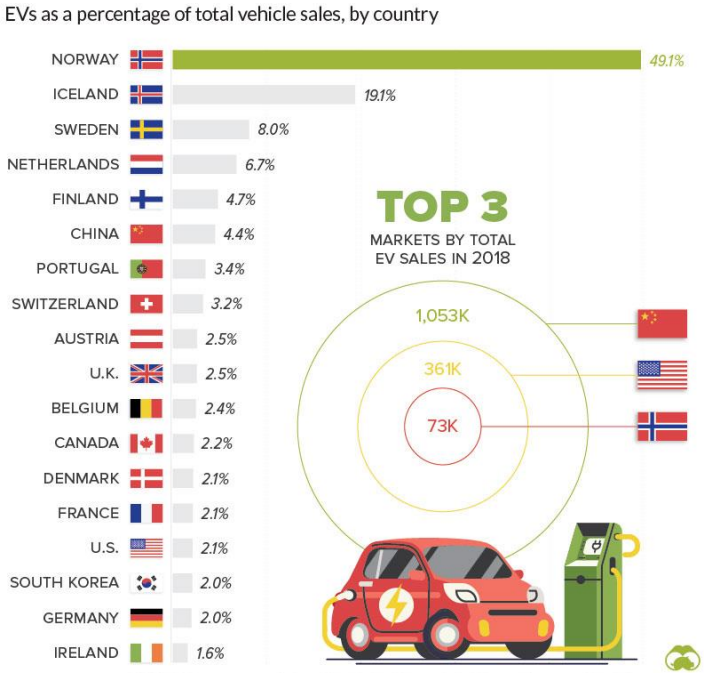

Figure 3 Countries that Sell the Most Electric Vehicles as Percentages and Amount (Routley 2019)

While countries tend to change their transportation habits and shift to using electric cars, one also needs to know the transportation methods of the citizens to grasp the concept's bigger picture. Cities with higher-incomes mostly (except Tokyo) incline to use private cars more often, compared to middle-income and lower-income cities in average, according to Rode et al. (Rode, et al. 2017) (see Figure 4). That is why it could be said that a shift in these cities' personal car transportation habits could make much more impact than in lower-income cities. For example, most of the European capital's citizens depend on passenger car transportation with at least 35 percent, while Canadian and Australian's cities this number ups to 70 percent. However, most of the African and Asian cities only rely on this method less than 25 percent (Rode, et al. 2017). The reasons could be many things, such as the desire of owning a car, lack or incompetency of public transportation, living in a huge city that public transportation is not enough etc. Bignami et al. state that in Italy, owning a car mostly brings more comfort and flexibility, and it is perceived as *good to have* by many people even though decent public transportation or other options with better performance, which is linked to socio-economic factor of wealth and psychological perception (Bignami, et al. 2017). However, since most developed countries in Europe are shifting to buy electric cars more; it could increase the sustainability impact capacity of private-owned cars more.

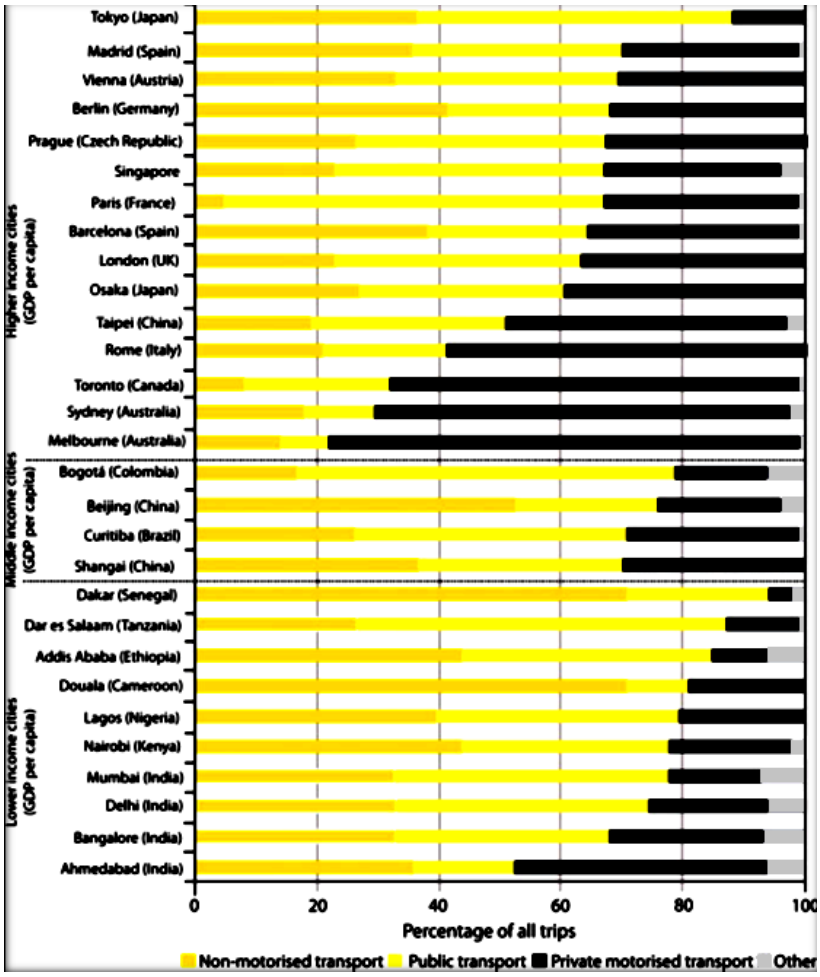

Figure 4 Share of transportation methods of different cities around the world, taken from (Rode, et al. 2017)

The figure above could be a starting point of where to develop a more sustainable transportation method with integrated public transport with possible solution mechanisms/characteristics of sustainable mobility, which is identified in the discussion section.

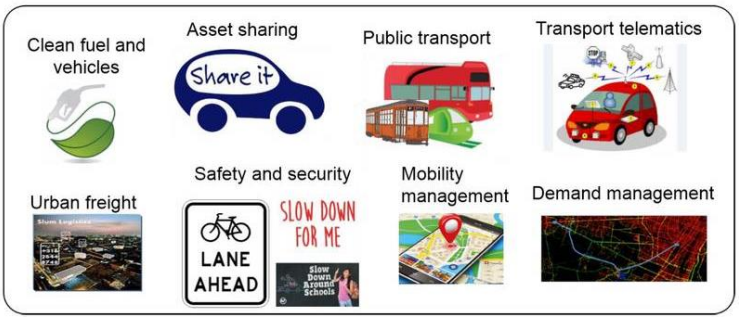

Figure 5 Sustainable Mobility Solutions (Rupprecht Consult 2016)

According to the figure above, there are many elements of sustainable mobility such as car sharing, public transportation, cycling etc. (Rupprecht Consult 2016); however, not every element is suitable for the *purpose of use* that private cars bring upon. Since the main issue is the passenger cars and their carbon emissions in this study, free-floating electric car sharing can be

seen as a substitute for using a private car, to transform to have more sustainable mobility via changing the ownership of the product.

The United Nations described the term of sustainability as "meeting the needs of the present without compromising the ability of future generations to meet their own needs". (United Nations 1987). According to Purvis et al., it has three pillars, which are economy, society and environment (Purvis, Mao and Robinson 2019).

Nonetheless, sustainability is a huge topic to assess and one cannot investigate every aspect of it as alone in a given time for this research. That is why just the environmental part had selected for this study as the main aspect; yet, some of the societal elements were also analysed.

From Walking to Using Car Sharing

Back in time, humans have used animals (such as horse, oxen) to transport from point A to B, and this situation has lasted a long time. After that, the invention of horse-drawn vehicles has taken it to another level, and a concept of vehicle sharing has started this way. By evolving technological advancement, Carl Benz finally invented the car in the mid-1880s (Daimler AG 2015), and things have changed for the road transportation of humanity. The first concept as modern car sharing had taken place in Zürich, in 1948 and its main point was to have an ownership share on a car, which was a luxury to buy at that time (Shaheen and Sperling 1998). After years, in Europe, the available cars in the car sharing market have risen to 15.6 thousand in 2020, from 0.2 thousand available cars in 2002 and day by day it is developing (Deloitte GmbH 2017).

Environmental problems that car ownership brings

As it is stated before, car ownership may bring different environment problems to the cities, and free-floating car sharing systems can offer solutions for those problems.

Firstly, the amount of cars per person seems to be the problem in the first place, and according to Bignami et al, a shared car could replace 7 private cars in average in Europe, and 11 private cars in average in the US and Canada (Bignami, et al. 2017). Therefore, due to the reduced space usage in the cities, traffic congestion can decrease and it can end up with lesser air pollution.

In addition, Best and Hasenheit state in their case study in Germany, car sharing has the potential to transform the energy outputs and GHG level, while it is a fast-shifting sector with many uncertainties (Best and Hasenheit 2018). It is because if the charger infrastructures are supplied

by the renewable energy, GHG level can reduce significantly, however not every city has this option for now (Best and Hasenheit 2018).

With the growth of new elements such as better infrastructure for mobility, innovative systems, seeing the cars as a threat for environmental and technical problems in the cities (pollution, noise, space) decreased the owned car per person, according to Bignami et al. (Bignami, et al. 2017). In the same book, it is stated that since the shared cars have lower lifetime due to intensive use, they need to be replaced more often, so that they will have better technology in terms of environmental performance (mainly for of non-electric cars) (Bignami, et al. 2017).

According to Ricardo Energy & Environment, the main air pollutants in European Union countries mostly come up as nitrogen-based with 36 percent and carbon-based with 19 percent, while the particulate matter (PM) is the third contributor with 11 percent of all air pollutants (Ricardo Energy & Environment 2020). It is shown in the figure below:

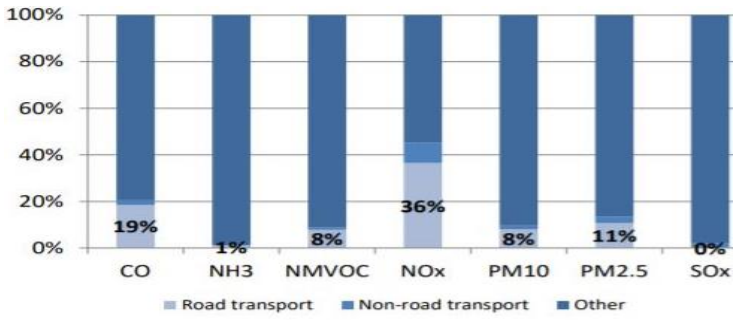

Figure 6 Road transportation's air pollutants, taken by pollutants (Ricardo Energy & Environment 2020)

That is why a new system for road transportation that could reduce these pollutants could be a way to solve some of the environmental issues in the cities. As it is given before, the era of the change for transportation with a personal passenger is at the door. According to Kunzty et al., in Germany, the new mobility concepts will surpass the conventional methods of railway, bus, tram etc. and reduce the use of individual cars, which is shown in the figure below (Kuntzky, Wittke and Herrmann 2013).

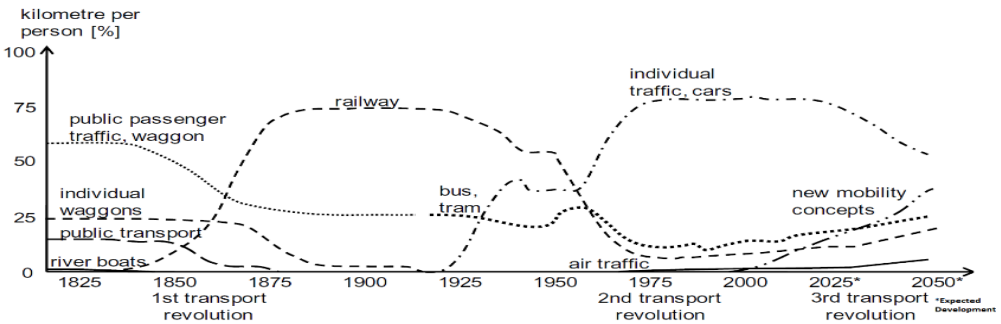

Figure 7 Transportation's development in Germany, taken from *(Kuntzky, Wittke and Herrmann 2013)*

It can be seen below that in some European cities, there are free-floating electric car sharing options (WeShare and Spark) for the current and future users:

Figure 9 Electric Car sharing in Berlin Streets (own picture)

Figure 8 Electric Car sharing in Sofia Streets (own picture)

The new approach of the product-service system for mobility

The development of new transportation systems for passenger mobility brings a term of Product-Service System (PSS) of mobility that consists of car sharing systems as a framework. For the purpose of this research, free-floating electric car sharing system was chosen to be the main subject. This system is a use-oriented system of PSS and allows its users to get benefit from the product (cars), and service (transportation) at the same time, (Tukker and Tischner 2006). Details of this PSS concept is given in the theories section.

In the concept of PSS, it can be said that companies also need to evaluate their business plans from selling, and leaving the responsibility of the product/service, to involve in all phases of these elements' functions.

However, the system of PSS may not be a good application in all phases of the concept. According to Tukker and Tischner, car sharing, the use-oriented system of PSS, may bring some negative issues such as not having the esteem and satisfaction of owning a car, control sense, freedom etc., (Tukker and Tischner 2006). These elements are also investigated through the research. The detail of this system is specified in the discussion part.

Car companies that offer the system

Many huge brands such as Daimler, BMW and Volkswagen offer electric car sharing around the world (car2go, DriveNow and WeShare platforms, respectively, but the first two have emerged for a new system called ShareNow) (Coates 2019). Their business strategy therefore has changed, due to the new system. Shifting from producing private cars to producing for car sharing systems is evaluated in the next chapters.

People's habits in terms of environmentally friendly action

In order to evaluate the system from the people's perspective, one also needs to see the people's decision-making mechanism in terms of shifting to environmentally friendly actions by choice (or mandating). Since it seems to be a more environmentally friendly and cost-effective action to use car sharing rather than private car ownership (Tukker and Tischner 2006), it can also mean leaving some of the standards of life by people that they were used to do. This approach was taken into account by the theory of Social Practice Perspective and the interviews. In the next chapters, detailed information is identified.

To sum up, the transition in the car/electric car ownership seems to be inevitable, and this transition needs more quality, user-oriented and with sustainable products/services to survive in the global market for the companies, while environmental impacts of cars are getting dramatic for the world. This is where the problem begins.

1.1 Problem

This chapter explains the problem statement and research question development, besides the analysis of the problem from a broader perspective.

1.1.1 Problem Statement and Research Question

Using private cars as a transport method is under pressure (some of the new generations see it as a burden e.g. fixed cost, maintenance etc.), which is why it is interesting to investigate some of the new solutions in the form of Product-Service Systems (PSS). PSS can help to solve this pressure to some extent and improve the car use's environmental performance at the same time. Much of the ongoing discussion for road transportation focused on the technical aspects of gasoline versus electric cars in the academia. However, this is a narrow aspect, which is why the aim here is on more systemic solutions such as car sharing, by focusing on electric cars. The possible solution mechanism and improvement methods of the environmental performance need to be investigated for the providers and users' perspectives.

From the given elements, the research question of the paper is being;

How can free-floating car sharing improve the environmental impacts of electric cars?

The subquestions of the research question are;

1) What are the characteristics of Product-Service System through free-floating car sharing?
2) How can the concept affect the societal and health issues within the cities?

The answers of main RQ and sub-question are given in the discussion part in detail, while the background information was elaborated through the theory and analysis chapters.

This concept emerged from the willingness to drive a car but not bearing the consequences of having a car like purchasing, maintenance, parking, and taxes. Its potential benefit of reducing the total vehicles travelling, since it is mostly done on purpose, meaning lowering the unnecessary car use (Barth and Shaheen 2015). It means that a different system could take place for cars using unlike the common buy and use systems.

That is why the given research question could be said that it is a valid question to investigate the "relationship between electric car sharing and its potential of bettering the environmental performance over the transportation with passenger vehicles" is an important issue to discuss from an academic perspective.

To summarize the problem formulation and research question development; firstly, the road transportation's impacts on global warming were the initial point of the problem, and a change was needed for the fossil fuel cars that emit GHG. In addition, the conventional ownership concept of cars was another issue that influences the total amount of cars on the roads, hence the pollution, land use, traffic etc. So that the electric car sharing systems could be a way to achieve more environmentally friendly transportation, alongside with PSS. The users of the car sharing platforms and providers of this system are the main elements to investigate in terms of the environmental-related activities/habits within the framework of PSS' characteristics, besides the societal and health issues. The mechanism is shown below;

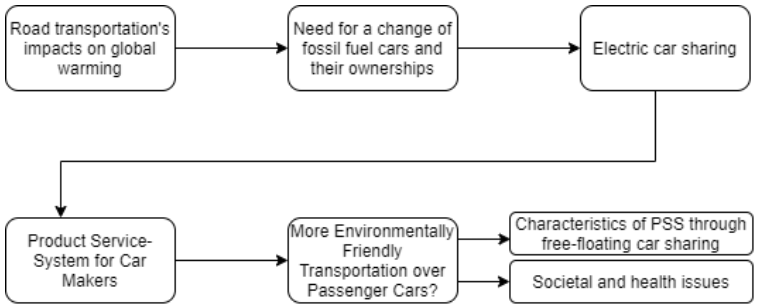

Figure 10 Problem formulation and research question development as a chart

The analysis of the problem is given in the next chapter.

1.1.2 Problem Analysis and the Broader Background

There is a term of the circular economy is described as keeping the materials and products in usage as much as possible, with the help of the design elements to get rid of pollution and waste in the system, according to Ellen MacArthur Foundation (Ellen Macarthur Foundation n.d.). Shifting through circular economy approaches could be considered as an important element for businesses to survive in the market. This transition and its relationship with keeping the businesses alive are given in the chart below, taken by Kristensen's master thesis from Aalborg University (Kristensen 2016):

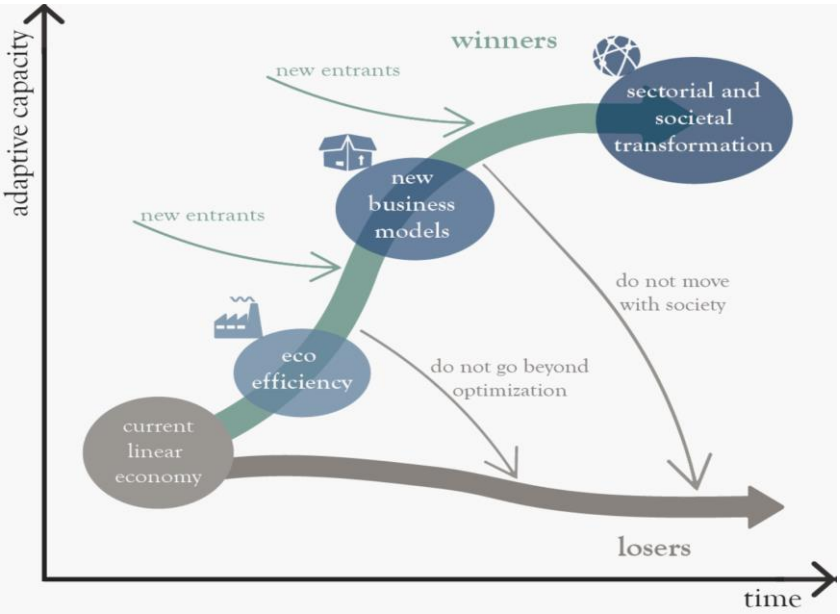

Figure 11 Shifting through to circular economy elements for businesses, taken by (Kristensen 2016).

To explain the figure, businesses and societies that do not follow the circular economy principles will lose by the time. However, the ones that follow those principles will adapt easier. Ecological efficiency for companies is crucial and with the new elements in the system, there could be innovative business models. These business models can survive in the market with the cooperation of the society, which they serve. The future (and the current) mobility systems need to be more sustainable with the help of circular economy and the societal practices that were investigated in this research. Since the automobile sector is a huge business everywhere around the world, it is also important to develop for this sector to be more environmentally friendly to comply with the goals of the Paris Agreement that is signed by the United Nations in 2016, which aims to keep the increase of the global rise of temperature at 1.5 degrees Celsius (UNFCCC 2016).. The image below taken from a report from Accenture consulting company describes the circular economy principles of the automotive business (Lacy, Gissler and Pearson 2017),

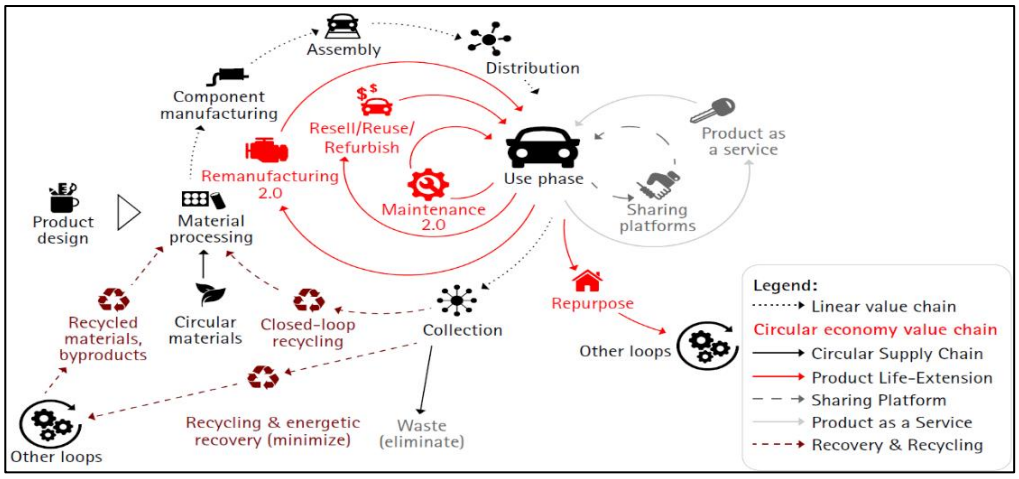

Figure 12 Circular economy of car production and service, taken from Accenture (Lacy, Gissler and Pearson 2017)

The figure seems to be complicated to comprehend the circular economy approach in terms of car production and service. However, the main elements to focus on are linear and circular value chain's differences. Firstly, the linear value chain's processes begin with product design and material processes, followed by the manufacturing of car components, assembly and distribution for the use phase. After the use phase, they are collected to be eliminated as waste. However, the circular supply chain is more detailed and complex. It consists of many other elements such as sharing platforms as a part of PSS (e.g. car sharing applications) and repurposing (e.g. using the old car's batteries for energy storage units). Moreover, in circular economy, there is no concept as a waste; every output is a part of another loop as an input (Ellen Macarthur Foundation n.d.). While users of cars can get benefit from the pay-per-use system instead of owning a car and bearing the tax, maintenance, parking spot problems etc., it could also be useful for the car companies' by using the materials for other processes as raw materials, so that everybody can win, like the environment.

About the impacts of car ownership around the world, according to Ellen MacArthur Foundation, in Europe, more than 90 percent of the cars are parked on average, and only 1.5 people in average are on the way (as driver or passenger), even though the cars have mostly five seats (Ellen MacArthur Foundation n.d.). This could make to question the *rightful consumption* of cars (Ellen MacArthur Foundation n.d.). The report also emphasises that, while 1 percent of people are in the congestion, around 1.5 percent is looking to park, and only the 5 percent is driving their cars (Ellen MacArthur Foundation n.d.). This element was discussed in the later chapters in detail.

This aforementioned brings up the emerging of a relatively new term, which is called sustainable mobility. Sustainable mobility is about the ability to access to mobility economically as a society while reducing the environmental effects of transportation, according to Ackrill and Zhang

(Ackrill and Zhang 2019). There are many different methods of sustainable mobility to reduce carbon emission. Feldman states that walking, biking, public transporting, electric car using, and car sharing are some of the elements of this concept (Feldman 2014).

On the other hand, PSS is also an emerging term in terms of more environmentally friendly approaches to achieve the goal of the Paris Agreement. According to Tukker and Tischner, product-service system (PSS) is a concept that changes the "standard way of doing business" by leaving the products or services' functional use to users in which the way they desire, in the idea of "useful purpose" (Tukker and Tischner 2006). It can be summarized as aiming to get the benefit of the function of the product/services instead of just owning the product/service by the customers.

About the PSS of car sharing, its meaning for the research is the free-floating car sharing by the automobile manufacturers such as Daimler, BMW and Volkswagen, since the impact of ownership concept are affecting their business strategy and environmental footprints significantly due the new responsibilities they acquire. Even though there are third party distributors that offers this system, the main aspects are not about them, because what they do does not have an impact as much as the environmental impact of car production and waste management have. This means that carbon credits for the production and the ownership that PSS brings to the companies for the after-use phase are significant parameters to assess the environmental performance of companies. (See the analysis and discussion)

To become more environmentally friendly in the transportation sector, individuals and products' carbon footprint need to be reduced. The way of assessing the cars' carbon emissions (or carbon footprint), one needs to investigate the CO_2 equivalent (CO_2-eq). The term of CO_2-equivalent measures the global warming potential of activities or products, which is shown as a metric system, which also converts the other types of gases to their carbon dioxide equivalent quantity (Eurostat 2001). This term also applies to different types of cars, to evaluate the potential of the greenhouse gases emitted for the entire life of cars. The figure below shows the CO_2-equivalent of different types of car types over their life cycle, with different city energy grids, from a study by Helmers and Marx (Helmers and Marx 2014).

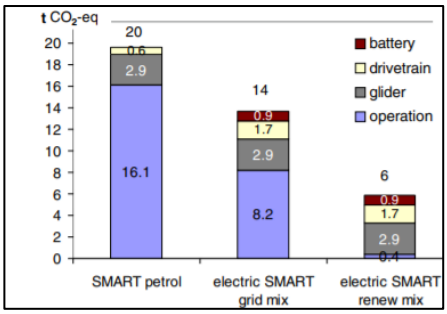

Figure 13 Life Cycle Assessment comparison of different types of cars, figure taken by *(Helmers and Marx 2014)*

On top of free-floating car sharing, if the vehicles in the aforementioned sustainable mobility system are electrical, there is the potential for reducing the carbon footprint per car's lifecycle in the use phase, compared to systems that use fossil fuel-based vehicles as it can be seen on the figure above. The reason for the huge difference is as the following; not every city has an electricity grid that comes from renewable energy sources yet, and they still mostly depend on fossil fuels to generate electricity. Therefore, the first two scenarios on the figure could be considered as the most common ones in the world, and the operation part (use phase) of cars is the most polluter part for the environment with 16.1 percent and 8.2 percent, respectively. That is why a new mobility approach (PSS of electric cars) that can decrease the impact of the use (operation) is worth to investigate, because of the potential of the new system that can bring the environmental emission reduction.

In essence, petroleum cars are the most polluter ones with a conventional city grid, while the fully electric cars with the renewable energy grid are the least polluter (Helmers and Marx 2014). However, the real change can happen in the cities that do not use renewable sources for its city grids by changing the grid to a renewable one.

Even though manufacturing of electric cars battery is energy-intensive, in the long term, electric cars are responsible for less carbon footprint in total, thanks to the use phase (Petrauskiene, Skvarnaviciute, and Dvarioniene 2019), (Helmers and Marx 2014). Especially, if renewable energy sources are used in the city, the carbon emission level of electric cars reduces severely (Helmers and Marx 2014).

Thus, a car sharing system that consists of electric cars could be more environmentally friendly (depending on the city's electricity grid), so that it could be a way to achieve Paris Agreement targets. Within the light of this goal, since it is also getting more and more profitable for the supplier, and getting more integrated and convenience for the customers, many companies are involving to this system of free-floating car sharing, e.g. Daimler (also known as Mercedes-Benz), BMW, Volkswagen, etc., (Guilford 2016) (Coates 2019).

The figure below explains this current free-floating electric car sharing system, inspired by a WeShare car sharing platform (WeShare 2019).

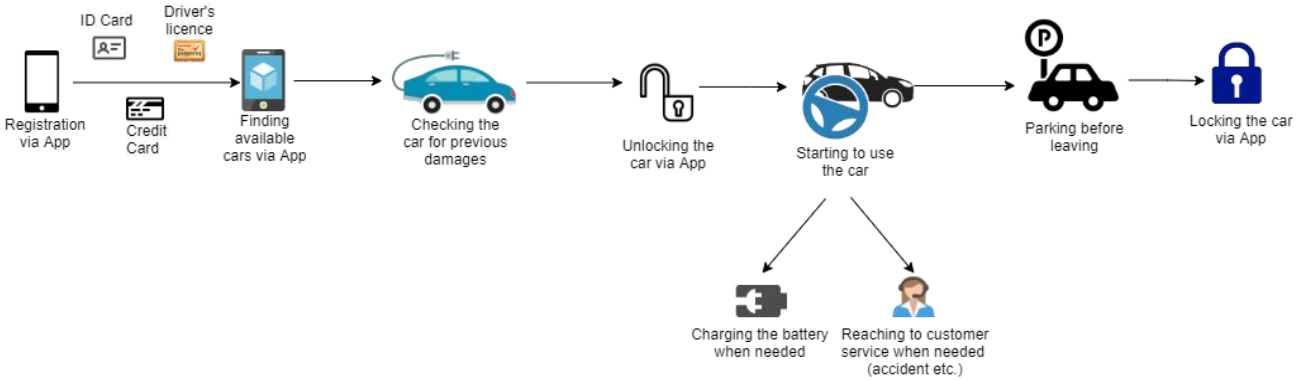

Figure 14 Simple chart of using electric car sharing system (own figure, inspired from WeShare's tutorial *(WeShare 2019)*)

According to figure inspired from WeShare electric car sharing application (WeShare 2019), in order to use this system, firstly people need to upload their ID card, driver's licence and credit card's picture to the mobile phone application of the system. After the registration, via using a smartphone with internet access, people can see where the cars are around the city, so they can go, and start to use the car by unlocking it via application, after they are sure the car has no damage from the previous customer. When the battery needs charging for energy, customers can use the electric chargers along the cities freely, and if an accident or undesirable situation happens, they can contact customer service through the application. After the use, they need to park the car appropriately on designated parking spaces and lock the car via the application. Customers must leave the car charged until a certain level to avoid fees, so that the next customers can use the car at least until a certain place/charging units. Other companies' applications are also similar to this process.

In addition, Volkswagen press release states that it only takes 45 minutes to charge the 80 percent of the battery (Volkswagen 2019). It means that people can even charge it while in their lunch/dinner times to avoid extra waiting.

This concept has many advantageous points according to Daimler AG, as free-floating car sharing benefits compared to private cars are shown in Table 1 (Daimler AG 2016).

Table 1 Differences between private cars and free-floating car sharing, taken by (Daimler AG 2016)

Facts about private cars	**Facts about Free-Floating Car sharing**
They are mostly not used due to the owner's activities (sleeping, working etc.).	Possibility of using cars more efficiently in general.
Being having to pay fixed costs even when not using (taxes, tickets).	Since the payment includes the possible maintenance fees, customers will not be surprised with the bill.

People cannot act spontaneously, since they depend on their cars. (e.g. not wanting to leave the car at somewhere, because of needing to take it back later)	It allows people to act spontaneously and freely. (they can basically leave the car wherever they want in the allowed zone)
The amount of passenger space is not changeable.	It allows people to choose the car type they need (e.g. two-seater or five-seater).
They are a burden to city traffic and to the environment.	Since cars are used only when they are needed, it has a possibility to reduce the traffic. Also, when electric cars are used, it has the potential to reduce carbon emission and air pollutants.
They restrict other family members' car use if there is one car in the family.	Everyone can use it at any time when the service is available in the region.
Parking may be a huge problem, if a personal parking space does not exist.	There are more arranged parking spaces for car sharing companies' fleets due to some agreements (with municipalities, universities etc.)
Having a private car brings responsibilities in many ways (buy/use/sell phases)	People do not need to be responsible of cars except for the use phase.
Sometimes, when people need privacy while driving, they may not have the experience they want.	People who need their private time while driving can easily have it.
When other transportation methods are needed to use (e.g. plane or trains), people may not bring their cars to avoid parking fees in the airports etc.	Due to connected mobility, it allows people to have cars almost everywhere (in specific regions).

From Table 1, it can be seen that car sharing has many advantages compared to having private cars. Nevertheless, the real problem could be considered as the GHG emissions that conventional cars emit, in terms of environmental issues. In addition, inner-city traffic that pollutes the air due to NOx (nitrogen oxides) and PM (particulate matter) come from the non-electric cars and the noise (Filho and Kotter 2015) are not hand-in-hand with sustainable society because of the congestion and health issues (United Nations n.d.). These environmental problems and their possible mechanism to solve were given in the discussion section.

The difference of free-floating car sharing compared to other sharing systems

On the other hand, free-floating car sharing has many differences than car leasing/rental services those are other concepts of utilizing a car without owning one. To begin with, free-floating sharing offers more flexibility thanks to being not binding for a long term unlike the leasing or rental cars. For leasing, one needs to sign a contract for a particular amount of time to use the cars and pay the charge whether using or not using the car, and it is mostly for a long time like 3-6-12 months or years, and one also needs to have a good credit score to get it for private applications (Carbary 2019). These whole processes could seem complicated compared to a free-floating system. About the conventional car rental, people need it for a mostly planned trip for a day or a week for their leisure activities (to use it on vacations, from airport to city or vice versa

etc.) and also one needs to pay for the whole rental duration mostly, but there are also companies that offer to charge per kilometre (Sixt SE n.d.). However, people's knowledge about these options is mostly wider than free-floating electric car sharing platforms, due to their history (Tournier 2017).

A new possibility of experiencing electric cars for citizens

Furthermore, Funke et al. state that the electric car sharing allows people to be acquainted with electric cars that are normally not very accessible for public use for the time being without having financial consideration, besides electric cars help to targets of emission (Funke, Gnann and Plötz 2015). So that some prejudices can also be overcome by the public, to achieve more sustainable mobility. Because, the customer side of the system is also important and the people's approach to this new concept could affect the system from top to bottom. To evaluate that, Social Practice Perspective (SPP) involves in the project, in terms of the society's habits and thoughts about the concept. Smolka from the State University of Campinas explains the human's practices based on different conditions that they have faced in her review of "Activity Theory and Social Practice", by indicating that if there is a need for an investigation for a new activity theory, one needs to focus also on social changes (Smolka 2001). That is why the SPP could be a decent way to investigate people's actions for electric car sharing system use.

Conclusion of introduction

This study aims to evaluate the potential benefits and drawbacks of shifting to using a free-floating electric car system (as a concept of the product-service system) as a society, in terms of the environmental consequences (by focusing on footprints of users and providers). The challenges and opportunities of transitioning to this system were evaluated as the system's characteristics. While the focus is the new ownership concept of cars and its environmental impacts on the climate especially in the use phase (due to the potential of decreasing emitted GHG and air pollutants), the other types of environmental-related issues were also discussed (public health, repurposing of materials etc.) from people's and company's perspective.

2. Methodology

Methodology chapter aims to explain the research methods for answering the given research question and sub-questions.

2.1 Aim and Scope

The reason for choosing the free-floating car sharing as a scope rather than other car sharing applications is related to the purpose/function of transportation. This concept is different from

other popular transportation applications of ridehailing (e.g. Uber), or ridesharing (BlaBlaCar), because, the customer is the driver in this concept, unlike the previous examples that would affect the study's direction. In addition, instead of private cars, public transportation, walking, biking, taxi could be used, however, it is too hard to evaluate these cases and make a comparison with private car ownership.

The electric car sharing system was chosen because of its capacity of contributing to fight against climate change, unlike petroleum cars. As aforementioned, the cities with renewable energy grids – and use this energy for the vehicle's fuel needs – can show better results in terms of GHG emission.

That is why; the range of this research is mostly limited to free-floating electric car sharing systems.

2.2 Philosophy of Science Approach

Mainly, there are three methods of reasoning for scientific research, which are inductive, deductive and abductive reasoning, according to Nandasena et al. (Nandasena, Silva and Kumara 2018). These methods could be explained as given in the table;

Table 2 Three main scientific reasoning methods

Method	Description	Example
Inductive reasoning	Creating a statement of an abstract that is based on a limited amount of parallel observation in an experimentation (Nandasena, Silva and Kumara 2018).	E.g. seeing that a healthy bird (not a cripple one) has two wings. After the second, third and hundredth times seeing that healthy birds have two wings, one can generalize that all healthy birds have two wings.
Deductive reasoning	Getting to a specific conclusion that is based on a general statement (Nandasena, Silva and Kumara 2018).	E.g. learning that when cell phones receive a call, they ring/vibrate. After that, one can say that if he/she calls a friend, his/her friend's phone will ring/vibrate.
Abductive reasoning	Generating a new form of a reasonable idea by being creative and/or intuitive approach with some partial testing and/or experimentation (Nandasena, Silva and Kumara 2018).	E.g. if a person A says his only laptop is stolen, person B thinks that person B does not have a laptop anymore. After some time, when person B sees the person A with a laptop, person B can think that person A got a new laptop or he borrowed it from somebody, rented etc.

It can be seen that inductive reasoning is creating a form of ideas thanks to experiencing some of the evidence and generalizing that *this idea is right* for all similar situations. The deductive reasoning is specifying a general idea to smaller examples. Even though there are some of the examples in this research based on generalizing or specifying, the main reasoning method is the abductive one, which is generating a new form of a meaningful statement with the help of experiments, data collection and theories. In addition, going back and forth between these

elements, a better solution for the research question's answering had been made by the author. Analysis and discussion were made through the abductive approach by putting the theories, collected data and background information into a framework.

2.3 Research Design

This research aims to fill the gap in the literature that is mostly conducted with conventional car sharing systems, by increasing the knowledge about the free-floating electric car sharing systems and beyond. The motivation for the research was the author's personal interest and previous professional experience in the automotive sector. Furthermore, the increasing researches in the area of product-service systems in the mobility sector affected the study's motivation positively. The main processes of the research are given below;

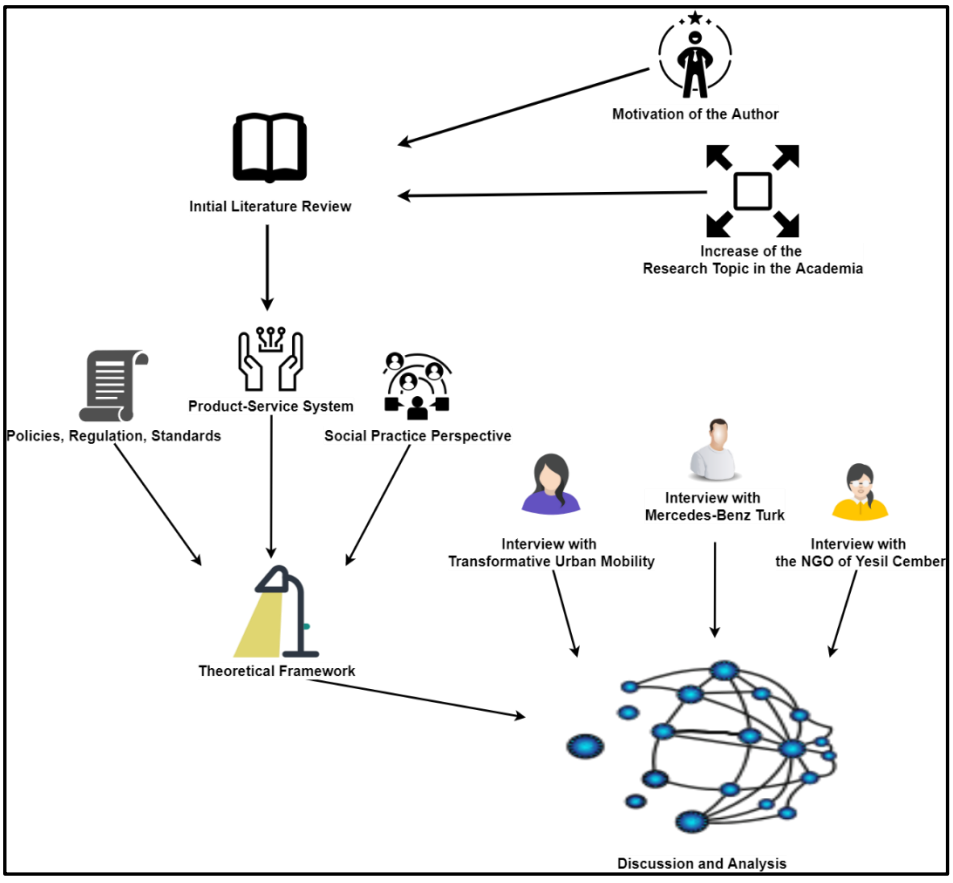

Figure 15 Research Design

The research design starts with the motivation that was collected from previous experiences of the author in the automotive sector, besides another factor of increasing studies about the subject (electric cars and car sharing in general) in the academia. So that the initial literature review has conducted to see what type of subject to focus on to limit and frame the research. The PSS and SPP theories were found to be interesting to investigate within the functionality of the free-floating electric car sharing, while the policies, regulations and standards also were important to

implement this system into the cities. By systematically thinking and researching of what to include from the theories for the main purpose of the research, by going back and forth between the well-known authors' journal articles from Web of Science and Scopus, company reports, related webpages, besides with the help of interviews and online third party video talks.

It is an abductive approach to reach the analysis of the study, since what has been done was not a specifying or generalizing, mostly; but there is creative thinking and trying to reach to best available solution for the research question. Hence, it could be said that the approach is an abductive method to reach the data. To put the detailed literature sampling into a framework, it can be said that it comes from the Seven-Step Model. This model is summarized as 1-"exploring the beliefs and topics", 2-"initiating the search", 3-"storing and organizing the information", 4-"selecting or deselecting the information", 5-"expanding the search or including more (**m**edia, **o**bservation, **d**ocuments, **e**xpert, **s**econdary data → **MODES**)", 6- "analyse and synthesize information" and 7"present the report" *(Onwuegbuzie and Frels 2016)*. The figure below shows the connection between the steps;

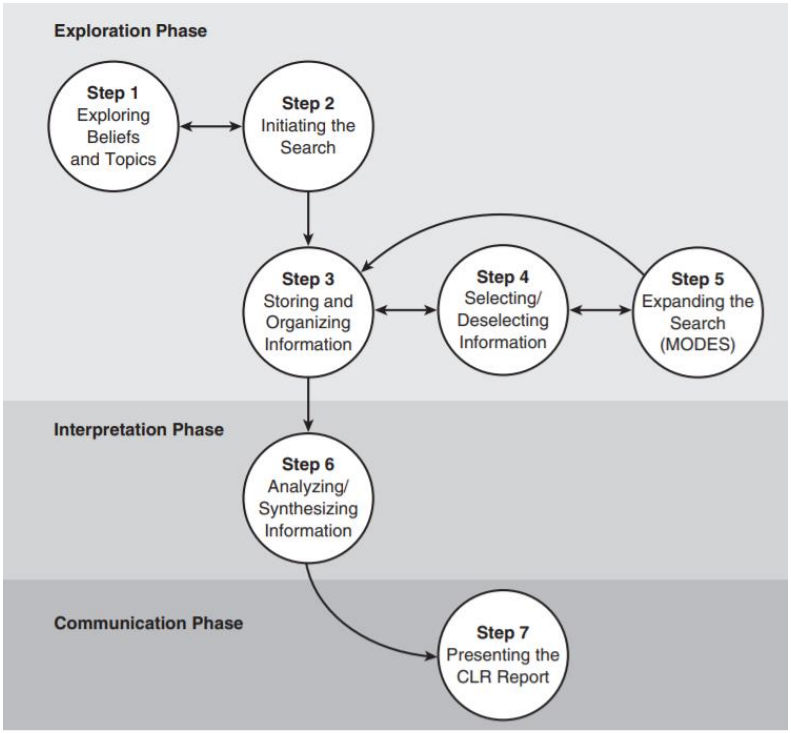

Figure 16 Literature review processes, taken from (Onwuegbuzie and Frels 2016)

Exploration phase starts with the topic and beliefs of the author, which are the electric cars as a new system in the mobility. The sharing system could be a game-changer in the industry from that perspective. Secondly, the search has begun to find more about the topic. After enough secondary data was found, storing and organizing the data is the next step, which is clustering

the theories and concepts (the PSS, SPP, SDGs, LCA, policies etc.) in different folders in the computer so that easier accessing could be assured. To begin with these theories and concepts, PSS was the frontier of all. It opened a gate for the other theories and concepts, once the literature study has made. This way, SPP theory was found because of the necessity of investigating the people's habit for a change in ownership concept that PSS offers. In addition, SDGs were hand-in-hand with the circular economy framework, which the PSS is also a part of it. The subjects in SDGs directed the study to investigate the LCA of engines of cars (electric vs internal combustion). Afterwards, it ended up with investigating the policy of car production and carbon market. As stated in the figure, the necessary information has taken from those documents as the fourth step during the writing process, then, more possible MODES (media, observation, documents, expert, secondary data) were found to improve the study as the fifth step. It includes the interviews conducted by the author and online open sources video interviews as well. The last three mentioned steps are interconnected with each other to access the most beneficial information by going back and forth in-between them. By checking the interview transcription and translation processes in these steps via abductive reasoning, logical elements were chosen to include more. The next step is analysis and information synthesizing, as the subchapter of the interpretation phase. Here, the findings were given in detail in relationship with the theories and interviews. The real connection has created for answering the research question and subquestions. Lastly, the report was sent to the digital exam platform of the university to be presented later as communication phase subchapter.

2.4 Data Collection and Literature Study

The research has been made through a qualitative literature analysis (as secondary data collection) of the challenges and potentials of free-floating electric car sharing as a PSS concept within the framework of environmental issues (mostly GHG and secondly the societal perspective), Afterwards, the empirical data was collected through interviews (primary data collection). The research analyses and discusses the given concept, to improve cars use from the systematic aspect, as means of transportation as a function and its environmental performance (CO_2, air pollutions, remanufacturing etc.), based on the collected data.

The reasons for chosen theories & concepts of PSS, SPP and policies were the to analyse the free-floating car sharing system in the framework of company and user's perspective to understand the impacts of the system's environmental and societal (to a certain level) impacts. The PSS was used to analyse as the main theory, specifically for describing the system's ownership approach and its shifting situation by sharing cars. This brings many different

responsibilities to producers (e.g. maintenance, fuel, customer service, research-design etc.), while taking many responsivities from the car users (fixed costs like maintenance, taxes, insurance, and others like parking, depending on the cars etc.). It explains the interdependent relationship between providers, customer service and users. The shifting of ownership mechanism needed to be analysed through a related theory, in this case, it is the PSS. SPP on the other hand is needed to identify the use-pattern of mobility solution by the users, technology adaption, acceptance mechanism among public etc. Policies and regulations were important to understand to the applicability of the system from the carmakers to join system (incentives or mandatory approaches etc.), and for the city's perspective (integration with public transportation, emission laws to improve the air quality, traffic planning etc.).

To access to literature, keywords of "free-floating electric car sharing", "product-service system", "sustainable mobility", "social practice perspective", "sustainable development goals", and "life cycle assessment" concepts have been used through the research. Scopus and Web of Science journal search and indexing databases were used. Google Scholars page was used to make ranking the articles by their citation amounts to reach the most cited journals to assure better credibility for the research.

Interviewees were the author's first contacts whom he worked/cooperated with before, during his internships and professional experiences. They were chosen based on their roles in their companies. Mr. Ediz from Mercedes-Benz Turkey is the manager of the supply chain department, and the Ms. Aksoy from environmental and waste management department in responsibility for waste management of the vehicle components. Ms. Aksoy's interview is planned to conduct after the submission, and it will be used during the presentation of the project. Their knowledge about sustainable mobility and electric cars through the company, and waste management was useful for this research to evaluate the car industry's outputs for the PSS of electric cars and their afterlife phase. Ms. Aydogan from Yesil Cember GmbH is the project leader of the NGO in Berlin, and she was contacted because of her knowledge about sustainable actions and tendencies among the society and her knowledge was used to evaluate SPP theory. Ms. Sensoz, from Transformative Urban Environment Initiative – a German governmental transportation office, was chosen to understand the cities' dynamics by shifting to free-floating electric car systems in terms of sustainable mobility planning. Her knowledge also contributed to SPP theory. The interview guidelines are given as appendix at the end of the document.

In addition, interviews from different YouTube channels with electric car sharing companies' authorities and private customers' reviews also watched by the author and necessary statements

were taken. These channel's interviews and reviews consist of e.g. the CEO of ShareNow – (Daimler's car sharing app), CEO of Catch a Car (A Swiss car sharing start-up), product manager of Alphabet International (a consulting firm for car sharing applications), environmental manager of Düsseldorf city and many other individual customer's channels. It is needed to say that some of these channels could be biased, or may have attempted to promote the product/system; however, the interpretation of these data has been carefully taken into consideration during the importing of data process.

As the author, I need to say that in an ideal world, the interviewees could be the head of environmental and/or mobility departments of Daimler, BMW or Volkswagen car companies that are the leaders of the (electric) free-floating electric car sharing sector. Additionally, a commissioner from European Union bodies e.g. The Directorate-General for Environment could be nice to interview with due to her/his knowledge about the European policymaking and the incentive mechanisms for the car manufacturers. For the sustainable mobility perspective, a city's head of environmental planning department could be ideal to have an interview due to her/his project implementation within the city. These cities could be Berlin, Oslo, and Amsterdam etc. because of their developed electric car sharing systems. Nonetheless, the current interviewees were also capable of answering the author's question in general; the research completed its goal by interviewing with those people.

Lastly, for the drawings, "Draw.io" website has been used to simplify and illustrate the concepts.

2.5 Delimitations, Barriers and Uncertainties

This research has conducted with only via the author's initiative, not a company or institution gave any foreground data to him. That is why it is mostly a literature study except for the interviews. Since this research has not made in a particular city, it could not be considered as a case study, which is why the results may differ a lot from users to users, or from company to company, depending on the city/country. However, the research can offer an avarage solution mechanism for an average European city.

As free-floating electric car system is not truly wide around the world, though there are some applications in some developed cities, it is an emerging system, which its users are limited with these cities' population. That is why it could be not fair to generalize the results to every city or country. Infrastructure still needs some improvements to assess it coherently.

Therefore, the study is limited to conceptual change about the electric car sharing's potentials in terms of the environmental outputs by the people, companies and governmental bodies.

Policies around the world for the electric cars and car sharing applications are still getting developing, some municipalities even have some agreements with the companies about parking, charging infrastructure and connected mobility. However, they are not finalized to analyse them more efficiently.

On the other hand, hygiene of cars' interior could be a barrier for users to choose this system, since especially as of 2020; the COVID19's pandemic effects are getting dramatic for the world. However, people can still choose car sharing platforms over public transportation to avoid crowded metro wagons. Some people may not want to participate to use of the free-floating car sharing system due to this problem in the short-term.

The electricity grid of the cities that have an electric car sharing system also differ the results of CO_2 emission per car in its life cycle, especially in the use phase. That is why it could be hard to say how every city will be affected by this change results. Besides, LCA has not conducted, only the literature review has made, and the necessary information has taken, for readers to understand the concept.

The study mostly focuses on the use phase of the system, not the manufacturing or disposal phases; however, some of the outputs correlates with these phases (production restriction of petroleum cars, remanufacturing, remarketing or reuse), especially from the company perspective.

3. Theoretical Framework

To understand what to expect from the research and how to build/limit the connections between investigated subjects, the theoretical framework is the key element.

To understand the framework, it is also important to know the relationship between the main actors of the system of car sharing. It is important to state that mobility as a function (in this case the PSS of electric cars) was taken as the main element of the framework, which means the flexibility and integrated systems are taking place within this approach. It is not just about changing from petroleum cars to electric ones; it is about a whole system change via the shifting of the ownership of the product systematically with the actors, and its impacts on the environment.

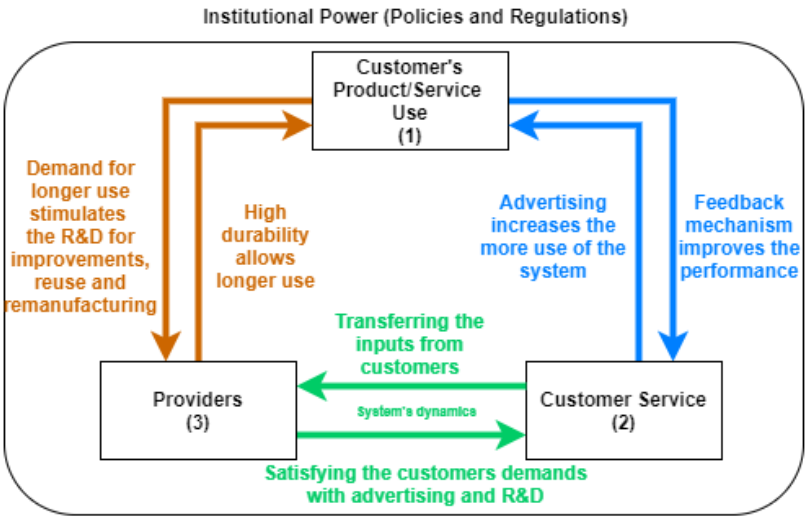

Figure 17 theoretical framework of the study, credits to (Nishino, Takenaka and Takahashi 2017)

The figure describes the relationship between the customer's product/service use, customer services and providers, inspired from Nishino et al. (Nishino, Takenaka and Takahashi 2017). According to the figure, the theoretical framwork could be described as the following; the more research and design (RD) ensures the more durable/trustable products/services, besides the reuse and remanufacturing of used cars, so that cars or car parts could be used as long as possible. The RD also emerges from the consumers' demand, since they would like to use the PSS' item as long as possible when the product/service is convenient for them. The same approach is applicable for the customer service in terms of the car sharing service's improvement via the feedback mechanism, and the customer service is the party to make the most of the advertisement part to the customer to use it. Between the providers (car manufacturers) and customer service of electric car sharing, there is a relationship that also dependent one another, since RD takes the inputs from the service, and give them back as improved outputs as advertisement and RD.

Whole PSS approach is about giving and taking information in-between these three elements of the customer's product/service use (1), customer service (2) and providers (3), in terms of free-floating electric car sharing process. To explain the framework in detail;

Firstly, from the relationship between the first two could be summarized as the following: if there was not any customer service, there could not be any feedback to take from the customers. The customers could share their experience before or after the use of the service to improve it by the app's feedback option or e-mailing/calling options of the customer's service department. This way, customer service's existence is needed to embrace, the customer's complaints or compliments directly about the mechanism, to see what could be improvable, and what is

satisfying about the service. For example, it could be also about to implement a system of integrated public transportation that could better the service use in demanded areas. This could trigger customers to use the system more often and more conveniently. So that the environmental performance could be also improved.

Secondly, the relationship between the second and third, customer service transfers the inputs from customers to providers and visa-versa, in this case, the car manufacturers, to design the service more user-friendly. The better-designed service could be advertised to customers via customer services and this shows the interdependent relationship of the two of them. This could influence the environmental performance of the manufacturers directly. Since the system's dynamics can change in any cases with the new improvements or bugs, this relationship needs continuous interaction. The ownership of vehicles by the company needs a strong take and back process in-between these two.

Lastly, the first and third ones' relationship, since customers would expect cars to be more durable, with more range, more environmentally friendly or more seats options etc., it could also affect the research and design process of cars' materials and efficiency. Customer's demands about the car's performance could increase the RD of car manufacturers in terms of more durable, more environmentally friendly options, etc., so that the RD could increase the products' performance, whilst seeking for options about reuse/remanufacturing/remarketing of cars and car parts. Therefore, this relationship could also assure the longer use of the product and service in the sake of the environment.

All three elements are also controlled and driven by governmental policies & regulations. It is because to assure the service is not harming any citizens, company and environment, while being beneficial to these parties. E.g. when companies serve a poor service that is not related to the customer's fold, it needs to be controlled and punished by the law. Alternatively, another example of governmental bodies' inclusion could be related to incentives that the company can get by implementing a sustainable solution.

Therefore, a system change – that encourages using and serving more environmentally friendly and flexible mobility – needs to be done systematically within all the actors to avoid any unwanted results that the shift may bring upon.

Nishino et al. claim that the demand from the customers based on their wishes for the product (intention of use, lifestyle etc.) also influences the RD and production volume (that is expected to be decreased due to sharing services) (Nishino, Takenaka and Takahashi 2017). In addition,

the *functionality* could be considered as another important element for PSS. Nishino et al. state that companies need to focus on the functionality of their products/services, and make them more durable to avoid any inconveniences that could discourage the customers, since customers are going to demand to practise new applications with good quality to use via sharing services (Nishino, Takenaka and Takahashi 2017).

3.1 Product-Service System in Framework of Car Sharing and Sharing Economy

Well-known authors for PSS of Tukker and Tischner assert that there are different types of PSS, which are given in the figure below (Tukker and Tischner 2006);

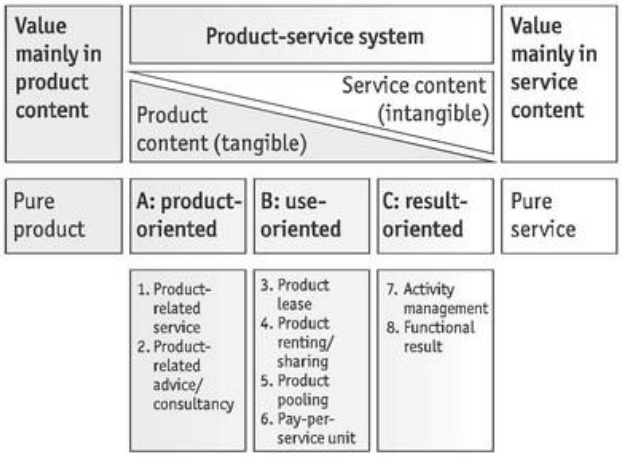

Figure 18 Product-Service Systems as concept *(Tukker and Tischner 2006)*

The figure above shows that there are three types of PSS, as the product, use and result oriented (Tukker and Tischner 2006). To decide on what type of PSS the free-floating car sharing system is, one can say that sharing is the main objective of the car sharing system, besides that car sharing is also a pay-per-service system, it is a mix of product sharing and pay-per-service concepts. For the purpose of this research, free-floating electric car sharing is a system that is use-oriented and allows its users to get benefit from the product (cars), and service (transportation) at the same time, as it is given in the middle of the pure product and pure service systems. While the cars are the tangible part, transportation service as the function is the intangible element.

It is needed to give example for each process of PSS for readers to understand the theory well. Firstly, for product-related service (1), the example of supplying ink cartridges belongs to this element, due to the take-back agreement when product is not functional anymore, meaning there is no more ink in them (Tukker and Tischner 2006).

The product-related advice/consultancy (2) example could be advice from a consultant for more efficient use of inner-plant logistic of car tires, where the product is used in the manufacturing of a car (Tukker and Tischner 2006).

The product-lease (3) example could be an agreement of use of office furniture for five years between furniture producers and an office, where the user give a certain amount of money to leaser for the leasing duration, and the leasers are responsible for the maintenance as well (Tukker and Tischner 2006).

An example for product renting/sharing (4), it could be using an office area by different start-ups, where the users do not take responsibility of the ownership, however, use the function of the product (Tukker and Tischner 2006).

BlaBlaCar could be an example for the product pooling (5), where people fill the empty seats in their cars by offering relatively lower cost compared to other transportation systems; the use of the product is simultaneous with the owner and user (Tukker and Tischner 2006).

For the pay-per-service unit (6), the example of using the printers in the copy shops, where customer only use copy or scanning function and pay for the service (Tukker and Tischner 2006).

For the activity management (7), the example could be using a third party for cleaning an office area, by subcontracting with an actor who runs the cleaning job (Tukker and Tischner 2006).

Lastly, the functional result (8) example could be the following; offering a nice wedding package, where the providers are responsible for delivering a good service result, the way they would like to do (Tukker and Tischner 2006).

Tukker and Tischner state that putting the value in the centre of products and services' use is getting more important… and it could help to lower the environmental pressures of these in two means; firstly, companies get incentives by serving as stated, so that they earn benefits, secondly, the users change their habits/behaviours once they have the understanding of costs for the use phase (kilometres travelled) (Tukker and Tischner 2006). This applies to car sharing as well. According to Tukker and Tischner, car sharing is also a PSS model with use-oriented where the same product is continuously in use by the different users of the system (Tukker and Tischner 2006).

Even though it may seem that private cars are indispensable parts of modern people's life by many authorities, their use is actually not very efficient by the owners. According to a report from Allience – Bax & Company, people use their private cars around 4% of the total life of

cars… and because of this, customer's choices are leaning to question the ownership concept and shifting to only pay what you use concept (Reiland, Bax and Ierides 2019). The same report also gives data about other important details for this sector in terms of the current and future situation. Reiland et al. claim that the loyalty concept of cars has already changed and even major automotive manufacturers accepted that fact, so they launched car sharing platforms such as car2go from Daimler, ReachNow from BMW and WeShare from Volkswagen brands (Reiland, Bax and Ierides 2019). Rival companies of Daimler and BMW have even merged their platforms in the name of ShareNow at the end of 2019 (car2go 2019).

These types of actions from major car companies could show that car sharing is getting more and more important. Furthermore, this new system needs new organizational aspects to run the business that depends on the individuals. In this case, the product-service system (PSS) concept could be considered as a new era in the automotive sector, which can also stimulate the sustainability elements in the sector, especially socio-environmentally.

As it was given before, PSS is a system that distributes service/product differently than common approaches like buy-sell. The traditional model of demand and supply of cars has been changing over time as well. The figure below shows the characteristics of new business models versus conventional ones for the car market (Colmorn and Hülsmann 2016).

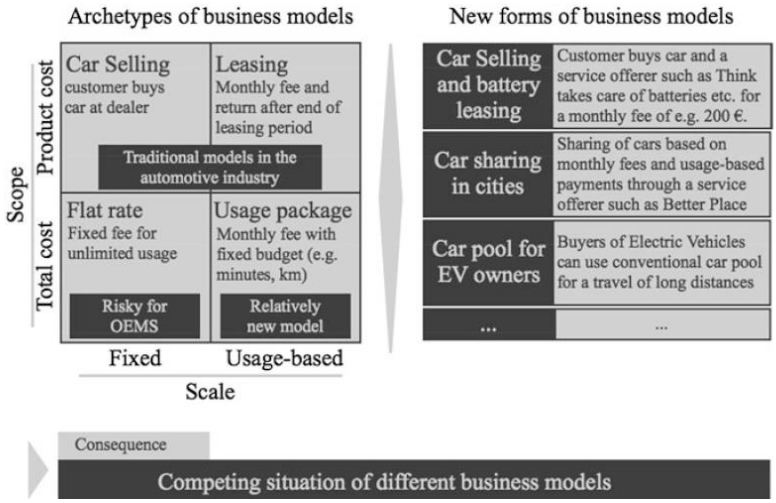

Figure 19 Electric mobility's business forms, taken from *(Colmorn and Hülsmann 2016)*

According to the figure taken by Colmorn and Hülsmann's study, traditional models in car industry's market are selling, leasing, flat rate and usage package with fixed or usage-based options, in the scopes of total cost and product cost mind-set (Colmorn and Hülsmann 2016). The "relatively new model" that refers to the usage package is similar to a free-float car sharing system in a way that customers pay what they use (Colmorn and Hülsmann 2016). However, the

new business models also aim to utilize the battery and its sharing approach more than traditional ones (Colmorn and Hülsmann 2016). It can improve the system's functionality from the car manufacturer's perspective, since as the responsible of the cars and batteries after the use phase; they can reuse, remanufacture or remarket the parts that are hand in hand with the circular economy elements.

Ownership of the cars passes to the companies, and this brings more responsibility to them rather than just selling cars. Nilsson from KTH Royal Institute of Technology stated that, according to United Nation Environment Programme, PSS brings changes to a company's culture, while includes particular challenges such as in design, distribution and improvement of product or service, so producers need to broaden some of their activities such as remanufacturing, reuse (or remarketing) due to the ownership (Nilsson 2018).

Annarelli et al. state that use-oriented PSS is the ideal way for the user and the companies for the newly emerged system, since the costs are divided into both parts (companies' high investments due to the new infrastructure is compensated by the user's, indirectly) (Annarelli, et al. 2019). The same book emphasises the importance of PSS offering by the companies needs to be aligned with the circular economy concepts, and shall include reuse etc., (Annarelli, et al. 2019). So that, in terms of car sharing, the involvement of circular economy concepts will also bring these after-use elements. Annarelli et al. also state that the customer's satisfaction can be made through an ideal design and after-sale (in this case, the customer service of car sharing) mechanisms. These mechanisms, as it was stated before as the core of the theoretical framework, keep the system alive and working.

The user's incentives also play important roles to keep the one-way car sharing system alive. Angelopoulos et al. state that incentive mechanisms for the users such as leaving the car to more available free parking spaces, by referring a friend or informing the defects of the system or product and so that getting bonus uses, can be the incentives for users for a more effective system (Angelopoulos, et al. 2018).

Even the incentives play important for the spreading this platforms to wider populations, this concept would not be enough to assess the subject without focusing on users' perspective in terms of environmental-related habits, so that another theory is needed for this element, which is the Social Practice Perspective.

3.2 Social Practice Perspective for the Car Using Patterns by Society

To understand the people's activities and practices' change in the society, in this framework it is the shifting to free-floating electric car sharing systems, a theory is needed. To begin with, one can start with social norms and their pillars. According to Palhte, there are three elements identifying the people's actions, which are cultural-cognitive, normative and regulative ones (Palthe 2014). These three pillars play important roles on every action and they can be described as firstly, the cultural-cognitive pillar is defined by the value and beliefs of individuals whose actions come from their inner ideas (Palthe 2014). Therefore, these are the actions that people "want to" do without consulting any groups or regulations (Palthe 2014). Secondly, there are normative pillars that are defined by morals and norms where people think they need to behave that way in the society (Palthe 2014). So, these actions could be said as "ought to" do actions (Palthe 2014). Finally, the regulative pillars play roles on behaviours that consist of policies, regulations and rules (Palthe 2014). Therefore, it can be said that people "must-do" these actions, in order not to face penalties or punishments (Palthe 2014).

To comprehend the shift for the car driving in society to see if that changes from owning to using sharing options, one can look at the lifestyles of the people. According to Karim, identification of the change in mobility planning, three elements play the role, which is the rate of adaptation to innovation, patterns of travel and parameter of services (Karim 2017).

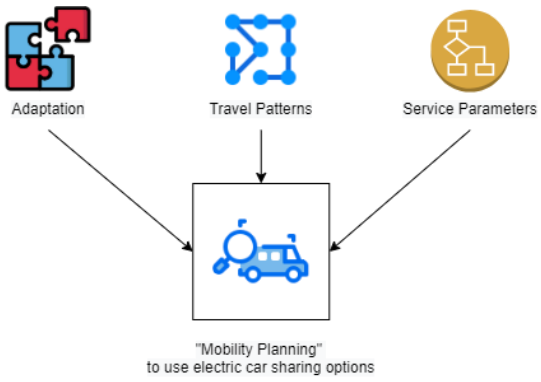

Figure 20 The changes for new mobility planning, inspired by (Karim 2017)

Karim also states that these policies and economic pillars also play a part to understand the mobility trends in the society, besides the environmental concerns in some of them (Karim 2017).

On the other hand, populations' ability to be capable of using new technology could be considered as another important issue for social practices. Because, if one cannot use the technology, it does not matter how much he/she wants to change the habits to be more environmentally friendly in mobility actions (in this case, using the applications of car sharing

services via a smartphone). Karim claims that cooperative consumption habits and "new social orders" steer the people in order to reshape the mobility for better environmental outputs for the climate, with the technology alongside (Karim 2017).

Since a new practice (in this case, the sharing mobility rather than using personal cars) in the society needs a new set of behaviour, besides changing some of them, while limiting and delimiting the factors that can affect behaviours in order to function, a new perspective for this subject is needed to be investigated to identify the society within this framework. To do so, the social practice perspective (SPP) could be a way to investigate and assess society. Smolka states that "the theory of activity" principles have based on a fundamental methodology in the '70s, and practices are affected by social actions and vice-versa, while in relationship with historical perspectives of groups (Smolka 2001). Shove et al. state that the theory consists of three pillars "material, competence and meaning" and they are interconnected (Shove 2012) (see figure 21).

That is why it is significant to investigate this theory within the framework of "the shifting habits of society for electric car sharing use" to analyse the main reason for people's behaviours (whether they are inclined to go for more environmentally friendly actions or not).

Smolka also emphasizes that interacting with other people is the key for developing new abilities and behaviours (Smolka 2001). According to Vihalemm et al., citizens need to be informed for their new practices and well thought, for long-term socio-technical effects (Vihalemm, Keller and Kiisel 2015). That is why it could be said that governments, people in charge of the companies and NGOs need to give as much information to the society to achieve successful environmental practices among society. Vihalemm et al. give an example about the society and sustainable changes, by saying that all sustainable improvements for the society are based on consumers' choices and the designers need to calculate the society's norms (Vihalemm, Keller and Kiisel 2015).

On the other hand, companies could be considered as one of the biggest actors in terms of new innovations, since they are the ones who produce and bring new outputs to people's use. Calestous states in his book of "Innovation and Its Enemies: Why People Resist New Technologies", the majority that resists changing for a new habit or technology is forced and informed by the companies to make this shift (Calestous 2016). He adds that some of this resistance can come from fear of change (Calestous 2016). It can be said that some people may think that it could be hard to leave the *comfort zones,* so that they would not want any changes

that could make them learn new skills and habits, because of the fear of not being capable of using new technologies.

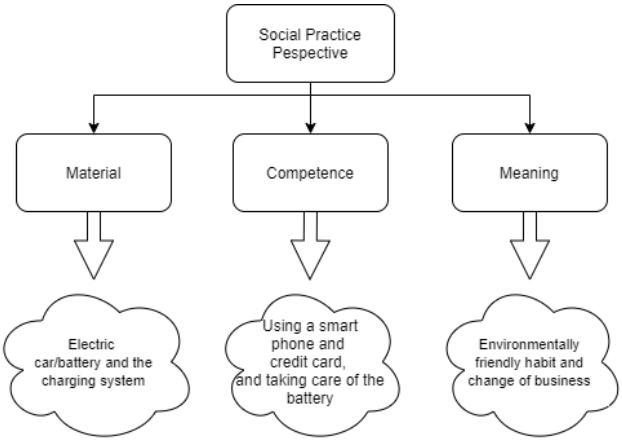

Figure 21 Social Practice Perspective and its pillars for free-floating electric car sharing, inspired by (Shove 2012)

To sum up the theory, the figure above explains the pillars of free-floating electric car sharing mainly from the societal part, as well as the company's part. Firstly, the material part is about electric cars/battery, and the new payment system of paying due to the new ownership concept. The users need to be acquainted with the new materials, as well as the companies. For the competence, the users need to learn how to use a smart phone to be involved in the system, while importing their credit cards information to the app. On the other hand, companies now need to take care of the battery's waste management. The meaning part for both users and companies is about environmentally friendly habits, and it will bring the change of the business for car ownership.

In the discussion part, these elements were discussed in detail.

3.3 Governmental Body's Perspective for Car Sharing Implementation

Governmental policies, regulations and standards are important elements of daily life, as well as for the manufacturers. If activities are not completed in order, fines and penalties could take place. On the other hand, governments can also support manufacturing or service activities. It applies to free-float car sharing as well. Filho et al. state that governmental bodies are aware of the electric mobility service and its potential of GHG reduction as a new solution to mobility, that is why they are also interested in this sector to regulate it (Filho, et al. 2015). This regulation, policies and standards come from the governmental bodies are mostly binding, and companies must obey them in order to abstain from fines. This could be prevented through a good organizational method, e.g. checking the data regularly, more involved customer-company relationship. Therefore, since the attention of governmental bodies to the electric car sector

especially in recent years, the production lines of electric cars shall be careful about the policies and regulations.

An example from the automotive sector could be that; according to BBC, the emission scandal of the Volkswagen brand that happened in 2015 ended up very badly for the companies' value and image (Hotten 2015). For the car sharing companies, it could be related to insurance, the improper service like partly broken car distribution into the market, false information and parking regulations etc.

The report from Accenture asserts that the cars that are not used at a moment worth near to 7 trillion dollars and sharing applications are on the way to change this excess car's production to better the use rate, so that companies profit more, by rearranging their assets into new methods (Accenture 2016). This asset rearrangement could be made via regulatory incentives from governmental bodies.

Since the companies that offer mobility solutions are dealing with the infrastructure improvement and travel plans, they are involved in governmental policies regarding traffic, according to Robert from environmental planning officer of the Royal Institute of Technology (Robert 2016).

Other examples of government's subsidies are as follows; implementing an electric car sharing test region in Dublin with the help of government, and the city council of Paris became responsible for some part of repairing and maintenance costs of the shared vehicles due to a contract with the government (Yang, et al. 2019). Therefore, companies do not bear the whole responsibility for problematic issues.

Those examples show that, electric car producers that offer car sharing need to be more involved with governmental bodies, since they also need to take care of the batteries besides other production line rules, in the sake of the environment and the company's future. In analysis and discussion parts, the role of the governmental bodies and their relationship with companies and customers of the system were given in details.

4. Results and Analysis

The results, mostly from interviews and online open sources videos of company people, besides some of the literature study elements, are analysed in this chapter to make a base for answering the research question and subquestions.

To comprehend what has been given in the research until now; the Earth has been facing appalling events links to climate change especially in the recent decade, such as heatwaves, lethal

rainfalls in drought areas and glacier melting in poles (Mandel 2019). Auston et al. state that, the reason for this change is due to the greenhouse gas (GHG) emissions from many sectors, and one of the most contributing industries to GHG emissions is the transportation sector (Auston, et al. 2016). For example, in the United States, 37 percent of the whole GHG emissions comes from transportation, and 71 percent of this number comes from the passenger vehicles, while in European and Asian countries, the proportion does not differ much (Auston, et al. 2016). Amatuni et al. also state that developed countries' transportation sector rate was around one-third of the total GHG emission in 2010 (Amatuni, et al. 2020).

Furthermore, Hoffman et al. claim that the European Commission is aware of the increase of CO_2 and NO_x emissions stem from transportation with the passenger car, which increased almost 20 percent from 1990 to 2014, and that is why the commission focuses on this sector (Hooftman, et al. 2018). In order to fight against climate change, a shift is needed for the road transportation sector around the world, to accomplish the goals of the Paris Agreement. Moreover, the Sustainable Development Goals (SDG) that are created by the United Nations are also aiming to have more environmentally friendly cities to reduce the impacts of global warming (United Nations n.d.). The United Nations also set different goals for sustainable developments around the world, as given in the figure below;

Figure 22 Sustainable Development Goals (United Nations n.d.).

These goals aim for sustainable developments while keeping the production and consumption rates at their ideal levels for economic development, without harming to the environment (United Nations n.d.). It shows the governmental inclusion's importance for the new world order, in this case, the car sharing.

To start with, the policy mechanism concerning free-floating car sharing is given in the next chapter.

4.1 Policy and Electric Car Sharing's Relationship

Firstly, incentives for companies by governments is an important subject for businesses to keep alive. There are some incentives for battery recycling, end of life cars and greener services. Filho et al. claim that electric car sharing sector needs support from governments to make the automotive industry adapt to it, in terms of new distribution methods, customer relations etc., (Filho, et al. 2015). Iacobucci et al. state that data sharing is an important process for PSS applications for companies to get best practices, hence getting incentives that are policy-related (Iacobucci, Hovenkotter and Anbinder 2017). This data sharing process has also security of personal information of customers like credit cards, address, location etc., which need an extra measure and surveillance mechanisms for companies and governments, respectively.

Another point of Iacobucci et al. is creating connected transportation to enhance the car sharing application, that is essential for more sustainable mobility, and this collaboration could be made among the city transportation officials, NGOs and federal government policymakers (Iacobucci, Hovenkotter and Anbinder 2017). However, connected mobility in the cities could be hard to implement as of now, since the infrastructure is not improved in all cities. Iacobucci et al. claim that sideways, walking paths, charger stations need to be arranged by the municipalities ideally to assure a better life for citizens while changing the infrastructure (Iacobucci, Hovenkotter and Anbinder 2017).

Illgen and Höck state that possible customers are not ready to pay extra to use electric cars, just because they are electric (Illgen and Höck 2018), so the incentives from the governments could be a way to break this barrier by lowering the prices.

For electric cars, there are different types of requirements all over the world. According to the United Nations Economic Commission for Europe, these requirements differ a lot, which are seen at the figure below (Economic Commission for Europe 2014):

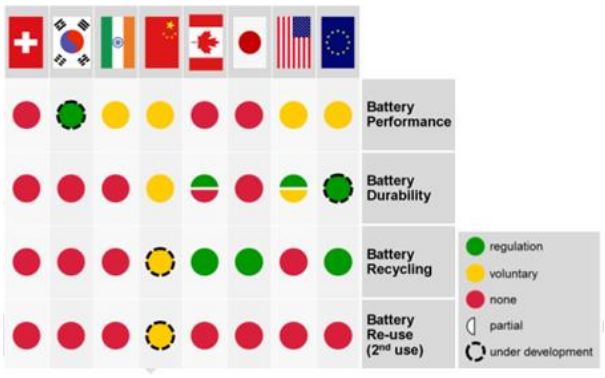

Figure 23 Electric Vehicles' Battery Regulations around the World

From the figure, it can be seen that Europe is mostly ahead of other regions in terms of regulations for the batteries, which is followed by the US. While in Japan and Canada, there are some regulations for batteries, in China there is none. That is why it could be harder for companies to produce and distribute the same type of car into different regions, hence applying the same type of PSS to different regions.

There are different incentives for electric car manufacturers and sharing providers upon waiting or have implemented. Some of them are, super-credits, eco-innovation credits and pool system (Lemerle and Benz 2019).

Table 3 Credits for passenger car manufacturers

Incentive System	**Actions**	**Result**
Super Credits	Producing cars with 50g/km CO_2 Emissions (hybrids or fully electric)	These cars will be counted as 2 cars, so the emissions credits will lower.
Eco-innovation Credits	Lowering the other processes emission (efficient lights etc.)	Monetary incentive
Pool System	Joining a pool of car manufacturers to meet the CO_2 targets (e.g. Tesla and FCA group partnership)	Not being having to pay penalties thanks to meeting targets, even though individually not meeting them

Therefore, the manufacturers that go with producing electric cars are getting different types of incentives from the governmental bodies. However, according to Transport Environment, while some car manufacturers produce electric cars to get super credits, they also take an advantage of these credits outcomes, and so that they can produce less efficient petroleum cars which harm to targets and the environment, just to get more benefit from sales (Transport Environment 2013).

About the pool system, as it can be seen from the figure below, FCA (Fiat Chrysler Automobiles) brand is the most polluter brand; yet, its partnership with Tesla (fully electric car producer) decrease FCA's emission targets.

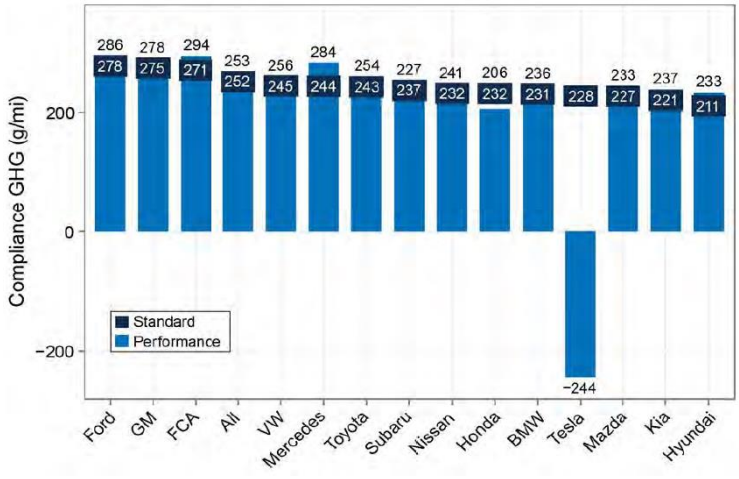

Figure 24 Compliances of car producers for GHG g/mi (USEPA 2020)

The figure explains that electric car producers can comply easily; they even could sell their credits to others and earn money this way (USEPA 2020). Tesla brand only produces electric cars and its performance for the compliance of GHG emission is much easier compared to other brands. This way, it can sell its credits to others and make more money thanks to producing only electric cars.

From the car sharing perspective from governmental perspective, Wuppertal Institute for Climate, Environment and Energy has an interview with an environmental officer of Düsseldorf, Mr. Zahn, on YouTube (Zahn 2014), and Zahn states;

"There are three main reasons for car sharing. First of all, ecological reasons. Second, financial reasons and in the third place, Düsseldorf being the role model. From the ecological perspective, land use is a very important factor. Especially in large cities… land use competition is a problem. Car sharing can reduce the parking space needed for cars." (Zahn 2014).

According to the interviewee of Sensoz from Transformative Urban Mobility Initiative – a governmental organization – from Germany, "*We cannot expect a 100% bottom-up (approach) if the education and culture of people are insufficient. But top-down is also a way of using the city, uniting with the city, making it integrated. Public transportation, public space, city layout, all of these are very organic on the one hand. Things that can be integrated with organic development ... I'm talking about a compromise. The state can approach with such a top-down approach. But a system that doesn't work after 5 years is not something we want*." (Sensoz 2020).

According to a report by McKinsey & Company report written by Grosse-Ophoff et al., in Berlin, taxi-related regulations can limit some of the mobility options; while in Beijing, one company leads the market as a monopoly (Grosse-Ophoff, et al. 2017). To regulate these issues are the governments' responsibility.

Overall, car sharing brings more responsibility to companies and this responsibility needs governmental support. In terms of electric car producing, it is advantageous for companies due to carbon credits. In terms of car sharing, it is seen as an improvement for the cities by governments.

4.2 Challenges for Electric Car Sharing through PSS

This section is the part to identify the challenges for the electric car sharing industry in general. Firstly, electric car sharing mobility is a concept that comes with its strength parts; it also has

some weaknesses such as being electric, unlike the conventional cars that could bring some issues to deal with. A study from Illgen and Höck about electric cars' challenges could be summarized as the following; there are some technical issues with electric cars in general such as limited range without charging due to electric battery compared to gasoline cars, maximum speed, a limited number of vehicles by the service providers, limited charger infrastructure, needing internet access and smartphone to use it as a prerequisite to use the app, charging the cars when necessary by the providers etc., (Illgen and Höck 2018).

Mr. Reppert, the CEO of ShareNow car sharing platform, gives an interview in a conference, which could be accessed on the YouTube channel of NOAH Conference, and he states that;

"It (not finding a car nearby) is one of the biggest challenges we have, because we know in order to be relevant, if you open five times the application and you do not find a car around you, it is very frustrating… our challenge is exactly to provide a certain level of availability, as soon as you open our app… The biggest competitor is the mind-set of the people in the cities, a lot of people still believe they need to own their own cars, that is why we are happy also having other providers in the market … to bring more relevance to this type of mobility and sharing to the customers" (Reppert 2019).

A joint interview by the BMW Group YouTube channel with the CEOs of BMW and Daimler at the time of the interview, Mr. Krüger and Mr. Zetsche respectively, they state that;

"You need to partner and be in the dialogue with the regulators, with governments, with the communities and we should not underestimate the cities… We will deliver what we promise with the government's we are always in contact. We are working closely. You need to do that in every country of the world" (Krüger and Zetsche 2019). It shows the complexity of the system from companies.

From the societal part, the knowledge about electric car sharing (or car sharing in general) could be considered as not that wide, so it could be the biggest barrier for many companies, while some of the people still consider that owning a car would be a social power image. However, ownership concept affect this situation. Ediz from Mercedes-Benz Turkey (MBT) states, *"What is seen now is that the new generation does not want to own any property… This goes for the house ownership, goes for the car ownership as well. They want practical solutions that are as simple as possible and always ready for themselves, and that they can get rid of immediately when they do not want to. Especially in big cities, with Uber etc. it started to become very common. Since*

Daimler saw this, it switched to the mobility side, completely independent from the electric motor, and there is a system in mind here." (Ediz 2020).

The rivalry between the other types of car sharing applications could be also another issue to transform the industry. These societal and intercompany issues are also related to the conceptual change of the sharing potential in terms of environmental impacts, which is the central point on this research. There are also indirect impacts such as due to cleaning the air via shifting to the electric car from gasoline cars, health issues related to air pollution could be considered that it will reduce as well.

On the other hand, the battery limits, renewability of batteries, securing the efficient use of batteries and cars in general etc. could be a barrier for the technology to be implemented within the framework of circular economy. However, a Daimler interview made with Mr. Michel - Group Research & Sustainability Project Manager - emphasises this challenge from a new perspective (Michel 2020) as the following;

"This (circular economy) is where batteries have great potential in terms of the diverse and sometimes rare raw materials that are used from the battery cell in this case. More and more people want to be independently mobile – and we want to offer them the vehicles for this, and of course continue our own growth. At the same time, it is very important to preserve valuable resources by bringing raw materials back into circulation. With our "Ambition 2039", we have therefore not only defined a CO_2-neutral vehicle fleet as a goal, but also decoupling our consumption of resources from the growth of our production volume." (Michel 2020).

He continues as*, "…we not only want to reclaim individual materials from the battery, from which electric toothbrushes can be manufactured for example. Instead our aim is to safeguard our own, increased raw material requirements by recycling. We can do this if we consider this last stage in the battery life cycle right from the start – for example in the battery design – and regard today's batteries as a mine for the batteries of tomorrow… And especially since the current battery systems require valuable raw materials, we have to design them in such way that they can be repaired… However, because batteries are classified as hazardous goods or hazardous waste, we need to observe special legal requirements. This applies to their transportation, for example, and this is very complicated owing to the regulatory requirements. ... Our colleagues at Mercedes-Benz Energy use batteries that are no longer suitable for vehicles in a stationary energy storage, and feed thousands of kilowatt hours into the power grid each day. We have really made a lot of progress, and we can already keep the components of a battery*

in the cycle for a very long time before recycling is due. And here, too, we already achieve relatively high recycling rates together with our partners. Now it's a matter of returning the recovered raw materials back into the battery cycle." (Michel 2020).

Besides, since it is still not a strict policy to ban cars with petroleum, by authorities due to the feasibility issues for many reasons; for today, these types of cars are expected to be manufacturing for some time. This uncertainty limits the policy review for the future, in terms of expanding the use of electric cars. E.g., United States' withdrawal from Paris Agreement could be considered as a huge issue in terms of global warming (Chakraborty 2017). This can discourage companies to transform to electric cars so that the fully electric car sharing process could be delayed because of this situation. The news from The Guardian claims that the biggest oil companies spend millions of dollars to support the industry from shifting to clean energy options (Laville 2019). It shows petroleum lobbyist's influence on the energy market.

Some incidents of electric cars' explosion could emerge trust issues for the customers, yet they are getting safer by the developing technology. E.g. in 2019 in Russia, a Tesla electric car reported to be exploded after a crush in the middle of a highway (Coldewey 2019).

The COVID-19 pandemic, on the other hand, is drawing an uncertain future for the sharing platforms, while being still hopeful, according to Ediz (Ediz 2020). He states that, *"I think the current pandemic will affect this (sharing platforms) issue, at least in a soon period. People have started to have a serious antipathy toward common use. I do not know how long this pandemic will last. However, if it continues for two or three more years, since the hygiene and isolation are getting more prioritized by the people, this will affect the cultures and hence car sharing etc. Of course, the water finds a way eventually."* (Ediz 2020).

In addition, even though the sector's recent economic figures had not been showing a positive image, the pandemic increased the car sells, according to Ediz (Ediz 2020). He emphasises that *"At the moment while we were waiting for the crisis regarding passenger vehicle sector, let me tell you something from Turkey, we saw record sales in July and while a very big economic crisis in the country. Yet, because everyone put their health first. So, they somehow managed to buy cars, by banking credits, by selling some assets etc. just to transport in a healthy way… (On the other hand) companies that are at the forefront with their engines, such as Daimler and BMW, are losing an important advantage, because of the conversion to the electric motor and battery…Therefore, there is the risk of losing the advantage of know-how in those important fields… Simply, now the playing cards are being shuffled again. A situation can seriously change*

the positions of companies in the automotive scene against each other. Another point is that you have been seeing automotive companies lately, while automotive companies were used to be in the top 10 in as top valuable brands list, now none of them has a place in there, instead the IT companies completely occupied the list. What does that mean? Automotive companies were the most important tool for investors in the past. Because the most valuable brands in the world that brought the highest earnings and showed the most serious value increases were the automotive and beverage brands. Now there is no such thing, of course the g*overnments will come into play here to help them, EU etc. for development purposes. After all, automotive companies are also a great source of jobs. It is an industry that increases the brand values of the countries and they attach great importance. Therefore, nobody will tell automotive companies to take care of themselves. But the more automotive companies adhere to these incentives, etc., the more their range of action becomes dependent on governments." "* (Ediz 2020).

About the incentive mechanism about supercredits, Ediz's views are interesting, as follows; "*This is not an incentive, but this is an obligation. After that, they did not produce Euro 7 (engine). From now on, it will continue to reduce the total carbon emissions by certain percentages. They will be responsible for carbon emissions for the total vehicle they produce. These will be asked to be reduced in certain percentages in the coming years. Because it happens to be an obligation as its nature. It does not give you the right to produce more than allowed anyway…If you leave a footprint more than the allowed carbon limit during production of that specific good, you must buy it on the carbon trade mechanism. It is the right of some other companies... But, it (incentives) may also be that less tax is charged from developers who work in the production of electric motors, who work in their development… or sustainable solutions."* (Ediz 2020).

4.3 User's and Customer Service Perspectives of Electric Car Sharing through PSS

To identify a different customer perception of car sharing, one needs to analyse the user's preferences. Sensoz states that "*This (psychological factors) varies depending on the geography ... While vehicle ownership is an indicator of wealth in developing countries, things such as cycling and walking actually seem to be ""you are poor"". ""If you have a car, you are socioeconomically superior, I respect you, you are a superior person, if you ride a bicycle, if you walk, you are a poor person"". It is about prejudice. This is fundamental in developed countries, especially in Europe, where the cycling culture is 100-200 years old. This is something that needs to be resolved socially. Financial incentives, regulation, technical capacity are the further topics to look at after handling this issue. Mind-set is an issue that needs to be changed*." (Sensoz 2020).

A YouTube video that explains the car sharing in Toronto by the *J and C Toronto* channel on the website, and they emphasise the favourable aspects of car2go car sharing platform as following;

"I think the most convenient thing that we have found is the fact that parking is included, you do not have to drop it off at the same location you rented it, all you have to do is make sure that is parked back in the home area (inner city) in a legal parking spot. I also love that parking is free in any green parking (place). Because parking is… difficult to find in that city. Also, it is Smart car (a smaller car model compared to normal ones) makes it easier. I love the gas is included (it works for the electricity for electric cars)… If you do pick up a car and there is not enough fuel to complete your trip, all you need to do is full it up, keep the receipt, take a photo of it and your licence plate, and send it to car2go. Either via the app or by email. Another great aspect of car2go is the insurance is 1$ a trip and that is for your first 90 trips in the period of one year. If you do more than 90 trips, you do not get charged after that. 90 dollars a year for insurance, I think that is pretty affordable." (Paulson and Mickolwin 2017).

The same YouTube interview explains the drawbacks about the system as the following;

"It is still more expansive by the day than most rental cars do in advance. Another thing is, they can approve upon is widening the home area, because it is a little bit small. As realtors, we use car2go to go to different viewings and showings of multiple properties around the GTA (metropolitan area). When we go outside of home area, we cannot drop the car off and stop the clock. You can keep it outside the home area, but then you will be on the hour or the day rate. We have also reserved cars and found that when we have gone to pick up, they are just not there. When we contacted car2go to let them know about this, they actually gave us 23 (extra) minutes for our inconvenience but they also explained that occasionally drivers will drop them off and go away zones, and the car may then just be zipped away and gone. Or, it is parked in a parking lot that is multi-level, sometimes the GPS… (may not work). However, it is great customer service from car2go with helping us out with that issue." (Paulson and Mickolwin 2017).

Another YouTube video from GARNIK channel about the car2go (free-floating system) reviewing in New York, Garnik explains the situation after he found a ticket at the window of the car as (Garnik 2019);

"*I am going go ahead and call the customer service and ask what I should do with this ticket. I am still waiting on the line; it has been about seven or eight minutes. However, I found out in FAQ that "" I found a parking ticket before I use the car, what do I do with it?"". They are*

clearly saying that no need to worry, place the ticket in the glove box, we will take care of the rest." (Garnik 2019).

Another complaint about Garnik's experience of using car2go was having low pressure on the car's tire (Garnik 2019) and his talk with customer service after finding it out was as follows;

Garnik: *"I should end the trip because the pressure monitor inoperative right? Am I getting correct?"* (Garnik 2019). Customer service: *"Right, if you see an exclamation mark, it is not a good sign to drive it. We are sorry."* (Garnik 2019). After that, he approaches to another car to use in the area, however, he finds out that this car also has a problem; it is the bending tire (Garnik 2019).

His experience with the customer service continues as the following;

Garnik: *"It (voicemail) says again, it is over five minutes, last time I was waiting about twelve minutes for somebody to pick up the phone… Let us hope this one is okay."* (Garnik 2019). Customer service *"I believe this time will be okay… So, I have given you ten dollar, you can use it on your next time."* (Garnik 2019).

A YouTuber also tried car2go system in Wien, from airport to city centre (Koltai 2019), and states her experience as following;

"This is a very nice service… The driving experience from where I set was really good; you could speed up the car very fast… The price is similar to Uber. And you do not have to wait for it; it is there in the parking garage. You just take it, and drive anywhere." (Koltai 2019).

The councilmember Lisa Bender from Minneapolis City states in her senate speech, that is available on YouTube Minnesota Senate Media Service, *"People from Minneapolis and St. Paul choose not to have a car or perhaps cannot afford one and use car sharing as part of a system of ways to get around. Car sharing is an important part of our transportation network… it complements the other options, for example the retired couple… sold their car to save the $9,000 it costs and depreciation and insurance to own a car. They use car sharing to get groceries, to visit friends who are not accessible by transit... We also heard from others who use car sharing as part of their regular commute trips when they have an unexpected trip...or they may have to leave late when transit service is not as frequents*" (Bender 2017).

A press release of Volkswagen, the interviewee of Ms. Linbenciuc mentions about the car sharing platform of WeShare as "I have got 1,500 cars in Berlin" (Volkswagen 2019).

Aydogan from Yesil Cember claims, "*80% of those who use those platforms (sharing) are environmentally friendly, 20% maybe because of lack of money (or other reasons). Although their aim is not to be environmentalist, they unwittingly serve this purpose. For car sharing, the age is around 25-35. I am not sure, but… The thing is, the more and more people are living in the cities now... Houses are small. Houses used to be big (for a garage).*" (Aydogan 2020).

On the other hand, on the mobile application store of Apple products, the Apple Store, people can write their complaints or compliments about all applications (it is the same for Android phones on appstore). The following images of SHARE NOW (the joint app of BMW and Daimler for electric car sharing), taken from the United Kingdom's Apple Store on 12.10.2020 show some of the comments and rating of the app;

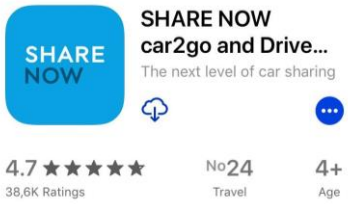

Figure 25 SHARE NOW's profile on Apple Store (own image)

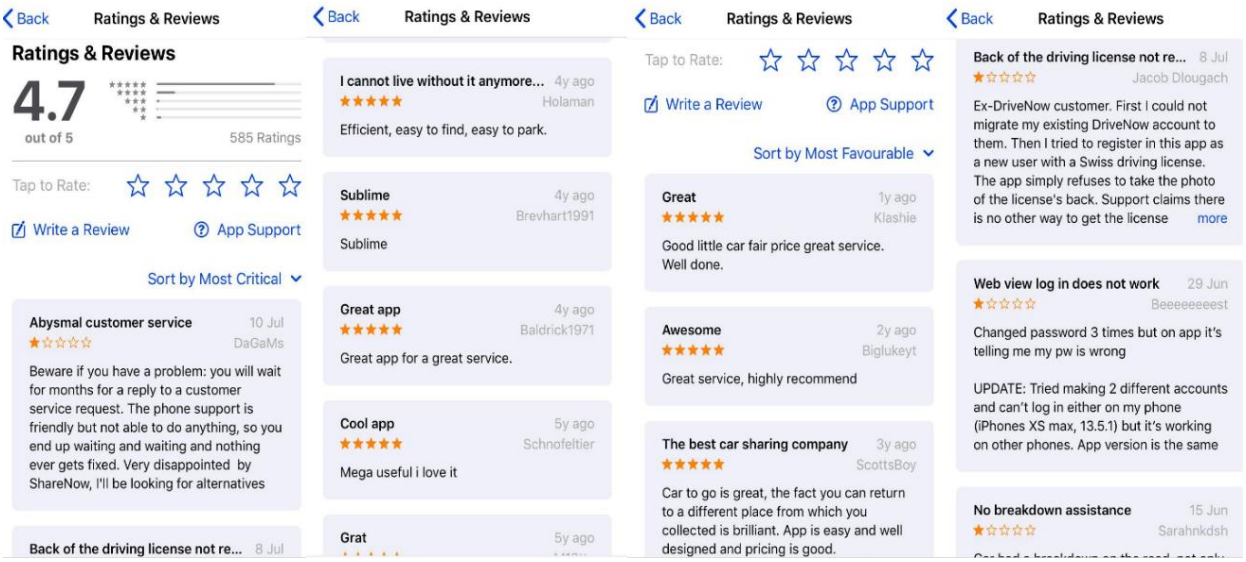

Figure 26 The comments on the United Kingdomg's Apple Store about SHARE NOW (own image)

According to the figures above, SHARE NOW has 4.7-star ratings out of 5.0, with almost 40 thousand reviews. In order not to be biased, both positive and negative comments have taken. Even though there are many favourable comments, there are also some complaints about the app and customer service. E.g., there are people "looking for alternatives", having password problems, issues with the photo of the driver's licence etc. On the other hand, many people also stated that they like it.

According to Bert et al., people will still continue to use private cars, due to being have to drive in outside of the home area of the apps, also the desire for modifying your own car's interior etc. triggers some of the car owners (Bert, Collie and Xu 2016).

4.4 Business Model Change and Marketing Activities from Company Perspective

This chapter describes the changes that businesses face by shifting to new mobility solutions.

Ediz from Mercedes-Benz Turkey asserts his thoughts about structural change for sustainability innovations that "*Daimler also set its own goal (for sustainability) ... By 2039, Daimler announced its vision that it will not use internal combustion engines in any production, including buses, in October last year…Actually, these (electric cars and mobility) are two things need to be separated from each other. There is an electric concept and there is a mobility concept. Daimler has now established a unit within itself called mobility. However, the mobility unit produced many different programs… long before electric cars hit the market... It is necessary to make this (change) feasible, not to reduce the capacity... Plus, of course you are also talking about a huge structural change here. Daimler has internal combustion engine plants in many countries. Daimler produces all its engines itself ... Therefore, these factories also need a transformation."* (Ediz 2020).

About the partnership mechanism, Ediz states that *"2020 was already set as a milestone for all brands (in terms of sustainability). This shift is currently changing all the brands. Everyone is investing in electricity and mobility. This is not just Daimler. But, everybody also knows that it cannot be done alone, in my personal opinion. That is why partnerships started to increase a lot. The best example is the partnerships between BMW and the Daimler that have grown significantly in recent years. Partnerships that Daimler have made with the Chinese battery manufacturer. Fiat-Chrysler 's merging with PSA (Peugeot, Citroen, Opel) to get in to the top 3 car producer group in the league. This change in to electric cars, in my perception, is a very big scary challenge for the companies. Because it involves a very serious amount of investment and a huge transformation. This change has very delicate points. From production to after-sales, how will internal combustion engines (ICEs) continue, how long will they have to support them (the ICEs), where will they do this support, or increasing battery life, battery recycling are also very serious problems for all companies. How active will they have to be in setting up the charging infrastructure. Plus, security measures are also required. Always keep the battery at a constant temperature, etc."* (Ediz 2020).

About the ownership mechanism of cars by the company, Ediz state, *"In MBT, we do not do car sharing, nor leasing. (However), Daimler actually gives cars to its own employees (manager positions). This can actually be seen as some internal leasing/sharing. Here is what Daimler does: They are observing the second-hand needs of the market. Whatever models of second-hand vehicles are needed in the market, they give these vehicles to their employees as new cars, take these vehicles from the employees at the optimum level by changing with new ones and sell them to the second-hand market again…, I think the same system will be applied there (car sharing). These cars never stay in the hands of companies until the end of their life. Because this is not a profitable situation. Rental companies, for example, hold a car for a maximum of 2 years. Often at the end of the first year, they change the car. Because the most profitable phase of second-hand car remarketing is changing it every year, when you think about the cost, value loss, investment etc. It is accepted by the car leasing companies that it is profitable this way. Another reason is the competition with other brands. No one would want to use 5-year-old rental cars, while your competitors offer brand new ones. If you offer these cars, you need to reduce the prices mechanisms a lot to charm your clients and it is not the best for companies. So, I think the same rules apply for the sharing companies as well. When a company offers brand new cars with new batteries, and B offers old cars with low capacity battery, B would lose eventually. Hence, a car would normally never completes its lifecycle in the car sharing system; it would be sold to the second user, after 3-4-5th user and it continues like that.. Also, when a car runs out of battery, it doesn't mean it dies. They are going to change batteries."* (Ediz 2020).

In an online interview with the CEO of Catch a Car – Mr. Maeder (a free-floating car sharing start-up) in Switzerland with Global Tech Box YouTube channel, he answers the question of "how to start a business in a new city?" (Maeder 2018), as the following;

"There is one little thing that we need to operate, and this is rather complicated, need to have the allowance to place our cars on public parking space … for unlimited time. This is the basic need… Nobody can start free-floating car sharing, not giving the car back at the place where you started without the permission to place or to change the cars from one member to the next member on the public parking… Currently, we just grow the company using performance marketing… growing the number of members… we find them on social (media) and search platforms… we want to our cars be proper… safe to drive… as good as possible cars with fair price." (Maeder 2018).

Mr. Wachtmeister - product manager of Alphabet International (a consulting firm for car sharing applications) has an interview with his own company on the YouTube channel of Alphabet International state that,

"... Consulting approach, which allows us to better understand the mobility pattern, like frequent routes, peak times and mobility ups. Based on this insight, recommendations can be made for the most appropriate solution, which not only includes the number of vehicles, but as well as booking routes and services which can be attached and applied." (Wachtmeister 2018).

Another input from Mr. Reppert's interview is;

"If you compare this type of transport to what you are doing with a taxi, we know that we are minimum 30 percent cheaper." (Reppert 2019).

Bert et al. claim that car sharing "will not do to the automotive business what iTunes did to music: it will not redirect a stream of revenues to a disruptive upstart, and it will not spark a widespread change in consumption", but it will affect the ownership costs (Bert, Collie and Xu 2016).

On the other hand, Bert et al. assert that car sales will lower in the future; however, the increasing opportunities for car sharing and vehicle replacement can create more openings for the market (Bert, Collie and Xu 2016).

4.5 Sustainable Mobility Planning Perspective

To understand the concepts of sustainable cities and mobility planning, literature review and interviews from YouTube channels have implemented, besides the own interviews of the author.

Bert et al. state that car sharing can only meet 40 percent of the city's need for inner-city drivers (Bert, Collie and Xu 2016). It means that a city cannot only trust car sharing methods.

Another input from Mr. Wachmeister's – the CEO of ShareNow– interview is;

"They (customers) understand that your urban mobility is very easy to do with combination between car sharing but also using public transport, using other services like bike sharing and so on. Honestly, in a city like Berlin, you really do not need to own car to be very flexible in the type of mobility you need… We want driving cars, not parking cars… They (Daimler and BMW) understood that mobility in an urban area will be disrupted in the future and you have to be with a different type of offer being able to provide the mobility with your products and that is

why it is reported during the last ten-eleven years, that concept (free-floating car sharing)… we are now in the biggest cities in Germany, but our objective is clearly to go also in the second-tier cities… Access to the cars is very easy (in smaller cities).” (Reppert 2019).

Even though the range of electric cars could seem like a problem from the user’s perspective, since car sharing is mostly used inner cities, and secondly a better infrastructure (connection to public transportation, electric charger stations etc.) around the world could eliminate these uncertainties for the customers’ changing to this system. In addition, the developing technology helps this problem to be solved, e.g. Tesla cars are recently updated and their range increased around 0.4 to 0.8 percent without changing any material (Lambert 2020).

Aydogan from the environmental NGO of Yesil Cember – Berlin, expresses her opinion about the societal level of sustainability practices’ perception as follows, *“Those who have grown here are already (sensitive). Of course, there is also every nationality in Berlin, there are different ideas/habits…There are many ads about sustainability everywhere. That subject came to poor districts too. I also think that more people are thinking about that subject now… but, there are still many things to do.”* (Aydogan 2020).

Aydogan’s observation about sharing application in the city is as the following; “*It (sharing platforms) is also gradually (progressing) ... In the past, for example, in the Middle Ages, people were sharing only. That was over too, but gradually ... (people) are doing it (sharing) now as well… It (sharing) is more than a few years ago. The effect was also huge. As I said, new companies have arrived, their ads are hanging everywhere ... There are many car sharing ads. I think its percentage has increased. New platforms are also coming.”* (Aydogan 2020).

About the NGO’s and governmental perspective for planning, Aydogan asserts that “*there are (NGOs) about bicycles. They give suggestions of course…Compulsory and legal things are also required ... It should start in large companies (and governments). If it gets binding, large companies will (do)... After that, we ... It would be easier for us as consumers But of course, it should not only be mandated, but also willingly… As I said, it would be easier for us if it comes from top to the bottom.”* (Aydogan 2020).

According to Sensoz, “*NGOs also reach the local area. They reach the authorities too. They also have serious ties to the academy. In fact, NGOs are a very nice discussion and production platforms. It is a very good intersection point if you take into account the partners, networks, the stakeholders they reach. And the information and projects they produce, so it is a good tool. So it's a nice tool, if you also think about the projects they produce.”* (Sensoz 2020).

Sensoz's thoughts about the car sharing's potential for sustainable cities are given as the following; "*The EU is addressing this subject in the New Green Deal. Until this time, we had checked the private car usage, it was falling. Until this time, we checked the private car usage. It was falling. Will it rise again now (due to the pandemic)? This is one of the biggest fears. If it will rise, it is very logical to solve this with car sharing.*" (Sensoz 2020).

The integration potential of car sharing applications with public transportation to assure sustainability, is another thought of Sensoz, as the following "*It definitely has a very important potential. Free floating is a great incentive and comfort. How do you integrate this? You simply have to bring the stakeholders together. For example, if cars have certain drop-off points, which are discussed with the city/transport planners. He can park, get on the U-Bahn (subway), then get on the tram, get off the tram, then take it (the car) and go elsewhere. To establish a whole system by bringing together different planners, people from the private sector, government, academia, and thinking of different segments with an integrated system. Then, sustainability is could be achieved*." (Sensoz 2020).

The Comparison of Free-Floating Car Sharing with Other Mobility Options

To compare with other mobility options, the image taken from Bignami et al. could summarize the differences in terms of flexibility and distance that are two of the most important factors of transportation (Bignami, et al. 2017);

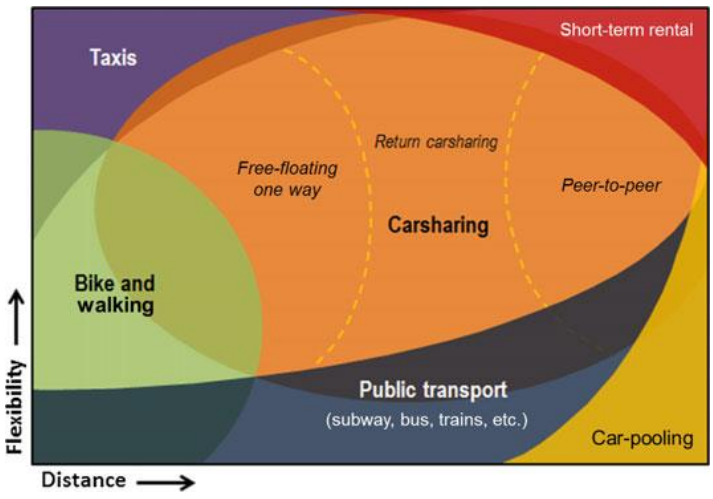

Figure 27 Comparison of different mobility options in terms of flexibility and distance (Bignami, et al. 2017)

To explain the figure, the taxis are the most flexible method with a limited range that exist only inner cities. Biking and walking could be considered as the ones have the least distance due to the need for muscle energy. Public transportation, especially in Europe, it could be considered as the very inflexible, however, it has a very long distance range (inner and outer cities). While

carpooling (BlaBlaCar etc.) is one of the least flexible, its range could be very high depending on the destination. About the short-term rental, it seems to be the most flexible with the highest distance capacity, since people can drive wherever they want in the given amount of time. On the other hand, car sharing has three methods. Firstly, free-floating one-way car sharing is very flexible compared to many other methods, while its range is mostly limited to inner cities. Secondly, return car sharing could be considered as the most flexible one, however, one still needs to bring the car, and its distance is relatively higher than other methods. Lastly, peer-to-peer sharing, that sharing a friend's/acquaintances' car to go somewhere together, has one of the highest distance capacity and flexibility potential, since it is only limited to where they would like to go.

(Bignami, et al. 2017).

For the sustainable mobility planning for the user's perspective, the user's preferences of more distance and more flexibility could be considered as important parameters.

4.6 Life Cycle Assessments of Car Types and Sustainable Development Goals

To understand the life cycle assessment (LCA) of the cars, at first, one needs to know what the life cycle assessment is and why it is used. According to Pre-Sustainability, LCA is the "factual analysis of a product's entire life cycle in terms of sustainability" (Pre-Sustainability n.d.). This entire life cycle stands for production, use and end-of-life phases. LCA can evaluate the environmental issues that stem from the product/service for its entire life, which is called "cradle to grave" (Pre-Sustainability n.d.).

This study has initiated by the problem of global warming, partly stems from the passenger vehicles' GHG and air pollutant emissions. That is why, the impact assessment – that allows having ideal business-related choices – classifies the "kg CO_2-eq" as the unit (Pre-Sustainability n.d.), (Helmers, Dietz and Weiss 2020). To see the potential environmental improvements over the personal gasoline cars by the electric car sharing system, one needs to grasp this unit.

Girardi et al. state that vehicles, that have internal combustion engines, generates more GHG in comparison to the same size of electric vehicles (Girardi, Gargiulo and Brambilla 2015), and it is shown at the figure below;

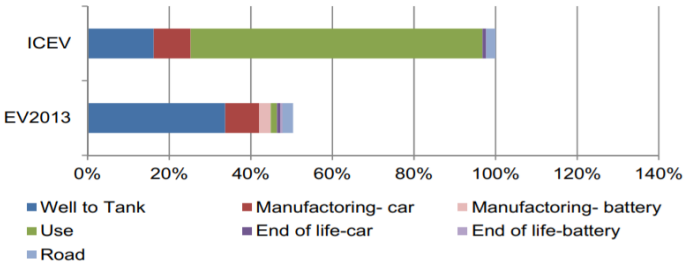

Figure 28 Comparison of GHG emissions of ICE vehicle and Electric Vehicle (Girardi, Gargiulo and Brambilla 2015);

The figure does not have a unit; however, it is not the focus of this study to find out the exact amount of GHG potential of cars for their life cycle. A comparison is in-between two types of car explains the cars with internal combustion engines have much more GHG impact than any other steps due to the use phase, while the electric vehicles' well-to-tank (a term that explains the raw material extraction) impact is the down-side, mainly due to lithium extractions (Girardi, Gargiulo and Brambilla 2015).

To connect it to car sharing, since it is important that the use phase of sharing cars are more intensive, this impact has the potential to lower the GHG of cars. The figure below shows the historical evolution of use phase of cars (kilometre per person), and it is projected that new mobility concepts (car sharing etc.) is increasing greatly and could surpass the individual car use in the long term (Kuntzky, Wittke and Herrmann 2013).

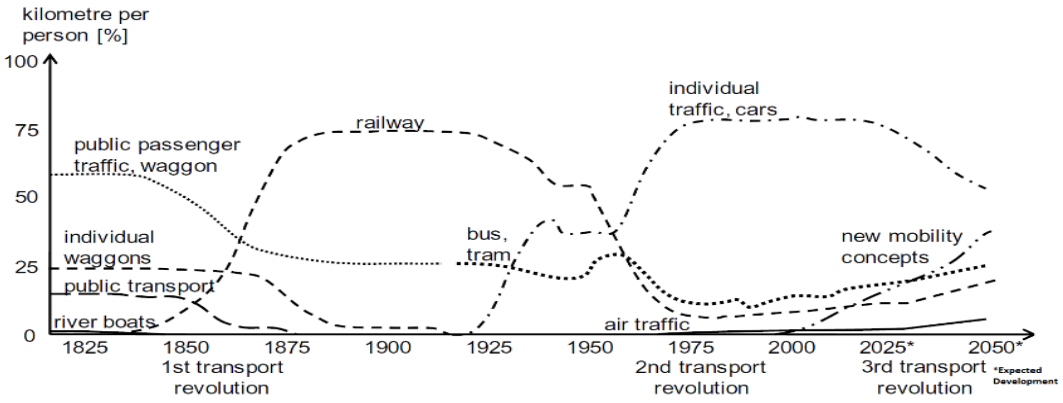

Figure 29 Transportation's development in Germany, taken from *(Kuntzky, Wittke and Herrmann 2013)*

New mobility concepts consist of car sharing/electric car sharing as well, with the help of the third transport revolution. The potential of these concepts is important for calculating the emission data per drivers. The next figure shows the emission reduction potential of car sharing in selected European cities.

A study from Karlsruhe, Germany shows the CO_2 decrease in selected cities thanks to using car sharing mechanisms of car2go and DriveNow (Fromm, et al. 2019).

Table 4 Emission data from selected cities by using car sharing applications, taken by (Fromm, et al. 2019)

	car2go						DriveNow				
	Amsterdam	Berlin	Hamburg	Madrid	Rome	Vienna	Brussels	Copenhagen	Helsinki	Lisbon	London
Emissions of newly registered vehicles 2008 / 2009 [g/CO_2 per km][1]	219	231	231	207	203	221	199	195	220	187	210
Annual CO_2 emissions prevented by sold vehicles [t/yr]	2,924	15,356	9,238	2,986	5,420	6,020	3,854	2,966	1,273	1,005	2,303
Emissions of newly registered vehicles 2016 / 2017 [g/CO_2 per km][1]	148	178	178	160	159	169	162	150	165	147	170
Annual CO_2 emissions prevented by suppressed vehicles (conservative scenario) [t/yr]	1,677	5,621	5,315	1,685	3,639	2,497	1,152	3,500	640	861	1,817
Annual CO_2 emissions prevented by suppressed vehicles (optimistic scenario) [t/yr]	6,709	22,483	21,259	6,742	14,557	9,987	4,609	13,999	2,561	3,444	7,269
car2go / DriveNow CO_2 emissions [t/yr]	0	2,387	1,933	0	762	1,456	220	129	112	105	118
CO_2 emission reduction due to car2go / DriveNow (conservative scenario) [t/yr]	4,602	18,590	12,620	4,671	8,296	7,061	4,786	6,337	1,801	1,760	4,002
CO_2 emission reduction due to car2go /DriveNow (optimistic scenario) [t/yr]	9,633	35,452	22,564	9,727	19,214	14,551	8,243	16,836	3,721	4,343	9,454
CO_2 emissions reduced per car2go / DriveNow vehicle (conservative scenario) [t/yr]	14.0	17.9	15.4	10.2	13.3	10.2	16.8	14.8	12.2	8.8	11.2
CO_2 emissions reduced per car2go / DriveNow vehicle (optimistic scenario) [t/yr]	29.4	34.1	34.8	21.3	30.9	21.1	28.9	39.4	25.2	21.7	26.4
Reduction of CO_2 emissions per customer (conservative scenario)	10%	18%	12%	4%	7%	10%	16%	16%	17%	4%	33%
Reduction of CO_2 emissions per customer (optimistic scenario)	22%	33%	27%	9%	16%	20%	28%	43%	35%	11%	79%

The table shows the emission's data of the ten given cities in Europe, and how data changes with car sharing applications. Those cities belong to developed countries. It can be seen that in Amsterdam and Madrid, car2go's emissions are zero ton per year, which means they use electric cars in those cities. In both conservative and optimistic scenarios, there are net reductions of CO_2 emission per customers thanks to car sharing.

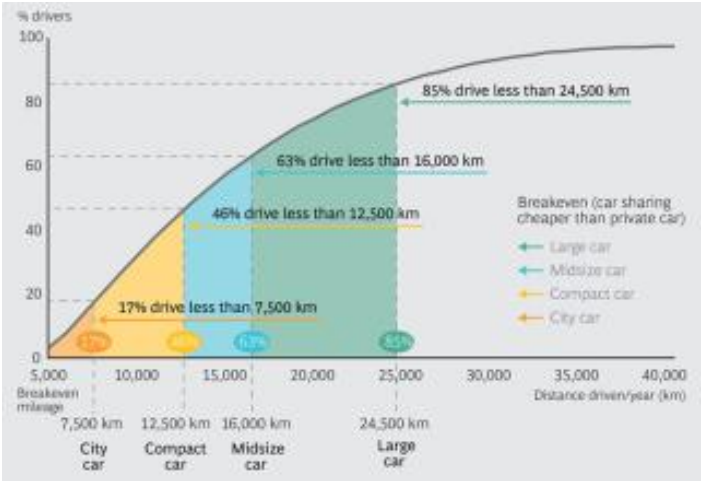

Figure 30 Breakeven points for car sharing compared to private cars, taken from (Bert, Collie and Xu 2016)

A quantitative calculation that Bert et al. has made shows that if inner-city drivers drive not more than 7,500 kilometres in a year, it makes more sense to use car sharing, in terms of monetary and environmentally concerns. (Bert, Collie and Xu 2016).

SDG 11 Sustainable Cities and Communities

The UN defines the SDG 11's goal as making cities more involved, safer, more resilient to changes and sustainable (United Nations n.d.). Its sub-goals related to car sharing are given below;

- Providing safer, more affordable and accessible transportation systems by expanding public transportation and other methods by 2030,
- More comprehensive urbanization with sustainability, better urban planning and management by 2030,
- Reducing the environmental impacts per citizens to improve air quality by 2030,
- Supporting the environmentally friendly connection between rural, semi-urban and urban.

(United Nations n.d.).

SDG 12 Responsible Consumption and Production

The description of the goal SDG 12 is attaining the economic growth with sustainable development and changing the consumption and production habits to keep the resources safe, according to the UN (United Nations n.d.). Its sub-goals related to car sharing are given below;

- Implementing the consumption and production sustainability by the lead of developed countries, around the world within a 10-year programme,
- More efficient and sustainable use of resources by 2030,
- Reducing waste generation through circular economy principles (recycling, reuse, reduction),
- Improving renewable energy innovations via incentives.

(United Nations n.d.).

SDG 13 Climate Action

The definition of the SDG 13' goal is action urgently to fight against climate change and its effects on the earth (United Nations n.d.). Its sub-goals related to car sharing are given below;

- Improving the durability and adaptation capacity of cities for climate-related problems
- Implementing policies to support climate-friendly actions,
- Educating the public via awareness-increasing projects (like Green Climate Fund)
- Promoting better management of cities

(United Nations n.d.).

All these three actions show that car sharing has many roles to comply with these goals. E.g. integration of public transport through semi-urban and urban areas, reducing the per capita emission hence improving the air quality, more sustainable consumption through less owned cars hence less car produced etc. For the companies' part, car sharing has the potential to reduce generated waste thanks to the ownership mechanism, so that improving more circular methods, renewable energy investment, natural resources efficiency etc. For the governmental and NGO's part, bettering the policy of car sharing, improving public awareness for climate-related issues, better urban planning etc. All in all, car sharing through PSS is an indispensable part of SDGs.

Other Related SDGs to Car Sharing

Other goals that relate to research question could be as the following: Firstly, SDG 3 (good health and well-being) could be related to cleaning air quality thanks to not using fossil fuels within the vehicles' bodies. Due to the decreased particulate matter comes from the exhaust gasses from the pipes of vehicles by changing to electric ones, air quality will increase, hence the diseases stem from the bad air quality conditions will decrease. In addition, SDG 7 (affordable and clean energy) could also encourage the renewable energy system's implementations to cities. This could solve the problem of electric chargers' energy resource that is mostly fossil fuel-generated and creating GHG emission somewhere other than the city itself, however still counts for climate change impact. SDG 9 (industry, innovation and infrastructure) is another goal that could connect to the research, by PSS applications and their widening around the world; thanks to increasing of PSS-based electric car sharing's advertising as a good solution for sustainable consumption and production. Lastly, SDG 17 (partnership for the goals) could also connect to the research, due to need of government & private sector relationship to implement environmentally friendly solutions for the world; in this case, it is the PSS solutions.

4.7 Air Quality and Lung Health Relationship for Citizens

According to the organization of Breathe, because of the poor air quality in Europe and its damages to the lungs, people lose their one year of a lifetime in average, half a million premature baby dies and it could be as hazardous as smoking passively (being in the same room where

people are smoking) (Breathe 2016). In addition, people who live near a busy street in terms of traffic are at the same risk level as the people who smoke half a package cigarette per day (Breathe 2016). Schikowski et al. claim that better air quality in cities lower the lung-related diseases (Schikowski, et al. 2013).

Since it is stated that the air quality stems from road transportation because of fossil-fuel cars, PSS of free-floating and electric sharing cars may have the potential to reduce these problems, thanks to reducing the owned car per capita and not producing GHG emission. This approach could be considered as another goal of SDGs.

5. Discussion

The discussion section identifies the study's important topics in a specified way as the author's further reflection.

5.1 Challenges and Opportunities for Free-floating Electric Car Sharing in Broader Perspective

To answer the first sub-question, which is about the characteristics of PSS through car sharing, one needs to identify the challenges and opportunities of the system. These challenges and opportunities for the system of free-floating electric car-sharing need to be discussed to identify the system's implementation potential in the cities. A survey conducted by Zeng shows some of the barriers and opportunities for the emerging car-sharing market (Zeng 2015) in the table below;

Table 5 Challenges and Opportunities for Car Sharing, taken by (Zeng 2015)

CATEGORY	BARRIERS	OPPORTUNITIES
Potential Users	▪ Strong desire for car ownership and usage ▪ Limited driving experience ▪ *Unfamiliarity with carsharing service* ▪ *Price sensitivity*	▪ Desire for car access ▪ *Familiarity with bike sharing (China)*
Transportation Infrastructure	▪ Road congestion ▪ Insufficient public transport, cycling infrastructure to provide alternatives to car use for short trips ▪ *Limited parking for carsharing (on street or public garages)*	▪ Public transport system improvements ▪ *Poor taxi and rental car options (China)* ▪ *Low rate of car ownership* ▪ *Limited or expensive parking for private vehicles*
Governance	▪ Lack of procedures for checking driving record ▪ Lack of personal credit system ▪ *Public agencies unfamiliar with carsharing* ▪ *Vehicle restriction policies*	▪ Air pollution concerns ▪ Vehicle restriction policies (even carsharing is not exempted) ▪ Clean vehicle promotions ▪ High cost of private car ownership
Business	▪ *High capital investment* ▪ Limited access to capital ▪ Difficult to reach a certain level of operational scale ▪ Potential competition from intermediate public transportation modes like rickshaws and taxis and personal two-wheelers.	▪ Low labor cost

5.1.1 Users and Customer Service Perspective

From the *user* perspective, as also stated in the previous chapters, the desire of having a car still makes people attracted to the ownership concept rather than using sharing applications (Zeng

2015). It is the psychological factor of the societies who think that having a car brings a social image. Because mostly in developed countries it is still the phenomenon of social mind-set. People's lack of experience with driving a car, especially a third party's car, is also another barrier (Zeng 2015). It can make people feel insecure about using a third party's car as their own cars. Because, even though it is stated that car sharing takes many responsibilities from users, it still brings the feeling of using a car that does not belong to them, and they are inclined to use those cars more carefully even though they all come with the insurance. People may not want to involve in an accident report and dealing with the police after an accident or any unwanted situation, because it may be seen as a waste of time for a car that does not belong to them. Another reason is, also as stated before, the unfamiliarity with the new system of car sharing (Zeng 2015). People are more familiar with the taxi, rental car, even Uber-like options than free-floating car sharing. Using an app on their phones, uploading their driving licence to the app etc. could make people not to choose the free-floating option, since they can reach the aforementioned options easier in some cities, (e.g. just a call for a taxi is enough). On the other hand, even though the car sharing's fleets are expanding, if people do not see an available car in their neighbourhood in the app, they can also go for other options. This is related to the instant or emergency needs of transportation. Price mechanism could be another barrier from the users' side (Zeng 2015). Even though some incentives from companies for users like bonuses for first a few use, referring a friend, finding a defect of the system (like reporting a not functional car in the area) give people app-money, it is still not the equivalent expense compared to using their own cars at that moment. It is fact that owning a car in long term brings more cost for maintenance, tax, and parking; for the short term, the price mechanism is a barrier for users, especially for the car owners. Aside from the barriers, more available parking spots for car sharers, not being have to drop the car off at the same neighbourhood due to the one-way concept, the inclusion of fuel (gas and electric) to price, cheaper insurance per trips (and being free after some time e.g. 90^{th} use), price mechanism's in comparison to other sharing systems could be counted as pros of the system from users' side.

Besides the given factors in Table 5, other elements may hinder people to use the free-floating electric car sharing system as well. Since having a car comes with its own feature like more self-esteem of the owning, more sense of control for the product, the feeling of freedom etc. could discourage people to change the ownership concept what people may think as staying in the comfort zones. The social norms of users also are significant. The wish they would like to do for

the sake of an environmentalist choice, hence compromising some of the standards in their life is related to “want to do”, “ought to do” and “must-do” actions.

When users are about the change the habits or activities to show more environmentalist actions as an individual, “want to do” action plays an important role, especially for car ownership. It is because having a car brings some luxuries as explained and leaving those could lower the standard of life. Especially in developing countries, the poor service of public transportation plays an important role for this environmentalist decision mechanism of individuals, while in developed countries which have a better service for public transportation, it could be easier to become more environmentalist for car ownership mechanism.

The actions of “ought to” do are controlled by society, since people value society’s thoughts. In terms of car sharing use instead of private cars, again, in developing countries, this situation could be harder to change, because people feel the superiority of owning a car, over the people who do not. This is relatively different in developed countries, because environmentalist actions have been taking place in those societies for years and the communities see these actions as respected behaviours.

While “must” do actions may not differ from society to society that much, it is still important that in developed countries, the government’s control mechanism is well established. In terms of shifting to the car sharing application, it could be easier to transform in developed countries compared to not developed ones, since people are more inclined to follow the regulations and laws in those countries.

On the other hand, SPP theory’s outputs of adaption, travel pattern and service parameters, people who resist to adaptions will always exist. It could be related to the travel patterns of using their own cars for their jobs or free times, since it could be more convenient for them, or service parameters like costs, availability, passenger seats etc. Those will affect the people’s decision depending on the conditions they have. Other outputs of SPP theory of material competence such as shifting to the electric car could be an incentive for users to experience those, since it is still not a wide concept in the world, the trust issues could be also another problem. However, some of the people may miss the feature of non-electric cars like the noise, range, shorter fuelling time. About the competence, the new mobility system needs a smartphone with constant internet access to use the app, by uploading the driver licence and credit cards information, which could be harder for old generations to use this system, while for the young generation it is not a big

problem. For the meaning of the system, since the new system is more environmentally friendly, some people may choose the concept just because of this.

From the *customer service* (and the technical issues) perspective, not finding a car nearby could be a barrier, so that with more customer service relationship, this barrier could be overcome by analysing the data of possible users in specific areas. Also, the app does not allow to bring the cars to outer areas of the regions, even it allows, it makes the customer pay on a daily base. Customers would not want to take the cars to go to their works and use the same car to come home, if their work area is outside of the app's home area. On the other hand, some reserved car may not be in the location it seems on the app, so that the customer service needs to take care of this inconveniences. In addition, some of the experiences from the online open sources data show that; sometimes the waiting line to reach customer service via calling is too long. This could be solved by hiring more people for customer service to decrease the per user amount for customer service employees.

Another issue for the technical issues could be offering not functional cars like with defected tires or air conditioner etc. that stem from previous customer use. In order to solve these issues, giving bonuses to the customers that report those problems could be an option, which is done by most of the companies.

Lastly, the customer service can reach the possible future users by focusing on the crowded routes in the city, peak times' traffic congestions (e.g. business entrance and exit hours), and mobility ups (e.g. a football game in the city stadium, a concert in a performance centre etc.). This way, the more customer can use the system, hence the more inputs from customers can improve the service.

5.1.2 Infrastructure Perspective

From the *infrastructure* perspective, the cities with insufficient roads for cars that brings congestion is another barrier (Zeng 2015). However, this does not relate to shifting of the ownership and using the car sharing rather than own cars. It is related to using other transportation methods like public transportation, biking, walking. Nonetheless, if car sharing needs to be promoted, the cities roads need to be proper for the system. Lack of enough free parking areas and charging stations (for electric cars) could discourage people to use the system. Because car sharing supposedly needs to come with free parking within the region thanks to the agreements with local companies, municipalities or universities. After paying relatively more money compared to an average car owner for the same road, people would not want to pay extra for the

parking, because it is how companies advertise their product/service. With their own car, they are already paying for parking, and lack of this could discourage potential users. Also, for big cities, enough charging infrastructure is needed to encourage people, since the range of electric cars is still an issue and they need to be refilled more often compared to non-electric cars.

5.1.3 Government Perspective

From the *government* perspective, policies for the new mobility system and electric cars need to be taken into account differently. There is a different mechanism for a car sharing system like parking agreements, partnership with companies and NGO's to plan better mobility and traffic in the cities are related to government perspective. However, the lack of procedures, unfamiliarity and vehicle restriction policies are the barriers (Zeng 2015). For the electric car's implementation side via the governmental help, again, the policies need to be improved e.g. fewer taxes and more available spaces for electric cars owners and providers, substantially banning non-electric cars, incentivizing the sustainable methods developers for electric vehicles and sustainable mobility applications to assure the SDG targets within the cities are the governments' role. However, it is seen as a good initiative by the governments to use sharing applications and it seems that they will try harder to improve these new mobility concepts.

On the other hand, the Paris Agreement, SDGs, carbon credit and trading system in-between the car manufacturers are also part of the government's responsibility. E.g., even the carbon trading between the companies may seem as an incentive mechanism, since the incentive amount brings a huge difference compared to the companies that do not use it, it can be considered as a mandating system.

In addition, ISO standards could be another point to discuss, to be sure, that companies are following international standards. In this point, consultancy companies also have a role to help companies to assure the standards.

About the NGOs, since they are one of the key element between the stakeholders (public, municipality, the federal government, international organizations, academia), NGOs shall not be left out from this system to work. An integrated and well working sustainable mobility can be achieved with this cooperation.

While there are different law in terms of electric car battery regulations, the world needs to be meet at a point that is sustainable to produce and dispose of the batteries. The extraction of lithium is harming the developing/undeveloped countries ecosystems, while the disposal of the batteries

is still problematic from many perspectives e.g. how to treat the chemicals environmentally friendly.

Lastly, the companies that buy carbon credits of others shall not continue this way to assure a cooperative sustainable production for climate goals.

5.1.4 Business Perspective

From the *business* perspective companies need to invest for research and design; however, since automotive companies losing their investors to technology and software companies in recent years, finding the money could be a problem. Those investments could be about the increasing the range and maximum speed of the cars, lowering the battery charging duration, securing the data of customers and the electric battery temperature at a certain level, implementing more available fleets in different regions and so on. In addition, while the rivalry between the car producers and free-floating electric car sharing providers increase, the marketing and advertisement of the concept become easier thanks to this rivalry.

In addition, companies will face huge structural changes due to both shiftings to electric cars and new mobility methods. These will affect the profits margins and business standards. To survive in the market, companies need to take actions as soon as possible, since the change is at door, incoming. Also, the partnership will play an important role to distribute the roles among different companies to survive.

Companies on the other hand may be in charge of *forcing* change the habit of people who resist shifting from private car use to sharing application. By making surveys with potential users, companies can analyse the demands from the user side. In addition, by not producing a diesel or petrol car anymore, they indirectly affect the use of electric cars, by convincing them indirectly to use electric cars. To do that, they need to cooperate with many stakeholders, such as regulators, municipalities, federal governments and city planners as well. Nonetheless, the shift cannot happen only by mandating, but also a willingly approach from the customers is also needed. In other words, an organic transition is a key element.

In terms of batteries, companies must obey the rules of safety, since there are some examples of exploded cars after crashing in the middle of the street. This can harm people's life. So that, keeping the battery temperature in the safer condition in any kind of situation is a challenging part for the manufacturers.

Bert et al. state that car manufacturers can be in contact with the customers via the car sharing systems, so that they can know their needs of owning a personal car in the future and that is a

good marketing strategy for both parties because of the history between them (Bert, Collie and Xu 2016).

According to a news from Clean Energy Wire, a journal for the energy transition, Daimler and BMW's plan is create at least a thousand of new jobs by uniting their sharing platforms car2go and DriveNow (Amelang 2019). These jobs could be for the customer service, car maintenance, drivers to take the cars to bring them to central areas or in the responsibility of charging the electric cars. However, it could also affect the current workers who work in car manufacturing plants, since it is expected to decrease in the car manicuring due to the lower owned car per capita.

People could use electric car sharing systems even though they can use public transportation or walking, which are more environmentally friendly options.

The environmental perspective of the concept was discussed in the next chapters.

5.2 Environmental Potentials of the System

To answer the main research question, this section is the key section of the study.

Table 6 Car sharing's possible replacement of other transportation methods in USA *(Chen and Kockelman 2016)*

	Mode split (%)
Private car	33.6
Rail transit	19.4
Bus transit	11.6
Bike	3.8
Walk	31.6

According to the table above, car sharing's potential of replacing private cars among other transportation methods has 33.6 percent in the USA (Chen and Kockelman 2016). As it was given before, car sharing has the potential to substitute 7 vehicles in Europe and 11 in the USA and Canada (Bignami, et al. 2017). This means that 33 percent of the whole substituted transportation equals to 11 cars. From this equation, around 6-7 people will shift from rail transportation, 4 people from bus transportation, 1 person from biking and 10 people from walking can change to use car sharing. From the environmental part, biking and walking are always more environmentally friendly than compared to any type of car use. While for bus and rail transportation it is hard to assess, since the CO_2 emission stems from those transportation methods will be more than using free-floating electric car sharing. However, public transportation is considered more environmentally friendly due to the shared vehicles in general. Besides, the traffic congestion potential of electric car sharing compared to public transportation

is higher. That is why it is hard to assess the difference that depends on many parameters. Nonetheless, it is a fact that 7 to 11 private cars are not small numbers in terms of the environmental burden.

Another point is the idle passenger vehicles, which are around 90 percent of all cars at a time, as Ellen MacArthur Foundation stated (Ellen MacArthur Foundation n.d.). The rightful consumption of cars thanks to car sharing can be a way to achieve more sustainable consumption.

The research and design process by the companies could be limited due to decreasing sell, since the less volume of the sold products due to sharing services could mean the less revenue for companies to improve the RD. However, according to a report from Accenture, the connection between the customers and companies can expand the business models and it can make companies earn more revenue (Accenture 2016), and this can trigger the decreased car consumption per capita, which can end up with more sustainable consumption in general, thanks to the functionality of the business model. Because functionality brings up more efficient use of any product or service, thanks to its feature of using those whenever needed and only needed. While the decreased consumption and production already could be considered as a good output for the environment (SDG 12 & 13, responsible consumption and production, and climate action, respectively), electric car's capacity of lowering the cities' emissions thanks to not using carbon-based fuels, it can also contribute to SDG 11 (sustainable cities and communities) directly.

Fromm et al. state that, in European capitals where free-floating electric car sharing is available, the net CO_2 emission per capita decrease drastically (Fromm, et al. 2019), as well as the NO_x and PM (Filho and Kotter 2015). While this situation will help to comply with the Paris Agreements goals, it will also clean the air quality in cities. Especially the big cities have much more potential in this case, since most of them are relying on private car use (Rode, et al. 2017). That is why; focusing on the metropolitans is a clever approach for the car sharing companies in both economy and environment-related approaches. On the other hand, big cities with the young generation have more potential, since the new generation's ownership concept is looser than the older generation.

In addition, the societal and healthy factors of cleaner air quality can reduce the lung-related diseases and deaths in the cities. While lung cancer is a huge problem around the world, which one of its reasons is poor air quality, more environmentally friendly car engines and lower per capita car use can have a huge impact for lowering this problem. Societies who live in a city with

better air quality can do sports, joggings, walking in open air easily, and more healthy generations can raise.

About the economic perspective, it was aforementioned that using the car sharing application more than 7,500 kilometres in a year is more sensible compared to use private cars (Bert, Collie and Xu 2016). Even though it may be seen that, per shorter amount of use, it is a little more expensive compared to using a private car, in the long term, it compensates its value, due to not paying maintenance, tax, insurance and parking tickets.

On the other hand, cities with electric car sharing platforms can implement renewable energy grids easier, since the infrastructure for greener energy could be easier in those cities, because of the policies. They are mostly metropolitans, and policymakers' success in terms of implementing renewable energy could bring more trusts to those politicians.

Also, the noise could be a disturbing factor in a city centre with higher traffics, because of the ICE cars, while shifting to electric cars can solve this issue easily (electric cars' noise are very low compared to other car types because of the engine).

The circular economy concept of PSS for the car manufacturers and its application mechanisms in the market is the next chapter.

5.2.1 Reuse/Remanufacturing and Remarketing of the Old Cars and Batteries

The linear concept of manufacturing does not serve the circular economy. The PSS of electric cars for car sharing has the potential to change the linear method for car manufacturers, thanks to the ownership concept. Since the new owners of cars in the system are the manufacturers, they need to take care of the cars after their end of life or end of the functional use date.

The first approach is about the car manufacturer's responsibility for the end of life vehicles and battery. To start with, car bodies that come from car sharing's vehicles need to be reused, or remanufactured for the other processes to assure more environmentally friendly waste management. This could be done via third-party companies that deal with waste management or in the manufacturers' own plants. The ownership can force the companies to do this more efficiently due to the regulative rules. For the electric batteries, the most applied and *supposedly sustainable* system is turning the non-functional batteries for vehicles to energy storage units. Since the batteries still have the potential to store energy after losing their functions for a vehicle, they are still usable for other processes. These storage units can be used for balancing the production plant or cities' energy grids, depending on the number and capacity of the batteries. This way, batteries life could be extended as long as possible within the current technology. Even

though new systems are developing for battery's waste management, this method is considered as the most efficient and profitable way as of now (see figure 31). Nonetheless, it reduces the generated waste per car and assures better standards for natural resource use, which are considered as environmentally friendly methods, within the framework of circular economy. Filho et al. state that second-life electric cars' batteries could be an alternative for cities' electricity grid (Filho, et al. 2015). This way, its utilization will be more and its impacts on the environment will be minimized.

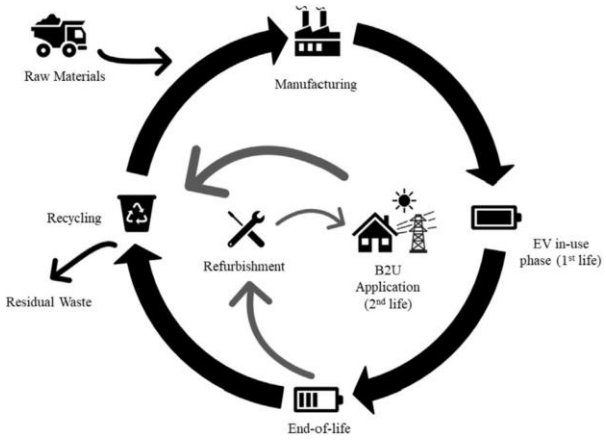

Figure 31 Life cycle of electric batteries with second use *(Reinhardta, et al. 2019)*

The second approach is changing the cars belonging to car sharing's fleets in one or two years, and selling them to the second-hand car market for further use, by changing the batteries. This is called remarketing. The purpose of this method is related to the car companies' profits from old cars (for car sharing), and renewing the fleet to compete with other brands. However, it can be expected that, by the time, the second-hand market will not need these cars, due to the oversupply. Therefore, the environmental burden can occur, due to the excess number of car production. Governments and companies need to be careful for this rebound effect.

5.3 Rebound Effects of PSS for Electric Car Sharing

As stated earlier, since car sharing also has the potential to transform more environmentally mobility methods (e.g. walking, biking), it can increase traffic congestion to some extent.

On the other hand, when electric cars became wider in a region that has not durable for instant loads on the grids (for charging cars), it can break the city's grid and end up with costly maintenance. That is why the cities need to be prepared for high loads. Another point is, when a

person thinks that if the car he/she uses is energy efficient, it can end up with feeling to drive more due to this energy saving (Ottelin, Heinonen and Junnila 2017).

Companies could produce fewer quality products to produce cars, since people do not spend much time in the same car, compared to the sold cars. This can bring up safety issues e.g. more damages in crashes due to a lower level of material quality. However, the ISO standards and governmental mechanisms mostly hinder this option.

While creating new jobs for customer service, maintenance people etc, it can end up with not needing blue-collar employees in the manufacturing companies, due to the decreased car production numbers.

5.4 COVID 19's Impact on Private Car Ownership and Car Sharing Use

The COVID-19 pandemic has been affecting the world, especially in the beginning of March 2020. A very dangerous virus, that is also very contagious via the air and droplets, made people think about the use of sharing applications. Especially in urbanized populated areas, it became a norm to keep the social distance. Using a car that is also used by the others during the day is not a charming option as of now. The interviewees also mentioned about these change. This situation increased car sales around the world, because of the "safer feeling" by using a private car rather than public transportation or car sharing applications. This could even continue after the COVID-19, according to a journalist from CNBC, Vishwanath (Vishwanath 2020). According to Campbell et al., the decrease in the car sales before the pandemic is raising now due to the fear of the virus, and it increases the private car ownership (Campbell, et al. 2020).

Scientists still do not know when the solutions (vaccines, pills) will be developed for the COVID-19, while some of the projections show that it may last until the end of 2021 as the best guess, people need to rearrange their transportation habits. It is not clear if the *new normal* will become a permanent phenomenon or not. Yet, it is certain that in the short-term, it will affect the car sharing's use, negatively. Users who clean their cars in a daily/weekly basis cannot have the potential of shifting for car sharing as of now.

6. Conclusion

The research focuses on the free-floating electric car sharing as a Product-Service System concept and its environmental impacts. The findings for the environmental potentials of the new system are as follows; the new concept can lower the CO_2 emission per capita and per car, besides reducing the air pollutants of NO_x and PM in the cities that can be related to health and

societal issues. User preferences in terms of social practices and mind-set play important role in shifting to car sharing applications, while policies, companies' investments and NGOs cooperation are also other key elements for environmental improvements.

While investigating the environmental impacts, the characteristics of the new mobility concept were also analysed in terms of opportunities and challenges of the system. The findings could be summarized as the following; the free-floating electric car sharing system consists of car manufacturers (providers), customer service and user's strong relationship within the control and surveillance of governmental bodies. It aims the change the ownership concept of the cars from users to providers, and this brings many responsibilities to the manufacturers (e.g. maintenance, insurance, recycling, remarketing, battery and charging infrastructure) while taking many from the users what they see as a burden (e.g. fixed costs, taxes, parking space etc.). On the other hand, users also lose some of the function of car use such as freely using their own cars whenever and wherever they want to use, since the new system is still limited within the city centre and not available for very long-distance travels, besides the limited fleet size for all citizens.

The collected data of this study, as a qualitative analysis with the interviews and literature, is interpreted by the author by abductive reasoning. Therefore, it can be said that it is a layered knowledge, but not the representation of reality directly (Kristensen 2016); however, it is not to say that the analysis and discussion parts are not good enough for further use in the academia.

In addition, even though all interviewees had knowledge about the questions they were asked, their jobs' focus mostly differs from a real expert in the area. However, this is not to say that their answers are not valid, since due to the abductive reasoning, logical parameters that interviewees contributed were applied to the research in a coherent way. In addition, this gap of real expert knowledge was filled with YouTube interviews from the free-floating electric car sharing companies' managers.

Lastly, since the interviews were not conducted in English languages, there could be some minor issues like *lost in translation,* however, concepts and main ideas keep their value, since the translated documents were also sent to interviewees to check the correctness, before adding to the research.

7. Future Considerations

7.1 Autonomous Vehicles

Future's vehicles will be much more different than today's ones. Ellen MacArthur Foundation summarizes the vehicle of the future with the figure below (Ellen MacArthur Foundation n.d.);

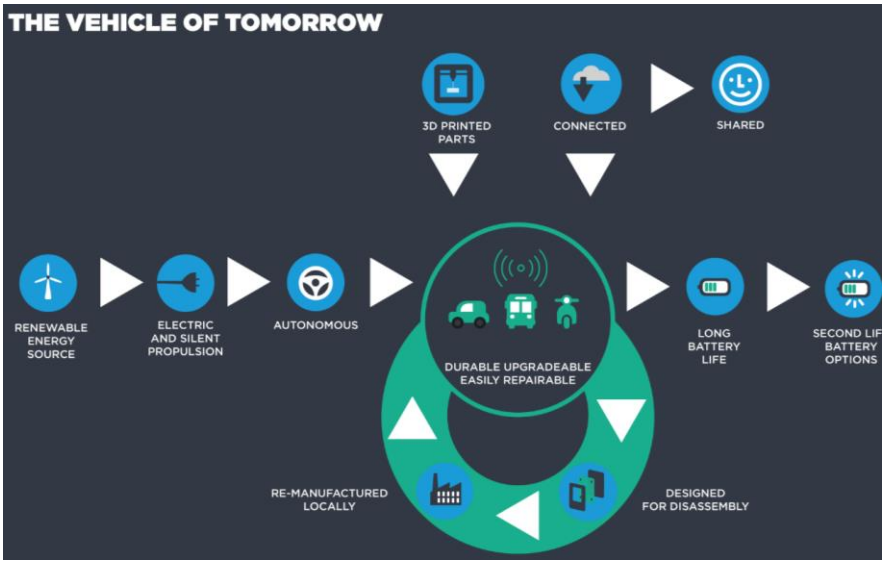

Figure 32 Circular Economy concept of cars, taken by (Ellen MacArthur Foundation n.d.)

The information from the figure could be summarized as the following; the circular economy within the vehicle life cycle (in this case, passenger car) is a concept that uses renewable energy that feeds the electricity needs of the autonomous cars. This vehicle will be produced via 3D printers and will have a cloud base connection with transportation systems. This system will include also a *sharing option* that is the core of this research. One can talk about free-floating sharing options here and with the connected mobility thanks to technology; there could be a better chance to integrate this system into modern cities in the future. Since the providers will have the ownership, they may need to update their cars' performance in favour of environmental-friendly options, because society would want to use cars that do not perform to global warming.

Also, since the vehicles will be fully electrical, its battery will have long battery life and could be used in other processes for its second life. About the afterlife of vehicle, the processes will be continuing with remanufacturing in local plants easier, since it will be designed for easier disassembly features. These whole processes actually will benefit to environment positively, since the production, use and waste phases of vehicles are optimized for better environmental outputs, which means more efficient production (less raw material extraction), more efficient use (car sharing), and more efficient waste management (remanufacturing and second lifetime).

In addition, Ediz claims *"For the cars, now the vision is, they'll be driving around without a driver. You will call the car whenever you want, it will come directly, you will get on the car, maybe buy some accessories you want in the car as an app. This (app) can be anything, like a massage. Or, it can be the simplest option like navigation, or using it manually. You will choose them. By offering you these options, the car will take you wherever you want."* (Ediz 2020).

According to Grosse-Ophoff, autonomous vehicles will enact the actors in mobility, by repositioning them to produce to smaller fleets for assuring the acceptable cost; also smaller cars reduce the city traffic, these benefits could make governments be convinced easily (Grosse-Ophoff, et al. 2017).

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9. Appendix A

Interview Guideline for Mr. Kerem Ediz – Supply Chain Manager at Mercedes-Benz Turkey, 30.09.2020, Conducted via Skype

Here, the short answers was given for readers to reach the information easily. The whole transcription, translation and audio of the interviews could be found through the following link;

https://drive.google.com/drive/folders/1ZEo7-JxZA6gbG504UctwHu0gij2kXO4Y?usp=sharing

Opening Question

Ideally, this part is about the interviewee's resume; however, since the author knows him from his previous experience in the company, self-introduction part was not discussed. He was working as the manager of Quality/Health/Safety and Environment Department for 6 years. This year he changed his position to Supply Chain Manager at Mercedes-Benz Turkey.

Introductory Questions

What is Daimler's vision for electric vehicles?

Transition Questions

If we talk about only in the passenger car specification, I will also go towards the use of electric cars and car sharing. But, could you evaluate firstly the changes in the use-pattern of the car users?

Short answer is; use pattern has been changing recently to now owning anything in general, from cars to house etc.

Do you have any experience in customer service, did they reach you when something happened in any part of the vehicles, buses or with service, and how were these problems solved?

He has received some issues regarding vehicle's parts and he managed the fix it by sending the product firstly the distributor's maintenance house, if not fixed, Mercedes-Benz takes it to fix it in the company body, if not fixed again, they change the product completely.

Key Questions

Supports, incentive packages, whether from the EU or from various governmental bodies, for electric vehicle production or for sustainable mobility. Do you have any information about the incentives for electric cars and sharing apps?

He thinks incentives seems as mandatory applications, since when a company does not get those incentives (super credits etc.), they are greatly limited for the production. While he does not deeply know the mechanism, he knows that EU has many of them to offer to car manufacturers.

You said there is no car sharing from MBT (Mercedes-Benz Turkey), but I guess there is at least car leasing, and I will ask in that direction. But, hypothetically let us say the owner is still Mercedes Benz, and then these cars should be recalled after a certain period of use. How would the waste management be done, in the form of remarketing or remanufacturing (or reuse)?

Even though MBT does not offer car sharing, it gives its managers cars that MBT made. These cars are collected by the time, to sell them to second-hand car market. And the models of the cars are selected by the needs of the market. Basically, MBT does not deal much about the cars rather than remarketing.

Circular economy and product-service system issues are actually my focal points. MBT does not do PSS probably much (based on previous comments). On the basis of circular economy, we said that the work is done by automotive companies are remanufacturing and remarketing. When I say circular economy, what comes to mind in terms of a car company perspective?

He thinks that even though it is not mandatory yet, to deal with the cars that are set for scraping, it will be mandatory by the time. The regulations will be applied by the EU soon, to save the waste of cars and their hazardous potential for the environment. Currently, second party companies are doing it.

End of life vehicles, cars used in car sharing, especially electric cars. What kind of a recycling system do they consist of? E.g., the cars have used a certain capacity; it has dropped to 70%... Do you have any information about the batteries, e.g. how to change it or what happens to old batteries?

He stated that a car never finishes its life under a sharing/leasing company's ownership. They are always remarketed for the second hand car market. For the batteries, there are some application to use the battery in energy storage warehouses.

Are the company's investments hand-in-hand with the brand value brought by the sustainable practices?

Since it is really competitive market, they have to invest in sustainability, in terms of electric cars and mobility concepts. They are increasing the brand value.

Will this (not getting much money from the investors as previous years) push companies to produce their own know-how and increase competition even more?

Since companies' stock value has been decreasing relatively, compared to tech companies, car companies cannot attract investors like before. When they cannot get investment, it is hard for them to produce know-how, and vice-versa.

Closing Question

Thank you very much, I guess, it is the time now, is there anything you would like to add?

Besides the main topics, conversation went to some other directions like the impact of the current pandemic on the car companies and sharing platforms. He thinks that sharing platforms will lose its charm, if the pandemic will continue for a few years, because of the personal space and hygiene concepts. People will own cars rather than sharing in this case.

10. Appendix B

Interview Guideline for Anja Aylin Aydogan – Project Leader at Yesil Cember GmbH 01.10.2020, Conducted via Skype

Opening Question

Ideally, this part is about the interviewee's resume; however, since the author knows her from his previous experience in the same company, self-introduction part was not discussed.

Introductory Questions

Regarding a sustainable transportation, if you look from the eyes of an environmental NGO (NGO), where exactly is Berlin, what can be improved, what is missing, what is good?

Bike sharing and car sharing is improving. Public transportation is also well. Bike lanes are not at their best.

Transition Questions

As an active working person at an environmental NGO in Berlin, you did many activities focusing on the consumption habits. I also was involved in some them, when I was there working. What kind of approach Berliners have towards green consumption, not only in terms of food / drink but any product, such as driving a car, or using any kind of service, in anything you can think of. Let me say a sustainable lifestyle actually. What do you think about this issue in general (environmentalist consumption habits of Berliners)?

Germans are more inclined to consume sustainably. Ethnic groups do not prioritize it mostly. However, due to many campaigns, these types of actions are increasing.

Key Questions

There was also an application called Repair Café under Yesil Cember's responsibility. Repair Café platform is hand-in-hand with the culture of sharing. Car sharing is also a sharing culture, when we look at it on the framework of circular economy. How effective do you think such common use/sharing mechanisms are in spreading social sustainability?

It is also gradually progressing. Not like in the middle Ages where people use most of the things common, but there are many applications to spread these actions.

Do you think it is possible for people to see these behaviours (use of sharing platforms) from their acquaintances and reflect such an environmentalist behaviour to themselves?

Definitely, sharing's effects are huge. Also there are lots of advertisement around the city about the car sharing. The new platforms I mentioned encourages people, because they can access easier. But, it is not to say they people are just shifting to that way just because it is environmentally friendly, it is just the more convenient way for some people.

What are the effects of age, social class, region of residence, in the use of sharing platforms?

Young generation use them the most. However, old generation is also inclined to use them, because of some specific needs. Social classes were discussed before.

If we relate it (having small houses) to the car issue, can we say that they do not intend to buy a car because most of them do not have a garage like time old times?

How effective do you think NGOs are in spreading these sharing platforms to communities?

The NGO I am working at is not specifically, but we do have some sharing events like tool sharing, cloth sharing etc. Some NGOs offer sharing regulations to city governments.

Closing Question

Thank you very much. Is there anything you would like to add?

No, that was all.

11. Appendix C

Interview Guideline for Ms. Sensoz – Project Assistant at Transformative Urban Environmental, Germany, 12.10.2020, Conducted via Skype

Opening Question

Hello, Ms. Beste, could you introduce yourself?

Beste Şensöz is an architect and city planner, graduated from ITU (Istanbul Technical University) as architect and from TU-Berlin as urban manager. She recently completed her sustainable urban mobility project in TUMI-GIZ, which took 6 months. She has about 1.5-2 years of experience with her internships, on architecture, urban design and sustainable transport planning.

Introductory Question

What are your thoughts on car sharing? Why do people choose it? How did it emerge? If we ignore the Covid19.

Before and after Covid19 is very different. Car sharing is an important trend, but if we look from the perspective of sustainable mobility, it is still not an ideal method of transportation. However, it is actually an important alternative especially for developing countries and countries whose public transportation infrastructure is not very developed. Because still car dependency is an important factor, especially for developing countries. Nowadays, it is an important development that these are electrified. The EU is addressing this subject in the New Green Deal. Until this time, we checked the private car usage. It

was falling. Itis one of the biggest fears that the car ownership could rise. If it will rise, it is very logical to solve this with car sharing.

Transition Question

What are the psychological factors of car ownership?

This varies depending on the geography. It differs in developing countries and developed ones. Mind-set is an issue that needs to be changed. Developing countries see it as a social indicator, while in developed ones it is a fundamental approach to use sustainable methods.

Key Questions

Which of the "want to", "ought to" and "must" actions are effective in choosing sustainable and environmentalist actions of people as a society? Which one of the individuality, sociability or the sanctions of the state are more effective?
If we are talking about bottom-up and top-down approaches, they need to compromise. The transition needs to be organic.

What are the possible contributions of free-floating (car sharing) to integrated transportation or to the understanding of sustainable cities in general?
It definitely has a very important potential. Free floating is a great incentive and comfort. To establish a whole system by bringing together different planners, people from the private sector, government, academia, and thinking of different segments with an integrated system.
What kind of conveniences can be provided for electric car sharing rather than a mandatory mechanism?
We can achieve this integration by identifying these needs with local people and analysis.

What is the importance of NGOs' collaboration with society to spread the SDGs?

It is a very good intersection point if you take into account the partners, networks, the stakeholders they reach, besides the projects they produce.

Closing Question

Do you have anything to say extra?

No.