THINKING OUTSIDE THE ROLLING BOX: TOWARDS SUSTAINABILITY IN AUTOMOBILITY

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Sander Tjoelker

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Author:	Sander Tjoelker
Student number:	s3223329
Email address:	s.s.tjoelker@student.rug.nl
University:	Rijksuniversiteit Groningen Faculty of Spatial Sciences Landleven 1 9747 AD Groningen
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Supervisor:	F. (Farzaneh) Bahrami f.bahrami@rug.nl

ABSTRACT

The current system of automobility has resulted in a path-dependence and a change is desired due to several challenges: pollution, energy consumption, privatization of space and time-space consumption. The automotive industry itself can have a significant impact in such a transition. Globally the industry employs over 50 million people, both directly and indirectly (OICA, 2006).

By doing a case study, an analysis of literature and a variety of different secondary sources, understanding is developed on how (and how well) the automotive industry tries to incorporate more sustainability in the process of developing future automobility. First, an analysis is being done what strategies to achieve sustainability are being proposed by the automotive industry, using a case study. Second, the conceptual model (as shown in paragraph 2.3) serves as a template for an ideal sustainability strategy. Third, an assessment is being done how well the proposed strategies fit the model, which results in a projection of how much potential success the strategies could have.
Based on the results from the case study, it becomes clear that the automotive industry has proposed some promising strategies, which deal with the challenges to a certain extent. However, currently there is no single strategy that deals with all the challenges itself. It needs to be supplemented with the other strategies. Together, they may tip the system of automobility in a *post-car* system.

PREFACE

You are about to read my Bachelor Thesis: 'Thinking outside the rolling box: towards sustainability in automobility'. It addresses how the automotive industry itself is trying to achieve a more sustainable automobility system. Cars and the automotive industry have always fascinated me. In particular, its Volkswagen (and its sister brands) I developed a taste for. However, Volkswagen AG has also been a controversial topic for the last 4.5 years, because of the diesel scandal (Mansouri, 2016). This inspired me to do this research.
This thesis represents the final step of my Bachelor Program Spatial Planning & Design at the University of Groningen, that started almost three years ago. In this thesis, all the knowledge, skills and tools that have been aquired are put together, resulting in an all-encompassing research. The completion of this project marks the end of the first chapter of my academic career, which will be continued next September with the Master Program Real Estate Studies. I am looking forward to the exciting times that lie ahead.

Now that this intensive period of four months has come to an end, I have definitely learned a lot about the concept of automobility and the sustainability strategies as proposed by the automotive industry. I would like to thank my supervisor Farzaneh Bahrami for her useful and constructive feedback during the process of conducting research and writing the thesis. I would also like to thank who assisted with finding data related to Volkswagen AG.

Last but not least, I would like to thank my fellow students, friends and family who were willing to share their time and knowledge and were supporting me during this process.

In the meantime, I hope you enjoy reading my thesis!

Sander Tjoelker
Kollumerzwaag, June 2019

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CHAPTER 1 INTRODUCTION

1.1 Background

In the 19th century, public transport was the dominant mode of transport (Urry, 2004). However, throughout the 20th century, it was the car that gained an unquestioned impact within the system of automobility (Dowling & Simpson, 2013). It has provided people with a desire for freedom, only the car is able to satisfy. Therefore, unrestricted movements of the individual are considered an absolute right and the car has become an instrument for exercising that right. In fact, many social activities could not be undertaken without the flexibilities of the car and its 24-hour availability (Urry, 2004). So in this context, Dowling & Simpson (2013) regard the car as a symbol of progress, freedom and independence. This has been a key driver for the increase in the number of cars over the years. In 2004, there were around 700 million cars around the world (Urry, 2004). And by 2010, this number had already exceeded 1 billion (Tencer, 2011).
However, due to a path-dependence, the current system of automobility needs to change. For example, transportation is responsible for 20% of the total greenhouse gas (GHG) emission in the European Union (EU) (Scarinci et al., 2017). The primary cause of climate change is this emission of GHG by combustion of fossil fuel related to energy production for human activities, such as transport. Climate change is a great risk for the society, environment and economy. Moreover, the transportation sector is responsible for 30% of the total energy consumption (Scarinci et al., 2017) and almost half of the world's oil consumption(Papatheodorou & Harris, 2007) .
Another major issue is congestion, especially in urban areas, since as of today, 55% of the world's population lives in urban areas. That proportion is expected to increase to 68% by 2050 (United Nations, 2018). In this context the car no longer unproblematically symbolizes progress, freedom and independence, but is more considered as an (un)necessary evil. Therefore, governments start looking at ways to combat the challenges and construct more sustainable cities (Dowling & Simpson, 2013). Recently, the will to reduce cars in policy making has increased substantially, by promoting a modal shift from the car to bicycle (Schepers & Heinen, 2013) or public transport like the bus (Davison & Knowles, 2006) for example. According to Scarinci et al. (2017), transport policies can have a significant impact on GHG emission and energy consumption and on achieving a modal shift. However, most trips made by cars were never made by public transport (Urry, 2004).
Therefore, the automotive industry itself can also have a significant impact in such a transition. Worldwide, over eight million people are employed directly (manufacturing), which is more than 5% of the world's total manufacturing employment. About 40 million people are employed indirectly (other services). So in total, more than 50 million people are employed worldwide by the automotive industry (OICA, 2006). Moreover, if the automotive industry were its own country, it would be the 6th largest economy worldwide (Wickham, 2017).
As mentioned before, the current system of automobility needs to change towards a more sustainable state (Urry, 2004). The model by Dennis & Urry (2009) could be an example of such a state. Therefore, this research discusses how the automotive industry is striving for such a transition by looking at one particular case: Volkswagen AG. The sustainable state, referred to in this research is inspired by the system as described by Dennis & Urry (2009).

1.2 Research problem

While the societal relevance is of significant importance, as described in the previous section, the academic relevance should not be overlooked either. Research already has been done on automobility as a system (Urry, 2004) and on sustainable states in automobility (Dennis & Urry, 2009). This research applies these concepts to the automotive industry, so it builds upon previous knowledge to make a useful contribution to academic knowledge. Therefore, with this research, understanding of how (and how well) the automotive industry tries to incorporate more sustainability in the process of developing future automobility is developed. This is investigated using one main research question and multiple sub questions.

Research question:
How does the automotive industry strive for sustainability transition in (auto)mobility? A case study at Volkswagen AG.

Sub questions:
1. *What are mobility, automobility and the sustainability transition?*
2. *What has been the impact of the diesel scandal regarding the sustainability transition?*
3. *What strategies have already been designed by the industry to tip the system into a more sustainable state?*
4. *What are the implications of these strategies for the future of mobility?*

1.3 Hypothesis

The main hypothesis involves that dieselgate is the main driver for car manufacturers to strive for a sustainability transition in automobility. In other words, if dieselgate would not have happened, there would not be such a strong focus on the sustainability transition. The notion of congestion and pollution caused by automobility was already clear before dieselgate, which came out in 2015 (Mansouri, 2016; Urry, 2004). So there should already be some focus on sustainability for quite some time. Yet, when looking at Volkswagen AG for example, the hypothesis still seems plausible. Before dieselgate, the main focus was to improve conventional cars with a combustion engine, because they believed that it still had lots of potential. They did not want to consider focusing on electric vehicles (EVs). But after dieselgate, most of the management team was replaced and a whole new business plan was adopted: developing a completely new series of EVs on the newly developed MEB platform. This would be considered impossible before dieselgate (Kerler, 2018; Van de Weijer, 2019). This statement is tested using the research questions from the previous section and the methodology described in chapter 3. Also, chapter 4 goes into more detail on Volkswagen AG and dieselgate.

1.4 Structure of the thesis

This thesis consists of five subsequent chapters. The following chapter, chapter 2 contains the theoretical framework that discusses the key concepts and challenges. It addresses the conceptual model, which is used further in chapter 5. Chapter 3 discusses the research methodology and explains why specific decisions were made regarding methodology. Chapter 4 introduces the case study, which is key for the concluding remarks. In this thesis, the case is Volkswagen AG and the strategies with which they strive for sustainability in automobility. Chapter 5 analyzes the aforementioned strategies from chapter 4 and assesses how much potential success the strategies could have. It also discusses the policy implications that are related to such strategies. Finally, chapter 6 answers the research questions and discusses these answers. Moreover, recommendations for future research are proposed in this chapter.

CHAPTER 2 THEORETICAL FRAMEWORK

2.1 Mobility, automobility and sustainability transition

Mobility

Sheller & Urry (2016) consider travel and movement of people and objects, but also imaginative movements all as forms of mobility. But the focus of mobility research goes beyond physical and virtual transportation. Elaborating on that, Grieco & Urry (2016) identify 5 interdependent mobilities that are producing social life across multiple distances and that give rise to its contemporary structure. The first one is corporeal travel of people, organized in terms of contrasting time-space patterns. This can be daily commuting, but also a once-in-a-lifetime movement. Second is the physical movements of objects like foods, presents and souvenirs moving from producers to retailers and consumers. Third is the imaginative travel, made possible by places and people appearing on images and other visual media. Fourth is the visual travel in real time transcending both geographical and social distance. Finally there is communicative travel through messages, letters, texts and phone calls between people (Grieco & Urry, 2016). Communications and the internet are interconnected with transportation. Information and communication are incorporated into moving objects. Therefore, cars, roads and buildings are re-wired to send and receive digital information (as with Intelligent Transport Systems). Such technologies are connecting machines to create new hybrid mobilities (Urry, 2004).

Mobility and the ability to leave home are also considered essential aspects of people's quality of life, especially of the elderly (Hjorthol, 2013). Thus, movement has become important in the contemporary world, especially the freedom of movement, due to the widespread attention in media, public sphere and politics. This has become the ideology of the 21st century. Both the United Nations and the EU consider movement as a right in their constitutions, even more than knowledge, celebrity and economic success itself (Grieco & Urry, 2016).

Automobility

According to Urry (2004), automobility consists of six components: the manufactured object produced by leading industrial sectors and firms, the major item of individual consumption, a powerful complex constituted through connections with other industries, the global form of 'quasi-private' mobility that suppresses modes like walking and cycling, the dominant culture that determines what the good life is and finally, the most important cause of the use of environmental resources (Urry, 2004). These components create a system that consists of fluid and interrelated connections. Automobility thus can be conceptualized as a self-organizing and non-linear system that spreads worldwide and that generates the preconditions for its own self-expansion (Urry, 2004). With automobility, the most important thing is not the 'car' itself but the system of these interconnections. Yet, within the system the car has gained significant power, due to the embeddedness in contemporary society (Urry, 2004). This is one of the main aspects that makes a break from the current system of automobility so challenging (Urry, 2004).

Despite automobility being a system of mobility, it generates minimal movement once the driver is strapped in his/her seat. The other traffic determines the direction of the car, its speed, its lane et cetera. In other words, automobility is defined as a coherent system which involves autonomous humans combined with machines with capacity for autonomous movement along a variety of paths and routeways (Urry, 2004).

Sustainability

In general, sustainability means that any economic or social development should improve, and not harm, the environment in a global context. Since the second half of the 20th century, it is one of the most applied concepts among professionals and academics when discussing the future (Newman &

Kenworthy, 1999). The most discussed feature is the environmental issue. However, this is only one aspect of sustainability. Therefore, Newman & Kenworthy (1999) propose four approaches to achieve global sustainability: the elimination of poverty as an environmental issue, the first world must reduce its consumption of resources and the production of waste, a global cooperation on environmental issue is no longer a weak option and finally, sustainability can occur only using community-based approaches that acknowledge local cultures seriously.
A desired state of sustainability is what Urry (2004) defines as the *beyond steel and petroleum system* or *post-car*. This state is more refined by Dennis & Urry (2009), which will be the inspiration for the conceptual model used in this research. It is called *post-car*, not because they believe we should ban cars completely, but more as a way to clarify that the current use of it needs to change. We need to be reconsidering the automobility and the car in its current form (Dennis & Urry, 2009; Urry, 2004).
As mentioned before, recently there has been more and more attention for a modal shift from the car to other modes of transport like bicycle or public transport for example. However, to achieve sustainability, the dominance of buses and trains from the 19th century will not be re-established, since any *post-car* system involves individual movement, which automobility requires (Urry, 2004).
Furthermore, much of the old (current) automotive industry like production locations, brands, products and companies are likely to disappear over the next few years, because the industry ceases to be sustainable due to flaws in business models and an inability to incorporate technologies required for sustainability (Wells, 2010). Therefore, Wells (2010) advocates for an industrial ecology approach and he proposes a more diverse industry. This regards industrial systems as if they were ecological systems and diversity is seen as a healthy, and thus sustainable, characteristic for an ecosystem. However, currently the automotive industry has been characterised by globalisation and a form of technological monoculture.

2.2 Challenges in automobility

The path-dependence in automobility is explained with four challenges, that play an important role in the system. Not only the pollution and emission related topics are relevant, also the congestion and time-space consumption need to be addressed. These four challenges are defined as the following: environment, energy, public space and time-space.

Environment
Climate change is a great risk for the society, environment and economy. The primary cause of climate change is the emission of GHGs by combustion of fossil fuel related to energy production for human activities. The transportation sector accounts for 20% of the total GHG emission in the EU (Scarinci et al., 2017). Apart from GHG and climate change, it is also an important source for other types of pollution, including urban air pollution, acid rain and water pollution from road building and run-off (Böhm et al., 2006). Therefore, alternative fuel systems like EVs (Hooftman et al., 2016) or hydrogen powered vehicles (Edwards et al., 2008) help to reduce the emission of harmful pollutants. Also, green mobility, that is travel by foot, bike or public transport reduce resource consumption, emissions, and decrease noise pollution (Gehl, 2010).

Energy
Second is the energy problem. The current system of automobility both has a car and oil dependence that needs to be addressed (Dowling & Simpson, 2013). Oil is a scarce resource, which has a finite lifetime (most suggesting a century at best), yet is the single most important fuel for the organization of mass transport (Böhm et al., 2006). According to Shove et al. (2015) people use cars, energy and natural resources not for their own sake but for accomplishing social practices. These are examples of human activities, as described by Scarinci et al. (2017) that contribute to climate change and the energy and oil consumption. In fact, road transportation is responsible for almost half of the world's oil consumption (Papatheodorou & Harris, 2007). As mentioned before, transportation is responsible

for 30% of the total energy consumption (Scarinci et al., 2017). Over the long term, hydrogen-methane technology could help to reduce the energy consumption, since excessive wind and solar power generated during peaks can be stored. This stored, excessive energy is used as a way to meet the growing demand for renewable energy sources (Buchal et al., 2019). Also, transport policies can lead to a significant modal shift toward more energy efficient modes of transport (Scarinci et al., 2017).

Public space

Due to the car, more and more public space is being privatized. As shown by the graph in image 1, the level of car-ownership been increasing everywhere in the world between 1998 and 2008, resulting that there are simply too many vehicles per inhabitant, that all take up public space. In West EU for example, the number of vehicles per 1000 people has increased from 400 to 500. Therefore, the degree of car-ownership has to be reduced (Parolotto, 2012).

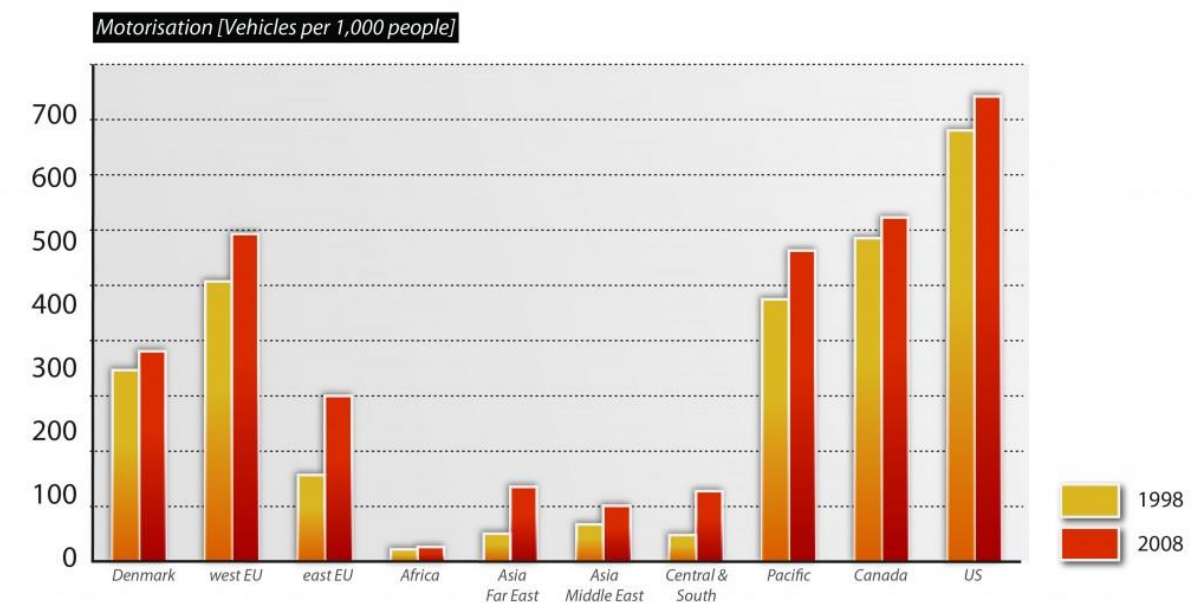

Image 1: Illustrating the continuous growth of car-ownership between 1998 and 2008. (Parolotto, 2012)

Urban environments used to be shared public spaces an area where different social functions and practices like work, home and leisure were integrated. However, the car has divided these functions, resulting in long commutes into and across the city. This undermines local retail outlets to which people used to walk or cycle, which deteriorates urban centers and public spaces. In return, people now inhabit congestion and health-threatening environments due to moving around in their private capsules. Public space has become a structure of auto space (Urry, 2004). As a result, more and more people protest against the auto space. One example is in Latvia, shown in image 2 (which is also on the front page), where people constructed the silhouette of a car on their bikes and cycled across town protesting in favor of more bike lanes. At the same time, it can be seen how the space consumption of one car relates to that of a bicycle.

Image 2: Cyclists protesting in Latvia. (CityMetric, 2014)

Redesigning infrastructure to stimulate walking, cycling and mass transit (human scale) would bring health and economic benefits, leading to a higher quality of life (Zuegel, 2018). This is substantiated by Gehl (2010), since he concludes that increased concern for the human dimension reflects better urban quality. However, in order to increase widespread walking and cycling, a city must increase both the quantity and quality of well-planned public spaces that are based on the human scale and thus sustainable. In fact, everyone should have the right to accessible open, public spaces, just as they have a right to clean water (Gehl, 2010). We thus should build cities for people and not for cars (Zuegel, 2018).

Time-space

All the aforementioned more or less comes together in the final challenge: time-space consumption. This may be one of the more relevant aspects from an urban planner's point of view. According to Böhm et al. (2006), automobility involves spatial movements that take time. The flexibility of car travel and the fact that cars allow people to travel further in a given unit of time than other modes, has transformed time-space significantly (Urry, 2004). Even if engineers were able to produce a car that does not emit pollutants at all, at any stage of its life-cycle, they are an ineffective technological fix. In most cities, the high number of cars on the road provides the greatest challenge to making our cities liveable. When stationary, automobiles also consume valuable land space, both public and private (which could be used for benefitting urban quality (Gehl, 2010)), for garages, parking lots as well as public streets where they are parked, because there are no garages for example (Dowling & Simpson, 2013). In image 3 it is illustrated how much space one car consumes, compared to bicycles. The result: a single parking space can store 10 to 15 bikes.

Thus, more emphasis on decreasing automobile dependence is required. In other words, society needs to transform not only the way they use energy, but also the way they use cars. An example that sees this transformation in car use is carsharing (Dowling & Simpson, 2013), since it inhibits the tendency for increasing flexibility in personal travel patterns. Sharing a car requires a conscious decision to be mobile and trips in shared cars are usually planned in advance. Therefore, using the car becomes a rational decision, rather than a status symbol. Also, vehicle sharing shifts the fixed costs of owning a car to variable costs of only using it. Moreover, shared cars are often smaller, low emissions vehicles (Kent & Dowling, 2013). Also, by influencing the traffic flow with driving systems like adaptive cruise control (ACC) an increased capacity, and thus efficiency of the transportation system may be realized, since they allow for very small time gaps and platoon driving (Kesting et al., 2008). This then may lead to less space consumption. When the degree of automation increases, the automotive industry eventually shifts from selling cars to selling mobility (Tillema et al., 2015). Both the degree of sharing and automation matter for a sustainable traffic flow system, as becomes clear from the scenario study by Tillema et al. (2015).

Image 3: One parking space for a car can store 10 to 15 bicycles. (CityMetric, 2014)

Over the years, not only the size of travel has increased, but also the modes have changed. Fast modes of travel became more and more popular, at the expense of slow modes such as walking and cycling (Grieco & Urry, 2016). This is not beneficial to the flow of traffic. Elaborating on this, Kretz (2016) made a simulation where he lets 200 people pass a traffic signal in different modes. All typical values for desired speed and acceleration et cetera were used. These values and results are illustrated in image 4. Based on these results it becomes clear that the queue of cars requires both the most space (1030 m) and takes the longest time to cross the stop line (248 s). Also the person flow per second (and hour) is much lower compared to public transport and slower modes of transportation (Kretz, 2016). To increase the efficiency of the car, two things can be considered. One is to increase the occupancy per car, thus resulting in a higher density and two is to create smaller cars or *inbetween cars*. For example, the space required for 1 car in the queue is 1030/133 = 7,7 m. If we assume that, just by implementing smaller vehicles, we would be able to decrease the required space of one car in the queue by 2 m. That would mean that the queue would be 5,7*133 = 714,21 m long and in other words, a decrease of 1030-714,21 = 315,79 m. By increasing the occupancy per car as well, this decrease could be even larger.

	Cars	Busses	Trams	Bikes	Pedestrians
	Input for simulation				
Number of persons	200	200	200	200	200
Number of “vehicles”	133	10	5	200	200
Mean occupancy per vehicle	1.5	20	40	1	1
Mean desired speed [km/h]	53	53	53	23	6
Mean desired speed [m/s]	14.72	14.72	14.72	6.42	1.67
Width of link [m]	3.50	3.50	3.50	3.50	3.50
	Results of simulation				
Length of queue [m]	1030	134	197	115	27.6
Time until the last crosses the stop line [s]	248	31	32	119	38
	Derived from results				
Vehicle (line) density [1/km]	129	75	25	1739	7246
Person line density [1/m]	0.19	1.49	1.02	1.74	7.25
Person density [1/m²]	0.06	0.43	0.29	0.50	2.07
Vehicle flow [1/s]	0.54	0.32	0.16	1.68	5.26
Vehicle flow [1/h]	1931	1161	563	6050	18947
Person flow [1/s]	0.81	6.45	6.25	1.68	5.26
Person flow [1/h]	2903	23226	22500	6050	18947
Person flow per cross section width [1/s/m]	0.23	1.84	1.79	0.48	1.50
Person flow per cross section width [1/h/m]	829	6636	6429	1729	5414

Image 4: Numbers and results derived from the experiment. (Kretz, 2016)

This experiment does not use a completely new concept, since the city of London already came to the same conclusion in the 1960s and thus tried to stimulate the use of the bus, which can be seen in image 5 here on the right.

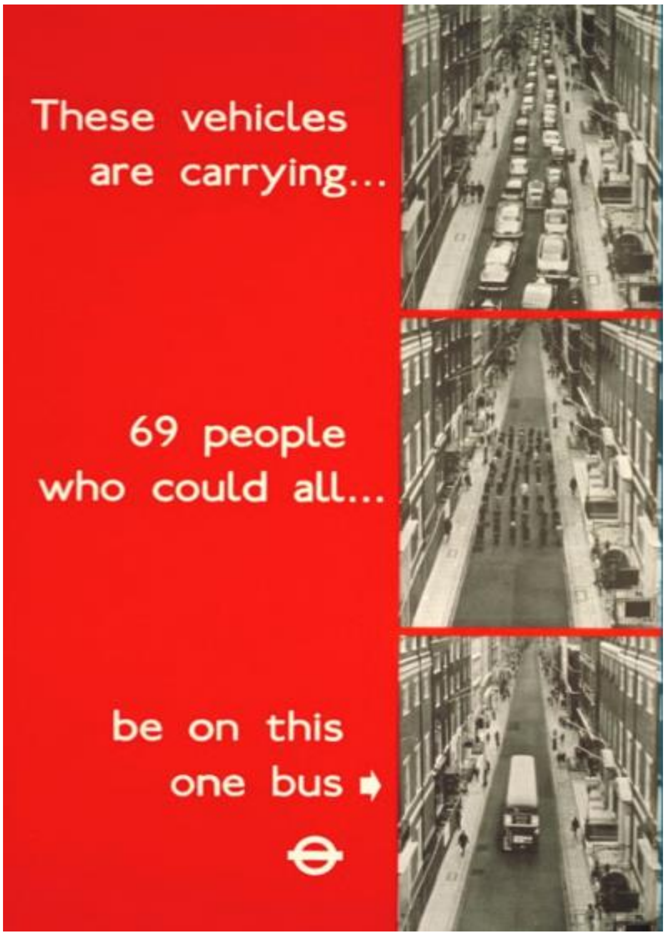

Image 5: Campaign to promote the bus in London in the 1960s. (CityMetric, 2014)

2.3 Conceptual model

Although Urry (2004) states that there is no single solution. Small changes on the other hand, may tip the system into a *post-car* automobility system, if they occur in a certain order. Considering the aforementioned challenges, the following conceptual model is proposed, as shown in image 6. It shows examples of criteria the ideal strategy could adhere to. This model is inspired by the model as described by Dennis & Urry (2009), since they introduced the phrase *post-car* system. This model represents a sustainable state in automobility and thus could be a tool that is used when proposing strategies to achieve such a state. The 'ideal' strategy is one that fits the model perfectly. It also shows that its components are interrelated, which is in line with Dennis & Urry (2009).

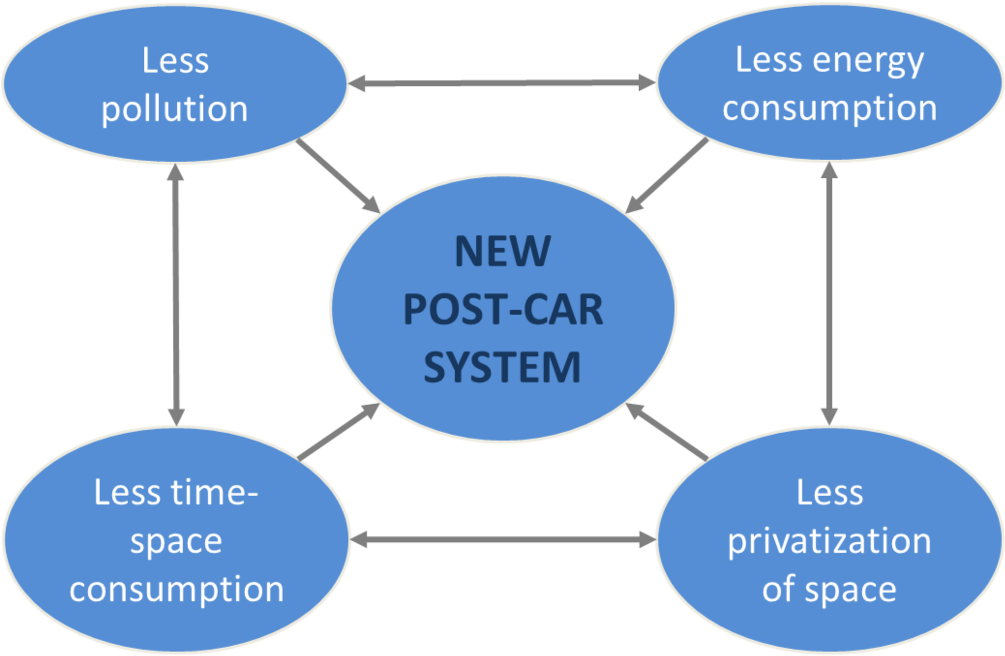

Image 6: The new *post-car* system. (Source: author)

CHAPTER 3 METHODOLOGY

3.1 Supporting the research methodology

The data for this thesis comes from three sources: academic literature, an analysis of a variety of secondary data and case study research. Literature is very useful when defining key terms and concepts. After all, that is the first stage when conducting a literature research (Clifford et al., 2016). For this thesis, a variety of other secondary data has been analyzed as well. Examples are websites, business publications, policy documents, news articles and magazine articles. Due to the way the research questions and the aim of this research are set up, it is best to look for descriptive, in-depth knowledge on how (and why) certain events take place. One of the most relevant ways to gather such knowledge is through a case study (Clifford et al., 2016). Case study research is also relevant for identifying how strategies are being put into practice (Yin, 2013).
The flipside is that generalizations cannot always be made, which should be realized as well (Clifford et al., 2016). Therefore, it is relevant that first a literature research is needed in order to look at the system itself and as a whole. Then, to adapt the scale to a more practical approach, you use a case study.

3.2 Research process

For this research, the initial plan was to conduct interviews. The most relevant data to be gathered is qualitative data and therefore, an interview is a relevant method (Clifford et al., 2016). The type of interviews to be conducted were semi-structured interviews, because they provide a small predetermined set of questions, while still maintaining the freedom of structuring the interview on-site. Also, from an interviewee point of view, there is the ability to clarify and highlight certain issues beyond the actual question. This is considered effective, since different people bring about different points of view. Specific motivations and explanations may appear then (Clifford et al., 2016).
These interviews would be conducted at Volkswagen AG headquarters in Wolfsburg, but unfortunately, acquiring the right connections turned out to be difficult, since the link of a car dealership in the whole supply chain is too small to arrange an interview at the headquarters of a multinational. This initial process is visualized in a scheme in image 7.

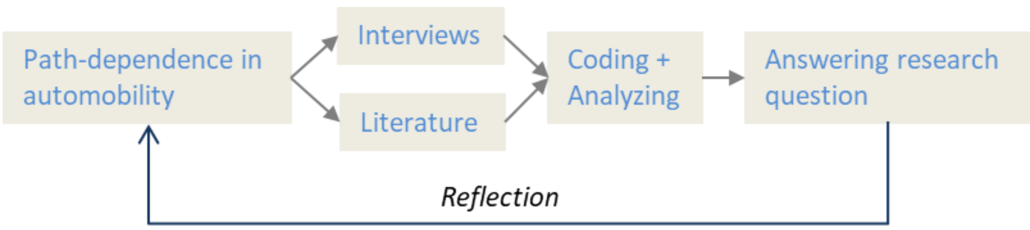

Image 7: The initial research process. (Source: author)

Therefore, an alternative approach, without interviews, was set up. Here, the results are based on three sources of data: literature, a case study and an analysis of business publications, news articles and policy documents for example. First, there is an outline what strategies to achieve sustainability are being proposed by the case. The following step is to analyze and assess how well the strategies fit the conceptual model (as shown in paragraph 2.3), which results in a projection how much potential success the strategies could have. This produces primary data as well, although in a different way. This process is illustrated in image 8.

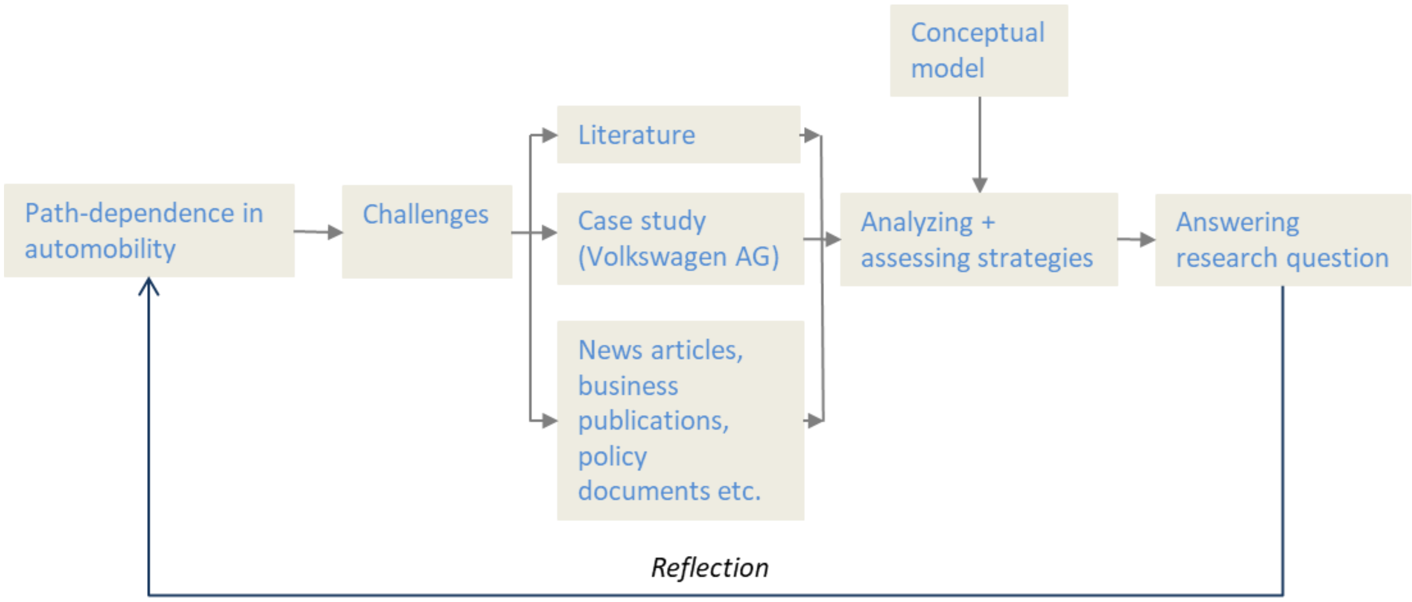

Image 8: The actual research process. (Source: author)

Due to the use of documents from the case study itself, the quality of the data can be questioned in terms of biased data. On the other hand, in this way, such business documents have the opportunity to be assessed thoroughly as well. These documents contain actual measures and by looking at it with a critical eye, keeping other data in mind, a conclusion can be drawn if such measures are indeed successful. This methodology basically has the same characteristics as triangulation. With triangulation, data is generated using different methods (Clifford et al., 2016). However in this research, it is produced with a variety of different sources instead of different methods. These sources need to be analyzed with different methods. Therefore, from an interpretative point of view, the aim is to give a wider understanding of a specific issue. So to say then that a source is biased can be questioned, since all sources will be seen then as positioned and all representations made in a specific context for specific reasons (Clifford et al., 2016).

CHAPTER 4 CASE STUDY

4.1 Why Volkswagen AG?

Worldwide, the automotive industry employs over 50 million people both directly and indirectly (OICA, 2006). Considering Volkswagen AG in particular, it is the second largest car manufacturer in the world (Mansouri, 2016).

Volkswagen AG has a rich history that dates back to 1937, where a company called Deutsche Arbeitsfront was asked to design a car that was affordable enough for every German family: 'Ein Wagen für das Volk'. During WWII, workers from the working camps built cars for the German army. When the war was over, the factory was taken over by the British and used to produce Volkswagen vehicles, which is German for 'People's Car'. In the next ten10 years, the Beetle model became more and more popular. Over the years, the company faced acquisitions and legal issues, which resulted in the automobile empire as we know it today. Nowadays, the company owns the following renowned brands: Audi, Bently, Bugatti, Lamborghini, Porsche, Ducati, Seat, Skoda, Scania, Man, Volkswagen and Volkswagen Commercial Vehicles. In 2014, Volkswagen AG produced 41.000 vehicles every week and sold around 10.1 million vehicles (Blackwelder et al., 2016).
For several years Volkswagen AG has focused on what they considered their strength and competitive advantage: an attractive and environmentally friendly series of cars. In 2014, they introduced initiatives to reduce CO_2 emissions and to increase the numbers of EVs on the road and to promote ride sharing. The company also dedicates to corporate and social responsibility and commitment to ethical practices. Therefore, they have launched several ad campaigns over the years. Examples are Think Small and buy the Beetle, Think Blue to promote eco-friendly driving and green initiatives. They also promoted clean diesel techniques like BlueMotion. They were even awarded the Green Car of the Year Award in 2009 and 2010 for the Jetta TDI Clean Diesel and Audi A3 TDI Clean Diesel. These were the first non-electric and non-hybrid vehicles to be selected for the award. In Volkswagen AG's Code of Conduct the company underpins the responsibility for continuous improvement of the environmental tolerability of their products and for making ecologically efficient technologies available all over the world (Buchal et al., 2019).

However, not everything about Volkswagen AG is positive. One of their most controversial decisions of the last five years is the diesel scandal. The company attempted to crack the United States diesel market after the Environmental Protection Agency tightened emission control because of harmful effects of NO_x, coming from exhaust pipes of cars. These new emission standards especially made it more difficult for car manufacturers to manufacture fuel-efficient diesel cars for the United States market. One of the market players in automobile industry – Volkswagen AG – tried to crack the United States diesel market. That was not without success, since Volkswagen AG became a substantial seller of diesel cars in the USA. Other car manufacturers found new emission standards significantly challenging eventually leading them to cease their attempts. However the reason for this success was that Volkswagen AG fitted their cars with software to make diesel vehicles seem emitting less pollutants than what they really emit. This is also known as the diesel scandal or dieselgate (Mansouri, 2016).

Dieselgate had several effects on the automotive industry and Volkswagen AG. Currently, the total bill of penalties and fixing cars has already been lifted to around €25.000.000.000 (Schwartz &Bryan, 2017). Another consequence is that it has resulted in a substantial sales drop of Volkswagen vehicles, especially in the USA (Mansouri, 2016). In Europe fewer diesel cars have been sold. In Germany, for example, the market share of diesel cars dropped from 40% in 2017 to 30% in 2018 (Kerler, 2018).

That should be a good thing, but it actually means that German car manufacturers are less likely to meet stricter standards regarding CO_2 emissions set by the EU, because, despite the higher NO_2 emission, diesel cars emit less CO_2 compared to gasoline cars. This new standard sets limits for the average CO_2 emissions of the total of vehicles sold by a company and thus, without the share of low-CO_2 emission diesel cars, German companies have little chance of meeting these standards. The only chance would be to sell more EVs (Kerler, 2018).
German companies have the tendency to be technology followers rather than technology leaders. For example, when considering hybrid vehicles, Toyota launched the first one in 1997 already, while Volkswagen AG waited until 2010 to begin selling its first hybrid car. German car manufacturers usually roll up the market from behind after a few years, thus regaining the leadership position. However, sometimes being late can mean being too late, as dieselgate has showed us (Kerler, 2018). Therefore, it is argued that it actually benefitted the Volkswagen AG. Before dieselgate, they were not really investing in electric cars, autonomous driving or mobility services, even though it was quite clear that that would be the future of the auto industry, so without dieselgate, Volkswagen AG would have failed (Kerler, 2018; Van de Weijer, 2019).

4.2 Announced strategies to achieve sustainability

In total, six strategies are discussed. They have been regrouped into three main categories: new vehicles, smart mobility and rethinking urban & mobility systems. These strategies come from the two largest brands within the company: Volkswagen and Audi (Blackwelder et al., 2016).

New vehicles
Volkswagen AG is developing a variety of new, sustainable vehicles. One example is a series that is known as ID. It is said to be the first volume-production vehicle to have a CO_2-neutral footprint, which is possible due to high levels of energy efficiency, an efficient and compact cogeneration plant near the factory and the use of green electricity generated from 100% renewable energy such as hydropower (Adomat & Ernst, 2019). The first car of this series, the ID3, which is shown in image 9, is coming off the assembly line at the end of 2019 (Volkswagen AG, 2019). With ID, Volkswagen wants to achieve a 45% decrease in the consumption of resources by 2025 compared to 2010 (Adomat & Ernst, 2019). This ID is built on the newly developed MEB-platform (Modular Electric Drive Toolkit) which allows e-drivetrain components, auxiliary systems and interior features to be linked together intelligently. In the long term, it will make manufacturing of EVs more efficient and less expensive. For example, the engine and batteries are being integrated in the axles and the chassis, resulting in more efficiency and less waste of indoor-space (Adomat & Ernst, 2019; Volkswagen AG, 2019). Most EVs however, are unaffordable (compared to a conventional car) for an average household (Voermans, 2019). A relevant feature is that the price of an ID3 is around €30.000, which is similar to a Volkswagen Golf diesel. Also regarding dimensions, the ID3 will resemble the Golf (Volkswagen AG, 2019). Therefore, the diesel car will become less and less attractive.

Image 9: Volkswagen ID3. (Van Essen, 2019)

The company is also considering micromobility with Cityskater and Streetmate, which are electric concept vehicles for urban areas. They are visualized in image 10. Cityskater is a three-wheeled, electrically powered street surfer that has a top speed of 20 km/h and is said to have a range of up to 15 km, which is convenient for covering the last mile and bridging distances too far to cover on foot. It weighs 11.9 kg and can be folded up to fit into luggage compartments so it is allowed on public transport for example. Streetmate is a medium-range electric scooter that serves as an alternative to a car, as it offers the same amount of flexibility when it comes to medium-range travel. It weighs 65 kg, has a top speed of 45 km/h and a range of up to 35 km. It can also be driven either in a sitting or standing position (Peine, 2019).

Image 10: Volkswagen Streetmate (left) and Cityskater (right). (Peine, 2019)

Smart mobility
Volkswagen AG is also paying substantial attention to smart mobility systems. The first ones are shared mobility concepts, called MOIA and WeShare. MOIA is an on-demand mobility service system that was launched in Hamburg in April 2019 with a fully electric vehicle fleet of around 150 vehicles. MOIA complements existing railroads and bus routes in a practical and inexpensive way and thus offers an attractive alternative to private cars. The service is available to all residents

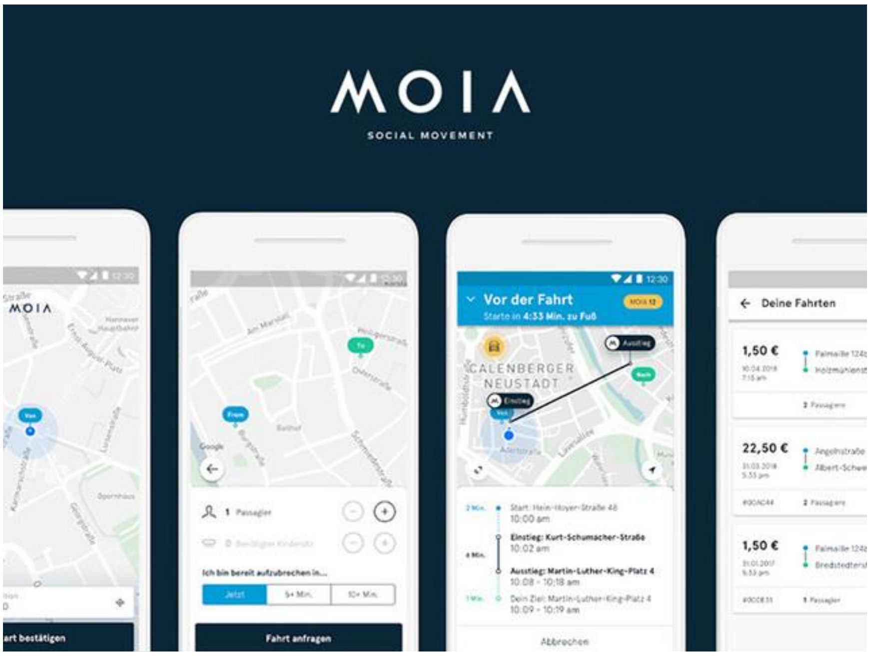

Image 11: The MOIA app (Volkswagen Italia, 2018).

and can be booked using an app, which is shown in image 11. On average, the fee is between that of public transport and a taxi. Using WeShare, Volkswagen AG is introducing a comprehensive, purely electric carsharing service in selected big cities (Volkswagen AG, 2019). It is roughly the same idea as MOIA. With WeShare, there will be a strong focus on the We-ecosystem which is aimed at people who do not own cars. From 2020, the concept will also be expanded to European countries and even cities in the USA and Canada (Volkswagen, 2019).

Second, SEDRIC (SElf-DRIving Car) is a mobility concept based on autonomous vehicles. It is an innovative and integrated mobility concept for urban traffic in the future, which is operated by using, for example, an app. Then, the car will drive passengers to their destination in a comfortable, reliable and safe manner. Since the launch of SEDRIC, significant progress has been made regarding the development of the self-driving system, but also regarding systems for environment recognition and traffic data analysis. With SEDRIC, Volkswagen AG hopes to be a symbol for smart mobility solutions that contribute in removing pollution and congestion issues from urban areas. In 2018 Volkswagen AG presented the latest version within the concept for fully automated driving: the SEDRIC School Bus, which is visualized in image 12. With this bus, the company substantiates their claim form the TOGETHER – Strategy 2025 future program: becoming a global leader in the area of autonomous driving. Another aim is that as many people as possible should be able to share an autonomous car (Volkswagen AG, 2019).

Image 12: The SEDRIC School Bus , designed as a U.S. school bus. (Volkswagen AG, 2018)

Third, Vehicle to Infrastructure (V2I) is a service Audi is introducing in Europe In July 2019. The service is illustrated in image 13. In this way, cars will be more likely to catch a green wave in the city. Audi drivers will receive a notification in the cockpit what speed is required to reach the next traffic light on green. If that is not possible within the speed limit, a countdown to the next green phase will appear. Driving in cities will thus become more efficient. The first new models to be linked with the traffic lights will be in Ingolstadt, Germany and from 2020 onwards, more European cities will follow. Eventually, V2I technologies will facilitate automated driving. However, a city is one of the most complex environments for an autonomous car and therefore, data exchange with the traffic infrastructure can be very useful contribution (Schneider, 2019).

Image 13: V2I. (Schneider, 2019)

Rethinking urban and mobility systems

The final group involves rethinking urban and mobility systems as a whole. The Audi Urban Future Initiative is a competition Audi has been hosting since 2010. It is an interdisciplinary forum that analyzes challenges and examines possible solutions regarding mobility in the world's megacities. The solutions take different aspects (technical, ecological) into consideration (Audi, 2012).

Over the years, the competition has brought relevant insights, when for example considering the following question: How will autonomous cars change how our cities work, and how will our cities adapt to accommodate them? Probably the most physical impact of autonomous cars will be a reduced need for parking infrastructure. If cars can park themselves, then there is no need in parking infrastructure to be located within walking distance of the destination and thus could be concentrated in remote locations or at the edge of urban areas. Implementation of autonomous car systems could even remove the need for parking completely. All the area, once dedicated to parking, could then be used as public open space or other types of development. To put things in perspective, in some cities, one-third of the total land area is devoted to parking. Even when a small portion of that space is being used for alternative uses represents significant opportunities (Douglass-James, 2016).

For example, in their project Assembly Row the city of Somerville made an optimization assessment, illustrated in image 14, and concluded that when you remove people (including staircases, elevators and circulation spaces people require when parking their car) from the parking process, you can save two square meters per car (Quintal, 2015).

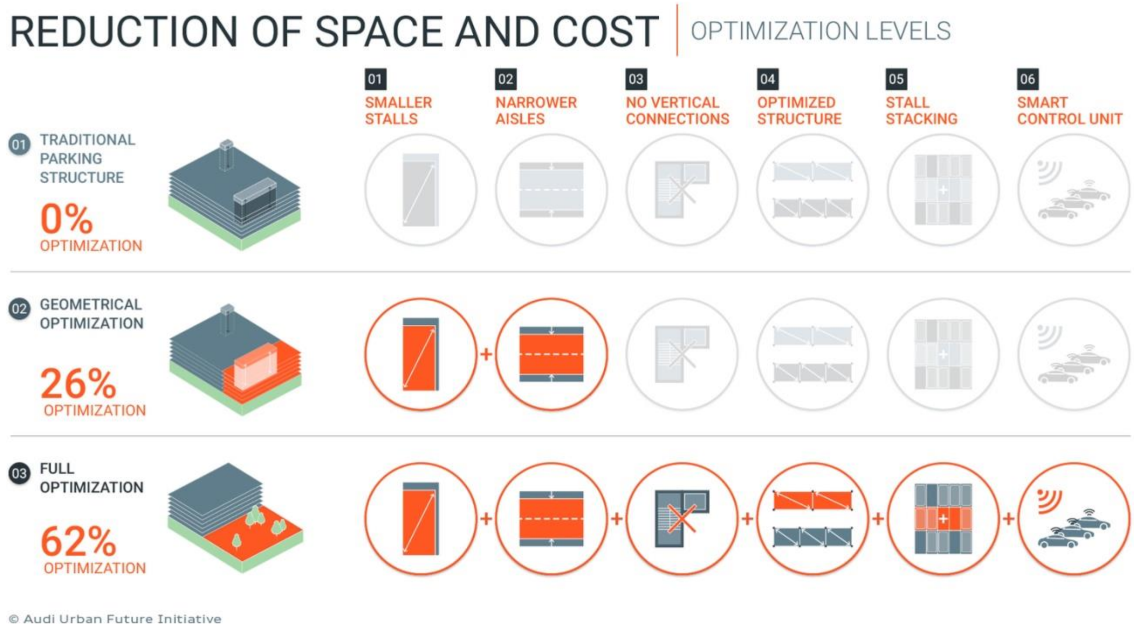

Image 14: Optimization level assessment. (Quintal, 2015)

CHAPTER 5 RESULTS

5.1 Strategy analysis and assessment

For each of the strategy explained in the previous chapter, a table has been made with the challenges from chapter 2. Then it is concluded to what extent the strategy deals with the challenges.

New vehicles

ID	
Pollution	ID emits zero emissions, so no pollutants like CO_2 are being emitted.
Energy	Since the ID is fully electric, there is less dependence on oil and fossil fuels.
Privatization of space	Here, the strategy could be improved, since the ID is still presented as a way of private mobility.
Time-space consumption	With ID, Volkswagen aims at a 45% decrease in resources by 2025, so this could lead to less time-space consumption to some extent. However, regarding dimensions the ID3 is similar to a Volkswagen Golf. The Golf is considered an average car, so here the strategy could be improved as well.

Cityskater / Streetmate	
Pollution	Both emit zero emissions, so no pollutants like CO_2 are being emitted.
Energy	Since Cityskater and Streetmate are also fully electric, there is less dependence on oil and fossil fuels.
Privatization of space	Both are also presented as private forms of mobility, but since they are smaller than a car, less public space is being privatized, thus benefitting the quality of life.
Time-space consumption	Since these are forms of micromobility, they consume less space. Especially Streetmate has high potential, since it operates at medium-range, like a car, which is ideal for longer distances within cities.

Regarding new vehicles, the potential success seems high, since it deals with all the challenges to a certain extent. ID could be improved by focusing more on the privatization and time-space challenge. However, when considering pollution and energy, recent research has concluded that the CO_2-footprint by an EV in the best case, is slightly higher a conventional diesel engine, and are otherwise much higher (Buchal et al., 2019). So looking purely at CO_2 emissions, a diesel car would be more sustainable. However, then there is still a dependence on oil, which is a scarce resource with a finite lifetime (Böhm et al.,2006). Therefore, over the long term, hydrogen-methane technology offers a greater advantage, compared to EVs. In this way, surplus wind and solar power generated during peaks can be stored. This stored, excessive energy can be used as a way to meet the growing demand for renewable energy sources (Buchal et al., 2019).

Smart mobility

MOIA / WeShare	
Pollution	The on-demand mobility fleet consists of fully electric cars. They could be IDs for example, so no pollutants are being emitted.
Energy	Because the fleet is fully electric, there is less dependence on oil and fossil fuels.
Privatization of space	The service can be booked using an app and is available to all residents. The residents all share mobility. The thing that can be helpful is that the

	fee is between public transport and taxi.
Time-space consumption	No new infrastructure needs to be constructed, since the service uses existing railroads for example.

SEDRIC	
Pollution	SEDRIC does not improve the pollution issue directly, but indirectly. It will make the system more efficient with autonomous vehicles that eventually remove congestion and thus pollution issues from urban areas.
Energy	SEDRIC does not give clear guidelines how it deals with the energy consumption. So here, the strategy could be improved.
Privatization of space	The goal is that eventually, autonomous cars will be implemented on a shared basis, so that as many people as possible should be able to use and share an autonomous car.
Time-space consumption	Due to SEDRIC, significant progress has been made regarding the development of the self-driving system, leading to increased efficiency and thus less time-space consumption.

V2I	
Pollution	Same as with SEDRIC: due to increased efficiency, the pollution issue could be decreased indirectly.
Energy	V2I does not give clear guidelines how it deals with the energy consumption. So here, the strategy could be improved.
Privatization of space	Also, no clear guidelines are proposed how the privatization of space will be addressed.
Time-space consumption	Eventually, V2I technologies will facilitate automated driving, which means higher efficiency and less space consumption.

Considering smart mobility, there also seems to be high potential. MOIA / WeShare initially address all the challenges to a certain extent, but mainly the privatization of space. WeShare in particular is targeted at people who do not own cars. If the service becomes a big success, due to the favorable fee, then more and more people could be using the system, resulting in a decrease in car-ownership and thus the privatization of space and time-space consumption. The point of concern is the same as with new vehicles: EVs do not have a favorable CO_2-footprint.
Both SEDRIC and V2I result in less time-space consumption due to increased efficiency. Most of the improvements come indirectly, like the pollution issue. However, especially regarding the energy consumption SEDRIC and V2I could be improved. V2I could also be improved by considering the privatization of space more. Another aspect that needs to be considered with V2I is the possibility to fit cars from other brands with this system as well. Otherwise, if only Audis are fitted, then the system does not work as efficiently as it could be. Audi is only a part of the fleet.

Rethinking urban & mobility systems

Urban Future Initiative	
Pollution	Due to the interdisciplinary approach, technical issues like pollution are taken into consideration. However, no clear actions have been proposed so far.
Energy	Same as with pollution. Issues like energy consumption are taken into consideration. However, no clear measures have been taken so far either.
Privatization of space	When cars park themselves, a significant amount of (private) space, once devoted to parking can be transformed to public open space,

	benefitting urban quality.
Time-space consumption	When you remove people from the parking process, you can save two square meters per car.

Even though aspects like pollution and energy consumption are taken into consideration, the competition so far has not resulted in actual measures yet reduce such issues. Yet, while maintaining the debate, using the competition, people are challenged to come up with promising solutions. Eventually, this may lead to the ideal measure in the (near) future.

5.2 Policy implications

Transport policies have direct effects on GHG emission and energy consumption and they can lead to a significant modal shift toward more energy efficient and more sustainable modes of transport such as walking and cycling (Scarinci et al., 2017). Europe has implemented exhaust emission regulations for more than 20 years . However, the desired improvements in air quality have not been achieved yet, so, the effectiveness of the Euro emission standards for road transport can be questioned. Therefore, looking for alternative, more sustainable fuel systems like electric vehicles (EV) (Hooftman et al., 2016) or hydrogen powered vehicles (Edwards et al., 2008) is also desired.
In order to meet climate agreements, the Dutch government for example wants every new car to emit zero emissions by 2030. In the past, the focus was more on making EVs more attractive financially. Nowadays, a new policy focus has been adopted that wants to achieve a new mindset by using psychological and social tools as well (Berveling & Moorman, 2018). However as mentioned before, the CO_2-footprint of an EV is higher than a diesel engine. Therefore, over the long term, hydrogen technology offers a greater advantage (Buchal et al., 2019). In fact, hydrogen (and 'green' hydrogen in particular) are crucial for Europe to meet the standards in the Paris Climate Agreement (Kouwenhoven, 2019). So regarding policy, there could be a greater focus on hydrogen.

What is also important is that less taxes are levied on EVs (or other sustainable modes). This means less revenues for the government. A conventional car includes taxes for purchasing the car, road taxes and fuel taxes for example. These taxes are not applicable to EVs. In this way, it could be that the government loses €3800 per car. If the entire car fleet transforms from the combustion-engine to EVs, then the government should change the system of taxes levied on cars. Otherwise, it may become too expensive and not feasible (Lukassen, 2019).

The final policy implication is regarding smart mobility, like automated driving systems. As became clear from previous chapters, the automotive industry is also focusing more and more on automated driving. Automated cars are mostly tested in the USA where the physical environment and policies are different compared to elsewhere in the world. Autonomous vehicles can be implemented more easily there because streets are wider and due to the fact that the car is already the main mode of transport. In European countries like the Netherlands, this is different. The Netherlands are prepared pretty well for autonomous vehicles, but cyclists could be a problem. Due to Dutch legislation, cycling is promoted a lot and therefore, it is unclear how they will react to autonomous vehicles (Kastelijn, 2019). Also, people often consider only the cost of gas regarding individual car trips. Therefore, with autonomous vehicles each and every errand will be done by the autonomous vehicle, so we do not have to do anything ourselves, including filling the car up for example. If single-occupancy vehicles are the already the main cause of congestion on highways and in cities right now, then (without the right policies) the congestion could be even greater caused by zero-occupancy vehicles (Chase, 2014).

CHAPTER 6 CONCLUSIONS

From the case study, it becomes clear that the claim that before dieselgate there was no focus on sustainability is not (completely) true, given the notion of promoting CO_2 emission reduction, promoting ride sharing and several campaigns for clean diesels like BlueMotion. However, according to the challenges and the conceptual model this is not necessarily sustainable.
Based on the case study, it also becomes clear that the automotive industry has proposed some promising strategies that address the challenges, while maintaining automobility. Mobility and the capacity for autonomous movements are considered as a human right. Therefore new vehicles are proposed. These vehicles do not depend on fossil fuels and some of them are also smaller, which helps to reduce time-space consumption. Furthermore, there is a substantial focus on smart mobility systems. These systems make the automobility system more efficient, using autonomous vehicles for example, so less space is consumed. There is also a mobility service on a shared basis, which is targeted at people who do not own cars. Finally, there is a strategy that uses an interdisciplinary forum and a competition to produce solutions for the challenges in the current system of automobility. Because multiple expertises are combined, this may lead to the perfect solution in the (near) future.
These strategies give rise to certain policy implications. First, in policy making there could be a greater focus on the importance of hydrogen. Second, when making sustainable transport more attractive financially, a change in the tax system is also desired. Finally, there is concern that cyclists may be a disadvantage to autonomous vehicles, despite good preparations. Moreover, it is unclear how cyclists will react to autonomous vehicles (Kastelijn, 2019). Another concern is that autonomous cars will be used all the time, while single-occupancy vehicles are already causing congestion, let alone what zero-occupancy vehicles could cause (Chase, 2014).
However, there is no single strategy that addresses all the challenges. It needs to be supplemented with the other strategies. Together, they may tip the system of in a sustainable *post-car* system and thus maintaining automobility. This is also in line with Urry's conclusion (2004).

Reflection and recommendations
Although the conclusions drawn from the results seem coherent, a discussion is taking place in this paragraph concerning certain elements and aspects of the research which need to be considered. First, the fact that a substantial part of the results are based on sources directly from the case study itself. On the other hand, by using such sources, they have the opportunity to be analyzed thoroughly and therefore, it can be concluded how much potential the measures could have actually. Yet, this still may lead to a biased point of view. Second, not all proposed strategies have been taken into consideration. And the ones that were taken into account, originated from only one company in the automotive industry. Also, as mentioned before, the results were only based on secondary sources, because collecting primary data turned out to be more difficult than expected with this specific research. And when assessing the strategies, there was only a focus if the strategies dealt with the challenges directly and indirectly. Perhaps the results would be more realistic if each challenge was weighed differently or assessed quantitatively. Then it may become easier to assess the strategies in terms of success, for example with a score from 1 to 10. Moreover, this research only emphasized the urban area perspective, but it is unclear how these results affect rural areas

The aforementioned could be taken into account when doing future research. Future studies for example could focus on other car manufacturers, leading to a broader perspective regarding the strive towards sustainability by the automotive industry. Another aspect for future research is considering to what extent a higher vehicle occupancy and *inbetween cars* help in reducing the time-space concumption. Finally, future research could focus on what the implications of a transition are for rural areas.

REFERENCES

Adomat, C. & Ernst, S. (2019). *ID. INSIGHTS*. Dresden: Volkswagen.

Audi (2012). Audi Urban Future Initiative. Retrieved on March 16, 2019 from https://www.audi-technology-portal.de/en/mobility-for-the-future/audi-future-lab-mobility_en/audi-urban-future_en/audi-urban-future-initiative_en

Berveling, J. & Moorman, S. (2018). *"It's electrifying!". Het stimuleren van elektrisch rijden met gedragsbeïnvloeding*. Amersfoort: KiM

Blackwelder, B., Coleman, K., Colunga-Santoyo, S., Harrison, J.S. & Wozniak, D. (2016). *The Volkswagen Scandal. Case Study*. University of Richmond: Robins School of Business.

Böhm, S., Campbell, J., Land, C. & Paterson, M. (2006). Introduction: Impossibilities of Automobility. *The Sociological Review*, 54(1), 3-16.

Buchal, C., Karl, H.D. & Sinn, H.W. (2019). Kohlemotoren, Windmotoren und Dieselmotoren: Was zeigt die CO2 -Bilanz? *IFO Schnelldienst*, 72(8), 40-54.

Chase, R. (2014). *Will a World of Driverless Cars Be Heaven or Hell?* Retrieved on March 15, 2019 from https://www.citylab.com/transportation/2014/04/will-world-driverless-cars-be-heaven-or-hell/8784/

CityMetric (2014). *In pictures: Do cars take up too much space on city streets?* Retrieved on June 3, 2019 from https://www.citymetric.com/transport/pictures-do-cars-take-too-much-space-city-streets-483

Clifford, N., Cope, M., Gillespie, T. & French, S. (2016). *Key Methods in Geography.* Third edition. London: SAGE Publications ltd.

Davison, L.J. & Knowles, R.D. (2006). Bus quality partnerships, modal shift and traffic decongestion. *Journal of Transport Geography*, 14(3), 177-194.

Dennis, K. & Urry, J. (2009). *After the car*. Cambridge, UK & Maiden, USA: Polity Press.

Dowling, R. & Simpson, C. (2013). 'Shift – the way you move': reconstituting automobility. *Journal of Media & Cultural Studies*, 27(3), 421-433.

Douglass-James, D. (2016). *How Driverless Cars Could, Should - and Shouldn't - Reshape Our Cities*. Retrieved on May 13, 2019 from https://www.archdaily.com/780512/how-driverless-cars-could-should-and-shouldnt-reshape-our-cities

Edwards, P.P., Kuznetsov, V.L., David, W.I.F. & Brandon, N.P. (2008). Hydrogen and fuel cells: Towards a sustainable energy future. *Energy Policy*, 36(12), 4356-4362.

Essen, M. van (2019). *Volkswagen ID.3 al 10.000 keer gereserveerd*. Retrieved on June, 7 2019 from https://www.autoweek.nl/autonieuws/artikel/volkswagen-id-3-al-10-000-keer-besteld/

Gehl, J. (2010). *Cities for People*. Second edition. Washington, D.C.: Island Press.

Grieco, M. & Urry, J. (2016). *Mobilities: new perspectives on transport and society*. London, UK & New York, USA: Routledge.

Hjorthol, R. (2013). Transport resources, mobility and unmet transport needs in old age. *Ageing & Society*, 33(7), 1190-1211.

Hooftman, N., Oliveira, L., Messagie, M., Coosemans, T., & Mierlo, J. Van (2016). Environmental Analysis of Petrol, Diesel and Electric Passenger Cars in a Belgian Urban Setting. *Energies,* 9(2), 1-24.

Kastelijn, N. (2019). *Nederland 'best voorbereid' op autonome auto's, fietsers maken komst lastig*. Retrieved on March 15, 2019 from https://nos.nl/artikel/2271646-nederland-best-voorbereid-op-autonome-auto-s-fietsers-maken-komst-lastig.html

Kent, J.L. & Dowling, R. (2013). Puncturing automobility? Carsharing practices. *Journal of Transport Geography*, 32, 86-92.

Kerler, W. (2018). *How dieselgate saved Germany's car industry*. Retrieved on June 5, 2019 from https://www.theverge.com/2018/9/19/17878730/dieselgate-saved-germanys-car-industry-vw-volkswagen-bmw-eu

Kesting, A., Treiber, M., Schönfhof, M. & Helbing, D., (2008). Adaptive cruise control design for active congestion avoidance. *Transportation Research*, 16(6), 668-683.

Kouwenhoven, E. (2019). Groene waterstof onmisbaar voor klimaatdoelen. *Algemeen Dagblad*, February 12, 2019.

Kretz, T. (2016). *5 modes of transport with 200 people each – FLOW of people*. Retrieved on May 13, 2019 from http://www.traffic-inside.com/2016/04/18/flow-of-people/

Lukassen, R. (2019). Twijfel over ambitieuze plannen elektrisch rijden: 'Onhaalbaar en onbetaalbaar'. *RTLNieuws*, October 24, 2018.

Newman, P. & Kenworthy, J. (1999). *Sustainability and Cities: Overcoming Automobile Dependence*. Washington, D.C.: Island Press.

Mansouri, N. (2016). A Case Study of Volkswagen AG Unethical Practice in Diesel Emission Test. *International Journal of Science and Engineering Applications*, 5(4), 211-216.

OICA (2006). *The World's Automotive Industry: Some Key Figures*. Paris: OICA

Papatheodorou, Y. & Harris, M. (2007). The Automotive Industry: Economic Impact And Location Issues. *IndustryWeek*, Januari 6, 2007.

Parolotto, F. (2012). *The future of transport and cities*. Retrieved on May 13, 2019 from http://www.flow-n.eu/2012/03/the-future-of-transport-and-cities/

Peine, C. (2019). *Micro mobility by Volkswagen: Streetmate and Cityskater*. Geneva: Volkswagen.

Quintal, B. (2015). *Smart Moves for Cities: The Urban Mobility Revolution Will Start With These 3 Projects*. Retrieved on May 13, 2019 from https://www.archdaily.com/777791/smart-moves-for-cities-the-urban-mobility-revolution-will-start-with-these-3-projects

Scarinci, R., Rast, F. & Bierlaire, M. (2017). Needed reduction in mobility energy consumption to meet the goal of a 2000-watt society. *Transportation Research Part A: Policy and Practice*, 101, 133-148.

Schepers, J.P. & Heinen, E. (2013). How does a modal shift from short car trips to cycling affect road safety? *Accident Analysis & Prevention*, 50, 1118-1127.

Schneider, T. (2019). *Audi networks with traffic lights in Europe*. Ingolstadt: Audi.

Schwartz, J. & Bryan, V. (2017). *VW's Dieselgate bill hits $30 biln after another charge*. Retrieved on June 6, 2019 from https://www.reuters.com/article/legal-uk-volkswagen-emissions/vws-dieselgate-bill-hits-30-bln-after-another-charge-idUSKCN1C4271

Sheller, M. & Urry, J. (2016). Mobilizing the new mobilities paradigm. *Applied mobilities*, 1(1), 10-25.

Shove, E., Watson, M. & Spurling, N. (2015). Conceptualizing connections: Energy demand, infrastructures and social practices. *European Journal of Social Theory*, 18(3), 274–287.

Tencer, D. (2011). Number Of Cars Worldwide Surpasses 1 Billion; Can The World Handle This Many Wheels? *The Huffington Post Canada*, August 23, 2011.

Tillema, T., Berveling, J., Gelauff, G., Waard, J. van der, Harms, L. & Derriks, H. (2015). *Chauffeur aan het stuur?* Den Haag: KiM

United Nations (2018). *2018 Revision of World Urbanization Prospects*. Retrieved on March 3, 2019 from https://www.un.org/development/desa/publications/2018-revision-of-world-urbanization-prospects.html

Urry, J. (2004). The 'System' of Automobility. *Theory, Culture & Society*, 21(4), 25-39.

Volkswagen AG (2018). *Urban Mobility is child's play: the SEDRIC School Bus*. Retrieved on June 8, 2019 from https://www.volkswagenag.com/en/news/stories/2018/03/the-sedric-school-bus.html

Volkswagen AG (2019). *Sustainability report 2018*. Wolfsburg: Volkswagen AG

Volkswagen Italia (2018). *A new way to move around the city: MOIA débuts in Hanover*. Retrieved on June 8, 2019 from https://modo.volkswagengroup.it/en/q-life/a-new-way-to-move-around-the-city-moia-debuts-in-hanover

Voermans, T. (2019). Elektrische auto onbetaalbaar voor modaal gezin. *Algemeen Dagblad*, April 16, 2019.

Weijer, B. van de (2019). 'Bet your company': hoe Volkswagen AG helemaal elektrisch ging. *De Volkskrant*, February 20, 2019.

Wells, P. (2010). Sustainability and diversity in the global automotive industry. *International Journal of Automotive Technology and Management*, 10(2-3), 305-320.

Wickham, A. (2017). *The Automotive industry employs more people than you think*. Retrieved on June 3, 2019 from https://www.fircroft.com/blogs/the-automotive-industry-employs-more-people-than-you-think-71462610395

Yin, R.K. (2013). *Case Study Research. Design and Methods*. Fifth edition. London: SAGE Publications ltd.

Zuegel, D.M. (2018). *We Should Be Building Cities for People, Not Cars*. Retrieved on June 4, 2019 from https://www.strongtowns.org/journal/2018/7/2/we-should-be-building-cities-for-people-not-cars