Ecosystem Exploration of Micro-Electric Mobility Market in the Netherlands

Ghanshyam Chandrashekar

Technische Universiteit Delft

TU Delft Delft University of Technology

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Ecosystem Exploration of Micro-Electric Mobility Market in the Netherlands

Ghanshyam Chandrashekar

Master of Science
in Sustainable Energy Technology

Electric Vehicles
Department of Transport, Policy & Analysis
Faculty of Technology, Policy & Management
Delft University of Technology

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Thesis Committee	:	Dr. Bert Van Wee
		Dr. Jan Anne Annema
		Dr. Gautham Ram Chandramouli
		Dr. Benjamin Sprecher
Daily Supervisor	:	Dr. Jan Anne Annema

This thesis is confidential and cannot be made public until December 31, 2019.

Delft University of Technology

Preface

The master thesis process was very eventful and involved a long arduous process of learning, unlearning and iterating. I chose this topic for various reasons and they are listed below. As a graduate in sustainable energy, the energy and societal relevance of urban electric mobility is exciting and worth pursuing. Electric mobility, smart cities, IOT are all penetrating modern lifestyles while at the same time, creating a cleaner greener environment to live in. Having lived in Europe for over two years now, and observing people use alternate cleaner methods of transport makes me hopeful that electric vehicles in every shape and form can have an impact on the environment, be it, big or small. People should pave the way for electrification and its journey to aid the energy transition away from fossil fuels.

There is also a personal aspect to this thesis as I am passionate about skateboarding and scooters, although not electric. The passion for these vehicles came about after moving to Netherlands and bike pathways provided for space, infrastructure and safety to try newer vehicles that I am sure I cannot try back home in Asia. My interest in skateboards and further impatience to buy or build my own electric skateboard is what eventually diverted me towards choosing such a thesis topic and eventually the hope is to see these vehicles running smoothly on Dutch streets legally.

Although, this topic was the final choice, I went through multiple conversations and meetings with my daily supervisor, Dr Jan Anne Annema before finally deciding on this topic and I am glad he shared the same enthusiasm about the topic as I did. Importantly, he always repeated the words - "Try something new or novel that does not have much knowledge or information". Through the research, interviews and city observation, I learned a lot about the research process and I am glad I insisted and took his advise about exploring this subject.

Ghanshyam Chandrashekar
Delft, October 2018

Acknowledgment

When I first set out to pursue this thesis, I wanted to assimilate information to help understand the electric mobility market (PLEV) in its entirety and explore the ecosystem due to the sheer lack of structured information in scientific literature and online. Although it started out as a simple user-oriented analysis, with time and further exploration, it transformed into something more.

Most of the shifts, progress and trajectory changes in my thesis could be attributed to the advise and suggestions of my daily supervisor, Dr Jan Anne Annema. He was instrumental in guiding me and charting my process throughout the thesis period. I remember numerous meetings when I walked in clueless and came out with clarity. His cheerful, positive and funny demeanor made the mutual discussions better, learning more fun, and research more exciting. His patience and understanding through my thesis period is the reason I am successfully defending my thesis. Indeed, I am grateful to him for letting me work on something that I am passionate about.

This project could not have been possible without the constant support of Dr. Benjamin Sprecher and the bi-weekly meetings at the Resilient City Hub. He connected me to important stakeholders, answered a plethora of questions I had at every meeting and also helped setup peer reviews with other students from the HUB which helped maintain the momentum and motivation towards work. His energy and positive outlook toward the research process is contagious and it is no surprise that all the students in the hub look forward to each meeting. I remain indebted to him for inducting me into the HUB.

I would like to also thank Dr Bert Van Wee and Dr Gautham Ram Chandramouli for agreeing to a part of my thesis committee and providing me with the suggestions and direction needed to complete my report on time and also provide feedback on my thesis. Dr Bert provided feedback with the theoretical side and details about the framework which was really helpful and Dr Gautham helped me understand the technical side and in specific, energy and emission numbers and make sense of it the bigger context.

I am lucky to have great friends like Xander, Ali, Saurabh whose camaraderie and presence have undoubtedly propelled me through the period of my thesis.

Finally, I would like to thank my family, who have made a lot of sacrifices in order to watch me succeed and not give up. Frankly, without the constant support of my brother, mother and father, I would have not completed my thesis and I am forever grateful to them for their unconditional love.

I hope to have reverberated a positive energy and experience toward everybody around me through this process and that this thesis acts as a precursor for anybody interested in pursuing this further.

Thanks,
Ghanshyam Chandrashekar

Summary

Rising oil-scarcity combined with the climate change concerns have forced nations to look toward incorporating renewable energy technologies and sustainable practices in every field, but especially in the field of transport. Governments are undertaking various steps to propel the transition and push renewable energy alternatives to the mainstream. The most common transition area that is widely believed to have an impact on the energy sector is the movement from conventional gasoline vehicles to Electric vehicles (EVs). Electric vehicles are shaping clean energy goals and have become the poster for climate change and the energy transition. Its not only cars that is sparked the market but in recent times, micro-electric vehicles have disrupted entered the mobility space.

Micro-electric vehicles (mEVs) have disrupted first/last mile solutions apart from providing new cleaner modes of transport that are convenient, portable and affordable. There is a knowledge gap in this domain that needed to be addressed. To understand the nature of this market and all aspects that influence the growth of this market, an exploratory study was carried out with the help of a theoretical framework. Reviewing literature/theory showed that the field of micro-mobility is nascent and there is a severe lack of scientific knowledge detailing different aspects of mEVs. The Transport Theory by Bert Van Wee helped setup a lens to understand the top-down view of transport system and different factors that simultaneously influence transport resistance as seen in Figure 1.4. The concepts and insights from the framework helped direct which aspects or parameters to explore that indeed influenced transport resistance. It also helped understand drivers and barriers to potential future impact of mEVs on urban mobility. Generally, a new transport system lowers resistance which results in more transport, in this case, a shift also from slower to faster modes of transport on bike pathways. An additional question that arose was whether it leads to more vehicles or just modal splits. Additionally, the new concept of Peskin Ratios were used as a barometer to understand current state of success of shared micro-mobility. Present studies are too limited in subject and data and hence various non-academic sources of information were accessed and referred to complete this picture of what micro-mobility stands for in the context of the world and Netherlands in specific. As a result, the main research topic : ***Ecosystem Exploration of Micro-electric Mobility in the Netherlands.***

The Theory addressed the different parameters that needed exploration: *Technology, Demography, Environment, Safety, Policy*. The mEV market was investigated in general with the help of desk research. Data like the different kinds of vehicles, their specifications and their worldwide presence were used to understand the background of mEVs. A user analysis (users were interviewed) was carried out to collect data like age, cost, mode of transport substituted and reason for use. This laid out the demographics of users and user behaviour towards mEVs. Desk Research aided in understanding the business cases involved in implementing mEVs. It targeted affordability and cost-competitiveness. Safety implications of mEVs was investigated by using desk research to summarise the accidents, injuries and risks involved in mEVs worldwide. It helped assess the current state of technology and how much improvements it needs apart from also outlaying the different kinds of user behaviour that led to these crashes. Policy development always follows the introduction of a new transport system as a trigger response and hence policy responses in each country were discussed. In order to establish the dutch context of mEVs, experts from the municipality, Ministry of I&W and Segway-Ninebot (highest selling e-scooter company in the Netherlands) were interviewed (3 interviews). The data from the interviews helped portray the policy status-quo and how it lacks refining and enhancements to tackle the growth of the mEV market. It also outlined the lack of stakeholder interaction and communication that aids the process of implementation. Lastly, desk research was used to shed light on the environmental impacts of mEVs and e-scooters were used a barometer to understand the approximate CO_2 emissions. The emissions were found to be different in the case of private ownership and ride-sharing which has further implications in policy trajectories which need to be focused on attaining clean energy goals.

In conclusion, the market was found to be extremely novel and hence lacks scientific knowledge, engineering knowledge and regulatory structures governing their implementation. The technology is

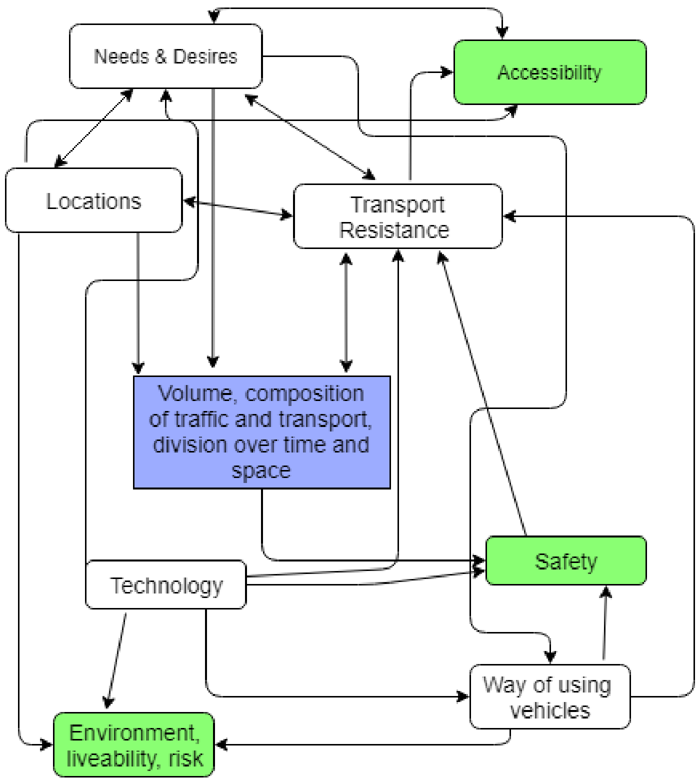

Figure 1: Conceptual framework on transport system and parameters influencing transport volumes; Uncolored boxes represent determinants of transport and traffic volume. Green colored boxes represent transport and traffic effects. The blue box is the traffic broken down over space and time [1]

indeed new, and constantly undergoing design iterations and improvements to increase durability. The current state of quality and lifetimes of the products are very subpar. Peskin Ratios of shared micro-mobility were found to be so high which pointed to the plethora of problems mEV implementation faces at this point in time. However, they are very disruptive and are spearheading the revolution towards micro-mobility solutions. mEVs can definitely have an huge impact on urban mobility, given, it is implemented moderately with a regulatory interference and oversight. Uptake was found to be dominated by 20 - 35 demographic which has implications on environment and safety. Some of the vehicles are already cost-competitive and with increasing innovation in vehicle and battery technology, more vehicles will penetrate the urban mobility landscape. Its environmental impact is clean and when operated and implemented in better ways, it can truly have a net positive impact on CO_2 emissions. Private ownership seems more attractive at this point in time but ride-sharing can have an impact when vehicles become more durable and the charging process is revamped. Safety implications throughout the world triggered policy and regulatory barriers in order to control the technology and the market for consumer welfare. The premature stage of technology and products currently necessitated the need for regulatory structures.

In the Netherlands, mEVs is almost neglected by the Govt and the policymakers. The lack of regulatory structure governing mEVs is the biggest roadblock to mEV growth in the Netherlands. Although, it needs no further infrastructure due to the presence of biking lanes, policies have not accommodated them rendered these vehicles illegal. Consumer interest and shaky laws have permitted companies to sell these products which have found their way to the dutch streets. Continued neglect might cause further accidents and have safety implications with increasing uptake and sales which will influence transport resistance in a negative connotation. The Netherlands needs to either fully ban these vehicles or define product types to make them road-illegal but leaving the policy to retain its status-quo will have negative consequences. mEVs are here to stay and constant upgrades will enhance the quality of vehicles and micro-mobility needs to grow as space constraints will increase with more people and more time and moving away from cars will become a dire necessity.

If and when implemented in the Netherlands, physical infrastructure would need almost no changes due to the presence of bike lanes. It is important to understand vehicle and traffic flow in bike pathways as a physical implication of mEVs. On the contrary, digital infrastructure would need constant upgrades to address the the growth of mEVs. Cities may need more digital infrastructure like speed cameras since the bike lanes would now have faster moving vehicles that can do higher speeds. Lastly supervision and regulatory conformity needs to be addressed to control bad behaviour, irresponsible and unruly riders which has financial implications and public costs.

As this study was explorative in nature and lacks strong scientific backing, it is recommended to perform further research into the domain of mEVs and any limiting parameter that influences it from technology, safety, policy to environmental impacts. The available data on this domain is severely lacking and more data will help in better studies and analyses.

Table 1: Drivers and Limiters of Micro-electric vehicles in the Netherlands

Drivers	**Limiters**
Environmental Impact	Safety Implications (Product Quality & User Inexperience)
Affordability	Policy & Regulation

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List of Abbreviations

EV	-	Electric Vehicles
mEV	-	Micro-Electric Vehicles
PLEV	-	Personal Light Electric Vehicle
ePTW	-	Electric-Powered Two-Wheelers
e-scooter	-	Electric scooter
e-skateboard	-	Electric skateboard
e-bike	-	Electric bicycle
I&W	-	Ministry of Infrastructure and Water Management
RDW	-	Road Traffic Service
BABB	-	Beleidsregel Aanwijzing Bijzondere Bromfietsen

1 Introduction

This chapter lays the foundation for the rest of this report. The motivation and purpose behind the research are presented by addressing some key parameters which include:

- Why (Motivation)
- What & When (Objective, problem definition and subsidiaries)
- How (research methods, approach and total design)
- Who (Who does this research benefit?)

These main parameters guide the reader through the research, its execution and purpose.

1.1. Motivation

The energy transition has brought ample changes in technological utility especially in the field of transport. The surge in energy demand has called for a move away from fossil fuels and electrification is on the rise and in specific, the micro Electric Vehicle (EV's) market. mEVs encompass e-bikes, e-scooters, e-skateboards and more which are taking up market spots in First/Last mile solutions. Newer designs and vehicles are being launched every day and the market continues to grow all around the world. The introduction of new technologies, namely e-bikes, e-scooters and e-skateboards have brought in a new ecosystem of innovation, social behavior and policy requirements [17]. This can be classified as an "innovation ecosystem" for the following reasons:[17]

- **Digitalization with the use of ICT:** ICT plays a central role in using information and communication technologies to connect the actors and create new products and services. Micro-mobility in the ride-share capacity uses ICT to connect users to scooters, juicers to scooters and helps the company maintain and evaluate real-time information on their fleet. This cross-flow of information between all the stakeholders have been very crucial to its initial success.
- **Explicitly Systemic:** Innovation always diffuses through a social system [18]. The literature emphasizes on the appreciation of the connections among the different actors of innovation. Micro-mobility market is hugely dependent on the richness and diversity of the actors who can in turn give rise to emergent behaviour. The users, policy and regulatory appeal and companies in turn need to work together to make the transition sustainable. The interaction between policy-makers, manufacturers and users and their implications influence pace of growth of any transport system.
- **Open Innovation:** The different activities like borrowing, open-sourcing, licensing and alliances enhance the ideation process by pooling diverse sources to form new products and services. The micro-mobility industry is very nascent and premature and hence most technological advances have been made with the collaboration of contractors, manufacturers, SMEs and events on the ground have triggered better products with time.

It is important to understand everything about this market from how much energy these vehicles consume and how would their penetration influence the ecosystem since they are very novel and *there is not yet enough information and literature describing their characteristics and influences on the market as seen in Table 1.1 and subsection 1.3.1.* To follow with, government policies need to keep up with these genius inventions that are flooding the market and regulations are very important to control the use of these vehicles. What is micro-mobility and what kinds of transport does it entail? Who are buying or using these kinds of transport and what does it substitute? What are the current regulations governing these vehicles and are they all-encompassing? These are some of the questions explored in the research as they helped in assessing and building a picture around such technologies and how they will influence surroundings. The research explored this novel world of micro-mobility in Netherlands to also understand broader implications in society.

1.2. Research Objectives and Problem Definition:

Biking as a culture and tradition is very old and established in the Netherlands. In recent years, technological advances have shown a pattern of more people using micro-sized electric mobility transport like skateboards, mini scooters, segways and hoverboards. Although the bike usage rate has not slowed down, bikes have been electrified which has brought in new business opportunities. The already existing bike pathways have provided the infrastructure for a smooth transition to mEVs . Consumers have shifted to these technologies for reasons ranging from portability, convenience, and recreation [19].
The importance of electrifying urban mobility recognized over the last decade and seen a lot of change especially in the Netherlands [20]. A lot of people, mainly students and some young workers have substituted bikes (but also cars) with these micro sized EV's for convenience, quicker movement and portability. The transition to micro-sized mobility transport brings in a set of advantages such as decongestion, reduction of CO_2 emissions, reduction of government spending on parking spaces and consolidation of unused and damaged bikes left in different parts of the city [21]. Keeping in mind, the Netherlands has set a 49% greenhouse gas emission reduction target by 2030 and a 95% cut by 2050, the GHG emission levels in the transport sector are significant and a problem that should take center stage.
There is a need to better understand the different kinds of vehicles that are currently available, their power/energy ratings and if and how they can have an impact on urban logistics. Most literature is catered to experiences in China and Taiwan and there is limited information on this market in Europe and America [22]. *Due to the simple lack of scientific data or exploration in this topic, an exploratory study like this aids in filling the huge academic knowledge gap.* The research aims to explore the ecosystem surrounding this new market of micro-mobility and aspects surrounding it. The stakeholders in this process are as seen in Fig 1.2. It explores how the three stakeholders connect each other and the aspects that connect them together.

It is important to understand how these three verticals interact through the different parameters and what connects them in different ways. The demographics of users, companies manufacturing these products, methods of implementation, affordability and policy/regulatory barriers were the parameters researched in this study. The research was wide-ranging and discovered all aspects surrounding mEV market. Long-term goal of this research was to understand the extent to which micro electric mobility transport had been implemented so far and can influence urban mobility in terms of penetration, effects on environmental sustainability and substitution to other kinds of transport.
The shared micro-mobility market got the world by surprise even in terms of typical products driven by *hype*. The *hype cycle* surrounding was so sudden and progress was so quick, that no version of the chart could identify it as seen in Figure 1.1 [2]. The market boosted and grew so quickly, that it was one of the first to have broken the curve. In contrast, even with all this hype, information about its impact are low in both the scientific and academic world. This underpinned the necessity for this exploratory study about the market and the ecosystem surrounding it.

The ability for the market to grow is unopposed but the question of whether it truly is green or can be made greener is primal. The CO_2 emissions are a good barometer of the environmental effects of such mobility devices.

The severe lack of scientific knowledge in this domain acted as a knowledge gap to proceed with this exploratory study. The research was designed to fill this scientific gap and provide an initial picture of this market and its influence on the mobility space.

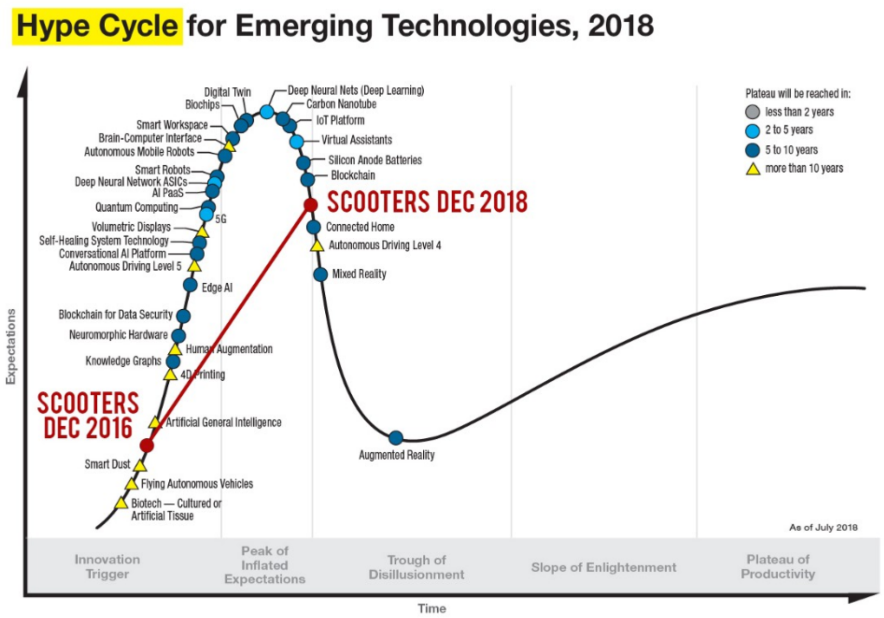


Figure 1.1: Shared Micro-mobility disruption since 2016 [2]

Micro-electric urban mobility was explored in its entirety. *Although a general exploration of the market all over the world for context was fulfilled, the research was carried out in the Netherlands since it was important to understand the Dutch context and implementation.* Having set out to explore the research in this segment of my search, a qualitative study and explorative framework towards tackling the research question was conducted. The hypothesis of sustainability aspects of mEV's was tested. Majority of research on this subject is too specific to one type of vehicle or one aspect of consequences such as safety or one country such as China [23]. Hence, different research questions were posed in order to understand the bigger picture and address the scientific gap.

1. *What is micro-mobility and what are the different kinds of novel transport in this sector?*

This began by defining micro-mobility and collecting data online on the different kinds of vehicles currently being sold in this sector throughout the world. Desk Research aided in tabulating and listing all major vehicles that have become common in different marketplaces. Most users buy them online or use apps to use these devices, so looking online for non-scientific sources helped gather most background information about this very premature but fast-growing industry. Some technical specifications were also listed. Although, this provided valuable information, live observation helped establish a more concrete perspective of events on the ground. Consequentially this information led to the next sub-question.

2. *Who are the major consumer of these mEV's (students, workers,demographic) and which mode of transport is most substituted (trains, cars, conventional bikes,etc)?*

This question involved some real-time observation in dutch cities followed by an informal questionnaire that clarified the reason for substitution, knowledge of regulation and legalities. This was instrumental in understanding not just the demographic of consumers but also the how much users know about mEVs and its implications. Since this was a initial exploration, it comprised of *early adopters of e-scooters and e-skateboards*. This study had certain limitations in its approach as there is a scarcity of knowledge and connectivity between the various stakeholders. It may not be precise but is accurate to get a brief outlook on status-quo in reflection to the approach taken by [24].

3. *What are the different ways of implementing usage of these technologies and what are their business cases?*

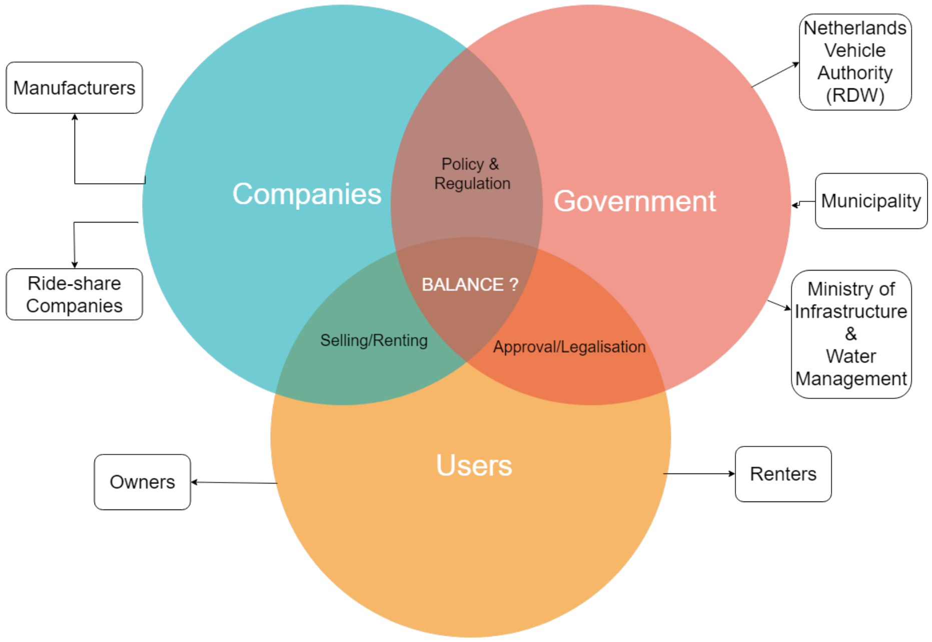


Figure 1.2: Stakeholders and actors in micro-mobility market

As of this moment, the two ways of implementing mEVs is either through private ownership or public-sharing fleet system. The second question will enforced the answer to this question by providing information on the private ownership but the public ride-sharing side needed further exploration. The most important factor to look at was cost-competitiveness and affordability. Desk Research and information from interviews helped shed light on the cost side of the ride-sharing system. The economics of ride-sharing of e-scooters was explored and explained in this chapter.

4. *How important are safety and policy to the growth of this market? Do they act as a barrier or catalyst?*

These technologies are very new and their lack of research, development and testing has led to worldwide safety concerns. Additionally, section 1.5 also outlines the implications transport systems have on both safety and policy. Policy in most cases is a trigger response to safety implications initially experienced by new transport systems. Micro-mobility, like every other disruptive innovation in the transport sector has had its fair share of safety concerns and policy roadblocks. Desk Research assisted in exploring the safety ramifications of these kind of vehicles. Data was collected on number and kinds of injuries/deaths caused in initial cities of implementation. Types of injuries and incidents were also listed based on the amount of information available online on media and tech companies. There was no better way of finding accident information than media, news outlets and technology blogs which follow and publish articles on information regarding disruptive technologies. Further company and government experts were interviewed to understand the ramifications of safety in regulation and policy trajectories. Three interviews were carried out with three experts from the different stakeholders as seen in Table 5.1. The interviews investigated barriers to implementation, safety aspects and absence of regulatory structure. The interviews were chosen to aid understanding the direction of research due to the lack of available information on almost every aspect of mEVs. [25] delved into regulatory and policy barriers and this aspect most often proves to be the driving force for expansion or on the flip-side, abolition.

5. *What are the environmental impacts of mEVs?*

The novelty of these technologies, as mentioned before, have a huge lack of scientific and academic knowledge on clear environmental impacts. Desk Research aided in producing a calculation from a few non-academic sources and show an approximate CO_2 emissions in private ownership and ride-sharing modes. Due to lack of available scientific literature about environmental impact, blogs and Audit Reports were used to provide an approximation of environmental impact of both private ownership and ride-sharing and how the ride-sharing aspect can be improvised to reduce net emissions.

An important thing to note here is that only passenger micro-mobility was explored in this thesis and cargo and freight micro-mobility was left out due to the lack of information and lack of significant industry growth and presence. To conclude, the ecosystem surrounding micro-electric mobility was explored to understand the intricacies of the market, types of implementation and roadblocks to further development.

1.3. Research Design and Methods

The topic aimed to explore micro-mobility as a field of transport. This comprised of understanding the entire ecosystem including business case, safety and environment and policy trajectories. The questions which were then summed up to understand the topic at hand are seen in Fig 1.3.

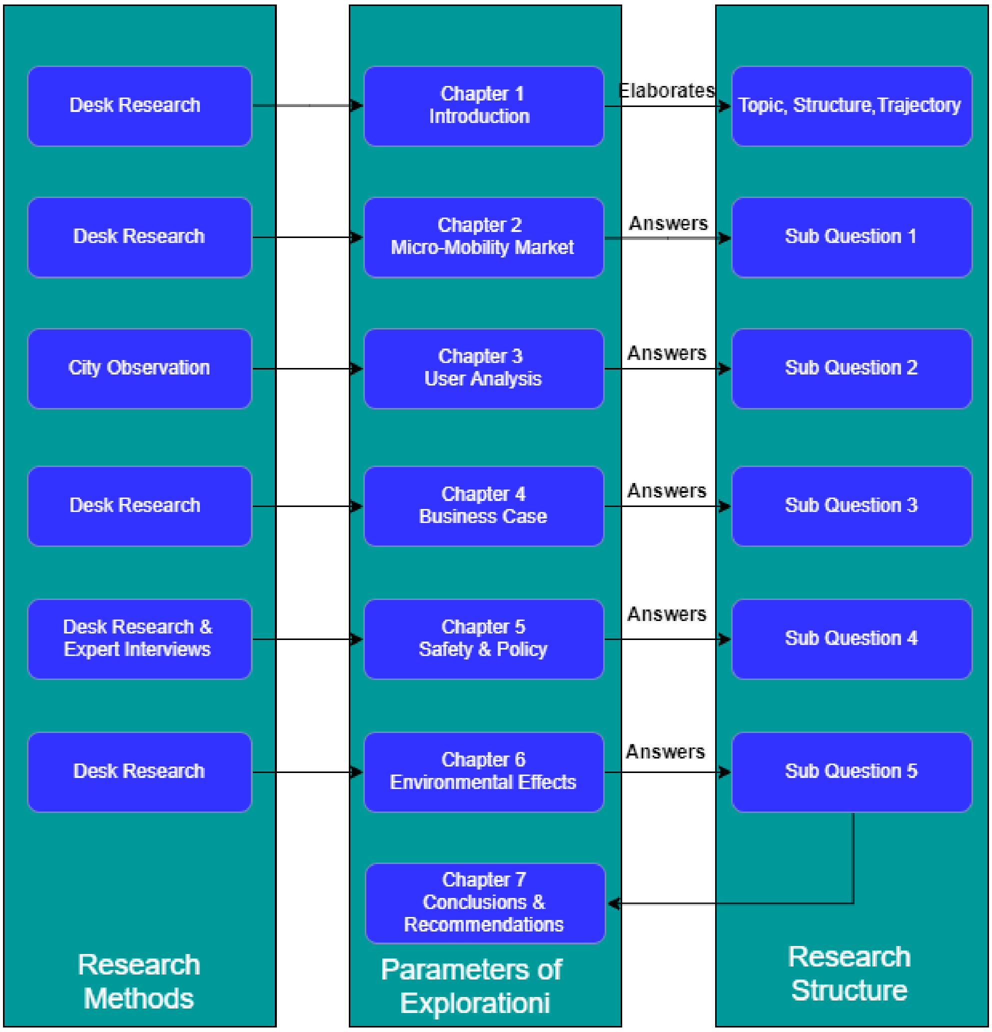


Figure 1.3: Research Flow Diagram

1.3.1. First Question

The first sub-question involved understanding the micro mobility market in general and what are the different kinds of novel products that are currently available using *Desk Research.* This composed of finding and collecting information on the different technologies currently sold in the market and garnered some attention in the recent past, selling their products in the Netherlands, especially. Google and most merchant e-commerce websites were used and keywords like "micro-mobility", "e-scooters", "e-bikes", "e-skateboards" were searched. There was very low scientific information available about this market, users, safety, policy, environmental impact. Some of the literature used in this chapter and following ones are:

Table 1.1: Majority of the Scientific Literature cited in this Thesis

Main Author	Title	Year
M Krosen	User characteristics and trip patterns of e-bike use in the Netherlands, results from the dutch national survey and the mobility panel Netherlands	2018
J Hollingsworth	Are e-scooters polluters? the environmental impacts of shared dockless electric scooters	2019
C Hardt	Usage of e-scooters in urban environments	2018
J Pucher	Making cycling irresistible: Lessons the Netherlands, denmark and germany	2008
J Weinert	The future of electric two-wheelers and electric vehicles in China	2008
J Weinert	The transition to electric bikes in China: History and key reasons for rapid growth	2007
J de Kruijf	Evaluation of an incentive program to stimulate the shift from car commuting to e-cycling in the netherlands	2018
T Eccarius	Exploring consumer reasoning in usage intention of electric scooter sharing	2018
T Eccarius	Categories of reasons for and against using e-scooter sharing	2019
LJ Mayhew	Impact of e-scooter injuries on emergency department imaging	2019
M Aizpuru	Motorized scooter injuries in the era of scooter-shares: A review of the national electronic surveillance system	2019
J Hoek	Lime e-scooters avoiding a collision course with public health?	2019

Since there is very less scientific literature on this topic, I referenced and used a lot of data and information from the following websites and more throughout my thesis document since they report the latest news from the world of mEV : (and more)

- The Verge (media firm covering Science & Technology)
- Electrek (news website dedicated to electric vehicles and sustainable energy)
- Clean Technica (news and commentary channel for Cleantech)
- TechCrunch (online publisher focusing on disrupting technologies)
- Bloomberg Technology
- Overheid.nl (Beleidsregel aanwijzing bijzondere bromfietsen)
- RDW Website (rdw.nl)
- Sprout.nl (entrepreneurial platform for startups and scaleups)

- Financial Times (Newspaper and online publisher in the field of business)
- Wired (Publisher relating to emerging technologies)
- Engadget (Technology news and reviewer)
- Medium.com (blog for disrupting tech)
- McKinsey & Company Energy Reports : McKinsey Center for Future Mobility
- MIT Technology Review

These sources were also used for other questions and chapters throughout the document.
The reasonably low amount of scientific literature to this topic clearly underpinned the knowledge gap and positively reinforced why an exploratory study like this was needed.

1.3.2. Second Question
The second sub-question was the most important and involved a combination of *desk research and empirical data gathering.* Initial research helped gather some numbers for data analysis using earlier literature, but real-time observation was carried out in three cities (Delft, Hague, Leiden). This portrayed a picture of the consumer nature and behavior and what the reasons are for slow transition. Crowded hubs of cities like central stations or city centre were observed for one or two hours biweekly. Data such as age, type of vehicle, reason for use, substitution, knowledge of regulation were parameters explored through the consumers. This not only shed some light on the initial picture of early adopters but also gave us some patterns on demographics connected to such vehicle use. A very important inference that was made from this is a connection between demographics, affordability and presence of mEVs.
A general picture of the mEV market exclusively focusing on was the goal:

- Products and Technical Specifications
- Cost vs Affordability
- Current trends in Product Technology

1.3.3. Third Question
The third sub-question dealt with the cost and business cases that involve the implementation of mEVs. *Majority of this chapter was answered through Desk Research.* The combination of information derived from the interviews with stakeholders and collecting pricing information online, the business case structure on the private and public side was explored. The private side is already explained in the Chapter 3 and this question targets *vehicle fleets and ride-sharing.* Consequently, it is important to identify if there is a close connect between the cost and the demographics of usage. *The interview with the spokesperson from Ninebot aided in understanding the private ownership business case because they are the biggest manufacturer of scooters and have the biggest market share in the Netherlands.* Additionally, it became integral to understand which parts of the business case can be changed to make it more profitable.

1.3.4. Fourth Question
The fourth sub-question investigated the safety perspective of mEVs (in specific, e-scooters) and how it impacted further expansion around the world. Desk Research was used to explore incidents and accidents over the world since the onset of these vehicles. Some of the literature used in this chapter are in Table 1.1. Additionally, the policy and regulatory side of mEVs were explored through interviews with the experts and collecting data online. Experts belonged to the stakeholders and their opinions assisted in understanding the bigger picture of pace of policy support toward technological innovation. Information such as roadblocks to business development are important from the manufacturer's perspective and information such as safety concerns are important from the policy-maker's side. *This was done with the help of empirical data gathering using interviews or questionnaires based on their*

schedule and availability. An interview structure with a combination of *OPEN & CLOSED* questions was chosen to obtain the story-line on safety and policy interactions. The three experts interviewed were from Municipality of the Hague, Ministry of I&W and Segway-Ninebot Group. The municipalities control the implementation of micro-mobility in their respective cities and it was important to see the story from the municipality's perspective. The Ministry of I&W governs all regulatory structures and policies targeting micro-electric vehicles or Special Mopeds (Bijondere Bromfietsen) and this interview aided in understanding policy status-quo and roadblocks to further growth. Segway Ninebot is the leading manufacturer (in the world) and seller of e-scooters (in Netherlands) and this interview aided in more about the consumer and roadblocks to business development in the Netherlands which stemmed from policy, or lack thereof. It was of primal importance to understand the story from the perspective of all stakeholder and understand the level of transparency and convergence. The interview experts and their role is seen in Figure 5.1. The process of obtaining interviews was gruelling and over the period of 7 months, only 3 interviews could be scheduled and completed due to low response rate.

Table 1.2: Interviewed experts and their function and expertise

#	Expert	Function and Expertise
A	Sven Mittertreiner	Policy Advisor, Urban Development at the Municipality of the Hague
B	Robbert Verweij	Senior Policy Advisor, Ministry of Infrastructure and Water Management
C	Yun Chen (Fred) Chang	Product Marketing Manager, Segway Ninebot

The information from the interviews supported the findings from the desk research.
Interview Structure:

A PRIVATE OWNERSHIP: (Fred Chang)

1. What product(s) do you currently manufacture and sell?
2. Based on pricing, what is the age demographic connected to your sales?
3. What are the problems the company faces with business development in NL?
4. What are the changes that could be made to help this transition and increase the use of such vehicles?
5. Has government policy and approval process been streamlined or has there been roadblocks? If yes, what are your suggestions on how it can be improved?

B PUBLIC-SHARING:

1. Has your company deployed public-sharing fleets in the Netherlands?
2. If yes, how was the journey towards implementation and if no, why not?
3. How dynamic is safety and charging requirements for the development of the business model?
4. Have government policies and regulations been supportive for continued implementation and expansion, if not, are receiving approvals easy or cumbersome?
5. What would be the cost of rentals (per km or per hour) and what are the tech specs of your vehicle?
6. What are the current obstacles to business development in Netherlands? Can they be streamlined or improved for future implementation?

C GOVERNMENT/POLICY: (Sven Mittertreiner & Robbert Verweij)

1. What is your designation and your role (your organization's) in shaping e-mobility vehicle policy in NL?
2. What are the policies that currently regulate/control mEVs in NL?

(a) If not, do we need regulation and policy to control the growth of such mobility? (Especially keeping in mind, the failures in America, Paris and Australia)

(b) If yes, are these policies enough or is the municipality looking to improvise and make changes to adapt to the growing landscape?

3. Are policies for all types of mEVs the same or are they distinguished?
4. What are the problems the municipality currently faces with these kinds of vehicles? Is safety a primary concern for policy framework?
5. What are the changes that the municipality is planning/should plan in order to ease the use of such vehicles daily?
6. Has there been any communication/agreements with the companies manufacturing these vehicles and if so, what has that yielded?

A point to note is that the interviews were meant to be exploratory and hence the interviews took trajectories based on the answers to the first principle questions. The data from both municipality, ministry staff, company staff described the process clearly and clarified whether the stakeholders are well connected or not.

Since this is a novel sector, there are not many companies and many users and hence the data set and the number of interviews was small (3 interviews). The parameters mentioned were a good starting point to underline roadblocks to system innovation. Also, this method clearly described the status of regulation and policies and whether these need revision in order to propel the transition. Consequently, it also provided further research opportunities on aspects that the author could not present through this thesis.

1.3.5. Fifth Question

The micro-mobility industry has been very disruptive, innovation and implementation is rapid and the the market is very volatile and dependent on key indicators. However, since the electric vehicles have transcended the world of sustainable energy and it is important to understand the environmental effects of these mEVs and whether it can have a significant impact on the energy transition. This depended on the surroundings they were implemented in and how they were implemented. *Desk Research* helped provide a calculation that approximated the CO_2 emissions in private ownership and ride-sharing modes. The two modes practically have a huge difference in impact just due to aspect of recharging. *This chapter expanded on the CO_2 savings with the help of desk research.* It also recommended methods to increase energy savings and make these vehicles green. As mentioned earlier, there is very little or rather no information or scientific literature that caters to mEVs. So this information can be a precursor for further scientific research with the help of collaborating with companies directly. These were the sources used in the chapter.

- Chester Energy & Policy
- CB Insights
- J Hollingsworth & B Copeland (2019)
- M Harms & Lucas Kansen (2018)

1.4. Expected Research Relevance

1.4.1. Academic Relevance:

The ecosystem exploration of this novel market provides for a good first impression and general view of this market and its ability to disrupt the mobility landscape. Vehicle electrification is a very integral part of the creation of "smart cities". Many European countries are working on "smart city" pilots and research and this helps in supplementing mobility plans and first/last mile solutions. Academically, most literature is antiquated and there is a necessity to dive deep into electric vehicles and mobility solutions. To add to this, the electric mobility industry and market is changing at such a rapid pace that academia needs to keep up. Surprisingly, the driving factors for innovation in this industry has been mostly on the private side. As mentioned earlier, there is a wide knowledge gap in this topic and a mismatch between industry and academia and there is a necessity for more research in this field to understand its potential for growth and implications.

1.4.2. Practical Relevance:

This is typically useful for civil servants working in transport, smart mobility & infrastructure. It is also beneficial to entrepreneurs and innovators as it is important to understand market growth, social behavior and policy barriers for them to decide on whether to venture into a new city/country for expansion or not. The results of this study will be very helpful in understanding the actual effect of these types of micro-sized electric transport in long term sustainable energy goals and better environmental standards.

1.5. Theory

Micro-mobility took off in 2018 and since has been growing although the market is still nascent. The future of micro-mobility seems uncertain, technological and design innovation needs to happen and their actual environmental impact is unclear. Transport system theory was used to understand the micro-mobility market and factors influencing its growth. *Additionally, it was also used to find the potential societal impacts (safety, environment) and hence the research questions were also framed to understand societal implications.*

According to the theory, transport volumes and their decomposition by modes and vehicle types result from:

1. The wants, needs, preferences and choice options of people and firms;
2. The locations of activities such as living, working and shopping;
3. transport resistance, often expressed in time, money, costs and other factors, which are referred to as 'effort' and which include, among others, risks, reliability of the transport system and comfort.

Peoples' driving behaviour and technology do have an impact on travel comfort and travel times and therefore on accessibility, safety and the environment. Peoples' preferences are what attribute to driving behaviour. The transport system and its influences on society is understood better by combining economics, civil engineering, geography and psychology. Additionally, transport systems cause negative consequences: environmental degradation, safety impacts and congestion being the most important ones. Developments in transport kick-start policies in land-use, infrastructure, pricing, subsidies and regulations that govern safety (crash tests and safety standards of products)and environment (CO_2 emissions). Hence, breaking down any transport system into its roots brings up multiple questions for both policymakers and researchers. The conceptual framework for factors influencing transport volumes and how the system effects accessibility, safety and the environment is seen in Figure 1.4.

1.5.1. The needs and desires

People's needs and wants need to be fulfilled at different times of day in different locations. These wants and needs vary strongly and does depend on income level. The branch of psychology studies this aspect of transport systems and looks into reasoning and logic behind peoples' decision to buy and use different modes of transport. In addition to income, time also plays a huge role. Again, time needed for different activities varies from person to person. Economists and geographers focus on impact of time on activity patters and travel behaviour [1]. Micro-mobility offers quick, easy travel to fix the biggest logistical nightmare: first/last mile solutions. Travel-time is seen as the biggest motivation for people to venture into micro-electric mobility apart from wanting to try new technologies. Also current generations are shifting from car/product ownership to using services which are most affordable, convenient and cost-effective. The reason for use of micro-electric mobility and the mode of transport substituted gives us an insight into where the disruption happens and how it can be enhanced. Although, this aspect is important theoretically, travel behavior and psychological aspects were not explored in this thesis.

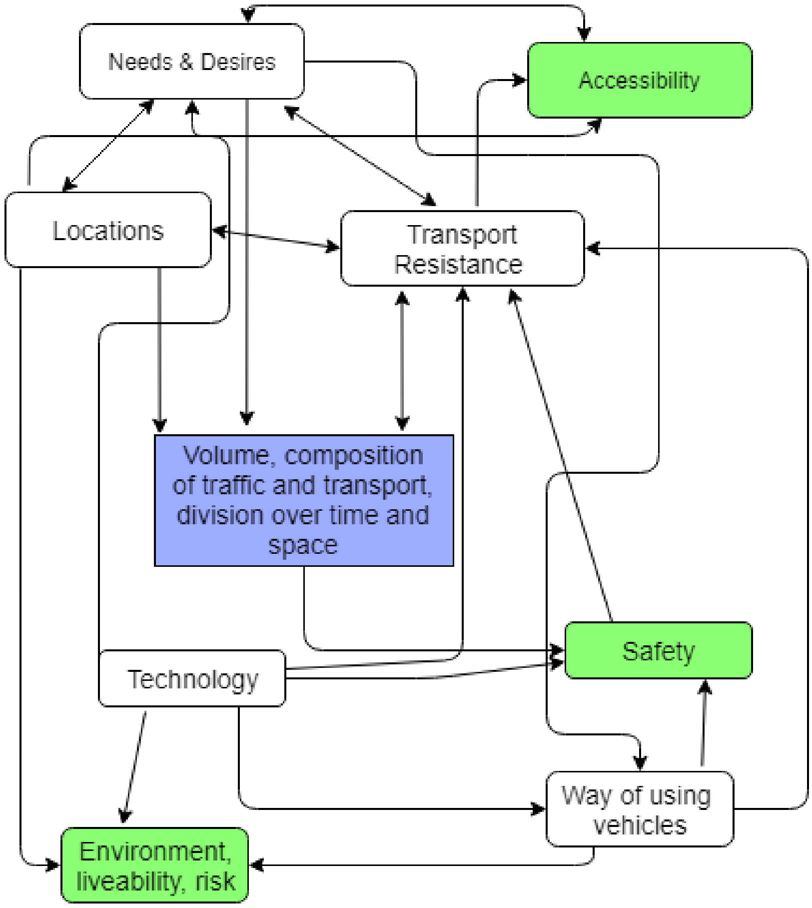


Figure 1.4: Conceptual framework on transport system and parameters influencing transport volumes; Uncolored boxes represent determinants of transport and traffic volume. Green colored boxes represent transport and traffic effects. The blue box is the traffic broken down over space and time [1]

1.5.2. Locations

Another important factor that influences transport is location of activities. Peoples' movements around the city for different reasons ranging from work, family, food, home, etc form a space-activity distribution which is very important to urban planners and geographers to forecast infrastructure requirements and city planning. Micro-electric mobility offers the ability to move around cities and urban centres quickly without the burden of product ownership, parking restraints and carbon emissions. Micro-electric mobility has the potential to disrupt car ownership and usage and can decrease congestion in crowded urban areas by banning cars.

Taking Netherlands into account, urbanisation patterns are more poly-centric, with medium sized cities in close proximity to each other [26]. Additionally, the presence of good bicycle and rail infrastructure encourages the use of mEVs as sustainable alternatives [27]. Other countries where micro-mobility has been implemented lack basic infrastructure for these vehicles since they are used either on car lanes or in pedestrian space which has negative impacts for all actors present in that physical space. The biking lane infrastructure is a great catalyst to the sustainable growth of micro-mobility by preventing an important step of space redistribution. Since a large proportion of the population already uses these bike pathways, the transition to these vehicles is easier and safety is higher when compared to other countries. This underpinned the necessity of implementing mEVs in full capacity in the Netherlands specifically.

1.5.3. Transport Resistance

Travel resistance is a very important factor relevant to transport development. These comprise of travel time, monetary costs and aspects such as safety and comfort. The sum of these resistance parameters is called ”Generalised Transport Costs (GTC)”. As the GTC gets lower, transport penetration and use increases. GTC is influenced by quality and quantity of available infrastructure (rivers, rail, roads, airports & ports, canals). Travel times depend on supply/demand of transport at that particular point in time. *Micro-electric mobility is a new innovative technology and influences transport resistance.* These vehicles are smaller, cheaper to use, more convenient and reduce travel times significantly due to speed and portability. Although the vehicles and the market maybe new, bike pathways in Netherlands provides the much needed infrastructure already for safe implementation. Biking and walking are very important in the Netherlands and hence micro-mobility fits right in and would have an impact on accessibility. According to Statistics Netherlands (CBS), living in the Netherlands involves using some form of transport. Data showed that only four out of ten employees live and work in the same borough or municipality and hence 60% use cars, bikes, public transport or a combination of public transport and a bike [28]. Approximately 70% of working inhabitants cross municipal borders for their job and travel on average 22.6 km to the workplace. Now considering this section of travellers, more than 50% use cars but the rest use trains to travel long distances and use bikes to cover the first and last mile [29]. It is very common in the Netherlands for employees or students to have two bikes in two cities, the one they live in and the one they work/study in. With the growing economy and increased jobs, the number of employed travellers and urban congestion will increase and these vehicles can help increase travel distances up-to a point where it can replace cars and help in space optimisation apart from having a cleaner impact on the environment. Currently costs of these vehicles are affordable in some segments and most are cheaper than the conventional e-bike. In terms of safety, the market needs more growth, products and iterations to implement better, longer lasting vehicles which enhance safety of riders and general public. Finally, the travel time can be reduced significantly even if mEVs replace a bike. With better battery technology which will propel longer ranges on these vehicles or swappable batteries, mEVs can truly influence transport resistance resulting in modal splits and increase in penetration. The combined prospect of trying newer vehicles and them having a cleaner impact on the environment can act as a catalyst to encourage higher uptake in the Netherlands.

Even evidence from USA has showed that micro-electric mobility does have the capacity to cause changes in transport volumes and modal splits which in turn has consequences for environment and safety. Hence, this necessitated an in-depth study of micro-electric mobility as a master thesis.

1.5.4. Demography

The theory assumes a constant population size and distribution. However, demographic changes have a significant impact on transport volumes. Age and household classes combine to produce different travel modes and preferences. Hence, it is important to understand age of users and cost affordability of the mode of transport used. Micro-electric mobility attracts a certain demographic due to the complexity and novelty of these vehicles and hence it is important to know the age of the users of such vehicles. The age and affordability aspects are very integral to understanding the implementation and penetration of these technologies. Demographics have an influence on safety and environmental impacts of mEVs. Since uptake has been dominated by a younger demographic, it is important to analyse the ramifications of younger users on road safety. Younger users tend to be less experienced, less attentive and more bold which increases the probability of crash risk and injury concerns. Evidence from car rental companies over the past and current day have shown higher insurance premiums on drivers younger than 25 for similar reasons and hence micro-mobility in terms of demographics will have an impact on safety and the environment. One consequence of micro-mobility is its high uptake by younger demographic and this might need some regulatory or policy structure to optimise and reduce safety implications.

1.5.5. Technology

The technological innovation in the transport industry has been growing fast and now, research is being undertaken towards autonomous vehicles and IOT. Technology in this space not only refers to the vehicle itself but also the infrastructure used to support these vehicles. The introduction of electric vehicles has brought it more fuel-efficient cars that are cleaner to the environment [30]. Global aspirations toward emission free future have helped the transition to electric cars by reducing emissions of pollutants like CO, NO_x and CO_2. The technological progress in transport has produced higher speeds, cheaper modes of travel and more comfort. The need to tackle climate change and bring about newer technologies also played a role in the development and implementation of electric vehicles.

Although, the micro-electric mobility market is not as big and transport volumes are low but its impact can still be significant based on substituting gasoline cars. Currently, transportation sector's share in GHG emissions is approximately 20 to 30% [31]. Figure 1.5 represents the socio-technical system for road-transport. It depicts all intertwined parameters within the socio-technical system and explains how technological innovation in transport is dependent on institutions, market, physical infrastructure and culture.

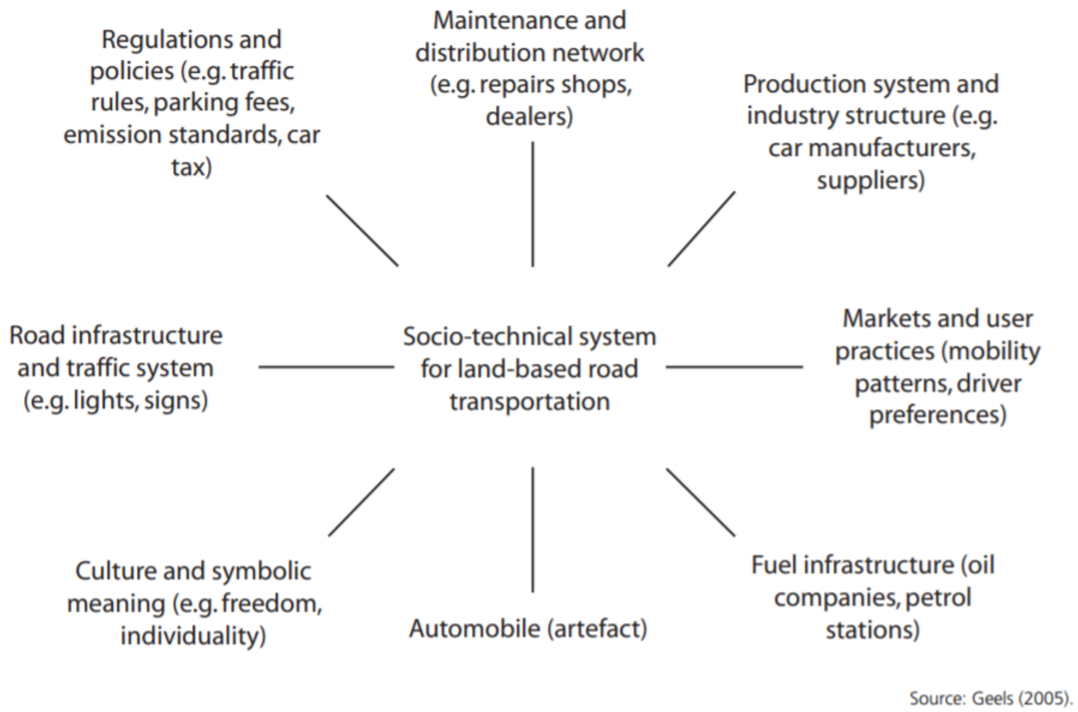


Figure 1.5: Socio-technical system governing land based road transport [3]

The micro-electric mobility market is a subsidiary of electric vehicles and hence are cleaner. Technological innovation is key to the growth of the mEVs. Considering the micro-mobility market, the most influencing parameters are regulation, infrastructure (bike pathways and ancillary traffic system support) and safety. mEVs represent electric vehicles and hence their impact on the environment makes them attractive. But also, peoples' constant need for change, to try new vehicles, to be adventurous also helps in the development and penetration of newer technologies. Additionally, technology in infrastructure like IOT has helped launch shared micro-mobility (mobility as a service). These have all been driving factors for the growth of mEVs over the last three years.

Electric vehicles are not just attractive for reasons relating to zero vehicle emissions but also zero noise. Noise has been a huge parameter of focus over the years due to the aviation and road transport. Engines and tyres make noise and these need to be reduced or prevented. Electric vehicles have brought that advantage of no noise and the cars or scooters or trucks are very quiet. Technological innovation in the micro-mobility market is also stimulated by push from factors relating to safety, policy and culture. Technology in infrastructure from speed cameras, automatic number plate recognition (APNR) and use of IOT in aiding driving experience are all steps in the right direction to reduce safety implications and increase transport volumes in the cars segment. Similarly for mEVs, strict safety standards need to be maintained to have sturdy rigid products that do not harm the rider or others around the rider. At current day, transport volumes of mEVs is less in the Netherlands but it is important to understand user practices, regulations and policies in order to implement sustainable growth. The technologies implemented in these vehicles are still premature and novel, and they need enough time to grow and gain reputation as a safer mode of transport. Hence the novel nature of this market warrants safety incidents during the initial maturity stage of the technology.

Table 1.3: Bicycle trauma categories [15]

Bicycle Subgroup	N (%)
Regular bike	1655 (83.3%)
Race bike	195 (9.8)
Off-road bike	78 (3.9)
E-bike	58 (2.9)
Total	1986

1.5.6. Environment

The issue of carbon effecting the environment came into central debate only in the last two decades. The reports of the Intergovernmental Panel on Climate Change (IPCC) provided the most updated insights on climate change and GHG emissions [32]. Emissions from vehicles can have negative health impacts to local populations apart from damaging the soil and ecology in the surroundings. As mentioned earlier, the advent of electric vehicles has pushed the cause of fighting climate change and should continue to do so. Although mEVs are not as large scale as public transport or cars,it can still have an impact on the environment long-term by building the right regulations and incentives to encourage its use.
The EU has set ambitious environmental goals in the transport sector: By 2030, reduce GHG emissions by 20% below 2008 level. Additionally, reduce 60% GHG emissions by 2050 [33]. In order to fulfill these goals, electric vehicles and newer transport technologies need to penetrate the market. mEVs will play a huge role in transition to EVs and also help provide a foundation for smart cities. These vehicles have a very clean effect on the environment with zero emissions during operation. Although, secondary aspects like manufacturing, transport and sale to customer needs to be considered. To understand the true impact of micro-electric vehicles, the environmental impact of mEVs have been explored in this master thesis.

1.5.7. Safety

Injuries, crashes, fatalities and deaths are the major downside of existence of transport systems. The number of these incidents in many countries are very high and need attention. To put Europe in context, the EC announced the aspiration of cutting down road deaths to half by 2020 [34].
The fundamental risks involved in road traffic are speed, mass and vulnerability of the human body [1]. When the speed on the road increases, the crash risk elevation can be described as a power function: 1% increase in speed triggers a 2% increase in injury crashes, a 3% increase in serious injury crashes and a 4% increase in fatal crashes [35]. Speed and impact cause crashes which will depend on inertia and kinetic energy. *Speed Differences* are also a big reason that governs crash risk. This is especially important here since the mEVs operate in bike pathways which are smaller and area to overtake is minimal. Vulnerability also plays a role in crash statistics. Technological advances such as seat belts, airbags and the compulsory use of helmets have all aided the journey towards lower crash risk. The reduction in injury risk is about 40% with the use of seat-belts and more than 50% when combined with airbags [36]. When compared to mEVs, where not many safety gear is used and high speeds are possible in narrow bike pathways with so safety net for surrounding riders. The bike pathways are narrow and higher speed differences between categories of vehicles will cause more overtaking which will result in higher chances of crashes. The Netherlands has already a lot of bike related accidents to prove that safety on the bike pathways is still a concern. Between 2007 and 2017, 1986 bike related accidents were recorded and their breakdown is seen in Table 1.3 [15].

However, the reasons for crashing or risk-elevating factors are as follows:

- **Lack of Driving Experience:** This results in higher crash risk. Age and experience play a role in crash risk and this reduces rapidly within the first year of passing a driving test [37]. Around 60% or crash risk can be attributed to inexperience(<100,000 kms driven) and the balance 40% is attributed to age [38]. Additionally, considering mEVs, there is a lack of of regulatory approvals, licenses and hence the chance of underage illegal riders is very high and method of supervision is a big question. Additionally, the speeds on these are electrically not limited and hence less confident riders are bound to increase crash risk for themselves and for others on the bike pathways.

- **Drugs & Alcohol:** Alcohol and Drug consumption by road users is one of the most common factors of increased crash risk. An exponential increase in traffic risk is observed with a spike in Blood Alcohol Content (BAC). The influence of drugs or psycho-active substances increases crash risk by a factor of 25 [39]. Combined use of both increases the factor by 200 relative to sober drivers. Since these vehicles are easier to use than cars, and are available easily, the number of cases of DUIs have been significant in the past and are a concern in the future. Supervision and regulation through personnel and technology might become a necessity for these to achieve stability.

- **Emotion & Aggression:** Over the last decade, some have expressed this view that traffic aggression is a major contributor to crash incidents. Road rage has become ever more prominent and increased stress in peoples' lives and on the road due to traffic has made road rage very common. Although research till date has not made a direct correlation, there is a connect between road rage and road safety [40]. Aggression, unintended or intended, increases crash risks in mEVs since their braking is not completely accurate and some of these vehicles do not have a seat which means the rider falls off the vehicle. So inattentive riding in any form may have harmful impacts to users and other riders.

- **Distractions:** Distractions were found to be a very frequent crash cause according to police reports [41]. Mobile phone use is the most common distraction that has caused accidents on the road. Inattention to driving circumstances and intermittent focus has been one of the main concerns of policymakers when it comes to road risk. Other activities also cause crash risk such as drinking, eating, smoking, checking navigation, tuning the music player and talking to other passengers [42]. Biking or using mEVs in bike pathways needs even less attention than normal roads due to less volume and speeds but micro-electric vehicles introduce the high speed aspect. Cell Phone use can be very harmful to the implementation of these vehicles and inattentive riders need to be penalised. Again, their braking is very sensitive and needs utmost attention while riding.

Safety has been a limiting parameter to the growth of transport technology. Safety implications generally trigger policy development and policy forces companies and manufacturers to increase quality and safety standards. This cycle generates better products with time. mEVs have had their share of safety implications due to similar reasons and these reasons will be explored not just to find out the nature of accidents but also the policy responses that followed in all countries in implementation.

1.5.8. Policy

Transport and Policy have always gone hand in hand and over the past, policy structure and motivations have been integral to the development of newer transport systems. Policies target different approaches:

- To decrease transport resistance factors.
- To influence the needs and locations of activities
- To improve environmental performance of vehicles.

There are also different ways of classifying transport policies:

1. Based on policy goal, for example, policies to improve transport safety or emission reduction.
2. Based on kind of instrument, for example, pricing policies and new infrastructure.
3. Based on body implementing policy, for example, councils, supranational bodies, regulatory bodies and national and regional governments.

The main focus in this thesis context is policy relating to environments and accidents. Policies have over decades tried to counter safety implications and environmental degradation. Strong regulatory standards for the technical characteristics of vehicles and fuels are always necessity. Policy trajectories should enforce more climate conscious citizens and propel them towards cleaner impact transport and slowly disincentivise gasoline transport. Also, they target accessibility by providing new infrastructure, reducing public transport fares. All these policy goals root back to improving vehicle and fuel standards.

Micro-mobility helps in this aspect since it adds to the EV market share.
mEVs have undergone policy roadblocks and the reasons have been majorly the pace of policy development apart from safety implications experienced worldwide. Micro-electric mobility is very new and hence needs regulatory context to expand unhindered. Since these vehicles are used in the bike pathways, it needs clear mandates on design, speed and usage since it has consequences for other normal bike riders. It is important to understand that no transport system can achieve full functionality without the necessary policy support and policy definitions which generally take time after the introduction of a new transport. This justified the exploration of organisations governing policy for mEVs and their status-quo.

1.5.9. Peskin Ratio

Newer transportation systems have demanded newer metrics of measurement and analysis. With the onset of a micro-mobility revolution, the Peskin Ratio was introduced by Aaron Peskin, a member of the San Francisco Board of Supervisors. It indicates the ratio of *"Failed Rides"* to *"Successful Rides"* an average user experiences while utilising a transportation system or service. Let us consider an example of a car to understand this metric. Cars typically might fail once every 1000 trips and hence the Peskin Ratio would be:

A Car's Peskin Ratio = 1 failure/1000 trips = 0.001

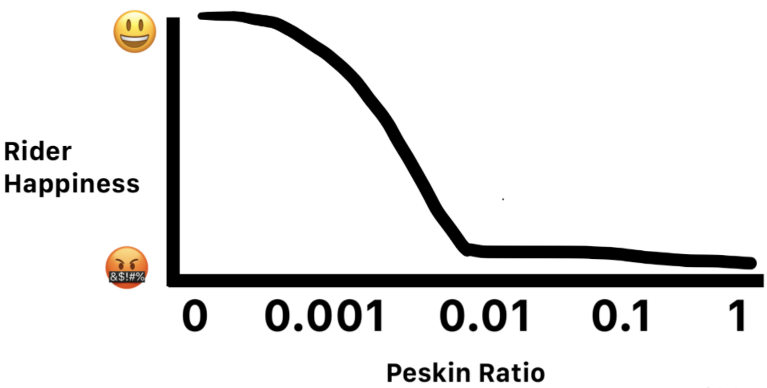


Figure 1.6: Log Scale was used on the x-axis [4]

The more the Peskin Ratio, lesser the happiness and satisfaction of using that particular mode of transport as seen in Figure 1.6. This generally leads to change in behaviour and opting alternative modes of transport. Public Transport and taxis (like Uber) have low Peskin Ratios which make them extremely attractive and convenient. Approximately every thousand trips or so, the trains might be down or the Uber app might be dysfunctional which leads to a failed ride but the frequency of failures is of primal importance.

Shared micro-mobility and ride-share e-scooters in specific have displayed excessively high Peskin Ratios which frustrates users and forces a modal split or transition to another mode. Poor user interface of the mobile apps, lack of available scooters at time of need, and non-removal of damaged scooters from the fleet are some of the reasons that drove up Peskin Ratios in the initial period of implementation. The mobile interface and its poor design led to multiple issues in uptake and attributed to higher Peskin Ratios.

The physical implications of higher Peskin Ratios is higher crash risk and probability of accidents and injuries. Safety has been a big concern since the introduction of mEVs and initial experiences from USA show that current technology and poor scooter riders has necessitated huge developments and improvements in product design and safety requirements.

1.5.10. Conclusions

The transport theory from Bert van Wee breaks down the different aspects of a transport system and what connect them together. Different aspects like psychology, geography, economics and engineering are combined to project the functionality of a transport system. The potential of mEVs to disrupt first/last mile solutions is completely dependent on all aspects explored in the transport theory. A user analysis was conducted to understand the user demographics of mEVs. The experts in the interviews were asked about safety, policy and infrastructure roadblocks that have slowed the growth of the micro-mobility market in the Netherlands. The knowledge from the theory helped decide which areas of the micro-electric mobility market to explore and hence find out which factors are the most limiting to its success. Additionally, the concept of Peskin Ratios helped outline current state of shared micro-mobility and addressed where it needs improvements. In conclusion, the foundation of knowledge from the theory, the data collected from stakeholders and users aided in formulating better conclusions regarding the ability of mEVs to disrupt the market in the future. An overview of theoretical study and implications is seen in Table 1.4.

Table 1.4: Overview of Theory findings and implications

Limiting Parameter	Findings	Research Implications
Technology	Technological innovation aimed at decreasing transportation's negative external effects is dependent on technical, economic, social and political feasibility	Electric vehicles have better environmental standards, the market is premature but innovation is ongoing. It is important to explore the technological status-quo of mEVs and their market in entirety.
Environment	The worldwide CO2 emissions from transport are increasing despite emission reduction targets. New technological solutions are needed to deliver large-scale emissions reductions over time.	Electric vehicles have shown to be much cleaner in operation. Although, mEVs in specific need to be explored and their impact on the environment needs to be analysed.
Safety	Intentional and unknown errors caused by speed and mass differences are the major contributors to crash risk. Net fatalities in the transport sector can be lowered through different mechanisms.	The safety of mEVs is highly unknown in the scientific world. Experts will be asked whether safety aspects have influenced the market and other aspects of growth of mEVs.
Policy	Governments implement policies from a social perspective and they aim to increase efficiency and accessibility. It all boils down to vehicle and fuel standards which in turn influence everything else.	Experts were asked about the current status-quo of policy and regulation governing mEVs. Aspects about regulations regarding vehicle design and battery performance were also explored.
Demography	Demographic changes have an impact on transport volumes. Age and affordability do influence mode of transport chosen.	User Analysis was conducted to find the age of users, reason for use, mode of transport substituted and cost of vehicle.

1.6. Structure of Document

The rest of the document is structured in the following manner. Chapter 2 defined micro-mobility and elaborates on different kinds of vehicles that are now a part of this market. In Chapter 3, user analysis was carried out with results from real-time observation. Chapter 5 elaborated on the safety and policy side investigation of the micro-mobility market both abroad and in the Netherlands. Chapter 4 briefly discussed business cases and types of implementation of mEVs. In Chapter 6, environmental effects were explained with the help of CO_2 savings. Chapter 7 presented the conclusions drawn from the entire study. Recommendations are also provided on how to alleviate some of the roadblocks and provide for a smoother transition to mEVs. Appendix A contains all background information regarding the interviews taken and other miscellaneous information. Although the term mEVs were used in most areas, Chapters 5 through Chapter 6 target e-scooters as they are most widely used innovative mEVs.

2

Micro-Mobility Market

The main research question was established in Chapter 1. This chapter defines the micro-mobility market and the vehicles that are widely used. Also describes the companies operating internationally and the part of the market that is well-known.

2.1. Definition of Micro-Electric Mobility

"Micro-mobility constitutes modes of transport that can occupy space alongside bicycles." Micro-mobility can be defined based on multiple criteria [43]:

- Weight (< 500 kg)
- Number of Passengers (1 to 2)
- Power Output (4W to 4kW)
- Payload Capacity (up-to 120 kgs)
- Powertrain (human-powered or electric)
- Maximum Speed and Range(depends on product prototype and local laws)

These vehicles typically focus on first/last mile solutions and provide better connectivity and transit for short distance trips. The vehicles are of different types, with newer designs and technologies being launched frequently. The first/last mile has always been a logistical nightmare and these vehicles can ease the problem in many ways due to a combination of weight, portability and speed as seen in Fig 2.1. Additionally, micro-mobility is split into two catogories: passenger and freight/cargo.

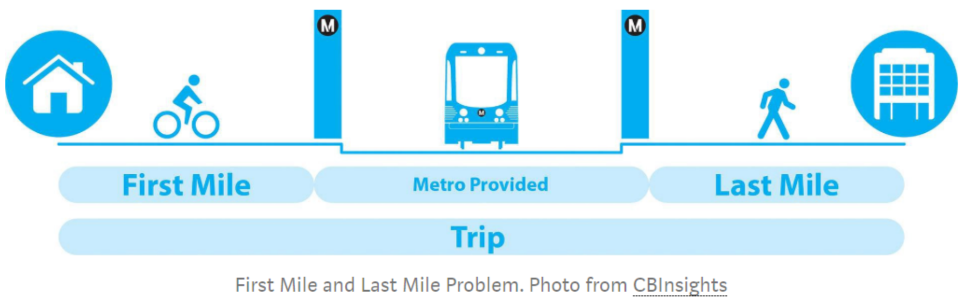


Figure 2.1: First/Last Mile Solution, need of the hour! [5]

2.2. The Growth of Micro-Mobility

The emergence of Smart Cities has been a consistent catalyst to the growth of micro-mobility around the world. The need for more electric vehicles, lesser gasoline cars, and more innovative modes of transport have brought in a new sector of innovative micro-sized transport. Additionally the increase in mobility-as-a-service has also increased the presence of these vehicles across the four continents [6]. The micro-mobility industry as such has been growing rapidly, with significant increases in design quality and worldwide presence. The industry is poised to grow to around $300- $500 billion by 2030 [10]. It is important to understand how this growth would take place and what would influence the pace of growth. Micro-mobility works for many reasons, but to list a few:

- Stress buster for urban consumers.
- Higher average speeds in crowded urban centres which implies faster travel.
- Less time waiting or parking.
- A much lower cost of ownership.
- Health benefits of being outdoors.

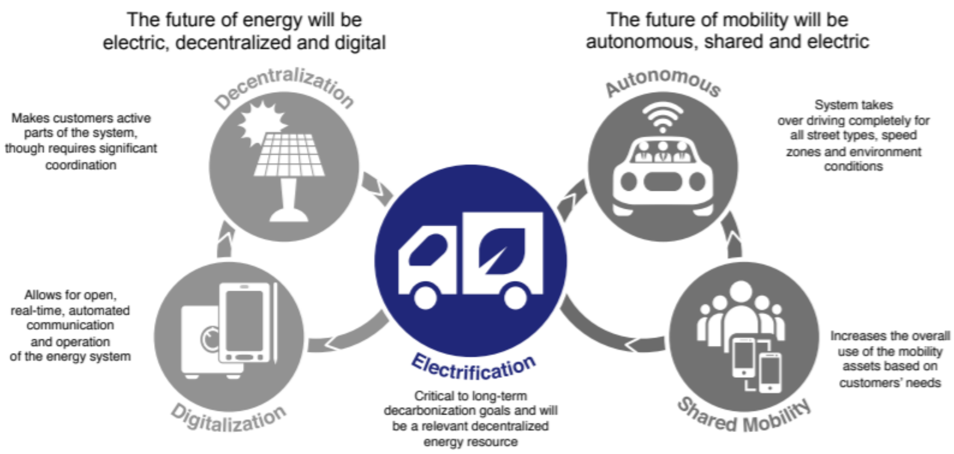


Figure 2.2: The convergence of mobility and energy futures [6]

Mobility & Electrification are very important aspects to the creation of smart cities and hence this industry is bound to grow ten fold over the next decade and hence these vehicles and this market will play a crucial role in the formation of smart cities and shifting the public away from cars as seen in Fig 2.2. Additionally, recent times have changed youngster perception and consumers are moving from ownership of products towards using services. From Uber to Lime, services are paving the way for a convenient ownership-free life due to the technological advent and the access to the internet [44].

2.3. Types of Vehicles

This new industry has introduced ample number of vehicles that run on charged batteries and this section discusses some of the vehicles currently being sold and implemented in different cities in the world. Fig 2.3 depicts some of the different categories of vehicles currently operated in this market.

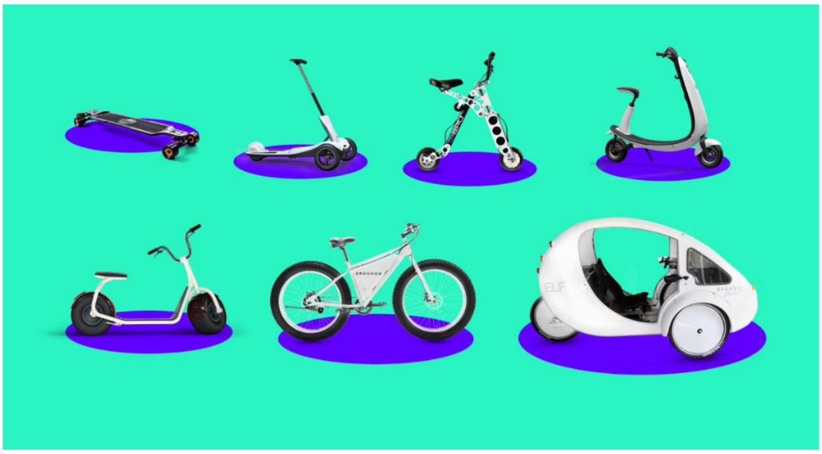


Figure 2.3: Different vehicles currently implemented in the micro-mobility market (from top left to bottom right). 1. electric skateboard,2.step scooters,3. portable scooters, 4. folding scooters,5. human pods, 6. electric bikes, 7. scooters [7]

2.3.1. E-bikes

The introduction of electric bikes has been successful, especially in the Netherlands because of the already existing biking infrastructure. Electrification of bicycles has helped increase consumption of bikes and distance travelled on bikes by introducing more senior demographic into the consumption bracket.

(a) Gazelle e-bike, very common in the Netherlands

(b) VanMoof Electrified S2, a new e-bike designed by a startup

E-bikes uptake in the Netherlands has seen a steady rise. In 2015, e-bikes accounted for 6.5% of all bikes sold in the 28 EU member countries [8].

The latest trends in the Netherlands can be seen in Fig 2.5.

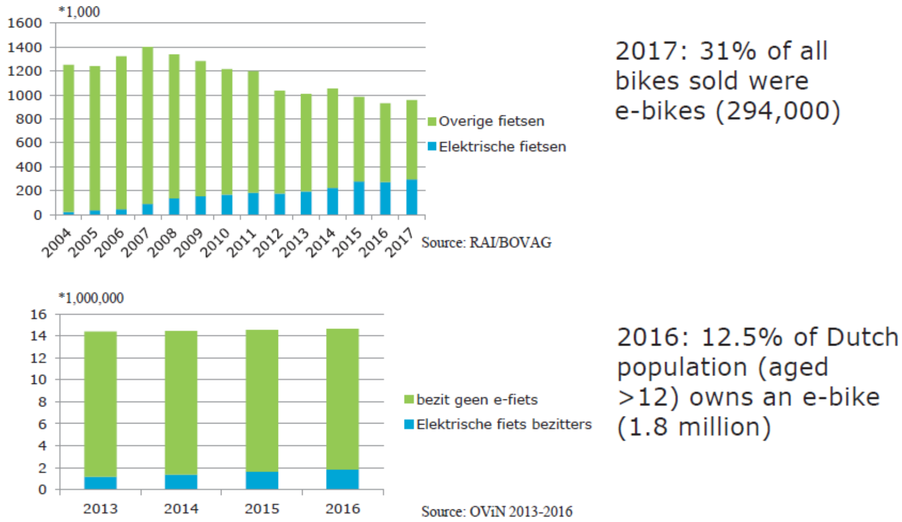


Figure 2.5: E-bike Trends in the Netherlands in 2017 [8]

Many traditional companies have started selling e-bikes apart from start-ups that have launched recently that only design e-bikes.*The biking side of the industry is stable, well guarded in regulation and there are no roadblocks to further development except cost competitiveness. So this segment of the market will not be expanded upon beyond Chapter 3.*

2.3.2. E-scooters

E-scooters have made a huge impact in worldwide electric mobility especially in the form of first/last mile "mobility-as-a-service". They were first observed in California where Lime and Lyft tested them on the streets for a one year period which saw huge success and also a few downsides. Now, the number of companies have grown and these scooters have been implemented in multiple cities on multiple continents and have had both positive and negative impacts on society. Lime and Bird, two of the biggest companies are currently valued at *$1B & $2B respectively. Both of them had a recent funding round of $300M in February 2019 and this marks the category of fastest growing mobility companies in the world. In response, European based startups* ***Tier, Wind, VOI, DOTT and Flash*** *also raised more than $150M in 2019.* E-scooter companies and their current valuations are depicted in Fig 2.7. The impacts are discussed further in Chapter 5.

Figure 2.6: E-scooter, also known as e-step

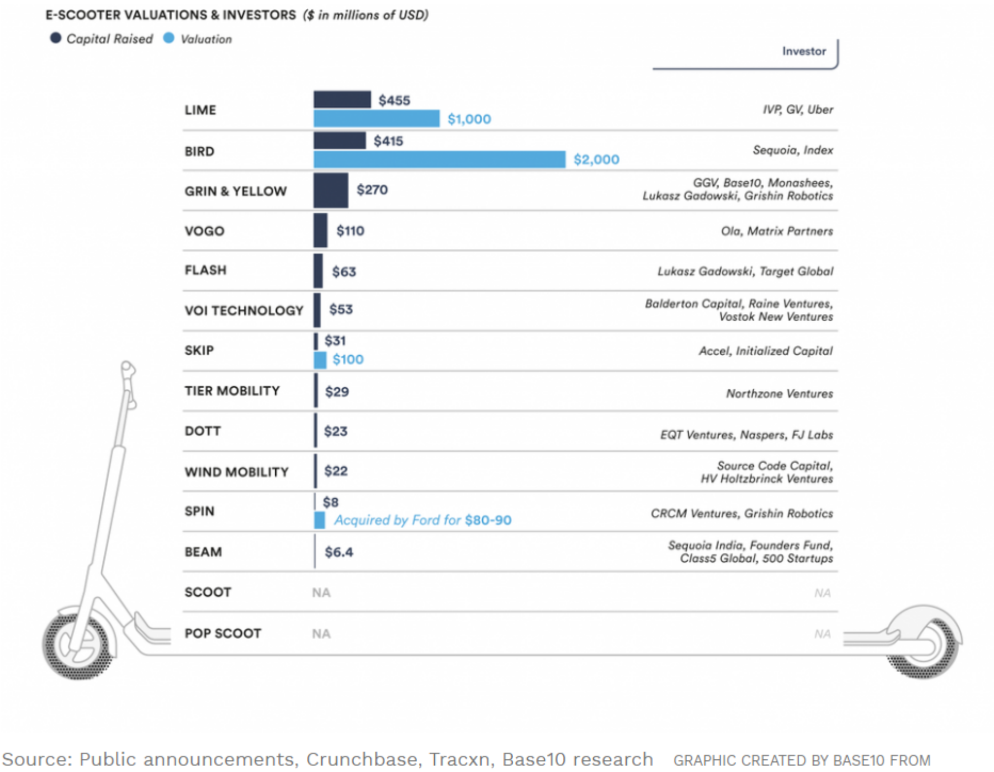


Figure 2.7: E-scooter companies in the world and their investment partners [9]

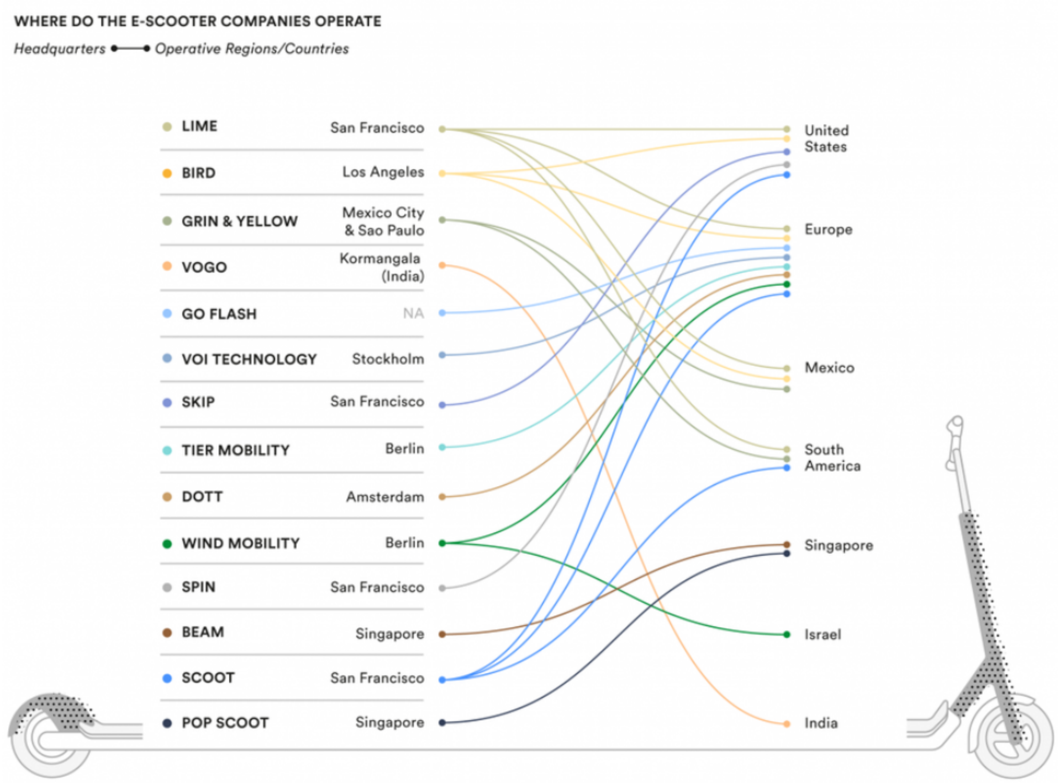


Figure 2.8: E-scooters companies and their worldwide operations [9]

A list of ride-share companies and their operating cities is seen in Fig 2.8. *This showed us that* *e-scooters are growing faster than any other micro-electric vehicle and can have a huge impact on short distance urban mobility.*

Although many vehicles fall under the category of mEVs, *this thesis focussed mostly on e-scooters as they are most disruptive, highly used vehicle in the world.*

2.3.3. E-skateboards

E-skateboards are very new to the market and occupy a very small market share of mEVs. They comprise of electric batteries and motors attached to conventional skateboards and longboards as seen in Fig 2.9 . They are very innovative, but also very self-intuitive which is why these vehicles would only be available for private ownership and not publicly available for fleet-sharing. *These vehicles were investigated in the user-analysis but will be not be studied in depth due to their extremely low numbers and presence.*

Figure 2.9: Boosted 1st Gen E-skateboard

2.3.4. E-unicycles

There have been many new swanky designs of mEVs with one-wheel. These are very new to the market and the world had not seen vehicles like this prior to the 21st century. Very few companies have launched successful products in this unique design, namely, OneWheel and Segway. Their products have different kinds of stances and operation as seen in Fig 5.4a and 5.4b. These vehicles, like e-skateboards, are very self-intuitive and hence safety is still a very big question. These vehicles also would only be available for private ownership and not publicly available for fleet-sharing for the same complexities mentioned with respect to ease of operation and ride-ability. *Hence, these vehicles will not be investigated in this thesis.*

2.3.5. Cargo Vehicles

The cargo segment of mEVs is a very small market with a few vehicles currently sold in large numbers. In the Netherlands, bakfiets has a become very prominent cargo vehicle. Bakfiets helps in transporting luggage, cargo and personnel(kids) and pets. Current designs can carry between 1 and 6 kids on a bakfiets e-bike as seen in Figure 2.11b. It uses a 450 Wh battery with a speed limiter at 18 km/hr. Most companies in the Netherlands like Gazelle, Koga, Batavus, etc, manufacture their own bakfiets. Gazelle Cabby C7 is seen in Figure 2.11a. These vehicles are very common in the Netherlands and since they are designed as bikes, they are mainstream and do not have regulatory roadblocks.

Additionally, in the cargo segment, DHL introduced the first cubicycle in order to achieve zero logistics-related carbon emissions by 2050 as seen in Figure 2.12. These vehicles have reduced emissions by 398.6 kg per year when compared to a van. In addition to manual steering, an electric assistance of upto 250W is activated and has a 50 km range per day [45].

(a) OneWheel, innovative one-wheel micro electric vehicle

(b) Segway OneS2, innovative one-wheel micro-electric vehicle

(a) Gazelle Cabby C7

(b) Babboe Max-E, cargo e-bike for 1-6 children, 450Wh

Figure 2.12: DHL Cubicycle

Cargo mEVs are becoming more mainstream in some parts of the world and at the moment do not have a huge global presence except in a few countries where support infrastructure is already available. ***These vehicles will not be discussed in detail and will be ignored for the rest of the thesis***

document.

2.4. Chapter Summary

This chapter introduced the mobility market as a whole and how it impacts society to this day. Micro-electric mobility will play a huge role in the transition towards *Smart Cities*. It disrupted America and this wave can disrupt Europe too as seen in Figure 2.13.

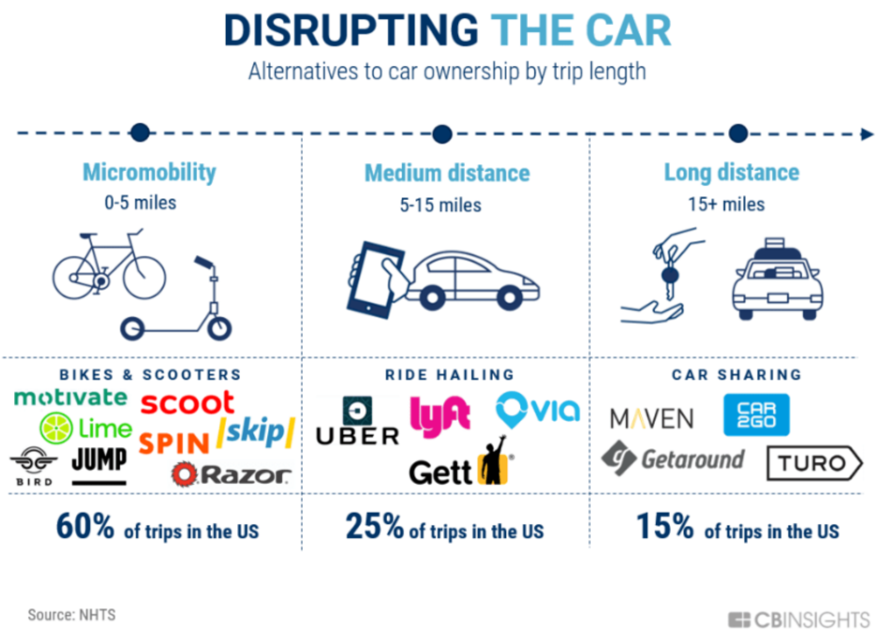


Figure 2.13: Trip Length and their implications in modal splits[5]

The most prominent and evident passenger mEVs on the market in the world are e-bikes, e-scooters, e-skateboards and e-unicycles. These are the newest mEVs in the market and are constantly undergoing design iterations to produce better products with time. These vehicles are portable, quick, easy and dependable for short-distance mobility especially in the 0-10 km bracket (0-5 miles). From the different categories of vehicles found, e-scooters were found to be the most disruptive due to their ride-share growth. E-bikes and e-scooters are the only vehicles implemented in a ride-share capacity but with time, ride-share companies are all transiting to e-scooters. Biking in the Netherlands is well established and hence the e-bike category is stable and growing. This segment of mEVs will also not be discussed further due to their stability and lack of regulatory roadblocks. In essence, mEVs provide a clean mode of transport for first/last mile solutions and this market will grow in the future and replace cars due to growing traffic concerns and lack of space.

In the Netherlands, cargo segment was also found to have a presence. Bakfiets for carrying children and pets and the DHL cubicycle were found to be the two most common cargo vehicles to be found, although the cubicycle is still new and have not been launched in huge numbers. This segment has a very small target consumer base and hence will be ignored for the rest of the thesis.

3

User Analysis

This chapter investigated the users of different mEVs observed in three cities in the Netherlands. Types of vehicles, technical specifications,age of users, price range, mode of transport substituted, reason for use and awareness of regulation were all presented in this chapter for each kind of vehicle observed.

The user analysis was carried out in Delft, The Hague and Leiden over a period of 7 months. Live city observation was carried out in *crowded and important urban centers,namely, the Central Station and the University campus (and around that area) in all three cities as seen in Fig 3.1.* The motivation behind this idea was to understand the penetration of micro-electric mobility in the Netherlands and understand demographics, different kinds of new technologies (privately owned) and user knowledge of national regulation. All the technologies are very new to the market, and hence the observation included *early adopters (small sample space) of e-scooters and e-skateboards and general adopters of e-bikes.* E-bikes as such in the Netherlands are well established due to the cycling history of the country. E-bikes do not have any regulatory roadblocks like the other new mEVs and its stability makes it the prime reason for no further discussion in this thesis.

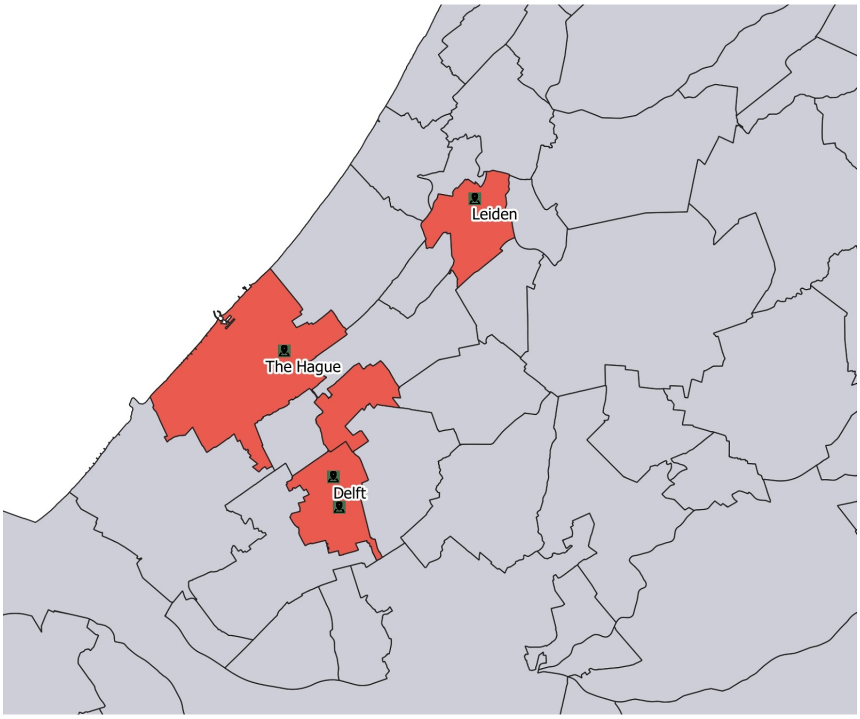


Figure 3.1: Cities and Locations observed in Zuid-Holland.

3.1. Electric scooters

The results on e-scooters observations are listed below as per different parameters of observation. The vehicles were observed for over seven months, two hours three days a week. Over that period of time, a total of 34 e-scooters were observed, stopped and interviewed for a minute or two about age, regulation, reason for use, and mode of substitution. Observations were done during 8-10 AM for the first few months, but later switched to 5-7 PM and sometimes 9-11 PM in the Hague. The evenings showed better results. **All vehicles were observed in the same timeline but some steps were not uniform and were deviated due to the nature of the vehicles. Users of e-skateboards and e-scooters were questioned about regulation due to their regulatory roadblocks and users of e-bikes were questioned about their acceptance and approval to the newer mEVs. However, all users were questioned about age, reason for use, mode of substitution and price.**

3.1.1. Model and Type

On observation, it was found that only four scooters from Ninebot, Xiaomi and Denver were found in the whole analysis as seen in Fig 3.2.

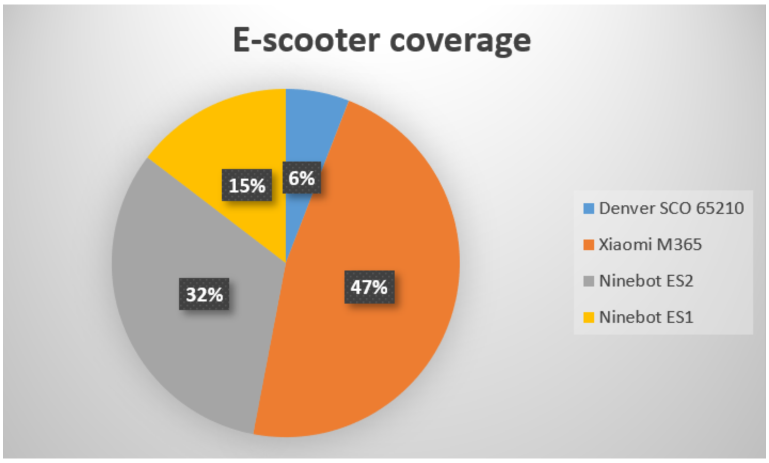


Figure 3.2: Percentage of appearances based on model type

3.1.2. Pricing

The pricing on the 4 models of e-scooters were observed to be in the range of 200 - 600€ as seen in Fig 3.3.

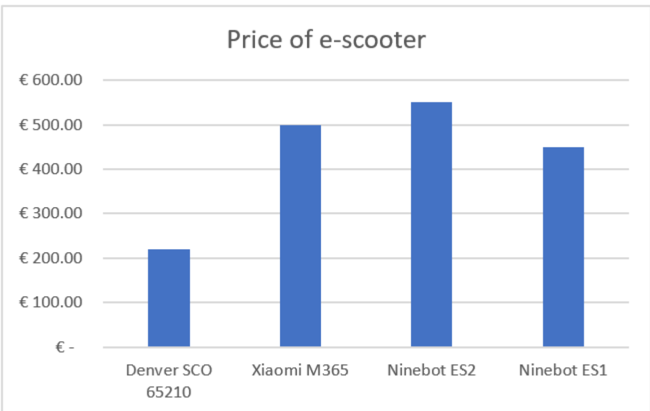


Figure 3.3: Pricing based on Model type

3.1.3. Age Demographic

The interviews included questions and age was one of them. All the 34 observed were interviewed and only the users that could be stopped and interviewed made it to the final analysis and the rest of the vehicles just observed were removed. The most significant age limit of users was found to be 25 - 28 although the most prominent age range of users with these vehicles was found to be 25 - 35 as seen in Fig 3.4.

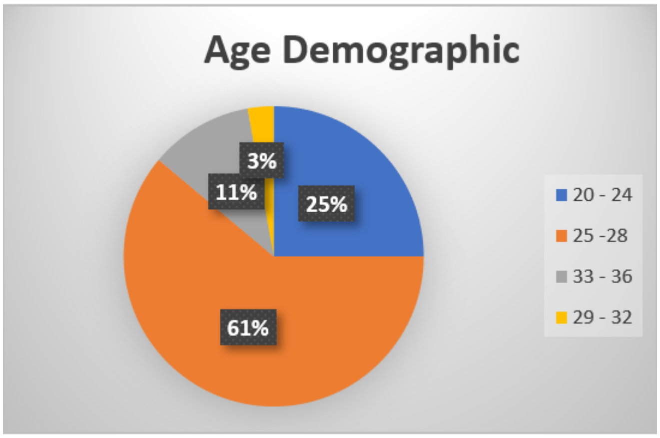


Figure 3.4: Age demographic of users of e-scooters.

3.1.4. Technical Specifications

The power output (W), average range (km), and average speed (km/hr) of the four models of e-scooters are listed below in Table 3.1.

Table 3.1: Technical Specifications of e-scooters observed

Type of e-scooter	Power (W)	Avg Range (km)	Avg Top Speed (km/hr)
Denver SCO	300	8	15
Xiaomi M365	250	16	25
Ninebot ES2	300	18	25
Ninebot ES1	250	16	20

3.1.5. Mode of Substitution

This subsection depicts the mode of transport substituted by users. This was the second question in the interview. E-scooters substituted different modes of transport including Public Transport, Car, Walk or a combination of two. The results from all the 34 users are depicted in Fig 3.5.

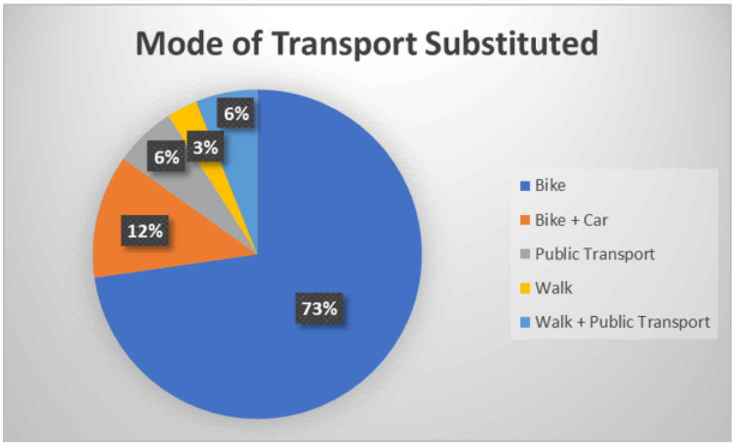
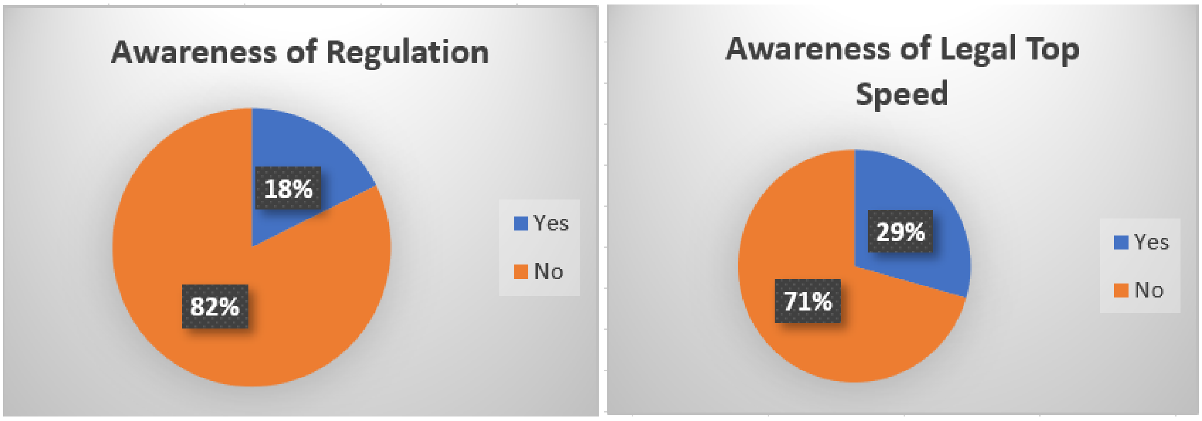


Figure 3.5: Mode of Transport substituted

3.1.6. Awareness of Regulation and Top Speed

In the user analysis, the last question targeted knowledge of regulation and top speed. The regulation is non-existent and the top speed for Snorfietsen is 25 km/hr. The legal ramifications of these vehicles will be discussed further in Chapter 5. A plot of awareness of users to regulation is seen in Figures 3.6a and 3.6b. 82% were unaware of the regulation for mEVs ad 71% did not know the the speed limit of 25 km/hr. This data supported the argumentation made in Chapter 5 which outlines current state of regulation and policy ramifications.



(a) User Awareness of Regulation

(b) User Awareness of Top Speed

3.2. Electric skateboards

Electric skateboards are still a very niche market and these vehicles are only available for Private ownership. Even skateboards were observed in the same timeline as e-scooters. The vehicles were observed for over seven months, two hours three days a week. Over that period of time, a total of 16 e-scooters were observed, stopped and interviewed for a minute or two about age,regulation, reason for use, and mode of substitution. Observations were done during 8-10 AM for the first few months, but later switched to 5-7 PM. The university areas showed the most riders (75%). All the 16 users were interrogated about age, reason for use, mode of transport substituted and price. Only the users that could be stopped and interrogated were included in the user analysis.

3.2.1. Model and Technical Specification

The analysis yielded different types and models of e-skateboards that possessed different ranges and max speeds. Most of these boards were imported and there are no local manufacturers or retailers of these boards except Yuneec which sells locally in the Netherlands. The list of different models are listed below in Table 3.2.

Table 3.2: List of different models with range and max speed

Type of e-skate	Range (km)	Max Speed User (km/hr)
Kooboard Gen 1	7	22
Boosted 1st Gen	17	20
Boosted Mini	9	18
Backfire G2S	21	27
Yuneec E-GO 2	27	27
Razor X1	8	13
Wowgo 2S	18	35
Meepo V3	27	40
Backfire G2T	20	28
Backfire Ranger X1	26	35
Kooboard Gen 2	12	35
Enertion Raptor 2	35	45
Boosted Mini S	12	27
Boosted Stealth	18	35
Mellow Surfer	12	37

3.2.2. Age Demographic

The 16 users were interviewed about various aspects, firstly, their age. The age demographic of the respondents was found to be concentrated in the 20 - 30 but the spread can be found in Fig 3.7. The average age was found to be 26.

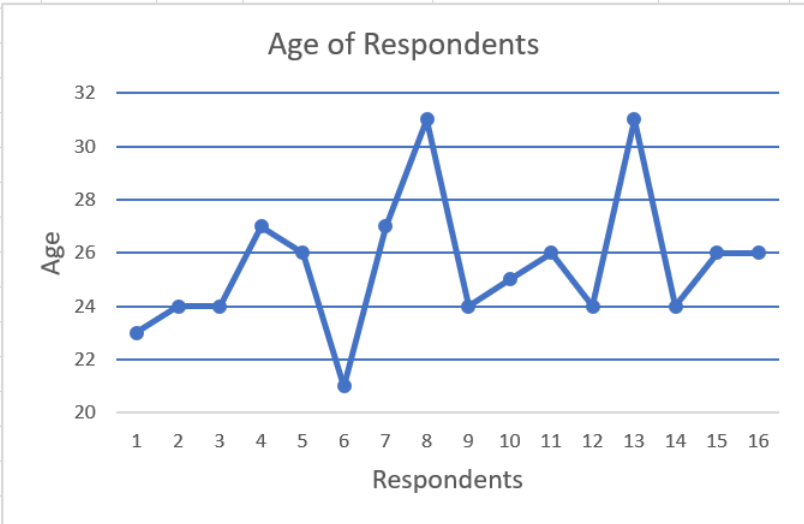


Figure 3.7: Age Demographic of e-skateboarders

3.2.3. Pricing Distribution

The price of different e-skateboards observed is seen in Fig 3.8. The prices were based on electrical specifications, quality and region of export. These parameters also govern range and max speed of the e-skateboard. Affordable e-skateboards are available below €700.

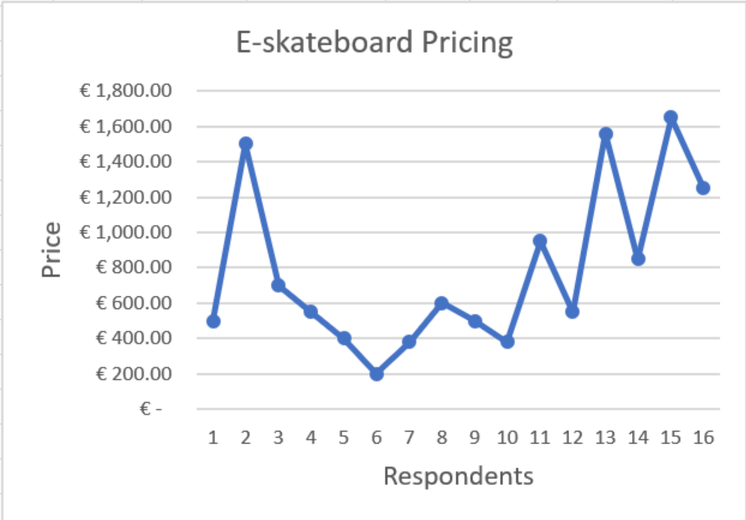


Figure 3.8: Price Distribution of e-skateboards

3.2.4. Reason for use

The reason for use of e-skateboards was also questioned in the interview. This also helped understand the age of users. The different reasons for use of the 16 users is observed in Fig 3.9. 62% were found to be students and they used it for university and for general recreation.

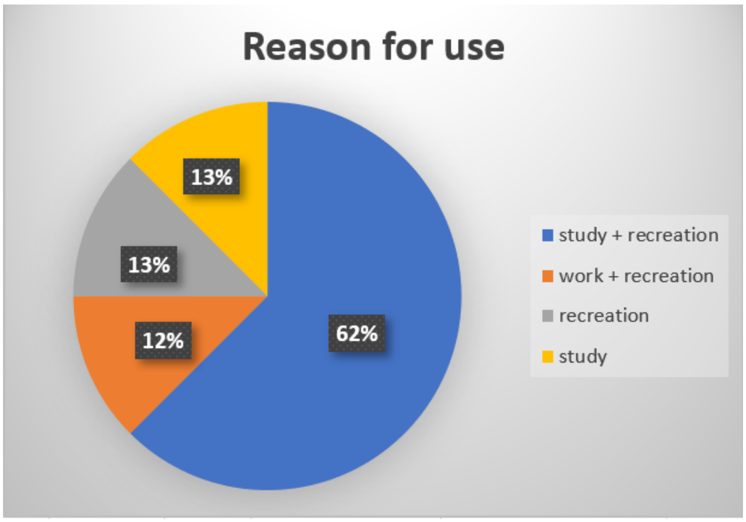


Figure 3.9: Reason for Use of e-skateboards

3.2.5. Mode of Transport Substituted

The mode of transport substituted by the 16 users of e-skateboards is observed in Fig 3.10. 81% of users substituted biking and 13% substituted the combination of car and bike journeys by being able to afford more expensive, higher range models.

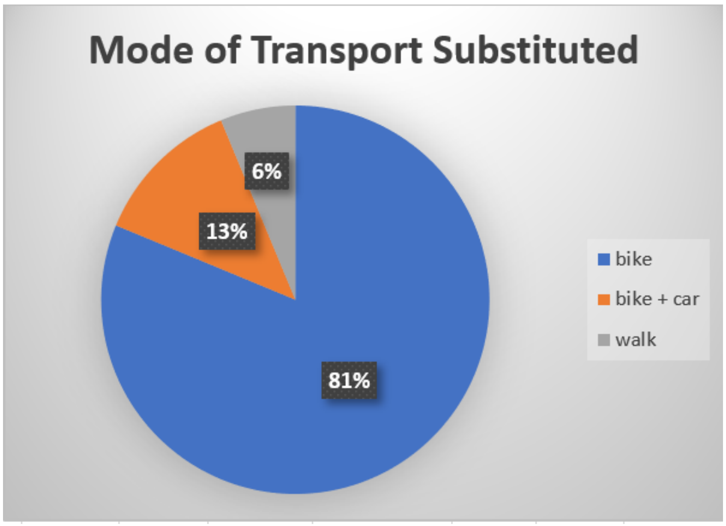
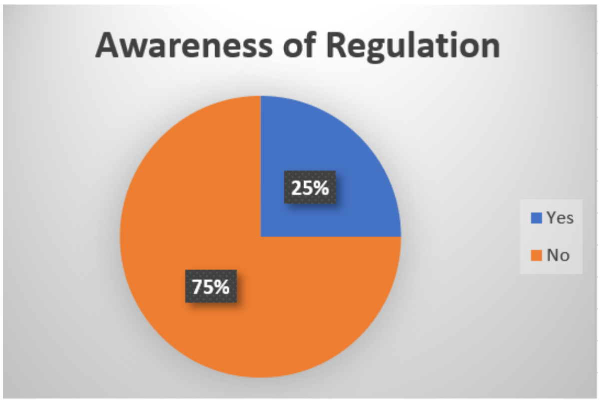


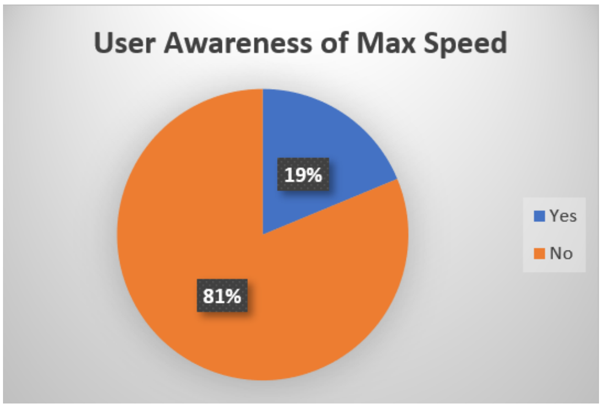
Figure 3.10: Mode of Transport Substituted

3.2.6. User Awareness of Regulation

The user awareness of regulation was the main reason for stopping users and conducting interviews. The 16 users were questioned about this and the results are observed in Fig 3.11a and 3.11b. 75% of users had no knowledge of mEV policies and 81% had no knowledge of the 25 km/hr speed limit.



(a) User Awareness of Regulation



(b) User Awareness of Top Speed

3.3. Electric Bikes

Electric bikes have become very common in the Netherlands due to their already existing biking culture that spanned decades and proper biking lane infrastructure. This prompted a quick and easy transition to electric bikes although prices are still very steep and age demographic is much older. The bikes were also observed for over seven months, two hours three days a week. Over that period of time, a total of 31 e-bikes were observed, stopped and interviewed for a minute or two about age,their acceptance of newer mEVs, reason for use, and mode of substitution. Observations were done during 8-10 AM for the first few months, but later switched to 5-7 PM. The evenings showed better results. It is important to note that most time spent on observation were focused on the newer mEVs and hence not many e-bikes were stopped. The analysis yielded 31 e-bike riders that could be successfully stopped and interrogated.

3.3.1. Model and Type

The user analysis yielded different brands of e-bikes from various companies and the breakdown is seen in Fig 3.12. Out of 31 riders found, 39% were from Gazelle but Koga, Batavus and Cortina also had a big presence. These companies have been there for a long time and their experience puts them ahead with stellar products.

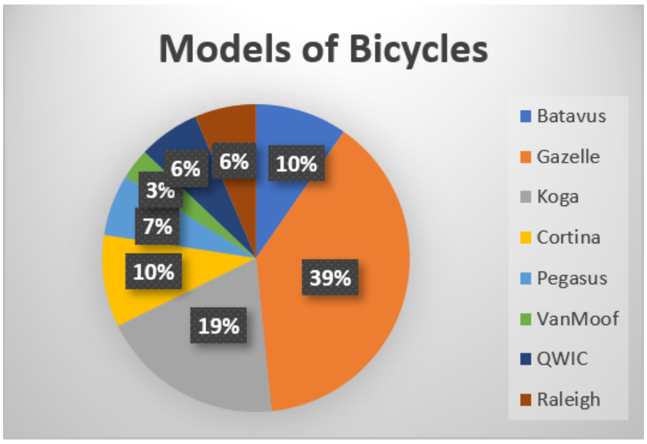


Figure 3.12: Model of e-bikes

3.3.2. Technical Specifications

The battery capacity, average range and max speed were investigated in the user analysis. The battery capacity range of the 31 e-bikes is observed in Fig 3.13. The majority of them have either the 400 Wh or the 500 Wh version with an average range of 80 - 100 kms.

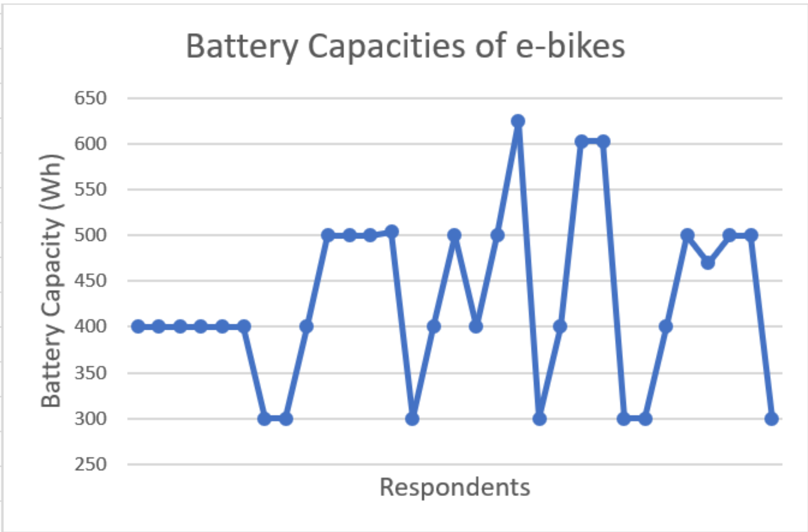


Figure 3.13: Battery Capacities of e-bikes

Average Max speed was found to be 25 km/hr. *Important thing to note here is that most of these vehicles are electrically limited to 25 km/hr by the manufacturer which helps in implementing regulation and safety.* But some startups and newer companies do not have the electric limiter which can have dire consequences on road safety which will be discussed further in Chapter 5.

3.3.3. Reason for Use

The reason for use of e-bikes was observed as well which logically connects with both the age and cost of e-bikes. The different reasons for use of the 31 riders is observed in Fig 3.14. 90% of riders used it for recreation and the rest used it for work. The high price and health aspects attached to e-bikes makes it an attractive opportunity for the older demographic as was indicated with conversations with the users.

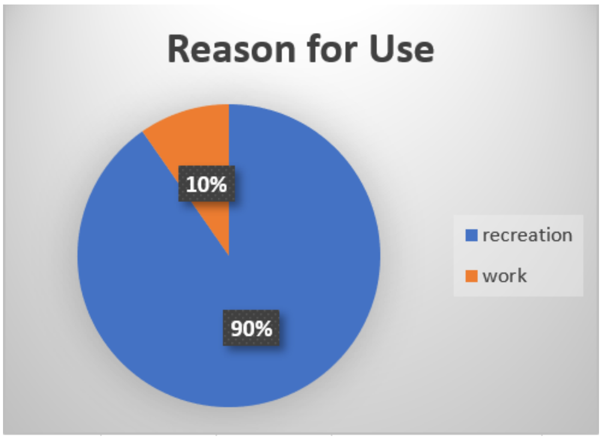


Figure 3.14: Reason for Use of e-bikes

3.3.4. Mode of Transport Substituted

The mode of transport substituted for the e-bike can be observed in Fig 3.15. Out of the 31 riders, 87% of them substituted biking.

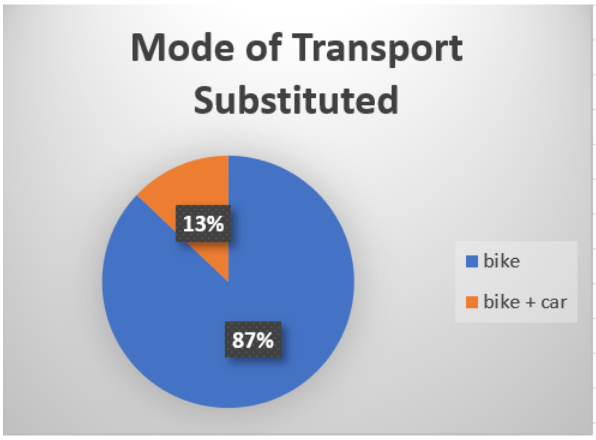


Figure 3.15: Mode of Transport Substituted

3.3.5. Age Demographic

The age demographic of the 31 respondents was questioned in the interview and was found to be concentrated in the 60 - 70 but the spread can be found in Fig 3.16.

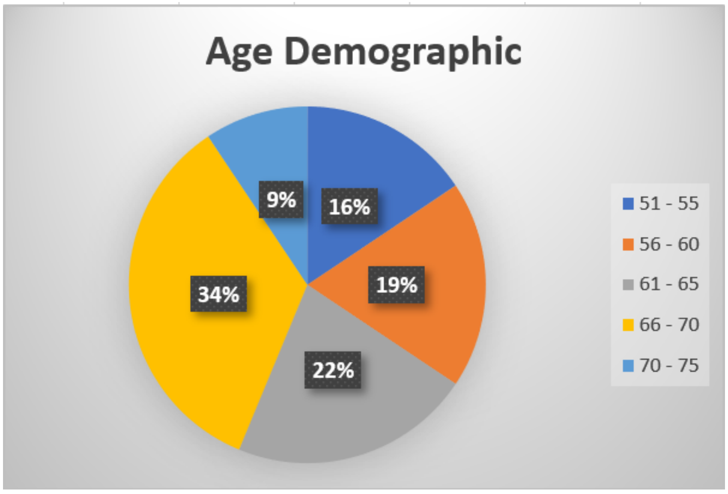


Figure 3.16: Age Demographic of respondents

3.3.6. Pricing Distribution

The price of different e-bikes can be seen in Fig 3.17. The interview process with the 31 riders did not yield all the prices since some of them did not know the technical specifications or the price by memory. Those details were fulfilled with desk research and online surfing. The prices are based on company, technical specifications and power capacity of the battery. The prices were found to be very steep in comparison to the other mEVs.

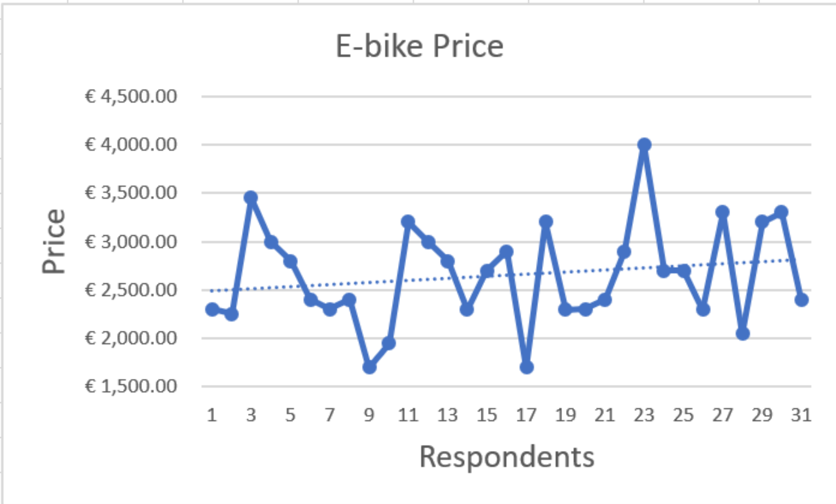


Figure 3.17: Price Distribution of e-bikes

3.3.7. Social Acceptance of New Technologies

Understanding the lack of regulatory road-blocks and the age demographic of e-bike users due to cost, it was integral to understand what e-bike users felt about the other mEVs that are very new to bike pathways, faster and sometime annoying. The 31 respondents had different responses, majority were unhappy (55%) with the new technologies that go too fast, some neutral (35%), and very few happy (10%) with the innovation in the mobility market. The results are observed in Fig 3.18. This proved that the older demographic did not appreciate the new, innovative faster moving mEVs due to more overtaking, less safety and irresponsible riders.

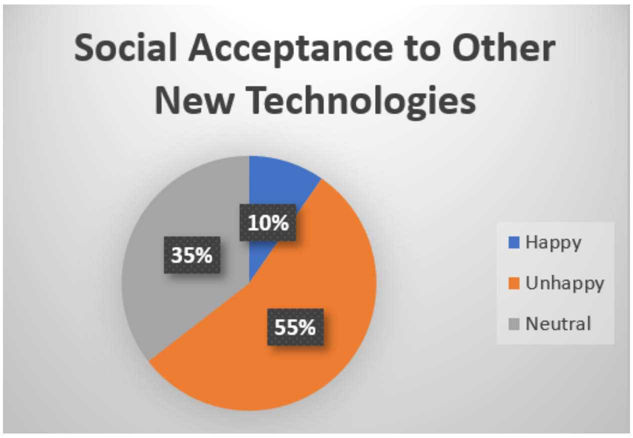


Figure 3.18: Opinion of 60+ years e-bikers on newer mEVs in bike pathways.

3.4. Chapter Summary

The following data was collected to correlate price, age, technology with the micro-mobility market in the Netherlands. The size of the market was found to be small due to a lack of regulatory structure and lack of knowledge. Out of the 31 e-bikes, 34 e-scooters and 16 e-skateboards interviewed, the following results were summarised and the conclusions were made.

Summary of Data Collected

- *E-scooters*

  1. Majority consumption by a much younger demographic (25 - 28). *Although this number covered a very small part of the market. Interview data showed the market coverage extends till 40. They come from bigger cities I did not observe such as Amsterdam, Eindhoven, Rotterdam since these cities are bigger in space and have larger spaces and infrastructure for such vehicles.*
  2. It substituted biking (73%), walking, car and public transport.
  3. Majority of users (82%) have no knowledge of regulation and safety concerns.
  4. They are low powered (250 - 300 W) and do not travel above 25 km/hr.
  5. The Ninebot and Xiaomi are the major manufacturers of this product and make up a majority (47% each) of the market in the Netherlands. Ninebot ES1, ES1 and Xioami M365 were the three models that comprised of 94% of the vehicles observed.
  6. Costs between €200 and €600.

- *E-skateboards*

  1. Many startups have taken up this market space but Boosted from America is the most famous and established brand worldwide.
  2. The size of the batteries can vary and much larger ranges and speeds can be achieved with larger batteries and more power.
  3. The age demographic of the majority of users was found to be 20 - 30.
  4. The prices were found to be between €200 and €3000 but the average was found to €700.
  5. It was used for study (62%), recreation and work.
  6. It substituted biking (80%), walking and car.
  7. Majority (around 80%) of the users were unaware of regulation and legal top speed.

- *E-bikes*

1. They make up a relatively small size of the market worldwide but on the flipside, make up a huge part of the market in the Netherlands. As mentioned earlier, they are common and well established.
2. Multiple companies have broken into this space including the established older bike companies and new startups. The market is big and there are many players.
3. The bikes are sold with battery capacities ranging from 300 to 650 Wh.
4. They were bought and used mostly for recreation by a very much older concentrated demographic (60 - 70).
5. It substituted biking (87%) and car.
6. E-bikes are really expensive and cost €2750 on average.
7. This older demographic were mostly unhappy with the newer mEVs ridden by youngsters on the road (55%).

Micro-mobility is about hype, they are novel and they attract a very young demographic. Only e-bikes since they are essentially not new products but bikes, have attracted a much older demographic due to a higher pricing curve. As mentioned earlier, biking is very established and will continue to have stable growth in the e-bike segment. An important point to note here is that around 55% e-bike riders were disapproving of newer mEVs in the bike pathways for reasons relating to high speed overtaking, noise and increased anxiety. This is important to note here since these vehicles have yet to establish a good reputation for being safe, regular mobility vehicles. This also proves that the probability of people older than 40 trying new mEVs is very low.
E-scooters and e-skateboards were used by a younger demographic (20 - 35), majority being students. The prices are affordable depending on range and quality and definitely cheaper than e-bikes. Younger users has safety implications since inexperience and aggression is common and the number of accidents are higher with younger users. Additionally, these vehicles are new, innovative designs which need some experience or practice before constant or frequent use. These vehicles in all three cases substituted biking the most which is important to understand. The battery technology needs improvements before these vehicles attain better speeds, range and durability so that in time, they do replace car trips and have an impact for distances > 10 km. Till such a time, these vehicles will continue to replace biking in a majority of the cases. In the Netherlands, all mEVs replacing biking implied that there will be a lot of pressure on the bike pathways which influences transport resistance and flow of traffic. The increased speed differences between vehicles are a cause of concern and will need further investigation. Interestingly, all 34 e-scooters and 16 e-skateboards interviewed were illegal users and around 80% of users were unaware of regulation and speed limits which is problematic at the moment. These vehicles are still road-illegal but uptake still continues and not many vehicles/users are confiscated or penalised. Awareness of regulation and safety nets for use of mEVs are primal to its stable implementation. Hence, there is a necessity to spread awareness of regulation to users in the Netherlands.
In conclusion, factors like age, reason for use, mode of transport substituted influence transport resistance and will have implications in bike pathways as reflected in the transport theory discussed in 1.5. Micro-mobility market when implemented in the Netherlands will only be used in bike lanes and hence traffic flow and speed differences will be a growing concern.

4
Business Case

This chapter briefly discusses business case of electric mobility and cost of different modes of implementation.

The mEV industry is growing by leaps and bounds and in less than half a decade, $5.7B have been invested in this space, although more than 85% targeted China since most of these vehicles are manufactured there. Interesting point to note is that the market has attracted a good, loyal customer base and the growth has been three times faster than ride-hailing or car-sharing. The reason for fast paced growth can be attributed to the *ease of scaling up mEVs.* McKinsey forecasted the market to grow to somewhere between $300B to $500B by 2030 considering the USA, European Union and China as seen in Fig 4.1. [10]

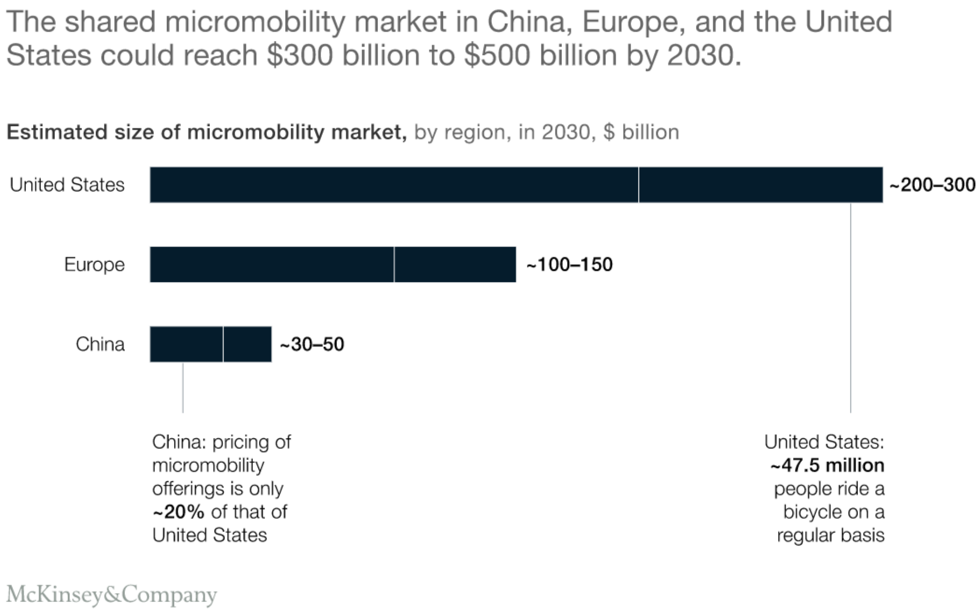


Figure 4.1: Future Forecast of Micro-Mobility market growth by 2030 [10]

4.1. Private Ownership

In the private ownership segment, pricing is still high since the technology is nascent, and affordability is still an issue and prices would come down eventually with better technological developments in batteries. Since the market is relatively new, even options or avenues for repair/maintenance are low and depend on the user. So the analysis carried out in Chapter 3 encompassed early adopters. The cost range of these mobility products and affordability is still a big question as seen in Table 4.1.

Table 4.1: Price Range of micro-mobility vehicles from User Analysis

Vehicle Type	Price Range (€)	Age
E-scooters	200 - 600	25 - 40
E-bikes	1300-6000	55-70
E-skateboards	300-2700	20-35
E-unicycle	600-2700	20-35

A combination of *affordability, lack of regulation and safety concerns* cast a shadow on private ownership in the Netherlands. The country will not see a change in the user landscape until one or all of the factors are explored and improvised. With more design iterations, bigger market expansion, and higher quality of products and spare parts, the private side of this market is bound to take a slow pace unless policy shifts, cost affordability and safety converge quicker than expected.

4.2. Ride-Sharing

Fleet-sharing system is a great way for locals or users to use these vehicles short term and pay a small fee for rentals (1$ + 0.15c/min) [46]. This makes it easier for users, especially those who cannot afford these devices privately and also looking for new innovative methods to traverse short distances inside urban centres.

Ride-sharing is actually financially unsustainable and if the business continues in a similar fashion, it is possible for that these scooters will end up in a mass graveyard like like in China as seen in Fig 4.2 [47].

Figure 4.2: Ride-share bikes oversupply leads to a mass graveyard

So it boils down to unit economics, which connects lifespan of these scooters which from past experiences has been abysmal. The ability to make profit depends on this unit economics, i.e, the durability of the scooter and how many rides it can cover in its lifetime in comparison to the production costs of each scooter [12]. The major reasons that influence profitability are [48]:

- Durability of the scooter, which depends on quality of materials. Better technology means sturdier bikes and longer life.
- Usage rate of these scooters which from past experiences have been seasonal.
- Battery Performance of these scooters which depends on current battery technologies.

The unit economics of e-scooters is seen in Fig 4.3. The costs mentioned in the figure reflect costs in developed countries. Hence, operating costs should decrease and profit per scooter will increase in developing economies,for example, Latin America and India [9]. In conclusion, these ride-share companies are currently not profitable, but have to make quick changes to technology,safety, durability in order to achieve long-term profitability goals.

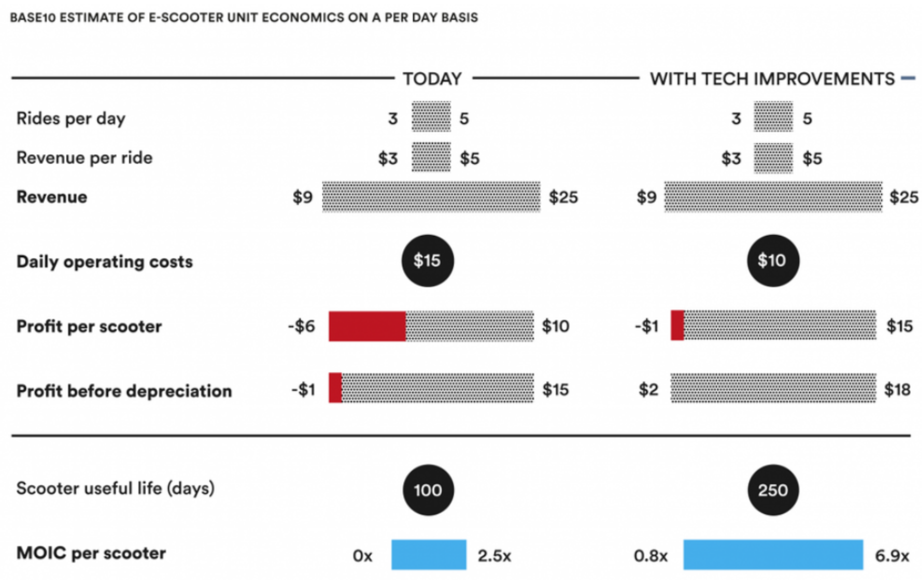


Figure 4.3: Unit Economics and how e-scooters generate money [9]

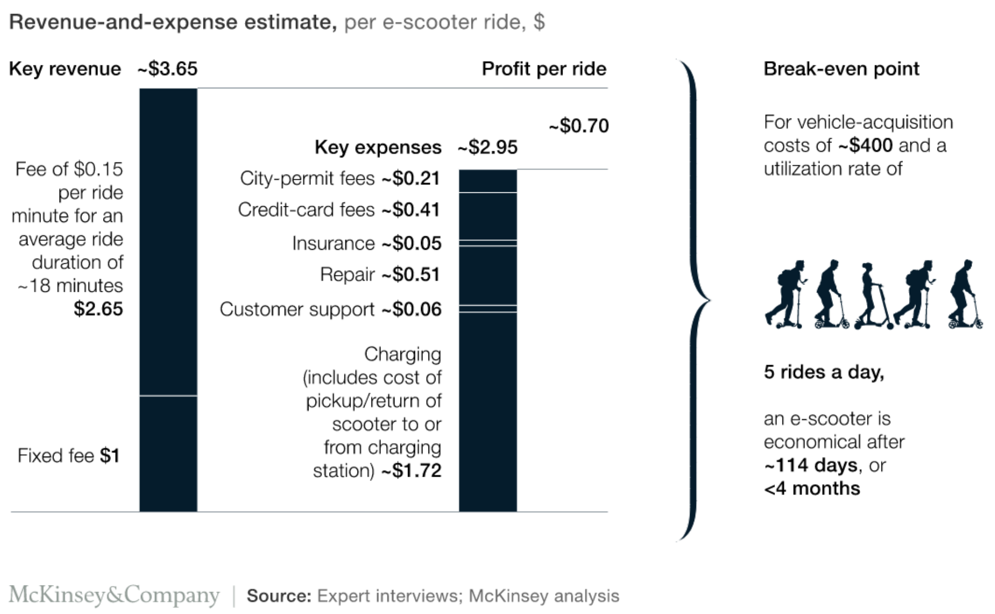


Figure 4.4: Economic Analysis of e-scooter [10]

Fig 4.4 shows approximate e-scooter economics by McKinsey and Company in $. *Their study estimated break-even period in less than 4 months.*

As observed in Fig 4.3, current day numbers show a maximum of 2.5x MOIC (Multiple on Invested Capital) considering rides per day, revenue per ride, profit per scooter and daily operating costs. Current technological standards limit the numbers but assuming innovation and design iterations, profitability can go up-to 6.9x MOIC through increased profit per scooter, lower maintenance costs and higher durability of vehicles. McKinsey projected current technologies in e-scooters creates a lifetime of 4 months but this can be improved over time to increase profits. These developments depend on fleet size in the that city, current city permit charges, technological advancements and societal acceptance to the product(keeping in mind, hooliganism and vandalism).

The average business case of one e-scooter in current day involves the following parameters [9]:

- **No. of Rides:** Four to Five rides a day.
- **Vehicle Acquisition Costs:** $400 for one e-scooter
- **Variables:** Total expenses is *$2.95*.
  - City-permit fees *$0.21*.
  - Credit-card fees *$0.41*.
  - Insurance *$0.05*.
  - Repair *$0.51*.
  - Customer support *$0.06*
  - Charging cost *$1.72*
- **Ride Duration:** Average ride is 18 mins and the ride costs *$3.65*.
- **Profit per ride** is *$0.70*.
- **Break-even point** is around 114 days or around 4 months.

The most important variables that can be tweaked to attain a better net profit are :

- Charging Cost
- Durability of Scooter

The number of rides is also essential to the success of the business case. This can change based on seasons, weather, space constraints, road infrastructure and social acceptance. The release in California boosted both Lime and Lyft to the top just by sheer number of rides established in quick succession as seen in Fig 4.5. Hence uptake of these new technologies is not a factor to be worried about since consumers are always interested in trying something new, innovative but safe.

4.2.1. Enhancements to current business Model

Ride-share companies like Bird are venturing into new territory to create multiple revenue streams since their business is currently burning cash in lieu of market share [49]. In response to bad business, they have initiated two new ways to bring in more funds [50].

- Launching a newer version to their product and selling it online for *$1299*. Apart from much better specifications, single ownership guarantees longer lifetimes. **This alternative is private ownership but listed in this chapter since the company is a ride-share company traditionally and there are not many companies who are participating in both spaces.**
- Bird has also launched monthly rentals as a way around government regulations. Monthly rentals are priced at *$24.99 (€22.39) in San Francisco and $38.54 (€34.99) in Barcelona.*

The first approach is moving into private ownership whereas the second approach is a second attempt at longer rental concept. These ideas are still new and premature and hence remains to be seen how these new services will impact the company's business model.

4.2.2. Options to Increase Profitability

Currently, the only way to charge these vehicles is to pick them up at the end of their charge cycle in trucks/vans(which run on fuel) and bring them to the charging centre. *This process is called juicing and the personnel are called juicers.* After charging, the vehicles are released back to the street. As seen in the previous calculation, charging cost is the highest variable cost. Innovation in this segment of the business model is necessary to drive in more business but also make it more green since juicing creates most of the CO_2 emissions. Companies need to innovate, promote competition which will in turn bring in more innovation into shared micro-mobility. There are many ways to reduce charging cost:

- Increased battery life and/or interchangeable rechargeable batteries , which will significantly reduce the cost of juicers. (Interchangeable batteries will help reduce juicing costs.)
- Sturdier e-scooters with better materials, efficient construction, and larger wheels which will increase e-scooter life by a factor of 2x or more.

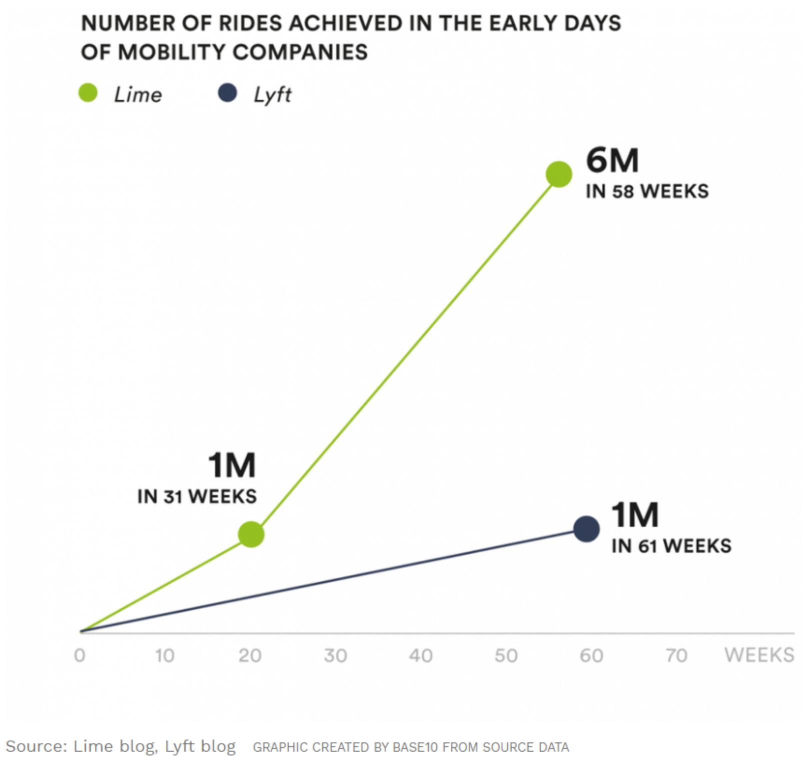


Figure 4.5: E-scooter uptake graph as seen in USA in year 2018 [9]

According to Assaf Biderman, Founder of Superpedestrian and Associate Direction of MIT Senseable City Laboratory, their company has produced scooters with AI based software to extend its lives. He projects this would increase the lifespan from 1-4 months to 9-18 months which is huge shift in the right direction. Additionally, he projects the battery would last 3-7 days [51]. This is exactly the innovation that is required to trickle down more changes to the product development process. This in turn yields better products long term purely by iteration.

4.3. Chapter Summary

This chapter explored different ways to implement and use mEVs through both ownership and ride-sharing methods and the following was concluded.
As seen in Chapter 3, the private ownership segment of mEVs was investigated in the Netherlands. The e-scooters were the most disruptive and also the cheapest mEVs considering standard specifications of 15 km range on a single charge. Cost of product, and cost of travel is a very important aspect of

transport resistance as mentioned in section 1.5. GTC is a very important part of transport resistance and the costs of implementing of using mEVs will determine future uptake. Considering travel costs over long-term, buying a mEV privately will be more cost-effective. But since these products are new and regulatory barriers still exist, the sales of these vehicles is very low in the Netherlands.

On the contrary, the ride-sharing segment is very different and the business case is more complicated. Implementing mEVs in a ride-share capacity involves *unit economics* of the vehicle which depend on the durability of the scooter and the charging costs (Juicing). Juicing, which is the process of picking up, recharging and dropping off the scooters in the city. Current durability standards projected a break even period of 4 months which is very low and not profitable. Most ride-share companies function on a loss in order to implement and provide cheap mobility services to citizens. Current MOIC is 2.5x and technological improvements and design iterations to provide better sturdier scooters will elevate it to 7x. The conclusion is that these vehicles can be implemented in both private ownership and ride-share segments. In the Netherlands, due to regulatory barriers, none of these mEVs have been implemented in a ride-share capacity which leaves only the private ownership route at this moment in time. These vehicles have seen a good uptake when launched in other countries and hence uptake in the Netherlands, when implemented, will be good.

5

Safety and Policy

This chapter explored the safety and policy side of mEVs. It discusses the current state of the market in different countries and their failures to provide context to what can happen in the Netherlands. The safety and policy aspects go hand in hand as it becomes harder to implement safety standards in the absence of concrete policy and regulations. The transport policies in the Netherlands are discussed with their respective downsides. Further, environmental effects are analyzed and finally conclusions are drawn and recommendations are provided in the following chapters.

Safety has been a very important issue that has influenced the growth of the micro-mobility market. These vehicles are new, attractive, but lack long-term research and evidence of good safety standards. According to ***B***, "the advent of e-scooters and e-bikes has brought with it many downsides of which, safety has been the most primal concern." The transition to electric vehicles and subsequent bans on gasoline two-wheelers has in turn increased sales and penetration of short distance urban mobility vehicles [52]. E-scooters uptake were attributed to multiple reasons ranging from convenience, climate conscience, cheap, and pleasure [53][54]. The transition to e-scooters, both through fleet sharing and private ownership, have caused numerous injuries from paralysis to death[55][56]. This section elaborated on safety concerns observed all over the globe over the last decade and circumstances that drew the attention of the policy-makers. Although e-bike safety is an issue of its own, e-scooter safety has been the most significant roadblock in recent times and this section would deal specifically with **e-scooter related injuries** across the world to provide context. In addition, regulatory responses in each location to safety concerns were also discussed. This chapter used data provided from interviews with experts. All experts interviewed in order to attain information are listed in Table 5.1. **The statements in this discussion will be attached to the experts and each statement will be quoted and preceded by their assigned Letter.**

Table 5.1: Interviewed experts and their function and expertise

#	Expert	Function and Expertise
A	Sven Mittertreiner	Policy Advisor, Urban Development at the Municipality of the Hague
B	Robbert Verweij	Senior Policy Advisor, Ministry of Infrastructure and Water Management
C	Yun Chen (Fred) Chang	Product Marketing Manager, Segway Ninebot

5.1. Lessons from Abroad

5.1.1. San Francisco

The advent of e-scooters began in California which is the Technology and Entrepreneurship capital of the world. Conventionally, since all companies are headquartered there, San Francisco and other cities in California are the quintessential testing grounds for all new innovative products. The scooter culture grew very big in Santa Monica, a tiny locality in LA where the culture of scooters, skateboards is very big. A list of significant accidents that happened over the year 2018 is seen in Table 5.2.

Table 5.2: List of injuries suffered in California in 2018

Date	Location	Reason	Injury	Injury to Rider/Pedestrian
July 18, 2018	Los Angeles, CA	Break Failure	Face Concussion and Laceration	Rider
July 3, 2018	Santa Monica, CA	Lack of Rider Knowledge	Eight Broken Teeth, Lip Laceration	Rider
June 11, 2018	San Diego, CA	Lack of Rider Knowledge	Six Fractured Ribs, Collapsed Lung	Rider
June 9, 2018	Santa Monica, CA	Break Failure	Torn ACL meniscus in Knee	Pedestrian
May 18, 2018	Santa Monica, CA	Break Failure	Head Impact, Fractured Clavicle	Pedestrian
May 15, 2018	Southern California	Break Failure	Dislocation of Left Ankle, Fibula Fracture	Rider
March 15, 2018	Santa Monica, CA	Lack of Rider Knowledge	Fractured Arm	Pedestrian
February 21, 2018	Westwood, CA	Broken Handlebar	Broken Teeth	Rider

Also the UCLA Medical Centre reported 249 scooter related injuries starting September 2017 [57]. The results showed:

- 11% were under the age of 18 which is against company regulations.
- Majority were injured by falling.
- 11% hit something (stationary object).
- 8.8% were hit by a car or a moving object.
- 21 people were hit by a scooter, fell over a parked scooter, or hurt themselves trying to lift one [58].

A study conducted by the Centers for Disease Control and Prevention (CDC) in Austin, Texas concluded the following [59]:

- 271 scooter-related injuries between September 5 and November 30 of 2018.
- **20 individuals injured per 100,000 e-scooter trips** in that three month period.
- 50% of injured riders sustained head injuries. 15% sustained traumatic brain injuries.
- Only one out of every 190 injured scooter riders was wearing a helmet.*(Lack of helmet a big concerning factor here)*

These studies and reports prove that safety is a concern and the stakeholders have to do a better job of creating a safer ecosystem, provide resources and knowledge on rider safety and riding instructions, ensure safety gear is a minimum requirement legally to prevent or reduce damage to riders.

5.1.2. Paris

Safety has been a huge issue in Paris and e-scooters have been in the news frequently for injury related concerns. The injuries range from being paralysis to actual death in many cases [60]. The media attention went big after a career ending wrist injury to a Philharmonic pianist who was hit by an e-scooter rider. A mother with her seven-week-old baby strapped to her chest fell to the ground after a man riding on an e-scooter collided into them. In another incident, a e-scooter rider killed an octogenarian after speeding through a red light [61]. The third death caused was an e-scooter collision with a motorbike on a French Motorway where these scooters are actually banned [62]. The injuries mentioned were not only limited to mobile circumstances but also parked e-scooters on pavements. The number of e-scooters is increasing in Paris day by day as there are currently around 20,000 and the number is bound to double. Till date, there have been three deaths and numerous injuries to prove the fatal impact of these e-scooters [63]. These e-scooters were parked all over the place as they are dock-less, leaving pedestrians vulnerable to accidents and also causing a lack of walking space in crowded public areas [64]. The major reasons for accidents were found to be:

1. Brake failures in the scooters, meaning, the technology is still nascent and safety guidelines need to be more stringent.
2. Weak parts, such as stems and fold-able sockets breakdowns have led to a few accidents.
3. No speed limit led to unruly riders which increased the number of collision-related injuries.

4. Lack of safety gear, such as helmets, shin guards, elbow pads, etc, have been the difference between injury and death in many causes. The number of brain related injuries has gone up.

5. Scooter riders' physical vulnerability and the lack of proper education about the integration of scooters into traffic has lead to a lot of pediatric deaths and injuries.

Growing frustration among policy-makers have led to the following consequences, both good and bad:

- Bad
  - Countless scooters have been vandalized and destroyed by general public due to anger and frustration towards these vehicles.
  - Many scooters have even been thrown into the canals and rivers in Paris and clean up services are required.
  - Policy makers are not able to introduce regulatory changes and policy definitions quickly or in time to save these accidents.
- Good
  - Until regulatory barriers are applied, police supervision has been elevated, a speed limit of 20 km/hr and steep fines have been introduced. 35€ for bad parking, 135€ penalty for getting caught on the sidewalk.
  - Till date, more than 1000 tickets have been handed out and over 600 scooters impounded [63].
  - A new surveillance force has been setup to combat scooter related issues.
  - A fee of 50€ has been introduced for the first 499 units and then elevated to 65€ for companies operating more than 3000 scooters.

Even after all these measures being taken, the public seem very skeptical and social acceptance to these technologies is only dwindling with time.

5.1.3. London

The UK also had its fair share of scooter related injuries in its nascent stage of implementation. Two specific incidents brought the this subject national and worldwide attention.

- On July 12, 2019, a famed YouTube star and TV Presenter, Emily Hartridge collided into a truck and died on the scene [65].

- Two days later, a fourteen year old boy suffered serious head injuries after crashing into a bus stop [66].

The important aspect to note here is that these vehicles by law weren't allowed to ply on public streets or pavements but most users flouted the rules. These vehicles can only be used in private land with the permission of the landowner. Following both incidents, the government created a 300£ penalty for using e-scooters.

5.1.4. Oslo

Oslo, a city known for multiple mixes of public transport, bicycling and pedestrians also faced similar circumstances with increasing penetration of micro-mobility devices. Since they ply on the pedestrian walkways, the constant movement irritates and upsets normal pedestrians and the police have taken notice. Electric scooters were categorized as bicycles in April 2018 and this turned out to be a bad move as indicated by the Trygg Traffik [67].

The NTB reported a total of 187 scooter related injuries just over the summer of 2019 and the city council termed the result of unregulated scooter instigated injuries as "**chaos**" [68].

5.1.5. Sweden

The Swedish Transport Agency called a ban on electric scooters from bicycle lanes after a 27 year old man died in a crash [69].

The authorities then passed the following guidelines [70]:

- Maximum engine power is 250W and max speed is 20 km/hr.
- Vehicles above 250W can only be used in Private Property.
- Every e-scooter has to have brakes, bell, front and rear lights and reflectors.
- If rider younger than 15 years, helmet is compulsory.

5.1.6. Germany

On 15 June 2019, Germany approved e-scooters as an official category of vehicles for use with the following conditions [71]:

- The max speed is 20 km/hr.
- The vehicles are not allowed on pavements and in pedestrian pathways.
- The rider minimum age is 14 years.
- The vehicle should have breaks and lights.
- The vehicle needs special insurance.
- However, it is not mandatory to wear a helmet.

Recent news from Berlin reported *74 accidents, 65 drunken driving cases and 233 traffic violations.* [72]

- **Accidents:** 16 serious injuries vs 43 lighter injuries.
- **Cause of Accidents:** 65 accidents caused by scooter drivers. 27 of them were solo accidents. The main causes are ”drunken driving”, driver inattention and use of unauthorised paths.

There were instances of accidents and injuries in Cologne and Munich but they seem isolated and for reasons related to quality of the product and DUI’s [73].

5.1.7. Spain

The only significant incident relating to e-scooters took place in August 2018 when a 92 year old woman died after being run over by an e-scooter. Post the incident, Barcelona and Madrid banned the vehicles from pedestrian zones considering the crowding in the city areas [74].

Although the Spanish Traffic Authority (DGT) is working on a set of national guidelines for e-scooters, there is still no nationwide regulation about their use [69].

5.1.8. Australia

Australia also experienced many accidents involving e-scooters. Most incidents started after the introduction of Lime e-scooters in the country (Brisbane).

Till date, Australia has only recorded one death related to electric scooters. It involved a 50 year old man who suffered head and facial injuries after a fatal crash in South Bank [75].

The accidents caused in general were due to the following reasons [76]:

- Overspeeding
- Riding without a helmet.

Table 5.3: Overview of Safety incidents in different countries with respective regulatory responses till May 2019

Country	Deaths	Injuries	Policy Response (Yes/No)
USA	11	20 per 100,000	No
France	3	170 per day	No
UK	2	200 per day	Yes
Sweden	1	262	Yes
Norway	1	187	No
Germany	2	294	Yes
Spain	1	570	Yes
Australia	2	170	Yes

- Doubling-up,i.e, having two people on the scooter which is extremely dangerous.
- Distractions: Using mobile smart-phone while riding a scooter (this is very common).
- Drugs and Alcohol: Many riders were found to be DUI and hence misbehave with these vehicles and flaunt the rules.

Australian authorities responded with fines and some regulation but face roadblocks with implementation and supervision.Although different territories adopted different regulations based on local experiences and infrastructure, regulations were established in every state in Australia. Steps taken in Brisbane were:

- Fines of $130 for misbehaving riders.
- Helmet is compulsory.
- No carrying passengers.
- Pedestrians get priority over scooter riders.

A study by the Royal Australasian College of Surgeons found the following [77]:

- Users aged between 20 and 34 were responsible for 66% of all injuries.
- Ambulances had to pick up 34% of those injured to the ER and surgery was needed in 10% of all cases.

5.1.9. Summary

The summary of all injuries, deaths and regulatory responses from all countries studied uptil May 2019 is seen in Table 5.3. These consequences caused media attention and eventually escalates to the government and policymakers who in some cases did respond quickly with regulations and in some cases, like the UK, complete bans. Safety is of primal importance and triggered policy responses help regulate and control the pace of growth and implementation and all the experiences in these countries prove that regulation for mEVs is a dire necessity and should be the prime focus of the respective transport body in every country. To reflect from the spaghetti transport theory, safety implications play a huge role in influencing transport resistance, in particular, comfort and ease of using the technology which slowly drives users away from it. Eventually regulatory responses follow and products undergo refinement but as shown in this chapter, there is a lot of collateral damage.

5.2. Policy Analysis

The quick advent of micro-electric mobility devices brought with it a dire need to maintain current applicable policy definitions. The clear lack of regulation and policy in certain locations has brought about loss of resources, damage to public property and human injury as seen in Section 5.1.

5.2.1. Current Policy in the Netherlands

Policy in the Netherlands is still nascent but also depends on the business case or type of implementation. The two ways of using these vehicles are **private ownership and public fleet-sharing.** At this juncture, e-bikes and e-scooters are available (or can be implemented) either privately owned or as a fleet-sharing model but e-skateboards are still very new and will never be implemented in a fleet sharing concept due to safety and complexity reasons. E-scooters in specific are scrutinized by the approval process but e-bikes are not in the Netherlands. *Hence, this chapter would mostly deal with regulatory and business aspects of mEVs. Policy definitions and ramifications are elaborated in this chapter.*

According to the ***B***, "the current policies that involve e-bikes and (or) micro-mobility in general are as per European Regulation Directive No. 168/2013 in Table 5.4. "

Table 5.4: Current Policy Definitions for e-bikes under RDW Regulation [16]

Bike	· E-bike with pedal assistance up to 25 km/h (pedelec)	· Always allowed on cycle path · No speed limit · Helmet not compulsory
Light moped SNORFIETSEN (max. 25 km/h)	· E-bike with pedal assistance over 25 km/h and classed by RDW as light moped (speed and high speed pedelec) · E-bike with electric motor that works without pedelling up to 25 km/h (power-on-demand electric bike)	· Not always on cycle path · Speed limit of 25 km/h · Helmet not compulsory · Moped licence - for this you need to be 16 or older · Blue registration plate · Insurance
Moped BROMFIETSEN (max. 45 km/h)	· E-bike with pedal assistance over 25 km/h and classed by RDW as moped · E-bike with electric motor that works without pedalling and can go faster than 25 km p/h (power-on-demand electric bike)	· Not always on cycle path · Speed limit of 45 km/h · Helmet compulsory · Moped licence - for this you need to be 16 or older · Yellow registration plate · Insurance
Special Moped BIJONDERE BROMFIETSEN (max. 25 km/hr)	· New category added to allow new innovative light and slow vehicles.	· It falls outside the scope of EU 168/2013 · Max Speed 25 km/hr · Cylinder capacity upto 50 cc or electric motor upto 4kW · Most of these vehicles need a saddle and steering assistance in order to receive approval. · Insurance plate and VIN required. · Good lighting is required with red reflectors on the rear and white/yellow on the front.

Snorfietsen and Bromfietsen currently fall under EU Regulation 168/2013 but Bijondere Bromfietsen does not [78].

Some of the vehicles that are currently legal under the Bijondere Bromfiestsen include [79]:

1. Segway
2. Qugo Runner
3. Kickbike Luxury & Kickbike Cruise
4. Zappy3

5. Trikke

The document ***"Beleidsregel aanwijzing bijzondere bromfietsen"*** *(referred to as BABB) was referred to many times and their article numbers were quoted. All images of those articles are attached to Appendix A.*

According to ***A***, "Currently Veeley (foldable seat) and Stigo (foldable e-moped) are examples of approved legal mopeds. The irony here is these products are the least chosen and least used product for specifically the same reason, the saddle. Observing the demographic, most users aged 20-30 choose e-steps or e-skateboards or e-unicycles."

These vehicles are manufactured by small companies that do not have an international presence whereas the vehicles actually elaborated in this thesis are **currently road-illegal**. According to ***C***, "So far no electric scooters can be type approved by RDW since there is no category/type in the Netherlands at the moment. Unlike Germany which just set the new PLEV vehicle type on June 15th this year."

5.2.2. Product type categorising and Max Speed Limit

The lack of a specific policy definition or category for e-scooters, e-skateboards and e-unicycles creates barriers in its implementation and supervision. Lack of user knowledge and absence of regulatory structure were proved to be a big barrier to current growth in the Netherlands. According to ***A***, "these vehicles currently fall under Snorfietsen but most of them exceed the speed limit which makes them illegal, but people still continue to use them. New category called "Bijondere Bromfietsen" was introduced but need more updates and improvisations to keep pace with current technologies." *However, Article 16 of BABB covers speed limits and a physical limiter in the vehicle design as seen in Figure A.3."*

When it comes to speed, according to ***A***, "Although illegal, assuming they are legal, the challenge is speed. From all the vehicle types and brand names mentioned, some of them do have a physical delimiter in their product to limit speeds to less than 25 km/hr which makes them legal and prevents over speeding. But most other companies do not sell their products with delimiters and these products become dangerous to use on the cycle pathways. In these cases, policy definitions become harder and safety ramifications are huge."

5.2.3. Consequences of Speed Differences in Cycle Pathways

There are countless ramifications to the aspect of over-speeding which has been one of the main reasons for accidents in the bicycle pathways. Speed differences in vehicles used on cycle pathways is the number one reason for most accidents involving persons aged above 60 years. They happen because:

- Older people trying new technology. E-bike fatalities are higher than car deaths.

- Differences in speed creates more overtaking which in turn makes older people who ride slowly more vulnerable to accidents and injury.

Additionally, these vehicles are legally bound to 25 km/hr whereas normal race bikes can go up-to 40 km/hr which creates a policy paradox. According to ***A***, "There is a contradiction here and something needs to be done but defining policy in this scenario is difficult. Multiple pathways based on speed are possible in cities where there is space but most cities like Den Haag where there is not much space left for new infrastructure." Additionally, *Article 11 of BABB targeted the safety aspects Article 16 targeted a 25 km/hr limit on speed as seen in Figures A.1 and A.3.*

5.2.4. Sale of Illegal Vehicles

After concluding these vehicles as "illegal", they are still sold in good numbers across the country which seems counterproductive. According to ***A***, "Companies add a disclaimer that states these vehicles can only be used inside public property (or) check local laws for permitted use".
This is verified in Fig 5.1 which depicts Segway's NL website, which is the highest selling e-scooter in the Netherlands.

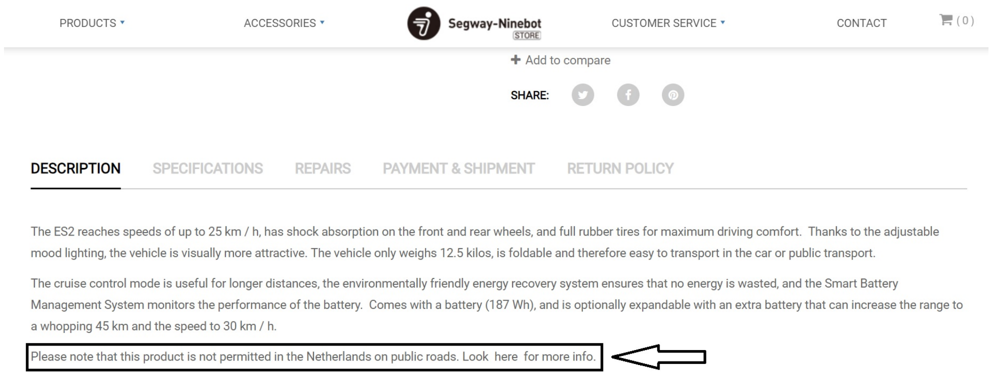


Figure 5.1: Disclaimer on Segway NL website

5.2.5. Procedure for Approval

Companies manufacturing and selling these vehicles need to first receive approval from the Ministry of Infrastructure and Water Management for their product type before they can implement their product on dutch roads legally. If they do not, they need to attach a disclaimer that their vehicle can only be used in Private Property.

- **Private Ownership:** Vehicles bought privately that are still illegal can be made legal through an approval process wit the RDW. The personal vehicles need to be taken to RDW for safety and quality check after which a Insurance Plate is required for the vehicle. This process costs around €120 [11]. The plate registration and the forms is seen in Figures 5.2 and 5.3. Although, this approval step is not official and unknown to most users, the steps to get approval after purchase of vehicle are as follows: ***(None of the 34 e-scooters found in the user analysis knew about this step and none have approved their vehicles for road use)***

    1. Make an appointment with the RDW before entering VIN (approximately €84).
    2. Have the VIN strike at a local inspection station. Vehicle category "moped without license plate".
    3. Request insurance (between €5 and €10 per month).
    4. Fit the insurance plate (approximately €10).

    Article 13 of BABB targeted this aspect of processas seen in Figure A.2.

- **Ride-Sharing:** Companies need to approach the I&W directly for approval of their vehicles before launching them in the Netherlands. Consequently, they need approval from the Municipalities of the cities they intend to launch in. However, the Municipality has the legal right to reject the proposal even after I&W approval.

Article 44c targeted this aspect of the processes seen in Figure A.8.

This marked as evidence to the fact that none of the ride-share companies explained in this thesis have launched in the Netherlands. The only e-scooters, e-skateboards, e-unicycles observed were owned privately and are being used illegally.

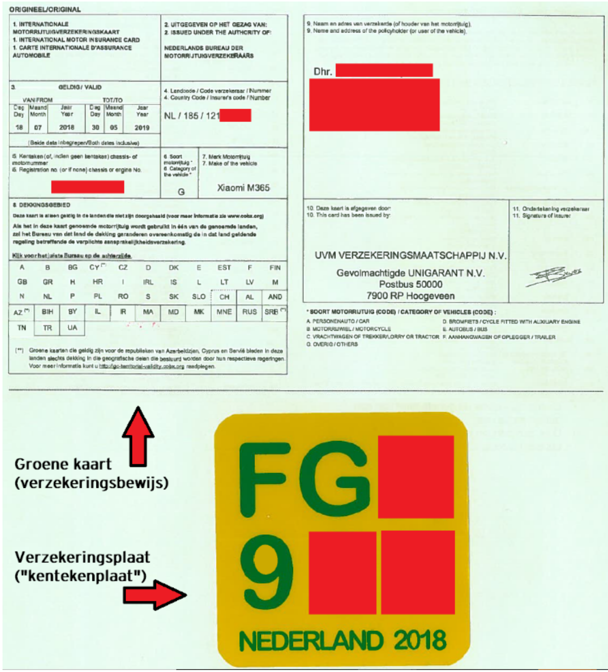


Figure 5.2: Proof of Insurance and License Plate [11]

Figure 5.3: Insurance Plate [11]

5.2.6. Legal Mandate of Municipality

According to ***A***, "The Ministry of I&W controls approvals and once they receive approval, they can approach any municipality for implementation. But on a side note, municipalities do have the legal mandate and power to reject the proposal in their city."
Policy is central to the government and municipalities cannot orchestrate or create their own regulations with respect to these kind of vehicles. However, municipalities can reject proposals from ride-share companies and have the last call.

5.2.7. Reason for Non-Approval

According to ***A***, "The Ministry of I&W believes that a motorized vehicle should have a steering installation or seats in order to be safely operated. This is illogical because there are many safe ways of transportation where no hand-operated steering device is needed, for example, electric mono-cycles are steered with the use of body weight which feels very natural, like walking or running. A hand-operated steering would add nothing in terms of safety."

Hence, in some cases, the generalities of policy definitions do not hold any logical meaning and hence categorization is even more important. It also reinforced the fact that policy definitions in most cases are illogical and antiquated like in the case of Segway and Onewheel as seen in Fig 5.4a and 5.4b.

Article 22, 31a, 31b targeted details about the seat and article 30 targeted steering system as seen in Figures A.4, A.6 and A.7.

(a) OneWheel, innovative one-wheel micro electric vehicle

(b) Segway OneS2, innovative one-wheel micro-electric vehicle

5.3. Chapter Summary

The onset of mEV's have brought multiple downsides to society that have become evident since the start of 2018 when they boomed. The Transport theory stipulates that in the initial stages of a new transport system, there will be safety concerns which will trigger policy and better technology. Safety has been a crucial concern with news from all over the world about accidents and deaths connected to mEV usage. And policy exploration and further, lack of regulation have wreaked havoc in cities across the world and this has raised doubts on the true impact of these vehicles and whether they do more harm than good. In all geographical locations of implementation, ride-share e-scooters, grave safety concerns were recorded and their corresponding triggered policy responses were mentioned. Safety, as mentioned in the transport theory, has an influence on the transport system especially in terms of environment and policy. mEV market was found to be premature and hence, the products launched over the last two years have had multiple disadvantages an downsides which have resulted in multiple deaths and numerous injuries all over the world. Evidence also showed that these incidents and deaths have triggered policy responses in Germany, Sweden, New Zealand and UK. The Transport theory validated and also justified the necessity of policy and regulation to implement such vehicles on the road. From the safety analysis, it can be concluded that mEV technology needs to improve to provide sturdier, longer lasting vehicles. Also, bad behaviour needs to be penalised as inattentive riders, aggression and irresponsible users can increase crash risk and them and others. Another cause of concern is hooliganism and vandalism which was observed in USA which also resulted in pedestrian injuries. This underpinned the fact that for such a market to attain equilibrium, regulatory structures are needed.

The policy and regulatory side of mEVs in the Netherlands is very antiquated and needs revision. The only policy currently governing mopeds is EU Directive 168/2013 dictating rules for both Snorfietsen and Bromfietsen. *"Bijondere Bromfietsen"* was included later to allow certain new vehicle designs but have not been updated since to allocate e-scooters, e-skateboards and other newer mEVs. *This lack of regulatory allocation renders mEVs, especially, e-scooters, e-skateboards and e-unicycles illegal in the Netherlands.* This is slightly problematic since these vehicles continue to be sold online and used illegally on the streets which needs to be addressed by the I&W and the RDW. The Bijondere Bromfietsen rule necessitates a steering system and a seat which renders most new mEVs illegal. E-bikes and e-scooters in most cases are limited physically and electrically to a max speed of 25 km/hr in the Netherlands which makes supervision and regulation easier and also reduces crash risk. E-skateboards and certain newer e-bikes do not come with the speed limiter which makes conformity and supervision a cause of concern. The rise of speed differences in pathways due to better and faster mEVs will have safety implications on bike pathways. The lack of regulatory definitions for these product types and their technical specifications has set a tone for slow pace of growth or no growth in the mEV market in the Netherlands. Additionally, stakeholder relationships are non-existent, with low or zero communication channels between the stakeholders. Evidence clearly pointed a mismatch and disconnect between the Municipality, I&W and companies and the severe lack of market knowledge and data sharing between the stakeholders had left the mEV segment in the Netherlands stagnant. Also, I&W staff did not indicate an inclination or interest towards making mEVs more mainstream and legal in the future.

6
Environmental Effects

This chapter discusses the environmental effects of these vehicles, in specific, e-scooters. Their contribution to energy savings depends on a few factors and those are elaborated on in this chapter.

Micro-electric vehicles have a clean effect on the environment due to the use of batteries which also have lesser noise problems. To make the discussion easier, only e-scooters were discussed in this chapter, both in the private ownership and ride-share approaches.

6.1. Energy Consumption

These e-scooters typically expend very low energy and when operated privately, can show cleaner rides than other modes of transport. A Xiaomi M365 was considered for a 3 km ride (3.2 is the typical average scooter ride).

- Siemens Combino (number 155) tram operated by GVB in Amsterdam requires 1.84 kWh/km, regenerative breaking included. Hence, 3km takes 5520 Wh. Average tram occupancy is 53 passengers although total capacity is 150-160 including seating and standing spaces. Hence 3km x (1840Wh/km)/53 passengers = 104,2 Wh/passenger/3km. [80][81]

- The Xiaomi M365 has a battery of 280 Wh and a max range of 30 km. The range is discounted to 25 km because not all users weigh 60 kg which is their product specification. Hence, 3km x 280 Wh/25km = 33,6 Wh/passenger/3km. [81]

In conclusion, the e-scooter is thrice more energy-efficient than trams. Also, it is 18 times more efficient than the Tesla Model S with 621,9 Wh/passenger/3km. This is important when data revealed that half of all passenger car trips in the Netherlands are shorter than 7.5 km [82]. So keeping limited road space in mind, these numbers can help policymakers make better decisions.

6.2. CO_2 emissions of shared micro-mobility

Ideally, privately owned e-scooters only have a 8g CO_2 emissions per mile (from charging). (In this case, the example is America). However, e-scooters in the Netherlands would produce 4g CO_2 emissions per km since the dutch grid has a lower emission rate due to a better energy mix. (Netherlands 4g CO_2 emissions per km and USA 5 g CO_2 emissions per km for comparison). In order to keep the uniformity of the following information, the data will continue in American units since information was obtained from American sources.

1. Divide the battery capacity by range, hence producing energy consumption per mile.

2. Then multiply the previous output with emissions per watt-hour of the DC grid (approximately 0.622g CO_2 [83] per Wh in the case of USA and 0.418g CO_2 per Wh in Netherlands [84].)

However, The life-cycle global warming impact of shared e-scooters is *202g CO_2 eq/passenger-mile* on average. At this point in time, these are the other modes [85]:

- Car (414g CO_2 per mile)
- Moped (119g CO_2 per mile)
- Bus (82g CO_2 per mile)
- Biking (8g CO_2 per mile)
- Walking (0g CO_2 per mile)

It was ironic to observe that the daily scooter electricity as such does not contribute to the impact but *Juicing* does. [12]

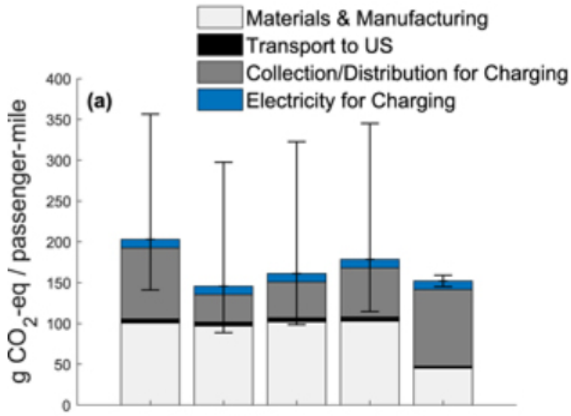


Figure 6.1: LCA of Environmental Impacts for Shared Electric Scooters for [12]

- Manufacturing (50%) (due to high cost of aluminium)
- Daily Collection for charging (43%). (carbon produced by vehicles used by independent contractors to collect and recharge the fleet overnight)

These values were dependent on and highly sensitive to scooter lifetimes which need to be extended in the future as a method to increase net environmental gains. Additionally, electricity for charging and transport from manufacturer are so inferior they hardly play a role.

6.2.1. Consequences of Juicers

Juicing is the process of picking up, recharging, and dropping the scooters after every discharge. This process id done with the help of sub contractors. This recharging process is fulfilled by gasoline vans and trucks which pick these scooters up from across the city and put them back in the hubs. Just the vans used contribute to most of the emissions although the charging of the scooters also contributes a very small share based on the source of the electricity grid. Juicing composes of 43% of the emissions and hence, charging methods need to change and environmental impact can be pushed down.

This is an average calculation from Bird's Data taken from experiences in America so far. Scooters are picked up every night by independent contractors and they have to pick up the scooters and drop them back after recharge. [13]

- In San Francisco, a scooter experienced an average of five times per day with each ride averaging 1.5 miles [86].
- Bird capped the number of scooters per contractor per night at 20. Competition limits each contractor to 5 or lesser. The numbers below are based on scooters in groups of 5, 10, 20 in one car. [87].

- Distances were assumed to be short (2 miles), medium (5 miles) and long (10 miles) as an approximation to aid the math.

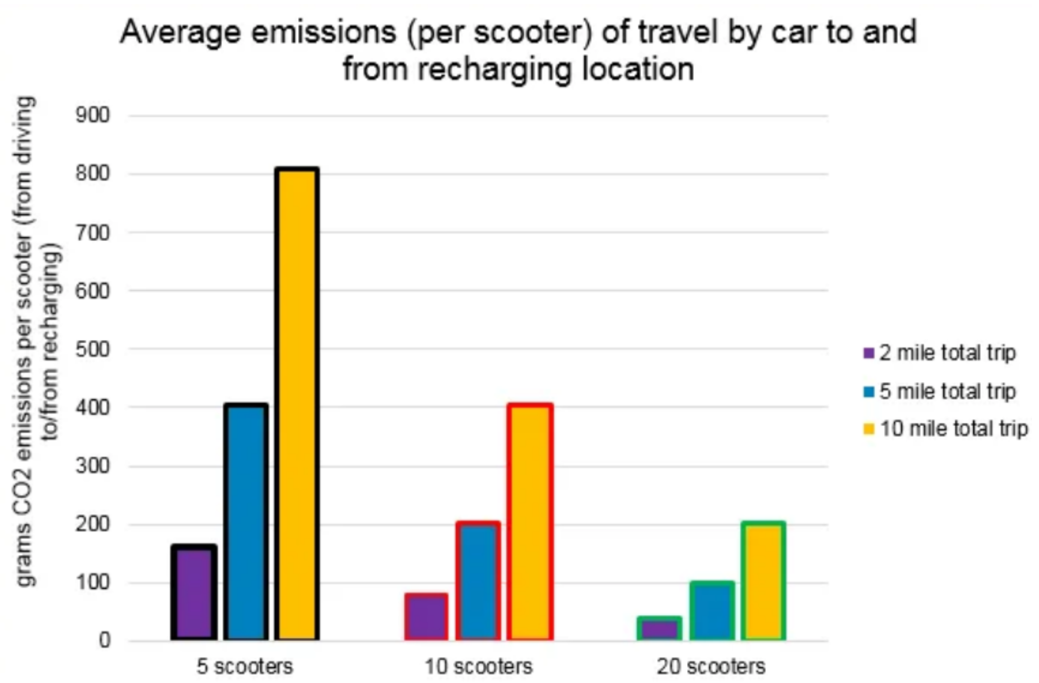


Figure 6.2: Emissions due to Juicing[13]

Table 6.1: 3 Cases and Emissions added in each case [13]

Case	CO2 Emissions added per scooter per day
5 scooters, 10 mile round trip	808 g
10 scooters, 5 mile round trip	202 g
20 scooters, 2 mile round trip	40g

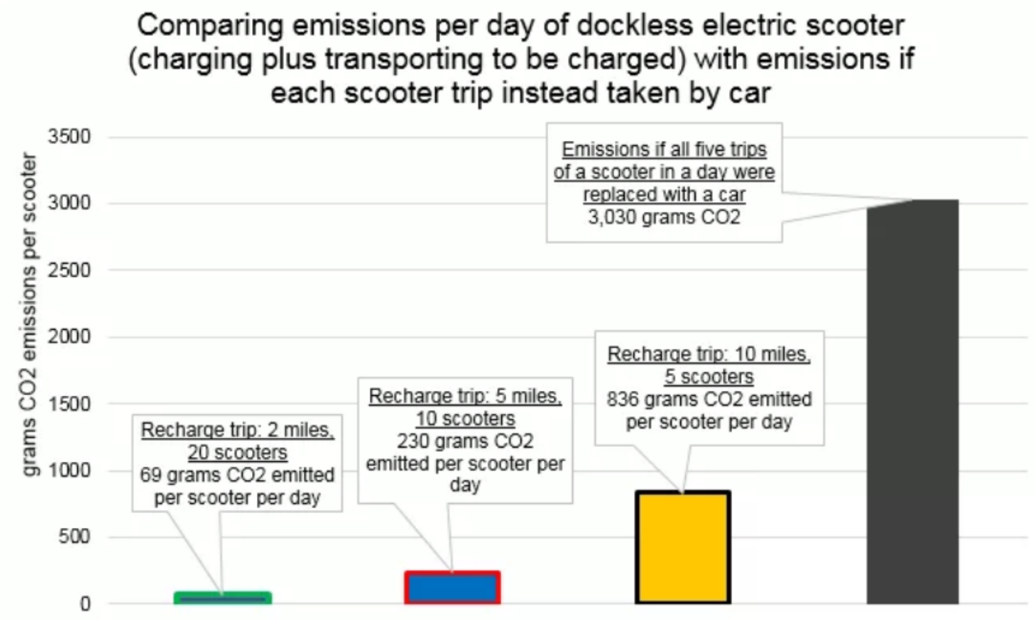


Figure 6.3: Comparing the different cases with a car trip[13]

The Table 6.1 showed the results of emissions added per day per scooter. This reinforced the fact that juicing and how the process is done greatly influences energy implications of shared e-scooters. The aspect to note here was that even considering the variables in juicing, these vehicles have a better impact than if all scooter trips were done in car instead as seen in Figure 6.3.

These vehicles begin to show impact once they replace enough car trips. The study showed that when 27% or more of the trips replaced car trips, the e-scooters began to have an impact.

In the USA, shared micro-mobility had a huge impact as seen in Figure 6.4. *The real question is whether it can have an impact in Europe, a continent that relies more on first/last mile solutions. If this market can target that short distance of 4.66 miles (7.5 km) which marks half of all car trips in the Netherlands [82].*

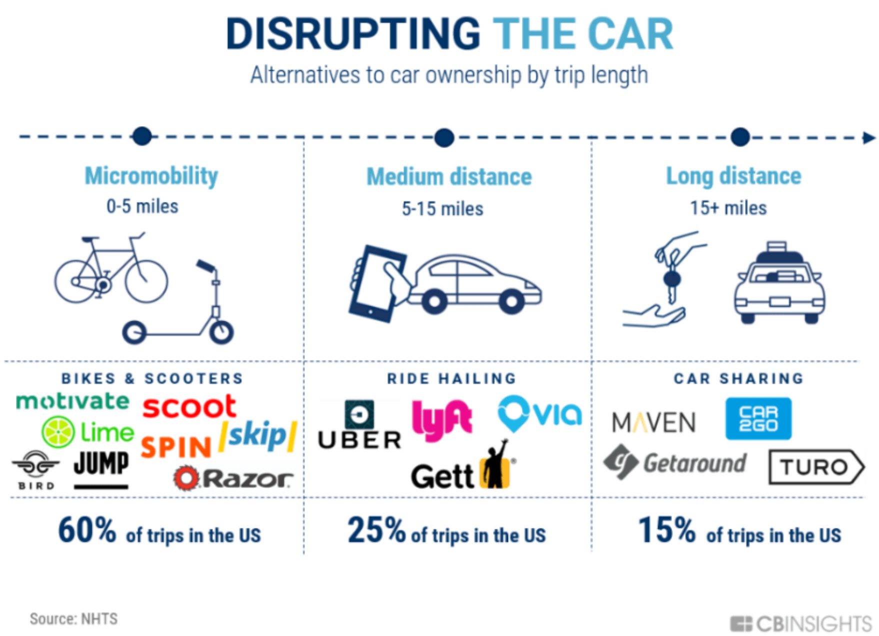


Figure 6.4: Mode of Transport as a function of distance[5]

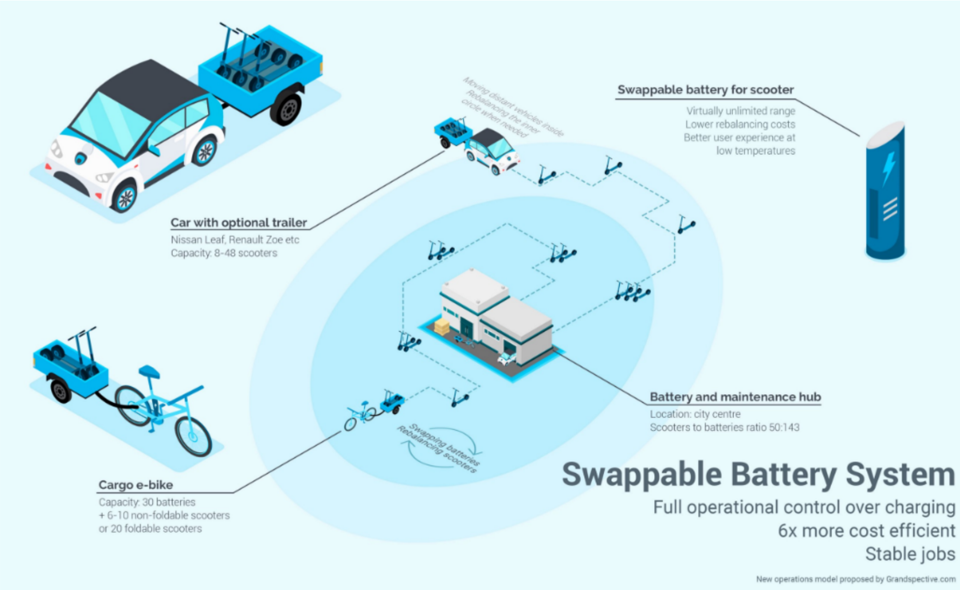


Figure 6.5: Alternative proposal using Swappable Battery System [14]

6.3. Chapter Summary

The environmental effects of these vehicles in a nutshell is very low and can substitute other modes of travel. When owned privately, they consume as much energy as bikes, however, this energy would depend on the source of electricity in the grid which either reduces or increases the CO_2 emissions per mile. When privately owned, e-scooters release about 8g CO_2 emissions per mile (although it depends on source of electricity in the grid). Privately owned mEVs can compete and substitute biking and public transport in terms of environmental impact. Also, private ownership can overcome regulatory barriers and problems caused by implementing a ride-share service and hence buying these vehicles should be encouraged.

On the contrast, ride-sharing ironically is not as environmentally clean due to the process of recharging known as Juicing. Juicing constitutes nearly 43% of CO_2 emissions and due to this aspect, current scooter emissions are roughly 202g CO_2 emissions per mile on average (which is 25 times the value of privately owned scooter). Ride-share companies use gasoline trucks and vans at night to collect, recharge and drop the scooters in the city every morning. Hence Juicing is a big roadblock to actual cleaner implementation of the vehicles. Additionally, scooter lifetimes are a crucial parameter that influences total environmental impacts and hence current generation of scooters are not environmentally clean. Technological improvements in scooter quality will elevate scooter lifetimes which will in turn help in reducing total environmental impact. Newer technology like swappable batteries needs to be explored to make the process cleaner as seen in Figure 6.5. Since the mEV market impacts only 0 - 5 mile mobility market, mEVs will have a net positive effect on the environment if it replaces more than 30% car trips. Better technology will produce higher range vehicles and will help increase the ability to replace car trips. Currently, mEVs are replacing bikes and hence their environmental impact is not necessarily net positive. Keeping Netherlands in mind, policies should encourage users to shift to micro electric vehicles and also reduce car trips by using these vehicles for distances shorter than 10km.

7

Conclusions and Recommendations

This chapter assimilates all the information and data analysed from Chapter 2 to Chapter 6. Conclusions were drawn, recommendations were given and also pitfalls were mentioned.

7.1. Conclusions

This research sheds light on the potential of micro-electric mobility to change the landscape of short distance mobility. Although the status-quo has left a number of questions about its future which will be discussed in the following paragraphs, funding and growth points towards mEVs become more prominent all over the world. The research only investigated personal mEVs and not the cargo segment which is also pushing the boundaries of cleaner logistic goals as indicated in Chapter 3 which addressed what DHL is transforming to electric vehicles for inner city logistics and being the biggest logistics operator in the world, this will have a huge impact on the reduction of GHG emissions. The research also targeted e-scooters in specific since it still is the most disruptive mEV to launch (ride-share and private ownership) and penetrated worldwide. The novelty of this sector pointed to the severe lack of scientific knowledge which acted as a knowledge gap which was addressed by this thesis. The exploratory study is evidence to the knowledge gap and necessitates the need for further research in the domain of mEVs. The lack of depth but more width acted as a consequence of understanding the ecosystem surrounding this novel mode of transport that has disrupted the world over the last three years.

The research aimed at understanding the micro-electric mobility market and the aspects that influence its growth in the world and in turn, lend context to its presence in the Netherlands. Trying to have a helicopter view of the market helped understand the roadblocks to implementation and growth. The research questions were framed in a way to understand the market of mEVs, and all aspects that influence its growth. The spaghetti transport theory was used to understand the outline of a transport system and its ability to disrupt the ecosystem. The theory helped outline the different aspect that nudge the movement towards wider implementation of a new system although the novel and disruptive nature of micro-electric mobility market makes it extremely hard to gauge the perfect future scenarios given the lack of scientific and non-scientific sources that shed light on this domain of vehicles. The research targeted the different type of products, the nature of users, safety and environmental impacts, Policies and Regulatory barriers and the different ways of implementation.

The personal consumer landscape of mEVs included e-scooters, e-skateboards and e-bikes. Since biking was an established mode of transport in the Netherlands, e-bikes was ignored for the majority of the thesis. On further exploration, these vehicles were found to be present sparingly in the Netherlands and this is due to policy and regulatory roadblocks which have rendered these vehicles illegal and hence drafting new legislation and pushing climate goals by encouraging uptake and implementation of mEVs is very important. E-scooters were found to be the most disruptive and the thesis focused mostly on these vehicles.

The most observed vehicles were e-scooters, e-bikes and e-skateboards. The reasons for the low number are the lack and absence of policy definitions, which rendered these vehicles illegal. The user analysis pointed towards the fact that most of these mEVs are currently replacing biking which has implications in the bike pathways. Additionally, these vehicles are preferred and used largely by younger demographic which also influences transport resistance due to safety implications as reflected in the Transport theory. A very important thing to note here is that around 82% of e-scooter users and 80% of e-skateboard users were unaware of regulation and the fact that their vehicles were illegal at the time of observation. A combination of younger users, lack of regulatory knowledge, riding illegally and ease of bike pathways indicated that safety and supervision will be a concern in the future and will have implications in the bike pathways. This necessitates the need for a system and structure to implement and control mEVs.

The business side of mEVs is based on two categories of implementation: through private ownership and ride-sharing although only e-bikes and predominantly e-scooters are the ones deployed in a ride-sharing capacity. Private ownership is still very affordable long-term choosing environmental impact as a priority. This is only true for e-skateboards and e-scooters. E-scooters were found to the cheapest alternative for a certain fixed parameters of travel. However, it is still illegal in the Netherlands. Ride-sharing is based on the unit-economics model and profitability is not high at the moment. Currently, charging costs were found to be high and product durability is very low and both of these parameters need to improve with time to have the best effect on business irrespective of location of implementation. Although ride-sharing is currently not profitable, companies are launching with an objective of market dominance and future prospects. Implementation across the world indicated that these fleets need to be tailored to each city/country and the system needs to be designed according to local requirements. The cost of using mEVs in the Netherlands is only through purchase and in the long-term, it is cost-efficient and influences transport resistance by offering modal splits and cleaner modes of transport. A combination of comfort, costs, accessibility and reputation of technology correlates to its widespread implementation as reflected in the transport theory. Manufacturers need to focus on making technology improvements and increasing the quality and lifetimes of these vehicles in order to have a significant impact.

The mEV market has been influenced by safety concerns all over the globe. It is fair to say that safety and policy connect since policy is generated as a response to safety concerns and doubts about quality of consumer products. The theory pointed to the safety aspects, reasons for crash risk and how it influences development of the transport system. The research revealed at least one death and multiple injuries in every city. Brain injuries and bone breaks have become a huge public health concern. The different but important impacts of shared micro-mobility has been irresponsible users, lack of regulatory knowledge and a general sense of basic human disregard toward societal safety. Hooliganism, vandalism, DUIs and the lack of quality and safety standards causing multiple injuries and accidents proved with evidence that regulatory structure in this segment is a necessity. Out of the 8 countries explored, 5 of them responded to safety incidents with regulatory definitions and especially in the UK, a complete ban. Irrespective of chosen location, experiences worldwide have proved the need for regulations to streamline safer implementation. In the case of Netherlands, bike pathways are a big boon for the safe implementation of mEVs since every other country mentioned earlier lacks bicycle infrastructure. In all of these countries, mEVs are adopted on either pedestrian space or roads which makes them very dangerous. This implied that Netherlands would be a great fit for mEVs due to existing infrastructure. However, these vehicles bring in higher speeds and hence more overtaking. Speed differences on bike pathways are a concern due to their small size and safety needs to addressed. Regulation can fix these issues in order to have a smoother transition. Although, in the ride-share approach, there are implications with space since most older dutch cities are small and have canals, it is impossible to redistribute space for this new entrant without creating problems of congestion. Space restrains are an important parameter that influences the implementation of mEVs in the ride-share approach.

Countries which have undergone safety concerns have made regulatory changes to counter the madness on the street. Although, in the Netherlands, there is a clear lack of regulation, lack of policy definitions governing e-scooters, e-skateboards and e-unicycles.No ride-share companies have been implemented in the e-scooter space like everywhere else abroad. The only policy directive at the moment is EU Directive 168/2013 that defines Snorfietsen and Bromfietsen apart from Beleidsregel aanwijzing bijzondere bromfietsen (policy rule for special mopeds) which still to this date does not include e-scooters and e-skateboards due to the absence of a seat and a steering function. The Netherlands needs to work on policy while simultaneously the companies need to speed up research and implementation on safer and durable scooters. On safe and regulated implementation, it can work in certain cities in the Netherlands. The severe lack of convergence and collaboration between the stakeholders (Companies, I&W, RDW, Municipalities) observed through the interviews was a good indicator of the status-quo of mEV policy and hence stakeholder interaction needs to be enhanced. Inter-agency communication and data-sharing can help in carefully observed sustainable growth. The approval process for both ride-share and private ownership needs to be concrete and established in order to see these vehicles become more prominent in the Netherlands.

The environmental impacts of mEVs were investigated to assess if these vehicles were truly clean or not. When privately owned, mEVs have very low emissions and are cleaner than public transport (8g of CO_2 emissions per mile approximately). Although the exact level depends on source of charging. If regulation is put in place, private ownership can have a better influence on environmental impact than ride-sharing. Ride-sharing constitutes a significantly high environmental impact at current day due to the process of juicing (recharging methods). It constituted approximately 202g of CO_2 emissions per mile but can vary based on size of van, number of vehicles, picked up, distance travelled, etc. This part of the their operation cycle needs innovation and cleaner alternatives. Swappable batteries has been a widely suggested method with the combination of using electric vans and electric cargo bikes for maintenance and swapping activities. The status-quo of dutch policy dictated that private ownership is the better option environmentally at this point in time as it is cleaner and can overcome regulatory barriers more easily. Ride-sharing involves more regulation, stricter rules and more checks when compared to private ownership. Since Netherlands relies largely on public transport (trams, trains, buses), mEVs can help in influencing transport resistance by providing modal splits and assisting in first/last mile solutions to all categories of passengers although uptake till current day has indicated a demographic of 20 - 40. It need not necessarily cover whole distances but portability helps to cover intermittent journeys. mEVs can have a net positive impact if they replace enough car trips (>30%) and if regulation can help provide incentives to encourage mEV uptake, the mobility system truly influences carbon emissions. Experiences from the past have shown that mEVs replaced cars but in the Netherlands, it will in majority replace biking. In order to transform environmental impact and make it net positive in the Netherlands, mEVs would need multiple incentives with a combination of disincentivising cars.

7.2. Physical Implications

Micro-electric mobility requires infrastructure and space for implementation. Bike pathways provide the infrastructure for mEV movement, but speed differences, more congestion and more overtaking is a concern. Regulation and supervision for mEVs might come with the requirement of technology like cameras and sensors for monitoring riders breaking the rules. Also mEVs require more digital information and IOT can help in expanding mobility as a service. The bike pathways need to be optimised, and methods of surveillance either with personnel or technology is required to aid the growth and promote safe implementation. Space is a limiting factor to the growth of mEVs. Not all cities are equipped to launch mEVs as a service and hence spatial and urban design needs analysis before implementation. Cities like Amsterdam and Den Haag have severe lack of space and hence space redistribution in order to allow mEVs is impossible.

7.3. Digital Implications

Micro-electric vehicles began with the aid of smartphones and technology. IOT is aiding in the formation of smart cities, and mobility as a service is a very big part of that objective. In ride-sharing, factors like vehicle location, vehicle selection, and information on rides (CO_2 emissions, distance travelled, charge left) are very important to the implementation of ride-share vehicles. Technology and data-sharing will eventually provide more information about rides and this will aid further development in the field. To conclude, physical infrastructure does not warrant many changes due to the presence of bike pathways but it is important to stay compatible and updated to upcoming digital technologies.

7.4. Limitations of Research

This section details the limitations of the research conducted:

1. The research was highly qualitative in nature and explored multiple aspects of the industry and what factors influence their growth. Although numbers were provided in latter chapters, the

research in its entirety showed a lack of numerical backing due to its explorative nature.

2. The research did not focus on e-bikes due to their established historic market presence rooted in the biking culture of the Netherlands. Only newer mEVs were explored, and e-scooters in specific due to their disruptive nature as shown in their market presence and hype cycle.

3. The market as such in the Netherlands is only active through private ownership and no companies except Urbee (e-bike) have been given approval. No e-scooter companies have launched in Netherlands at this point in time. The research is limited in Netherlands due to in large part, the lack of regulatory structure and the clear lack of market participants in mEVs market (except e-bikes).

4. Only 3 interviews were conducted over the period of the thesis and hence does not provide a very concrete or supportive picture of the conclusions. However, the industry in itself is small and the participants are mostly bike manufacturers selling e-bikes and Urbee(e-bike share company in Amsterdam). There are no market participants in any of the other vehicles including e-scooters, e-skateboards and e-unicycles and all products used have been imported and shipped to the Netherlands.

5. The User-Analysis covered only early-adopters and new users. All of the riders (except e-bikes) were using their respective products illegally which explained the low number of users observed over a period of 7 months. The lower sample space might not have taken into consideration all factors relating to mEV growth. Additionally, only the users that could be successfully stopped and interrogated have been included in the user analysis and the rest were ignored.

6. The interviews helped address the policy status-quo but did not help gather information on how policy can change in the future. The interviewee did not address any questions about how policy would change in the near future.

7. The shared micro-mobility industry has grown ten fold but there still isn't enough scientific, reliable information on their true environmental impact. The numbers are not concrete and were put together using a combination of different non-scientific sources and just provide an initial picture. There is a clear lack of scientific knowledge in micro-mobility and that has been proved through the necessity of such an exploratory study.

7.5. Pitfalls of Micro-Mobility

This section details some of the pitfalls of mEVs and their growth potential. Some of them are important to know and understand before cities implement these vehicles.

1. Age and good health is a very important factor for the usage of mEVs. They are new, innovative and self-intuitive and majority of users were found to below the age of 40. Older people may find it hard or unsafe to use. This limits the market demographic based on type of vehicle but is important to know.

2. Current technology limits rider weight at around 100 kg (220 lbs) which limits the number of users. Hardware improvements can help change this with time but current technology is still lagging behind. This is also have safety implications.

3. Road quality and Space are very integral to further expansion of mEVs. If the country in question has bad road systems and low quality of infrastructure or none for bikes or scooters, then using mEVs will be improbable but not impossible. It makes for rougher rides, lot of jerks or bumps on the road and this increases crash or injury risk.

4. It is important to ensure safety of pedestrians, safety of scooter riders and others in bike lanes while also ensuring safe parking. This is hard to accomplish without supervision, regulation and more personnel. The already existing rules attached to mEVs are in itself very hard to monitor. Aspects like age, DUI, knowledge of regulation, paperwork and insurance coverage can only be verified using more cops, more personnel employed for supervision purposes. This increases government expenditure. Hooliganism and vandalism by unruly citizens has also been a very

common occurrence in cities of preliminary implementation. This sums up to huge government costs and keeping and maintaining a system of mEVs.

5. mEVs have shown good performance in tropical cities where they can function throughout the year. There is still a big question about their validity and performance in subzero temperatures. Battery technology and design should eventually consistent performance through the year and all seasons. Also, uptake would reduce during winter months and hence reduce business as well. This is something to consider when designing future iterations of better vehicles.

7.6. Recommendations for Policy

The policy side of mEVs was found to be absent or obsolete in the Netherlands. Following the research and the conclusion, these are the recommendations to policymakers in order to make the transition to these vehicles smoother *in the Netherlands.*

1. **Stakeholder Convergence:** The lack of interaction between the stakeholders prompted this recommendation. A multi-stakeholder approach can help aid the confusion due to the disconnect. The RDW, I&W and Municipalities should come together with the companies and manufacturers and collaborate to draft and design the best comprehensive solution to the electrification of mobility.

2. **RAI/BOVAC Investigation of mEVs:** Advise RAI/BOVAG to start collecting and analysing data on mEVs and e-scooters in particular to aid more research and understand its true impact in specific dutch cities.

3. **Definition of Product Types:** Policies should introduce and define new vehicle types to keep up with innovation in mEVs or update existing rules to include the newer vehicles. The current special moped policy (Beleidsregel aanwijzing bijzondere bromfietsen) is antiquated and cannot regulate newer kinds of vehicles. These updates would target the current obstacles with the policy that necessitates **seating & steering.** for safety measures. Regulation needs to keep pace with innovation in order to have policy design and this necessitates greater convergence between policymakers and manufacturers.

4. **Speed Differences on Bike Lanes:** Micro-electric vehicles with battery technologies have high speeds which need to be controlled. Policy should enforce a strict condition for manufacturers to build a physical speed limiter (like most e-bikes) in all mEVs which increases user safety and prevents over-speeding.

5. **Categorising based on type of vehicle or speed:** Policy definitions based on *Type of Vehicle or Speed limits* should be introduced in cities where there is enough space for further infrastructure."Voortbewegingstoestellen" like in the case of Belgium, brings more lanes in bike pathways based on speed differences which aids smoother movement in bigger cities. With increasing congestion in the bike pathways, speed lanes can help regulate flow and safety given the space and budget for expansion.

6. **Licenses, Insurance and Safety norms:** Steps like helmets and guards,lighting and indicators should be made compulsory for using mEVs and can have a positive impact on safety. Additionally, insurance and VIN plates for these vehicles should be made compulsory like **Scootmobielverzekering**. This not only helps safety but also accountability and data for future improvements. Also, *special licenses for mEVs* can be created to add an additional layer of accountability and conformity.

7. **Government regulates companies and vehicle volumes**: Municipalities should regulate the number of companies, types of mEVs implemented, number of vehicles released on the street (only ride-sharing). Municipality moderation and interference is necessary for sustainable growth. The intel-sharing and data analysis between municipalities and companies helps in mutually assured success. Collecting and analysing data on testing these vehicles is important to learn long-term growth and impacts.

8. **Disincentivise bad behaviour:** Penalise users for bad parking, irresponsible behaviour through technology and surveillance. The mobile app can be used to track vehicle location and user behaviour and hence penalties and fines should be addressed through the app by the company. A combination of digital and physical infrastructure can help aid the conformity of users. This can be made compulsory by regulation.
   (a) Use app locations to penalise riders based on parking zones. The companies can work with the government to add hubs and spots on the maps to direct users where to and where not to park. Either add fine to the user or remove the user from their platform.
   (b) When implemented, sensors and cameras will help surveillance of bike pathways and users of mEVs.
9. **Discourage car usage and ban cars in specific locations:** Car bans should be enforced in certain crowded central localities or hubs of the city where shared micro-mobility is implemented. It is as important to discourage car usage as it is to encourage mEVs. Creation of car-free zones can help reduce congestion in urban centres while at the same time make space for mEVs and have a net greener impact on the environment.
10. **Disallow sale of illegal vehicles:** Policy should deny companies the opportunities to sell products that are currently illegal in a certain marketplace until regulation makes them legal. Till such point, the sale of illegal vehicles creates nothing but downside for the country and policymakers.

7.7. Recommendations for Future Research

1. **Lack of Scientific Knowledge:** There is a huge lack of scientific data and body of knowledge on mEVs. In order to build on this subject, there is a necessity for scientific research and data which will help understand this industry better and provide better analyses. The severe lack of scientific literature sheds light on the necessity for further research on every aspect of micro-electric mobility.
2. **Social Acceptance and Behaviour:** The number of illegal users of vehicles on the street are only increasing and their combined lack of knowledge on regulation can have dire consequences. This can be further explored in the realm of social acceptance and safety and what their respective implications might be if this trend continues.
3. **Ride-sharing needs cleaner implementation:** Swappable batteries is a good alternative to juicing to reduce environmental impacts of ride-share mEVs. There is no scientific literature exploring this and more research is required to check the validity of this choice or come up with even better alternatives in the future. Alternatives to juicing are of primal importance.
4. **Spatial Constraints and Infrastructure:** Cities like Den Haag and Amsterdam are impossible to introduce mEVs due to lack of space. They would need a huge redistribution of space at the expense of cars and establish an orderly way of parking [88]. In the Netherlands, only some cities can successfully implement these vehicles due to space constraints of dutch architecture and city centres. Cities like Rotterdam and Eindhoven are easier targets for micro-mobility. Space is a very integral factor and needs further research to understand traffic volumes, transport and people flow. The Netherlands cannot risk having incidents like San Francisco after trial and implementation.
5. **Social Costs of improving mEVs:** A very interesting aspect of micro-electric mobility implementation is supervision and road conformity. The mere evidence of bad users, hooliganism and vandalism creating a bad culture around these vehicles will bring about the need for more police personnel, more technology in infrastructure and these costs have not been researched. As a forecast to the future, a country like Netherlands can benefit from knowing the capital investment in order to implement these vehicles in some cities in the future.

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A

Appendix

A.1. Observation Data

The tables of observation data from Chapter 3 are listed below.

Table A.1: Observation Data from e-skateboards

#	City	Age	Type of ePTW	Reason for usage	Mode substituted	Range (km)	Max Speed User (km/hr)	Price	Energy Capacity (Wh)	Battery Capacity (Ah)	Motor Power (W)	Awareness of Regulation	Awareness of max speed
1	Delft	23	Kooboard Gen 1	study + recreation	bike	7	22	€ 500.00		3.5	500	No	No
2	Delft	24	Boosted 1st Gen	study + recreation	bike	17	20	€ 1,500.00			1500	No	No
3	Delft	24	Boosted Mini	study + recreation	walk	9	18	€ 700.00				No	No
4	Delft	27	Backfire G2S	study + recreation	bike	21	27	€ 550.00				Yes	Yes
5	Delft	26	Yuneec E-GO 2	recreation	bike	27	27	€ 400.00				No	No
6	Delft	21	Razor X1	recreation	bike	8	13	€ 199.00				No	No
7	Den Haag	27	Wowgo 2S	study + recreation	bike	18	35	€ 380.00	230	6.4		Yes	No
8	Den Haag	31	Meepo V3	work + recreation	bike	27	40	€ 600.00		4	1080	No	No
9	Den Haag	24	Backfire G2T	study + recreation	bike	20	28	€ 500.00	216		700	Yes	Yes
10	Den Haag	25	Wowgo 2S	study + recreation	bike	18	35	€ 380.00	230	6.4		No	No
11	Den Haag	26	Backfire Ranger X1	study + recreation	bike + car	26	35	€ 950.00	504		1800	No	No
12	Leiden	24	Kooboard Gen 2	study	bike	12	35	€ 550.00		5.5	700	Yes	Yes
13	Leiden	31	Enertion Raptor 2	work + recreation	bike + car	35	45	€ 1,560.00				No	No
14	Leiden	24	Boosted Mini S	study	bike	12	27	€ 850.00			1000	No	No
15	Leiden	26	Boosted Stealth	study + recreation	bike	18	35	€ 1,650.00			2100	No	No
16	Leiden	26	Mellow Surfer	study + recreation	bike	12	37	€ 1,249.00	99			No	No

Table A.2: Observation Data of e-scooters

#	City	Age	Type of ePTW	Reason for usage	Mode Substituted	Range (km)	Max Speed (km/hr)	Price	Power (W)	Awareness of Regulation	Awareness of top speed
1	Delft	23	Denver SCO 65210	recreation	walk	8	15	€ 220.00	300	No	Yes
2	Delft	25	Xiaomi M365	study	bike	20	25	€ 500.00	250	No	No
3	Delft	22	Ninebot ES2	study	bike	19	23	€ 550.00	300	No	Yes
4	Delft	27	Ninebot ES1	study	bike	18	18	€ 450.00	250	Yes	No
5	Delft	24	Ninebot ES2	study	bike	18	23	€ 550.00	300	No	No
6	Delft	27	Xiaomi M365	study	bike	19	25	€ 500.00	250	No	No
7	Delft	26	Denver SCO 65210	study	walk + PT	7	14	€ 220.00	300	No	No
8	Delft	24	Xiaomi M365	study	bike	17	25	€ 500.00	250	No	No
9	Delft	25	Xiaomi M365	study	bike	15	24	€ 500.00	250	No	No
10	Delft	23	Xiaomi M365	study	bike	17	25	€ 500.00	250	No	Yes
11	Delft	26	Xiaomi M365	study	bike	16	25	€ 500.00	250	Yes	No
12	Delft	26	Ninebot ES2	study	bike	18	24	€ 550.00	300	No	No
13	Delft	25	Xiaomi M365	study	bike	19	25	€ 500.00	250	No	No
14	Delft	22	Ninebot ES2	study	bike	17	23	€ 550.00	300	No	No
15	Den Haag	28	Ninebot ES1	work + recreation	bike	19	18	€ 450.00	250	No	Yes
16	Den Haag	35	Xiaomi M365	work	bike	20	25	€ 500.00	250	No	Yes
17	Den Haag	25	Xiaomi M365	study	bike	18	25	€ 500.00	250	No	No
18	Den Haag	33	Ninebot ES2	work	bike + car	17	23	€ 550.00	300	Yes	Yes
19	Den Haag	36	Xiaomi M365	work + recreation	bike + car	15	24	€ 500.00	250	No	No
20	Den Haag	34	Xiaomi M365	work	bike + car	15	25	€ 500.00	250	No	No
21	Den Haag	28	Ninebot ES2	recreation	bike	16	22	€ 550.00	300	No	No
22	Den Haag	27	Xiaomi M365	work	walk + PT	15	25	€ 500.00	250	No	No
23	Den Haag	25	Ninebot ES2	study	bike	17	24	€ 550.00	300	No	No
24	Den Haag	29	Ninebot ES2	work + recreation	bike + car	16	24	€ 550.00	300	No	No
25	Den Haag	28	Ninebot ES1	work	bike	15	18	€ 450.00	250	Yes	Yes
26	Leiden	24	Ninebot ES1	study	bike	16	17	€ 450.00	250	No	No
27	Leiden	25	Ninebot ES1	study	bike	16	18	€ 450.00	250	No	Yes
28	Leiden	26	Xiaomi M365	study	PT	18	23	€ 500.00	250	No	No
29	Leiden	26	Ninebot ES2	study	PT	17	23	€ 550.00	300	No	No
30	Leiden	25	Ninebot ES2	study	bike	15	24	€ 550.00	300	No	No
31	Leiden	24	Xiaomi M365	study	bike	16	25	€ 500.00	250	No	No
32	Leiden	27	Xiaomi M365	work	bike	16	24	€ 500.00	250	Yes	Yes
33	Leiden	23	Ninebot ES2	study	bike	15	23	€ 550.00	300	No	No
34	Leiden	25	Xiaomi M365	study	bike	18	25	€ 500.00	250	Yes	Yes

Table A.3: E-bike Observation Data

#	City	Age	Type of e-bike	Reason for usage	Mode Substituted	Avg Range (km)	Max Speed (user max in km/hr)	Price	Battery Energy (Wh)	Opinion on new mEVs
1	Delft	57	Batavus	recreation	bike	100	35	€ 2,300.00	400	Neutral
2	Delft	59	Batavus	recreation	bike	100	35	€ 2,250.00	400	Unhappy
3	Delft	54	Koga	recreation	bike+car	100	30	€ 3,450.00	400	Unhappy
4	Delft	52	Koga	recreation	bike	100	30	€ 2,999.00	400	Neutral
5	Delft	67	Koga	recreation	bike	100	25	€ 2,800.00	400	Unhappy
6	Delft	64	Koga	recreation	bike	100	25	€ 2,400.00	400	Neutral
7	Delft	61	Gazelle	recreation	bike	90	25	€ 2,300.00	300	Unhappy
8	Delft	66	Gazelle	recreation	bike	90	25	€ 2,400.00	300	Unhappy
9	Hague	71	Cortina	recreation	bike	100	25	€ 1,699.00	400	Neutral
10	Hague	74	Cortina	recreation	bike	120	25	€ 1,949.00	500	Unhappy
11	Hague	76	Gazelle	recreation	bike	120	20	€ 3,199.00	500	Unhappy
12	Hague	63	Gazelle	recreation	bike	120	25	€ 2,999.00	500	Unhappy
13	Hague	55	VanMoof	work	bike+car	90	30	€ 2,798.00	504	Happy
14	Hague	51	Gazelle	work	bike+car	90	25	€ 2,299.00	300	Happy
15	Leiden	64	Pegasus	recreation	bike	100	25	€ 2,699.00	400	Unhappy
16	Leiden	69	Pegasus	recreation	bike	125	25	€ 2,899.00	500	Neutral
17	Leiden	74	Cortina	recreation	bike	100	20	€ 1,699.00	400	Unhappy
18	Leiden	62	Gazelle	recreation	bike	120	25	€ 3,199.00	500	Neutral
19	Leiden	59	QWIC	recreation	bike	120	25	€ 2,299.00	625	Neutral
20	Leiden	66	Gazelle	recreation	bike	90	25	€ 2,300.00	300	Unhappy
21	Leiden	66	Koga	recreation	bike	100	25	€ 2,400.00	400	Unhappy
22	Leiden	63	Raleigh	recreation	bike	200	25	€ 2,899.00	603	Unhappy
23	Leiden	67	Raleigh	recreation	bike	80	35	€ 4,000.00	603	Neutral
24	Leiden	64	Gazelle	recreation	bike	80	25	€ 2,699.00	300	Neutral
25	Leiden	68	Gazelle	recreation	bike	80	25	€ 2,699.00	300	Unhappy
26	Leiden	72	Batavus	recreation	bike	80	25	€ 2,299.00	400	Unhappy
27	Leiden	58	Gazelle	recreation	bike	140	25	€ 3,299.00	500	Neutral
28	Delft	52	QWIC	work	bike+car	80	30	€ 2,049.00	470	Happy
29	Delft	57	Gazelle	recreation	bike	140	25	€ 3,199.00	500	Unhappy
30	Delft	74	Koga	recreation	bike	120	20	€ 3,299.00	500	Unhappy
31	Delft	69	Gazelle	recreation	bike	90	25	€ 2,400.00	300	Neutral

A.2. Interviews

The questionnaires from the interviews are listed below.

A.2.1. Interview A : Sven Mittertreiner

1. What are the current policies in place in the municipality?
Ans: They are currently illegal and there is no way to test safety of each single product. The ones with saddles are legal but the ones without are not.
2. How to choose which are legal?
Ans: The ones with saddle are legal (although the saddle maybe foldable). They are more robust. Veeley(foldable seat) and Stigo(foldable e-moped) are examples of approved legal mopeds. (because of the saddle which converts it into a moped or a e-bike). Monowheel mopeds (onewheel and Segway Z10 ONE S2). In terms of legality, there are no laws governing vehicles with one wheel.
3. Is the policy based on design, structure?
Ans: Newly launched vehicles need to receive approval through RDW. They need to pass safety tests, design tests and so on before going on to receive approval through Ministry of Infrastructure and Water Management.
4. How does the approval process work at this moment? Is it better for companies or users to go for approval?
Ans: Products currently sold online are only legal in private property, but users use it on the streets anyway. It seems logical for the manufacturer itself to go for approval. It is always advised for the companies to go through this process.
5. How do manufacturers to sell products online without prior approval?
Ans: Companies can sell their products online by attaching a disclaimer saying that it is road illegal to shield themselves from legal scrutiny.
6. Fleet Sharing companies (DOTT and Bird) have offices in Amsterdam and are testing their vehicle but not yet implemented it yet, what's wrong?
Ans: They even approached Den Haag Municipality but were redirected to IW for approval. INW is skeptical about e-scooters because of the short lifespan and causing traffic disruption/traffic safety. No e-scooter fleet sharing has received approval yet and the municipalities would have to wait for the INW before they approve it in their district.
Note: They are working on making laws to render one-wheel vehicles as illegal since they don't have steering assistance which is not logical at this moment. Skateboards are legal but e-skateboards are illegal since they have no steering which is again illogical because steering cannot be added to the skateboard.
7. Concrete laws on e-mobility vehicles are expected in autumn 2019, would these vehicles be banned because users are scared?
Ans: The police are not actively fighting or focusing on these kinds of vehicles and handing out tickets. But I cannot predict the changes the INW would be making but seemingly these kinds of vehicles are only going to expand.
8. What would current users have to do in order to make it road-legal or at least partially road-legal?
Ans: Users would have to get approval through RDW to get a VIN number and get separate vehicle insurance for their e-scooter or e-skateboard, its not required for e-bikes.
9. Did the accident with Stint slow down policy for micro-electric mobility vehicles? Ans: The accident has nothing to do with policy and one incident does notreflect the manufacturer or these kinds of vehicles. Just like cars, bikes, trains undergo accidents and we cannot ban them overnight. The Netherlands as a country has more stringent rules and regulations and this makes it harder to accomplish certain goals with respect to innovation and new technologies. The intricacies of safety regulations make it hard to permit vehicles under the common law. Policy should be easier and compliant.
10. What are the problems/complaints the municipality faces with these vehicles?
Ans: e-bikes are generally not subject to approval in free-floating form. But e-scooters are other vehicles are to be approved by INW first before they approach the municipality. Note: These are EU regulations and country regulations, and both need to be followed in order to implement the vehicle. In countries like Portugal, France and Belgium, the EU regulations are not necessarily followed. A solution that can be used would be what Belgium did by adding new categories (called "voortbewegingstoestellen") to special mopeds in add more regulation. (<18 km/hr. is considered a normal

pedestrian vehicle although this does harm pedestrians). Adding speed categories do help provide structure to policy.
11. Is policy local to municipalities or central to the government?
Ans: The Ministry of INW controls approvals and once they receive approval, they can approach any municipality for implementation. But on a side note, municipalities do have the legal mandate and power to reject the proposal in their city.
12. What are the solutions the municipality can do to control implementation and moderate their use?
Ans: Too many vehicles just released into the city-center would cause chaos and create a problem but the municipality found a way to collaborate with the companies like Mobike in order to regulate the number of vehicles in each area. Also, we ask companies to send us data on usage statistics in different areas to redistribute and control vehicle flow. If not, things could go out of hand like in San Francisco and Paris.
13. How is the relationship with micro-mobility companies working?
Ans: We do work with companies and have pilot projects so that we can use the data to study further expansion. We are working on a pilot with five companies, of which, felyx and cargoroo are electric. We have given them zones and numbers to regulate and study data.
14. Are municipalities interested in letting in more companies into the cities like other countries?
Ans: Even if their products are approved by the INW, we may not need more companies and the market is saturated. Although their business model is efficient, the municipality does not want to let in too many companies and create too much chaos unless users, or the market demands it. We also want to be fair to other companies already in place who might be de-incentivized. MARKET-FAIRNESS AND PEOPLE WELFARE MATTERS. It is difficult to monitor what city users may need plus Alderman and the Mayor are the final authority.
15. What are the laws on speed pedelecs(fast mopeds)?
Ans: Snorfietsen(blue license plate,<25km/hr, no helmet, can go on bicycle path) and Bromfietsen(yellow license plate,<45 km/hr, helmet required, cannot go on bicycle path) e-bikes are not under both categories, but speed pedelecs are bromfietsen and helmets are required.
16. The law says 25 km/hr is the max speed but most new innovate e-vehicles cross that mark, how to control that?
Ans: Some vehicles are technologically limited to certain speed and categorized into bromfietsen and snorfietsen but most e-skateboards, e-bikes and e-scooter that cross the limit and hence policy definitions become harder. And this influences safety ramifications.
17. Many accidents are due to difference in speed on cycle pathways, how to reduce accidents?
Ans: We have training sessions for older people on how to ride speed pedelecs and e-bikes in order to reduce accidents. A lot of accidents were caused by older people trying new technology and losing control.
18. E-bikes need to be under 25km/hr but normal bikes do go over 25km/hr, what can policy do? Could introducing multiple pathways based on speed limits be a good idea?
Ans: There is a contradiction here and something needs to be done but defining policy in this scenario is difficult. Multiple pathways based on speed are possible in cities where there is space but most cities like Den Haag where there is not much space left for new infrastructure.

A.2.2. Questionnaire B: Robbert Verweij

1. How does the approval process work for companies providing fleet-sharing e-mobility vehicles in the Netherlands?
Ans: We only have the policy rule designating special mopeds (bijondere bromfietsen) at the moment. It has gone undergone no changes since 2nd May 2019.
2. Does the approval process differ between e-scooters(BIRD) and e-bikes(URBEE)? What are the differences? Is docking a necessity?
Ans : E-scooters such as Bird are to be approved (through the 'aanwijzing'). E-bikes are exempt from approval by EU legislation (168/2013). Docking concerns the use of the vehicle and is hence not at all an issue for approval.
3. What are the main parameters of analysis in the approval process?(Safety/Design/Technology)
Ans: Please check the "Beleidsregel aanwijzing bijzondere bromfietsen " for the entire document with technicalities and parameters.

4. When compared to other countries, why has the Netherlands only handed out much fewer approvals?
Ans: National approvals cannot be compared with other countries. The 'aanwijzing' is a Dutch method.
5. Have there been open lines of communication with companies wanting to implement their business here and what has that process yielded?
Ans: Yep, we feel there are. However, we keep stressing that Bird steps and the likes much first be approved.
6. Have lessons about failure from other countries called for a more stricter approval process? (main reasons for failure in some countries being vandalism, durability and safety)
Ans: The approval process has been in effect since 2011 and has been updated recently. There is no direct causal relation between accidents with e-steps and this approval process. This process is for all types of 'bijzondere bromfietsen', not just for e-steps.

A.2.3. Questionnaire C : Fred Chang

1. Based on pricing (400-600 euros), what is the rough age demographic connected to your sales? 20-30 (or) 30-40 (or) 40-50 (a rough percentage would be fine)
Ans: Due to GDPR, we cannot collect too much personal information from the users. I can only tell you the highest percentage lies in the 30-40 group.
2. Has the company secured approval for the e-step through RDW?
If yes, was the procedure and requirements easy or was the approval process cumbersome and hard?
If no, why did the company choose not to receive approval from RDW?
Ans: No, it cannot be. So far no electric scooters can be type approved by RDW. You need to see the definition of car and scooter. What's the requirement? There is no type in the Netherlands at the moment. Germany just set the type on June 15th this year.
3. Has there been much interaction with the government officials over time? Has government policy been supportive or has there been roadblocks? If yes, what are your suggestions on how it can be improved?
Ans: Segway participated in the meetings of setting up the new vehicle type (Personal Light Electric Vehicle, PLEV) with EU coordinated by AFNOR.It's better the people who are interested in this type of commuting tool, they have to push the government to start thinking how to give approval.
4. How important are safety and design standards in the EU and Netherlands, and has your product been redesigned to sell in NL? (with respect to power output, max speed restrictions according to Dutch law)
Ans: What's the Dutch law concerning electric kickscooter?
As explained above, it is not a vehicle type yet. In the case of NL, it's not written then it's not allowed. We do small modification to our products to meet local requirements. For example, Denmark requires nominal motor power to be no more than 250W and 20km/h as the max speed.
5. In your professional opinion, what are the changes that could be made to help this transition and increase the use of such vehicles in Netherlands?
Ans: Like Germany, create a vehicle type and set the regulation on product design and rules for riders.
If INTERNATIONAL: 6. Does the company export to the Netherlands and other countries?
Ans: Segway Europe is the EMEA headquarter for Segway-Ninebot Group. We distribute to different countries where we have exclusive distributors in EMEA.
7. Considering customs and import duties and possibly shipping, is there a way to still reduce the price or increase affordability? If yes, what changes can be made in the supply chain or process to enhance sales? How do you plan to increase market share with these obstacles?
Ans: When the government starts allowing this type product to be used on the public roads, the sales will increase. Each pricing level attracts different target group. As long as the law is clear, it's easy to adapt and come up with a product that's suitable.

A.3. Articles of BABB

Article 11

Admission of the special moped corresponds to the following objectives of the law:

a. ensuring road safety;

b. protecting road users and passengers;

c. the prevention or limitation of nuisance, nuisance or damage caused by traffic, as well as the consequences for the environment;

d. the prevention or limitation of traffic-related damage to the character or function of objects or areas; and

e. promoting efficient or efficient energy use.

Figure A.1: Article 11

§ 4. Technical assessment criteria

Article 13

1 The special moped is provided with a VIN that is stamped into the frame, in the chassis or in a similar construction and that is easy to read. The VIN complies with Regulation (EU) No 901/2014 .

2 If the VIN is struck at a location that is not immediately visible during the technical assessment, the applicant must have adequate tools for the physical assessment referred to in Article 6 (1) to remove parts that obstruct the view of the VIN. to delete.

Figure A.2: Article 13

Article 16

1 The special moped has a design speed of no more than 25 km / h.

2 Without prejudice to the first paragraph, the special moped does not reach a higher speed by means of the drive than the maximum construction speed specified by the applicant in the application.

3 If the special moped can be driven by a combination of motor drive and muscle power, the motor drive switches off when a speed of 25 km / h is reached.

4 The special moped is not provided with a device with the apparent purpose of making it more difficult to control the construction speed.

Figure A.3: Article 16

4 The special moped does not move or comes to a standstill, if it is moving, if it is not operated, the driver is not in the driver's seat or the contact is not switched on.

Figure A.4: Article 22

Article 30

1 The special moped is equipped with a properly functioning mechanical steering system.

2 The dust covers are not damaged in such a way that the covers no longer seal.

3 The couplings and connections are free of play.

4 The parts required for transferring the steering forces are properly attached.

5 The operation of the steering system and the clutches are not impeded by any part of the special moped.

Figure A.5: Article 30

Article 31a

1 A special moped intended for individual transport or freight transport does not offer room for passengers.

2 A special moped intended for passenger transport offers a maximum of eight seats for passengers.

3 The seat:

a. offers sufficient space for the person to be transported;

b. is provided with a hip belt; and

c. if it is intended for a child, it must contain a clear indication of the maximum weight for which the seat is intended.

4 The material, the fastening and the fastening of the belt comply with UN / ECE Regulation No. 16 or No. 44.

5 , the points of attachment of the hip belt are positioned so that the belt can effectively abut on the hip of the passenger.

6 The strength of the belt conforms to UN / ECE Regulation No 14 in terms of strength, irrespective of the placement of the seats, taking into account the maximum construction speed of the vehicle and, if applicable, the weight referred to in the third paragraph, part c, provided that a minimum weight of 36 kg is used.

Figure A.6: Article 31a

Article 31b

The driver's seat of a special moped intended for the transport of persons or goods is provided with protection that can prevent the driver from falling off the vehicle.

Figure A.7: Article 31b

Article 44c

1 A designation applies in principle for an indefinite period of time. The designation may include the restriction that the designation relates to special mopeds produced within a period to be determined thereby.

2 The limitation to a specific period, as referred to in the first paragraph, is in any case set if there is a tightening of the technical assessment criteria, referred to in paragraph 4 . The minister can adjust the designation in such a way that it relates to a special moped that has been adapted to the changed assessment criteria. To this end, the applicant may offer an adapted special moped to the Minister for assessment as to whether the amended assessment criteria have been met.

3 When imposing a restriction as referred to in the second paragraph, a transition period of twelve months is observed to give the applicant the opportunity to adjust the production process and to offer a new vehicle for assessment as referred to in the second paragraph.

4 The designation shall include a limitation that, at the request of the applicant, no later than two years after the expiry of the period of validity referred to in the first paragraph, a maximum of 10% of the number of the last two years before the end of the may offer special mopeds on the market under the relevant designation, with a maximum of 100 special mopeds.

Figure A.8: Article 44c