Eindhoven, July 2016

Driving transitions on the local level

A case study on the role of local governments in stimulating the transition towards more sustainable mobility

by A.B. van Zante

Identity number 0766256

In partial fulfilment of the requirements for the degree of

Master of Science
in Innovation Sciences

University supervisors:

Dr. F. (Frank) Schipper	Faculty of Industrial Engineering & Innovation Sciences
Prof. dr. J.F. (Hans) Jeekel	Faculty of Industrial Engineering & Innovation Sciences

Company supervisors:

Drs. ing. M.P. (Mark) van Kerkhof	APPM Management Consultants
ir. A. (Alexander) Smal	APPM Management Consultants

Colophon

Title: Driving transitions on the local level

Subtitle: A case study on the role of local governments in stimulating the transition towards more sustainable mobility

Keywords: Sustainability transitions, multi-level perspective, strategic niche management, sociology of expectations, sustainable mobility, charging infrastructure, inductive charging

Author: Anna Bardina van Zante

University: Eindhoven University of Technology

Department: Industrial Engineering & Innovation Sciences

Graduation date: July 19, 2016

In partial fulfilment of the requirements for the degree of

Master of Science in Innovation Sciences

University supervisors: Dr. F. (Frank) Schipper
Prof. dr. J.F. (Hans) Jeekel

Company supervisors: Drs. ing. M.P. (Mark) van Kerkhof
ir. A. (Alexander) Smal

Preface

When I was younger, I was always intrigued by types of transportation. Whether it was a plane that flew by or a truck on the highway, it always sparked some interest. This interest has grown over the years, but it was not until my international semester in the United Kingdom that I realized I wanted to explore electric transportation in my thesis. This master thesis is the result of my passion for not only electric transportation, but governance, transitions and sustainability as well. By trying to give insight into the role of local governments and how they can stimulate a sustainable mobility transition, I hope to contribute to a small piece of the puzzle which I believe will help to make society more sustainable.

However, if it was not for the people who have supported me over the last six months, this thesis would not have been as it is. First of all, I would like to thank both of my supervisors, Frank Schipper and Hans Jeekel. Besides offering useful insights and providing me with feedback, thank you for the initial effort which led to my graduation internship at APPM Management Consultants. I value the trust you have given me, which gave me the confidence to write this thesis in an independent matter. Furthermore, I would like to thank Mark van Kerkhof and Alexander Smal for giving me the opportunity to conduct my thesis at APPM Management Consultants. I appreciate the freedom you have given me in thinking of a topic, and at the same time the guidance that you have provided me with during my thesis. Also, I would like to express my gratitude to all the other 'colleagues' at APPM Management Consultants, who have shown great interest in my thesis and who have welcomed me into the company in the best way possible. Thank you for giving me a glimpse of what life is like after graduation. Moreover, I would like to thank all the interviewees for the enjoyable conversations, in which they have provided me with plenty of interesting and relevant information for my thesis.

A special word of thanks goes out to Tanja, who has been of great help in the process towards this final document. Coffee breaks started to turn into two-hour discussions, often leading to new insights but sometimes also leaving me clueless. Thank you for all the time you have invested in our brainstorms, and your indefinite patience. Also, I would like to thank all my friends at Intermate for the wonderful time the last five years. Thank you for all the good conversations, incredible parties and most of all lots of fun. The final word of thanks goes to my family, and especially my parents, who have shown a lot of interest in my thesis, pointing me at interesting websites and even cutting out newspaper articles. Thank you for always having my back and supporting me in everything that I do.

Annabel van Zante

Executive summary

Within the transport sector, society is confronted with several sustainability challenges, including the need to reduce CO_2 emissions and improve local air quality. Electric transportation has been introduced as a solution to these challenges as it solves some of the negative externalities, such as emissions and noise production, and at the same time retains the current social and economic benefits of the car. However, due to the fact that several aspects, such as infrastructure, are currently aligned to and revolve around the dominant technology of fossil-fuel based cars (Geels, Kemp, Dudley & Lyons, 2012: 3), electric vehicles face difficulties in their upscaling. It is argued that especially the dimension of charging infrastructure is crucial in order to achieve a large-scale diffusion of electric vehicles (Funke, Gnann & Plötz, 2015: 73). Besides the currently dominant way of conductively charging a vehicle, by plugging the vehicle into a socket, inductive charging has been introduced as a novel way of charging. Given the importance of infrastructural developments, it can be argued that this type of charging offers a solution to current barriers and therefore leads to the scale-up of electric vehicles.

In this upscaling of electric transportation, local governments play a pivotal role. Since a substantial number of charging points is installed in public space, decision-making about the positioning and deployment of these points has shifted from the national to the local level. Due to the fact that local governments are given the task to locally facilitate charging infrastructure (Hop & Welleweerd, 2013: 4), they play an important role in the scale-up of electric driving, which contributes to the transition towards more sustainable mobility. Given the technology of electric driving and the infrastructural development of inductive charging, this research aims to identify the role of local governments and how they can contribute to more sustainable mobility. On the one hand, this will provide more insight into the role that local governments should take, and furthermore it will show how local governments deal with novel technologies, such as inductive charging, that might have a stimulating effect on sustainable mobility.

Research aim

Upscaling of electric transportation could contribute to more sustainable mobility, but this requires, among other aspects, a fitting infrastructure. Given that local governments play an important role regarding charging infrastructure, it can be argued that they are an essential actor in the mobility transition. By looking at their visions regarding sustainable mobility and the strategies they mobilize to achieve these visions, it is tried to gain insight into their current role and how they shape this role. Furthermore, attention is given to barriers that have been identified, and how municipalities deal with these bottlenecks. This research also tries to gain insight into how municipalities expect inductive charging to contribute to the transition, and if they mobilize this technology to achieve their visions. These insights contribute to defining the role of local governments, and eventually contribute to answering the research question, which is stated as,

What is the role of local governments in stimulating the transition towards more sustainable mobility?

Research approach

Because the study tries to explore the role of local governments, a qualitative approach is chosen. Within this framework, a multiple case study design is adopted, which consists of a total of four case studies. These case studies consist of municipalities, which are selected based on two selection criteria. Firstly, the size of the municipality is taken into account, based on its number of inhabitants, due to the fact that it is likely that municipalities of a different size deal with different issues. The other selection criteria concerns the policy regarding charging infrastructure, in which a distinction is made between an active and a passive approach. Municipalities are argued to pursue an active strategy if they financially stimulate charging infrastructure, and they are said to have a passive strategy if no financial means are available to stimulate this type of infrastructure.

In order to answer the research question, two transition theories were mobilized, namely the multi-level perspective (MLP) and strategic niche management (SNM). Whereas the MLP was used to position the dimension of charging infrastructure and distinguish niche-regime interactions, SNM was used to zoom in on the niche level. Within the latter framework, visions and expectations were emphasized as an important process for a successful transition, which were closely linked to actor strategies. Furthermore, an elaboration on this framework was used as a tool to distinguish between the global level of electric driving and the local level of charging technologies to gain insight in the dynamics at play. The empirical analysis was comprised of semi-structured interviews with municipalities, grid operators and experts on charging infrastructure. These interviews were complemented with other informative and policy documents, in order to ensure triangulation. The acquired data was analyzed by transcribing the interviews and carrying out a content analysis in order to create a structured narrative in which the results are presented.

Research findings

The role of local governments is researched on different levels, considering dynamics between current mobility practices and novel technologies, as well as processes between different types of charging infrastructure. The results show that although local governments generally share the same vision, they pursue different strategies. Municipal visions, including energy-neutrality and improving local air quality, are shown to play an important role in strategies as they explain why sustainable technologies are adopted, but they do not explain why different technologies are chosen. Expectations on the micro-, meso-, and macro-level provide an explanation regarding the preference of certain technologies over others. Furthermore, these expectations show that there is currently no consensus on the technology of inductive charging. Besides the fact that people doubt its technological performance, they ascribe different societal functions to the technology and they have different expectations regarding the future of sustainable mobility. These varying expectations have an influence on actor strategies, given that there is only a single pilot project in the Netherlands on inductive charging for private car use.

Next to the fact that expectations have an effect on the strategies that are adopted, novel technologies often face bottlenecks in their scale-up due to misalignments with current practices. Two bottlenecks are identified by the municipalities regarding charging infrastructure, consisting of the unviable business case and internal and external processes. However, the identification of these barriers is to a large extent dependent on the size and strategy of the municipality. If charging infrastructure is supported financially, it is argued that there is an unviable business case, and the larger the municipality, the more it is emphasized that electric transportation is difficult to embed into an organization as it involves multiple departments. Smaller municipalities, on the other hand, mention external processes, as they feel that the province could play a more important role.

Conclusion

Although local governments differ regarding their size, strategies and resources, they play an important role in stimulating the transition towards more sustainable mobility. Besides mobilizing passive measures, such as providing subsidies to make electric driving more cost-competitive, they also pursue more active approaches which originate from the responsibility that they ascribe themselves. By creating pilot projects themselves, opening up their public space for experiments and by integrating projects into their municipal fleet, they have an influence on the scale-up of electric driving. These activities can help in achieving more sustainable mobility, and contribute to the sustainability transition. Although larger municipalities often have more resources at their disposal, financially as well as human, and therefore can act as drivers in a transition, smaller municipalities can also contribute significantly by opening up as a living lab and welcoming innovative experiments. Since visions and expectations constitute an important factor in creating strategies, these should be articulated by municipalities. They should clearly outline their aims for the coming years, and align their visions with according strategies. All in all, if municipalities initiate these protective measures, both active and passive, they can have an influence on the transition towards more sustainable mobility. However, the mobility transition will not only encompass the introduction of more sustainable technologies, but local governments also need to direct focus to shifting the type of transportation and reducing demand for mobility. Furthermore, whereas local governments are currently mainly focusing on empowering niches, the transition can also contribute from measures which destabilize the current dominant system of fossil-fuel based cars.

Recommendations

According to the results, there is currently a lack of convergence regarding expectations on inductive charging. Since shared expectations are a requisite in order for a technology to develop, it is recommended that local governments keep track of the ongoing developments and organize discussions with a diverse group of stakeholders in order to align expectations. Furthermore, if pilot projects are created, attention should be paid to the fact that projects should not become overly contained. Knowledge which is acquired locally needs to be translated into global rules and practices, in order to contribute to a wider transition. This can be done by maintaining a close connection to the province, and also by creating innovative projects on a regional level. Last of all, novel technologies, such as electric driving, challenge the current organizational structure of a municipality. Whereas this is aligned in a vertical way, horizontal themes should be identified in order to create an integrated approach across the municipality, which will help to embed novel technologies.

Table of contents

List of figures

List of tables

List of abbreviations

BEV	Battery electric vehicle
EV	Electric vehicle
FEV	Full electric vehicle
ICE	Internal combustion engine
MLP	Multi-level perspective
PHEV	Plug-in hybrid electric vehicle
SNM	Strategic niche management

1. Introduction

Society is confronted with some fundamental sustainability challenges in a number of domains, including the transport sector. Challenges that arise in relation to automobility include environmental issues, such as local air pollution and CO_2 emissions. These sustainability challenges are subject to path-dependencies and lock-ins (Markard, Raven & Truffer, 2012: 955) which have been created by the dominance of fossil-fuel based technologies. User practices, regulations and infrastructure, among others, all revolve around this dominant technology which is deeply embedded in society (Geels, Kemp, Dudley & Lyons, 2012: 3).

However, an increasing amount of attention has been devoted to the question how to promote and govern a sustainability transition (Markard et al., 2012: 955). It has been acknowledged that a transition towards more sustainable types of mobility is necessary, but one of the big challenges remains how to retain the current social and economic benefits that are associated with mobility (Köhler et al., 2009: 2985-86). Whereas a couple of decades ago this mobility started out with a public transport regime, the 20th century brought along a regime change as the privately owned and driven car became the dominant mode of transportation (Geels et al., 2012: 4). Nowadays, the car still plays an important role in society. Especially from an economic point of view the car is a valuable asset, as transport is crucial for economic competitiveness and a large generator of wealth due to the car manufacturing sector. Electric vehicles (EVs) have been put forward as a potential solution as they resolve some of the negative externalities and preserve the benefits of the current car-based regime to a large extent (Newman, Wells, Nieuwenhuis, Donovan & Davies, 2014: 24). They continue to fulfill the important economic role that transport plays, while at the same time reducing negative aspects related to mobility, such as air pollution and noise production. However, the transition towards more sustainable mobility by using an alternative type of transportation such as EVs, also faces some challenges. Not only are alternatively fueled vehicles more expensive in their introductory phase, they also require a different fuel infrastructure. Furthermore, novel technologies are often surrounded by uncertainties regarding their performance, making actors reluctant to invest, which inhibits further development (Farla, Alkemade & Suurs, 2010: 1265).

In the Netherlands electric transportation has seen a rapid rise, amounting to more than 90.000 vehicles in total in 2016, of which approximately 10% is fully electric (Rijksdienst voor Ondernemend Nederland, 2016a). The infrastructure, consisting of public, semi-public and fast charging points, has evolved as well. Within five years the total number of these charging points has grown from 2000 to more than 20.000. The largest share of these points consists of semi-public charging points, which are only available to a specific group of e-drivers, but also fast charging points have seen a large increase. A Dutch start-up called Fastned, founded in 2011, has made a significant contribution to the latter type of charging points, where an EV can be charged in twenty minutes on average compared to eight hours using a regular charging point. The aim of the company was to work towards a country-wide network of fast charging points (Nieuwenhuis, 2015), which they claimed to have achieved at the start of 2016 when the 50th charging point was opened (Telegraaf, 2016). Despite these infrastructural developments, the chairman of the Formula E-Team – a public-private cooperative that has been established to stimulate the developments regarding electric transportation in the Netherlands – fears that there will be a shortage of charging points if the sales of EVs are to increase over the coming years (Broekhof, 2016). Especially a lack of *public* charging points presents a large bottleneck in the scale-up of EVs, as the majority of EV-adopters has no access to off-road parking and is dependent on these public points (van Beek, 2016). The deployment of this infrastructure is crucial in order to achieve a large-scale diffusion of electric transport (Funke, Gnann & Plötz, 2015: 73).

Currently, conductive charging is the dominant way of charging an electric vehicle, which simply entails plugging the vehicle into a socket, for example at a parking place or at home (CLP Online, 2013). However, new ways of charging are gaining attention, including inductive, or wireless, charging. This technology makes use of magnetic coils that are located in the EV and in the charging source, transferring energy without any physical contact between the two coils (APPM, 2014). This charging is either *static*, which includes parking the vehicle over a charging pad and charging it, or *dynamic*, which is charging the vehicle while it is moving (Fisher, Fairley, Gao, Bai & Tse, 2014: 87-8). Given the ongoing dynamics regarding sustainable mobility, and the importance of infrastructural developments, it can be argued that inductive charging is bringing a new dimension to the table regarding charging infrastructure, which might contribute to the scale-up of EVs. It is, for example, more user-friendly and easier to use as no cables are required, and the barrier of range anxiety might be lifted in the future by using dynamic charging.

Especially in the introductory phase of such a niche technology, there is an important task for institutional actors, such as different levels of government, to formulate and create a shared vision in order to contribute to a transition (Rotmans, Kemp & van Asselt, 2001: 25). When specifically considering sustainability transitions, it has been acknowledged that governmental bodies play a key role in stimulating more low-emission technologies (Rotmans et al., 2001: 31). It is also argued that governance on a regional level should be given more attention, since local governments provide the linkage between niche and regime levels. By incentivizing certain projects and experiments within an urban environment, they are pioneers in demonstrating the feasibility of a novel technology (Späth & Rohracher, 2012: 462). Besides this, these local levels provide room for more radical experiments, and there is a closer relation to citizens in comparison to national government (Rotmans et al., 2001: 25). Experimenting on a local level is therefore the perfect opportunity to introduce new technologies and demonstrate them to the wider public. However, the success of projects on a local level greatly depends on the strategic decisions that are made regarding the alignment and aggregation of knowledge (Quitzau, Hoffman & Elle, 2012: 1057).

In the transition towards more EVs, local governments play a pivotal role regarding the deployment of public charging infrastructure. As these charging points are installed locally in public space, decision-making about the positioning and deployment of these points has shifted from the national to the local level. Recent research has shown that the number of these installed public charging points, has a positive effect on the number of EVs within a municipality (Rijksdienst voor Ondernemend Nederland, 2016b). Besides being responsible for policies and regulations on the placement of this technology, some municipalities also actively engage in deploying charging points by investing heavily in them (Bakker & Maat, 2013: 1). Because of this task to locally facilitate charging infrastructure (Hop & Welleweerd, 2013: 4), local governments have an influence on the pace and direction of electric transportation, which contributes to the transition towards more sustainable mobility.

1.1 Research objectives and questions

As shown in the previous paragraphs, there is an urgent need to solve sustainability challenges in the mobility regime, and EVs have been introduced as a solution. However, since multiple dimensions, including infrastructure, are aligned to this regime, it is difficult to make the transition to more sustainable practices. Furthermore, it was shown that municipalities can play an important role in this. By creating a shared vision, they can contribute to a transition, and the local level provides a perfect space to experiment with novel technologies. Regarding electric driving, local governments play an even more important role as they have been ascribed to locally facilitate charging infrastructure, and therefore can alleviate the infrastructural barrier that is currently present. In this way they can influence the diffusion of electric transportation, which contributes to the transition towards more sustainable mobility. Therefore, the main question of this research has been framed as,

What is the role of local governments in stimulating the transition towards more sustainable mobility?

To answer this question, three sub questions have been identified which guide the research. These have been formulated as,

1. How do local governments tackle the bottlenecks that are identified regarding the implementation and managing of charging infrastructure?
2. How do visions and expectations shape the role of local governments in the rollout of charging infrastructure?
3. How will the inductive and conductive charging infrastructure influence each other, and how do local governments mobilize this interaction to stimulate the uptake of EVs?

Following the literature, this thesis argues that local governments can play a pivotal role in the transition towards more sustainable mobility. However, their role will go beyond the facilitating role that is currently often ascribed to them. By providing subsidies and opening up their municipality for experiments and demonstration projects, municipalities can contribute to the scale-up of EVs. Furthermore, their visions will be an important driver of their strategies, as these are written down in policy plans. The execution of these strategies, however, will differ per municipality, depending on their size and availability of resources. With regards to inductive charging, the introduction of this technology is expected to create a problem since it is an extra object that needs to be in public space. Despite this interaction, local governments will mainly adopt a passive strategy regarding inductive charging, considering the technology and responding to it when it is brought to their attention by an inhabitant of their municipality.

In order to acquire these insights, this thesis has defined a limiting scope that will guide the boundaries of the research. This thesis will focus on the Netherlands, as they have positioned themselves as frontrunners in the field of electric driving. It will be interesting to see what effect the introduction of inductive charging might have, and how it can possibly help the Netherlands to maintain its pole position. Already three experiments with inductive charging have been set up by different municipalities across the country. Two of these projects concern the inductive charging of buses, and another project looks at inductively charging privately owned cars. Since cars are the dominant mode of transportation, and therefore encompass a significant challenge regarding sustainable mobility, this thesis will focus on inductive charging applied to privately owned cars instead of public transport. However, the projects on public transport will not be disregarded, but they will be used to acquire knowledge on the technology and its future development.

1.2 Research justification

1.2.1 Scientific relevance

This research will provide more insight into the role of local governments in a transition, and how this role impacts the transition to more sustainable mobility. It will clarify how local governments deal with innovative technologies that might contribute to more sustainability. As will be elaborated on in chapter 2 of this thesis, sustainable mobility is a dynamic subject which has redefined certain boundaries, which is for example shown by the close connection that has arisen between the energy domain and the mobility domain. Due to these dynamics, it can be argued that the role of local governments might have shifted as well. By looking beyond the traditional facilitating role that is ascribed to local governments, this thesis has tried to see whether new roles can be identified that are a useful contribution to existing literature. It should be mentioned that although this research specifically looks at inductive charging and what role local governments play regarding this technology, some general recommendations will flow from this research that can be applied to other fields as well, in the context of the municipality.

Furthermore, this research will contribute to the field of Innovation Sciences. First of all, by looking at the role of local governments as well as considering the technology of inductive charging, this thesis will give insight into a complex multi-disciplinary process and the role that actor strategies play in such a process. Secondly, as will be elaborated on in chapter 2, this thesis will contribute to the lack of agency that is present in the framework of SNM by emphasizing visions and expectations. By including the sociology of expectations, a link is created between visions and expectations and actor strategies. Additionally, the framework of SNM is broadened by including literature on the distinction between local and global niches. Attention is directed at processes at the lower niche level, looking at what interactions are present and how multiple niches influence each other and either contribute to or inhibit a sustainability transition. Third, this thesis will add to the existing empirical work that is using the MLP as framework, showing how this framework can be applied, with a focus on the dimension of infrastructure.

1.2.2 Relevance for APPM

This master thesis research is conducted for APPM, a Dutch consulting company. As is described on their website, ‘the approximately 60 employees of APPM work with passion, courage and vision on planning, developing and restructuring urban and rural areas’. The company manages and organizes complex projects, which focus on better accessibility, infrastructure and mobility. Their goal is a future for the Netherlands that is climate-proof, abundant in water and sustainable. The employees of APPM are involved in a broad range of multidisciplinary projects, categorized into four different areas of activity, namely (1) Water, (2) Space & Real Estate, (3) Energy & Climate and (4) Infrastructure & Mobility. This research is located at the interface of the latter two areas, as it considers sustainable mobility, and can be seen as a follow-up of the quick scan on inductive charging that APPM published two years ago (APPM, 2014). The aim of APPM was to gain more insight into the pace and direction of inductive charging, and to find out what local governments should be prepared for regarding this novel technology. Local governments are key players when it comes to charging infrastructure, as they are responsible for the placement of these points in public space. By providing this service to society, they have a direct influence on the pace of a niche such as electric driving. As APPM works closely together with a number of local governments in the Netherlands, this research will help them to recognize opportunities in helping and guiding these local governments. Especially the role that local governments have in a transition will be emphasized, which will help these local governments in realizing more sustainable mobility.

1.3 Research design

As stated in the research question, this thesis will look at the role of local governments in stimulating the transition towards more sustainable mobility. Since the specific role of such an institutional actor has not been researched in this way before, the research goal is exploratory. Furthermore, because visions and actor strategies play an important role in this research, it has been chosen to adopt a qualitative research approach. This approach has been shaped by using a multiple case study design, in order to investigate possible differences within and between cases.

Prior to collecting data in order to answer the formulated questions, a literature study has been conducted. In this literature study, two transition theories have been mobilized. The multi-level perspective (MLP) has helped to position infrastructure as an important dimension in achieving a transition, and furthermore the approach was useful in distinguishing ongoing processes on three different levels, highlighting the importance of dynamics on these levels. Strategic niche management (SNM) served as an addition to this framework, as it is specifically aimed at one of these levels of the MLP, namely the niche. A combination of these two theories was used as the foundation for the questions as stated in the previous section.

Next to conducting a literature study, data was acquired by primarily considering local governments. A total of four cases was selected, which all encompassed a varying range of aspects that were deemed important for the research, such as strategies, activities and resources. Besides the selection of these cases, other stakeholders have been included as well as a data source. However, despite the involvement of actors such as experts and grid operators, still the focus of this research was to gain insight into the role of local governments in stimulating the transition towards more sustainable mobility.

1.4 Outline

In the next chapter, theories and concepts will be introduced that were acquired while conducting the literature study prior to this research. The chapter has been divided into multiple sections, discussing sustainability transitions and the two frameworks that have been used in formulating the sub questions. Also, the link will be established between these theories and the case study on charging infrastructure, arguing how the two frameworks can be used and deployed in mobility studies. This chapter will be followed by chapter 3, which will elaborate on the methodology that has been used. The selected cases will be introduced, as well as the data approach that has been used in collecting and analyzing data.

The body of this thesis is introduced by chapter 4, in which the importance of infrastructure, and especially charging infrastructure, in a mobility transition is highlighted. Furthermore, the current situation regarding electric driving in the Netherlands will be introduced, in order to provide the reader with the context that has directly fed into the formulation of the questions as stated in the introduction. This chapter will be followed by the results, which have been divided into three separate sections. First of all, the municipal visions and strategies will be introduced, which will be followed by the barriers that have been identified regarding charging infrastructure. The third and final section of the results focuses on expectations that have been expressed.

In chapter 6 the research is concluded by answering the research questions that have been posed at the start of this thesis. Since these questions focus on the role of local governments, policy recommendations will be derived which are targeted at improving the current role in order to stimulate the transition towards more sustainable mobility. The second part of this chapter is dedicated to reflection, discussing the strengths and limitations of the research. The chapter will be concluded with suggestions for future research.

2. Theory and concepts

This chapter will introduce the theories and concepts that have been the foundation for the research on the role of local governments, with a focus on charging infrastructure. First of all, the topic of sustainability transitions will be introduced, which will be illustrated using examples from electric driving and its charging infrastructure. Secondly, the frameworks of the MLP and SNM will be introduced, which will both be linked to the area of transport studies. Eventually, some general criticisms will be discussed, and it will be shown how this thesis mobilizes and combines the two frameworks in order to close identified gaps in the literature.

2.1 Sustainability transitions

Previously, innovation system approaches, such as sectoral systems of innovation, mainly focused on the production side where innovations emerge, and did not include the user side (Geels, 2004: 898). In order to broaden the perspective, Geels (2004) introduced socio-technical systems which also look at the diffusion and use of a technology. These systems can be described as a cluster of elements, which include technology as well as regulation, user practices, markets, cultural meaning, infrastructure and maintenance and supply networks (Geels, 2005: 446). Linkages between the different heterogeneous elements within the system are crucial in order to fulfil societal functions (Geels, 2004: 900).

An example of a socio-technical system is transportation. Through the interaction between different elements, services are provided to society such as the possibility to travel from one place to another (Markard et al., 2012: 956). Figure 2.1 gives a graphic overview of the socio-technical system of land-based road transportation, which includes the automobile. This system ‘works’ because all the different social and technical elements are embedded and linked to each other, and together fulfil the societal function of transportation.

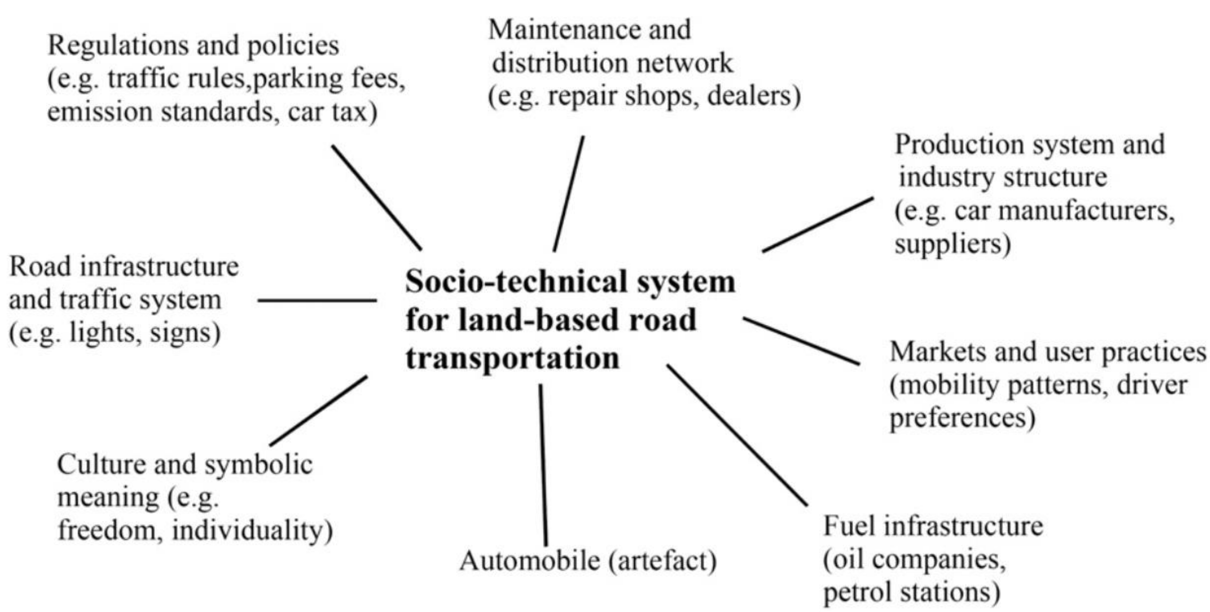

Figure 2.1: Socio-technical system of land-based road transportation (van Bree, Verbong & Kramer, 2010: 531)

A system such as transportation does not function autonomously, but is shaped through the agency of certain actors. Social groups, such as car owners and oil companies, actively create, (re)produce and refine a socio-technical system (Geels, 2005: 446). Interactions between different groups lead to changes within the system, consisting of either incremental improvements of the existing technology or the introduction of a novel technology. If new technologies are introduced, this will influence, for example, policy makers who will have to create new rules, and users, who will adapt their behavior (Geels, 2004: 909). These dynamics lead to the co-evolution of different elements within the socio-technical system.

However, despite the existence of these dynamics in a socio-technical system, radical technologies have a hard time trying to break through as all elements are synchronised to the existing technology (Geels, 2002: 1258). When a new technology is introduced, it therefore often faces a mismatch with the stablished system, which is characterized by stability (Geels & Kemp, 2007: 443). Due to path dependency and lock-in, dominant technologies have an advantage over novel technologies with regards to economies of scale, learning, networks and increasing returns (Geels, 2005: 447). This stability presents a challenge to new and more sustainable technologies that break with the existing regime and are in need of, among others, different regulations, infrastructures and user behaviors. Box 2.1 highlights the case of electric driving, and how it has a hard time trying to break through in the dominant fossil-fuel based regime.

Box 2.1: Socio-technical system electric driving

Although there are already established traffic regulations, the introduction of electric driving requires new policies, for example regarding the exploitation of charging points and the amount of subsidies that is awarded to EV-drivers. There are also difficulties concerning maintenance, especially with regards to car dealers and repair shops. New skills and knowledge are required in order to repair an EV instead of a conventional car with an internal combustion engine (ICE). This issue also plays a role for car manufacturers. Since they have gained experience in manufacturing conventional cars, most production systems are geared towards developing vehicles with an ICE. Some of the existing car manufacturers, such as Toyota and Nissan, have diversified their knowledge and developed a car with electric propulsion. However, mainly new car manufacturing companies, such as Tesla, are solely focusing on developing battery electric cars. EVs also have implications for user practices, as an electric car should be charged every day instead of once or twice a week. Furthermore, there is not a single charging point available for every EV, and recharging takes at least half an hour using a fast charger. Whereas the automobile as artefact has not changed regarding its appearance, there is a significant difference which is the fact that it has an electric engine instead of an ICE. Also, its cultural and symbolic meaning has changed as people feel restricted in their freedom, due to a smaller driving range. This cultural change is reflected in the fact that range anxiety is one of the largest barriers in buying an electric car.

If a shift from one socio-technical system to another, however, does occur, we speak of a transition (Geels, 2005: 446). A transition can be defined as a gradual and continuous process of change, in which the structure of society or a complex sub-system of society is transformed (Farla et al., 2010: 1261). Transitions usually unfold over time-spans of approximately 50 years or more, involving deep changes regarding various dimensions, and including multiple actors. Besides changing the structure of the existing system, related domains are also affected (Markard et al., 2012: 956). This is illustrated by electric driving, which has had an effect on the energy domain due to EV-drivers connecting their car to the grid at the same time, creating a peak demand which needs to be regulated using a smart-grid approach (Nijland, Hoen, Snellen, & Zondag, 2012: 25). A distinction can be made between regular transtions and sustainability transitions. The latter is the transformation of a system within society towards more sustainable types of production and consumption (Markard et al., 2012: 956-57). In the past there have been various transitions, including the transition from candle and gaslight to electrical light (Smith, Voß & Grin, 2010: 440), the transition from horse-drawn carriages to a transport system based on the automobile (Geels & Kemp, 2007: 446) and the gradual transition from sailing ships to steam ships (Geels, 2002: 1263). Box 2.2 elaborates on the latter example, which shows multiple similarities regarding the situation with EVs.

Box 2.2: From sailing ships to steamships (Geels, 2002: 1263-70)

The socio-technical shipping regime was first encompassed by shipping using sailing ships with a wooden construction. Experiments with steamships started to emerge in the late 18th and 19th century in Britain, France and America. These experiments emerged due to the so-called 'canal-boom' in which countries started to form interconnected networks of waterways. Steam tugs were used to maneuver ships through these water ways and into ports. The use of these steam ships was gradually scaled up, from ports to eventually crossing small seas. However, the downside of using steam powered ships was that they had to carry a lot of fuel. Therefore, there was little capacity to transport freight and they were mainly used commercially to transport passengers and mail traffic; the latter one improving telecommunications to a large extent. There were some isolated experiments with steamships on oceans, but the technology of the steam engine was mainly used as add-on on sailing ships that they could use during times of little wind. When trade expanded, the shipping regime started to change. Despite shipping an increasing number of emigrants, the technology of steamships remained inefficient. As the ships started to travel larger distances, more coal was needed. Therefore, attention shifted to technological steamship developments. At this point, a shift started to emerge from wooden ships to iron ships. This involved new challenges as different skills and competencies were needed. Iron ships were first used on a small scale, where its benefits were slowly discovered. As freight transport expanded increasingly due to liberalization, the number of shipbuilding innovations also quickened. Eventually all technological trajectories, aimed at improving individual components of steamships, came together and gradually resulted in a steamship regime.

Similar to the gradual scale-up of the use of steam, the electric engine was used as an add-on to existing vehicles with an ICE in its introductory phase. These cars, known as hybrid vehicles, recharged their engine using regenarative breaking instead of retrieving power from the grid. This add-on of the electric engine gradually scaled up to plug-in hybrids, which are plugged into the grid in order to recharge the battery. Eventually these developments resulted in battery electric vehicles which no longer have an ICE (Canadian Automobile Association, n.d.). As the technology of the batteries improved and the range was extended, the use of EVs shifted from an urban level to travelling larger distances. Currently, these different types of electric vehicles all co-exist with conventional cars, just as sailing ships have continued to exist side-by-side with steamships. Furthermore, just as the shipping regime had an effect on other domains, such as telecommunications, electric driving has had an effect on the energy domain. Whereas the former was a *positive* effect, EVs have had a *negative* impact on the energy grid. Due to the capacity that is required in order for electric cars to recharge, a smart grid is needed in the long run which will require significant investments. This illustrates that linkages between different domains can either have a positive or a negative effect, and can therefore either contribute to or inhibit the diffusion of a technology.

Lastly, the actual shift to steamships was incentivized by a landscape factor, namely the expansion of trade. In the transportation regime, climate change has been the driver on the macro-level, emphasizing the need for more sustainable types of mobility. Another implication of this shift to other technologies is that new skills and competencies are required. In the shipping regime this encompassed the change from using wind to using steam, and from wood to iron. A similar shift is witnessed concerning EVs, as electric engines differ from the conventional ICEs.

This example already gives some insight into the internal dynamics of a system, which play an important role regarding transitions. One way of analyzing these internal dynamics is by using the MLP, which will be explained in the next section. Besides describing the three identified levels and how they work together, attention will be given to how this framework is relevant in analyzing sustainability transitions.

2.2 Multi-Level Perspective

As mentioned in the previous section, the MLP is a useful tool for understanding transitions. These transitions are seen as the result of multi-dimensional interactions at three levels, consisting of niches, socio-technical regimes and an exogenous landscape. Together these concepts help in understanding the dynamics that are at play regarding sociotechnical change (Geels, 2002: 1259). Figure 2.2 graphically represents the three levels of the MLP, which can be seen as a nested hierarchy.

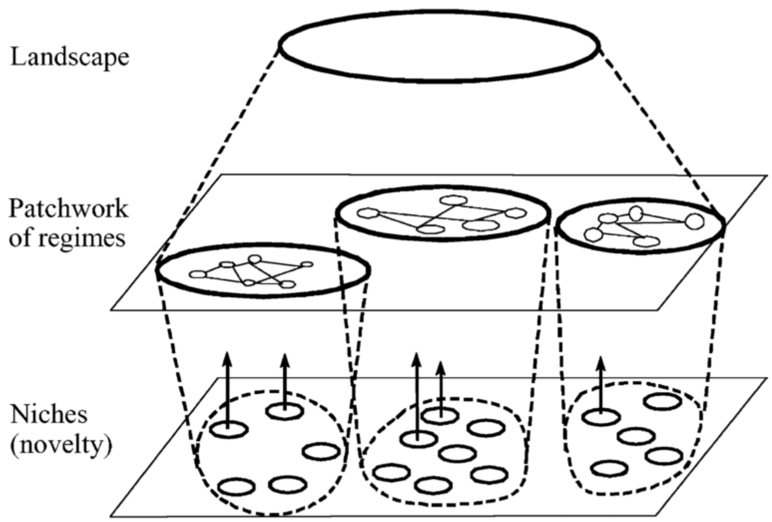

Figure 2.2: Three individual levels as nested hierarchy (Geels, 2002: 1261)

Beside the three levels, there are some elements that characterize the MLP (Geels, 2012: 474). First of all, it has a co-evolutionary approach. As mentioned previously, transitions are not driven by single factors, but occur due to developments at different dimensions. Secondly, the approach is actor-based, which means that it focuses on strategies, perceptions and interactions. The third characteristic is that the MLP encompasses stability, as well as change. It studies lock-ins into the current regime, but also looks at radical change that emerges in the niche. Lastly, the MLP captures all the complex dynamics that take place within the system, and primarily looks at how certain developments reinforce each other. We will now turn to the three different levels, and the section will be concluded on the interactions between these analytical concepts.

2.2.1 Nested hierarchy and its dynamics

The micro-level within the MLP is represented by niches, which are essential in order for a transition to occur as they provide the ‘seeds for change’ (Geels, 2002: 1261). Niches can be seen as ‘protective spaces’ or ‘incubation rooms’ in which different selection pressures prevail, as the performance of these new technologies is not yet competitive given the selection pressures of the regime (Smith et al., 2010: 440). Because of this protection, niches are given the opportunity to grow until they are mature enough to take on competition with the incumbent technology. This protection can have many forms, including subsidization for demonstration and learning, or a specific environment for adoption and experimentation. Due to this protection, niches mainly produce radical innovations, whereas more incremental innovations are usually created within regimes (Geels, 2002: 1260). However, despite the protection measures, many niches are not successful in trying to expand themselves or in surviving for a long time (Smith et al., 2010: 441).

The socio-technical regime represents the meso-level of the MLP, and can be described as the current and dominant way of doing things in order to realize a societal function (Smith et al., 2010: 441). This term was first coined by Nelson and Winter (1982), who talked about ‘technological regimes’. They argue that these regimes are created by engineers and firms who share the same routines. If this community of engineers guides their search in the same direction, the regime can grow out to become a technological trajectory (Geels, 2002: 1259). Because socio-technical regimes are known for their stability, mainly incremental improvements take place along these trajectories.

The technological regime concept was widened by Rip and Kemp (1998) who added ‘rules’ as a category. Whereas Nelson and Winter also included some form of rules, they argued that these shared rules were solely embedded in the practices of engineers. The widening of the regime concept by Rip and Kemp implied that more social groups, such as policy makers and users, had an influence on technological trajectories compared to just engineering communities (Geels, 2002: 1259-60). The prevalent rules act as guidance regarding research activities, and furthermore they have an influence on the strategies that different actors will undertake (Hoogma, Kemp, Schot & Truffer, 2002: 19). This guidance can be described as blinding, since social groups tend not to look at developments outside of their focus (Grin, Rotmans & Schot, 2010: 20). Therefore, rules account to a large extent for the stability and lock-in that characterizes socio-technical systems.

The socio-technical landscape, the macro-level of the MLP, provides the structural context for the socio-technical regimes as well as the niches (Smith et al., 2010: 441). It can be seen as an exogenous environment that consists of a set of connected technological and societal trends, deep structures and events (Hoogma et al., 2002: 27). Examples of these trends are oil prices, economic growth, political coalitions and environmental problems (Geels, 2002: 1260). The landscape itself is not influenced directly by the success of innovation processes within the niche or the regime, but acts as a source of pressure for change on the level of the socio-technical regime (Smith et al., 2010: 441). On the one hand landscape processes can reinforce technological trajectories, and on the other hand they can put stress on dominant regimes such that niche alternatives are considered. Furthermore, landscapes do change, but this happens at a slower pace than the change within socio-technical regimes (Geels, 2002: 1260).

Despite the fact that three individual levels can be discerned, there are a lot of dynamics at play between these levels, which have been illustrated by figure 2.3. On the level of niches, innovations can either break through to compete with the regime, or they can turn out to be failures. The regime-level is characterized by multiple dimensions, which have internal dynamics and may cause tensions. Transitions arise due to these tensions and co-evolutionary developments between various dimensions, after which dimensions are aligned to the new regime. On the landscape-level, broader drivers of a transition can be discerned.

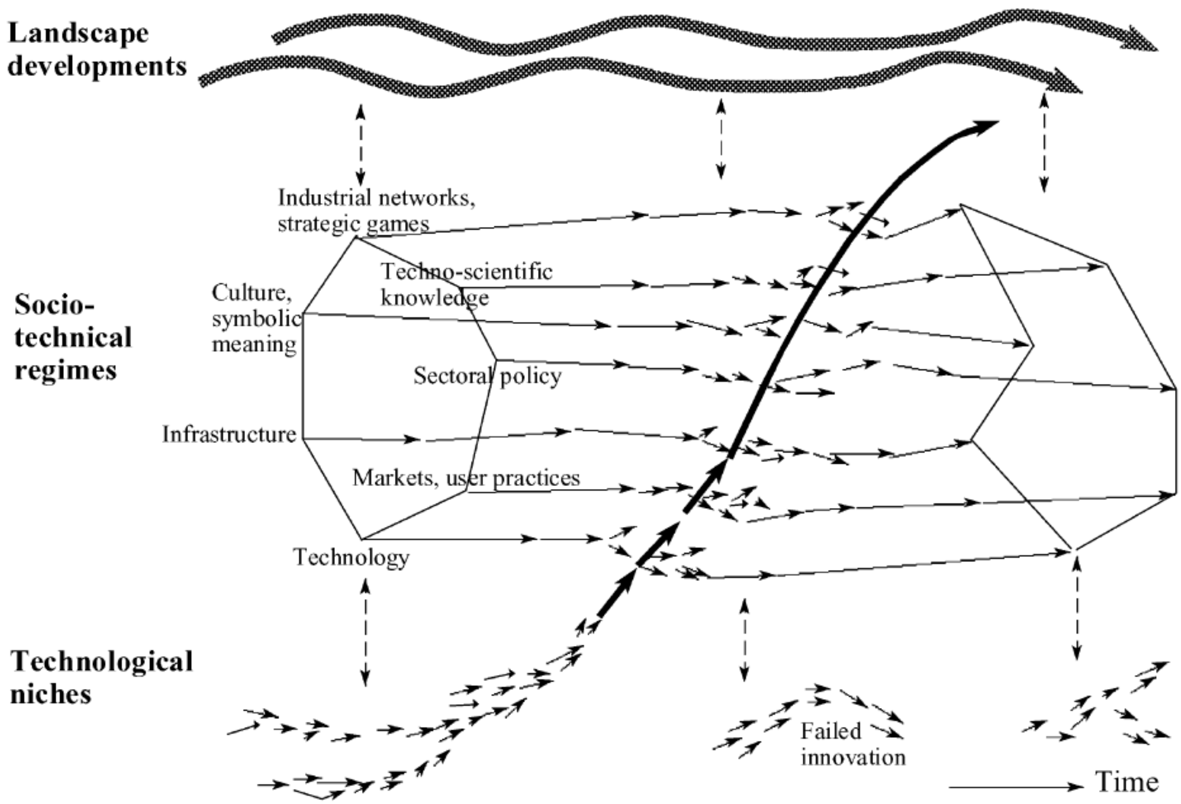

Figure 2.3: Multi-level perspective on transitions (Geels, 2002: 1263)

An example which demonstrates the ongoing dynamics within a socio-technical system, is the transition from horse-drawn carriages to automobiles (Geels, 2005). This transition was initiated by landscape pressures of industrialization and urbanization, leading to different travel patterns. The horse was introduced in order to travel larger distances, but this type of transportation was characterized by various negative aspects, including diseases, due to manure on the streets, and high maintenance and operational costs. These disadvantages created a window of opportunity, leading to the rise of the electric tram and the bicycle. This change was also accompanied by a cultural shift, as driving became associated with fun and entertainment and streets became transport arteries instead of social meeting places. Both the bicycle and the electric tram did not become the dominant way of transportation, but respectively grew out to be a children’s toy and a type of transportation in urban surroundings. Automobiles emerged as a radical new transport option, in which the gasoline car won over steam and electricity. Eventually, this niche transformed the existing regime and a ‘car culture’ emerged. This example shows that the success of a technology, such as the car, does not depend on a single factor or level. There are socio-technical processes at stake, which co-evolve within niches and regimes, and which are subject to an exogenous landscape with certain trends and events.

Whether a shift from one socio-technical system to another will occur depends on the alignment of developments within the three levels. First of all, pressures and tensions from the landscape-level may open up the existing regime and destabilize it, creating windows of opportunity. If niche-innovations have matured enough and are able to build up internal momentum, they might take an advantage of this window of opportunity and leave their protected space in order to develop into a mainstream technology. If this novel technology becomes the dominant practice, this will lead to broader socio-technical changes and, eventually, also result in landscape-changes (Grin et al., 2010: 26). However, there is no guarantee that these dynamics will take place. If niches fail to generate momentum and if there are only small tensions within a regime, windows of opportunity will not emerge.

In our current era, climate change has been an important landscape-factor, driving the need for more *sustainability* transitions, of which electric driving is an example. In the initial phase of such a transition, niche technologies play an important role. As illustrated by the example from Geels (2005), niches incorporate the shortcomings of the regime and present a solution, introducing a technology which improves current practices. For example, bicycles emerged in a niche due to the need for a more hygienic and healthy environment, and inductive charging is being developed since it can remove range anxiety, is more user-friendly and is less intrusive in public space since it is integrated into the ground. However, as long as the different dimensions, which include infrastructure, are aligned to the current regime, it will be difficult for the niche to establish itself. This shows that niches, as well as the related dimensions of the socio-technical system, are important in achieving a transition.

It has been acknowledged that we need to escape lock-in of current regimes and avert path dependencies if we want to move in a more sustainable direction (Smith et al., 2010: 441). The MLP proves to be a helpful tool in this, as it is able to simplify complex transformations and map ongoing dynamics in a straightforward way. Whereas the framework can be applied to numerous sectors, the next section will show the use of the MLP within transport studies as the case study involves sustainable mobility.

2.2.2 MLP in transport studies

There have been numerous mobility studies which have used the MLP as analyzing framework. Geels (2005: 446) has emphasized the importance of the MLP, compared to other frameworks such as large technical systems (LTS) and innovation literature. The former mainly looks at the emergence and development of systems, whereas the latter concerns different analytical levels such as innovation at the national or sectoral level. However, both of the frameworks lack an explanation of how *change* takes place from one system to another. This is where the MLP has an added value, as one of the aspects of this concept is how transitions to new socio-technical systems come about. Furthermore, it is argued that existing literature primarily looks at path dependency and lock-in, while there is no answer to the question how we can understand ‘lock-out’ or change (Geels, 2005: 447). Also, approaches normally only take into account technologies and markets, while aspects such as policies and regulations, user preferences, infrastructures and cultural and symbolic meanings are neglected (Geels, 2005: 448).

The example presented in the previous section, on the transition from horse-drawn carriages to automobiles, shows the strength of the MLP with regards to how transitions take place. Using a substitution approach, this case study is often seen as a case in which horse-drawn carriages were replaced by cars. However, when the MLP is applied to this case, it can be seen that technologies such as the electric tram and bicycle actually acted as stepping stones in achieving the eventual transition towards car-based transportation.

Therefore, the MLP adds great value as a tool in analyzing internal dynamics and historical transitions, uncovering processes at the micro-, meso, and macro-level.

A different paper by Geels (2012) also applies the MLP, and introduces it into transport studies. Using the framework, he identifies promising niche developments, stabilities within the socio-technical regime, and landscape developments. According to Geels, the destabilizing landscape pressure of Peak Oil has a big influence on the automobility regime, since the majority of cars run on petrol. However, despite these destabilizing pressures, he argues that the current regime is kept in place by cultural preferences. People rather have a car as private property compared to collectively owning it, and furthermore the car is characterized by values such as freedom, choice, progress, wealth and status (Geels, 2012: 477). It can be argued that EV is an answer to both these stabilizing and destabilizing pressures. While it retains the benefit of modern cars to a large extent, it still is aimed at making the mobility regime more sustainable as it is not reliant on fossil fuels. This shows that the research of this thesis on EVs and their corresponding infrastructure is valuable in realizing a sustainable mobility transition. Furthermore, Geels argues that various innovative niches have emerged over the last years, but that they are still characterized by uncertainty due to the fact that there are no rules of thumb yet, or stable routines. As an example he mentiones battery-electric vehicles (BEVs), which have seen a declining hype due to uncertainties about technical issues, costs and infrastructure (Geels, 2012: 476). In the author's opinion, the diffusion of such technologies will be slow, due to the fact that they require a completely different refuelling infrastructure. This highlights the importance of novel infrastructures, including the current development of inductive charging.

Van Bree, Verbong and Kramer (2010) also apply the MLP to a sustainable case study, namely the introduction of hydrogen and battery-electric vehicles. They analyse the two cases regarding developments on the three levels, taking a closer look at the relationship between car manufacturers and consumers. The authors come to the conclusion that there is an institutional lock-in of the ICE technology, which complicates the introduction of more sustainable cars. Furthermore, the BEVs that are on the market are not in protected spaces, but still their stability is low as niche experiments have not reduced uncertainty significantly (van Bree et al., 2010: 535). Two scenarios are proposed that could provide the seeds for a transition, including stricter emissions regulation and rising fuel prices. Despite the fact that the MLP is not a predictive framework, this case study shows that it can help to reveal underlying processes of a socio-technical system and draw future lessons from these dynamics.

The different dimensions that are present within the mobility regime are mapped by Geels (2002: 1259), who illustrates the complexity of this socio-technical system. There are, for example, road infrastructures and car regulations which are maintained by ministries. Furthermore, the car has a certain cultural and symbolic meaning which is created through the interaction between users and other societal groups. There are also user practices and patterns regarding mobility, and of course there are car designers and engineers who embody the technological knowledge needed to manufacture a car. The strength of the MLP lies in the fact that it is able to analyze these dimensions separately, but can also bring all the dimensions and levels together to give an overall view of the socio-technical system.

This insight into the use of the MLP in transport studies reveals that transportation systems are highly complex, with many internal dynamics and developments. Furthermore, each case illustrates that there is a lock-in of the automobile regime, which is kept in place by the dimensions that are aligned to this situation. This thesis will go into detail on one of these dimensions regarding sustainable mobility, namely the charging infrastructure of EVs. By using the MLP as framework, linkages will be created between the charging infrastructure and other dimensions, such as user practices and technology, in order to analyze the internal dynamics that are at stake with regards to electric driving. By reflecting on the current status of the sustainable mobility transition, lessons can be drawn that can be fed back into strategic actions for the future in order to stimulate the transition.

2.3 Strategic Niche Management

As mentioned in the previous section, it is interesting to take a closer look at the niche-level where novel and sustainable technologies emerge. For this purpose, SNM has been developed. First, an outline of SNM will be given, with an emphasis on visions and expectations as these are considered important within the framework. The visions and expectations will be linked to actor strategies, after which a distinction will be made between local and global niches. This distinction is especially relevant given the technology of inductive charging, which was used as a case study for this thesis. Finally, an elaboration will be given on how SNM has been used in transport studies.

2.3.1 Introduction to SNM

SNM was introduced as a strategy for governments in order to manage the transition to a different socio-technical regime (Kemp, Schot & Hoogma, 1998: 185) and to understand the 'valley of death' between R&D and the market introduction of a technology (Schot & Geels, 2008: 538). The framework not only encompasses managing the creation and development of new technologies, but also directs attention to the eventual phase-out of beneficial selection pressures that prevail within the niche. In the end the aim of the framework is to learn about the desirability of a technology and to stimulate further development. Whereas the MLP has been proven useful in providing the overall context, SNM zooms in on the micro-level in order to give a detailed description of the ongoing processes at this level. The SNM and MLP can therefore be seen as two complementary frameworks, as SNM focuses on so-called 'niche-internal' processes whereas the MLP also includes external processes, i.e. the socio-technical landscape (Schot & Geels, 2008: 537). However, there is also a significant difference between the two frameworks. Whereas the MLP mainly maps historical transitions and categorizes the processes on the three levels, SNM is looking at existing preferences and tries to find ways to build new ones (Hoogma et al., 2002: 5). This is done through experiments, but it has been shown that these pilot projects often only demonstrate a new technology and do not engage in societal aspects. Furthermore, projects tend to remain isolated and mostly there is no follow-up activity.

The process of niches growing out to new socio-technical regimes is argued to be a bottom-up process. First, novelties emerge in *technological* niches, after which they conquer *market* niches. Eventually they are scaled up and create a transition in which they take over the regime (Schot & Geels, 2008: 540). Three different processes have been distinguished which are essential for the successfulness of a niche, namely (1) the articulation of visions and expectations; (2) the building of social networks; and (3) learning processes at multiple dimensions. It has been argued that visions and expectations play a crucial role in the initial phase of a technology, as they help to broaden networks as well as learning processes (Schot & Geels, 2008: 542). Expectations also act as a guidance for governments, who are more willing to subsidize and invest in an innovation when they expect the technology to have a future benefit for society. Therefore, instead of elaborating on all three processes needed for successful development of a niche, the next section will highlight visions and expectations.

2.3.2 Visions and expectations

Various actors have emphasized the importance of visions and expectations in the early phase of a technology, which is characterized by uncertainty (Bakker, Maat & van Wee, 2014: 55). Especially in the initial phase of sustainability transitions, expectations are of great value since competition is based on expectations instead of on the performance of a technology (Alkemade & Suurs, 2012: 448). This is illustrated in the case study by Alkemade and Suurs, who analyze the expectations of biofuels, hydrogen and natural gas. There is a clear difference between the level of performance of the three fuels. Whereas hydrogen and second generation biofuels are only tested on a small scale, first generation biofuels and natural gas are already commercially available. The authors show that this is related to the convergence of expectations, which can clearly be seen in the case of natural gas. Regarding hydrogen there is a lack of convergence, meaning that there is no consensus regarding the performance criteria of the technology. Such a lack of consensus might become a barrier for the further diffusion of a technology, and therefore requires attention. The authors furthermore point at the important role that the government has in such a situation (Alkemade & Suurs, 2012: 454). They argue that switching to an alternative transport fuel, such as hydrogen or electricity, involves a substantial investment in infrastructure. Since such technologies are not able to compete with fossil fuels regarding price in their initial phase, they also argue that governmental subsidies are important.

Whereas visions and expectations play an important role on the side of engineers and scientists, who are engaged with the technological performance, they also play a central role for policy-makers and users (Borup, Brown, Konrad & van Lente, 2006: 286). Most of the time there is an entire range of beliefs among actors, which is in constant flux, and which has a substantial effect on either stimulating or inhibiting the development of a technology (Hoogma et al., 2002: 21). Expectations also have an effect on the building of social networks and learning processes, as they attract attention from actors and provide direction and guidance to learning processes (Geels & Raven, 2006: 377). This is illustrated by an example from the biogas regime, in which a successful project led to positive expectations, after which a follow-up program was established and eventually an entire biogas *community* emerged. This role of expectations is the strongest at the start of the development of a technology, when it is still uncertain what the future performance will be and how the technology is going to be applied (Alkemade & Suurs, 2012: 450).

Expectations can be divided into three levels, using the same levels as the MLP introduced earlier (van Lente, 1993: 182-83). At the micro-level, expectations about the performance of the technology are made. The meso-level encompasses the functions that the technology is going to fulfill. These expectations are less specific, as they say something general about the direction that the entire field is heading in. The third level is the macro-level, which includes broader statements about the technology as well as societal trends. It is argued that the same dynamics occur as in the MLP, with expectations at the three levels being able to reinforce or weaken each other (Budde, Alkemade & Weber, 2012: 1075). The case of hydrogen vehicles in Germany can act as an example, as expectations on the landscape-level changed opinions regarding hydrogen as niche. Although there were positive expectations regarding hydrogen as niche technology and the performance of fuel cell technologies, the German government reduced its support due to the macro-level expectation that there would not be a need for hydrogen technologies in the short term (Budde et al., 2012: 1081).

There are also some requirements regarding expectations which are needed in order for them to be successful and make a contribution (Schot & Geels, 2008: 541). Firstly, expectations should be robust, which means that they need to be shared by a substantial number of actors. In order to create a niche in which a technology can be developed, especially these *shared* expectations are a requisite (van Lente, 1993: 59). When there is alignment between different stakeholders, expectations tend to become stronger. Therefore, the larger the number of groups that share the expectations, the more successful they can be considered (Alkemade & Suurs, 2012: 450). However, there is a difference in the effect that a social group has on society, which is related to its level of influence. Expectations that are expressed by governments can be seen as more influential, and they might have a bigger impact than if they were expressed by a different social group. The downside of this is the high costs that are involved if credibility is lost, for example, due to the government not being able to fulfill certain expectations. This also has an effect on the technology in question, which will encounter more difficulty in its diffusion in society. The second requirement has to do with the specificity of the expectation, since too general expectations are not capable of giving guidance. More detailed expectations can mostly be found on a local level (van Lente, 1993: 49). Finally, expectations should have a certain quality which is empowered by ongoing projects.

This section has shown that visions and expectations have large influence on transitions, and in particular on niche-building. Besides influencing the path of a technology, expectations have also been shown to guide strategic behavior by stakeholders (van Lente, 1993: 449). Therefore, the next section will constitute the link between expectations and actor strategies, showing how they are interrelated and how they influence each other.

2.3.3 Actor strategies

There is a close link between expectations and actor strategies, which has been studied in the sociology of expectations (Budde et al., 2012: 1074). On the one hand, actor strategies are dependent on expectations, but on the other hand strategies are geared towards influencing the socio-technical system in a way that matches the actors' expectations (Bakker et al., 2014: 55). Eventually, actor strategies are translated into certain activities which have an effect on the overall transition (Budde et al., 2012: 1076). There is a wide range of reasons for actors to support a transition, whether these actors are incumbents or new to the field. This section will outline some actor strategies, which have been distilled from the literature. These actor strategies will primarily zoom in on governmental actions, since local governments are important in the planning of projects at the niche-level (Quitzau et al., 2012).

Transition management literature has defined a categorization of roles, depending on the phase the transition process is in (Rotmans et al., 2001: 25-6). In the preparation phase, the government should act as a catalyst, creating a diverse and substantial playing field and organizing discussions with relevant actors. In the second phase, take-off, the government should mobilize the actors and move them in the direction of the transition goal. In the acceleration phase, the government should take on the role of stimulator, encouraging learning processes. This can be done, for example, by setting the agenda or creating niches. The role of the government in the last phase, the stabilization phase, is characterized by controlling and consolidating. There should be guiding processes which are oriented at embedding the new technology in society, and preventing it from having backlashes. Overall, this theory on the categorization of roles gives insight in whether corresponding roles have been adopted in different phases of the development of a technology, and the effect that these roles have had on the further diffusion of the technology.

Traditionally, the role of governmental bodies is to finance the pre-competitive phase of an innovative or novel technology, but recently they have also been involved in actively creating and shaping a niche where experimentation can take place (Farla, Markard, Raven & Coenen, 2012: 995). As emphasized by SNM, building an actor network and engaging in learning processes are two other key aspects besides visions and expectations for a niche to be successful. Therefore, the government should contribute to a collective learning process and it should motivate other actors to get involved in a transition (Rotmans et al., 2001: 25). Particularly regional governments can play an essential role, since they are closer to their citizens and because their local areas provide the perfect spaces for experimentation.

An example of this is given by Quitzau et al. (2012) who look at the transformative capacities that strategic work can have at the spatial scale of a town. They outline a Danish case study regarding more energy efficient houses, in which a gap was identified between policy visions on sustainability and the actual implementation of these visions in practice. In this case, the local government had an important role as a new framework was needed for tighter regulations regarding energy efficiency. By adjusting certain regulations and mobilizing relevant stakeholders, the local government unchained a sequence of local energy efficient innovations, which were implemented in several houses. However, despite the fact that the political approach changed from traditional to transformative, there appeared to be so-called 'local anchorage'. Although demonstration projects and experiments have the potential to contribute to wider changes, knowledge tends to be contained on a local level (Quitzau et al., 2012: 1056). This 'local anchorage' has been emphasized by Geels and Raven (2006) as well, who argue that it is not only important to look at the developments *within* projects, but also *between* projects, in order to accumulate knowledge and make the translation from the local to the global level. In combination with the importance that local governments have, more research is therefore needed on how local policy-makers can act as a lever in challenging socio-technical regimes.

As mentioned earlier in this thesis, experiments should not be overly contained in order to be able to contribute to wider learning processes, and eventually the scale-up of a technology. Knowledge that has been acquired at a local level needs to be translated into general rules, which can compete with the existing socio-technical regime. The case of inductive charging is such a technology on the local level, which has the potential to contribute to the global level of electric driving. In order to gain insight into the dynamics at the two lowest levels within the niche, the next section will elaborate on the difference between local and global niches, and show how these two can reinforce each other to contribute to an overall transition.

2.3.4 Local and global niches

Whereas SNM mainly focuses on how a technological niche grows out to become a market niche and eventually triggers a regime-shift, the framework makes no clear distinction between projects on a local level and the global niche-level. A contribution to this distinction was made by Raven and Van Mierlo, who signaled the need for a differentiation between the two levels (Schot & Geels, 2008: 543). This addition broadened the core of SNM, which revolves around the three niche-internal processes discussed earlier. It is argued that niches should not be seen in isolation, but that they are an interconnected set of smaller, local niches, which may jointly create a new regime (Bakker, van Lente, & Engels, 2012: 423). Whereas the local niche is characterized by specific projects, that are carried out within firms or organizations, the global niche consists of an emerging field, such as electric vehicles. Despite this description, the distinction between the two levels can be interpreted in different ways. Box 3.1 therefore positions the charging infrastructure of EV according to this theory, as this is the subject of the case study.

Box 3.1: Positioning charging infrastructure

The local-global distinction can be made at different levels. According to the theory by Geels and Raven (2006), electric driving can be seen as a technological niche that contributes to the global niche of sustainable mobility, while competing with other technological niches such as hydrogen cars. However, when we translate this framework to charging infrastructure, it can be argued that this infrastructure is one of the ‘local’ niches contributing to the global niche of electric driving. As mentioned, there can be technological variations on the local level. Despite the dominance of conductive charging as infrastructure, inductive charging is a promising charging technology which might contribute to the scale-up of EV for various reasons.

Inductive charging is, for example, an easy-to-use technology, as it takes fewer steps in order for the vehicle to recharge compared to the current situation (APPM, 2014). Whereas conductive charging requires the user to connect its car to a charging point using a cable, users need not necessarily exit their car when using inductive charging. Since this is a user-friendly process, it is likely to contribute to the image of the electric car in a positive way. In the long run, inductive charging may even extend the range of the vehicle by applying *dynamic* charging. This will help to overcome range anxiety, which is currently one of the largest barriers in buying an EV. Multiple experiments are already being carried out with inductive charging in municipalities such as ‘s-Hertogenbosch, Utrecht and Rotterdam. These experiments justify the fact that inductive charging can be seen as a technological niche.

On the local level, niches can either complement each other, or they can become rivals and compete for support. Whereas research has already focused on the former process, it is argued that the latter leaves some questions to be explored (Bakker et al., 2012: 422). Especially this competition is important given the sector of mobility, as multiple car designs are introduced that differ radically from each other, including the infrastructure that they will use. According to literature, different design options should be brought together, and merge to form a single set of design rules that prescribe what the most effective and favorable design of the technology is (Bakker et al., 2012: 423). By combining expectations on the local level and translating them into generic rules, they can contribute to the perceived gap that has been identified within a niche and help it in order to mature and shape a new regime. However, it is difficult to end up with a generic design when multiple designs have to compete for the same resources, which actors have to divide between the available technologies. As we saw in the previous section, if there is a lack of shared expectations on which technology will eventually contribute to the global niche, this will influence its trajectory and therefore its contribution to strengthening the global niche. Translating this information and applying it to the case of electric driving and its charging infrastructure, it can be argued that inductive and conductive charging also compete for the same resources, which may influence their trajectories and the common goal of promoting electric driving.

Besides the distinction that has been made between the processes on the two levels, the levels have also been described regarding the type of knowledge that is prevalent, and its specificity. On the local level, knowledge includes more hands-on-experience and skills among involved actors, whereas global knowledge consists of more abstract and generic rules which are shared in a community. Although these global rules act as a guiding frame, there is still room for adjustments and interpretations on a local level (Geels & Raven, 2006: 377-78).

Developments progress simultaneously at both levels, and sequences of projects on a local scale may eventually add up and contribute to a technological trajectory at the global level. This process, known as niche accumulation, does not evolve autonomously, but is the outcome of ‘aggregation activities’. In these aggregation activities, such as standardization, writing handbooks and the formulation of best practices, local knowledge is translated into more generic and robust knowledge which is no longer tied to a specific context (Geels & Deuten, 2006: 266-67). Figure 2.4 illustrates the ongoing processes and how they contribute to a technological trajectory. Besides setting up aggregation activities, also an infrastructure has to be created in which knowledge is circulated. The theory emphasizes the importance of bringing together actors in activities such as forums, seminars and workshops, in order to exchange information from local projects and transforming this knowledge into more general rules at the global level (Geels & Deuten, 2006: 268).

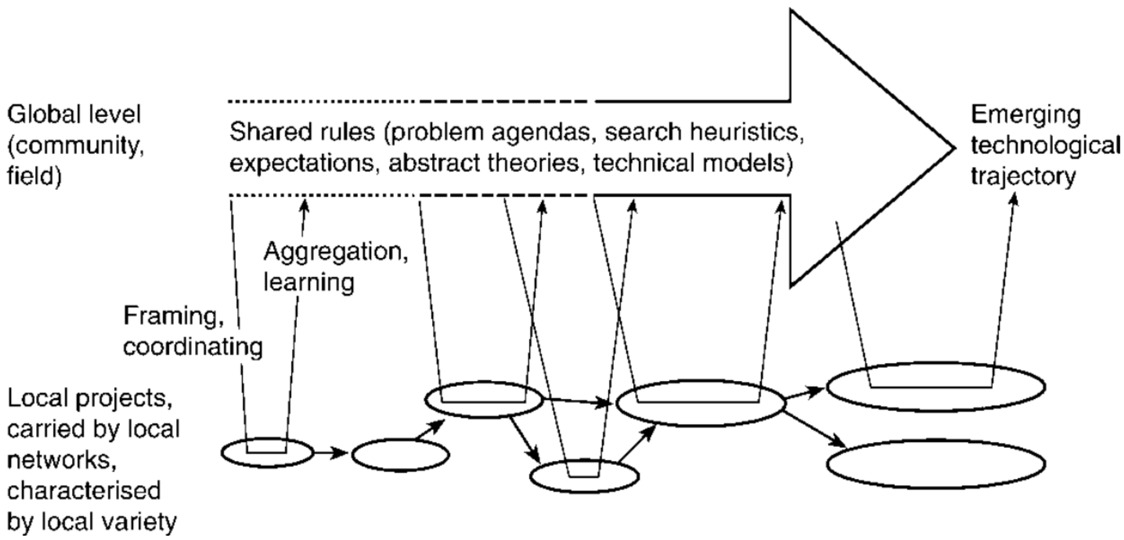

Figure 2.4: Technical trajectory carried by local projects (Geels & Raven, 2006: 379)

In addition to the need to bring together relevant actors, also learning processes are highlighted in this specific theory on local and global niches. These learning processes are the backbone of aggregated knowledge, leading to general rules which are more articulated, specific and stable than the context-bound rules at the local level. Even failed experiments can contribute to a transition, by sharing knowledge on what strategies *not* to pursue in subsequent projects. However, the overly contained way in which experiments are set up presents a drawback, as not all projects are willing to share their experiences (Schot & Geels, 2008: 544).

The preceding sections have shown that the theory on SNM has been broadened by several authors, regarding aspects such as expectations and local and global niches. Because of the scope of this theory, it can be applied to various domains, as was the case with the MLP. As the thesis will zoom in on the mobility domain, the next section will elaborate on how the framework of SNM has been used in transport studies.

2.3.5 SNM in transport studies

As mentioned previously, SNM is presented as a tool for managing certain niches in order for them to grow out to become a socio-technical regime. Besides analyzing these general transitions from niche to regime, the framework is especially useful for *sustainability* transitions. There are several domains with a promise for more sustainability, including transportation, but the niches that emerge in these fields often perform badly in the initial stage of their development (Schot & Geels, 2008: 538). Hoogma et al. (2002) have published a book which applies SNM to sustainable transport studies, primarily focusing on experiments within this field. One of the niches that they outline concerns electric driving, arguing that battery powered vehicles are likely to contribute to a regime-shift (Hesse, 2005: 104). They argue that this shift will be stimulated if the technical product is used in a more careful fashion. By this, they mean that people should for instance plan their trips beforehand due to the restricted range of the vehicle. In this light, it is interesting to research inductive charging, as it has the potential to be applied in a dynamic way in the future, reducing range anxiety. Furthermore, this will take away the barrier that niche technologies should be used in a different way compared to user practices in the regime, stimulating the transition towards more sustainable mobility.

Furthermore, Hoogma et al. (2002) outline eight mobility experiments throughout Europe. These experiments include a variety of options, ranging from bicycle schemes and car sharing to public transportation. Based on the analysis of these experiments, it was shown that the projects were overly self-contained, had a minimal involvement of outsiders and focused too much on technical learning (Hoogma et al., 2012: 192). This information is useful when considering inductive charging, since this technology is still in its experimenting and testing phase. In order for such projects to contribute to the higher level of electric driving, it should include outsiders, share knowledge and not only focus on technical aspects.

As was shown in the previous section, the distinction between the local and global niche-level was made in order to de-emphasize the processes *within* experiments and underline the importance of aggregation and accumulation *between* projects. This additional theory has been applied to the field of transportation as well, studying the emergence of electric vehicle recharging plugs (Bakker, Leguijt & van Lente, 2015). Taking the technological design of charging plugs as starting point, it was shown how local processes can lead to the lock-in of a certain design and, therefore, how they have a large influence on global processes that are needed for a transition. On the one hand, local projects should comply with local rules, but on the other hand they should be able to break free from this local context and diffuse globally. This, once again, underlines the importance of the aggregation of knowledge that resides within local projects and the crucial role that local actors play. Regarding inductive charging, it will prove interesting to look at the knowledge exchange that is present between different local governments and what strategies they pursue in this. This can help to map the development of the technology, and see where it is possibly hampered by a lack of information exchange and active strategies.

These examples show that for this thesis, the framework is useful in several ways. First of all, it complements the MLP as it helps to focus on the niche-level and especially on the experiments and demonstration projects that have been initiated regarding inductive charging. Secondly, the extent to which there are shared expectations, relevant actor networks and learning processes, tells something about the contribution of these niches to a sustainable mobility transition. However, although the MLP and SNM are relevant frameworks for this thesis, some criticisms have been expressed regarding the theories. Therefore, the next section will elaborate on these criticisms, also arguing how this thesis tackles them.

2.4 General criticisms

Despite the fact that the MLP has been presented as a suitable framework for analyzing the charging infrastructure of electric driving, the theory has received some criticisms. Therefore, this section will elaborate on these criticisms and show how this thesis has backed up these shortcomings. Findings have primarily been based on Geels (2011) who responds to seven criticisms, and Smith et al. (2010) who have dedicated a section in their paper on research challenges related to the MLP. The criticisms that will be discussed in the following paragraphs have been selected based on their influence on this research.

The first criticism that is mentioned by Geels (2011: 29) is the lack of agency, which is backed up by Smith, Stirling and Berkhout (2005: 1492). Geels refutes this point by saying that the multi-level alignments are enacted by social actors. However, the MLP groups actors according to their function, such as industry and government, neglecting the mutual differences that are present *within* such a category. Instead of looking at the interactions *between* different groups of actors, more attention needs to be directed at how actors shape their *own* strategies. For example, a local government can actively choose to invest in charging infrastructure, whereas another local government might outsource this task to market players and not dedicate any extra budget to this. Despite the fact that they can both be categorized as 'local government', their strategy is significantly different. In order to respond to this criticism, the decision has been made to include the framework of SNM which, among others, emphasizes the importance of visions and expectations. These visions and expectations will offer relevant insights regarding the strategic orientation of local governments, and therefore contribute to the level of agency.

Secondly, there is a criticism regarding the operationalization of the MLP (Geels, 2011: 31). Whereas Geels focuses his response on the regime-level, Smith et al. (2010: 443) extends this to the niche-level as well. The overall critique is that it is unclear how the different conceptual levels should be applied. For example, the mobility regime could be considered as a whole, but also the regime of public transportation could be studied. Both are categorized as a regime, but there is a substantial difference in what they comprise. A radical change in the latter regime, might only imply an incremental innovation on the level of the entire system. Therefore, this thesis has mobilized the theory of SNM in order to define the boundaries of the case study that is considered, since this considers the niche of electric driving. Furthermore, the theory on local and global niches by Geels and Raven (2006) has been used in order to further demarcate and position the case study.

Another comment regards bias towards bottom-up change models, which argues that changes start within niches and gradually work their way up towards regimes (Geels, 2011: 32). Smith et al. (2010) add to this that there are ongoing interactions between the niche- and regime-level, and that therefore regimes should not be disregarded. This thesis is subject to the bottom-up bias, since it uses the framework of SNM, which specifically zooms in on the niche as the place for radical innovations. In order to avoid this bias, the niche should be placed in context, and attention should be given to the dimensions of the regime which influence the niche. This is done by including the barriers of charging infrastructure, which contrast the niche-development with the current practices in the regime, giving rise to certain bottlenecks that need to be overcome.

Related to this is a criticism that SNM tends to focus too much on the experiment itself, instead of on the broader context. It is argued that a niche technology should also be considered and refined according to the *practical* context in which it will be applied (Quitzau et al., 2012: 1051). Regarding the charging infrastructure of EVs that will be considered, a strong interaction is present between the regime and this infrastructural niche. As mentioned earlier, this charging infrastructure, among others, has an impact on the electricity grid and it also has an effect on public space, which are both aligned to current practices. Despite the fact that this thesis will mainly devote attention to the two niche technologies of conductive and inductive charging and their trajectories, it will also link these technologies to the practical context to which they will be applied. As this context consists of the current infrastructure, also the regime-level will be taken into account. This again relates back to the previous criticism, which concerned giving attention to the dimensions of the regime as well.

Fourthly, critique is aimed at the historical case studies that were used by Geels to illustrate the MLP. In particular the quality of secondary data sources is questioned, which might have been interpreted incorrectly by the author. Despite the fact that this was aimed specifically at the empirical cases of Geels, this notion is also applicable in a broader sense. The quality of secondary data might play a role in this thesis as well, since inductive charging is a new technology, about which relatively little is known. Most data that is available with regards to this technology is about technical specificities, whereas this thesis will zoom in on more social aspects of the technology. However, the collection of primary data, such as interviews, can complement secondary data to a large extent and help in correctly interpreting these secondary sources.

All in all, this section has shown that the framework of the MLP has some shortcomings which need to be taken into account. The approach of SNM has been proven useful in filling the gaps that were identified, and has therefore been included as a framework in this thesis. Because of the technological developments that are taking place regarding transport, and especially *sustainable* transport, it is interesting to take a closer look at the niche-level where these novel technologies emerge. SNM has proven to be an appropriate framework for this, emphasizing the importance of visions and expectations, and linking them to actor strategies and activities which will help to achieve a transition.

2.5 Reflection on theory

The previous sections have provided the thesis with a theoretical roadmap with relevant literature on what aspects are important to achieve a transition. The MLP has shown that there are several dimensions which currently constitute a barrier between the niche and the regime-level. On the niche-level, SNM furthermore made a relevant contribution as it distinguished three internal processes that are needed for a successful transition. One of these processes, visions and expectations, particularly has an important function in the initial phase of a niche, as it helps to gather actors and guide learning processes. Furthermore, these visions and expectations showed a close and reciprocal relationship with actor strategies. Local governments were highlighted, showing their importance in the introductory phase of a novel technology. Since they are responsible for the local level, where radical experiments can be introduced in close interaction with citizens, it is argued that they have an influence on the pace and direction of technologies that contribute to a sustainability transition.

Since there is an increasing need for a transition towards more sustainable mobility, this thesis applies the theories and concepts to the case study of electric driving. Focus is particularly aimed at charging infrastructure, since infrastructure is an important dimension which has been identified by the MLP. Aligning infrastructure to a new technology might take down part of the barrier that is currently present between the niche- and regime-level, and therefore might help in the scale-up of EVs. Besides the existence of a conductive charging network, recently inductive charging has been introduced. Given the importance of infrastructure, it can be argued that this technology will help to stimulate EV as it is more user-friendly and since it is less intrusive than the charging points that have to be placed in public space.

In the transition towards sustainable mobility, local governments have started to play an important role. Whereas infrastructure in general is normally regulated by the national level, there has been a shift towards the local level because of the impact that charging infrastructure has, among others, on public space and local electricity grids. There has already been some research on the role of local governments in a transition, as shown in the example by Quitzau et al. (2012) which highlighted the importance of local authorities in the building sector, and the categorization of actor strategies according to the development phase of the technology that was presented by Rotmans et al. (2001). However, despite the need for a transition regarding sustainable mobility, and the availability of sustainable technologies such as EVs, there is no literature on the role of local governments in this field. To understand how they can guide and stimulate the transition towards more sustainable mobility, the broader and guiding question of this research is defined as,

> *What is the role of local governments in stimulating the transition towards more sustainable mobility?*

As already mentioned, three aspects have been identified that are crucial in achieving a transition. First of all, there are ongoing processes between the niche and the regime which create barriers and therefore inhibit a further diffusion. Secondly, visions and expectations play an important role as they are necessary for the successful development of a niche. The third aspect that has been identified regards the local niche level. Processes on this lowest level are important since they can contribute to the global niche, which in this case is electric driving. However, competition between multiple technologies might influence their technological trajectory, and have an effect on the contribution of these technologies to the global level. These three different aspects and their relations have been graphically represented in figure 2.5.

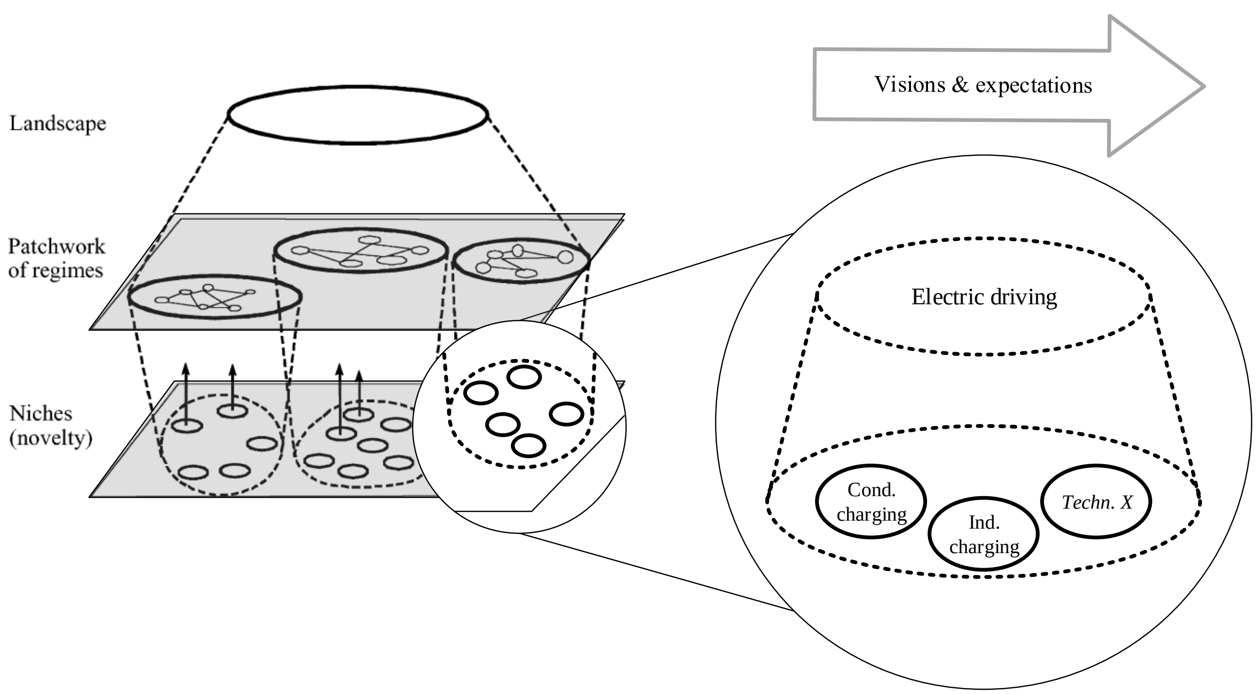

Figure 2.5: Representation of the three identified processes needed for a transition, according to the MLP and SNM

The literature highlighted the importance of dimensions in a transition. Misalignments between the dimensions of a niche and regime act as a barrier in the further scale-up of a niche technology. Despite the existence of charging infrastructure, EVs are not the dominant way of transportation. Therefore, it can be argued that there are still bottlenecks that withhold this niche from becoming the dominant practice. In order to stimulate the transition towards more sustainable mobility, these bottlenecks need to be identified and overcome. Given the importance of local governments regarding charging infrastructure, and the main question regarding their role in the transition, it proves interesting to look at how local governments currently tackle identified barriers. Therefore, the first sub question has been defined as,

> *How do local governments tackle the bottlenecks that are identified regarding the implementation and managing of charging infrastructure?*

Zooming in on the local level, visions and expectations are important since they are needed for the successful development of a niche. Especially regarding a novel technology, such as inductive charging, expectations and visions need to be aligned in order for relevant actors to get together and start learning processes. If expectations show a lack of convergence, this can inhibit the further diffusion of a technology. Since inductive charging might have a positive effect on the infrastructure of EVs, it is important to find out what expectations are related to it and to what extent there is consensus regarding its potential contribution. According to literature, expectations are furthermore important since they are closely related to actor strategies and therefore influence what strategies local governments pursue in achieving more sustainable mobility. These two aspects have been combined in the following question, which is formulated as,

> *How do visions and expectations shape the role of local governments in the rollout of charging infrastructure?*

Furthermore, the niche was divided into two levels, namely the local and the global niche. It was argued that on the one hand different technological niches can reinforce each other, but also competition can occur. Since inductive and conductive charging are both infrastructural technologies, it can be argued that they have to compete for the same resources, which may influence their trajectories and the common goal of promoting electric driving. It is therefore interesting to look at the two charging infrastructures and their interaction, and how local governments mobilize this expected interaction on the local level in order for it to contribute to the global level of electric driving. Given this information, the last question has been stated as,

> *How will the inductive and conductive charging infrastructure influence each other, and how do local governments mobilize this interaction to stimulate the uptake of EV?*

By looking at multiple levels that are important when considering a transition, and by identifying the role that local governments play on each level, this thesis aims towards answering what the role of local governments is in stimulating the transition towards more sustainable mobility. In order to show how the research has been executed, the next chapter will elaborate on the methodology that has been used and it will furthermore introduce the case studies.

3. Methodology

This chapter will explain in detail how the research for this thesis was conducted in order to answer the sub questions and the main research question. As already mentioned in the research design, a qualitative multiple case study design was used besides an extensive literature study. The first section of this chapter will introduce the cases that were selected for this case study design. The sections that follow will explain how data has been collected and analyzed, and attention will be given to the validation of the acquired data.

3.1 Case selection

The cases that formed the foundation for the multiple case study design were selected based on their added value to gain insight in the role of local governments. A total of four case studies was selected, which is illustrated in table 3.1. Two selection criteria have already been illustrated in this table, namely the size of the municipality and the policy regarding charging infrastructure. The former criterion has been included due to the fact that it is expected that municipalities of a different size experience different bottlenecks in the implementation of electric driving and its related infrastructure. Furthermore, the resources with which they shape their strategies and tackle these barriers will be different, despite the fact that the vision of municipalities of all sizes will encompass working towards a more sustainable society. A hypothesis is that larger municipalities will have more financial leeway as well as organizational capacity to take on novel technologies, compared to local governments with a smaller size. Since the main question concerns the role of local governments, it can be argued that the role of these municipalities is influenced by their size and that different roles can be ascribed depending on the municipal size. The categorization of sizes, which is shown in the second column of the table, has been made using the size classes of the Central Bureau for Statistics as a guideline.

The second selection criterion that has been used is the policy on charging infrastructure, in which a distinction is made between active and passive. Municipalities are argued to pursue an active strategy if they have a policy that stimulates charging infrastructure financially, and they are said to have a passive strategy if there are no financial means dedicated to stimulating charging infrastructure. It is expected that this distinction has an influence on the extent to which the municipality is able to contribute to a transition towards more sustainable mobility. Active municipalities are more likely to mobilize novel technologies, such as inductive charging, in order to stimulate the uptake of EV, and furthermore they are expected to handle identified barriers in a more pro-active and dedicated way than local governments with a passive strategy. The deliberate decision has been made to focus on four municipalities instead of six, since, in general, there are no small municipalities which have the financial means to pursue an active strategy, and there are no large municipalities in the Netherlands which are not actively engaged in deploying charging infrastructure. Furthermore, this decision also helped in narrowing down the scope of the research in order to obtain an in-depth analysis.

Table 3.1: Four selected case studies categorized according to their size and policy regarding charging infrastructure

Size municipality		*Policy regarding charging infrastructure*	
		Active	**Passive**
Large	> 250.000	Rotterdam	
Medium	50.000-250.000	Ede	Groningen
Small	< 50.000		Bladel

Another advantage of these case studies is that they reflect two market approaches which are the most common in the Netherlands with regards to charging infrastructure. The municipalities that pursue an active strategy have adopted the concession model, and the municipalities that are judged as passive have a licensing model. Additionally, the case studies are located in four different corners of the Netherlands, as illustrated by figure 3.1. This illustrates that electric driving is not a geographically clustered phenomenon, but that it is something all local governments should be prepared and equipped for. Related to this geographical scattering is the aspect that all municipalities are located in a different province, namely South Holland, Gelderland, Groningen and North Brabant. It is useful to take this provincial scale into account, since it might have an influence on the role of local governments, for instance by provincial rules and regulations that are prescribing policies on the municipal level.

Figure 3.1: Overview of the studied municipalities

Lastly, including Rotterdam as a case study provided the research with data on conductive charging as well as inductive charging, as they have recently initiated a project in which they look at inductively charging two passenger vehicles. The municipalities of ‘s-Hertogenbosch and Utrecht are working on inductive experiments as well, but they have included buses instead of cars in their experiment. Since this thesis focuses on the car as dominant type of transportation, Rotterdam was preferred as case study.

3.2 Data collection and recording

Data was collected in several ways, starting with an extensive literature study to uncover the dynamics that are at play when considering a niche technology and what concepts are important to consider in that context. The basis was mainly formed by academic articles from journals such as Research Policy, Technological Forecasting and Social Change, Technology Analysis and Strategic Management, and Energy Policy, among others. A snowballing method was applied to find more relevant papers, by looking at which papers were cited by the authors. Papers on the MLP- and SNM-framework formed the most substantial part of the literature, after which these concepts were linked to the subject of interest which is the dimension of infrastructure. This was done by analyzing academic articles on the importance of infrastructure, and this literature was complemented by other informative documents on electric driving and charging infrastructure in the Netherlands. Eventually, these concepts were translated into a main question and sub questions which guide the research.

Besides the literature study, interviews were conducted to collect relevant data in order to give an answer to the sub questions and the main research question. Conversations with stakeholders responsible for the charging infrastructure in each municipality formed the most important part of these interviews, as the research concerns the role of these local governments. Since there is a close link between the energy domain and the mobility domain, also interviews were held with grid operators. At first the idea was to interview the different grid operators that are active in the four municipalities, which are respectively Enexis, Stedin and Liander, but after three interviews with grid operators there was saturation of the data, so it was decided that no further interviews with grid operators were needed. Additionally, expert interviews were held with people engaged with the technology of inductive charging. This was done to acquire background knowledge on the subject, as well as getting an idea of the issues at stake regarding this novel technology and how these might interplay with the role of local governments. The method of snowballing was used in order to find out whether there were other potentially relevant interviewees. However, in the case of municipalities, there was often only one person responsible for the charging infrastructure and therefore the snowballing method had no effect. Furthermore, once the collected information showed saturation it was decided not to plan any more interviews due to time constraints. A list of all interviewees and relevant details can be found in Appendix A.

The interviews were conducted in a semi-structured manner, which made sure that all relevant information would be discussed, while at the same time providing room for the interviewee to bring up other information. The questions that were asked were based on the three sub questions, which encompass visions and expectations, barriers of charging infrastructure, and the interplay between the conductive and inductive charging infrastructure. The interviews were adjusted based on the background and function of the interviewee. Questions asked to the municipalities focused on three different parts, namely the conductive charging infrastructure, the inductive charging infrastructure and the combination of the two infrastructures. Although this is a different categorization than the three sub questions formulated earlier, visions and expectations, barriers and the interplay of the two technologies were incorporated into these questions. In the interviews with grid operators focus was shifted to the barriers they identified in deploying charging infrastructure and their expectations regarding inductive charging and what the consequences of this technology would be for them as grid operators. The expert interviews again had a different focus, as the questions asked in these conversations tried to uncover more in-depth information on the technology itself and its application in society. Finally, there was one interview with the municipality of Rotterdam which specifically focused on the project with inductive charging, and therefore the questions asked during this interview were adjusted to fit the narrow topic. An example of the interview guide, with questions asked to municipalities, can be found in Appendix B. Furthermore, because of the diversity of interviewees and their varying knowledge on the subject of inductive charging, a short narrative was sent along with the questions in order to give the interviewees an idea of the technology and its advantages and disadvantages. This short summary on inductive charging can be found in Appendix C. Originally, both the interview questions and the summary were in Dutch, but they have been translated for the purpose of this thesis.

Prior and parallel to the interviews, more information on the case studies was gathered, consisting of informative documents and policy reports, among others. This data was fed into the interview questions to acquire more in-depth answers or clarifications on certain issues. Besides gathering the data via interviews and documents, a visit was made to the inductive system that has been placed in Utrecht to get an idea of the technology and how it is actually implemented in the existing environment. All this data provided a solid foundation to move onto the analysis.

3.3 Data analysis and validation

Several steps were taken to analyze the collected data, taken from Creswell (2009) who elaborates on steps to be taken in qualitative data analysis. First of all, the interviews were transcribed and they were analyzed to a certain extent by retrieving relevant quotes from these transcripts. These quotes already gave an idea of the main concepts mentioned by the interviewees, and helped in creating a pattern. Afterwards, these transcriptions were structured by giving them specific codes in Excel, in a process known as content analysis. The codes were based on the three sub questions that were formulated, which encompass visions and expectations, bottlenecks in the deployment of charging infrastructure and the interplay of conductive and inductive charging. These codes formed rough guiding categories, after which the categories were adjusted based on the actual information that was retrieved from the interviews. Eventually, a total of four coding categories was defined, consisting of visions, the role of local governments, expectations and bottlenecks.

The mentioned visions and the identified role of local governments were taken together, as literature argued that there is a close relationship between the visions and strategies of an actor. Since the thesis focuses on local governments, these two codes were grouped according to the four case studies that have been selected, in order to say something about the visions and strategies that were pursued by each individual municipality that was analyzed. The expectations were also divided into multiple categories, consisting of electric driving, charging infrastructure and inductive charging. Whereas the former category described broader trends of electric driving and EVs, the second category mainly encompassed the current situation regarding charging infrastructure. Finally, expectations on inductive charging included both expectations about the technology itself, as well as the function that it is going to fulfill in society according to interviewees. This division helped to structure the expectations into three levels, namely macro, meso, and micro. The macro-level encompassed the expectations about electric driving and the current charging infrastructure, and the expectations about inductive charging fed into the micro- and meso-level. These levels are further elaborated on in the section on results. Last of all, a category was defined that considered the bottlenecks that were identified by grid operators as well as local governments. After grouping together the different barriers that were mentioned by the interviewees, it was found that two bottlenecks especially stood out as they were mentioned most often. The business case of charging infrastructure and internal and external processes have therefore been elaborated on in the results, since they are regarded important barriers in the transition towards sustainable mobility by the interviewees.

The findings derived from the interviews were complemented with data retrieved from informative documents and policy reports, after which it was written down in a qualitative narrative. The research process was iterative, going back and forth between the theoretical insights gathered by the literature study and the empirical data, and vice versa. This messy process is one of the main characteristics of qualitative research, which includes processes and contexts as part of the investigation.

In order to validate the research findings, the interview transcripts and quotes were sent to the interviewees to check whether their answers had been reported sufficiently and whether the information had been interpreted correctly. Furthermore, the use of other data besides the interviews ensured triangulation of the collected information. However, it should be noted that this triangulation does not hold for all the recorded data, as expectations and opinions were considered as well. These were sometimes stated by the interviewee as expectations that were shared within the municipality, and other times the interviewee gave his or her own opinion on a question. To justify the fact that no triangulation is possible, it will be shown if certain information in this thesis is the interviewee's own opinion or expectation by using quotation marks.

4. Context

In the chapter on theory and concepts, already the link was constituted between the different frameworks useful to analyze transitions, and the case study regarding charging infrastructure. This chapter will elaborate on the context of this case study, explaining what the role of charging infrastructure in a transition is. This explanation is followed by a description on electric driving in the Netherlands, and the chapter will be concluded with the envisioned role of municipalities, according to prescriptive guides on electric transportation in the Netherlands.

4.1 Role of charging infrastructure

Frantzeskaki and Loorbach (2010: 1293-94) coin the term *infrasystem*, in which they encompass both the physical and social component of infrastructure. They characterize infrasystems as large-scale, capital-intensive and having a long life cycle. These systems are important as they retain the welfare and functioning of a society by providing services such as energy, communication and mobility. Because of the dynamics of such a system, it can either act as a barrier or as an incubator for radical change. It is furthermore argued that competition between different infrasystems can stimulate and contribute to broader societal innovations, leading up to a transition. However, since new infrasystems are mostly characterized by uncertainty, changing dominant infrasystems entails a high risk. This pattern can be recognized in the adoption of EVs as currently the main barrier in the scale-up of these vehicles is its charging infrastructure, which is necessary for the basic functioning of the technology and helps to enhance public confidence (Maia, Teicher & Meyboom, 2015: 54). Because large investments are required for this infrastructural development, the transition towards more sustainable mobility is particularly difficult for this technology (Farla et al., 2010: 1261).

Regarding charging infrastructure, three different types can be distinguished, namely public, semi-public and private charging points (Funke et al., 2015: 76). Whereas public charging points are available to everyone, e.g. at a parking spot, semi-public charging points can only be accessed by a certain group of people, such as at a company's parking place or at a car park. If EV-owners have a privately owned space where a charging point can be installed, e.g. a drive or garage, the type of infrastructure is called private. In the Netherlands, which is the scope of this research, almost three quarters of EV-drivers are reliant on public charging infrastructure, as they have no private space where they can charge their car (van Beek, 2016). Considering the different types of charging infrastructure, it is argued that especially these public charging points are an important component in the scale-up of EVs (Funke et al., 2015: 73). Despite the fact that the majority of electric cars could be operated without any additional charging infrastructure, empirical evidence has shown that public points are necessary to decrease range anxiety. In Tokyo, for example, the technical range of EVs was not fully used until after the installation of a public charging infrastructure (Funke et al., 2015: 85). This 'social' function of charging infrastructure plays an important role in removing the uncertainty, fear and doubt that is currently related to electric driving. The confidence boost that will result from public charging infrastructure is therefore likely to stimulate widespread adoption of EVs (Maia et al., 2015: 54). This shows that not only infrastructure is an important dimension, because of its effect on a transition, but also *charging* infrastructure. Given that the majority of e-drivers is reliant on this type of infrastructure, it is an important aspect regarding the ongoing transition towards more sustainable mobility. The next section will zoom in on the Netherlands, outlining the policy plans that have been initiated and the current state regarding electric vehicles and charging infrastructure.

4.2 Electric driving in the Netherlands

Since 2009, when a road map was created on the role that the government was going to play regarding electric transportation, the national government has stimulated the development of electric driving (Agentschap NL, 2012: 53). The ambition was to make the Netherlands a model country and an international testing ground for electric transportation (de Bont, van Dijk, Hellinga & Silvester, 2010: 4). In the years up to 2011, the government invested 65 million euros in the development of electric driving, which has mainly been used to carry out experiments and pilot projects, besides creating stimulating financial measures. In 2011, the national government created a new program, outlining three aims that they wanted to achieve in the period from 2011 till 2015 (van Mil, van Schelven & Kuiperi, 2016: 3).

First of all, they wanted to stimulate the roll-out of electric vehicles, aiming for 20.000 EVs at the end of 2015. Furthermore, they wanted to stimulate the related charging infrastructure, both aims directed at achieving more electrically driven kilometers. Secondly, they wanted to increase the earning potential of electric transportation and capitalize it, as they argue that electric transportation is an important contributor to economic opportunities for certain businesses. Lastly, their aim was to stimulate innovations regarding electric driving. Due to these aims the number of electric vehicles has grown over the years to more than 90.000 in total, which is shown in figure 4.1. For the purpose of this thesis, only the growth of plug-in hybrid electric vehicles (PHEVs) and full electric vehicles (FEVs) has been plotted. The steep increase of PHEV sales at the end of the year 2015, can mainly be attributed to financial measures which have been changed since 2016. Since PHEVs did not contribute as much to the environment as previously thought, due to the fact that mostly their ICE is used instead of their electric mode, the subsidies on this type of electric vehicle have been reduced. By changing tax incentives, the national government has tried to make it more attractive to purchase an FEV instead (Thole, 2015).

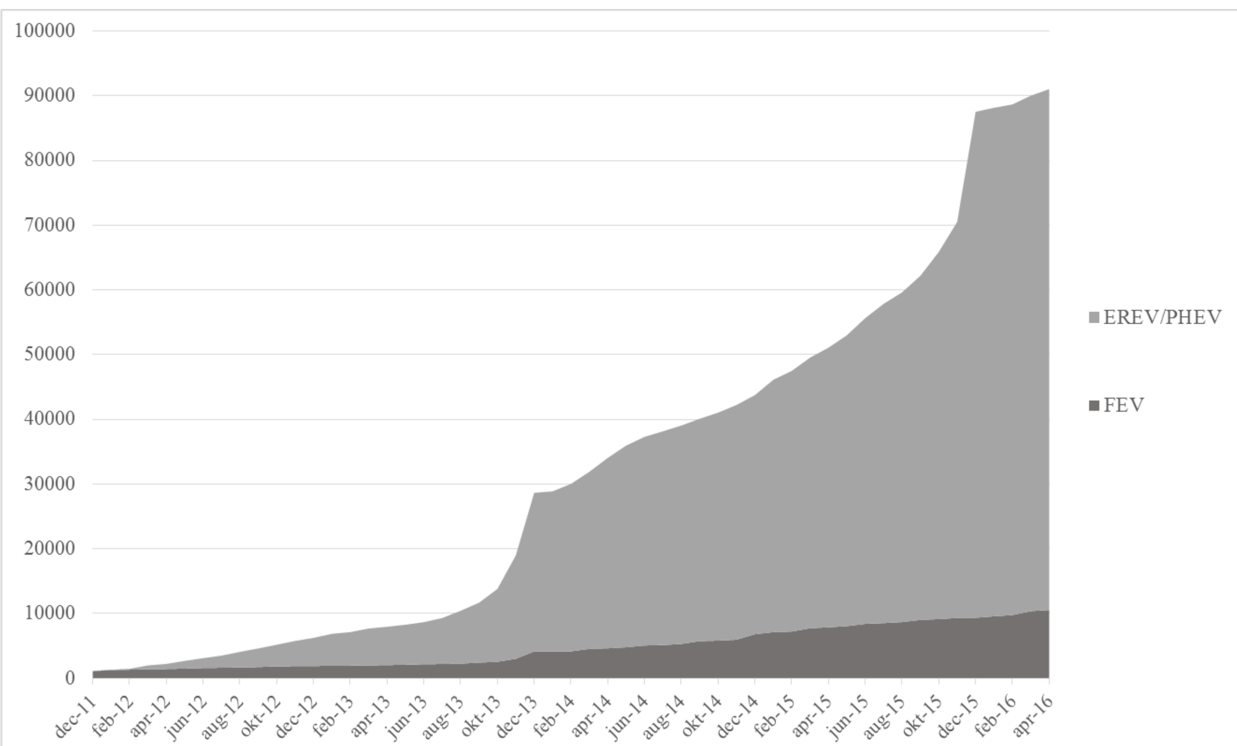

Figure 4.1: Number of EVs in the Netherlands (Rijksdienst voor Ondernemend Nederland, 2016a; adjusted by the author)

Besides stimulating the number of EVs, another aim was to stimulate its related charging infrastructure. As figure 4.2 shows, the charging infrastructure has evolved as well over the last couple of years, summing up to more than 20.000 charging points in total. The rise up to December 2013 can mainly be attributed to E-Laad, who placed around 3000 public charging points across the country (van Mil et al., 2016:15). This foundation was an initiative of grid operators in the Netherlands, and their initial aim was to install a total of 10.000 public charging points. However, the initiative was subject to discussion as it was unclear whether realizing public charging infrastructure should be done by grid operators. Eventually, E-Laad had to quit placing charging infrastructure. Nowadays, the foundation has been split into two, with one body maintaining the public charging points that they placed. The number of private charging points has not been included in the figure, as there is no exact data on the number of points. Despite the importance of public charging infrastructure, according to literature, it is expected that there will be a shortage in the coming years if more EVs are added to the current fleet, given the current number of charging points (ANP, 2016).

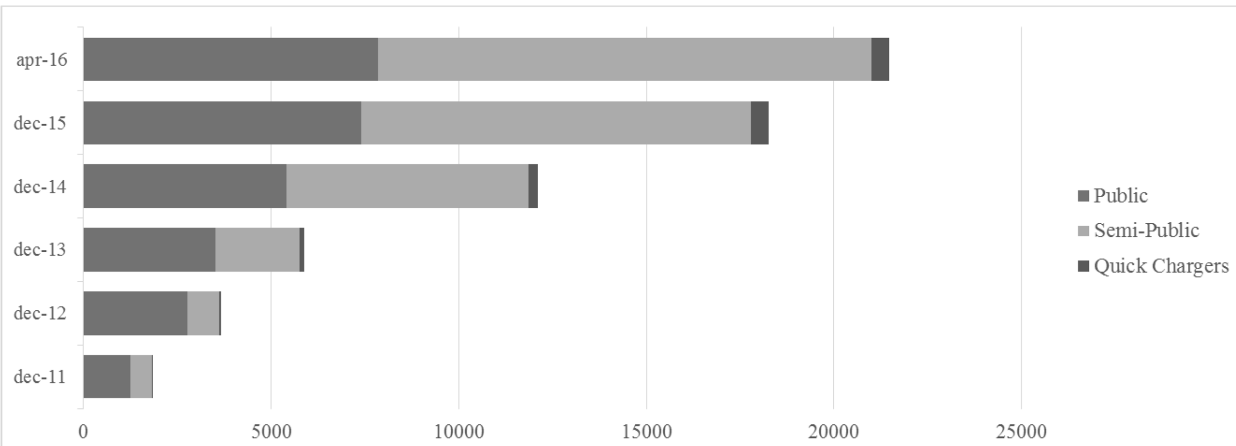

Figure 4.2: Number of charging points in the Netherlands (Rijksdienst voor Ondernemend Nederland, 2016a; adjusted by the author)

In 2016, the ‘Green Deal Electric Transportation 2016-2020’ was initiated, which is the successor of the previous policy plan and can be seen as an extension. An important focus in this policy plan is the increasing attention for the roll-out and exploitation of charging infrastructure (Rijksoverheid, 2016: 4). A budget has been made available from July 2015 to July 2018, for which parties can apply. Whereas the mentioned initiatives have originated on the national level of government, there are also roles ascribed to local governments regarding electric driving. Therefore, the next and final section will elaborate on these roles.

4.3 Envisioned role local governments

The executive body of the national government, the Netherlands Enterprise Agency, has formulated a guide for municipalities who want to get started on electric transportation (Agentschap NL, 2012). Electric transportation has been formulated as a technology which can contribute to municipal aims regarding the environment, their local economy and transportation, besides contributing to long-term goals that have been formulated by the national government and by the European Union. It is argued that besides companies, local governments play a central role in the development of electric transportation. Three roles have been identified by the Netherlands Enterprise Agency that local governments can fulfill, varying from a wait-and-see strategy to initiating and developing innovative solutions themselves.

First of all, it is argued that local governments need to establish frameworks regarding the development of public charging infrastructure. They can for example decide to get involved with pilot projects, and they can make traffic decisions when placing a charging point. However, it is argued that often governments are eager to stimulate the number of electric vehicles, but that they only implement deployment activities rather than experimental projects which are needed to explore more radical options (Newman et al., 2014: 35). Furthermore, according to Newman, niche experiments are often too diverse to have an effect on incumbent practices. Whereas the focus of EVs is mainly directed at technological substitution of fossil-fuel based cars, it should be seen as a wider process working towards a sustainable mobility transition in which attention should also be aimed at changing user patterns and behavior.

Secondly, it is stated that local governments can contribute to the development of electric transportation by taking on a facilitating role, which is also possible if no financial means are available. They can, for example, help entrepreneurs to develop their initiatives or bring them into contact with other companies and governmental bodies, and furthermore they can adapt policies and regulations. In third place, local governments can take on a stimulating role, which involves the investment of financial means in the roll-out of electric transportation. The aim of these investments is mainly to get entrepreneurs going. By actively developing electric transportation solutions, the municipality also contributes directly to achieving sustainability goals. An example is proactively realizing charging infrastructure, and setting the example by making the municipal fleet more sustainable and acting as a launching customer. Furthermore, they can integrate more sustainable types of transportation in their procurement.

Although these municipalities individually play an important role, it is also argued that multiple stakeholders should be included in ongoing processes. According to the guide, municipalities can jointly make agreements on charging infrastructure, in a regional setting. By doing this, charging infrastructure will no longer be restricted to the boundaries of a municipality, but it will become clear for e-drivers that they can charge their vehicle within the entire region. Furthermore, joining forces with other municipalities will make it easier to create and organize a lobby, and it will be beneficial when purchasing charging infrastructure or electric vehicles.

This chapter has shown that charging infrastructure is an important dimension, and that especially public charging infrastructure is a driver of electric transportation. Although electric driving has already seen a rise in the Netherlands, recently a new policy plan has been initiated with a strong focus on this charging infrastructure. Local governments are argued to play an important role in this, by establishing frameworks and taking on a stimulating and facilitating approach. In the following chapter the results will be introduced, which will also have a focus on the role of local governments, in order to eventually answer what the role of local governments is in stimulating a transition towards more sustainable mobility.

5. Results

In this chapter, the results will be presented. The chapter has been divided into three sections, guided by the different sub questions, which consist of the identified barriers, visions and expectations, and the interplay between the two charging infrastructures. Despite the fact that literature often mentions visions and expectations in the same breath, this thesis will discuss the two concepts in separate sections. The reason for this is that visions mainly concern conductive charging infrastructure, as it has already been implemented in society, whereas inductive charging is a novel technology which is still largely built on and influenced by expectations in this introductory state.

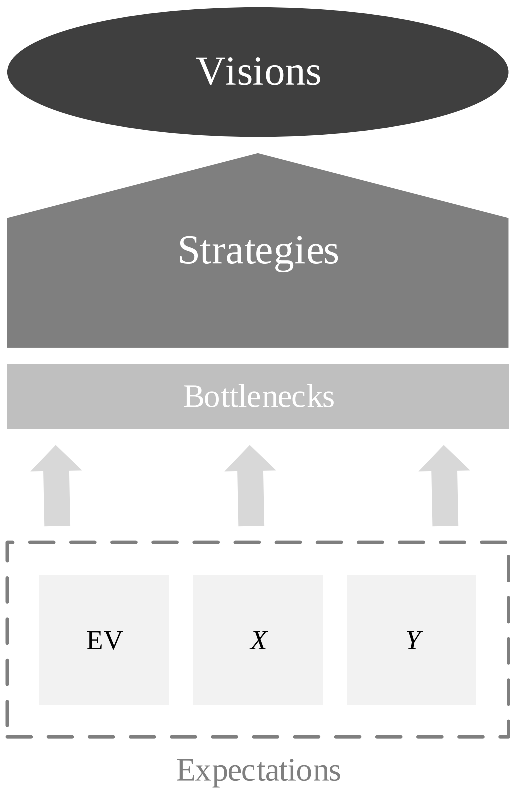

Figure 5.1: Overview of the layout of the results

Figure 5.1 has graphically shown the layout of this chapter. It starts with municipalities who create a vision that they want to achieve regarding sustainable mobility. In order to achieve this vision, they adopt a certain strategy. This already shows the close connection between visions and strategies, as identified in the chapter on theory and concepts. Therefore, section 5.1 will elaborate on these visions and strategies, structured according to the four municipalities that have been selected as case studies. Specific attention will be directed at how these local governments see sustainable mobility, and what strategies they have pursued. These strategies are given shape by adopting certain technologies or types of transportation that help the municipality achieve their vision. This can for example be electric transportation, but also cycling or the concept of car sharing can be mobilized to achieve a strategy. However, novel technologies often face bottlenecks that keep these technologies from becoming the dominant practice, since practices are aligned to the current regime. Car sharing, for example, changes current practices as cars are no longer privately owned and driven, and electric driving requires a different infrastructure than fossil-fuel based cars. Section

5.2 will therefore zoom in on two barriers that have been identified regarding electric driving and its charging infrastructure, consisting of the business case and internal and external processes. Besides these identified bottlenecks, expectations surround novel technologies and concepts. These expectations have an influence on whether a municipality will mobilize a certain technology, depending on whether they expect a technology to contribute to their vision or not. In section 5.3, focus will therefore be shifted towards inductive charging and the expectations that have been expressed regarding this technology, making a distinction between expectations on the micro-, meso-, and macro-level. Each individual section will be followed by a conclusion, which summarizes the results and in which the main findings are discussed.

5.1 Municipal visions and strategies

As mentioned earlier in this report, visions and expectations are important in the initial phase of a technology. The sociology of expectations has linked these expectations and visions to actor strategies, which are then translated into activities that have an effect on the overall transition (Budde et al., 2012: 1076). This section will introduce the four studied municipalities – Rotterdam, Ede, Groningen and Bladel – and elaborate on their visions and accompanying strategies and activities.

Rotterdam

Despite the fact that the municipality of Rotterdam thinks climate change is an important problem that needs to be solved, their main objective to get involved with sustainable mobility is the fact that they want to improve local air quality (Stadsontwikkeling afd. Verkeer&Vervoer, 2015: 3; HO, 2016). In this, their primary goal is to promote people's health by providing cleaner air. Regarding electric driving, they state: 'We are aware of the responsibility we have as municipality in the transition from fossil fuels to electric driving, and we play a role in that. People cannot drive electrically if they cannot charge, so we decided to make an end to the chicken-and-egg debate.' (QO, 2016). To achieve their goal of improving local air quality and to provide their inhabitants with charging infrastructure, the municipality has adopted a concession model. This approach encompasses that the municipality sets up a contract with a market party for a certain period, which includes placing as well as managing and maintaining the charging infrastructure. The difference with a contract model is that the market party receives exclusivity and exploits the charging points and also receives revenues that flow from that, instead of the municipality. In a contract model, the municipality itself is the manager of charging infrastructure, and responsible for maintenance and exploitation. Furthermore, this approach is stricter compared to a concession model. In the latter approach, room is made for the market party to implement innovative solutions (Agentschap NL, 2013: 4).

Several roles have been identified by the municipality of Rotterdam, which they argue to be important in realizing the transition towards more sustainable mobility. A change that they have implemented in their last policy plan is that their role has shifted from actively stimulating to more facilitating (Stadsontwikkeling afd. Verkeer&Vervoer, 2015: 3; HO, 2016). It is argued that '... if you are in a new market situation, you have to do more as a municipality to get it going. [...] Electric driving is still an emerging market, but it is not as novel as it has been. Therefore, we shifted our strategy from actively stimulating to facilitating, in order to help the market grow. From now on, we only need to support the market instead of pushing it. (HO, 2016). Another reason why they shifted their strategy, is that they have the feeling that they have a clear understanding of the market and its needs. According to the municipality, it is no longer affordable to place a single charging station for every applicant, while some points are not being used (HO, 2016). Therefore, if inhabitants file an application from the next tender onwards, they do not request a charging point, but they request to expand the current network of charging infrastructure.

Within this network of charging infrastructure, the municipality argues that all types of infrastructure are necessary. Despite this vision, the municipality focuses primarily on public charging infrastructure as ‘it is no longer complicated to charge at home. When you buy an electric car you get a charging point, which you can install yourself when you have a private driveway. (HO, 2016). Although they primarily focus on public charging infrastructure, the municipality still prefers people to charge at home instead of in public space as they find it less intrusive.

The municipality is characterized by a facilitating role, which can be derived from the fact that the municipality says that it works closely together with the market, as they think that is the place where innovations arise. They argue that the initiative to set up innovative projects mainly lies with the market, as the municipality does not want to start a project which eventually is not adopted. As an interviewee states, ‘What if we think of something ourselves, and we put it on the market. If the market does not see the potential – if it is not financially attractive – then parties are engaged in the project when subsidies are provided, but when subsidies are halted you see that the support for such trajectories often diminishes. That is why I favour the facilitating role – looking at what the market wants and responding to that, instead of coming up with something yourself and looking for a market.’ (HO, 2016). Furthermore, the municipality currently subsidizes the unprofitable business case of charging infrastructure, which lowers the charging fee, in order to help electric transportation to become cost-competitive with the fossil-fuel based regime. However, they still leave a lot to the market as well. In their opinion, ‘The market has to do it. If the market is not up for it, then we should not be the ones to impose it on the market.’ (HO, 2016). Additionally, they offer innovative technologies a place to innovate, giving these innovations the possibility to make use of the expertise that revolves within the municipality and its network.

Next to their role as facilitator, the municipality also mentions that they feel the responsibility for public space (QO, 2016). This responsibility has partly fed into their initiative to start a pilot project with inductive charging, besides the fact that there was money availabile to invest in an innovative technology. Since it was argued that inductive charging has potential as it is less intrusive in public space, the municipality of Rotterdam has chosen to facilitate this novel technology (HO, 2016). Their prediction of what will happen in the future is that, ‘when electric driving will become booming and when it will be adopted on a larger scale, it will be untenable to continue to place charging stations.’ (QO, 2016). Furthermore, the municipality already received questions on the necessity to install conductive charging stations, and whether there is not another solution available to implement, such as an inductive system. The municipality hopes that eventually the project will contribute to positive impressions of Rotterdam as an innovative city, which might lead to companies and research institutes wanting to finance other projects.

Ede

‘Strengthen the position of sustainability in Ede, together with inhabitants, companies and societal organizations to become a future-proof municipality with a long-lasting balance between people, planet and profit.’ (Gemeente Ede, 2015: 2). With this sentence, the municipality of Ede summarizes its vision regarding sustainability that was determined last year. Eventually their aim is to become part of the most sustainable municipalities within the Netherlands. Besides getting involved with renewable energy and saving energy in the built environment, they also are engaged with sustainable mobility. By investing in this type of mobility, they aim to improve air quality, noise production and climate change (Gemeente Ede, 2015: 9).

In the sustainability program that has been initiated, sustainable mobility is split into two parts (RS, 2016). On the one hand the municipality focuses on cycling, trying to stimulate cycling and get people out of their cars and onto their bicycles, and on the other hand they focus on sustainable vehicles. The latter part encompasses two projects, consisting of public charging infrastructure and making the municipal fleet more sustainable. The former project on charging infrastructure has been initiated due to requests from inhabitants who were unable to charge their car since they did not have a private driveway. Using money from the national government through the province, under the heading of the National Cooperation Program Air Quality, the project was incentivized (RS, 2016). As the title of the program shows, the money was given in the context of air quality, but when questions arose regarding charging infrastructure within the region, these two things were connected and the money from the subsidy was used to finance a public charging project. It can be argued that this project characterizes the vision of the municipality, which does not include a strong vision on how they see sustainable mobility in Ede in 2030, but mainly consists of an executive program (RS, 2016).

The municipality first came into contact with public charging infrastructure through E-Laad, who placed the first batch of charging stations. As an interviewee states, ‘That gave us food for thought, realizing that electric driving was something that was coming up. [...] At a certain point, E-Laad quit placing charging infrastructure, but the call for more charging infrastructure remained.’ (RS, 2016). Therefore, the municipality of Ede joined forces with the region Food Valley and some other regions in Gelderland, and together they set out a tender. They chose the same model as the municipality of Rotterdam, which is a concession model, in which the market party that wins the tender is given more freedom, and also exploits and manages the charging infrastructure. The local government has furthermore chosen to invest a certain amount of money per charging point, lowering the charging fee and therefore stimulating electric driving somewhat more. However, although their opinion is that you should invest in new technologies that are supported within Europe and within the Netherlands, they argue that you cannot keep doing this forever, stating that ‘We do not pay for a gas station where they sell petrol as well.’ (RS, 2016). They argue that the national government should take on the role to drive and stimulate the phase that electric driving is in now, and that eventually the market should be able to sustain itself. According to the municipality, once the market is able to take over this business, the role of local governments is finished from a financial point of view. ‘From then onwards, it is simply following and committing to tasks that are part of a municipality, such as pointing out locations where charging infrastructure can be installed.’ (RS, 2016).

Besides mainly facilitating charging infrastructure, the municipality does not feel the need to initiate more projects. A while ago they made an attempt to create a strategic map for the municipality, indicating possible locations for charging points. As they conclude themselves, ‘We never finished it, but at the same time it is not a necessary thing to do. There are only ten requests for charging infrastructure in the municipality of Ede each year, so it is manageable. Each time we receive a request, we look for a strategic location to place the charging station.’ (RS, 2016). Despite the fact that there is not a strategic map, the municipality does mention that they feel the responsibility for public space. They argue that due to this responsibility, everytime a charging point is requested, they consult with the applicant on where to exactly place the charging point since they do not place it in front of the e-driver’s doorstep. However, when it comes to inductive charging, the municipality does not feel the responsibility to be a pioneer and to initiate pilot projects. There is no ambition to start a project on inductive charging, but ‘if a pilot project would be possible on a smaller scale and if it would fit in with our sustainability program, then it would in theory be possible’ (RS, 2016). Still, they ascribe the role of creating pilot projects to larger municipalities.

Groningen

Within the municipality of Groningen, an increasing awareness of climate change and the fact that fossil fuels will run out, have both led to an important role for sustainability in municipal policies (Gemeente Groningen, 2011). One program that this realization has fed into is the energy program, which means that the municipality of Groningen wants to be energy-neutral in 2035 (AN, 2016). Despite this ambitious aim, the program restricts itself to energy savings and limiting the use of energy, deliberately setting aside the role of mobility according to the municipality. As is described by the coordinator Sustainable Mobility, 'We calculated that mobility is responsible for about 20% of all the energy consumption in our town. That is quite a large part, and at first we actually did not have a good policy regarding sustainable mobility. We do have a policy document [...], but if you look at the technical measures, such as the infrastructure, the hardware and the spatial integration of an alternative way of driving, then this is limited to one paragraph.' (AN, 2016). Despite the non-existence of clear policies regarding sustainable mobility, the city of Groningen managed to win the prize for the city with the most sustainable mobility. The reason for this is that the city of Groningen is all about cycling (AN, 2016). Last year a cycling strategy has been initiated, for which a substantial amount of 84 million euros has been made available to improve the status of the bicycle in the city in the coming years.

Although Groningen mainly focuses on cycling, last year it was suggested to create a program on sustainable mobility since the municipality almost daily received calls from inhabitants and companies regarding sustainable mobility. According to the municipality, 'It is a topic that you have got to have an opinion about [...], but until last year we had no opinion.' (AN, 2016). This characterizes the strategy of the municipality with regards to deploying charging infrastructure, as 'The reason that we place charging infrastructure is simply because the market asks us to.' (AN, 2016), and therefore they have ascribed themselves a facilitating role. They have also adopted a different strategy than the municipalities discussed above, as they have partnered up with Allego. This so-called licensing model requires less action and no financial means from the local government, as market players place, maintain and exploit the charging infrastructure (Agentschap NL, 2013: 4). The reason why they have signed an agreement with Allego is because 'We have to facilitate people who want to charge in public space, but our board has not given us any financial means to do that. [...] That is why we adopted a market initiative for charging infrastructure [...]. We allow market players to invest in our public space and do the exploitation as well.' (AN, 2016). The municipality states that if they want to have a bigger role, there should be some financial means available in order for them to stimulate.

Besides placing charging infrastructure, the municipality has put effort into making their municipal fleet more sustainable. According to the municipality, 'If we think that people have to drive in a more sustainable way, then we have to demonstrate and do this ourselves as well.' (AN, 2016). The fleet consists of approximately 350 vehicles, including delivery vans, as well as more specialized vehicles such as garbage trucks and aerial work platforms (GG, 2016). The municipality says that since 2007, they have set the course to reduce toxic pollutants by replacing diesel with gas-to-liquid, which was easy to implement in the existing fleet and which had a positive effect on people's health. At present, the fleet of the municipality also consists of hybrid vehicles and vehicles that run on natural gas. Additionally, the first truck has been ordered that will run on hydrogen, which is in line with the ambition of the municipality to get two hydrogen filling stations to Groningen (AN, 2016; GG, 2016).

Furthermore, the municipality explains that there is a positive attitude in the municipality of Groningen when it comes to innovations and experiments. As stated by one of the interviewees, ‘Go ahead and use our city as playing area. We want to cooperate, certainly concerning innovative subjects such as electric driving. Yes, please – bring it on!’ (AN, 2016). However, they also feel that municipalities will not make the difference as, according to them, they tend to be followers instead of leaders. It is argued that the breakthrough of electric driving was mainly initiated by stimulating measures taken by the national government, such as tax liabilities and vehicle taxes. According to the interviewee, the municipality mainly needs to facilitate ideas instead of initiate innovations themselves. ‘We need to facilitate these kinds of things as a municipality. When the market demands something, we have to get involved and be open to such initiatives and facilitate them.’ (AN, 2016). Although they see themselves as facilitators, they are involved in research on the possibility to combine lampposts with charging infrastructure, together with the Hanze University of Applied Sciences. This originates from the responsibility they argue to have regarding the public space, since ‘The disadvantage of charging points is the fact that you get extra objects in the public space. That is something we rather would not want to have, since they are placed on the sidewalks which spoils the public space.’ (AN, 2016). Despite the fact that they see inductive charging as a solution for public space, they again ascribe themselves a facilitating role. ‘Cooperate and try to make this technology possible within the city. Make public space available to carry out such initiatives, pilots and experiments.’ (AN, 2016). They mention that the technology will probably be discussed when creating a new policy plan, but that the trade-off will be made regarding how much the municipality would want to invest in such a technology, given that the municipality is primarily focused on the developments surrounding hydrogen.

Bladel

In 2008, a climate vision was created by the five Kempen-municipalities, consisting of Bergeijk, Bladel, Eersel, Oirschot and Reusel-De Mierden (van Oosterhout & Schaeffers, 2008). In this climate vision, the ambition of all five municipalities to become energy-neutral in 2025 was written down, as well as the claim that they would make a budget available to initiate projects. Together they created a joint executive program, with projects that they wanted to work on (CR, 2016). Originally they formulated nine goals, but they mentioned that once they got these projects going they found out that it was difficult to influence certain processes as a municipality. Eventually the number of projects was reduced from nine to three. The municipality has admitted that currently results are behind schedule. However, the municipality states that ‘we initiated several projects with which were are hoping to still make some progress towards 2025.’ (CR, 2016).

Although sustainable mobility is part of the climate vision, it is not specifically addressed in the projects. Still, the municipality is engaged with electric driving and charging infrastructure to a certain extent. As they describe themselves, ‘At a certain point we were approached by the province to take part in a project, [...], which would provide us with charging points, partially financed by the province. We decided to participate and two charging points were installed [...].’ (CR, 2016). Despite the fact that research, carried out five years ago, showed that there was no demand for charging infrastructure, the municipality mentions that they deliberately made the decision to place these two charging points, ‘because we have an exemplary role and we want to fill in that role.’ (CR, 2016). After this project, the municipality took a break and took a step back, to wait for demand to arise from the market. They say that recently they have noticed that everything is going well, and electric driving is picking up again. Therefore, they have started to get to work with their policies and they have decided to place charging points at the market, which is going to be renovated. According to the interviewee, ‘The subject has been prioritized and put back on the agenda, and as a municipality we want to be actively involved again.’ (CR, 2016). However, there are not a lot of requests for charging infrastructure within the municipality. It is argued that this is partly due to the fact that a lot of people within the municipality of Bladel have their own driveway. ‘They take care of it themselves, and the same holds for industrial sites. There are some companies who have arranged their own charging infrastructure, which reduces the role of the municipality to some extent.’ (CR, 2016). Furthermore, the municipality does have its own fleet of vehicles that they can make sustainable, such as in other municipalities. Still, they need to purchase certain services such as the transportation for disabled people. According to the municipality, they try to do this as sustainable as possible.

The strategy of the municipality is illustrated by the way they handle applications for charging infrastructure. ‘At the start of this year we got an application of a citizen who did not have his or her own driveway and who wanted a charging point. We took immediate action, since we want to facilitate charging infrastructure in the best way possible. We started right away by creating a policy, and we started to look for a partner which turned out to be Allego.’ (CR, 2016). As seen with the other municipalities as well, this local government is characterized by a facilitating role. Their vision is to stimulate and facilitate where possible, getting rid of any bureaucracy and having arranged as much as possible in advance (CR, 2016). They mention that this has influenced their decision to partner up with Allego, who looks at possible locations for a charging point together with the applicant. All the municipality needs to do is judge the application and make a decision about what traffic signs to place. Although Allego takes care of the entire process that surrounds the placement of charging infrastructure, the municipality mentions that they want to place charging points themselves too. ‘Within the municipality there is a positive atmosphere. If someone initiates a pilot project or if some enterprise or research institute wants to give something a try, our answer would be “let’s do this”.’ (CR, 2016). Besides the fact that a company is interested in the charging points that will be placed at the market, the municipality also places them in order to convey an image of sustainability. ‘If you would visit the municipality, you would notice these charging points next to the town hall.’ (CR, 2016).

The municipality has a clear view on what their role is within the transition towards sustainable mobility. They argue that, ‘As a municipality you primarily need to stimulate and facilitate. With regards to stimulating, you need to keep track of all the developments, and when you see that something has potential and it works for the municipality, you need to pick it up. If a technology is advantageous for society, in the field of sustainability, then I consider it a municipal duty to get involved. [...] Facilitating means that when someone approaches you with a nice idea, you need to at least reward them with an open attitude and a respectful treatment. Even if the answer is no, then you have to be quick to inform them about that.’ (CR, 2016). Furthermore, besides the lack of demand for charging infrastructure in this municipality, they mention that they have a positive and open attitude towards inductive charging. They argue that if this technology is developed a bit further, and a pilot would have to be initiated, the municipality of Bladel would be a suitable municipality to give a project with inductive charging a try. However, if their current partner, Allego, would say that it would install both conductive and inductive charging points, it is argued that such a decision would make things easier for the municipality.

Conclusion

All municipalities are engaged with sustainability and sustainable mobility since it reduces climate change and it helps to improve local air quality, which confirms the stated hypothesis about aligned visions and the aim to work towards a more sustainable society. Furthermore, Bladel and Groningen have both formulated a broader vision which encompasses energy-neutrality in 2025 and 2035, respectively. Despite their aligned visions, different strategies have been adopted by the municipalities. Whereas Rotterdam and Ede have made the decision to lower the charging fee by investing in charging infrastructure, Groningen and Bladel have adopted a different strategy and included Allego in their approach. Despite the fact that they have both been categorized as passive municipalities, their reasons for choosing this strategy differ. Bladel argues that it has a limited capacity to take on new projects such as electric driving, and Groningen has prioritized cycling and has made no money available for electric driving, therefore choosing the approach of Allego which requires less action and no financial measures from local governments. This shows that the resources that are available within each municipality, human as well as financial, influence the strategy that is adopted.

It was furthermore expected that active municipalities were more likely to take on novel technologies, such as inductive charging. The results have shown, however, that size is a larger contributor than the distinction between active and passive. Although Ede mentions that they feel the responsibility regarding public space, Rotterdam is the only municipality that has initiated a project with inductive charging, arguing that the technology can function as a solution for public space. The other municipalities acknowledge that creating pilot projects is something that they ascribe to larger municipalities, who they see as the pioneers of novel technologies.

Although theory has argued that there is a close connection between visions and expectations and actor strategies, the results show that visions only contribute to a small extent to the strategies that are pursued. Despite the fact that municipalities share visions on climate change and local air quality, they have adopted different models regarding electric driving and charging infrastructure. It is furthermore remarkable that the municipalities that have set themselves the goal of energy-neutrality, are not actively considering electric transportation as a solution. Groningen, for example, has invested in cycling and is working on the installment of two hydrogen filling stations, and has made no financial means available for EVs. This shows that visions help to clarify why municipalities adopt alternative types of transportation that are more sustainable, but it does not explain why the mobilized technologies differ between municipalities. As argued at the start of this chapter, expectations play an important role as well in mobilizing certain technologies, and therefore it is argued that expectations will clarify the differences between municipalities regarding their mobilized technologies. These expectations will be discussed in section 5.3.

Despite the fact that all municipalities have adopted a strategy that includes electric driving and charging infrastructure, whether active or passive, the dominant way of transportation is still running on fossil fuels. It can therefore be argued that there are still barriers that withhold electric driving from becoming the regime. Since the MLP emphasized the importance of infrastructure as a dimension, the next section will zoom in on charging infrastructure and elaborate on barriers that have been identified.

5.2 Barriers charging infrastructure

All municipalities have adopted policies regarding electric driving, but it can still be considered a niche given that it requires a protected space, that is for example created by providing subsidies. It can be argued that certain barriers withhold this niche of electric driving from growing out to become the transportation regime. Therefore, this section will focus on the barriers that have been identified regarding the current charging infrastructure. Two bottlenecks that have been mentioned most often have been highlighted. First of all, the business case of the current charging infrastructure will be discussed, and secondly this section will zoom in on internal and external problems from the viewpoint of the municipality.

5.2.1 Business case

The business case is a bottleneck that has mainly been mentioned by grid operators, who emphasize the fact that their experience is that charging infrastructure currently costs more than it yields (PB, 2016; BE, 2016). As one interviewee explains, 'If I understood correctly, it is all quite expensive; the maintenance and the costs that you need to pay to the grid operator to maintain your connection, service and managing the charging point, facilitating a back office and transactions. Because of all these costs, it is hard to make money out of the transactions at the charging point, let alone to break even.' (BE, 2016). Figure 5.2 graphically shows the costs that are involved regarding public infrastructure, and the gap that is currently present between all costs involved and the revenue that flows from supplying the charging point with energy.

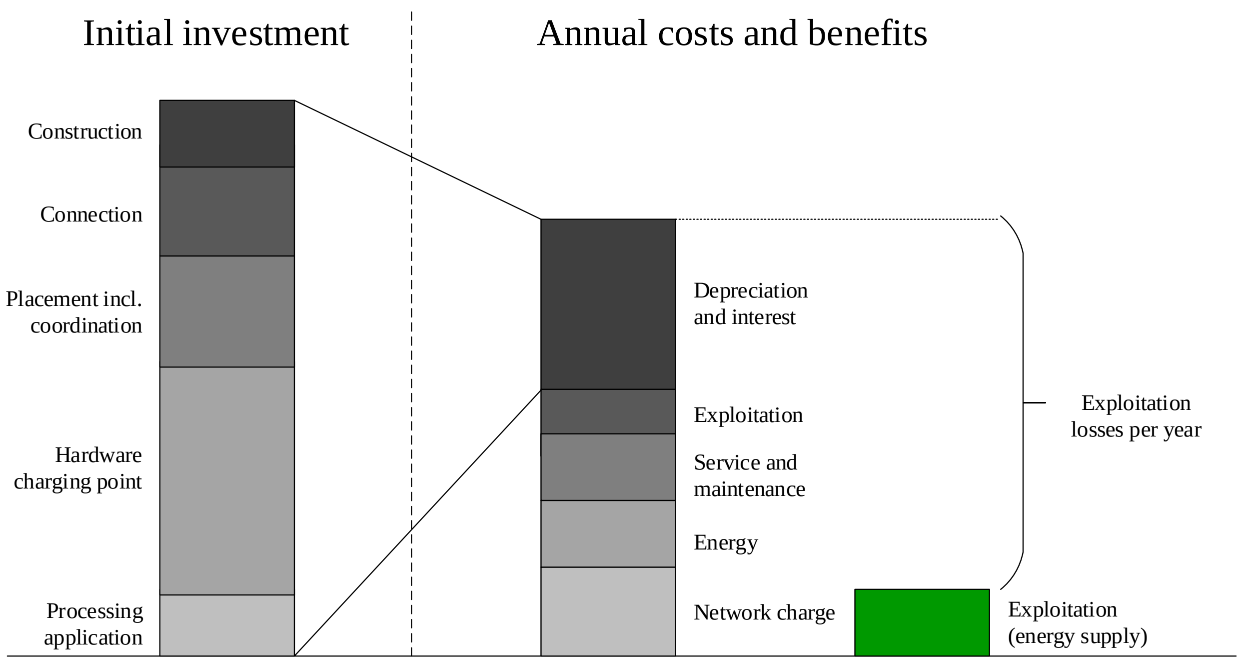

Figure 5.2: Graphic representation of the business case of public charging infrastructure (Holland, van Cuijk, van Kerkhof, & Verheijen, 2016:8; adjusted by the author)

Whereas mainly grid operators have expressed their worries about this issue, the municipality of Ede has also acknowledged the fact that it is difficult to get a viable business case on charging infrastructure. They have decided to invest some of their own budget to lower the charging fee, but still 'the connection fee and the charging fee are both not the best tariffs possible, which shows that it is difficult for parties to end up with a viable business case.' (RS, 2016). They also mention that not all neighboring municipalities have the same financial means available to invest in charging infrastructure, and therefore had to halt requests for charging points. From their experience, smaller municipalities sometimes wait till the end of the year to see if there is any budget left that they can use. Regarding the municipality of Ede, it is mentioned that 'Ede has some more financial leeway and therefore has initiated a program called 'Sustainability', which provides the municipality with more continuity.' (RS, 2016). Furthermore, they mention that their concession partner is receiving negative signs that the process of making the entire cycle cheaper is progressing at a slow pace, and that there has not been any improvement lately.

A subject that is argued to contribute to the unviable business case is the fact that 'you have to locate them [charging points] everywhere, even at places where they are not that necessary such as in the top of the provinces of Groningen and Friesland, in order to get a certain coverage.' (BE, 2016). According to the interviewee, this is a negative contributor, since he thinks that the solution for a viable business case 'is simply numbers: more vehicles, more transactions on a single charging point, or more charging points.' (BE, 2016). Municipalities have mentioned that strategically placed charging points turned out not to be so strategic and were underused. The municipality of Bladel states that they already discussed possibilities with Allego to move the charging points. In Ede they also moved a charging point, '[...] because the parking pressure was too high. The cars would park there for quite some time, and furthermore there were not a lot of transactions at the charging point.' (RS, 2016).

This links to another point that is mentioned in relation to placing charging points, which considers parking policies. As the municipality of Groningen describes, 'When a charging point is located in the city center, that parking place will not be used as often. [...] Therefore, the company that is responsible for these parking places will miss out on a certain amount of revenue, as the turnover of such a parking place is lower.' (AN, 2016). Not only costs are mentioned as an issue, but also the acceptance of people that there are not as many parking places available. In Rotterdam they mention that they have anticipated this, as they have decided to only reserve one parking spot for e-drivers in their new policy, although there are two connections available on a single charging point (HO, 2016). However, the issue of parking is not shared across all municipalities. Ede mentions that it cannot be compared to larger cities in that respect. 'It is more spacious. We also have more people who have their own driveway compared to larger cities. The parking pressure is also relative within our municipality.' (RS, 2016). Bladel recognizes this, as they mention that 'we do not cope with a parking issue. There are a lot of parking places and our city center is not busy.' (CR, 2016).

Several solutions have been thought of by grid operators as well as municipalities, which are argued to make the business case viable and at the same time solve problems regarding less revenue due to reserved parking places. On the side of the grid operator, it is tried to lower the costs that are related to charging infrastructure since these form a substantial part of the business case (Holland, van Cuijk, van Kerkhof, & Verheijen, 2016: 3). Therefore, it is currently being investigated whether it is possible to apply a variable load connection. 'That means that you realize a connection that can handle a lot of power, but you pay less for it. You then make a promise to the grid operator that you only use a small load during peak hours, and he will then allow you to use a larger load outside peak hours for a lower price.' (BE, 2016). Using this approach, the grid operator can save money on reinforcing the grid. However, this connection would require a higher network tariff, and stakeholders have expressed the view that they have no room left for more costs. As a municipality argues in the report by Holland et al. (2016: 19), it will be difficult to convince the local council of the fact that a more expensive connection is required.

Whereas the variable load connection primarily concerns the interests of grid operators, at ElaadNL they are working on a pilot called FlexPower, which focuses directly on the e-driver. In this pilot, it is considered what the contribution would be to the grid if a different price would be charged during different times of the day. As is explained, 'The system will for instance say that you are allowed to charge your vehicle between 17:00 and 19:00, but it will happen at a slower pace than normal.' (PB, 2016). This is a slightly different approach than the variable load connection, but it also helps grid operators in reducing their costs. Furthermore, by using this approach, the electricity price that is paid when charging an EV can be considerably lowered for consumers (Movares, 2016). Additionally, after an intensive lobby, grid operators recently managed to temporarily lower the energy tax on charging points, which also contributes to the unviable business case (PB, 2016).

Municipalities have also adopted strategies that influence the business case. In Rotterdam, they have shifted their strategy from providing everyone with a charging point, to combining requests. A charging point is placed if a minimum of 2000 kWh is charged every year by the people who are going to use it. As the municipality states, 'This mainly has to do with optimizing the network and making it profitable. We put the charging infrastructure out to tender, and a market player joins and spends a certain amount of money, and they want to make a profit as well. We cannot afford to haphazardly place charging points everywhere.' (HO, 2016). The same strategy was adopted by the municipality of Ede, who included a requirement in their contract that the user of the charging point had to charge at least 2000 kWh per year. The e-drivers had to subscribe and purchase a certain credit in order to charge. However, 'it turned out to be a messy process as most people who filed a request drove a leased car, and the payment could not be settled with the leasing company, and these people were not going to pay themselves. Eventually, [...] we turned it into the requirement that users have to use the charging point 'frequently'.' (RS, 2016). Furthermore, almost all municipalities mention that they still place charging infrastructure on strategic locations when they get an application from an e-driver. As the municipality of Ede describes, 'We do not place a charging point in front of someone's door. We locate it at walking distance of the e-driver's home, but still at a strategic place that is easy to find for other e-drivers as well, in order to encourage some more transactions by guest users.' (RS, 2016).

Lastly, some interviewees express their view on linking charging with parking fees. For example, 'A municipality can stimulate the number of transactions at a charging point by changing its parking fee, e.g. the longer people stay, the more they have to pay.' (BE, 2016). The municipality of Ede mentions that Arnhem is working on a penalty fee, which people have to pay if they stay at a parking place till after their vehicle has been fully charged. However, it is voiced that linking parking and charging may also have negative effects. An interviewee for instance mentioned that 'I can imagine that a municipality would want to see as few traffic movements within its city center as possible.' (BE, 2016). Another issue is pointed out by the municipality of Ede, where approximately 95% of the people who request a charging point drive a leased car, 'and they could not care less about the charging fee they pay.' (RS, 2016). Although these are solutions that have been initiated by local governments, it is argued that 'at a certain moment this has to become a market that can sustain itself. At a certain point, the role of the local government is finished, from a financial point of view.' (RS, 2016). Whereas the barrier of the unviable business case mainly concerns the current conductive charging infrastructure, some interviewees have also aired their views about inductive charging. They, amongst others, state that 'The business case for inductive charging is currently a bridge too far.' (BB, 2016) and that in their opinion 'The most important barrier for inductive charging will be its business case, simply because inductive charging is a more expensive technology.' (BE, 2016).

To sum up, there are still difficulties with the business case of charging infrastructure. However, it can be argued that this is dependent on the strategy that is adopted by the municipality. Municipalities, such as Rotterdam and Ede, who want to lower the charging fee in order to stimulate the electric driving and make it more cost-competitive, will run into an unviable business case. In comparison, it is remarkable that Groningen and Bladel, who have both partnered up with Allego, have not mentioned the unviability of the business case. This can be clarified by a statement of Allego on their website, where the organization argues that due to the strong increase in the number of e-drivers and the efficiency of processes, there is already a viable business case (Allego, 2016). However, this is also related to the fact that a higher charging fee has to be paid by the user, contributing to the viability of the business case. This section furthermore showed that the stakeholders who have acknowledged the negative business case, including grid operators and municipalities, try to solve the problem in multiple ways. Whereas grid operators are actively engaged with pilot projects to try to reduce their investments regarding the grid, municipalities are indirectly also working on the business case by increasing the number of transactions, for example by charging vehicles an extra fee once they are fully charged and requesting a minimal demand of kWh per year.

Additionally, Groningen mentioned the fact that their revenue stream is smaller due to the fact that a parking place for an EV is not used as often, compared to a regular parking place. This example already illustrates a difficulty that might be present within a municipality, given that there are multiple departments with multiple aims. Whereas the Sustainability department might want to stimulate electric driving, this influences the department that is responsible for parking places. Therefore, the next section will elaborate on internal and external processes that have also been highlighted by the interviewees as a barrier in the diffusion of charging infrastructure and electric driving.

5.2.2 Communication and collaboration

As already touched upon in the last paragraph of the previous section, internal and external processes have both been mentioned to act as a barrier in the diffusion of electric driving. They will therefore be discussed in the following paragraphs, which will start with internal processes after which the external processes will be discussed. The section will be finalized with an example of an issue that is related to external processes, which regards the throughput time of the placement of charging infrastructure.

Given the focus on local governments in the main research question, internal processes can be defined as the collaboration and communication that is present between different departments within a municipality. As an interviewee mentions regarding electric driving, 'Electric transportation is a subject that can be covered by multiple departments in a municipal organization.' (RS, 2016). As previous sections have already shown, electric driving and its corresponding infrastructure involve, amongst others, people who are responsible for making a decision about public space and people who need to see whether there is a budget available to finance these charging points. The municipality of Groningen also shared its experiences regarding electric driving and the link to parking, as they explain that 'higher costs are involved with regards to a parking place that includes charging infrastructure, compared to a basic parking place. Internally, it is difficult to find support for this as I am directly interfering with another department which is responsible for parking places. This shows difficulties on an organizational level [...].' (AN, 2016). However, the municipality of Bladel does not recognize this perspective as they mention that 'within our municipality there is a close cooperation between different departments, mainly because a lot of employees are located in the same room. [...] When I receive a question on whether we can install a charging point, I can immediately ask my colleagues from the other departments for their opinion.' (CR, 2016).

On the other hand of the spectrum, regarding municipal size, is the municipality of Rotterdam, who recognizes the view of Groningen that one department is working on electric driving, but that a lot of departments are not involved in that process. It is furthermore mentioned that the pilot project they have initiated might contribute to such internal issues. ‘There are also internal reasons to carry out a pilot project, because it enables you to connect multiple departments. [...] Internally, you start to cooperate more with regards to electric driving. The way we cooperate now is an advantage.’ (QO, 2016). This interviewee furthermore mentions that this internal cooperation also contributes to the acceptance of electric driving within the municipality, and helps to understand different points of view. As he explains, the people who are responsible for public space are not too keen on extra objects in public space, and he understands where they are coming from. ‘It is not my biggest concern whether there are charging stations or not, but the people responsible for public space have a different opinion. They remove traffic signs and parking meters, and subsequently we start installing charging points.’ (QO, 2016). All in all, this shows that there are different opinions regarding the internal processes within a municipality, also depending on the size. Whereas Bladel has a small municipal organization with close connections, the municipality of Rotterdam has more difficulties regarding internal processes.

External processes are approached on a broader scale, as issues have been identified regarding municipalities, provinces and grid operators. To start with governmental bodies, an interviewee mentions that there are several levels of government involved in a number of subjects, but eventually a lot comes down to municipalities. He explains that ‘charging infrastructure is a good example of something that the national government is playing an active part in [...], but when the province is not that eager to play a role in that as well, then it comes around and municipalities have to deal with it again.’ (RS, 2016). He argues that an intermediate layer would make things more efficient as it currently takes municipalities a lot of time to keep track of everything and attend every meeting. According to him, ‘not every municipality has to reinvent the wheel.’ (RS, 2016). This intermediate layer is suggested by the municipality of Bladel as well, who explains that they often work together with Environmental Services, who they argue to be the natural link between the province and municipalities (CR, 2016).

Within the municipality of Ede, who suggested that not every municipality has to reinvent the wheel, they have set up a project group ‘Electric Driving’ which includes municipalities from the province of Gelderland as a whole. In this project group they discuss several things, such as their own concession contract, but also other market models, such as the licensing model, and agreements with Ecotap. As is explained, they are currently cooperating with each other to be granted a budget for the deployment of charging infrastructure, which, according to the interviewee, ‘shows that it is sometimes beneficial to join forces.’ (RS, 2016). However, despite the fact that they are discussing issues that are related to electric driving with other municipalities, the province is argued to lack an active attitude in this. ‘Within the provincial context we talk about sustainable mobility, and recently the province of Gelderland has joined again. They kept themselves at a distance for a while, but it seems as if they have woken up again.’ (RS, 2016). When asked why the province is not involved, the answer is that it is difficult to predict what the province will do. As he explains, ‘Despite the fact that their involvement in a project on public charging infrastructure is limited, they are investing millions of euros in a driverless car between Wageningen University and the train station Ede-Wageningen.’ (RS, 2016). Although this signals some disinterest in charging infrastructure from the province’s point of view, the interviewee argues that he thinks it is going in the right direction again as the province has initiated an Agreement for Energy.

Another interviewee also highlights the collaboration between the province and the municipality. He uses an example of the province North-Brabant, who is going to set out a new tender with which they want to unburden the municipalities regarding the placement of charging infrastructure, asking a small financial contribution in return. Although this tender allows the province to take over municipal tasks, such as placing a road sign, the interviewee mentions that a lot of municipalities still want to do this themselves. As he concludes, 'Therefore, this does not work efficiently.' (BE, 2016). Regarding the same province, the municipality of Bladel says that they work quite segregated and that they have the feeling that the municipality is often taking the lead. 'Sometimes we already started to work on a subject, while the province announces a project or program somewhat later. However, this is not always the case.' (CR, 2016). Whereas the municipality has an agreement with Allego, they explain that they have recently been approached to collectively invest in charging infrastructure by means of a tender. As is commented, 'If you tell them that you already have an agreement, I do not get the feeling that they do something with this information. The cooperation is missing; it is not really a consultation. It is more one-way traffic; a top-down process.' (CR, 2016). Besides collaborative issues between municipalities and the province, also its advantages are highlighted. It is for instance mentioned that the scale of the province is a nice scale to start up pilot projects regarding inductive charging, and to start the lobby about things such as the business case of charging infrastructure (RS, 2016). Furthermore, it is argued that larger municipalities should be the driving force of projects, in close cooperation with provinces.

An example of the influence of external processes on electric driving that has been mentioned by municipalities, regards the throughput time of placing charging infrastructure. This process includes multiple parties, including grid operators and municipalities. As an employee from a grid operator mentions, 'What I am worried about is the throughput time. [...] It already takes approximately 18 weeks before a single charging point is placed. People, inhabitants, are going to be dissatisfied about that.' (BB, 2016). In Rotterdam, they have also acknowledged this problem between the municipality and the grid operator, which they ascribe to the fact that schedules are not aligned (HO, 2016). Together with the grid operator the municipality came up with a plan, but eventually it turned out not to be feasible from a legal point of view. It is mentioned that they are now going to reconsider the plan, to see whether a different approach is possible. In Bladel they have also looked at throughput time, by means of shortening the application procedure. Besides making an agreement with Allego, they have created a central point where people can file their application. Furthermore, they mention that as a municipality they officially have to wait four till six weeks before placing the charging infrastructure, which is the duration of the period that people can make an objection. Nonetheless, unofficially they can already launch the procedure, including making a decision about what traffic signs to place and ordering them (CR, 2016). According to another interviewee, eventually the aim is to place charging infrastructure with the speed of a mail order company – if you order in the evening, it will be placed in the morning. However, he mentions that 'that is our ambition, but it will probably be somewhere around a week.' (BB, 2016).

Conclusion

This section has highlighted two barriers that have been identified in relation to charging infrastructure. As stated in the hypotheses, it was expected that municipalities of a different size would experience different bottlenecks. The results have shown that this is the case for both bottlenecks, starting with the business case which is still a big challenge that involves actions from grid operators as well as the municipality. This issue was emphasized by the municipalities of Rotterdam and Ede, who both subsidize part of the costs of charging infrastructure. However, the barrier of the business case cannot be completely ascribed to the fact that the municipalities have a different size, given that Groningen, which is also a medium-sized municipality, did not mention the business case as a problem. This can be clarified by the fact that Groningen and Bladel have both adopted a licensing approach in which they have partnered up with Allego, who argues that there already is a viable business case and therefore the municipalities do not see this as a problem.

Furthermore, it was expected that these municipalities would tackle the identified barriers differently, depending on their resources. It becomes clear from the results that financial resources have an effect on how the business case is handled, since Ede and Rotterdam both subsidize part of the costs of charging infrastructure and therefore contribute to making the business case more viable. Still, it proves difficult to work on the business case, which is related to the lock-in of current practices. An example of this is the close link that is created between charging and parking. Whereas parking places are currently only used as a place to park fossil-fuel based cars, which constitute the regime, the introduction of EVs has made a parking place a fueling station at the same time. The introduction of this novel technology therefore not only requires a different charging infrastructure, but also alters rules and regulations regarding parking places. Since the current regime is not aligned to these novel practices, EVs experience a hard time trying to break out of their niche.

When looking at the identified bottleneck of internal processes, differences have been detected regarding the size of the municipalities as well. Larger municipalities have more internal struggles, but Groningen also mentioned internal problems, despite having approximately the same size as Ede. This can be explained using the categorization whether municipalities are either active or passive. It can be argued that Ede has a clear view on EVs and infrastructure as they are actively involved with this technology, and therefore this topic is more embedded within their organization compared to the municipality of Groningen, which primarily focuses on cycling. Despite the fact that the municipalities of Rotterdam and Groningen mentioned internal problems, it is not clear how this issue is tackled, but it can be argued that actively engaging in pilot projects can be a solution in bringing multiple departments together. Last of all, external processes were described as a barrier related to EVs and charging infrastructure. What can be concluded from the results is that there are less issues with the province, the larger the municipality is. On the medium-sized level, a difference can be found between active and passive municipalities. Despite the fact that regional commitment is mentioned as a bottleneck, Ede has tried to solve this problem by taking part in a project group and joining forces to achieve certain aims regarding electric driving and charging infrastructure. This is different for smaller municipalities, which generally need the support of the province given their scarce human and financial resources.

Both internal and external problems can be ascribed to the lock-in of the current socio-technical system as well, which is aligned to a vertically structured organization. Since electric transportation includes multiple departments, such as transportation and public space, it requires a more integrated approach. Furthermore, the results highlight a broader trend that is visible in the Netherlands, in which more processes are directed from the national government to local governmental bodies, which therefore have started to play an increasingly important role. However, this role is more difficult to shape for smaller municipalities, as they generally have fewer resources available.

Current charging infrastructure is subject to both the identified barriers, but inductive charging has been introduced as an alternative which might contribute in a positive way to these issues. As mentioned at the start of this chapter, novel technologies are often surrounded by expectations which influence the extent to which they will be mobilized by municipalities. Therefore, the next section will elaborate on the novel technology of inductive charging, focusing on expectations that have been expressed regarding this type of charging.

5.3 Expectations inductive charging

The previous section on the barriers of charging infrastructure showed that there are still some bottlenecks which keep electric driving from diffusing from the niche to the regime. Inductive charging is a novel technology, which could erase these bottlenecks and help the scale-up of EVs. As mentioned in the chapter on theory and concepts, expectations are important in the initial phase of a transition as competition is based on expectations instead of on the performance of a technology (Alkemade & Suurs, 2012: 448). Furthermore, expectations are a key driver of certain technologies as they stimulate, steer and coordinate the actions of involved actors (van Lente & Bakker, 2010: 694). This section will therefore look at the expectations of inductive charging, according to the categorization made by van Lente (1993: 182-83). In his paper, he distinguishes three levels of expectations, namely micro-, meso- and macro-level expectations. On the micro-level, expectations are expressed about the performance of the technology. The meso-level focuses on more general expectations, which say something about the function that the technology is going to fulfill. On the third level, the macro-level, expectations are expressed that contain broader statements about the technology and about societal trends. Structured by this theory, the following sub sections will discuss the state of the technology of inductive charging, its expected niche application, and broader expectations about the future of electric driving and public space.

5.3.1 State of the technology

Regarding the state of the technology of inductive charging, there is a broad range of expectations. Since the technology is relatively novel, it might have to face several technological challenges that make the development of the technology on a short term difficult. One of the most important aspects of an inductive system according to the interviewees are its costs, which are positioned as a trade-off to the actual comfort of the system. 'It is expensive, and I question whether the comfort it gives you actually solves something.' (BB, 2016). Although no numbers were mentioned regarding the costs of an inductive system, actors expect the costs to be higher than conductive charging points. As is explained, 'Costs are already a showstopper for conductive points, and I cannot imagine that an inductive system would be cheaper.' (RS, 2016). When asked about how these costs will change in the near future, an interviewee states that 'parties have expressed that they want to work towards offering the system at a competitive price compared to a conductive charging point, but as it stands, that will take years.' (BE, 2016).

Besides the costs of the system at the moment, its efficiency is also questioned. 'Moreover, I do not hear a lot of people about the actual efficiency of the system. I do see some numbers, such as that the loss of the system is 10%, but I think that if you include grid losses, the total losses of the system will approach 30%, which is a lot. [...] The business case is *by far* a bridge too far.' (BB, 2016). Experts have also expressed their worries about the efficiency of the system, given that it should contribute to the scale-up of *sustainable* mobility. 'When you talk about environmental awareness and saving energy, then I question why you start out with a system that will fundamentally perform worse than charging with a connection. You are searching for a system that, by definition, will not be able to reach a higher efficiency, or it is going to require more material in order to increase the efficiency.' (TU, 2016). However, an interviewee that is engaged with these inductive systems argues that the system has been developed further, and is nowadays able to deliver a higher wattage at a larger distance between the coils, with conservation of the efficiency and safety (JT, 2016).

Another issue that is related to the newness of the technology, is that there is currently a lack of standardization. In Rotterdam they managed to integrate the systems into two different vehicles, 'but if car manufacturers will start to offer this technology in a few years, will you be able to charge your BMW by using a Nissan-hotspot?' (BE, 2016). In order to tackle this issue, an international project group has been created that is working on the standardization of inductively charged vehicles, including a range of aspects such as the frequency of the system and guidelines on the permitted level of radiance (JT, 2016). This standardization will be a first step towards a ready-to-use system, which is not available yet (BE, 2016; QO, 2016). Also, whereas the system has been introduced as solving issues with charging points in public space, as it is not as intrusive, this leaves much to be desired at the moment. The pilot project in Rotterdam still had to place a pole next to the inductive system in order for the users to identify themselves with a card. These things contribute to the fact that there is still a lot of uncertainty regarding the technology of inductive charging in combination with public space. 'Perhaps this will change in the future. Integrating components into the ground, or installing one box that can power thirty inductive plates. That will be an improvement for your public space.' (QO, 2016).

Due to the state of the technology, people do not think that an inductive system will become the only charging system within the near future, but it will become optional. 'In the future you will order a car and say 'I want a sunroof and I want to charge inductively'. I do not think that it will become a standard system that when a charging point is placed, it will be an inductive system.' (BE, 2016). All eyes are therefore directed towards car manufacturers, who are seen as the pioneers of new technologies. 'If Tesla would start to manufacture a vehicle with a module to charge inductively, that would be a game changer.' (AN, 2016). Additionally, an interviewee that is involved in the project in Rotterdam has mentioned that 'At present, I think it will last at least ten years before inductive charging systems will be applied on a larger scale.' (QO, 2016). An indirect expectation about the technology is also illustrated by the fact that a meeting was scheduled with the municipality of Rotterdam and Rijkswaterstaat, as they were interested in the entire system, but although this conversation was planned a while ago, it never took place.

All in all, it is argued that the technology is still costly and immature. According to the interviewees, there is a lot of uncertainty on how the technology is going to perform, apart from the expert that actually sees the results of the system as it is implemented in buses in Utrecht. Based on these micro-expectations, some interviewees have also expressed their views on what function they think this technology is going to fulfill. The next section will elaborate on this function, saying something about how the technology is expected to be used.

5.3.2 Functions of inductive charging

Whereas micro-level expectations consider the performance of a technology, meso-level expectations focus on the function that a technology is going to fulfill in society. Four functions of the technology have been distinguished, namely making things easier for the user, reducing range anxiety, inductive charging as solution for public space, and inductive charging applied to transportation niches. The following paragraphs will elaborate on each of these functions.

First of all, inductive charging is by some interviewees seen as a more user-friendly technology, since people do not have to use cables anymore to charge their vehicle (BE, 2016; PB, 2016; QO, 2016). However, this function of inductive charging is immediately questioned, as an interviewee states, '[...] although I question whether fiddling with a cable is an actual reason for someone not to purchase an electric car. I do not think so.' (BE, 2016). In another interview it is mentioned that when electric driving was introduced, one of the main concerns was that people would trip over cables in the street. 'Entire conferences were organized about who should be held accountable if something happened, and how it should be solved. It was argued that if the issue was not solved, electric driving would die an early death.' (BB, 2016). However, nowadays electric transportation is still present and, according to an interviewee, people have taken these cables for granted (BB, 2016). Someone therefore also questions whether inductive charging is actually going to change the scale of electric driving, as 'people will be more influenced by price than by the fact that they have to plug their car into the grid.' (BE, 2016). This statement is supported by another interviewee, who mentions that costs and range anxiety are two of the most important trade-offs for people when deciding to buy an electric vehicle or not, instead of charging the car with or without a cable. Nonetheless, he continues his answer by stating that 'Eventually people will see the ease of use. Wireless charging will become an argument, but at present it is too early for that.' (PB, 2016). Although the function of ease of use has been ascribed to inductive charging by some interviewees, this view is not shared by everyone. As an expert states, 'Wireless charging is a luxury. I have the idea that it is primarily aimed at people who are too lazy to plug their vehicle into the socket.' (TU, 2016).

The second function that has been ascribed to inductive charging is to some extent related to the user-friendliness of the system. Some interviewees have mentioned that wireless charging will reduce range anxiety as it can be applied dynamically, which means that the vehicle will charge while driving. 'It may take a while, but in Sweden they have done some research on dynamic inductive charging, which you sometimes see in the news. [...] That is something which is going to take place.' (JT, 2016). Positive expectations are expressed regarding this application of inductive charging, including 'I think that it is a great idea, because you no longer have the problem of having to charge your car after 300 kilometers.' (CR, 2016), and 'It is the holy grail of electric driving, because you can drive indefinite distances without having to charge on the side of the road.' (PB, 2016). Although it is mentioned that the infrastructure will still be quite expensive, it is argued that this type of inductive charging will contribute to the scale-up of EVs (CR, 2016).

Thirdly, although the state-of-the-art technology leaves some things to be desired, inductive charging has been claimed to be a solution for public space, which is quickly filling up with charging points. As an interviewee states, 'I think that a solution such as inductive charging is a fantastic solution from an urban planning perspective; how you deal with the urban landscape [...].' (AN, 2016). This view of the municipality mainly originates from the fact that they are responsible for public space and therefore 'we argue that public space has to look good. Inductive charging fits with that vision.' (QO, 2016). This has also been one of the reasons for the municipality of Rotterdam to initiate the project with inductive charging, since it is expected that this technology can be integrated in the city. However, as mentioned in the previous section, the current project with inductive charging in Rotterdam still requires a pole so that users can identify themselves with a card, and therefore does not directly contribute to the problem with public space.

Finally, a view that has been expressed multiple times is that 'inductive charging will serve the niche instead of the wider public' (HO, 2016). However, there are several interpretations of what this niche will specifically encompass. Whereas one interviewee argues that the technology will mainly be used for certain branch organizations, such as transporting students or disabled people (HO, 2016), another person thinks that wireless charging will in the beginning be mainly used for fast charging and it will be used by companies instead of by private individuals (PB, 2016). An expectation which is expressed multiple times is the application of the charging technology for buses instead of vehicles. 'When you look at buses, which always drive the same route, then I think that inductive charging has more potential for such a niche, since a bus drives shorter distances and you can modify its schedule in such a way that it pauses for a longer time at some points to charge.' (BE, 2016). However, the municipality of Bladel mentions that for them it would be harder to integrate such a technology into buses, as they have tendered this type of transportation and thus have less influence as a municipality (CR, 2016). Additionally, it is expected that once this technology has been fully developed and costs can be lowered, it will be applicable to other things as well, such as a random parking place. 'However, the first pilot projects will probably be in combination with buses.' (RS, 2016).

This section has illustrated that there is a broad range of expectations regarding the function that this technology is going to fulfill. Whereas some see the introduction of this technology as a solution for public space, others argue that it has been created to increase the user-friendliness of EVs and therefore contribute to its scale-up. The state of the technology also influences the function that people ascribe to it. Because it is still not fully developed, people argue that it will start out as a niche. However, they also express some positive expectations regarding dynamic charging, which is currently still in its infancy as well. The view on public space is also expressed on a broader level, arguing that electric driving will take off in the coming years, filling public space with charging points. The next section will go into detail on these broader expectations, with a focus on the argument of public space.

5.3.3 Future of public space

At the macro-level, broader statements are expressed about the technology as well as societal trends. A trend that almost all municipalities pinpoint, is the fact that electric driving will continue to grow. One interviewee mentions that he thinks the Tesla Model 3 is going to be a milestone in this, driving municipal policies. 'The fact that there are already more than 400.000 preorders shows that there is market demand, and once these vehicles are on the road, the inherent need for charging infrastructure will arise.' (AN, 2016). He continues his story on electric driving, linking the number of applications to the number of charging points. 'Our strategy currently still works considering the number of applications that we get. In 2014 we got nine applications, in 2015 we got twenty applications, and at the moment, in 2016, we are already at twenty applications. If you plot that in a graph, then you will see an exponential function. If you translate that to the year 2020, then the number of charging points will become so large that we might have to rethink our strategy.' (AN, 2016). Because of this growth, the municipality also expect all parking places to be provided with a charging opportunity in the future.

The statement on public space is supported by the municipality of Ede, who mentions that it will become a problem in the future if the policy of the national government turns out to be true. They have written that there should be 1 million electric cars in 2025, which might bring along the problem of a lot of street furniture in public space (RS, 2016). Rotterdam also mentions public space, saying that 'you are not going to sustain implementing conductive charging stations. Filling up entire cities with these charging stations [...].' (QO, 2016). These statements show that there is an inherent link between the growth of electric driving, and the number of charging points. Regarding charging infrastructure in combination with public space, there is a broad range of expectations how it will develop itself in the future. Two types of expectations can be discerned, with one focusing on the technology of charging infrastructure and another expectation expressing a broader societal trend.

Regarding the former expectation, some interviewees expect the conductive infrastructure to last in the future, saying that 'I think that the wider public will continue to use conductive charging, which is fed by the second-hand market which is coming up.' (HO, 2016). Others expect the conductive and inductive charging infrastructure to coexist in the future. As an interviewee mentions, 'The two infrastructures will coexist. It are two separate trajectories, and one will not replace the other.' (AN, 2016). However, he continues his narrative by stating that he does not think that inductive charging will serve as a solution for public space, as 'it will be something extra that needs to be placed in public space.' (AN, 2016). The challenge ahead for municipalities is also emphasized, as the municipality of Bladel explains that 'it is difficult to predict what the combination of the two charging infrastructures will be like. Let us assume that the two technologies will exist side-by-side, then it will become difficult to make a decision when you install new charging infrastructure. Are you going to install an inductive system, do you install a charging point, or do you place both technologies which will be twice as expensive?' (CR, 2016).

Another opinion that is expressed in the interviews is that the two charging infrastructures will coexist, but that eventually wireless charging will supplant charging using a cable (PB, 2016) and that inductive charging will be phased into current technologies, until eventually overhead charging points will die out (RS, 2016). This is related to a broader trend, as one interviewee explains that 'when I look at the development of other devices and how we handle things indoors, things will become more and more wireless.' (CR, 2016). However, whereas most interviewees have expressed expectations about either conductive or inductive charging or a combination of the two infrastructures, not everyone expects charging points to be the future. 'Charging points are something temporarily. It is not a development that will grow out to become the standard.' (AN, 2016). The underlying reason for this statement is that this interviewee expects hydrogen to become the fuel of the future. 'My personal opinion, and when analyzing the market, is that hydrogen will be the future. [...] Inductive charging will not be adopted by car manufacturers and when it becomes interesting, it will be passed by hydrogen fueled cars.' (AN, 2016). Some advantages that are mentioned in comparison to the current charging infrastructure include that the fuel can be generated in a sustainable way, cars can be filled up more quickly and the range is somewhat higher.

What this section has illustrated, is that there are varying expectations about charging infrastructure which are mainly fed by the fact that people expect electric driving to grow. Not only do they see a growth in requests, but they also expect car manufacturers to contribute to this scale-up by introducing vehicles such as the Tesla Model 3. A close link is therefore constituted between the growth of electric driving and the growth of public charging infrastructure. Furthermore, the previous paragraphs show that the majority of the interviewees expect the charging technologies to coexist. Whereas inductive charging is often presented as a technology which is less intrusive for public space, this would mean that there are only more objects in which have to be located in public space. Another notable development that was mentioned, is the introduction of hydrogen as fuel. Considering the fact that it has multiple advantages compared to the current charging infrastructure, it can be seen as a competitive technology for inductive systems.

Conclusion

As this section has shown, a broad range of expectations has been aired on multiple levels. On the one hand the technology is seen as promising, but the majority of the interviewees judge the technology as being too costly and immature. However, the fact that people expect the technology to be more expensive is mainly based on their knowledge regarding the costs of current charging infrastructure, and seems less based on the actual developments of inductive charging. This shows that competition in the initial phase of a transition is mainly based on expectations instead of on the actual performance of a technology (Alkemade & Suurs, 2012: 448). Furthermore, multiple functions were ascribed to inductive charging. Whereas some actors expect it to make things easier for the user, in order to contribute to the scale-up of EVs, others see it as a technology to make transportation, such as buses, more sustainable or as a solution for public space. Last of all, there is a general expectation that electric driving will continue to grow, but expectations vary from the role that inductive charging is going to play in that growth. Whereas some people expect the two charging infrastructures to coexist, others think that everything will become wireless, and also hydrogen is introduced as fuel of the future. Given that the two charging infrastructures will exist side-by-side in the future, it is debatable to what extent inductive charging will contribute to public space, as this will only mean that more objects will have to be placed next to the current charging infrastructure.

What can be derived from these expectations is that there is no consensus on all three levels regarding the performance and function of inductive charging, and broader societal trends. According to Schot and Geels (2008), shared expectations are a requisite in order to create a niche. With regards to inductive charging, it seems as if there is still too much uncertainty on different levels of the technology, which might inhibit its further diffusion. Despite the lack of consensus on the three levels, multiple dynamics can be distinguished which, according to Budde et al. (2012: 1075), either reinforce or weaken each other. What is remarkable from the expectations regarding inductive charging is that although there are doubts on the micro-level about the performance of the technology, it is still argued to offer a solution to trends that have been identified on the macro-level, including the expected growth of EVs and subsequently the growth of charging infrastructure, filling up public space. However, despite the expectation that it is not feasible to continue to place charging infrastructure, not a lot of attention has been directed at inductive charging yet, given that Rotterdam is the only municipality that has started a pilot project on this technology. Although literature has argued that expectations give guidance to technological developments (Geels & Raven, 2006: 377), the beneficial functions that are ascribed to inductive charging have not resulted in a focus on this type of charging infrastructure. It can either be argued that the societal functions that inductive charging is expected to fulfill are not deemed as important, or it might be the case that the micro-level has a significant influence on the other levels, inhibiting further development.

6. Conclusion and reflection

This chapter will give an answer to the research questions that have been formulated at the start of this thesis. First of all, the three sub questions will be answered, after which an answer will be given to the question what the role of local governments is in stimulating the transition towards more sustainable mobility. From this outcome, some policy recommendations flow, which will be discussed in the section that follows. Furthermore, strengths and limitations of the research will be outlined, and the chapter will be concluded with suggestions for future research.

6.1 Answering the research questions

The aim of the first sub question was to find out what bottlenecks are present that inhibit further development of the niche of electric transportation, and also if local governments can play a role in taking away these barriers, given the importance that is ascribed to them by current literature. The exact formulation of the question was,

How do local governments tackle the bottlenecks that are identified regarding the implementation and managing of charging infrastructure?

Multiple bottlenecks were identified by the interviewees, but two of them were particularly emphasized, namely the business case of charging infrastructure and difficulties regarding internal and external processes. The former barrier is present due to the fact that charging infrastructure is still expensive, and that it is difficult for market parties to make a profit and at the same time offer charging fees at a competitive price compared to fossil fuels. Whereas it was expected that municipalities of a different size would experience other barriers, the results showed that mainly their policy had an influence on whether they acknowledged the business case as a bottleneck or not. The municipalities of Rotterdam and Ede, who have adopted the concession model, both mentioned the business case as a barrier. In order to tackle this issue, the municipality of Rotterdam has decided to combine requests until a minimum amount of kWh is reached that will be charged per year. Furthermore, the municipality invests a certain amount of money per charging point in order to close the gap that is currently present. Initially the municipality of Ede adopted the same strategy as Rotterdam, arguing that e-drivers should charge a minimum amount of kWh per year. However, they excluded this requirement from their policy when it turned out not to be feasible regarding issues with leasing companies. Since Groningen and Bladel partnered up with Allego, who argues that there is already a viable business case, they did not acknowledge this barrier and therefore also took no immediate action to alleviate the unviable business case.

What can furthermore be concluded, is that available resources are underlying the adopted model and therefore also have an influence on how barriers are tackled. Given that Groningen and Bladel did not have the same financial resources available as the other two municipalities, they decided to adopt the licensing approach which requires no financial means from the municipality. However, despite the absence of any financial means for electric transportation in these municipalities, it is argued that passive municipalities can also play an important role in alleviating this barrier of the unviable business case. By combining requests until a minimum amount of kWh is reached, a contribution can be made to lowering the construction and hardware costs, as it does not require that a charging point is placed for every individual e-driver.

The second barrier that was identified concerned organizational issues, internal as well as external. It was argued that electric driving is difficult to embed within an existing organization such as a municipality, due to the involvement of multiple departments who have varying aims. This was primarily the case for larger municipalities, which often have a larger organizational structure compared to smaller local governments, where there is close interaction between employees from different departments. Also, it can be argued that local governments who are more actively involved with electric transportation have a better view on how this type of mobility can be embedded within their organization, compared to municipalities which outsource the majority of activities to an external party, such as Allego. Despite the fact that no clear solution was offered regarding resolving this bottleneck, it can be argued that actively engaging in projects with novel technologies can help to bring departments together. Technologies such as electric driving and inductive charging require a more integrated approach, since it combines the domains of mobility and energy. Furthermore, cooperation between multiple departments could also contribute to the overall acceptance of electric driving in a municipality, which is beneficial when working towards more sustainable mobility.

Regarding external processes, issues were identified between municipalities and the province as well as between municipalities and grid operators. With respect to the former process, it was argued that the province provides a good platform for innovation, in close cooperation with municipalities, but at the same time it was pinpointed by some municipalities that the interaction between the two levels still left much to be desired. This issue was tackled in different ways, depending on the size of the municipalities and their policy regarding charging infrastructure. Given that larger municipalities have more resources at their disposal, they can create projects themselves and do not necessarily need support from the province. Smaller municipalities often have less financial and human resources available, and therefore could benefit from joining forces with the province. Regarding medium-sized municipalities, their behavior in tackling this issue is dependent on their approach towards electric driving. Since they often have enough human and financial resources available, they can take on local initiatives themselves and create project groups, but this depends on whether they want to be actively involved with this technology. However, it should be taken into account that projects could become too contained and too diverse if municipalities start to create pilots independently. In order to achieve a transition towards more sustainable mobility, there needs to be an aggregated level of knowledge in which niche projects are combined in order for them to contribute to the global level of electric driving.

The issue regarding external processes between municipalities and grid operators was illustrated by an example on the throughput time of charging infrastructure. Because of the number of parties involved and the misalignment of schedules, the throughput time is too long which acts as a barrier when people want to purchase an EV. In Rotterdam they have tried to shorten this throughput time by creating a plan together with the grid operator, but this plan turned out not to be feasible from a legal point of view. Although this plan did not work, they are going to reconsider it to see whether there is another solution to reduce this throughput time. In Bladel the municipality also worked towards shortening the throughput time, with a focus on the length of the application procedure. By making an agreement with Allego and by already taking a decision on which traffic signs to place and ordering them, they try to shorten the overall procedure.

Both barriers have shown to be related to the current regime. Charging is still a novel practice, when compared to fueling your car at a gas station. Besides offering a challenge regarding its throughput time, it also requires new user practices and offers a challenge to how this charging infrastructure can be exploited. Furthermore, the close link that it has established between a parking place as a charging place already shows that multiple aspects have become intertwined by the introduction of electric transportation. This close relation is also seen on a higher level, regarding the embeddedness of this type of transportation within an organization such as municipalities. All in all, this shows that, in accordance with literature, local governments can play an important role in tackling problems that constitute a barrier between the niche and the regime, inhibiting further diffusion of electric transportation. Regardless of their size or adopted model, local governments can contribute in a positive way to reducing existing bottlenecks and contributing to more sustainable mobility.

The second sub question was formulated in order to zoom in on the visions and expectations of municipalities, as these guide a technological trajectory such as electric driving. According to the literature, there is a close link between expectations and actor strategies (Budde et al., 2012: 1074) and therefore this question was defined as,

How do visions and expectations shape the role of local governments in the rollout of charging infrastructure?

The chapter on results showed that multiple visions and expectations were expressed by the four studied municipalities, and they adopted different strategies. To start with the municipality of Rotterdam, besides climate change, their specific aim is to improve local air quality in order to promote their inhabitants' health. According to them, sustainable mobility can contribute to this vision, and therefore they have decided to facilitate and stimulate charging infrastructure. Besides adopting a concession model, they have chosen to invest in charging infrastructure in order to create a viable business case and to lower the charging fee that drivers have to pay. Although they are primarily focusing on public charging infrastructure, they have expressed that they foresee issues with public space in the future. This has been a driver, besides the availability of financial means, to initiate a project with inductive charging. However, their experiences in this project have made them uncertain about the future of inductive charging, and at the moment there are no plans to apply the pilot project to a larger scale. Their expectation is that the technology will remain a niche, probably as propulsion technology of buses.

In Ede, local air quality has also been a driver to get engaged with sustainable mobility. Although they mention that they currently do not have a strong vision regarding sustainable mobility, the municipality has been welcoming the initiative of E-Laad a couple of years ago, who placed the first charging stations. When they noticed that there was a continuing demand for public charging infrastructure, the municipality decided to initiate a project on charging infrastructure using the money that was granted to them under the heading of the National Cooperation Program Air Quality. Furthermore, they adopted the same approach as the municipality of Rotterdam and also decided to invest a certain amount of money per charging point. Despite the fact that they are actively involved with charging infrastructure and also feel their responsibility for public space, they argue that larger municipalities should initiate pilot projects, demonstrating novel technologies such as inductive charging.

The sustainability policies of the municipality of Groningen are mainly driven by an increasing awareness of climate change and the fact that the municipality wants to be energy-neutral in 2035. Regarding sustainable mobility, there is an emphasis on cycling and a substantial amount of money has been dedicated to that strategy to promote the bicycle in the coming years. Given that their budget is mainly dedicated to cycling, the municipality has signed an agreement with Allego who places charging infrastructure for free. They have chosen this licensing contract as no budget was dedicated to electric driving, but still they had to handle their inhabitants' requests. Although they see inductive charging as a great solution from the point of urban planning, they think that this technology will be passed by hydrogen fueled cars. This expectation has directly fed into their strategy, as they are planning on getting two hydrogen fueling stations to Groningen.

The fourth municipality that has been considered, Bladel, is also driven by the aim to become energy-neutral in 2025. Although they included sustainable mobility in the climate vision that they wrote together with the other four Kempen-municipalities, they did not create an actual project with charging infrastructure. The municipality has adopted the licensing model as well, with the underlying reason that Allego takes care of the entire process. Their expectation of inductive charging is that it can become a contributor to the scale-up of EVs once it is possible to dynamically charge a vehicle. However, it is argued that it would be harder for the municipality to get involved with such novel technologies, as they have outsourced certain transportation services due to their municipal size and related human resources.

What can be concluded from these visions and expectations and corresponding strategies, is that they both have an effect on the role of local governments. However, a distinction should be made between visions and expectations, with a stronger connection between the latter and strategies. Whereas visions explain why sustainable technologies are adopted, they do not clarify why certain technologies are preferred over others. Due to the vision that sustainable mobility is improving local air quality and contributes to becoming energy-neutral, local governments have ascribed themselves a stimulating and facilitating role to include this alternative type of mobility in their policies. However, expectations are shown to guide competition and also explain why certain technologies are mobilized, which can be illustrated by an example from the municipality of Groningen. Despite the fact that both hydrogen and inductive charging are not available on a large scale in society yet, the expectation that cars can be fueled more quickly and have a higher range using hydrogen drove the strategy of Groningen to invest in hydrogen filling stations instead of getting engaged with inductive charging. Furthermore, the macro-expectation that was expressed regarding public space filling up with charging points, drove the municipality of Rotterdam to get engaged with inductive charging. Also, in smaller municipalities, the number of requests is still manageable and public space is not expected to become a problem, which might explain the fact that these municipalities express less interest in a solution such as inductive charging.

However, not all the strategic choices can be attributed to expectations. Although the municipality of Ede has expressed the same view as Rotterdam regarding the number of charging points in the future and also feels the responsibility they have as a municipality, they still ascribe an innovative role to larger municipalities and they have not mobilized the technology of inductive charging. This can be explained by the fact that two other drivers have been identified which are also argued to shape the role of local governments in the rollout of charging infrastructure, which are the municipality's size and the financial means that are available. These human and financial resources have a direct influence on the selected strategy and on the activities that a municipality can initiate. Rotterdam, for instance, explained that besides their expectation on the potential of inductive charging, another important issue was that there was still money available to invest in such a project. These financial resources have played a role as well in the strategy that has been chosen to provide inhabitants of the municipality with public charging infrastructure. Whereas Rotterdam and Ede had some financial leeway to contribute to charging infrastructure and chose the concession model, the municipality of Groningen was not granted any money for charging infrastructure. Therefore, they chose the licensing approach which requires no extra investment from them as a municipality. However, it is also debatable to what extent strategies are dependent on the resources within a municipality, given that Groningen has plenty of financial resources, but has chosen to invest its money in a cycling strategy. Although they receive requests from their inhabitants on charging infrastructure, this strategy may be fueled by a strong expectation that electric driving will cease to exist in the future. In the case of Bladel, they have chosen the licensing approach due to a lack of human resources. Since they are a relatively small municipality, they have outsourced some of their activities to other parties. They mention that an advantage of Allego is that a lot is arranged in advance, reducing the effort and capacity that is needed from the side of the municipality. This shows that despite the contribution of visions and expectations to how local governments shape their role, also resources are argued to play an important role in influencing strategies.

The final sub question that was introduced at the start of this thesis concerned the lowest level of the niche, namely the local niche. According to literature, a niche should be seen as an interconnected set of smaller, local niches which may jointly create a new regime (Bakker et al., 2012: 423). Given the case of electric driving, it can be argued that different charging technologies, including conductive and inductive charging, can contribute to the overall scale-up of EVs. However, technological designs can also compete with each other for the same resources. It was argued that this competition might arise as well between the two charging infrastructures as they both need their place in public space. Therefore, the third sub question was defined as,

How will the inductive and conductive charging infrastructure influence each other, and how do local governments mobilize this interaction to stimulate the uptake of EV?

This question again revolves around expectations, as the technology of inductive charging is still in its development phase and not implemented on a large scale in society yet. The current state of the technology and the functions that it is going to fulfill, both have an effect on the expectation how the two charging infrastructures are going to influence each other in the future. From the expectations that have been expressed, four functions were identified that people expect inductive charging to fulfill. Besides the fact that it will make current charging practices more user-friendly, people see it as a solution for public space, and as a technology that is going to reduce range anxiety once it can be applied in a dynamic way. However, given the current state of the technology, it is questioned to what extent inductive charging is able to contribute to the scale-up of EVs. At the moment, people expect inductive charging to be mainly applied to niches, such as buses and special transportation, including the transportation of schoolchildren and disabled people. What can be concluded from these expectations is that inductive charging is mainly seen as an aesthetic solution, solving the issues with respect to current charging infrastructure, such as its intrusiveness in public space. Unless the technology can be applied dynamically or when it is applied to buses, its contribution to the scale-up of EVs is not mentioned by local governments.

The functions that people ascribe to this new technology, also influence their thoughts on how the two charging infrastructures are going to influence each other. A total of three scenarios can be distinguished about the combination of charging infrastructures in the future. Whereas some people think that the wider public will continue to use conductive charging, amongst others due to the second-hand market of EV which is coming up, others think that inductive charging is going to develop itself and they think that the two infrastructures will exist side-by-side. Finally, expectations have been expressed about society eventually becoming wireless, including the current infrastructure. However, despite the fact that these expectations have been expressed, at present Rotterdam is the only municipality that has initiated a project with inductive charging for private car use.

It can be concluded that stakeholders primarily see inductive charging as a *replacement* of current conductive charging infrastructure, and therefore do not expect the two technologies to have an influence on each other. Furthermore, they do not see the direct contribution of inductive charging to the scale-up of EVs, but they mainly see it as a technology which has been initiated to solve issues with public space. This might be an explanation for the fact that Rotterdam has been the only municipality involved with inductive charging, as they foresee issues regarding the number of public charging points. Another explanation might be the fact that in general, medium- and smaller-sized municipalities think that larger municipalities should be the ones to pick up new technologies and demonstrate these, as they have more capacity and more financial resources available. However, a more important analysis that flows from this is the fact that the expectations about how the two charging infrastructures are going to influence each other, are not shared by the different actors. According to literature, a lack of convergence of expectations might become a barrier for the further diffusion of a technology (Alkemade & Suurs, 2012: 454). Eventually, shared expectations are a requisite in order to create a niche (van Lente, 1993: 59).

Together, these three sub questions have tried to explain processes on different levels that all have an influence on the eventual transition of the mobility regime. On the level of the local niche, technologies might either reinforce each other or inhibit any further development, guided by visions and expectations that have an influence on the strategies pursued by local governments. The case of electric driving and its infrastructure showed that, at the moment, there are no shared expectations regarding the function of inductive charging and how it is going to contribute to the scale-up of EVs. Current strategies are mainly driven by visions and expectations on EVs and other technologies, but also human and financial resources contribute to the extent to which municipalities initiate certain activities. On the level between the niche and the regime, two barriers were highlighted that currently withhold the niche of electric driving from growing out to become the new mobility regime, and it was explained how stakeholders currently deal with these issues. All in all, these questions have shown that local governments play an important role on different levels of the niche, which leads to the main question of this thesis that has been formulated as,

What is the role of local governments in stimulating the transition towards more sustainable mobility?

This thesis has shown that local governments fulfill several roles in relation to the niche, and therefore play an important role in stimulating the niche of electric driving so that it can contribute to a wider transition regarding sustainable mobility. According to literature, niches play an important role in a transition towards more sustainable practices as they provide the ‘seeds for change’. Besides the traditional stimulating and facilitating role that governments ascribe themselves, other roles have been identified as well. Since the performance of niches is often not competitive with the existing regime yet, protective measures are provided by the municipalities, which are given shape in many forms.

In contrast to the relatively passive measure of providing subsidies, in order to make the niche more cost-competitive, more active approaches are also pursued which originate from the responsible role that local governments ascribe themselves. Active approaches include the creation of pilot projects, which allow the technology to be tested and to be further developed. It has been argued that it is important to not only engage in deployment activities of charging infrastructure, but also create such experimental projects in which radical technologies are explored that will help to look beyond the simple substitution of, for example, fossil-fuel based cars by EVs. To obtain a more active role in these experiments, local governments have shown to open up their public space and integrate projects within their municipal fleet. This is closely related to another important issue, which regards the open attitude of the municipality towards innovative projects. By opening up as a living lab to other stakeholders, the municipality provides a protected space where novel technologies can be demonstrated in close cooperation with inhabitants.

Underlying these protective measures are visions and expectations, which guide municipal strategies and activities to a large extent. It is therefore important for the municipality to emphasize and articulate their aims for the coming years, as these lead to the creation of strategies which are the foundation in achieving more sustainable mobility. Due to the fact that not all local governments have the same opportunities, amongst others due to their size and financial means, their strategies are shaped differently, in a way that matches their aims and resources.

All in all, different roles can be ascribed to local governments, depending on their resources. Larger municipalities often have more financial and human resources at their disposal, and therefore they can act as drivers in a transition by investing in promising technological designs which might contribute to the global level of more sustainable mobility. However, smaller municipalities have an important role as well. Despite the fact that they have access to fewer resources, they can open up their municipality as living lab and welcome innovative experiments, which also contributes to the development of niche technologies, making them more mature. This shows that regardless of the size and resources of the municipalities, they can fulfill an important role in stimulating sustainable mobility.

Although this research has primarily focused on the role of local governments in a transition, also some broader conclusions can be deducted. First of all, the expectations regarding inductive charging showed no consensus, and despite the fact that it is seen as a beneficial technology to society, only a single experiment has been created that considers inductively charging privately owned cars. It is therefore debatable to which extent this novel technology is going to contribute to electric driving, and eventually to more sustainable mobility. However, it should also be acknowledged that charging infrastructure and electric driving are only a smaller pieces of the puzzle of sustainable mobility. Whereas electric driving is argued to be mainly focused on replacing fossil-fuel based cars, this will not be enough to achieve a sustainable society. Besides introducing more sustainable technologies, attention also needs to be directed at reducing mobility and changing the type of transportation. Concepts such as car-sharing and alternative types of transportation, such as walking and cycling, are also necessary in order to achieve a sustainable mobility transition. Besides trying to stabilize the niche, efforts should also be put into destabilizing the regime in order to create a window of opportunity for the niche. Furthermore, privately owned vehicles only present a narrow scope of the entire mobility arena. Other types of transportation, such as flying by airplane and shipping using container vessels, also need to be considered in the transition towards more sustainable mobility.

This shows that there are still multiple challenges ahead regarding the transition towards more sustainable mobility. As seen in this thesis, local governments have started to play an increasingly important role. Despite the fact that initiatives often originate on the national level, a growing number of tasks is directed to local levels of government. If this trend of decentralization is going to continue in the future, municipalities will continue to play an important role regarding processes, such as sustainable mobility, as well.

6.2 Policy recommendations

As this thesis has focused on the role of local governments, already a substantial number of their strategies and approaches have been highlighted in the previous sections. However, it is argued that some of the current strategies can be improved, in order to benefit the transition towards more sustainable mobility. Therefore, this section will elaborate on the identified strategies, and give recommendations on how these can be improved.

First of all, visions and expectations on the three different levels were shown to lack convergence regarding inductive charging. A total of four functions was ascribed to the technology, ranging from being more user-friendly to solving range anxiety, and also three scenarios could be distinguished regarding the future of this inductive charging infrastructure in combination with the current conductive charging points. In order for a technology to develop, it is important to have shared expectations among a substantial number of actors. Therefore, it is recommended that local governments and other governmental bodies keep track of the ongoing developments regarding novel technologies, which are argued to make a contribution to a transition. Furthermore, it would be useful to organize round tables including a diversity of stakeholders, in order to discuss developments and align expectations on what the function of such a technology will be in the future. This will help to guide strategies, which will then be able to contribute to more sustainability.

Furthermore, setting up pilot projects, as has been done in Rotterdam, is a fruitful contribution in providing a niche with a protected space and helping it to develop itself. However, although this has not been emphasized in this thesis due to stakeholders' interests, the knowledge that has been acquired in the project seems overly contained, and is not shared to a large extent with other actors outside of the project. In order for such local projects to contribute to the global level of electric driving, it is argued that there should be aggregation activities, in which local knowledge is translated into more generic and robust knowledge. This requires that an infrastructure is created in which knowledge is circulated. It is argued that this knowledge should be spread to a wider extent, since even failed experiments are argued to contribute to a transition. This can for example be done by bringing together actors in forums, seminars and workshops, in order for these local practices to be translated to the global level and make a contribution.

The same approach holds in order to solve the external problems that were identified between municipalities and the province. Using the same literature as guidance, it is argued that municipalities should maintain a closer connection to the province, and communicate their progress. Also, it would be beneficial to organize innovative activities on a provincial scale. This will contribute to more focused efforts regarding sustainable mobility, instead of individual projects which are often too contained. Furthermore, municipalities should provide signals if they think that the province is missing an important issue. However, these municipalities could also take matters into their own hands if they feel that the province is not as involved, as has been done in Ede by creating a project group. Such an active and independent approach is also likely to contribute to the diffusion of electric driving. Still, these processes need to be transparent and results should be communicated as the circulation of knowledge is a prerequisite in contributing to a technological trajectory.

The other bottleneck that was identified concerned organizational difficulties regarding electric driving on the internal level. Since this development involves numerous municipal departments, who each have their own visions and aims, it is difficult to embed this niche from an organizational point of view. This also has to do with the organizational structure of a municipality, which has been graphically depicted in figure 6.1. Since municipalities are structured in a vertical way, it is difficult to create an integrated approach. It is therefore recommended that these municipal departments collectively identify so-called themes, such as electric driving, in a horizontal approach. As has been illustrated in the same figure, this will help municipalities to structure tasks in an integrated way, and therefore these issues can be tackled more coherently, which will contribute to achieving overall sustainability challenges.

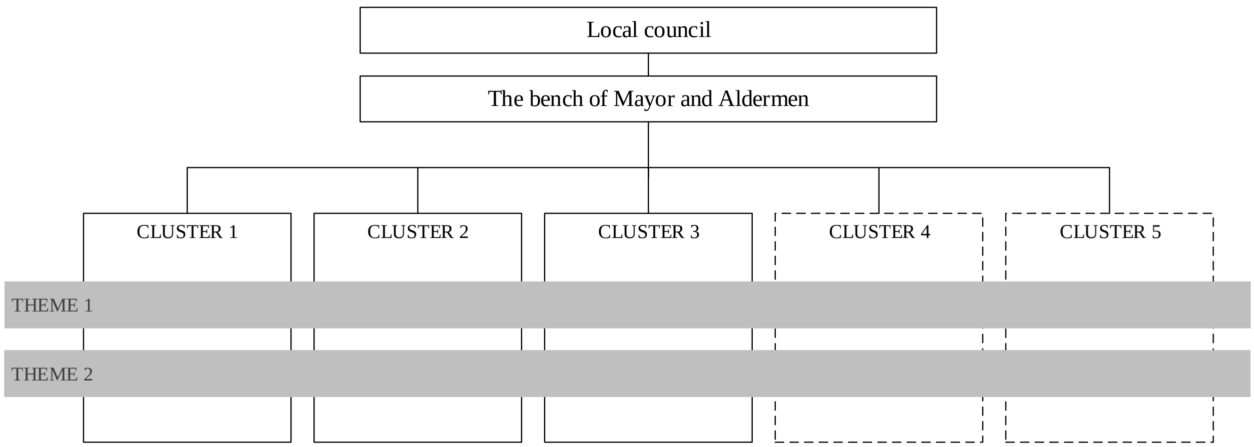

Figure 6.1: Organizational structure of a municipality with an integrated vision

This section has shown that although local governments already have an active approach when it comes to stimulating the transition towards more sustainable mobility, there are still some practices which they can integrate into their organization in order to improve this strategy. Whereas the previous sections have concerned answering the research question, and distilling recommendations from these answers, the next section will consider the strengths and limitations of this research, after which suggestions will be given for future research.

6.3 Strengths and limitations

Within this research, several strengths and limitations can be discerned which will be discussed in this section. First of all, since this research was conducted from within a company, this helped in getting into contact with interviewees. However, the affiliation with the university was emphasized when contacting these interviewees, in order to avoid the bias that the information given in the interview would be used for different purposes other than the thesis. By presenting the research in this way, it was avoided that people would give politically correct answers instead of their actual opinion and description of the current practices within the municipality with regards to sustainability.

Another strength was the fact that a variety of interviewees was contacted and spoken to. Despite the fact that this research focused on the role of local governments, experts and grid operators were included as well, since this added more insight to the data. However, a limitation regarding the interviewees from the different municipalities was that there was often only a single person who had knowledge on the charging infrastructure. This therefore reduced the number of visions and expectations, which were an important contributor in establishing the link to actor strategies. Still, this thesis has been able to give relevant insight in the relation between visions and expectations and actor strategies. Furthermore, it has been shown that resources are also important regarding strategies and how these are translated into activities. Additionally, by including a large number of quotes in the description of the results, a thick narrative has been created. According to Creswell (2009: 191-92) this is a strength of a qualitative type of research, as it conveys many perspectives about the issue at hand, and therefore creates a more realistic and richer image of the results, also contributing to the validity of the findings.

However, a limitation of the research was that bias may have been created in the interviews. Since interviews were directly analyzed after they were held, this analysis sometimes fed into the interview that was held subsequently. This might have steered the questions in a certain direction, zooming in on aspects that were highlighted in other conversations. Furthermore, bias might have been present in the information that was sent along with the questions, which included a short summary about the technology of inductive charging. Although this might have biased their view, it was tried to minimize this bias by including an equal amount of advantages and disadvantages on the technology, trying not to influence the participant's view.

From a theoretical perspective, another strength of this research is the fact that it has contributed to the framework of SNM. By zooming in on the distinction between the local and the global niche, and by furthermore identifying how expectations contribute to establishing a technological trajectory, more information has been collected regarding the dynamic processes and how they influence each other. Also, although the case study concerned charging infrastructure, more clarity has been provided regarding the role that local governments play in a transition in general. However, this focus on public parties also presents a limitation regarding the specific case of electric driving. Since it became clear from the interviews that market parties, such as Allego, play an important role in this as well, especially regarding the licensing approach, it would have been interesting to hear their opinion as well and include it in the research.

6.4 Suggestions for future research

The outcome of this research on the role of local governments, also distinguishes some next steps which may be taken by other researchers in future investigations. Firstly, whereas this research chose an institutional approach, looking at the role of local governments, it might be interesting to look into the different technologies somewhat more. At the start of this thesis it was expected that only inductive and conductive charging would have an influence on each other, but the development of hydrogen was mentioned in the interviews as well. It will be interesting to see how expectations regarding these three technologies influence each other, and how dynamics between the technologies influence their contribution to the global niche of electric driving. Besides acquiring more information on the technologies underlying electric driving, such research will also contribute to knowledge on the interaction between the local and the global niche-level.

Secondly, it would be interesting to put more focus on the province and see how they collaborate with lower levels. Since this research considered everything from the perspective of the municipality, it can be argued that this is a one-sided view on working towards a mobility transition. By including perspectives from the province as well, more information can be gathered on how the two can jointly work towards more sustainability. Also, this will contribute to the framework which argues that knowledge should be shared and that knowledge infrastructures should be created. A best practice could be derived from this research, stating something about how this knowledge infrastructure should be shaped.

Finally, it would be interesting to apply a different theory to this question on the role of local governments, such as Transition Management. The chapter on theory and concepts already showed that this framework identified multiple roles that governments can take on in several phases of the transition. Furthermore, the framework has originally been developed in order to create a governance approach for sustainable development, which can be used to implement governance strategies. As this research has only identified municipal roles, it can take this information further by investigating how these roles should be shaped in order to contribute to more sustainability and work towards a successful transition. Given the trend of decentralization, it will become more important in the future to understand the role that local governments have regarding sustainable technologies and how they can contribute to a transition.

Bibliography

Agentschap NL. (2012). *De stekker in elektrisch vervoer, maar hoe?* Retrieved from http://www.rvo.nl/sites/default/files/bijlagen/Startgids%20EV%20voor%20gemeenten.pdf

Agentschap NL. (2013). *Regionale samenwerking voor de uitrol van publieke laadinfrastructuur elektrisch vervoer.* Utrecht: Agentschap NL.

Alkemade, F., & Suurs, R. A. (2012). Patterns of expectations for emerging sustainable technologies. *Technological Forecasting & Social Change 79(3)*, 448-456. doi:10.1016/j.techfore.2011.08.014.

Allego. (2016). *Wat kost het*. Retrieved from Allego: https://www.allego.nl/overheid/waarom-elektrisch-vervoer/wat-kost-het/

ANP. (2016, February 12). *Meer oplaadpunten nodig voor elektrische auto*. Retrieved from Trouw: http://www.trouw.nl/tr/nl/4492/Nederland/article/detail/4243720/2016/02/12/Meer-laadpunten-nodig-voor-elektrische-auto.dhtml

APPM. (2014). *The Inductive Charging Quick Scan: An exploratory study of inductive charging opportunities and potential in the Netherlands.* APPM Management Consultants and Policy Research Corporation.

Bakker, S., & Maat, K. (2013). *Transitie naar Elektrische Automobiliteit.*

Bakker, S., Leguijt, P., & van Lente, H. (2015). Niche accumulation and standardization - the case of electric vehicle recharging plugs. *Journal of Cleaner Production 94*, 155-164. doi:10.1016/j.jclepro.2015.01.069.

Bakker, S., Maat, K., & van Wee, B. (2014). Stakeholders interests, expectations, and strategies regarding the development and implementation of electric vehicles: The case of the Netherlands. *Transportation Research Part A 66*, 52-64. doi:10.1016/j.tra.2014.04.018.

Bakker, S., van Lente, H., & Engels, R. (2012). Competition in a technological niche: the cars of the future. *Technology Analysis & Strategic Management (24)*, 421-434.

Borup, M., Brown, N., Konrad, K., & van Lente, H. (2006). The Sociology of Expectations in Science and Technology. *Technology Analysis & Strategic Management 18(3-4)*, 285-298. doi:10.1080/09537320600777002.

Broekhof, N. (2016, February 12). *Ruim 50.000 extra laadpunten nodig*. Retrieved from BNR: http://www.bnr.nl/radio/bnr-nationale-autoshow/473718-1602/ruim-50.000-extra-laadpunten-nodig

Budde, B., Alkemade, F., & Weber, K. M. (2012). Expectations as a key to understanding actor strategies in the field of fuel cell and hydrogen vehicles. *Technological Forecasting & Social Change 79(6)*, 1072-1083. doi:10.1016/j.techfore.2011.12.012.

Canadian Automobile Association. (sd). *Types of Electric Vehicles*. Retrieved from Electric Vehicles: What You Need To Know: http://electricvehicles.caa.ca/types-of-electric-vehicles/

CLP Online. (2013). *Typical electric vehicle charging methods*. Retrieved from CLP Online: https://www.clponline.com.hk/ev/Pages/ChargingSystem_ChargingMethods.aspx

Creswell, J. W. (2009). Qualitative Procedures. In J. W. Creswell, *Research Design: Qualitative, Quantitative and Mixed Methods Approaches* (pp. 173-202). SAGE.

de Bont, C., van Dijk, S., Hellinga, C., & Silvester, S. (2010). *Werkdocument: Verkenning elektrisch rijden.* D-incert.

Farla, J., Alkemade, F., & Suurs, R. A. (2010). Analysis of barriers in the transition toward sustainable mobility in the Netherlands. *Technological Forecasting & Social Change 77(8)*, 1260-1269. doi:10.1016/j.techfore.2010.03.014.

Farla, J., Markard, J., Raven, R., & Coenen, L. (2012). Sustainability transitions in the making: A closer look at actors, strategies and resources. *Technological Forecasting & Social Change 79(6)*, 991-998. doi:10.1016/j.techfore.2012.02.001.

Fisher, T. M., Fairley, K. B., Gao, Y., Bai, H., & Tse, Z. T. (2014). Electric vehicle wireless charging technology: a state-of-the-art review of magnetic coupling systems. *Wireless Power Transfer 1(2)*, 87-96. doi:10.1017/wpt.2014.8.

Frantzeskaki, N., & Loorbach, D. (2010). Towards governing infrasystem transitions. *Technological Forecasting & Social Change 77(8)*, 1292-1301. doi:10.1016/j.techfore.2010.05.004.

Funke, S. Á., Gnann, T., & Plötz, P. (2015). Addressing the Different Needs for Charging Infrastructure: An Analysis of Some Criteria for Charging Infrastructure Set-up. In W. F. Leal, & R. Kotter, *E-Mobility in Europe* (pp. 73-90). Springer International Publishing Switzerland.

Geels, F. (2002). Technological transitions as evolutionary reconfiguration processes: a multi-level perspective and a case-study. *Research Policy 31(8-9)*, 1257-1274. doi:10.1016/S0048-7333(02)00062-8.

Geels, F. (2004). From sectoral systems of innovation to socio-technical systems: Insights about dynamics and change from sociology and institutional theory. *Research Policy 33(6-7)*, 897-920. doi:10.1016/j.respol.2004.01.015.

Geels, F. (2005). The Dynamics of Transitions in Socio-technical Systems: A Multi-level Analysis of the Transition Pathway from Horse-drawn Carriages to Automobiles (1860-1930). *Technology Analysis & Strategic Management 17(4)*, 445-476. doi:10.1080/09537320500357319.

Geels, F. (2011). The multi-level perspective on sustainability transitions: Responses to seven criticisms. *Environmental Innovation and Societal Transitions 1*, 24-40. doi:10.1016/j.eist.2011.02.002.

Geels, F. (2012). A socio-technical analysis of low-carbon transitions: introducing the multi-level perspective into transport studies. *Journal of Transport Geography 24*, 471-482. doi:10.1016/j.jtrangeo.2012.01.021.

Geels, F., & Deuten, J. (2006). Local and global dynamics in technological development: a socio-cognitive perspective on knowledge flows and lessons from reinforced concrete. *Science and Public Policy 33(4)*, 265-275. doi:10.3152/147154306781778984.

Geels, F., & Kemp, R. (2007). Dynamics in socio-technical systems: Typology of change processes and contrasting case studies. *Technology in Society 29(4)*, 441-455. doi:10.1016/j.techsoc.2007.08.009.

Geels, F., & Raven, R. (2006). Non-linearity and Expectations in Niche-Development Trajectories: Ups and Downs in Dutch Biogas Development (1973-2003). *Technology Analysis & Strategic Management 18(3-4)*, 375-392. doi:10.1080/09537320600777143.

Geels, F., Kemp, R., Dudley, G., & Lyons, G. (2012). *Automobility in Transition? A Socio-Technical Analysis of Sustainable Transport.* New York: Routledge.

Gemeente Ede. (2015). *Startnotitie Duurzaam Ede.*

Gemeente Groningen. (2011, June 22). *Nota Duurzame Mobiliteit 2011-2020*. Retrieved from Gemeente Groningen: https://gemeente.groningen.nl/regelingen/nota-duurzame-mobiliteit-2011-2020

Grin, J., Rotmans, J., & Schot, J. (2010). *Transitions to Sustainable Development.* New York: Routledge.

Hesse, M. (2005). Remco Hoogma, René Kemp, Johan Schot, Bernhard Truffer, Experimenting for Sustainable Transport: The Approach of Strategic Niche Management. *Book reviews / Journal of Transport Geography 13*, 104-105. doi:10.1016/j.jtrangeo.2004.08.002.

Holland, L., van Cuijk, T., van Kerkhof, M., & Verheijen, L. (2016). *NKL Opleverdocument Variabele Netaansluiting.*

Hoogma, R., Kemp, R., Schot, J., & Truffer, B. (2002). *Experimenting for Sustainable Transport: the approach of Strategic Niche Management.* London: Spon Press.

Hop, G., & Welleweerd, H. (2013). *Gratis laadpalen zonder overlast voor de omgeving.* Over Morgen.

Kemp, R., Schot, J., & Hoogma, R. (1998). Regime Shifts to Sustainability Through Processes of Niche Formation: The Approach of Strategic Niche Management. *Technology Analysis & Strategic Management 10(2)*, 175-198. doi:10.1080/09537329808524310.

Köhler, J., Whitmarsh, L., Nykvist, B., Schilperoord, M., Bergman, N., & Haxeltine, A. (2009). A transitions model for sustainable mobility. *Ecological Economics 68(12)*, 2985-2995. doi:10.1016/j.ecolecon.2009.06.027.

Maia, S. C., Teicher, H., & Meyboom, A. (2015). Infrastructure as social catalyst: Electric vehicle station planning and deployment. *Technological Forecasting & Social Change 100*, 53-65. doi:10.1016/j.techfore.2015.09.020.

Markard, J., Raven, R., & Truffer, B. (2012). Sustainability transitions: An emerging field of research and its prospects. *Research Policy 41(6)*, 955-967. doi:10.1016/j.respol.2012.02.013.

Movares. (2016, June 1). *De waarde van flexibel laden.* Utrecht: Movares Nederland B.V. Retrieved from http://nederlandelektrisch.nl/file/download/44149462

Nelson, R., & Winter, S. (1982). *An Evolutionary Theory of Economic Change.* Cambridge, MA: Bellknap Press.

Newman, D., Wells, P., Nieuwenhuis, P., Donovan, C., & Davies, H. (2014). Learning from Electric Cars as Socio-technical Mobility Experiments: Where Next? *Transfers 4(2)*, 23-41. doi:10.3167/trans.2014.040203.

Nieuwenhuis, E. (2015, February 16). *Fastned: snellaadstations die Nederland elektrisch laten rijden*. Retrieved from OneWorld: https://www.oneworld.nl/groen/fastned-snellaadstations-die-nederland-elektrisch-laten-rijden

Nijland, H., Hoen, A., Snellen, D., & Zondag, B. (2012). *Elektrisch rijden in 2050: gevolgen voor de leefomgeving.* Den Haag: Planbureau voor de Leefomgeving.

Quitzau, M.-B., Hoffmann, B., & Elle, M. (2012). Local niche planning and its strategic implications for implementation of energy-efficient technology. *Technological Forecasting & Social Change 79(6)*, 1049-1058. doi:10.1016/j.techfore.2011.11.009.

Rijksdienst voor Ondernemend Nederland. (2016a). *Cijfers elektrisch vervoer*. Retrieved from Rijksdienst voor Ondernemend Nederland: http://www.rvo.nl/onderwerpen/duurzaam-ondernemen/energie-en-milieu-innovaties/elektrisch-rijden/stand-van-zaken/cijfers

Rijksdienst voor Ondernemend Nederland. (2016b, June 24). *Positieve invloed gemeenten op elektrisch vervoer*. Retrieved from Rijksdienst voor Ondernemend Nederland: http://www.rvo.nl/actueel/nieuws/positieve-invloed-gemeenten-op-elektrisch-vervoer

Rijksoverheid. (2016, April 14). *Green Deal Elektrisch Vervoer 2016-2020.* Retrieved from Green Deal: http://www.greendeals.nl/wp-content/uploads/2016/04/GD198-Elektrisch-Rijden-2016-2020.pdf

Rip, A., & Kemp, R. (1998). Technological Change. In S. Rayner, & L. Malone, *Human Choice and Climate Change* (pp. 327-399). Columbus, OH: Batelle Press.

Rotmans, J., Kemp, R., & van Asselt, M. (2001). More evolution than revolution: transition management in public policy. *Foresight 3(1)*, 15-31.

Schot, J., & Geels, F. W. (2008). Strategic niche management and sustainable innovation journeys: theory, findings, research agenda, and policy. *Technology Analysis & Strategic Management 20(5)*, 537-554. doi:10.1080/09537320802292651.

Smith, A., Stirling, A., & Berkhout, F. (2005). The governance of sustainable socio-technical transitions. *Research Policy (34)*, 1491-1510.

Smith, A., Voß, J.-P., & Grin, J. (2010). Innovation studies and sustainability transitions: The allure of the multi-level perspective and its challenges. *Research Policy 39(4)*, 435-448. doi:10.1016/j.respol.2010.01.023.

Späth, P., & Rohracher, H. (2012). Local Demonstrations for Global Transitions - Dynamics across Governance Levels Fostering Socio-Technical Regime Change Towards Sustainability. *European Planning Studies (20)*, 461-479.

Stadsontwikkeling afd. Verkeer&Vervoer. (2015, October 13). Kader voor de plaatsing van laadinfrastructuur voor elektrische auto's. Rotterdam.

Telegraaf. (2016, January 19). *Vijftigste snellaadstation in Nederland*. Retrieved from Telegraaf: http://www.telegraaf.nl/dft/nieuws_dft/25031973/__Fastned_opent_vijftigste_snellaadstation__.html

Thole, H. (2015, September 15). *Auto en fiscus: dit gebeurt er met de bijtelling, BPM en MRB in 2016*. Retrieved from Z24: http://www.z24.nl/geld/prinsjesdag-2015-auto-bijtelling-bpm-mrb-587052

van Beek, T. (2016, March 30). *Laden aan paal goedkoper maar voor wie?* Retrieved from EV Consult: http://www.evconsult.nl/2016/03/onduidelijkheid-belastingverlaging-staatssecretaris/

van Bree, B., Verbong, G., & Kramer, G. (2010). A multi-level perspective on the introduction of hydrogen and battery-electric vehicles. *Technological Forecasting & Social Change 77(4)*, 529-540. doi:10.1016/j.techfore.2009.12.005.

van Lente, H. (1993). *Promising Technology. The Dynamics of Technological Developments.* Enschede: Universiteit Twente, Faculteit Wijsbegeerte en Maatschappijwetenschappen.

van Lente, H., & Bakker, S. (2010). Competing expectations: the case of hydrogen storage technologies. *Technology Analysis & Strategic Management 22(6)*, 693-709. doi:10.1080/09537325.2010.496283.

van Mil, B., van Schelven, R., & Kuiperi, F. (2016). *Terugblik en vooruitblik op het beleid voor elektrisch vervoer.* Den Haag.

van Oosterhout, M., & Schaeffers, D. (2008). *Klimaatvisie Kempengemeenten.*

Appendices

A – Overview of used data

Table A.1: Details of interviews conducted

Reference	Person	Organization	Position	Date	Medium	Length
AN, 2016	Anonymous	Municipality of Groningen	Coordinator Sustainable Mobility	21/04/2016	Telephone	44 min
HO, 2016	Hulya Oudeman-Kul	Municipality of Rotterdam	Advisor Sustainable Mobility	29/04/2016	In person	32 min
TU, 2016	Maurice Roes and Jorge Duarte	TU Eindhoven (Dept. Electromechanics and Power Electronics)	Assistant Professor	29/04/2016	In person	46 min
PB, 2016	Paul Broos	ElaadNL	Project manager Electric Driving	02/05/2016	Telephone	23 min
BE, 2016	Bram van Eijsden	ElaadNL	Project manager department Development and Innovation	02/05/2016	In person	45 min
JT, 2016	Jac Turlings	Proov	Technical specialist	03/05/2016	In person	53 min
BB, 2016	Baerte de Brey	Stedin	Manager Electric Driving	06/05/2016	Telephone	36 min
QO, 2016	Quirijn Oudshoorn	Municipality of Rotterdam	Advisor Sustainable Mobility	11/05/2016	In person	53 min
RS, 2016	Rikkert Snitselaar	Municipality of Ede	Advisor Sustainable Mobility	13/05/2016	Telephone	42 min
GG, 2016	Gerrit Griffioen	Municipality of Groningen	Head of Department Equipment	18/05/2016	Mail	1 A4[1]
CR, 2016	Claudia Rieswijk	Municipality of Bladel	Policy officer Environment	31/05/2016	In person	57 min

[1] This mail conversation does not officially qualify as interview, but it was still included in the list as it clarified an issue that was brought up in another interview.

B – Example Interview Guide

Interview guide stakeholder local government

- Introduce myself
- Explain the goal of this research and what the purpose is of this interview. The thesis aims to give more insight into the role of local governments in a transition towards more sustainable mobility.
- Ask whether the interviewee is ok with the interview being recorded, and how they want to be referred to in the final report. Explain that the transcript of the interview will be sent to the interviewee in order to check whether everything has been written down correctly. Finally, ask whether the interviewee is interested in receiving the final report.

Ice-breaker: Do you own an electric car yourself?

Questions

Introduction

- Can you tell something about yourself and about your role within the municipality?
- Can you tell something about the vision of the municipality on sustainable mobility?

A. Conductive charging infrastructure

- What was the reason for the municipality to deploy charging infrastructure?
- What has been the role of the municipality in deploying charging infrastructure?
- Which bottlenecks has the municipality encountered in deploying charging infrastructure?
- How have these bottlenecks been tackled?

B. Inductive charging infrastructure

- What is your opinion on the potential of inductive charging?
- To what extent will this municipality become engaged with this type of charging?

C. Combination charging infrastructures

- What is your opinion on the extent to which these charging infrastructures (conductive and inductive) will influence each other?
- Do you see opportunities to successfully combine the two charging infrastructures?

Closing question: What is your view on the role of the municipality in a transition towards more sustainable mobility?

Wrapping up

- Is there any relevant information that I have missed?
- Are there other people I should talk to? – Snowballing
- Thank the interviewee for his/her time.

C – Information inductive charging for interviewees

Information inductive charging

Currently, conductive charging is the dominant way to charge an electric vehicle in the Netherlands. This type of charging consists of regular charging points, as well as fast charging points located on several highways. Recently an alternative type of charging has been introduced, known as inductive, or wireless, charging. This technology charges the electric vehicle without any cables, using the same technology as used to charge an electric toothbrush. This type of charging can be applied in a static way, charging a vehicle that is parked, or it can be applied dynamically, to a vehicle while it is driving.

The application of this technology is currently restricted to some pilots in three Dutch municipalities. The municipalities of Utrecht and ‘s-Hertogenbosch have started a project in which they inductively charge buses, and the municipality of Rotterdam has initiated a project in which they inductively charge vehicles. Besides that, the first signs appear that car manufacturers are working on this type of charging as well. Evatran Plugless Power is, for instance, going to offer a wireless power transfer system for the Tesla Model S[1].

Inductive charging can have several advantages for electric transportation. First of all, the effect of this technology on the public space is minimal, as the technology is integrated into the ground. Secondly, this type of charging has the potential to charge a vehicle while it is driving, which will increase the range of the vehicle and can therefore contribute to removing range anxiety. Furthermore, this technology will benefit user-friendliness as less activities are required to connect the vehicle to charging infrastructure.

However, this technology also has some disadvantages. Firstly, the costs are currently relatively high compared to alternatives such as conductive charging. Besides that, the technology of inductive charging is still in its introductory phase due to which there is no standardization and normalization of the technology yet. This implies that systems of different manufacturers are not able to communicate, which raises the barrier for the adoption of this technology. Additionally, there is uncertainty regarding the safety of the system as it works with radiation, and there are doubts concerning the spatial integration of the technology.

[1] http://www.groen7.nl/draadloos-laden-straks-mogelijk-voor-tesla-model-s/