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Driving transitions on the local level

Ms. A.B. van Zante MSc, Mr. M.P. van Kerkhof MSc*

**APPM Management Consultants, Spicalaan 8, 2132 JG Hoofddorp, The Netherlands*

zante@appm.nl / kerkhof@appm.nl

Abstract

In the Netherlands electric transportation has seen a rapid rise, amounting to more than 100,000 vehicles in total in 2016, of which approximately 10% is fully electric. The necessary infrastructure, consisting of public, semi-public and fast charging points, has increased more than tenfold in only five years. Especially local governments play an important role regarding this infrastructure, as they decide if and how they deploy public charging points. They therefore have an impact on the pace of the transition of sustainable mobility. Until now, only conductive charging points have been deployed, but inductive charging is gaining attention. Not only do local governments have a role in the introductory phase of this technology by demonstrating it to the wider public in pilots on a local level, but they also influence the uptake of this charging infrastructure. This paper therefore presents the view of municipalities on inductive charging, including their strategies and expectations about this technology. The results show that there is currently no consensus on inductive charging and that municipalities ascribe different functions to the technology, such as providing a solution for public space or offering the e-driver more comfort by not having to plug in their vehicle. This lack of consensus leads to a hesitant attitude towards novel charging technologies, which is reflected in the fact that only one Dutch municipality has started a pilot project on inductive charging. Furthermore, charging infrastructure challenges the current organizational structure of a municipality, as it involves multiple departments such as mobility, environment and public space. It is therefore recommended that horizontal themes, such as electric driving, should be identified across a municipality, in order to embed novel technologies and eventually contribute to more sustainable mobility.

Keywords: wireless charging, infrastructure, sustainability, policy, case-study

1 Introduction

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 [1]. However, the transition towards more sustainable mobility faces a number of 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 [2]. Currently, important aspects in the uptake of a technology, including infrastructure, are aligned to and revolve around the dominant technology of fossil-fuel based cars [3]. It is argued that especially this dimension of charging infrastructure is crucial in order to achieve a large-scale diffusion of electric vehicles [4]. Despite infrastructural developments in the Netherlands, including the roll-out of fast charging stations, it is feared that within a number of years there will be a shortage of charging points if the sales of electric vehicles (EVs) are to continuously increase [5]. 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 infrastructure [6].

Besides the current 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. This technology uses magnetic coils to transfer the energy without any physical contact between the charging source and the EV [7]. 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. 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 – charging the vehicle while it is moving [8].

In this upscaling of a novel sustainable technology, local governments play a pivotal role [9][10]. They can, for instance, demonstrate the feasibility of a novel technology or provide room for experiments. Since there is a close relation to citizens on the local level, this provides the perfect opportunity to introduce new technologies and demonstrate them to the wider public. 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, they play an important role in the scale-up of electric driving, which contributes to the transition towards more sustainable mobility.

1.1 Purpose of this paper

This paper is the result of a graduation project at Eindhoven University of Technology in the Netherlands. It not only aims to identify the role of local governments and their contribution to sustainable mobility, but also their view and strategy on how inductive charging will develop itself in the future. In order to acquire these insights, this study has defined a limiting scope that focuses on the Netherlands. As they have positioned themselves as frontrunners in the field of electric mobility, it is interesting to see what effect the introduction of inductive charging might have and how it can support the Netherlands in maintaining its pole position. Since cars are the dominant mode of transportation, and therefore encompass a significant challenge regarding sustainable mobility, this study focuses on inductive charging applied to privately owned cars. Dutch pilot projects on inductively charging public transport, however, will not be disregarded, but they will be used to acquire knowledge on the technology of inductive charging and its future development.

2 Theory

Transportation can be seen as a socio-technical system, in which different elements interact and provide services to society, such as the possibility to travel from one place to another [11]. This system does not function autonomously, but is shaped through the actions of certain actors. Social groups, such as car owners and oil companies, actively create, (re)produce and refine a social technical system [12]. Despite the existence of these dynamics in a socio-technical system, radical technologies have hard time trying to break through as all elements are synchronized to the existing technology [13]. If a shift from one socio-technical system to another, however, does occur, we speak of a transition. The multi-level perspective (MLP) is a useful tool for understanding these transitions. It makes a distinction between three levels: (i) niches; (ii) socio-technical regimes; and (iii) an exogenous landscape. These concepts help in understanding the dynamics that are at play regarding socio-technical change.

Niches can be seen as 'protective spaces' or 'incubation rooms'. 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 current and dominant way of doing things, is represented by the socio-technical regime. Because these regimes are known for their stability, mainly incremental improvements take place. The landscape provides the structural context, and can be seen as an exogenous environment that consists of certain technological and societal trends, deep structures and events [14]. In our current era, climate change is an important landscape-factor, driving the need for more sustainability transitions. In the initial phase of such a transition, niche technologies play an important role. Niches incorporate the shortcomings of the regime and introduce 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 compared to conductive charging, and is less intrusive in public space since it is integrated into the ground.

Strategic niche management (SNM) provides a framework to zoom in on these developments at the niche-level. It argues that novelties emerge in *technological* niches, after which they conquer *market* niches. Eventually they are scaled up to create a transition in which they take over the current and dominant regime [15]. Three different processes are argued to be essential for the successfulness of a niche, namely (i) the articulation of visions and expectations; (ii) the building of social networks; and (iii) learning processes at multiple dimensions. Especially visions and expectations play an important role in the initial phase of a technology, as they help to broaden networks as well as learning processes. Expectations can also act as guidance for governments, who are more willing to subsidize and invest in an innovation when they *expect* a technology to have a future benefit for society. Expectations can be divided into three levels: (i) micro-level, where expectations about the performance of the technology are made; (ii) meso-level, which encompasses the functions that the technology is going to fulfil; and (iii) 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 the levels being able to either reinforce or weaken each other [16]. There are, however, not only internal dynamics of expectations, but they also show a close link to actor strategies. 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 [17]. Eventually, these strategies are translated into certain activities which have an effect on the overall transition [16].

An elaboration on SNM zooms in further on the mentioned niche-processes and its levels, and makes a distinction between the local and the global level [15]. This framework argues that niches, such as inductive charging, should not be seen in isolation, but as part of an interconnected set of smaller, local niches, which may jointly create a new regime [18]. 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 mobility. On the local level, niches can either complement each other, or they can become rivals and compete for support. The local niches of inductive and conductive charging can either strengthen each other – enhancing charging infrastructure in general and contributing to electric mobility – or inhibit each other – competing for the same resources.

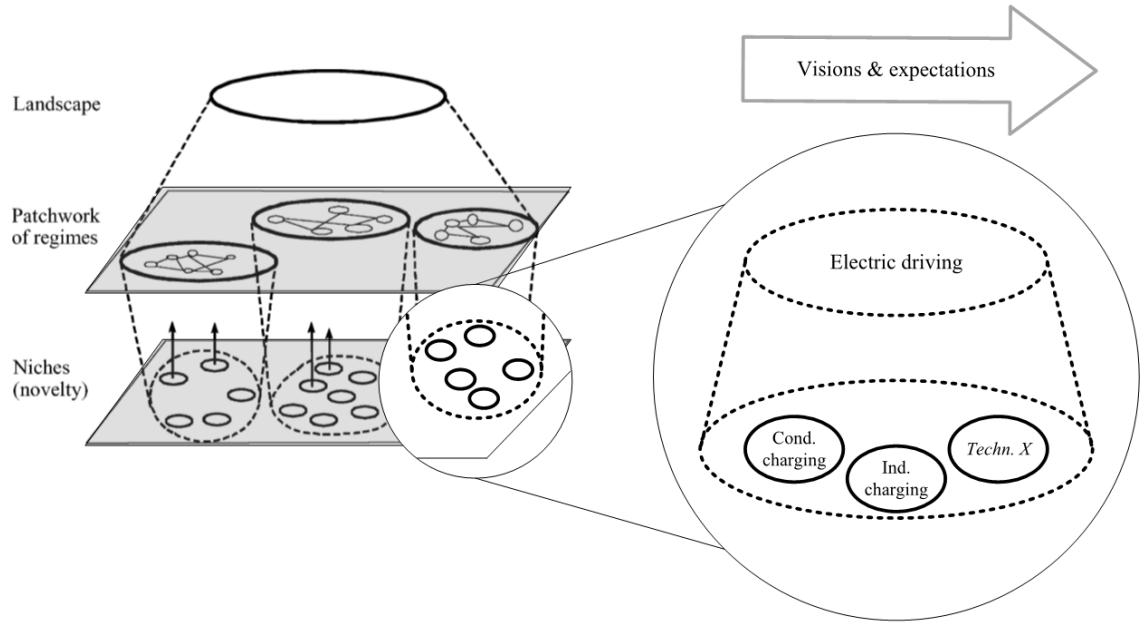

Figure 1: Representation of the three identified processes needed for a transition, according to the MLP and SNM

Fig. 1 has combined the beforementioned aspects that are crucial in achieving a transition, and has incorporated them into a single image. It shows the dynamics between the patchwork of regimes and the niche-level (MLP), and zooms in on the niche-level (SNM) where local niches contribute to global niches – both guided by visions and expectations. This figure shows the coherence between the different frameworks, that enables this paper to identify the role of local governments and their contribution to more sustainable mobility. Furthermore, it shows how their visions and expectations on a certain technology – in this case inductive charging – influence the development of the niche. The following chapter will provide insight into the methodology, after which the main results of this study are presented.

3 Method

As stated in the section on the purpose of this paper, the study explores the role of local governments in stimulating the transition towards more sustainable mobility. Because visions and expectations play an important role in this research, a qualitative research approach has been adopted with a multiple case study design. The four selected cases have been chosen based on their added value to gain insight in the role of local governments. This added value has been translated into two criteria: (i) the size of the municipality, and (ii) their policy regarding charging infrastructure. The first criterion has been included due to the fact that it is expected that municipalities of a different size experience different bottlenecks in the transition towards electric mobility and its related charging infrastructure. Furthermore, the resources with which they shape their visions into strategies might be different. The second selection criterion regards the local policy on charging infrastructure. A distinction is made between active and passive policies. Municipalities are argued to pursue an active strategy if they have a policy that financially stimulates charging infrastructure, and they are said to have a passive strategy if there are no dedicated financial means. 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. Table 1 illustrates the four selected case studies.

Table 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

* The categorization of sizes has been made using the size classes of the Central Bureau for Statistics as a guideline

The deliberate decision has been made to focus on four municipalities instead of six, since, in general, there are no small municipalities that 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. This narrowed the scope of the research and enabled an in-depth analysis. Additionally, the case studies are located in four different corners of the Netherlands, which illustrates that electric driving is not a geographically clustered phenomenon.

Beforehand, documents and studies were screened in a literature study. This study was complemented with a number of semi-structured interviews with civil servants in the sustainability domain of the respected municipalities, grid operators and experts on (inductive) charging infrastructure. The acquired data has been analyzed by transcribing the interviews and carrying out a content analysis in order to create a structured narrative in which the results are presented. The research findings were validated by sending the interview transcripts to the respected interviewees for a check. In order to ensure triangulation, the interviews were complemented with other informative and policy-related documents. The presented results only provide an overview of the Dutch case. However, some general conclusions can be drawn that are applicable to other types of governmental stakeholders engaged with sustainable mobility in other countries as well.

4 Results

In this section the results of the empirical analysis will be presented. It has been divided into three subsections, based on the content analysis of the interviews. The following sections consecutively introduce municipal visions and strategies regarding electric mobility and charging infrastructure, bottlenecks that municipalities come across which inhibit the development of charging infrastructure, and their expectations on how inductive charging will develop itself and how it can possibly contribute to the global niche of electric driving.

4.1 Municipal visions and strategies

All municipalities are engaged with sustainability and sustainable mobility since it reduces climate change and helps to improve local air quality. Some interviewees indicate that their municipality has formulated a broader vision which encompasses energy-neutrality in 2025 (Interview 11) and 2035 (Interview 1). Despite their aligned visions, different strategies have been adopted by the municipalities. Some of the municipalities have decided to lower the charging fee by investing in charging infrastructure themselves (Interview 2, 9), whereas others have adopted a different strategy and included a third party to deploy charging infrastructure (Interview 1, 11). Despite the fact that they have both been categorized as passive municipalities, their reasons for including a third party differ. The municipality of Bladel (Interview 11) argues that it has a limited capacity to take on new projects such as electric mobility, and Groningen (Interview 1) has prioritized cycling and has made no money available for electric driving. Including a third party requires less action from the municipality itself, and requires no financial contribution. This shows that the resources – human as well as financial – that are available within a municipality influence the strategy that is adopted. Furthermore, the results have shown that size of a municipality is a larger contributor than an active or passive strategy when it comes to how likely municipalities are to take on novel technologies such as inductive charging. Some municipalities feel the responsibility regarding public space (Interview 9), but only the municipality of Rotterdam has initiated a project with inductive charging (Interview 8), 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 (Interview 1, 9, 11).

Although theory argues that there is a close connection between visions, expectations and actor strategies, visions only contribute to a small extent to the strategies that are pursued. The municipalities have adopted different implementation 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. A respondent indicates that his municipality has invested in cycling and is working on the instalment of two hydrogen filling stations, but has not made any financial means available for electric vehicles (Interview 1). This shows that visions help to clarify why municipalities adopt alternative and more sustainable types of transportation, but it does not explain why the mobilized technologies *differ* between municipalities. Although all municipalities have adopted a sustainable strategy,

the dominant way of transportation is still running on fossil fuels in all regions. It can therefore be argued that there are certain (external) bottlenecks that withhold the transition towards sustainable mobility. Two of them have been identified by the interviewees: the business case of charging infrastructure and internal municipal processes.

4.2 Bottlenecks charging infrastructure

All municipalities indicate that they have adopted policies regarding electric driving, but it can still be considered a niche given that it requires a protected space, that is created by e.g. providing subsidies. According to the interviewees, there are two main bottlenecks that can be identified.

The business case of charging infrastructure is still a significant challenge, as charging infrastructure currently costs more than it yields (Interview 4, 5). Because of involved costs such as maintaining a grid connection, service and charge point management and maintenance – facilitating a back office and handling transactions – it is difficult to make money out of the transactions, let alone to break even (Interview 5). Fig. 2 graphically shows the costs that are involved regarding public infrastructure, and the gap that is currently present between all costs involved and the revenues that flow from charging transactions.

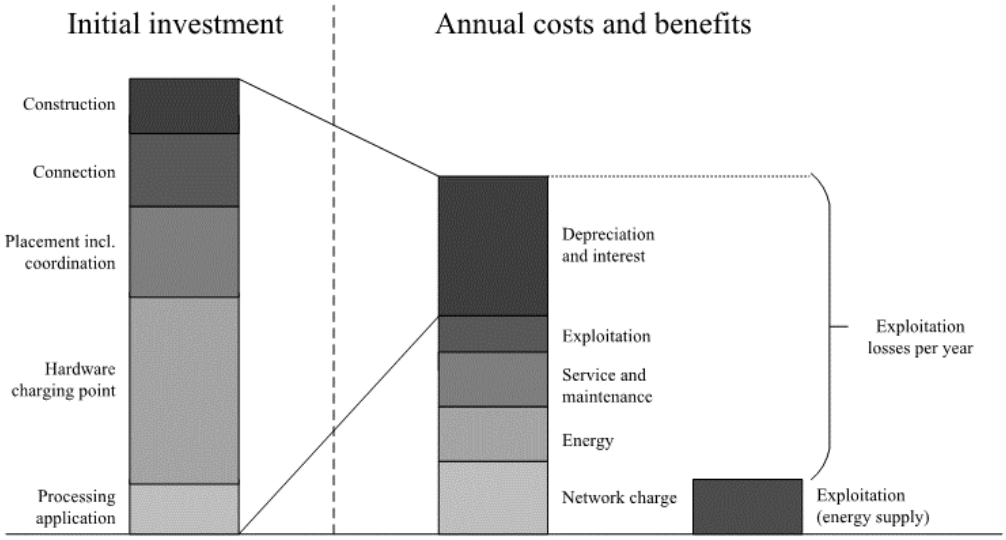

Figure 2: Graphic representation of the business case of public charging infrastructure [19]

Despite the decision of some municipalities to invest in local charging infrastructure, it is difficult to create a viable business case. Because of a lack of financial means, some municipalities had to halt requests for charging points (Interview 9). Furthermore, municipalities indicate that strategically placed charging points turned out not to be so strategic and were underused. Therefore, they are now considering to relocate these points (Interview 9, 11). Besides relocating charging points, municipalities also try to influence the business case by requesting a minimum charging volume of 2000 kWh per year (Interview 2, 9) and by adjusting parking fees (Interview 5). However, all municipalities agree that at some point the role of the local government is finished from a financial point of view and that electric driving should become a market that can sustain itself.

What is interesting to see, is that the bottleneck of an unviable business case is only brought forward by both municipalities who subsidize part of the costs of charging infrastructure (Interview 2, 9). The interviewees of the other municipalities – who have approached a third party for the deployment of charging infrastructure – do not see this as a problem, as their partner argues that there already is a viable business case. This might be related to the fact that a higher charging fee has to be paid when charging at these points, contributing to the viability of the business case. Additionally, the business case of inductive charging is currently seen as a bridge too far, given that there is already an unviable business case for conductive charging points (Interview 7). The interviewees also argue that inductive charging is a more expensive technology, and therefore do not expect its business case to be viable on the short term (Interview 5).

Another bottleneck that is pointed out, besides the unviable business case, encompasses internal processes. Some municipalities (Interview 1, 8) experience difficulties between different departments of their organization, e.g. public space, finance and sustainability, as electric transportation is a subject that can be covered by multiple departments in a municipal organization (Interview 9). Electric driving and its corresponding infrastructure involve, amongst others, civil servants who are responsible for making a decision about public space, but also employees who need to check whether there is a budget available to finance these charging points. This internal issue is emphasized by an interviewee who indicates that higher costs are involved with regards to a parking place that includes charging infrastructure, compared to a basic parking place. Therefore, he experiences that it is difficult to find support for electric driving as he is directly interfering with another municipal department that is responsible for parking places (Interview 1). The municipality of Rotterdam, which has initiated a pilot on inductive charging, mentions that the project has enabled the organization to connect multiple departments (Interview 8). Furthermore, this internal cooperation contributes to the acceptance of electric driving within an organization and it helps to understand different perspectives.

When looking at the identified bottleneck of internal processes, differences have been detected regarding the size of the municipalities. Larger municipalities seem to have more internal struggles (Interview 2, 8). However, both medium-sized municipalities argued to have different struggles: whereas Groningen has issues with internal processes, Ede does not recognize these difficulties. 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 charging infrastructure, as they are actively involved with this technology. Therefore, this topic is more embedded within their organization compared to the municipality of Groningen, which primarily focuses on cycling.

Current conductive charging infrastructure is subject to both the identified barriers. Inductive charging has been introduced as an alternative, possibly contributing to bottlenecks in a positive way. However, novel technologies such as inductive charging are often surrounded by expectations which influence the extent to which they will be mobilized by e.g. municipalities. By analyzing expectations of these stakeholders on inductive charging, something can be said about how the technology is likely to develop in the near future.

4.3 Expectations inductive charging

The previous section showed that there are still some bottlenecks regarding electric driving and charging infrastructure. Also municipalities tackled these barriers in various ways, showing that they have a significant contribution regarding novel technologies. Inductive charging is such a novel technology which could incorporate current bottlenecks and support the scale-up of EVs. As mentioned earlier, expectations are important in the initial phase of a technology, since they broaden networks and guide learning processes. Additionally, competition is mainly based on expectations instead of performance in the initial phase of a technology [20]. Therefore, expectations of inductive charging are considered, divided into micro-, meso- and macro-level expectations. They respectively tell something about the expected performance of the technology, the function that the technology is expected to fulfil, and broader statements about the technology and expected societal trends.

Regarding the state of technology of inductive charging, there is a broad range of expectations. Since the technology is relatively novel, it is expected that it has to face several technological challenges that make the development of this technology difficult on a short term. Costs are expected to be higher than conductive charging points, and also its efficiency is questioned (Interview, 7, 9). However, it can be argued that this comparison is skewed, since interviewees compare the *novel* technology of inductive charging to the already *developed* technology of conductive charging. Mutually, expectations differ as well, given that an expert on inductive charging technology indicates that nowadays the system is already able to deliver a higher wattage than before, with conservation of the efficiency and safety (Interview 6).

When considering the meso-level – on functions that the technology is expected to fulfil – four main functions are proposed. First of all, inductive charging is seen as a more user-friendly technology, since people do not have to use cables anymore to charge their vehicle (Interview 4, 5, 8). However, this function is also questioned since an interviewee does not expect someone *not* to purchase an electric vehicle just because inductive charging is not available yet (Interview 5). Secondly, it is expected that inductive charging will

reduce range anxiety, since it can be applied in a dynamic way – charging the vehicle while driving (Interview 5, 6, 11). Although it is mentioned that this type of infrastructure will still be quite expensive, it is argued that dynamic charging will contribute to the scale-up of EVs (Interview 11). The third function that is ascribed to inductive charging is that it provides a possible solution for public space, which is quickly filling up with charging points (Interview 1, 8). However, the current pilot project in Rotterdam still requires a pole on the side of the charging plates so that users can identify themselves with a card, and therefore the technology does not directly contribute to public space. The fourth and final function that inductive charging is expected to fulfil, is that it will remain a niche product instead of serving the wider public. Also, people see it mostly being applied to public transport (e.g. buses) instead of private cars.

Besides specific expectations on the technology, its performance and function, broader (societal) statements have been aired. A trend that almost all municipalities pinpoint is the fact that electric driving will continue to grow. Some municipalities already see an exponential growth in the number of requests for charging points (Interview 1), and others think that certain car types (e.g. Tesla Model 3) will drive the increasing need for charging infrastructure. Also, municipalities acknowledge the inherent link between the growth of electric driving and charging infrastructure, but their expectations vary regarding the *type* of infrastructure. Whereas some believe that conductive and inductive charging will exist side-by-side (Interview 1, 11), others expect inductive charging to replace charging with a cable (Interview 4, 9). One interviewee expects that inductive charging will not be adopted by car manufacturers, and that eventually it will be surpassed by hydrogen fueled cars (Interview 1).

The same scattered pattern on implemented strategies is also seen regarding the expectations of inductive charging. Municipalities doubt the performance of the technology, and expect it to take years before the technology is developed into a standardized product. Although there are no clear estimates yet on the costs of the technology, municipalities expect it to be more expensive since it is already difficult to create a viable business case around conductive charging points. They also ascribe different societal functions to the technology, such as a solution for public space or an increased level of comfort for the driver. Summing up, there is no consensus on all three levels regarding expectations. Shared expectations, however, are a requisite in order to create a successful niche [16]. These expectations also have an influence on their strategies, given that only a single municipality in the Netherlands has initiated a pilot project that tests inductive charging for private car use. What is striking, is that this is a large municipality which expects electric driving to grow, and foresees issues with public space. This sense of urgency, besides their abundance of human and financial resources, has influenced their decision to pioneer as municipality in the field of inductive charging.

5 Conclusions and recommendations

Although local governments differ regarding their size, strategies and resources, they play an important role in stimulating the transition towards more sustainable mobility. Large municipalities pursue more active strategies that originate from the responsibility that they ascribe themselves, such as solving the issue of an increasing number of charging stations in public space. Small municipalities with less resources can, however, also have a significant impact on sustainable mobility by simply opening up their public space as a living lab. These activities can help in achieving more sustainable mobility, and contribute to the sustainability transition. 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.

According to the results, there is currently a lack of convergence regarding the future of inductive charging. Since shared expectations are a requisite for a technology to develop, it is recommended that local governments keep track of 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 *best practices*, in order to contribute to a wider transition. Lastly, novel technologies, such as electric driving, challenge the current organizational structure of a municipality. Whereas this structure is aligned in a vertical way – with departments such as environment, public space and finance – horizontal themes should be identified in order to create an integrated approach across the municipality, which will help to embed novel technologies.

In future research, it might be interesting to look into the different technologies somewhat more. This research has only considered conductive and inductive charging, but some interviewees pointed out the influence of hydrogen technology. An interesting follow-up research would be to look at how these three technologies influence each other, and how dynamics between the technologies contribute to the global niche of electric driving.

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Interviews

Interview 1	Coordinator sustainable mobility, municipality of Groningen
Interview 2	Advisor sustainable mobility, municipality of Rotterdam
Interview 3	Assistant professor, Eindhoven University of Technology (dept. Electromechanics and Power Electronics)
Interview 4	Project manager electric driving, ElaadNL
Interview 5	Project manager dept. Development and Innovation, ElaadNL
Interview 6	Technical specialist, Proov
Interview 7	Manager electric driving, Stedin
Interview 8	Advisor sustainable mobility, municipality of Rotterdam
Interview 9	Advisor sustainable mobility, municipality of Ede
Interview 10	Head of dept. Equipment, municipality of Groningen
Interview 11	Policy officer Environment, municipality of Bladel

Ms. Annabel van Zante is a junior advisor in the field of Energy and Climate at APPM Management Consultants in the Netherlands. Her expertise includes transition studies, sustainability and electric mobility, which she puts to practice in complex and integral projects that she encounters in her job. Annabel has a master's degree in Innovation Sciences from Eindhoven University of Technology in the Netherlands.

Mr. Mark van Kerkhof is managing consultant Energy and Climate of APPM and senior strategy consultant E-Mobility. Mark was responsible for the development of the new E-Mobility strategy in the Netherlands for the period 2015-2020. He is also consultant for the chairman of the Formula E-team, which is a Dutch public-private partnership in E-Mobility. Mark is secretary of the Dutch National Taskforce on Public Charging. He is co-director of the Belgian company the New Drive and involved in many national and international strategic E-Mobility projects. Mark has an MSc in Public Administration at the Nijmegen School of Management and a bachelor Traffic Management at the Breda University of Applied Sciences.