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Social acceptance of electric mobility in Germany

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Abstract

Plug In Electric Vehicles (PEVs) can contribute to the decarbonisation of the transport sector and to alleviate some of the negative local impacts of car driving. As current market shares for PEVs in Germany are still small, it is important to investigate the social acceptance of electric mobility, taking into account different actors in the innovation system. Therefore we draw a link between the social acceptance concept (socio-political, market and local acceptance) and the technological innovation systems (TIS) approach and conduct a literature review. The results show that the majority of studies deal with the demand side of electric mobility, focusing on market acceptance. For a transition towards an electric transport system a deeper systemic understanding of all actors is necessary. The paper shows where the potentials for further acceptance research on electric mobility lie and provides an approach, which can be developed further and transferred to similar technologies.

Keywords: electric vehicles; social acceptance; technological innovation system; actors

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1 Introduction

Electric vehicles have received a lot of attention in recent years as they have the potential to decarbonise individual transportation, to reduce dependency on imports of fossil fuels, and to alleviate some of the negative local impacts of car driving like local emissions (exhaust, noise). This also applies to Germany, which has the biggest national car market measured in passenger car sales in Europe (ACEA 2019) and is home to global automotive players like BMW, Daimler, Opel, and Volkswagen, with a worldwide annual passenger car production of more than twelve million cars. Thus, the automotive industry is an important economic actor in the country which employs more than 800.000 workers (VDA 2018). In the light of the downsides of motorized transport, electric driving and more specifically Plug In Electric Vehicles (PEV: battery electric vehicles and plug-in hybrid electric vehicle) have received growing interest. The German government has directed significant funds toward supporting research institutions and companies in the electrification of vehicles. However, current market shares for PEVs in Germany revolve around the European average with the Nordic countries leading in Europe and worldwide (Plötz und Dütschke, in press).

That is, the transition to an electrified transport sector has started, but is still on a low level. In this context it is often discussed that (social) acceptance of this transition also plays a role - in addition to techno-economic factors like the costs for producing and purchasing or the technical maturity of PEVs. Acceptance is defined as a positive response to a new technology or a socio-technical system. The development of electric mobility takes place in a socio-technical system that is shaped by the promises and the challenges related to this technology as well as the actors in this system and their attitudes and behaviour in relation to this innovation - thereby shaping the further development. Electric mobility in this paper is defined as all forms of movement using electric drivetrains, e.g. in cars, bicycles and motorcycles, buses and commercial vehicles. In this paper, we focus on PEVs; we do not consider fuel cell-powered vehicles here.

Taking this understanding of the innovation system as a starting point and applying an actor-focused perspective, the aim of this article is to identify relevant actors in the innovation system of electric mobility which are important for the social acceptance of electric mobility. The theoretical approach of this paper is based on a combination of the technology innovation system framework (TIS) and the theory of social acceptance. To investigate the state of knowledge on the social acceptance of electric mobility in Germany and to identify research gaps we conducted a literature review.

In section 2 we explain the theoretical approach in more detail as well as its application to the German mobility system to identify relevant actors of PEV diffusion. In section 3 we describe our methodological approach and section 4 provides a review of studies that provide results regarding factors that influence the social acceptance of PEVs in Germany in different actor groups. In section 5, we discuss the findings of the review and draw conclusions regarding research gaps resulting from under-researched actors in the TIS and neglected research questions.

2 Theoretical approach

To determine the state of knowledge on the social acceptance of electric mobility in Germany and to identify open research questions, a broad approach is needed. The theory of social acceptance and the technological innovation system (TIS) concept are both rather broad concepts and their combination seems optimal for a holistic view as well as structuring a comprehensive review.

2.1 Theory of social acceptance

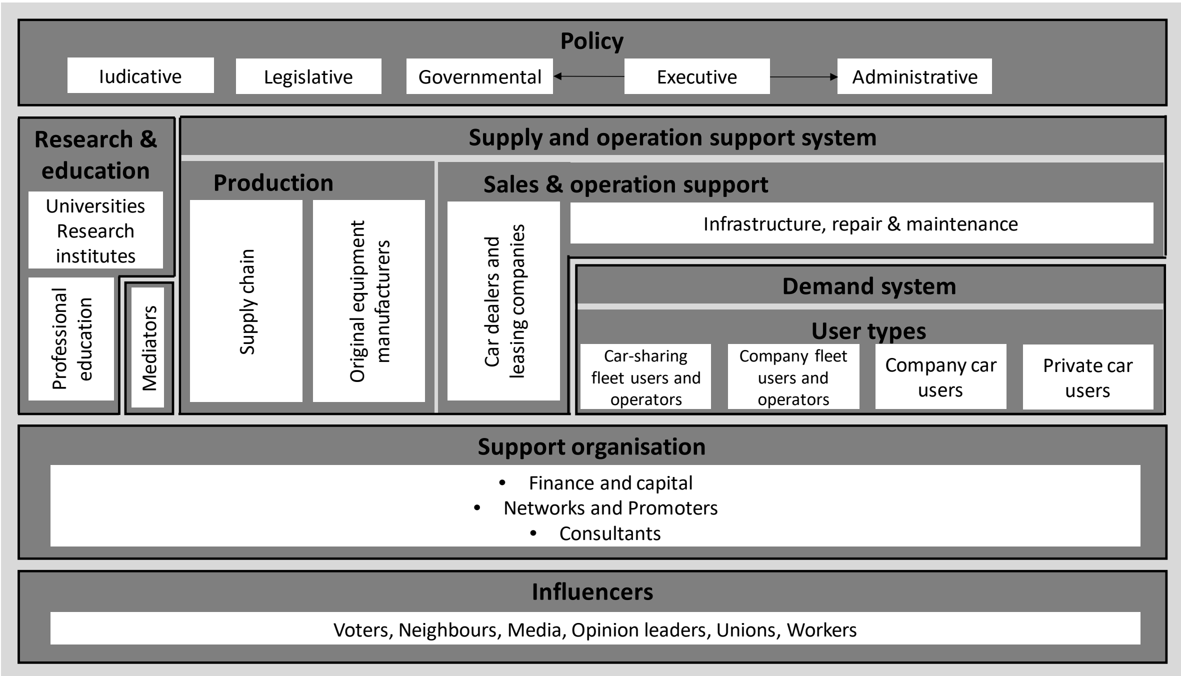
A recent definition of social acceptance defines the concept as “a favourable or positive response (including attitude, intention, behaviour and – where appropriate - use) relating to a proposed or in situ technology or socio-technical system, by members of a given social unit (country or region, community or town and household, organisation)” (Upham et al. 2015, p. 102). Wüstenhagen et al. (2007) introduce three dimensions of social acceptance of renewable energy innovations, namely socio-political, market and community acceptance. The first, socio-political acceptance refers to the general societal climate towards a technology or innovation within a society, i.e. in how far PEVs are positively or negatively perceived by the public and opinion leaders. Market acceptance describes the market success of an innovation and refers to the supply and demand side as well as intermediate actors (see next subsection). In the case of PEVs, market acceptance is observable in market shares, the purchase behavior of car-drivers, and the interest of carmakers. Community or local acceptance relates to the attitudes and behaviours exhibited by those indirectly affected, e.g. neighbours of installations like charging infrastructure or drivers of fossil-fuel powered vehicles in cities which give special rights to drivers of PEVs. All three dimensions of social acceptance are manifest in the attitudes, affects and actions of individuals and groups and are therefore closely linked to both individual and collective actors.

2.2 Actors in the technological innovation system

Technological innovation systems (TIS) can be defined as “set of networks of actors and institutions that jointly interact in a specific technological field and contribute to the generation, diffusion and utilization of variants of a new technology and/or a new product” (Markard and Truffer 2008, p. 611). The innovation is, hence, seen as embedded in a complex socio-technical system, which determines whether and how it will develop.

To analyse and sort the central structural variable of actors, (Hekkert et al. 2011) offer a sector-generic classification which was refined and extended in Dütschke et al. (2018; 2019). We use this classification as the basis for our article and adjust it to the energy and transport sector (Figure 1). From left to right, the figure follows the logic of the development, production and usage of an innovation or technology through the categories of research and education, supply and operation support system, and demand system. In this sequence, universities and research institutes in the category of research and education are central for the genesis of innovations, also by supplying knowledge and expertise through professional education. Mediators, on the other hand, are a subcategory of actors that link up research with application and provide the wider institutional conditions for the innovation to gain grounds. The supply and operation support system is divided into supply chain actors and OEMs on the production side and car dealers and leasing companies as well as actors providing infrastructure (e.g. for charging), repair and maintenance on the other side. As the figure visualizes, this last part of operations is closely interrelated with the demand system and usage where car-sharing and company fleet users, company car users and private car users make up the important individual actor groups. Part of the demand system are also the collective actors company fleet operators and car-sharing operators. Here, companies also include public bodies as operators and users of vehicles. On the top and bottom, this sequence of actors is surrounded by contextual actor groups. On the top, these are actors of the three government branches including the downstream administrative side. Their role is to provide a framework that enables and limits market development e.g. by directing public funds to certain innovations or by implementing and enacting regulations. On the bottom, influencers in the broader society such as voters, neighbours, the media, opinion leaders, unions, and workers are included who might not be market actors but shape individual and collective opinions on an innovation. In between there are the support organisations, which are more directly associated with the central sequence such as providing finance and capital, establishing networks between relevant actors or providing expertise as consultants, i.e. providing additional resources to the system.

Figure 1: Actor classification for the energy and transport sector based on Hekkert et al. (2011), Dütschke et al. (2018; 2019), Warnke et al. (2016)



The conceptualization of social acceptance into the three dimensions socio-political acceptance, market acceptance, and local acceptance has proven useful for analysing energy-related innovations with effects on different levels in society. Combining them with the actor system as outlined above it seems obvious that all of these groups influence acceptance dimensions, however, that they are also influential to a different degree depending on the acceptance focus. Socio-political acceptance is formed, sometimes shared by all actors listed and the different actors interact with each other on this dimension and the influencer category by definition plays an important role. Market acceptance is most strongly visible in market development and thus shaped by demand and supply side including individual as well as collective actors, i.e. manufacturers and car dealers as well as fleet operators or private households. However, policy makers set important framework conditions that may enable or hinder that a market actually develops while support organisations do or do not fuel the system with their resources. Community acceptance usually firstly becomes visible by reactions from influencers and citizens.

3 Methodological approach

To determine the state of knowledge on the social acceptance of electric mobility in Germany we conducted a literature review. The procedure was as follows: Initially, a systematic literature search (period: March to April 2019) was conducted on social acceptance, i.e. market acceptance (view of manufacturers, dealers and operators as well as potential users of the technology), socio-political acceptance (political stakeholders, the population and further groups) and local acceptance (road users, neighbours etc.) of electric mobility. For this purpose, the database Scopus was used.

The focus was on passenger transport, i.e. cars, and within this area both studies in the area of individual (private and commercial vehicles) and collective transport (sharing concepts) are considered. Only PEVs are considered here. From a geographical point of view, the focus was on scientific studies from Germany resp. studies that analyse the situation in Germany. If no German studies could be identified in a certain field, international studies were considered as well. The main focus is on work based on empirical data. Since the technology is developing rapidly, it was limited to studies from the past three to five years. The following keywords for the different actors in the different subsystems were used for the search:

- Policy: policymaker
- Research and education: science / researcher /education
- Supply and operation support system: OEM / automotive sector / manufacturer / sales / retailer / car dealer / garage / workshop / repair
- Demand system: user / private household / car sharing / company fleet / company car
- Support organisations: Finance / banks / investors / associations / consultants / political party / government / state
- Influencers: Media/ NGO / labour unions / role models / commercials / influencer / Social Media

With regard to the technology, the following variations were examined: “electric vehicle“, "electric mobility”, ”electric driving". In terms of user acceptance, we also searched for "perceptions" and "attitudes".

4 The social acceptance of electric mobility in Germany

As mentioned above, to analyse the social acceptance of PEVs we apply the concept of social acceptance and combine it with an actor conceptualization of the TIS approach. We try to assign the most important actor groups to the three dimensions of social acceptance: socio-political acceptance, market acceptance and local acceptance. For each of the dimensions the literature on the social acceptance of the several actors in the relevant subsystems in the technological innovation system is summarized.

4.1 Socio-political acceptance

Socio-political acceptance refers to general attitudes towards an innovation, in this case an electrified transport system, and behaviours related to an expression of these attitudes like political support or opposition - however, without including e.g. purchasing intentions or behaviours. Screening the literature as outlined above, it turns out that surprisingly little academic literature looks into general attitudes towards electric vehicles. Kühl et al. (2019) analyse needs raised around using electric vehicles, comparing the issues present in the current English and German research literature (identified from GoogleScholar) to those from German statements in Twitter from a recent period. Thus, their paper encompasses user statements intertwined with more general discussions which is why it is reviewed in this section of our paper. While they find that the literature is dominated by discussions around price and car characteristics (60 % of content), tweets vary more in scope, with infrastructure and societal issues as the strongest categories (around 40 %). Zaunbrecher et al. (2015) explore attitudes and perceptions of PEVs of non-users in focus-groups. The elicited discussions refer to environmental advantages as the main benefit and raise concerns around price, infrastructure, security of the technology and practicalities - partly guided by misconceptions.

Mazur et al. (2015a) compare the policy strategies of the UK and Germany, referring to differences in the system level that are relevant to policy makers. They point out that German policy makers were much more reluctant to increase regulative pressure, however stating “This does not mean that Germany is opposing the transition” (p. 96) as Germany is much more economically dependent on the current automotive industry. However, their analysis does also neither explicitly refers to acceptance nor to individual actors.

Finally, a recent study by Burghard et al. (2019) researches the activities of German municipalities in the field of electric mobility via a survey study and finds that 80 % are already active and that representatives from municipal administration regard electric transportation as highly relevant and promising. This study can be taken as an indicator for acceptance on this level.

Taking together the few research papers that analysed socio-political acceptance it turns out that even fewer actor groups are covered.

4.2 Market acceptance

Market acceptance describes the (potential) market success of an innovation. Market acceptance of PEVs can be analysed in market shares, the purchase behavior of car-drivers, or the interest of carmakers in the technology.

We subdivide this section in the supply and operation support system and in the demand system. Studies that refer to acceptance in the supply and operation support system investigate the extent to which corresponding actors are advancing electric mobility (manufacturing, sales, operation support). Studies that address the demand system evaluate the extent of interest of different user types in the use and / or the purchase of PEVs.

A precondition for the market success is the development of a technology; therefore, universities and research institutes are important. Since there is very little literature for Germany in this field (see Zhao 2018 for an exception), we do not take a closer look at it here.

4.2.1 Supply and operation support system

As part of the presentation of the results of the literature review in this system we differentiate between production system and sales and operation support system.

Production system. In terms of the production side it can be seen that the acceptance of electric mobility of German car manufacturers varies - the producers have different portfolios and business models with different strategies for electric vehicles. Modelling results show that manufacturers have a strong leverage regarding the market development and diffusion of electric vehicles especially when supportive policies are technology neutral (Kieckhäfer et al. 2017; Harrison et al. 2018).

Wesseling et al. (2015) analyse the incentive and opportunity to innovate (net income and PEV asset position) in relation to electric vehicle business strategies of large car manufacturers worldwide. They found that in the PEV commercialization period (2007-2011) manufacturers with a strong incentive and a strong opportunity to innovate (so-called first movers) sold significantly more PEVs than the other groups laggards and OEMs with mixed strategies. Radical innovation comes especially from less profitable firms. Thus, the incentive and opportunity to innovate can explain differences between different incumbents in terms of market success with PEVs.

Mazur et al. (2015b) conducted an event analysis, i.e. how the activities of the three main German car manufacturers fit with events at the landscape and regime in the field of low emission vehicle technologies. The results show that new activities related to niche technologies only occurred when actively introduced by external actors or induced by internally disruptive events (cf. the terms ‘innovation champions’ or ‘change agents’). In addition, there is only a limited influence of regulatory policy on the selection of particular disruptive technologies by the automotive industry, i.e. the industry by itself determines the technology they choose.

However these studies focus on the organisations as a whole and their observable activities in relation to electric mobility or other alternative technologies; they do not cover the attitudinal side of social acceptance.

Sales and operation support. Intermediaries between supply and demand are deemed crucial for the diffusion of new technologies. Important actors in the sales and operation support system of PEVs are car dealers and leasing companies as well as actors dealing with infrastructure, repair & maintenance. For electric mobility, the acceptance and resulting decisions of car dealers have a direct influence on whether models are available locally and whether clients are enabled or hindered in buying them. For Germany, no academic literature on the acceptance of electric mobility with car dealers or leasing companies could be found. Without geographic restrictions, three studies were identified which look at the acceptance of electric mobility of car dealers in Greece (Tromaras et al. 2017), Ireland (O'Neill et al. 2019), and five Nordic countries (Zarazua de Rubens et al. 2018).

Overall, the findings on PEV orientation were heterogenous, also within the group of Nordic countries analysed in the most comprehensive study so far by Zarazua de Rubens et al. (2018) which included Denmark, Finland, Iceland, Norway and Sweden. Norway stood out as the country with the highest PEV orientation in car dealers, while, for example, in Denmark dealers focused more on combustion engine vehicles in their sales practice (Zarazua de Rubens et al. 2018). In the Greek study, two interviewed product managers for electric vehicle series in big companies questioned that combustion vehicles would be pushed over PEVs by dealers (Tromaras et al. 2017). For Ireland, O'Neill et al. (2019) found mixed levels of acceptance of electric mobility in nine direct interviews with carmakers and car dealers summarized as a “reluctance of car dealers in Ireland to undertake the degree of effort involved to push sales of PEVs” (O'Neill et al. 2019, S. 123).

There were, however, some connecting factors between the countries, specifically regarding the barriers for PEV acceptance and sales at the car dealers. For Ireland and Greece, interviewees mentioned longer sales processes for PEV and “few easy sales” (Tromaras et al. 2017; O'Neill et al. 2019, S. 121). For the overall sales landscape, Zarazua de Rubens et al. (2018) find a lack of PEV availability and visibility as a central barrier at car dealerships. In line with O'Neill et al. (2019), a lack of models is seen as an additional barrier. Higher initial costs as well as differently factoring running costs and tax benefits was seen as a further barrier to overcome in the sales process, with sales personnel often arguing for the financial inferiority of combustion engine vehicles (O'Neill et al. 2019; Zarazua de Rubens et al. 2018). Finally, both dealers and the public are still subject to misinformation and misconceptions which presents the highest count of statements in the sales situations recorded by Zarazua de Rubens et al. (2018) and is also noted by O'Neill et al. (2019).

4.2.2 Demand system

In the demand system different individual actors can be differentiated: car-sharing and company fleet users, company car users, and private car user. In addition, the collective actors car-sharing and company fleet operators were identified. In this section, we differentiate between these user groups.

Car sharing fleets have an above-average share of electric vehicles and offer users the opportunity to test electric vehicles at low cost and thus bear the potential to reduce reservations against electric mobility. This can result in a higher diffusion of this innovative technology (BMVI 2016). Company fleet and company cars account for a high share of newly registered passenger cars (64% for Germany, KBA 2019a). In addition, they are resold more quickly than privately owned cars and diffuse through the second-hand car market (Gnann et al. 2015), i.e. commercial adoption is also likely to trigger private adoption. However, nearly 90 % of German vehicles are registered with households, i.e. forming the largest user group (KBA 2019b).

Car sharing fleet users and operators. In the last few years several studies were conducted that analyse the acceptance of carsharing with PEVs in Germany. (Kawgan-Kagan 2015; Burghard and Dütschke 2018) study the early adopters of electric carsharing in Germany who proved to be a socio-demographically specific group: Typical users are young, employed, highly-educated people, often men, from small households. There are some commonalities between PEV-sharing and private PEV users, i.e. overrepresentation of men, high level of education and employment (Burghard and Dütschke 2018). Burghard and Dütschke (2018) employ a segmentation approach and find that carsharing with PEVs is particularly attractive for younger car-free people living as a couple or for persons who are starting a family and use carsharing as a supplement to their own cars.

(Kawgan-Kagan 2015) study the relevance of environmental attitudes and find that carsharing-users seem to hold more positive environmental attitudes than non-users. Some studies examine the relevance of mobility behaviour and mobility-related attitudes for the acceptance of carsharing with PEVs (Kawgan-Kagan 2015; Burghard and Dütschke 2018; Hinkeldein et al. 2015). All of them find that PEV-sharing users attach less importance to owning a car than non-users and Hinkeldein et al. (2015) additionally work out that the early adopters are less dependent on the car for their daily mobility.

Some of the studies investigate the connection between attitudes for carsharing and PEVs (Burghard and Dütschke 2018; Kawgan-Kagan 2015; Schlüter and Weyer 2019). They agree that the affinity for carsharing and PEVs (e.g. interest, use and/or usage intentions) is closely connected. In more detail, (e-)carsharing users feel less strongly restricted by the use of PEVs, even compared to private PEV users (Burghard and Dütschke 2018) and they rate the perceived usefulness of PEVs more positively and show a higher intention to buy an PEV than non-users (Schlüter and Weyer 2019). The intention to use PEV-carsharing was high in all groups - carsharing users as well as non-users (Schlüter and Weyer 2019).

Beyond actual users, Burghard and Dütschke (2018) who also analyse potential adopters, point out that for individuals who are interested in using car-sharing social norms are relevant for their perceptions on carsharing as well as perceived compatibility with daily life. No further studies referring to the market acceptance of other actors, foremost operators of carsharing, could be identified.

Company fleet users and operators and company car users. The state of knowledge on the acceptance of PEVs in commercial fleets is very limited. With regard to the situation in Germany, we were able to find only four studies in the subject area of this review via Scopus (Globisch et al. 2017; Globisch et al. 2018; Kaplan et al. 2016; Ensslen et al. 2013). But even without this geographic restriction studies on the acceptance of PEVs in commercial fleets are rare.

Some of the studies on commercial fleets only address the decision-makers (e.g. car pool managers or CEOs) of organisations (Globisch et al. 2017; Kaplan et al. 2016) while others deal with PEV users as well as decision-makers (Ensslen et al. 2013; Globisch et al. 2018). In the latter studies, the surveyed PEV users are pool car users, i.e. the PEVs are shared with other employees. We are not aware of any acceptance studies dealing with other commercial usage scenarios in Germany, e.g. electric company cars, (see Koetse and Hoen 2014 on company car users in the Netherlands).

With regard to the acceptance of decision-makers, Kaplan et al. (2016) find that there is lower acceptance of PEVs in the forestry, agriculture and public administration and defense sectors. In contrast, respondents from high-tech sectors are more open to PEVs. Furthermore, Kaplan et al. come to the conclusion that a positive perception towards aspects such as environmental benefits and corporate image benefits by PEVs as well as the experience of driving a PEV have a strong influence on acceptance. Globisch et al. (2017) emphasize the relevance of the personal attitude of decision-makers. In particular, technological affinity plays an important role, which leads to a personal interest in PEVs and a willingness to champion for their procurement. Furthermore, the expectation of environmental benefits and increased motivation among employees have a positive effect on the willingness to advocate PEV procurement. Expectations of reduced mobility and reductions in vehicle reliability, on the other hand, are identified as potential barriers to PEV adoption efforts.

With regard to the role of vehicle users Globisch et al. (2018) come to the conclusion that subjective norm (here the perceived opinion of colleagues regarding PEVs) have a very strong influence on whether further PEV procurements are supported or not. Other factors that are relevant include the extent to which PEVs are regarded as useful for the organization, perceived environmental advantages, the usefulness of PEVs for one's own work tasks and their user-friendliness also have an influence on user acceptance. Ensslen et al. (2013) focus on the investigation of differences between German and French PEV users in commercial fleets. Their results provide insights regarding the potential importance of national framework conditions. For example, the maximum speed of PEVs is rated better by French users than by German users, which may be related to the fact that on some German motorways a speed limit is not existing.

In terms of public bodies as operators and users of vehicles results of the study of Burghard et al. (2019), which looked at the activities of German municipalities in the field of electric mobility, are presented here. The conversion of the municipal fleet is one of the two dominant fields of action (besides the development of charging infrastructure) in which 86% of the municipalities are already active or planning to do so (of those municipalities who reported they are or are planning to be active in the field of electric mobility, i.e. 80%).

Private car users. A series of research results is available for the acceptance of electric vehicles by private users. Several studies investigate the influence of technology-related factors, like range or charging infrastructure, on acceptance. Franke et al. (2017) analysed the individually perceived range satisfaction of PEVs with data from a BEV field trial and found that range satisfaction plays a central role for BEV acceptance. Several predictors influence the range satisfaction: The regularity or predictability of mobility patterns, the share of journeys not coverable because of range issues and the individual comfortable range of the users. Halbley et al. (2018) conducted a conjoint survey study with German users and non-users of BEVs and found similar results, i.e. a high relevance of range perception for acceptance - together with charging time and charging locations. Krause (2018) surveyed users and non-users of BEVs on the perceived additional value of public rapid-charging infrastructure and found that the perceived value depends on trip purpose: An increased perceived value was found for leisure and business trips, a low perceived value for shopping trips or trips to work. Between different user groups (e.g. amount of BEV usage or experience with rapid-charging) the perceived value did not differ. Kawgan-Kagan and Daubitz (2017) conducted repertory grid interviews with people with a high affinity for cars to investigate the acceptance of electric vehicles in combination with the perception of urban transportation means (ICEVs=internal combustion engine vehicles, public transport, e.g. trams and electric buses, pedelecs and segways). The results show that there is a heterogeneous and no discrete perception of BEVs; in contrast, three clusters of different construct systems emerged: BEV perception with high level of similarity to ICEVs, BEV perception with high level of similarity to public transport or BEV perception with high level of similarity to pedelec and segway.

Various studies focus on the influence of individual factors such as sociodemographic attributes, attitudes or mobility behaviour on the acceptance of PEVs. Hackbarth and Madlener (2016) investigated the preferences and willingness-to-pay for different alternative fuel vehicles (AFV) of German car buyers. They identified two consumer segments who are likely to choose at least one AFV: younger, slightly less educated and environmentally aware consumers with a high daily mileage are affine for AFVs in general (BEVs, PHEVs, biofuel vehicles = BVs and fuel cell electric vehicles = FCEVs) (class 6, 15%) whereas older technophile consumers with large cars show a preference for PHEVs (class 4, 20%). German car buyers show a considerable williginess-to-pay for the improvement for several vehicle characteristics (highest amounts were found for driving range and fuel availability), especially those in class 6. However, in terms of BEVs, the respondents are not willing to pay the necessary amounts of money for the increase in battery capacity, even the AFV-affine consumers in class 6. Some studies analyse the effect of direct experiences with PEVs and carsharing - further individual factors - on the acceptance of PEVs. Schmalfuß et al. (2017) investigated the role of direct experience with BEVs for their acceptance with two studies: an online survey and a field test. Both studies revealed that most BEV attributes were evaluated more positively by people with BEV experience. In the online study a direct effect of experience on purchase intention was found with path analyses, but not in the field test study, in which only effects of BEV experience on BEV attributes and attitudes were found. Similarly, Halbley et al. (2018) also found differences between BEV-users and non-users: The former group puts more emphasis on the charging locations and less on the range than the latter. Schlüter and Weyer (2019) examined the impact of carsharing experience on the acceptance of PEVs and find more positive attributes from current carsharers towards PEV.

In summary, it can be seen that there is only little literature for the perspective of actors on electric mobility in the supply and operation support system, e.g. manufacturers or car dealers. Acceptance of EVs with car dealers has so far not been researched for Germany and studies from other European countries cannot be transferred to the German situation. In contrast, there exists a lot of knowledge about user acceptance in the demand system, especially in the group of private car users. That is, a variety of technology- and context-related determinants for PEV acceptance as well as user-related variables have been investigated. Some studies focus on users of car sharing show, and so far only a few studies deal with the acceptance of decision makers in commercial fleets and company fleet or company car users.

4.3 Local acceptance

Local acceptance becomes a focus in primarily two situations around electric mobility. First, public charging infrastructure is rolled out in many places. While the infrastructure is not as visually prominent as other technologies related to renewable energy which have created a lot of local opposition, like wind turbines, it nevertheless takes away public space. In many cases, the parking spots close to charging infrastructure are reserved exclusively for electric vehicles and have been converted from formerly available spots for all vehicles. Second, some cities give special rights to drivers of electric vehicles who can use bus lanes and park for free in certain areas, for example. Such advantages can be felt as disadvantages for drivers of fossil-fuel powered vehicles and thereby affect local acceptance. On the other hand, electric vehicles could locally be experienced as more pleasant by bikers and pedestrians as well as inhabitants of busy streets since they have no local emissions. Literature on this aspect, however, does not exist so far besides some non-academic articles. Within the TIS actor system, local acceptance relates most closely to neighbours as a subgroup of potential influencers. For the mobile technology it can be useful to understand neighbours not only as those individuals living closely to charging infrastructure and (reserved) parking but also more widely as “traffic neighbors”. This area presents many open research questions and large research opportunities, especially now that electric mobility is diffusing further and becomes more visible.

5 Discussion and Conclusion

This paper started from conceptualising social acceptance and by developing an actor system for the PEV innovation system. It then moved on by reviewing the German focused literature along acceptance dimensions using an actor perspective. The results of the literature review on the social acceptance of electric mobility in the German innovation system show that the majority of the studies focus on social acceptance in the demand system, representing a market acceptance perspective. That is, there exists a lot of knowledge about acceptance especially in the group of private car users, and to some extent for carsharing users, company fleet and company car users. However, already those last groups are understudied. It turns out that studies tend to either focus on the micro, i.e. the individual level, e.g. drivers of PEVs and decision makers, or the meso level, i.e. policy makers as uniform collective. However, little analysis has been performed on interactions between actors on the micro level and how these relate to the behaviour of the collective, the meso level (see Globisch et al. (2018; 2017) as one of the few exceptions). Some first studies have started to look at the influence of car dealers, however, none of them specifically for Germany.

Beyond the demand system and market acceptance, there is very little further research on other actors' perspectives and behaviours as well as for socio-political and local acceptance: Whereas we were able to identify literature on the social acceptance in the German population, work on the acceptance of actors in further systems (policy, research and education, societal influencers) is rare. Grey literature and newspaper articles indicate that neighbors of re-purposed parking infrastructure and other road users could influence the development of the innovation system with their negative or positive reactions and resulting local acceptance. In this vein, Esmene et al. (2016) challenge the view of the neutral researcher acting as a single entity and illustrates "how communication and understanding can be nuanced by both the nature of the research carried out and personal characteristics of the researchers themselves" (p. 663).

Combining the actors structure from the TIS and social acceptance as concepts has enabled us to point to important gaps in the literature. Thereby the intention is to further the understanding of the move towards PEV as a system change that requires a broad involvement of actors - at least their tolerance, but in many cases also their active support for such a change.

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