Municipalities as promoters of electric mobility? A survey study in Germany

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Abstract
The use of electric vehicles (EVs) has the potential to make the transport system more sustainable and to improve the quality of life in local communities. Municipalities are an important player in the market diffusion of EVs as they can promote and implement electric mobility in various ways, e.g. in their own fleets or municipally owned companies. They are also in a position to create the conditions that make electric mobility more attractive, not only to local companies, but also residents. This includes supporting the development and expansion of infrastructure, e.g. charging stations. Furthermore, they can act as information brokers and thereby enhance levels of awareness and knowledge.

We conducted a survey of 540 German municipalities with 5,000 inhabitants or more, including all major cities in Germany. The survey aimed to examine which fields of action are the most promising from the point of view of municipalities, and which structural factors influence their decision to engage in this topic.

We found that electric mobility is an important topic for German municipalities: More than 80 % are already active in this field; another 10 % are planning activities. To analyse the degree of activity in more detail, we developed an activity index comprising different fields. This indicates that the majority of municipalities are classified as having only an intermediate or low level of activity. Electric mobility is primarily an environmental and transport issue as well as an image issue. The expansion of charging infrastructure and the electrification of municipal fleets are the dominant fields of activity. We identified several structural factors that can help to predict the activity of municipalities in the field of electric mobility. These include variables concerning population, population growth as well as urbanisation and density indicators.

Introduction
Electric vehicles (EVs) have high potential to contribute to a more efficient and more sustainable transportation system. EVs powered by electricity from renewable sources could help to reduce the climate change impacts of the transport sector. At the local level, EVs can improve the quality of life in communities due to their low local emissions and reduced noise levels. Germany, like many countries, is therefore supporting the market uptake of EVs. The German federal government has set itself the goal of significantly increasing the market share of electric vehicles to 1 million by 2020 and 6 million by 2030 (Bundesregierung 2009). Although it is likely that the 2020 target will only be reached after a slight delay in 2022 (NPE 2018), electrifying the transport system remains a standing goal. In addition, the negative consequences of internal combustion engines in cities are currently the subject of an intense debate surrounding air quality in Germany. Following a court decision after action taken by an environmental NGO, several local authorities have introduced driving bans on diesel vehicles and partly also on petrol vehicles with older emission standards in 2019. This contributes to increased interest in EVs.

Municipalities are an important player when it comes to the diffusion of EVs because they can promote and implement elec-

tric mobility in various ways. For example, by electrifying their own fleet or the fleet in municipally-owned companies, or by supporting the electrification of commercial vehicle fleets. Local authorities can introduce special privileges for EVs as part of the Electric Mobility Act (Elektromobilitätsgesetz, EmoG). Furthermore, municipalities are important implementers of charging infrastructure in the current market phase. In addition, they can enhance levels of awareness and information among citizens.

In Germany, the national-level support for electric mobility also includes measures directed at municipalities. The Federal Ministry of Transport (BMVI) is funding the electrification of the transport sector through its "electric mobility funding guideline" and the associated programme. The focus of this programme is on local authorities advancing electric mobility at the local level. This includes three instruments: financial subsidies for procuring EVs and constructing charging infrastructure as well as developing electric mobility concepts (so-called environmental studies). As the third instrument, research and development projects will also be continued to be funded. The "electric mobility-funding programme" is coordinated by the National Organization for Hydrogen and Fuel Cell Technology (NOW) on behalf of the BMVI. The funded projects are accompanied by scientific research to consolidate the results. The accompanying scientific research comprises four thematic focuses: innovative drives and vehicles, charging infrastructure, framework conditions and market plus networked mobility (BMVI 2018).

With the introduction of the Electric Mobility Act (EmoG), which came into force on 12 June 2015, municipalities were authorised to introduce special privileges for EVs. For example, privileges for parking on public roads, exemption from or reduction of parking fees and exemption for EVs from certain access restrictions (Deutsches Dialog Institut GmbH und Noerr LLP 2018).

In this paper, we analyse the activities of German municipalities in the field of electric mobility. On the one hand, we want to give an overview of what is happening on the municipal level regarding the electrification of the transport system in Germany. On the other hand, we want to determine what differentiates active communities from those that are less active in this field. Our analysis is based on survey data collected from more than 500 municipalities in Germany. This survey was conducted as part of the accompanying scientific research in the field of networked mobility.

We start by presenting information on the importance of municipalities for the diffusion of electric mobility. We present the approach and key findings of two previous municipal surveys on electric mobility in Germany followed by the approach of our study. We describe our survey in detail in the methods section as well as how we extended the survey database using structural data and methods of data analysis. The results are presented in two subsections: the level and type of activity of municipalities in the field of electric mobility, and the factors influencing this activity level. In order to do so, we constructed an activity index, followed by a regression analysis using survey and structural data from the municipalities. Finally, we draw conclusions with regard to the role of municipalities in the further diffusion of electric mobility.

Electric mobility in (German) municipalities

Electric mobility 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 battery electric vehicles (BEVs) and externally chargeable hybrid electric vehicles; we do not consider fuel cell-powered vehicles here as they require a hydrogen infrastructure (BMVI 2018). At the beginning of 2018, almost 100,000 electrically-powered cars were registered in Germany (around 44,000 plug-in hybrid cars and almost 54,000 electric cars (Kraftfahrt-Bundesamt 2018). Around 67,000 electric cars were added during this year; about half of them plug-in hybrids and half BEVs (Kraftfahrt-Bundesamt 2019b). There are 7,343 publicly accessible charging stations in Germany, which are registered at the German Federal Network Agency (Bundesnetzagentur 2019).

MUNICIPALITIES AND THEIR ROLE IN THE DIFFUSION OF EVS

In the federal system of the Federal Republic of Germany, municipalities form the lowest level of the three main administrative levels. The federal and state levels are superior to them and can assign them tasks that have to be implemented. However, the subsidiarity principle applies here: if something can be decided at local level, it should not be decided at a higher level. The municipalities have the right to local self-government and are responsible for public administration, but they cannot pass their own laws. However, they do play an important role in the political decision-making process, as they are in direct contact with citizens. Municipalities are responsible for public services ("Daseinsvorsorge"), i.e. the supply of infrastructure goods including electricity and public transport. Whether the construction of charging infrastructure is included in this is currently being discussed (Göttinger Institut für Demokratieforschung 2016).

Municipalities are an important player when it comes to the diffusion of EVs as they can promote and implement electric mobility in various ways. The following fields of action can be identified:

- Municipalities as consumers: They can integrate EVs into municipal fleets and support the electrification of fleets of municipally owned companies.
- Municipalities as role models: If representatives of municipal administrations and policy makers drive EVs, this could have a positive influence on the attitudes towards EVs among citizens and organisations.
- Municipalities as part of local networks: Municipal representatives are in contact with many societal groups within the municipality, e.g. companies, research organisations, households, associations, and can support the exchange of information and diffusion of knowledge and expertise among them.
- Municipalities as a link to other networks: Municipalities often cooperate with other local and regional authorities and thereby have access to further experiences, best practices, and information on electric mobility which they can share with the relevant parties within the municipality.

- Municipalities as regulators and implementers: Within their local area, municipalities also have some regulating power over the transportation system in terms of developing policies as well as implementing land use policies. Furthermore, they often play an important role in organising and granting permission for the installation of public charging infrastructure.

PREVIOUS STUDIES ON ELECTRIC MOBILITY IN GERMAN MUNICIPALITIES

Previous studies on electric mobility in German municipalities have been conducted by the Fraunhofer Institute for Industrial Engineering IAO (Fraunhofer IAO 2012) and the German Institute of Urban Affairs (Deutsches Institut für Urbanistik, Difu) (BMVI 2015), both on behalf of the BMVI as part of the accompanying scientific research in the electric mobility funding programme.

The aim of the first study was to develop a comprehensive understanding of the activities pioneering cities are pursuing in the field of electric mobility. The primarily quantitative study showed the importance of a systemic and holistic approach. Motivating factors for pioneering activities included the environment, transport, economy and image (Fraunhofer IAO 2012).

The second survey aimed at documenting the activities and needs of municipalities and covered cities with a population of 20,000 or more inhabitants. The study focused on the construction of an activity index, which showed that almost 80 % of the examined cities were active in this field. The main needs of the cities surveyed were found to be the expansion of financial support, the establishment of uniform standards as well as the further development of legal and political framework conditions (BMVI 2015).

In addition to these studies, another from 2016 examined the acceptance of electric mobility by municipal decision-makers in the metropolitan regions of Hannover, Braunschweig, Göttingen, and Wolfsburg in Lower Saxony. It aimed to identify the framework conditions necessary for successful implementation and included one-to-one interviews and workshops. The study showed that external factors such as federal policy guidelines, technical performance and the behaviour of industry are all influencing the way municipal decision-makers deal with electric mobility (Göttinger Institut für Demokratieforschung 2016).

OUR APPROACH

As the field of electric mobility is developing rapidly, the German Federal Ministry of Transport (BMVI) commissioned a recent update of the activities of German municipalities in this field. The aim of our study is therefore to build on earlier work and document the current range of activities and measures implemented by German municipalities. Another aim is to identify the factors influencing the level of activity in the municipalities. Finally, as the market for electric vehicles is expanding, our study also includes smaller municipalities that were neglected in earlier studies.

Data and methods

As mentioned before, we present results of a survey study in German municipalities on their activities in the field of electric mobility in this paper. We extended the survey database by including structural data on the municipalities and developed an activity index using the survey data to identify and classify active and inactive municipalities. This index then served as a dependent variable in a regression analysis to identify structural factors influencing the level of municipal activity.

This survey is part of the supporting scientific research for the electric mobility-funding programme in the field of networked mobility. The aim of this research is to strengthen competencies at the municipal level with regard to mobility strategies and associated measures that include EVs. This applies in particular to the development of regional and municipal strategies and to linking the energy and transport sectors at local and municipal level.

MUNICIPAL SURVEY

The survey was carried out using a standardised online questionnaire. The questionnaire was developed based on the two previous municipal surveys and discussed with representatives of municipalities and the scientific community. The final questionnaire consists of six parts: The first part addresses how the topic is anchored institutionally within the municipality. This is followed by questions about the perceived potential of electric mobility and the current relevant activities in the field. This self-reported level of activity served to divide the municipalities into active and inactive or formerly active municipalities for the rest of the survey. The active municipalities were then asked more precise questions about their activities in six fields of action, e.g. the electrification of municipal fleets (see Table 2), whether the topic is anchored strategically in the municipality and whether there are driving forces for electric mobility within or outside the municipality. The formerly active and inactive municipalities were also surveyed about the type of activities or support measures carried out or discussed. In addition, they were asked why they are not or no longer active as well as about their support needs.

The relevant population for the study consists of 2,914 German municipalities with more than 5,000 inhabitants. All municipalities with more than 20,000 inhabitants (691 municipalities) were invited to take part in the survey. Of the smaller municipalities with 5,000 to 20,000 inhabitants, a random selection was made of every tenth municipality (293 municipalities in total). Where possible and applicable, contact persons for the topic of electric mobility were searched for in advance; otherwise the mayors were contacted. The two central municipal associations, the Deutsche Städte- und Gemeindebund (DStGB) and the Deutsche Städtetag (DST) supported the survey. Community-specific internet links were used to track who had already completed the questionnaire, or to link the information in the questionnaire with structural data. The survey was launched in November 2017 and ran until February 2018.

Of the 984 municipalities contacted, 540 (55 %) submitted valid questionnaires. Representatives from all 14 German cities with more than 500,000 inhabitants took part in the survey. As the size of the municipality decreases, so does the proportion completing the survey. This dropped to 48 % for municipalities with between 5,000 and 20,000 inhabitants.

Cities with 20,000–50,000 inhabitants account for the largest share of the sample (50 %). Overall, the municipalities cover all the German federal states in a largely uniform manner. A fifth of all German municipalities were reached by the survey, which corresponds to 45 % of the German population

Table 1. Structural data added to the survey database.

Indicators and variables		Reference year	Data source
Influence and ability to act			
	Total population	2016	(Statistische Ämter des Bundes und der Länder 2019)
	Total tax revenues (in € per inhabitant)	2015	(BBSR 2018)
	Population growth (in %)	2011–2015	(BBSR 2018)
Pressure to act			
	Exceeding the NO_2 limit value (annual average >40 µg/m³)	2017	(Umweltbundesamt 2018b)
Level of urbanisation and density			
	Population and job density (inhabitants and employees per square kilometre)	2015	(BBSR 2018)
	Ratio of in- and out-commuters (per 100 employees at the job location)	2015	(BBSR 2018)
Demand for individual mobility/ range problems			
	Level of motorisation (number of vehicles per 1,000 inhabitants)	2016/2017	(Kraftfahrt-Bundesamt 2019a)
	Reachability of major regional centres (average driving time in minutes)	2015	(BBSR 2018)

(Statistische Ämter des Bundes und der Länder 2018; Statistisches Bundesamt 2018).

In many cases, the questionnaires were completed by clerical staff or climate protection managers, but also by the administrative head or the head of a department. In terms of profession, the respondents were most frequently from the areas of climate and/or environment or in a central overarching office such as the main office. People from the construction, planning and transport sectors also frequently completed the questionnaire.

EXTENSION OF SURVEY DATABASE WITH STRUCTURAL DATA

The survey database was extended by adding structural data, which can help to explain the activity of municipalities in the field of electric mobility. A preselection of possible indicators was done by (Ritschny 2017) based on the assumption that activity in the field of electric mobility results from the combination of the municipality's ability and pressure to act as well as its present framework conditions. Several corresponding variables were identified for the indicators (Table 1[1]). Besides theoretical considerations, variables were also selected based on the availability of data at municipal level.

Its influence and ability to act is determined by the size and financial strength of the municipality. Emissions from motor vehicles, which are a major source of air pollution in towns and cities, are one example of the pressure on municipalities to act. The pollutants that have regularly exceeded their respective limit values are nitrogen dioxide (NO_2), ozone (O_3) and particulate matter (PM_{10}). However, because PM_{10} pollution has gradually decreased to a point at which only one city exceeded the limit value in 2017, this was not included in the analysis. We also excluded O_3, because it is not emitted directly and frequently occurs at a considerable distance from the emission source (Umweltbundesamt 2018c). Carbon dioxide (CO_2) exhaust emissions are not measured directly and therefore also not used as a variable for the analysis (Umweltbundesamt 2015).

Important framework conditions of municipalities are represented by indicators and variables that indicate the level of urbanisation and density, since there is a great demand for and supply of sustainable and interconnected mobility in urban areas. Here, the positive effects of electric mobility on the environment, transport and the economy, which were identified as the main motives for its implementation in a previous study (Fraunhofer IAO 2012) are the most apparent. The demand for individual mobility is also important in this context, as this is generally lower in highly urbanised areas with a large variety of alternative mobility services. In addition, the limited range of EVs might be less important here in contrast to municipalities that are located further away from regional centres.

COMPOSITION OF THE ACTIVITY INDEX

An activity index is constructed based on survey data so that a single value representing the level of activity can be assigned to each municipality. This not only enables the researcher to measure the activity levels quantitatively, but also to identify and classify active and inactive municipalities. It is assumed that, in order for electric mobility to become widespread, it is necessary for municipalities to be involved in various fields of action. Furthermore, the topic should be implemented institutionally within the municipal administration.

The index constitutes the dependent variable of the subsequent regression analysis, which is conducted to identify the factors contributing to explain a municipality's level of activity. The index is constructed as a composite indicator of eight variables collected in the study. These depict various actions municipalities can take to promote electric mobility: Engagement in six fields of action (development of charging infrastructure, electrification of municipal fleets, supporting the electrification of commercial fleets and EV sharing as well as providing

1. Total tax revenues = property tax + trade tax + income tax + sales tax + other municipal tax - trade tax levy.

Table 2. Composition of the activity index (I_a).

Variable (x_{ai})			Response categories	Values	Weighting factor (w_i)
Fields of action					
	x_{a1}	Supporting the development of charging infrastructure	No (strategic) development	0	1
			Either existing development or planned strategies	0.5	
			Existing strategic development	1	
	x_{a2}	Electrification of municipal fleets	Inactive	0	1
			Planned activity	0.5	
			Active	1	
	x_{a3}	Supporting the electrification of commercial fleets	Same as x_{a2}	Same as x_{a2}	0.5
	x_{a4}	Providing information services for citizens	Inactive	0	0.5
			Active	1	
	x_{a5}	Promoting EV sharing	Same as x_{a2}	Same as x_{a2}	0.5
	x_{a6}	Execution of the Electric Mobility Act (EmoG)	Same as x_{a2}	Same as x_a	0.5
Institutional implementation of electric mobility					
	x_{a7}	Establishment of a unit responsible for electric mobility	Same as x_{a2}	Same as x_{a2}	1
	x_{a8}	Implementation of electric mobility in superordinate strategies and plans	Not implemented	0	1
			Planned implementation	0.33	
			Not implemented but influencing plans and strategies	0.66	
			Implemented	1	

information for citizens) and the institutional implementation of electric mobility (existence of a unit responsible for electric mobility and its implementation in strategic instruments). The level of activity in each field is measured by the values assigned to the response categories by the survey participants (Table 2). The results section presents a descriptive evaluation of the responses regarding the listed variables (How active are German municipalities in the field of electric mobility?).

The activity index is calculated by summing up the municipality's weighted values for each of the variables listed in the table above. As the index only accommodates values between 0 and 1, with 0 corresponding to inactive and 1 to the most active municipalities, the activity index has to be standardised (OECD 2008). Therefore, the equation for the number of index values I_a can be computed as follows:

$$I_a = \frac{(w_1x_{a1} + w_2x_{a2} + w_3x_{a3} + \ \dots \ + w_nx_{an}) - min\ (\sum_{i=1}^{n} w_ix_{ai})}{max\ (\sum_{i=1}^{n} w_ix_{ai}) - min\ (\sum_{i=1}^{n} w_ix_{ai})}$$

$$= \frac{\sum_{i=1}^{n} w_ix_{ai}}{\sum_{i=1}^{n} w_i} \qquad (1)$$

with w_i being the weighting factors of the indicators x_{ai}. Since x_{ai} is composed in a way that its highest possible value equals 1 and its lowest possible value equals 0, the equation can be reduced as shown above. The weighting factors of the indicators (see Table 2) are determined based on the insights from a descriptive analysis of the survey results. This analysis showed that most municipalities were active in the development and expansion of charging infrastructure (x_{a1}) as well as the electrification of the municipal fleet (x_{a2}). Furthermore, analysing the survey results highlighted the importance of the operational (x_{a7}) and strategic (x_{a8}) implementation of electric mobility for the municipality's level of activity. Based on these findings, these variables were weighted more than others.

IDENTIFICATION OF FACTORS INFLUENCING THE MUNICIPALITIES' LEVEL OF ACTIVITY

The factors influencing the activity level of the municipalities are examined in a regression analysis with the activity index as the dependent variable and the structural data as the independent variables. These regresses are represented by the predominantly metrically scaled variables listed in Table 1. The only binary-scaled variable is the NO_2 limit value of the annual average of 40 µg/m³, where exceedance is measured as 1 and compliance with the limit value is measured as 0. Based on the 39th Ordinance Implementing the Federal Immission Control Act, it is not mandatory for each municipality to measure the concentration of this pollutant. Instead, assessment regions are identified, in which the minimum number of measuring

stations is determined based on the current population and pollution situation. These regions may include one or more municipalities. The premise for locating the measurement stations in each region is to record the highest concentration of pollutants to which the population is exposed. Therefore, NO_2 is not measured for all the surveyed municipalities (Umweltbundesamt 2018a). The value 0 was assigned to the resulting large number of missing cases. If a city has more than one measuring station, only the one with the highest values was included in the analysis.

The multiple linear regression analysis was conducted by the stepwise inclusion of the regresses with the biggest partial influence on the dependent variable. The regression equation was calculated using the least squares method, where the sum of the squared deviations is minimised to estimate the regression coefficients β_i. The results are presented in the form of the following estimation equation of the number of b dependent variables y_b:

$$y_b = \beta_0 + \beta_1 x_{b1} + \beta_2 x_{b2} + \beta_3 x_{b3} + \cdots + \beta_n x_{bn} \qquad (2)$$

with β_0 being the intercept and β_i being the slope of the dependent variables x_{bi}. The validity of the model was checked by the visual interpretation of the standardised error values, which should be normally distributed, as well as by applying test statistics like the T- and F-test. Furthermore, unwanted multicollinearity between the regressors was tested by checking each indicator's variance inflation factor (vif), which should be lower than 10. The statistical significance of the model was also tested using the regresses' multiple correlation R with the dependent variable as well as R^2. This parameter was calculated as the quotient of variance explained by the regression model and the overall variance. R^2 can display values between 0 and 1, with values near 1 indicating the model's good fit to explain the overall variance of the activity index as well as its fit to predict the index values of municipalities not examined in the study. Further analysis of the strengths and weaknesses of the model was done by visually comparing the estimation results with the results of the activity index (Fahrmeir et al. 2013).

Results

The results are presented for the two aims of the study: Analysing the fields of activities and measures implemented by German municipalities, and identifying the structural factors influencing the level of activity in the municipalities.

HOW ACTIVE ARE GERMAN MUNICIPALITIES IN THE FIELD OF ELECTRIC MOBILITY?

81 % of the municipalities surveyed reported they are active in the field of electric mobility, with a further 10 % planning activities, i.e. they have taken action or are intending to do so in at least one of the fields surveyed. A few have discontinued their activities. This result is based on a question asking the municipalities to classify themselves as active/inactive. All the major cities reported activities; for municipalities with more than 50,000 inhabitants, over 90 % reported activities. Of municipalities with 5,000 to 20,000 inhabitants, two thirds are active. This is in line with the finding that many municipalities give high priority to the topic: In total, two-thirds of the municipal representatives surveyed answered that the significance of electric mobility is high or very high. The larger the municipality, the more importance is attached to the topic. In addition, it can be seen that municipalities with nitrogen dioxide (NO_2) pollution problems (58 municipalities) rate the significance of an electrification of the transport system more highly than municipalities without such pollution.

Those municipalities that have not yet carried out any activities in the field of electric mobility and are not currently planning such activities (9 %) cite primarily a lack of personnel and financial resources as reasons; some point to a lack of experience and knowledge, consider the topic unsuitable for their municipality or refer to the higher administrative level. Five municipalities have discontinued activities and gave various reasons for this, e.g. unsatisfactory purchase of vehicles or the local council's rejection of an electric mobility concept. Overall, however, the group of formerly active municipalities is very small and heterogeneous. The perceived potential of electric mobility for local authorities, i.e. the answer to the question of what hopes are associated with electric mobility (active and inactive municipalities) lies strongly in its contribution to image as well as to climate and environmental protection. This also includes its contribution to compliance with limit values for air pollutants as well as noise protection. In contrast, they perceive it as being less important for economic reasons or the promotion of tourism.

In order to analyse the current activities of German municipalities in the field of electric mobility in more detail, the municipalities were surveyed on the six possible fields of action (see Table 2). The dominant fields of action are the development of charging infrastructure and the conversion of the municipal fleet. With regard to implementing the Electric Mobility Act, there are still uncertainties among local authorities, demonstrated by the large number of "I don't know" answers (43 %). On average, the municipalities are active in 2 to 3 fields. 27 municipalities (5 % of the active municipalities) have taken measures in all fields. Basically, larger municipalities are active in more fields (Figure 1).

In some cases, the topic of electric mobility has already found its way onto the strategy or planning agendas of local authorities: This was the case for 53 % of the local authorities surveyed, and an additional 27 % have concrete plans to do so. Electric mobility is often strategically rooted in climate protection programmes or concepts (214 municipalities), action plans for electric mobility (62), as well as in transport development (57), noise reduction and air pollution control (51), and integrated urban development concepts (48). It is relevant to note that the last three categories mainly refer to binding papers, while the others function more on a conceptual level. This importance is also reflected structurally in some cities: Ten of the 14 cities with more than half a million inhabitants have their own unit for electric mobility. Of the cities with 100,000–500,000 inhabitants, a third report such a body; a further 10 % are planning to establish one. Every fourth to fifth of the smaller municipalities also has an electric mobility unit.

The following picture results from applying the activity index and classifying the resulting index values for the 540 examined municipalities into equal intervals (Figure 2). Values below 0.2 represent municipalities with a very low activity level and the subsequent intervals represent values where the activity level is calculated as low (0.2–0.4), intermediate (0.4–0.6), high (0.6–0.8)

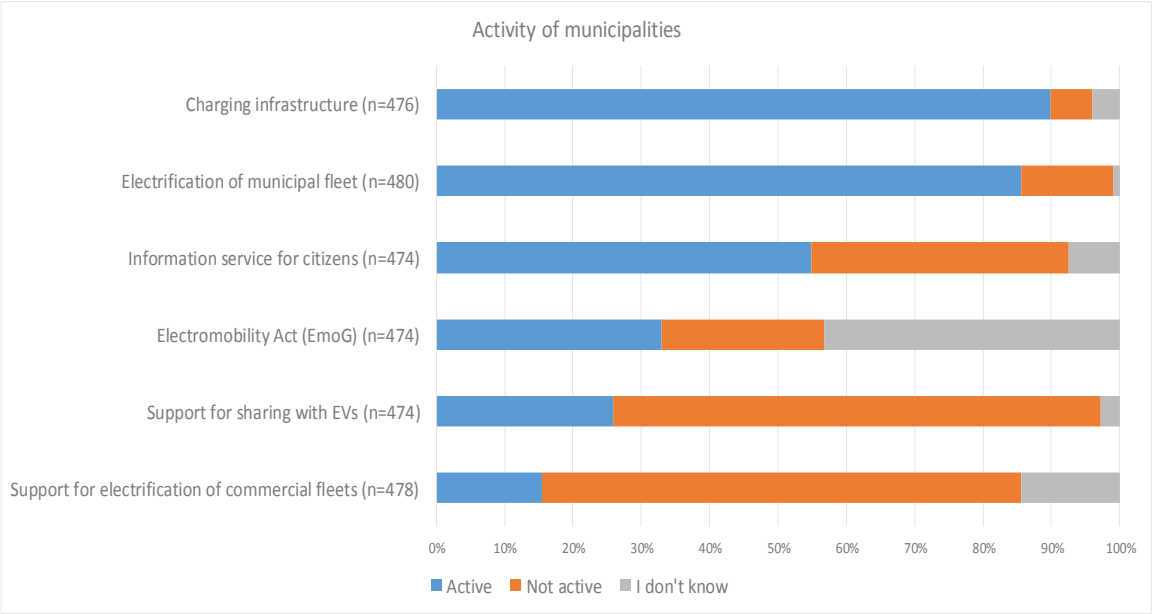

Figure 1. Activity of municipalities in various fields of action.

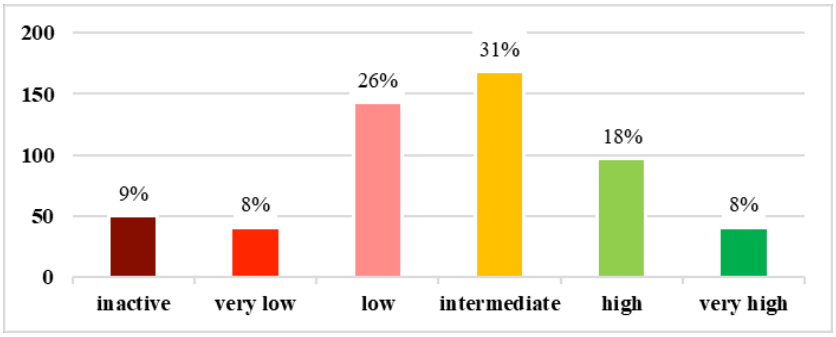

Figure 2. Activity level of the examined municipalities.

Table 3. Coefficients and test values of the components.

Variable (x_{bi})		Coefficient β_i	Standardised β_i	vif	T	F	R
	(Intercept)	0.358747			22.146***	26.469***	0.409
x_{b1}	Population and job density	0.000061	0.235	1.772	4.43***		
x_{b2}	Ratio of in- and out-commuters	0.000446	0.118	1.12	2.792**		
x_{b3}	Population growth	0.010172	0.111	1.139	2.609**		
x_{b4}	Total population	1.2097E-7	0.103	1.531	2.089*		
Standard errors in parentheses (*** p<0.001, ** p<0.01, * p<0.05)							

and very high (0.8–1). As an exception to the equally defined categories, the single value of 0 represents inactive municipalities.

The sample has a mean value of 0.44 and a standard deviation of 0.24. With the index values subdivided as described above, this indicates that the majority of the examined municipalities are classified as having an intermediate or low level of activity.

WHAT INFLUENCES THE ACTIVITY OF MUNICIPALITIES IN THE FIELD OF ELECTRIC MOBILITY?

The regression analysis showed that the activity level of the municipalities can best be explained by a model containing the following indicators:

The vif values between 1 and 2 indicate that multicollinearity is not a problem for the included variables. The model features a R^2 value of 0.168, which shows that 16.8 % of the overall variance of the activity index is explained by this model. This relatively low value indicates that other factors also influence activity in electric mobility. According to the results of the regression analysis, population and job density has the highest impact on the activity level of the municipalities. This is displayed by its standardised β_i value. Population and job density is used for the definition of densely populated areas. In other words, municipalities with a high density in terms of population and jobs are more likely to engage in the field of electric

mobility. This could be due to the fact that these municipalities are more likely to face heavy traffic, which is associated with congestion, parking problems, high noise levels and problems with local air pollution. Furthermore, these cities are economically strong and have an impact on the surrounding area. The ratio of in- and out-commuters features a standardised β_i value of 0.118. Municipalities with a commuter surplus (more commuters come into the region than leave it) are usually economically powerful, i.e. the higher the concentration of jobs in a city and thus its economic strength, the higher its activity in electric mobility. The third variable with an impact on the dependent variable is population growth: The more a city grows, the more likely it is to be active. Finally, the total population is positively associated with the activity level of a municipality; this may also be due to traffic problems and high air pollution. Four variables were excluded from the model: the total tax revenues, exceedance of the NO_2 limit value, reachability of regional centres, and motorisation. The variable on exceeding the NO_2 limit was not relevant for statistical and data reasons. These mainly derive from the high number of municipalities, where the concentration of air pollutants is not measured and to which the missing value of 0 is assigned.

In the scatter plot in Figure 3, the results of the regression equation with the variables and coefficients listed in Table 3 are juxtaposed to the measured values of the activity index:

The scatter diagram shows that the model is suitable to explain and predict the activity level of municipalities with an intermediate level of activity. However, it does not represent the most and especially the least active municipalities as comprehensively.

Discussion

SUMMARY AND DISCUSSION OF RESULTS

The study indicates that the electrification of the transport system has become an important municipal issue, according to the survey participants. A limiting factor here is that those municipalities that find the topic less relevant may not have taken part in the survey. The few municipalities that do not report activities do so because of their lack of resources and not because the topic lacks relevance. The group of municipalities that have discontinued activities is quite small, i.e. the majority have had good experiences with the topic of electric mobility and believe it is an important issue for the future. Furthermore, there is a clear correlation with the size of the municipality, which was analysed in more detail in the regression analysis. Larger municipalities attach higher importance to electric mobility, are more active and participated more often in the survey. Nevertheless, electric mobility is also of great importance for smaller municipalities with between 5,000 and 20,000 inhabitants shown by the fact that two-thirds are already active in this topic.

Electric mobility is primarily an environmental and transport issue. The dominant fields of action are the development of charging infrastructure and the conversion of the municipal fleet. Other areas such as citizen information, implementation of the Electric Mobility Act, sharing of EVs or the electrification of commercial vehicle fleets are implemented by some municipalities, but are less widespread.

By conducting the regression analysis we were able to identify structural factors that contribute to explaining the activity of municipalities in the field of electric mobility. Variables on population, population growth as well as urbanisation and density proved to be influential in the model. These variables are likely to be indicators of a greater pressure to act – large, densely populated and growing cities are more likely to face problems related to the high land consumption of cars and heavy traffic (e.g. traffic jams, parking problems, problems with local air pollution). EVs can be seen as helping to mitigate these problems as they have the potential to make urban air cleaner and city centres less noisy, and to promote the diffusion of new mobility services, such as car sharing, thereby reducing traffic-related problems. This is in line with the findings of the survey on the perceived potentials of electric mobility and is especially important in the context of the current debate on air pollution.

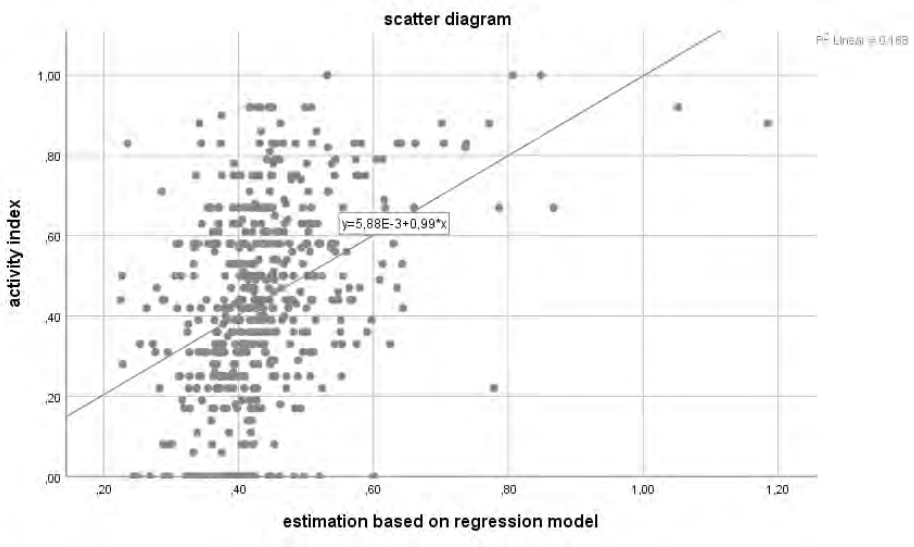

Figure 3. Scatter diagram of the actual and the estimated activity levels.

Furthermore, the significance of the total population variable underlines the greater engagement of larger cities in this topic. One possible explanation for this is that larger cities are more likely to have the financial and human resources needed to address the issue. These cities could also have greater scope from an institutional point of view to anchor the issue institutionally in the municipality.

Economic strength or more precisely the level of economic activity mirrored by the ratio of in- and out-commuters also makes it more likely that a municipality is more active in electric mobility. These municipalities might want to maintain and improve their attractiveness to firms by engaging in electric mobility. In addition, economically strong cities are also more likely to be better off financially and to have the necessary resources for such activities.

Conversely – and surprisingly – the financial situation (using tax revenues as an indicator) of the municipalities proved to be not significant in the regression model. This does not mean, however, that the financial strength of municipalities does not influence their level of activity. In the survey, inactive municipalities stated that the lack of financial and human resources was one reason for their inactivity. On the one hand, the low influence of tax revenues on the level of activity might be due to the support programmes in the field of electric mobility directed at municipalities, which have been established over the last few years. Consequently, their own financial situation might be less important. On the other hand, this result may be due to the fact that tax revenues are measured in euros per inhabitant. The total tax revenues are very high in large cities, but if the tax revenues per inhabitant are considered, the surrounding suburbs actually have more funds at their disposal. These opposing effects may have led to the non-significant result.

In the current discussions about air pollutants and driving bans, adversely affected municipalities in particular expect an improvement due to electric mobility: All of them stated they were already active or planning activities and they attach greater importance to the topic than municipalities not affected by high levels of air pollution. The pressure due to high air pollution is therefore accelerating the transition away from a transport system based on fossil fuels and towards a more electric one. Although the variable on exceeding the NO_2 limit was not significant in the regression analysis, it is assumed, as explained above, that this is due to statistical and data issues.

Overall, the regression model identified significant relationships with the activity index, although a large share of unexplained variance remains. Possible further influencing factors might be non-structural ones: For example, one or more committed individuals or local networks that promote the topic within the municipality can have a big impact.

CONCLUSION

The purpose of this study was to acquire knowledge on how to support the diffusion of electric mobility on a local level. We surveyed the level of activity as well as the various fields of activities in municipalities and then identified structural factors influencing the level of activity using an activity index. Compared to the previous city surveys in Germany that were conducted between 2011 and 2014, it should be noted that ours is the most comprehensive to date – both in terms of the number of municipalities surveyed and the inclusion of municipalities of different sizes. Over time, all three surveys show a consistency of topics for which electric mobility is considered relevant, with a strong focus on environmental issues. Adding structural data to the survey database allowed us to analyse the influence of several structural indicators on the decision to engage in electric mobility. The analyses were possible due to the relatively good data situation at municipal level in Germany.

The majority of the municipalities show a medium level of activity. Levels of activity seem to be higher in case of higher pressure (e.g. more densely populated) and higher resources (e.g. more commuters). However, the variables identified in the regression analysis are not sufficient to explain all the variance in the municipalities` level of activity and future research should therefore integrate non-structural variables as well.

Large and growing cities are currently and will probably continue to be the pioneers in the field of electric mobility, as they feel the greatest pressure to act and are most likely to provide the necessary resources. Therefore, one future challenge will be to support smaller and structurally weaker cities in tackling the transition of the transport system, so that they are not left behind. The many existing possibilities of obtaining financial support are important enablers in this direction. In addition, some of the smaller cities have already started activities in the field of electric mobility, which indicates that this topic is perceived as attractive.

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