ELECTRIC MOBILITY IN GERMANY: UNDERSTANDING PIONEERS AND
MARKET NICHEs IN COMMERCIAL TRAFFIC

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ABSTRACT

Innovations theories focusing on socio-technical regimes assume niches to be an initial point for social changes and innovations’ development becoming a mass market. This paper uses the niches approach and analyzes electric mobility in commercial transport in Germany. Central questions are: Which niches are realized? And which further potential exists within these niches. Challenges are to identify current niches in commercial sector which are addressed by electric mobility and to determine further potentials for the niches identified. For this purpose a two-step analysis have been conducted in the paper: the first step concentrates on pioneers of battery electric vehicles (BEVs); meanwhile the second step addresses owners of vehicles with internal combustion engines (ICEVs). The paper therefore provides a scheme to identify market potentials out of realized niches.

One central finding of the analysis is that cost-inefficient use profiles are predominant among BEV pioneers. It is reflected in their purchase motivation: current pioneers are primarily motivated by environmental and image aspects than of rational economic reasons. Further, the analysis shows and describes further potential for the niches to stabilize and to increase. For current usage profiles electric range is not a restriction. Having niche expansion potentials of up to 20 % indicates that within these profiles a critical mass of EV usage could be reached. Of special relevance for niche expansion are public or public related branches. The paper shows that cost-driven analyses are insufficient to describe niche markets of commercial electric mobility because soft motives drive the demand for EVs.
INTRODUCTION

Electric engines were already present at the beginning of automobile use; however, demand rapidly declined in the early 19th century in favor of Otto and Diesel engines. Nearly a century later in 1990, electric mobility again gained interest in policies like the Zero Emission Vehicle program (ZEV) set up in California to address challenges resulting from internal combustion engines. However, public interest for electric vehicles remained low.

Following the financial crisis of 2008, stronger environmental targets (e.g. EURO VI by the European Commission) combined with renewable energy policies led to “electric mobility” with increased attention. For example, the German government strove to have Germany as the lead market for electric mobility. The lead market theory explains the origin of globally successful innovations by a realized innovation design which is specific to local demand. Global diffusion of innovation begins thus with advantages in demand, price, export, transfer and in the market structure (1). For this purpose the German government created several research programs and policies measures starting in 2009. In total 200 projects were partially or fully financed publicly (2). To date, over 1.6 billion dollars were provided for research and development projects by the German government (3). In this context it should be noted that the German electric mobility policy focuses on the private sector. In 181 public funded showcase projects (since 2012) in Germany, a majority (73 %) made individual electric mobility to the subject (4).

Nearly 19,000 registered electric vehicles (hybrids excluded) in Germany in 2015, the EV share is increasing compared to 2010 with almost 1,500 vehicles (5). However, 70 % of the electric vehicle owners are companies (12,900 vehicles) and less than a third of these vehicles are privately owned (5). Commercial usage (e.g. services or transportation of materials) therefore presents the early market and niches in Germany; not the private usage of vehicles. This paper thus sheds light on the commercial users of electric vehicles and addresses the question: what characterizes the realized demand, the current niches of electric mobility in German commercial transport (transportation of goods and materials, public sector, business passenger transport)?

Further, from an innovation research perspective it is clear that innovations differing from current technological and behavioral pathways (like battery electric mobility), normally emerge in niches (6, 7, 8). In the early stages of new technologies, many niches are testing fields. Out of these testing processes a winning technology concept arises which has a potential to compete with the existing socio-technological regime in the mass market (8). This paper therefore asks in the second part: what kind of further demand within the identified niches is not activated but worth considering?

After providing an overview of the central findings of current researches towards commercial electric mobility in Germany the papers approach including a two-step analysis will be described and discussed. The first part of the two-step analysis clusters the commercial users of electric vehicles into different user groups aiming to identify and characterize realized niches of electric mobility in commercial transport in Germany. Based on the resulting cluster characterizations, the second analysis concentrates on identifying potentials for the niches to expand. The paper closes with a critical discussion of future research needs and development steps to support electric mobility’s market share growing.
There are two usual approaches in empirical studies for identifying niches or potentials, a) strategic niche-management studies and b) market-potential analysis (9, 10, 11). To identify effective stimulation instruments strategic niche management (a) is seen as an appropriate concept. Studies using niche-management approaches identify niches by classifying demonstration projects and experiments or other form of use cases which are in sum qualitative data. Davies et al. identify two realms where electric mobility is operating currently (9). These realms are niches and subsidies. In order to gain enhanced penetration in the market, Davies et al. claim the market requires stimulation markets in various ways. Meanwhile Steinmüller, Wells and Thanappan identified barriers towards electrification of the transport sector (9, 10). Davies et al selected nine types of niches of electric mobility. The majority of these broad categories concern public transport. Only one is focused on commercial usage, indicating depot-based commercial vehicles as being the most viable application of EV technology (ibid.). While strategic niche management mainly uses qualitative data market-potential analysis (b) primarily are referring to quantitative studies. However, likewise as for niche-management studies, studies focusing the commercial users of EVs in Germany are relatively rare. The majority of studies and projects try to describe primarily private users and aims to analyze the factors that have influenced decisions to purchase. Several German literatures reviews focused on identifying the potential of EVs on the German market or try to characterize the main potential of individual early adopters (see e.g. 11). When focusing on potential commercial users a central evaluation criterion regarding the profitability of electric vehicle usage is cost aspects. Further reasons or purchase motives only fade into the background. From a methodological point of view these potentials are identified first based on stated-preference surveys or on test-user surveys which are part of pilot projects (12, 13, 14). Second, potentials are derived from large traffic or transport data sets (11). In Germany, only a few studies focusing on buyers of EVs have been conducted. These studies include relatively small sample sizes with less than 100 participants; therefore their results are limited generalizable (15). Studies combining niche identification and potential analysis based on these niche parameters have not been realized in Germany, so far. To describe the status quo of the usage of electric vehicle, and to get an impression of the pioneers and their user behavior, the Institute of Transport Research at DLR (German Aerospace Centre) therefore conducted for the first time a survey across all owners (private and commercial) of electric vehicles in Germany (16). These data are the basis to identify occupied niches of commercial electric mobility by using cluster analysis. The data set and its application in the first analysis is described in the following sector.

ANALYSIS 1: CURRENT NICHES OF ELECTRIC MOBILITY IN GERMANY

Data description and methodology of cluster analysis

The survey across German electric vehicle owners conducted by Institute of Transport Research at DLR took place between December 2013 and February 2014. Over 9,200 persons were addressed. One third (n=3,111) of them responded, 37 % (n=1,165) of which were commercial electric vehicle user constitute.
The survey contained questions on the following subjects:

- characteristics of the electric vehicle
- motivation for vehicle purchase
- use of vehicle
- charging pattern and
- general information about companies using electric vehicles

This paper therefore has the data basis to identify niches by clustering commercial pioneers of electric mobility (the current user market). In the following, this chapter concentrates on identifying and describing current niches of commercial electric mobility in Germany.

In order to identify distinct niches of commercial electric vehicle (EV) users, a cluster analysis was applied. In this context commercial user means that the vehicle is registered by a company and/or it is used for commercial, business purposes, mostly (more than 50 % of operation time). Further, the analysis focused on users of battery electric vehicles (BEVs) and considered 895 cases in total. The clustering is based on the variables electric range and distance traveled per day (kilometers). In general, cluster analysis is a statistical method for grouping a set of objects or individuals into groups (called clusters) in such a way that variability is minimized within the group and maximized between the groups (17). In this study, a hierarchical cluster analysis (HCA) was conducted since the number of clusters and their relative size was not known a priori. From a variety of hierarchical cluster methods, the single linkage method was used in a first step to identify outliers. In the next step, the Ward linkage method with Squared Euclidean Distance as a distance measure was applied to find the most homogenous clusters (18).

The cluster analysis using Ward linkage algorithm and the Squared Euclidean Distance was conducted for 3 to 5 cluster solutions. The solutions were considered according to the criteria of stability, homogeneity, heterogeneity and interpretability. Finally four clusters were selected. One-way ANOVAs and Turkey post-hoc tests showed that the means of the constituent variables differed significantly between the clusters (p<0.05).

Identified niches

The cluster analysis used two variables to define the clusters and further variables where used to describe and interpret the clusters. By clustering the two variables distance traveled per day and electric range (both in kilometers) four clusters arose: 1. small distance users, 2. standard users, 3. green sport car users and 4. heavy users (Figure 1). These clusters can be seen as current niches of electric mobility in German commercial transport.
In the following, the clusters are described by their specific, varying characteristics. Table 1 and table 2 provide an overview of all cluster characteristics, such as the constituent variables (daily mileage and electric range), as well as additional variables which were not used for clustering.

Cluster 1 - The standard user niche

Standard users define the first and biggest cluster (n=345). The word “standard” refers to the values regarding the constituent and additional variables. The user profile of the first cluster corresponds to the average over all commercial electric vehicle users (n=1,165). This user profile includes a daily covered distance of 49 km on average with an average reported electric range of about 108 km.

The niche of standard users is mainly located in the construction sector (14 % and public administration (11 %). This cluster uses mainly small cars (49 %) and light duty vehicles up to 3.5 tons gross-vehicle weight (22 %). An interesting factor is the replacement rate (the share of vehicles which were substituted by electric vehicles). In this group the rate is about 40 %. That means that the standard users purchased their electric vehicle in addition to their fleet.

In order to sharpen the user profiles, soft aspects such as purchase motivation and prior experiences were also considered. A closer view on soft factors demonstrates that only few of the standard users (8 %) had previous experience of owning another electric vehicle.

Naming the cluster “standard users” demonstrates that these users correspond with the average over all commercial electric vehicle users of the survey (n=1,165). It will therefore serve as a reference case to point out differing aspects and special characteristics of the other three niches.

Cluster 2 – The heavy user niche

The profile of the second identified niche is described by their electrical daily mileage of 89 km on average while reporting an electric range of about 105 km. The users (n = 166) of this niche
are therefore classified as heavy users. These users form a special niche. Due to the daily deployment the heavy users are the only identified niche operating their EVs on a cost-covering basis. To achieve cost coverage EVs have to perform an annual mileage between 18,000 km and 25,000 km depending on vehicle size (13). By calculating the average daily mileage over 250 working days per anno, heavy users reach an annual mileage of 22,250 km on average. This group of users are more cost sensitive compared to the others. This is also illustrated in their purchase motives. A difference in heavy users purchase motives lies in the importance of using favorable energy costs per kilometer. This motivation is mentioned comparatively more often. Heavy users have the highest share of EVs within their fleets. One further special characteristic is that heavy users’ fleets are accompanied by a relatively high substitution rate. More than every second purchased EV (52 %) in this niche substituted another vehicle. This niche is defined exclusively by their relatively high daily mileage especially compared to the available electric range, EV share within their fleets and replacement rate. It could be assumed that heavy users calculated precisely whether they can implement electric vehicles in their fleets and therefore have the highest share of EVs and utilize the battery capacity most effective. Interestingly, this niche is located in rural areas comparatively frequently.

Cluster 3 – The small distance user niche
The third niche (n=346) is profiled by their small daily driven distance. Users of this niche drive very small distances per day, only 25 km on average and reporting an average electric range of about 81 km. From a cost perspective this usage profile appears less likely to be realized by an electric vehicle. Moreover, the EVs are purchased mostly in addition to the fleets. Only every third EV replaces a conventionally equipped vehicle. Interestingly, public administration excels as the most common sector within this niche with a share of 15 %. A second important sector is the energy supply (11 %) which consists to a high percentage of public institutions as well. It can be assumed that the comparatively high proportion of public institutions is reasoned by the fact of having less cost pressure on operating fleets within public authorities. A main motive beside interest in innovative technology (85 %), reduction of environmental impact (80 %) is image (77 %). Using self-generated electricity in particular is less relevant for purchasing an EV. The latter is due to the fact that small distance users are having their own photovoltaic systems less often compared to other clusters. The share is of about 41 % which means 12 % lower than other users. This niche is mainly defined by a very low daily mileage, bigger company and fleet sizes and the low replacement rate.

Cluster 4 – The green sport car user niche
The fourth and smallest cluster (n=31) is the green sport car niche. This cluster is a special niche because these users combine several characteristics of the other niches. They cover for instance a daily distance of 82 km on average which is almost identically to the heavy users. The electric range signalizes the specialty of the fourth cluster. It is built up of mainly electric sport class cars (84 %) such as Tesla Roadster (58 %) and Tesla S (26 %). This is the reason why green sport car users are not operating their EVs on a cost covering basis. The relatively high daily mileage faces an above average purchase-price. The ranking of motivations to purchase electric vehicles, especially of the sports category, differs in two aspects from other users profiles. First, image is ranked as very important more often than at other users. Second, it seems that green sport car drivers tend to be more ecologically motivated because besides the reduction of environmental impact as most mentioned, they also
mentioned the usage of self-generated electricity as motivating factor comparatively frequently therefore this niche is defined by green sport car users. A further indication for a special ecological awareness is the share of green electricity usage. More than two third (68 %) have a contract with a supplier of renewable energy, which is 17 % more than on average. Interestingly, regarding the purchase motives ranking is that this niche is consists primarily of the information and communication sector (17 %) and the freelancer, scientific and technical service sector like consultancies (17 %) as well as energy supplier (17 %) and the construction sector (17 %). Especially for the two first mentioned it can be assumed that a certain external visibility and image is an important part of the business. Cost aspects seem to pay less attention in this special small niche as well. This is confirmed to a certain extent by the relatively high share of experience the green sport car users gained by already having electric vehicle prior to the purchase of the reported one. Every fourth (26 %) already had EVs integrated in their fleet. This is 18 % more than average.
<table>
<thead>
<tr>
<th>Characteristics</th>
<th>Standard users (n= 235)</th>
<th>Heavy users (n=166)</th>
<th>Small distance users (n=346)</th>
<th>Green sport car users (n= 31)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Electric daily mileage in km (average)</td>
<td>49</td>
<td>89</td>
<td>25</td>
<td>82</td>
</tr>
<tr>
<td>Range (5 %-95 %) of electric daily mileage in km</td>
<td>30-60 km</td>
<td>70-130 km</td>
<td>10-40 km</td>
<td>25-120 km</td>
</tr>
<tr>
<td>Electric range in km (average)</td>
<td>108</td>
<td>105</td>
<td>81</td>
<td>291</td>
</tr>
<tr>
<td>Main trip purposes</td>
<td>Service trips (excl. passenger transport)</td>
<td>Service trips (excl. passenger transport), transportation of materials</td>
<td>Service trips (excl. passenger transport)</td>
<td>Service trips (excl. passenger transport)</td>
</tr>
<tr>
<td>Fleet size at company's site (average)</td>
<td>13</td>
<td>11</td>
<td>13</td>
<td>8</td>
</tr>
<tr>
<td>Number of EV in the fleet at company's site (average)</td>
<td>1.4</td>
<td>2.5</td>
<td>1.7</td>
<td>1.6</td>
</tr>
<tr>
<td>Replacement rate</td>
<td>40%</td>
<td>52%</td>
<td>35%</td>
<td>50%</td>
</tr>
<tr>
<td>Number of employees company's site (average)</td>
<td>99</td>
<td>63</td>
<td>125</td>
<td>31</td>
</tr>
<tr>
<td>Main branches</td>
<td>construction (14%)</td>
<td>public administration (15%)</td>
<td>electricity, gas, steam and air conditioning supply (17%)</td>
<td>information and communication (17%) professional, scientific and technical activities (17%) electricity, gas, steam and air conditioning supply (17%) construction (17%)</td>
</tr>
</tbody>
</table>
### TABLE 2: Characteristics of current commercial electric mobility niches towards spatial distribution, EV sizes, motives and technological facts

<table>
<thead>
<tr>
<th>Characteristics</th>
<th>Standard users (n=235)</th>
<th>Heavy users (n=166)</th>
<th>Small distance users (n=346)</th>
<th>Green sport car users (n=31)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Spatial distribution</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Major city</td>
<td>26%</td>
<td>30%</td>
<td>32%</td>
<td>37%</td>
</tr>
<tr>
<td>Medium-sized city</td>
<td>27%</td>
<td>19%</td>
<td>32%</td>
<td>44%</td>
</tr>
<tr>
<td>Small-sized city</td>
<td>38%</td>
<td>35%</td>
<td>29%</td>
<td>11%</td>
</tr>
<tr>
<td>Rural area</td>
<td>9%</td>
<td>16%</td>
<td>8%</td>
<td>7%</td>
</tr>
<tr>
<td><strong>EV sizes</strong></td>
<td>small cars (49%), light duty vehicles up to 3.5t gross-vehicle weight (22%)</td>
<td>small cars (54%), light duty vehicles up to 3.5t gross-vehicle weight (29%)</td>
<td>light city vehicles (27%), small cars (45%), light duty vehicles up to 3.5t gross-vehicle weight (21%)</td>
<td>sport class and luxury cars (84%)</td>
</tr>
<tr>
<td><strong>Top 3 important purchase motivation (rated as important by a 7-likert scale, category 5 to 7)</strong></td>
<td>1. interest in innovative technology, 2. reduction of environmental impact, 3. favorable energy costs per kilometer</td>
<td>1. reduction of environmental impact, 2. interest in innovative technology, 3. favorable energy costs per kilometer</td>
<td>1. interest in innovative technology, 2. reduction of environmental impact, 3. image</td>
<td>1. reduction of environmental impact, 2. interest in innovative technology, 3. image</td>
</tr>
<tr>
<td>Prior experiences by other EV usage</td>
<td>8%</td>
<td>13%</td>
<td>7%</td>
<td>26%</td>
</tr>
<tr>
<td>Own photovoltaic system</td>
<td>53%</td>
<td>56%</td>
<td>41%</td>
<td>53%</td>
</tr>
<tr>
<td>Green electricity contract</td>
<td>51%</td>
<td>55%</td>
<td>50%</td>
<td>68%</td>
</tr>
<tr>
<td>Prefer usage of battery changing system</td>
<td>57%</td>
<td>63%</td>
<td>54%</td>
<td>42%</td>
</tr>
<tr>
<td>Importance of fast charging (80% battery power within 30min) option (very important)</td>
<td>41%</td>
<td>55%</td>
<td>39%</td>
<td>61%</td>
</tr>
</tbody>
</table>
To sum up the results gained by analyzing commercial pioneers of electric mobility in Germany, it is clear that three out of the four identified niches are not operating their electric vehicles on a cost-covering basis. This implies an importance of other motivations to purchase an EV as assumed and utilized by other studies especially in potential analysis. A closer view showed that their decisive motivations for purchasing electric vehicles are interest in innovative technology and reduction of environmental impact. Both were rated as most important by all users. Whereas the order varies from niche to niche, both levels of importance are almost similar. In contrast, national (intended) policy measures were more or less unimportant when deciding to purchase electric vehicles. The environmental awareness of the commercial EV users is also reflected in the share of used renewable energy supplier and self-generated electricity. Regarding stimulating measures all commercial electric vehicle users would appreciate to have the ability of fast charging and battery changing. In the following analysis, the clusters are described by their specific, varying characteristics. Besides these similarities the analysis identified one special niche. The green sport car users are combining characteristics of the other niches. They only excel by the chosen EV type, the sport and luxury class car. This in combination with the fact that green sport car users on average have a daily driven mileage which could be cost-covering when choosing other vehicles (lower purchase price) emphasizes once again that costs are one aspect, in times subordinate. In this case image is of more relevance.

This analysis of current commercial pioneers of electric mobility is important to distinguish different user profiles and to determine their descriptive characteristics. These specialties serve as templates which are applied in a second step to the total market of commercial vehicles (vehicle owners) in Germany. The underlying intention is to analyze additional potentials within each niche profile and further to demonstrate possibilities and amounts of niche expansions.

The approach of this paper is therefore to use the defined descriptive characteristics as basis for further analysis of external data to finally identify potentials within these niches. Identifying niches by clustering pioneers of electric mobility (the current user market) in combination with market analysis is therefore a novel strategy which is provided by this paper.

**ANALYSIS 2: POTENTIAL EXTENSIONS OF THE NICHES**

Based on the results of the cluster analysis the second analysis elaborates the question: what kind of further demand within the identified niches is not activated but worth considering? The cluster analysis revealed four use patterns or use deployment niches of electric vehicles concerning vehicle type, trip purposes and ranges. It is now important to address the description of further fields for experimentation with technologies, services and demand. External data will be analyzed by adopting described niche characteristics as filter variables. The aim is to find out what the relevant (potential) demand for existing niches of electric mobility is in Germany. Since (as described in the introduction) the major buyer group of electric vehicles is defined by companies and not individuals, the potential analysis in this section sets branches as reference category to indicate and differentiate niche expansion potentials.

**Data base and evaluation methodology**

The external data base used is named *Kraftfahrzeugverkehr in Deutschland* (KiD 2010) (Traffic of vehicles in Germany) (19). This is a nationwide survey and claims to be representative for
Germany’s traffic. The control sample was defined under consideration of the vehicle type, the spatial distribution of registered vehicles in Germany and by characteristics of the vehicle owner. Participation in the survey was voluntary, though strongly supported by the government, authorities and associations so that a high response rate could be reached. The obtained net sample was around 50,000 vehicles covering all vehicle types (cars, light duty vehicle (LDV), heavy duty vehicle, trailer trucks, busses, motorcycles, etc.). These vehicles made more than 120,000 trips registered during the survey period from October 2009 to December 2010. The survey respondents were requested to report the usage of their vehicle on a preselected day. However, the usage of the vehicle is just one part of KiD 2010. The data base contains more than 100 variables which cover the attributes of the vehicles, attributes of the vehicle owner and the driver, attributes about the trips and attributes about the spatial area where the trips took place (20). A data specialty is that extrapolation factors are not adaptable to the objective of the paper’s analysis. Potentials are therefore exclusively indicated by percentages.

The KiD data were analyzed concerning use profiles of the niches containing vehicle types used (size, power) and use pattern (trip purpose and realized distances, deployable radius). Such an analysis is enabled by the chosen design of the electric vehicle survey which partly based on the questionnaire design of the KiD. Facts concerning use pattern and vehicle characteristics were queried equally. In Table 3 these equally designed variables describing the four user profiles per niche and their values for the KiD data evaluation are presented. The daily trip length as the limiting variable for the range is taken from 5 % to 95 % of the mentioned daily trip length in the data (the average electric daily mileage is depicted in Table 3).

**TABLE 3: Filter variables defining the niches’ use profile applied in the potential analysis**

<table>
<thead>
<tr>
<th>Variable for data evaluation</th>
<th>Standard users</th>
<th>Heavy users</th>
<th>Small distance users</th>
<th>Green sport car users</th>
</tr>
</thead>
<tbody>
<tr>
<td>Trip purpose</td>
<td>Services (assembly, repair), other services,</td>
<td>Services (assembly, repair), other services, transportation of materials</td>
<td>Services (assembly, repair), other services</td>
<td>Services (assembly, repair), other services</td>
</tr>
<tr>
<td>Range of daily trip length</td>
<td>30-60 km</td>
<td>70-130 km</td>
<td>10-40 km</td>
<td>25-120 km</td>
</tr>
<tr>
<td>Deployable radius</td>
<td>&lt; 50 km</td>
<td>n.a.*</td>
<td>n.a.*</td>
<td>n.a.*</td>
</tr>
<tr>
<td>Vehicle type</td>
<td>cars, light duty vehicles up to 3.5t gross-vehicle weight</td>
<td>cars, light duty vehicles up to 3.5t gross-vehicle weight</td>
<td>light city vehicles, cars, light duty vehicles up to 3.5t gross-vehicle weight</td>
<td>cars</td>
</tr>
<tr>
<td>Vehicle power (only to separate sport and luxury cars)</td>
<td>n.a.**</td>
<td>n.a.**</td>
<td>n.a.**</td>
<td>&gt; 200 PS (147KW)</td>
</tr>
</tbody>
</table>

n.a.* = not applicable because in the data only the restriction below 50km was reported, higher level were the state level
n.a.** = not applicable because no valid limits of vehicle power can be set for the vehicle used in these clusters
Identified potential for niche growing

The KiD data were evaluated to find out which extent these use profiles have per branch. This number is related to all trips in a branch and therefore this indicator is given as a percent. The underlying assumption is that the greater the proportion of the niche use profile is per branch, the more potential to deploy electric vehicles exists in this branch. The results of the evaluation of all commercial vehicle users are shown in Table 4. The cells marked bolt are the branches which are occupied by the current users (pioneers) in the niches described above. However, to avoid misinterpretation of specified percentages, we rank the values without units. Finally, the top 5 indicator values per niche are marked lime green as the highest potential for niche growing.

The results show that besides the pioneer branches within the clusters, obviously several additional branches have a considerable high indicator value representing their fitting to the electric mobility user profiles. Overall, these branches are most relevant for the niches’ expansion.

In Table 4 it is visible that the current pioneer branches reached an indicator value to be under top 5 branches in most cases. In the other cases they are nearby to these indicator values (only exception is the energy supply branch in cluster 4).

Having in mind what the indicator value is based on (i.e. the share of trips with characteristics of the niches compared to all trips) the general level over all indicator values is low across all profiles of current vehicle usages. It can be stated that 20 % or less of the commercial deployment of ICEVs directly fits to the described niche profiles. This relatively high share emphasizes the point that in case of electric mobility we are faced with a non-incremental innovation, which normally requires and implies changes in user behavior. The profile of the small distance users constitutes thereby the largest shares within the branches.

Moreover, the evaluation reveals that some branches fit to three of four niche profile. These are namely:

- Electricity, gas, steam and air conditioning supply
- Water supply, sewerage, waste management and remediation activities
- Real estate activities
- Human health and social work activities

In Germany energy supply, water supply and human health care are branches operated publically or are closely related to public procurement. For niche expansion activities this is an interesting fact.
TABLE 4: Share of niches’ use profiles over all commercial vehicle users differentiated by branches

<table>
<thead>
<tr>
<th>Branches (Classification NACE Rev. 2)</th>
<th>Standard users (cluster 1)</th>
<th>Heavy users (cluster 2)</th>
<th>Small distance users (cluster 3)</th>
<th>Green sport car users (cluster 4)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Agriculture, forestry and fishing</td>
<td>6.5</td>
<td>6.9</td>
<td>11.2</td>
<td>0.2</td>
</tr>
<tr>
<td>Mining and quarrying</td>
<td>5.4</td>
<td>5.0</td>
<td>4.1</td>
<td>0.6</td>
</tr>
<tr>
<td>Manufacturing</td>
<td>2.8</td>
<td>6.8</td>
<td>5.7</td>
<td>1.4</td>
</tr>
<tr>
<td>Electricity, gas, steam and air conditioning supply</td>
<td>10.6</td>
<td>9.2</td>
<td>17.1</td>
<td>0.4</td>
</tr>
<tr>
<td>Water supply; sewerage, waste management and remediation activities</td>
<td>10.7</td>
<td>16.1</td>
<td>14.9</td>
<td>0.3</td>
</tr>
<tr>
<td>Construction</td>
<td><strong>7.7</strong></td>
<td><strong>8.0</strong></td>
<td>12.6</td>
<td><strong>1.9</strong></td>
</tr>
<tr>
<td>Wholesale and retail trade; repair of motor vehicles and motorcycles</td>
<td>2.9</td>
<td>9.1</td>
<td>4.5</td>
<td>1.3</td>
</tr>
<tr>
<td>Transportation and storage</td>
<td>2.3</td>
<td>8.0</td>
<td>3.9</td>
<td>1.0</td>
</tr>
<tr>
<td>Accommodation and food service activities</td>
<td>1.7</td>
<td>8.6</td>
<td>4.3</td>
<td>1.8</td>
</tr>
<tr>
<td>Information and communication</td>
<td>5.2</td>
<td>7.0</td>
<td>8.2</td>
<td><strong>1.1</strong></td>
</tr>
<tr>
<td>Financial and insurance activities</td>
<td>2.1</td>
<td>8.5</td>
<td>4.6</td>
<td>2.8</td>
</tr>
<tr>
<td>Real estate activities</td>
<td><strong>12.0</strong></td>
<td>5.5</td>
<td>19.5</td>
<td>3.1</td>
</tr>
<tr>
<td>Professional, scientific and technical activities</td>
<td>4.2</td>
<td>7.6</td>
<td>5.5</td>
<td><strong>2.6</strong></td>
</tr>
<tr>
<td>Administrative and support service activities</td>
<td>5.6</td>
<td>7.7</td>
<td>9.7</td>
<td>1.8</td>
</tr>
<tr>
<td>Public administration and defense; compulsory social security</td>
<td><strong>7.1</strong></td>
<td>6.7</td>
<td><strong>17.5</strong></td>
<td>0.1</td>
</tr>
<tr>
<td>Education</td>
<td>1.9</td>
<td>4.8</td>
<td>9.2</td>
<td>0.0</td>
</tr>
<tr>
<td>Human health and social work activities</td>
<td><strong>9.2</strong></td>
<td>9.0</td>
<td>20.5</td>
<td>0.3</td>
</tr>
<tr>
<td>Arts, entertainment and recreation</td>
<td>3.4</td>
<td>6.8</td>
<td>9.1</td>
<td>0.0</td>
</tr>
<tr>
<td>Other service activities</td>
<td>5.3</td>
<td>7.7</td>
<td>9.0</td>
<td>0.8</td>
</tr>
<tr>
<td>Activities of extraterritorial organizations and bodies</td>
<td>0.0</td>
<td>8.1</td>
<td>8.1</td>
<td>0.0</td>
</tr>
</tbody>
</table>

**Legend:**
- Light green Top 5 potential branches per niche
- Green Branches of current pioneers

DISCUSSION OF THE FINDINGS OF BOTH ANALYSIS APPLIED

The presented results provide three central findings we will now discuss.

Our results first indicate that the majority of commercial pioneers of electric mobility are motivated by soft factors and their focus is not on cost-covering. With the exception of the heavy user all other niches are primarily motivated ecological and by image factors. A practical proof is
the existence of cluster 4 (the green sport car users) which attracts the new and visible market
entrants such as Tesla Motors or Faraday Future. On the contrast, current policy measures
primarily address economic aspects like tax exemptions or free parking and charging (direct
subsidies are not implemented in Germany, currently). The relevant branches and their EV usage
profiles, their buying motives and company conditions indicate to consider other policy measures
besides economically guided. In general, clear advantages and arguments for users focusing in
motivating factors have to be presented and communicated. This applies both for policy
measures and technological development. It implies that there should be innovative technology
available (not only design innovations) because one major motivating factor is interests in
innovative technology. Innovative charging infrastructure (e.g. fast charging or battery changing
systems) is one related topic. And it further implies that electric vehicles have to be connected
with images because image is an important motive for purchasing EVs. Current niches are
occupied mainly by companies with smaller fleet sizes with on average between 8 and 13
vehicles. While we identified motivating aspects this characteristic gives hints towards which
kind of target groups is and further should be concerned.
Second, beside the identified purchasing motives in current niches, we could recognize
noteworthy potential for the niches to grow when transferring the pioneers’ characteristics to all
commercial vehicle users in our second analysis. The first interesting result is that niche
expansion potentials exist under current technological conditions. That implies battery research
for example is necessary but apparently not a precondition for successful electric mobility in its
starting phase. A second interesting finding thereby is that contrary to possible assumptions the
current pioneers within the niches did not reach the highest indicator values within the market
potential analysis. They are rather on the lower limit. We can therefore interpret that the greatest
potential demand of the niches is not activated, currently. A third finding towards this topic is
that in general the indicator values are relatively low by not exceeding 20.5 %. On the one hand
it means that current niches can grow by approximately 20 % without major modifications,
depending on branch and niche. This implies further, if this potential could be motivated to
electrify their fleet a critical mass would possibly be reached. On the other hand side this result
implies that higher technological level, particularly for batteries, could gain further potential.
This than can be realized in later market phases and further niches which naturally will rise and
accumulate (see e.g. 8).
Third, the analysis further shows that many of the branches identified as potentials for niche
expansion are related to public authorities. For example the water and energy supply for
municipalities is mainly maintained publicly in Germany. Human health and social work
activities are mainly financed by the state as well. For policy measurement implication this could
be interesting. It could be assumed that EV purchases in this niche are directed by another
financial background. This is an important aspect for defining future policy measures. Public
institutions are acquirable differently and could be addressed by other measures compared to
potential private sector users. Two possible measures are EV quotas for public administration
and certificates for partners in public procurement what signalizes a special environmental
awareness and a sustainable mobility.
The question we cannot answer by our analysis but which is directly implied is: What kind of
restrictions carry the current non-users within the niche profiles? Meanwhile companies having
the same profile felt activated. Especially, the heavy user niche potentials are an interesting
group in that field due to fact that they even constitute a cost-covering profile. This prominent
restriction therefore not applies to these potential users. Consequential sub-questions could arise
out of a non-user analysis concerning the influencing non-buying factors or the impact of battery
technology on future demand. These are examples of important information for both: industry
and policy measures.

CONCLUSION

In Germany the majority of current vehicle owners are companies and just a minority private
demand for EVs. In this paper we therefore shed light on the demand niches of current
commercial electric vehicle users and the niches demand potential. A survey on commercial EV
user and a national traffic survey are the bases for our investigation. We applied a two-step
analysis, 1) a cluster analysis to identify and characterize niches 2) a potential analyses to
identify opportunity to expand the niches’ demand.

We found four clusters (niches) by the first analysis: standard users, heavy users, small distance
users and green sport car users. We highlight that only one niche operates on a cost-covering
basis indicated by the mileage (the heavy users). Moreover, for each niche non-financial
arguments (like image, environmental liability, interest in innovative technologies) are guiding
purchase motives. A third point concerns the technological level of EVs. Our data indicates that
current electric ranges deal with current niche requirements because the battery capabilities are
only almost exhausted within their daily usage by one niche (by the heavy users).

For the second analysis, the market potential analysis, we highlight that within current niches
profiles potentials for niche expansion emerge in various branches. In particular, public or public
related branches fit to EV niches by their daily car use profile. However, we also found that the
market potential of current EV usage profiles reaches a maximum level of approximately 20 %
depending on branch and niche. By combining the first step and second step analyses results we
conclude that electric range is not a restriction to reach a critical mass of EV usage. We further
can conclude a critical mass could possibly be reached by current technological conditions. Two
special kinds of groups could be focused by future activities. First, users fitting to the heavy
users profile due to their cost-covering usage and second, public and public related institutions.

Further main conclusions based on these central findings are first, commercial users should be
set in focus to develop electric mobility. The paper therefore provides a scheme giving policies
and industries hints towards which branches and company sizes should be addressed by which
arguments, besides clarifying economic aspects. This means for example policy measure could
more often target non-financial arguments. To intensify learnings towards purchase motives it is
essential to evaluate reasons for non-usage within the identified niche potentials. A further
research issue should therefore focus on the aspect why purchase motives of current commercial
users of electric mobility did not stimulate respectively convinces the potential users providing
the same profile.

Finally, we can conclude that the two-step analysis of this paper provides results towards a
market analysis giving special considerations of various kinds of purchase motives beyond cost
aspects. Particularly, in the context of considering soft purchase motivating aspects (e.g. image
and interest in innovative technology) it is a novel approach compared to existing studies
regarding market potential of electric vehicles focusing on cost factors and the break-even point.
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