EVS28
KINTEX, Korea, May 3–6, 2015

Early adopters of electric vehicles in Germany unveiled

Stefan Trommer,[1] Julia Jarass, Viktoriya Kolarova
[1]*Corresponding author. Institute of Transport Research, German Aerospace Center, Rutherfordstrasse 2, 12489 Berlin, Germany, Stefan.Trommer@dlr.de*

Abstract

The socioeconomic characteristics of early adopters of electric vehicles (EVs) differ from those of buyers of conventional vehicles, as do their attitudes towards new technologies, their mobility, and their awareness of ecological issues. They are found to have a higher average income, a higher level of education and more cars at their disposal per household. However, most of the existing studies are based on small samples, or used stated preference surveys which attempted to describe potential purchasers of EVs. Furthermore, when it comes to the kind of EV, most of the studies analyse the adoption of battery electric vehicles (BEVs) only, with just a few looking at the adoption of plug-in hybrid electric vehicles (PHEVs). An analysis of representative data collected from more than 3,000 owners of BEVs and PHEVs in Germany partially confirms the findings mentioned, but finds that aspects such as socioeconomic characteristics and their attitudes vary greatly among EV users.

First the paper gives an overview of the socioeconomics of EV drivers in Germany, and key facts about their driving and charging behaviour. Subsequently, the main factors motivating people to buy an EV are identified and analysed for owners of BEVs and PHEVs. This is complemented by an analysis of general attitudes of EV owners towards factors such as the image of EVs, environmental awareness and mode choice. To conclude, the willingness to pay for technologies such as fast-charging, inductive charging and battery size selection is analysed.

Keywords: early adopters, electric vehicles, user segments, empirical analysis

1 Introduction

While it did prove possible to reduce total greenhouse gas (GHG) emissions within the EU-27 by more than 15% between 1990 and 2010, those from transport increased. With a share of 22%, road transport is the second biggest contributor to GHG emissions among all sectors, and the biggest in the transport sector [1]. Technological progress in reducing the fuel consumption of internal combustion engine (ICE) vehicles has not thus far been able to compensate for the ever-increasing demand for mobility. However, the European Union has committed itself to reducing its GHG emissions by 20% compared to 1990 levels by the year 2020 [2]. Besides the overall reduction of private motorised transport and the shift to non-motorised transport modes, a widely discussed solution is the introduction of electric drivetrains in cars and light commercial vehicles.

The Federal Government of Germany has set a target of seeing about one million electric vehicles (EVs) on German roads by 2020 [3]. To make the

purchase of EVs more attractive, various measures – such as exemption from road tax for a period of ten years, and changes to company car taxation – have been implemented. With an expected 2015 market ramp-up, further measures are planned beyond 2015. Currently, the so-called 'electric mobility law' is at draft stage, and allows individual states to grant EVs priority over other users when, for example, parking in public spaces or using bus lanes [4].

A breakthrough in the uptake of EVs in Germany has not been achieved to date, as is evident from the fact that in June 2014, the Federal Motor Transport Authority (KBA) had only just under 20,000 plug-in electric vehicles registered [5]. This is in comparison to an entire car fleet in Germany of around 44 million vehicles as of that month.

It is of great interest to the automotive industry, utilities, policymakers and researchers to investigate early adopters of EVs in order to derive possible strategies for further product development and deployment. Such investigations may include, for example, the motivation for buying an EV and various sociodemographic factors relating to users, such as age and household structure, but also encompass the actual use of EVs in the real world and limitations to their use.

2 Relevant Literature

Previous studies on early adopters of EVs have focused on profiling the consumers by socioeconomic indicators, and identifying factors and motives which influence the purchasing decision. However, most of the existing studies are based on stated preference surveys which attempt to identify and describe potential EV buyers. Only a small number of studies have addressed actual owners of EVs. Furthermore, most of the studies analyse the adoption of only certain kinds of EVs: battery electric vehicles (BEVs) and – in the case of just a few studies – plug-in hybrid electric vehicles (PHEVs). The following paragraphs summarise the major empirical findings of these EV-early-adopter studies.

There are some socioeconomic characteristics common to the various groups of early adopters across the different countries. Stated preference surveys, as well as EV-owner studies, found that the users of EVs are mostly highly educated middle-aged men [e.g. 6; 7; 8; 9; 10]. Hagman and Ozaki both found that EV owners are on average 50–60 years old [9; 10].

Further socioeconomic characteristics that were analysed in EV early adopters were income, household size, and the number of vehicles per household. Early adopters tend to have a higher income compared to the average of their country [9; 10]. Surveys of both potential EVs buyers and actual EV owners found that the early adopters live most commonly in a household consisting of two or more people, and often have at least one conventional car in addition to the EV [11].

Besides profiling early adopters by socioeconomic factors, several studies also attempted to identify the main consumer motives for buying EVs. The results suggest that the perceived financial benefits – such as lower running costs, environmental benefits and regulatory advantages – play a key role in the purchasing decision. However, some other studies came up with contradictory results about the degree of influence of these factors. A study on potential EV users in the USA, for example, found that although sustainability and environmental benefits of EVs have some influence on their adoption, other factors such as cost and performance had a greater influence on the purchasing decision [12]. In contrast, surveys of actual EV users showed that EV owners purchased their alternative-fuel cars because of environmental reasons in the first place. A large study on EV owners in California (USA) showed that environmental benefits were, for more than 70% the users, particularly important purchase motives; this was followed by energy independence (67%), tax credits (52%) and fuel savings [13]. Studies from the UK and Norway have come to a similar conclusion [9; 10].

However, it should be mentioned that the strength of consumer purchase motives could vary from one country to another, depending on government incentives for EVs such as tax credits or rebates, or other benefits for EV drivers such as free parking or the permission to use bus lanes. A majority of early adopters of EVs in California stated that tax credits, state rebates and HOV (high occupancy vehicle) lane access were important purchase motives [13]. A large international survey of more than 7,000 individuals from thirteen countries found that the top three incentives across all the countries were the exemption from car tax, free parking, and toll discounts [14].

Another aspect of EV use, one that is important but which has hitherto been analysed mainly in the context of fleet tests, is their limitations, and the potential for improvement. The findings, be they in experimental conditions or by theoretical analysis, can thus represent only in part the requirements for electric mobility in everyday life.

While countries such as the USA and Norway already have the initial results of comprehensive studies carried out among owners of EVs [13; 15], it is in Germany that no significant analyses of actual users of EVs have been undertaken so far.

International studies have shown that EVs are used mainly for short distances, which can be attributed to their shorter range as compared to conventional vehicles. In Norway, the majority of owners of an EV drive distances of 30–40 km (almost) daily. More than half of them indicate that they make trips of more than 50 km with their EV very rarely (one to four times a month) or never [15].

A study of private buyers of EVs in the US state of California comes to similar conclusions. The study shows that over half of the EV users (64%) drive no more than 30 miles (48 km) daily, with the vast majority (50% of the total sample) travelling 15 to 30 miles (about 24 to 48 km) daily. Only very few trips (8%) are of more than 45 miles (about 72 km) with the EV [13]. Although more than 90% of first-time buyers of EVs in California are very pleased with their vehicle's performance, almost 60% of respondents want an extended electric range of 101–200 miles (about 163–322 km).

An analysis of the driving patterns of BEVs in Norway shows that they are most commonly used for the daily commute to work. Owners of PHEVs use the vehicles more frequently for the additional purposes of recreational trips and personal business [15; 16].

In the USA, the most frequently mentioned trip purposes were the journey to work, personal errands and shopping. Limitations arise – owing to the limited range – when it comes to recreational and holiday trips. As well as the use of the EV, charging behaviour was also investigated in this study. The most common charging location is at home. According to the study, users normally start the charging process in the evening (from 18.00 – 22:00). Additionally, 37% of respondents indicate that they also have the ability to charge their vehicle at work. Approximately 77% of the owners of an EV indicate that they are dissatisfied with the public charging infrastructure [9].

Accordingly, the aim of this study is to analyse the characteristics of early adopters of EVs in Germany, and to investigate the use of these vehicles in everyday life. The characteristics of the users are described in detail, and their motivation for buying an EV has been investigated.

3 Methodology

Between December 2013 and February 2014, the Institute of Transport Research contacted more than 9,200 owners of EVs in Germany. Ultimately 3,111 people took part in the online survey. The target group of respondents included owners of all kinds of EVs. These include BEVs, which derive their power only from battery packs that are recharged externally; and so-called plug-in hybrids (PHEVs), which, in addition to the electric motor, are equipped with an ICE. As a result of the (comparatively) widespread use of electric light vehicles (e.g. the Renault Twizy), these were also those included in the sample, provided they satisfied the requirement of being a three- to four-wheeled vehicle with at least 300 kg gross vehicle weight.

The target groups within the survey were divided into private and commercial owners. Because these two groups were expected to exhibit different uses of their vehicles, two different questionnaires have been developed. They contained several questions relevant for both user groups, allowing a comprehensive evaluation of all users for specific issues. The survey was conducted using a standardised online questionnaire. The target group was contacted by mail in co-operation with the KBA and made aware of the online survey.

The survey contained questions on the following subjects: characteristics of the EV, motivation for vehicle purchase, use of vehicle, charging pattern, and sociodemographics of the users of the vehicles.

This paper focuses on private users. To classify and better understand their profile and their use of EVs, comparisons are made with users of conventional vehicles. Thus, in order to make the

two groups being compared as similar as possible to each other, only private owners aged eighteen years or older who were users of a new car were selected from the country-wide survey *Mobility in Germany 2008* (MiD) [17].[1] Users of new cars have been defined in the data set as those whose vehicle's year of construction and year of acquisition are no more than one year apart. Moreover, only persons who purchased their new cars in 2007 or later were selected – this corresponds with the period of statistical increase in the number of registrations for EVs. It was important to select only users of new cars for comparison, since the vast majority of EVs within this survey were acquired new.

4 Results

4.1 User profile

The private users of EVs form a relatively homogeneous group. Their mean age is 51 years, and the vast majority are men (89%). Nevertheless, the ages range from 19 to 94, from which it can be seen that EVs attract both younger and older users. Users of new conventional cars are of a similar average age, but the proportion who are men is noticeably lower at 55% (own calculation based on BMVBS 2008).

Half of all private users of an EV have completed a university degree; 70% of the respondents are in full-time employment. The majority of respondents (46%) had a net monthly household income of between €2,000 and €4,000. A further 44% of respondents stated that their monthly income was higher than €4,000 (see Figure 1).

EV users have significantly higher incomes than drivers of conventional cars. Within the comparison group only about a quarter of the respondents belonged to the high-income category at a similar distribution of household sizes (own calculation based on BMVBS 2008). Private users of EVs tend to live in towns with less than 20,000 inhabitants (41%), and about another quarter live in medium-sized conurbations (of population 20,000 to 100,000) or in large cities (with 100,000 or more inhabitants). Rural communities play only a minor role, meaning that electric mobility is currently more of a small-town phenomenon than a metropolitan one.

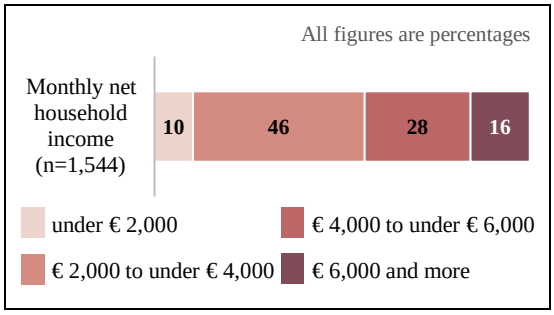

Figure 1: Monthly net household income

In addition to the spatial context, it was also of importance to investigate the type of dwelling for users of EVs. More than half of the respondents live in a detached family house. Overall, 92% of private users state that they park their electric car on their property overnight, with the capability to charge it. Additionally, private users were asked about their attitude toward specific issues such as the environment, vehicle image, and their affinity towards cars (Figure 2).

Overall, the respondents were found to be very conscious about environmental issues. 84% of the respondents said that they think conventional vehicles pose a major threat to the environment. Furthermore, 54% stated that they always try to choose the most environmentally friendly means of transport. Looking at the issue of vehicle image, however, gives a different picture: nearly two thirds of the respondents said that for them an EV is merely a consumer product, but at least 41% also stated that EVs will become a status symbol in the future. 42% of private users also confirmed the statement that it was important to them in their social environment to be among the one of the first people to be driving an EV (multiple answers were possible). This underlines the pioneering role that EV users often quite deliberately adopt. The car affinity of respondents is expressed quite differently: 43% indicated that they are interested in journals and websites about cars, but an almost equal proportion (44%) did not agree with this statement. Among their acquaintances and relatives, the majority of EV owners are not considered to be experts on general questions about cars: 57% of the respondents stated that they are not being asked for advice by friends or relatives planning to buy a car.

[1] The analyses are based on anonymised data from the survey "Mobility in Germany 2008" (MiD). The data provided by the Federal Ministry of Transport and Digital Infrastructure (BMVI) were obtained from the Clearing House of Transport Data at the Institute of Transport Research (DLR).

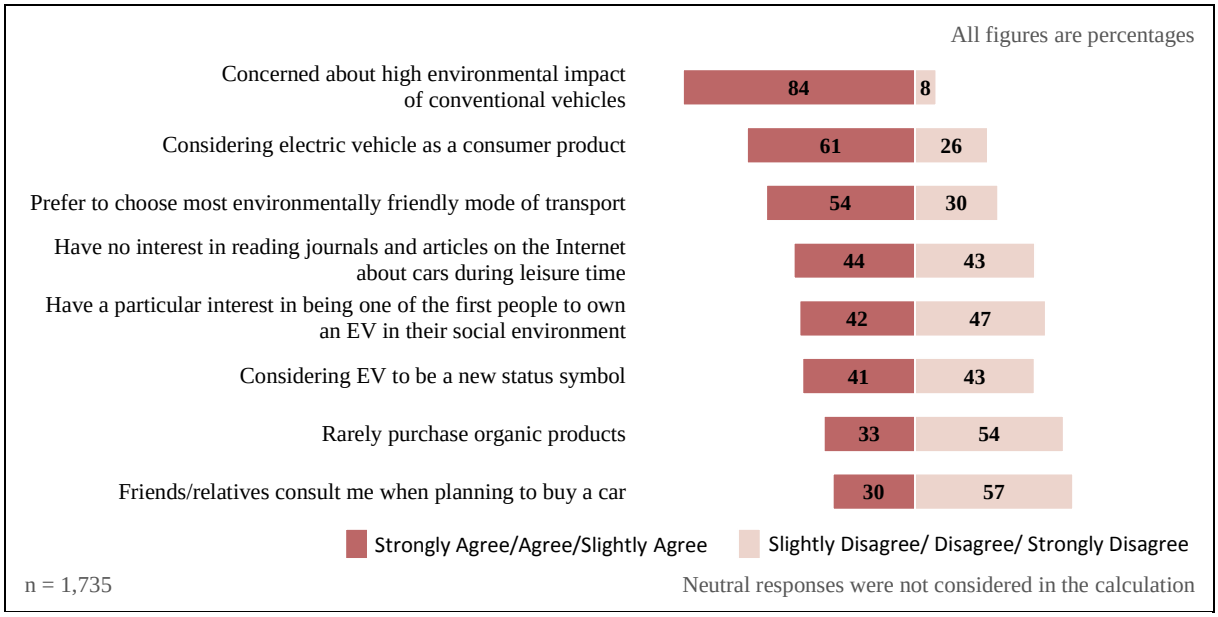

Figure 2: Attitudes of private EV users

4.2 Motivation for purchase

Two aspects were the dominating motivational factors in buying an EV: an interest in innovative vehicle technology (88%) and the reduction of environmental impact (87%). Especially the latter one highly corresponds with the attitudes of the majority of EV users. In addition, the respondents indicated that the lower energy costs per kilometre (80%) and the driving pleasure associated with an electric drivetrain (77%) were also important factors in their purchase of the vehicle. Interestingly, political incentives, such as exemption from road tax or free parking/charging, hardly played any part in the purchase decision (see Figure 3).

4.3 Vehicle use

The private users of BEVs cover an average distance of 43 km per (business) day. Users of PHEVs drive about 30 km in pure-electric mode and clock up an overall daily mileage of 42 km. The average annual mileage of BEVs is more than 10,300 km. The annual mileage of PHEVs is about one third higher, at 13,600 km. However, users of conventional cars (see section Methodology for the definition of the comparison group) put in an average of 15,400 km within the course of one year (own calculations based on BMVBS 2008).

Travelling to work was the most common trip purpose for private users. 63% of respondents indicated that they use the vehicle (almost) daily for work/education trips. A quarter of the respondents also carried out leisure trips by EV, as well as trips for personal business and shopping, on an (almost) daily basis. It can thus be seen that the vehicle is suitable for most types of trip purposes.

However it was reported that undertaking recreational trips in particular is restricted by the range of EVs. Usage constraints arise for private users in particular when considering holiday trips. More than half (56%) stated that they like going on holiday trips with their car, but cannot use their EV for this purpose. Similarly high (at 51%) was the proportion of private users who want to use the EV for short stays and weekend getaways.

In order to be able to undertake these trips, respondents for the most part fell back on another car available in the household. Only a minority chose the train or went by plane. It is clear that using an EV is difficult for longer distances; ordinary trips, however, barely pose any problem. In a separate analysis on the feasibility of holiday trips among BEV and PHEV users, it becomes clear that 88% of PHEV users do not feel restricted in making them. Only 12% stated that they cannot perform such trips owing to certain vehicle characteristics. These attributes can, for example, be insufficient luggage space in the face of particularly high space requirements, or the

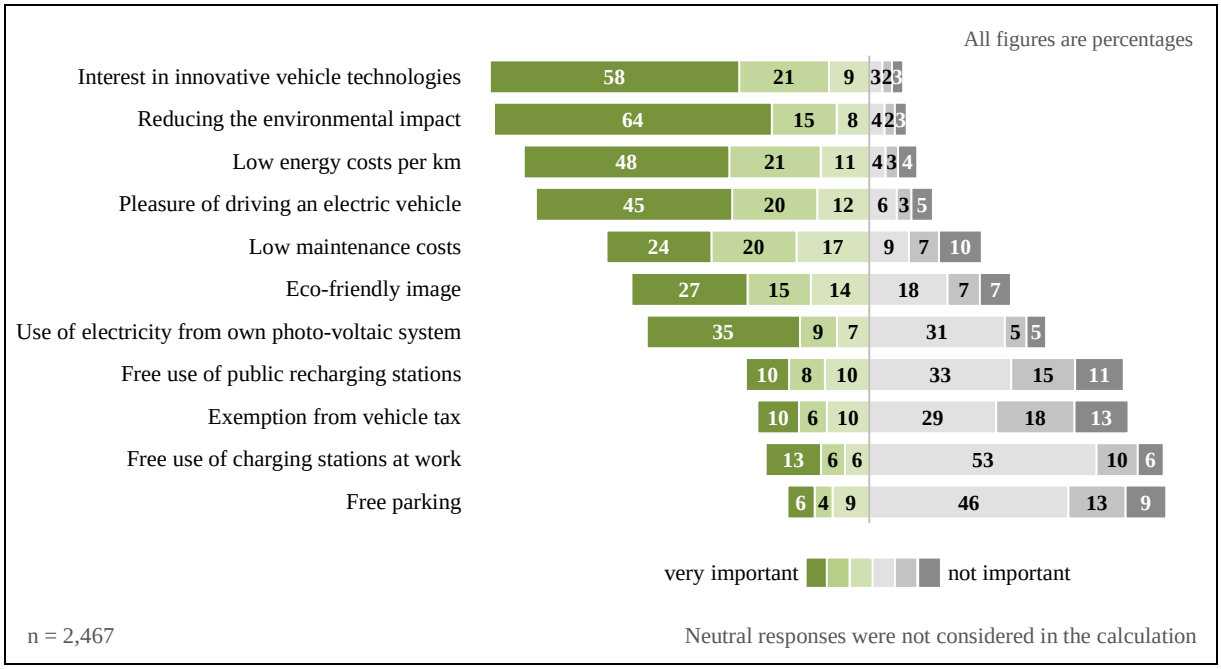

Figure 3: Relevancy of factors influencing the decision of buying an electric vehicle (multiple answers possible)

relatively higher fuel consumption of PHEVs when running in ICE mode.

4.4 Charging

The most common location for charging the car is at home, with 93% of respondents saying that they charge here during the week. At least 50% state that they also charge the EV regularly at charging stations on-street and 30% are able to charge their vehicle (almost) every day at work. More seldom used are charging stations at shopping locations (17% at least once a week), recreational facilities (7%) and charging stations along motorways (4%). It is seen that the only places where charging is carried out on an (almost) daily basis are at home and at work (60% and 30% respectively). Vehicles are charged at other locations very infrequently. Charging locations other than home and work therefore currently play hardly any role in EV use (Figure 4).

However, the general usage pattern, and frequency of use, of these charging locations does not indicate whether the respondents are satisfied with this situation or not. For this reason, the respondents were asked at which locations they would like to charge, regardless of whether they already charge there or not.

Again, at home was by far the most commonly desired place for charging: 95% said that they would like to charge there. But charging the vehicle at work also plays an important role, probably because of the significant time spent there. Almost 60% of the respondents like charging their vehicle at work. Almost half of the respondents indicated that they want to charge on-street within the city limits, indicating a demand for additional public charging stations.

EVs are charged mainly at night: 51% of private users plug in the vehicle between 6 p.m. and 10 p.m. This charging period relates to the working hours of the users: people plug in their vehicles when they get home from work.

Around 20% of the users initiate a charging process in the morning hours (07.00 to 12.00 noon) and/or the afternoon hours. These are users that have the opportunity to charge the vehicle at work.

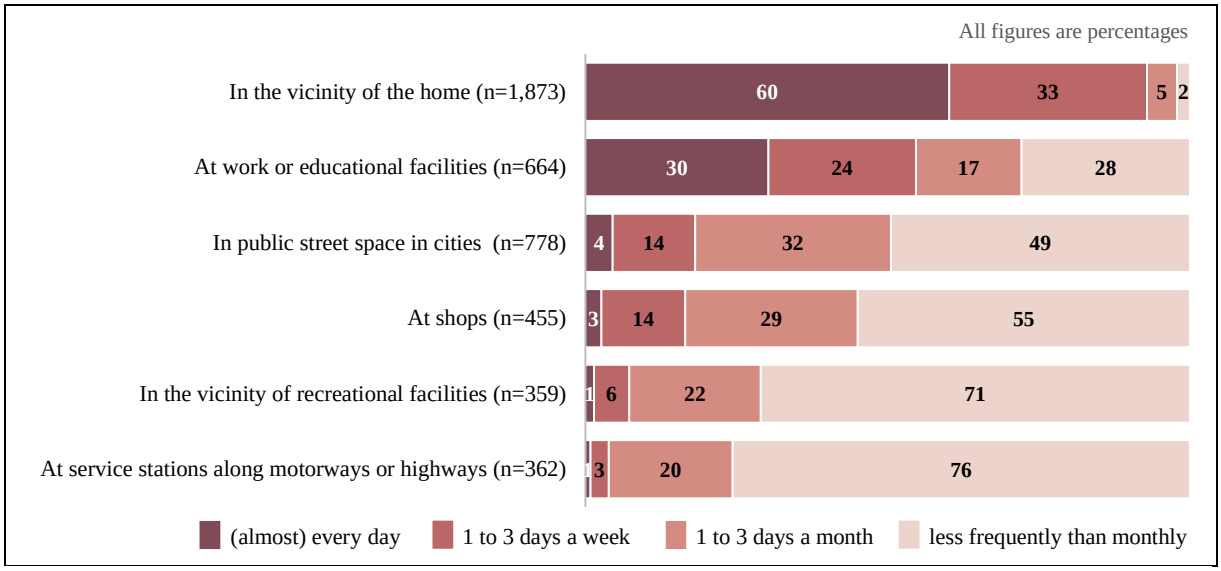

Figure 4: User frequency of charging stations

4.5 Technologies

The range of EVs is one of the key issues that will decide the future of electric mobility. In the following section, charging technologies, and also technologies considered to support the use of EVs, will be analysed from the user's perspective.

4.5.1 Fast-charging

Because of the limited distribution of public charging infrastructure, but also because of the long charging times needed with currents of 3–10 kW, the vast majority of charging takes place either at home or at work. Nevertheless, fast-charging stations that allow, for example, charging a BEV up to 80% of the total battery capacity in less than 30 minutes, would provide a useful supplement. This technique would allow users of BEVs in principle to overcome present obstacles to driving longer distances without lengthy intermediate stops.

Private users show great interest in the ability to fast-charge their EV. 58% of the respondents rate fast-charging as an important technology. Here, the interest among BEV drivers is about 10% higher than for drivers of PHEVs.

The keen interest in a faster-charging feature is also reflected in the willingness to pay for it. 77% of users are in principle willing to purchase or retrofit the vehicle with a fast-charge option. Only 17% would not be willing to pay a premium. Slight differences arise only in the acceptable level of the surcharge. The vast majority of users would accept additional costs of €500 to €1,000. The willingness to pay is approximately equal between drivers of PHEVs and BEVs. Only 7% of the vehicles belonging to private users are already equipped with the ability to fast-charge.

4.5.2 Inductive charging

In addition to the standard conductive (wired) charging, users were interviewed about their interest in inductive (wireless) charging.

The ability to charge EVs inductively has not been offered by any manufacturer of vehicles represented in the study. Only 3% of the users have retrofitted their vehicle with inductive charging technologies. This lack of interest in such a solution is also reflected in the assessment of its importance by the users who do not yet have access to such a charging option. Only 28% of private users of EVs rated the ability to charge their vehicle inductively as important or very important.

However, there are differences when comparing BEV and PHEV users. Overall, 38% of PHEV users rate the ability to charge their vehicle wirelessly as important. This compares to only 27% of BEV users. The difference between the importance of such a technology to users of PHEVs and BEVs is again evident when considering the response category "not important": 47% of the BEV users and 33% of drivers of

PHEVs gave this response. It can be assumed that this convenience feature is more important to users of PHEVs because of the higher frequency of charging events due to their lower electric range compared to BEVs.

When asked about the willingness to pay for the ability to charge their vehicle wirelessly, it is seen that the majority of users would not spend more than €1,000 for such a feature.

As with the level of interest in wireless charging, the willingness to pay among PHEV drivers is also relatively higher. About 16% of the BEV drivers would not be prepared to pay any surcharge at all, whereas the equivalent proportion for users of PHEVs is only 9%. The proportion of those who would pay between €1,000 and €1,999 is 7% higher for PHEV users.

4.5.3 Electric range

Studies have shown that potential users of EVs are looking for electric ranges similar to those of cars with ICEs [6]. In addition, it is often not possible to replicate the manufacturer-specified electric range in real life. Respondents reported differences of 20–40% (depending on EV model) between the manufacturer's specified figure and the range that is possible to obtain in everyday life. In the light of this limited range, users of EVs need a reliable indication of the remaining electric range.

Alongside the addition of on-street fast-charging stations, increasing the electric range of the vehicle would be another way to extend the operating range of EVs. Currently available EVs are offered with a fixed configuration. It is not possible to increase (for a surcharge) or even decrease (for a discount) the electric range to better suit the personal mobility needs of the owner. The Tesla Model S is the only exception, being available in two different range configurations.

Regardless if the respondents drive a BEV or a PHEV, the vast majority of users (69% of the BEV drivers and 71% of the PHEV users) would have chosen a larger electric range at the time of purchase if given the option. Only 1% of BEV drivers decided that they would have opted for a discount in return for a shorter range. Slightly less than one third of users of EVs are satisfied with the electric range of the vehicle purchased.

In order to approach the question of personalisation of the electric range, the extent of the additional electric range desired by the users was asked in a follow-up question. By combining this with the reported electric range, the overall desired range could thus be identified. The results show that BEV drivers in particular, but also users of PHEVs, would have chosen significantly higher electric ranges.

Overall, 62% of BEV users would have liked a range of 200 km or more. The average desired range is 265 km. In addition, it was possible to identify clusters of certain desired electric ranges: ranges of 100/120/150/200/300/400 km were cited very frequently by BEV users.

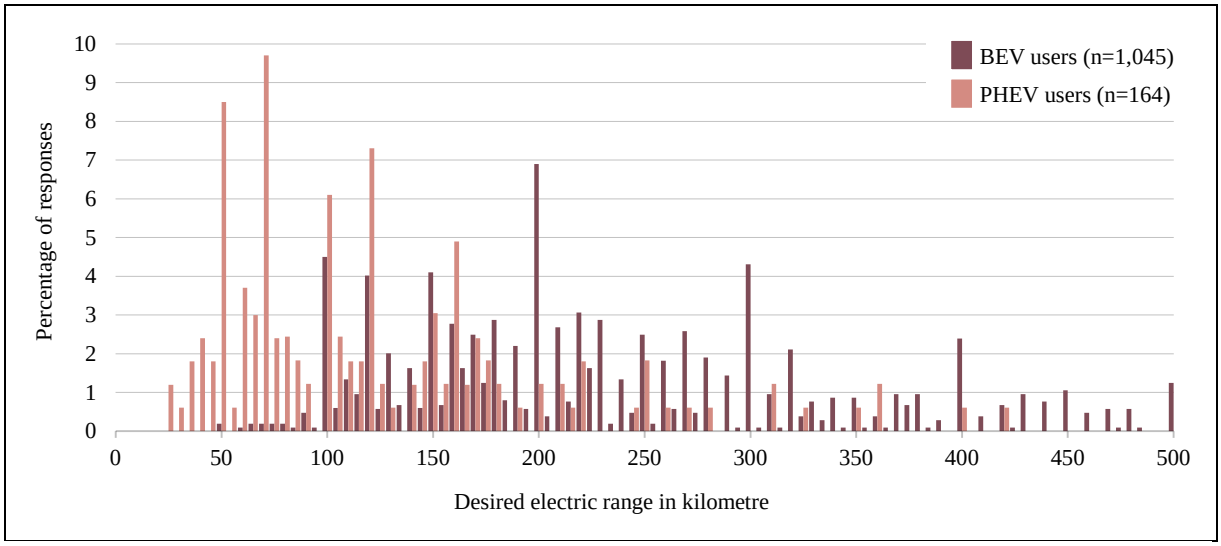

Figure 5: Distribution of the range of electric vehicles required by the users

The variability of desired electric ranges is less strong for PHEV users. In general, almost 60% of the owners of PHEVs want an electric range of 100 km or more. The average desired range is 138 km. This is surprising, given that these users can rely on a 'fallback' engine, especially since (as shown above) PHEVs are driven on average 43 km on weekdays, which is well below this value. It is possible to identify strong clusters of values similar to the results for the BEV users. These are at 50/70/100/120/160 km (see Figure 5).

As well as the desired additional electric range, users were also asked how much they would have been willing to pay to get to this extra range. Results show that almost 44% of the drivers of BEVs (37% of the PHEV drivers) are ready to pay up to €1,000 extra when purchasing the vehicle. However, approximately 27% of the users of BEVs, and 35% of PHEV users, are willing to pay up to €2,000 to achieve their desired electric range. Around 30% of users of BEVs and PHEVs even contemplate investing more than €2,000.

When looking at the absolute numbers, BEV users would be willing to pay on average €2,884 more to achieve the range that they desire, whereas drivers of PHEVs would invest only €2,254. However, taking into account the fact that the additional desired electric range of PHEV drivers is on average lower than that of users of BEVs, PHEV drivers have a higher willingness to pay per electrical kilometre. This figure stands for PHEV users at nearly €23, and for BEV users at around €18 per kilometre.

5 Discussion

The results show that incentive measures which have already been implemented, such as the vehicle tax exemption for EVs, have only a marginal effect on the decision to purchase such a vehicle. It can be assumed that users would have bought the vehicle without this measure anyway. Moreover, incentives under discussion, such as free parking and charging, were of only minor interest as a motivating factor when choosing an EV over a conventional vehicle.

Against this background, it is important to develop effective policy measures that have the potential to partially compensate for the continuing significant disadvantages of EVs, and thus to lower the threshold for interested potential buyers. In the light of the current additional costs of an EV compared to a vehicle with a conventional ICE, the question must be raised as to whether the goal of having one million EVs in the German vehicle fleet is still achievable without financial incentives such as special depreciation or purchase premiums.

When analysing the use of EVs it has been found that BEVs, at least, cannot be used for some trip purposes. Thus, these trips (mostly weekend getaways or longer holidays) are usually carried out with another car available to the same household. However, the aim should be that the EV can eventually replace the conventionally powered car completely, and not require an additional vehicle in the household. Accordingly, solutions should be found which increase the electric range of these vehicles. This could be achieved by increasing battery capacity, or lowering the electricity consumption of the vehicle. But to complement this, a network of fast-charging stations could provide for achieving longer distances – with short breaks along the way. In addition, alternative business models are conceivable in which the (pure-electric) vehicle is sold in combination with coupons for long-distance travel by other modes (e.g. rail), or the option of renting a conventional car for such trips.

The results show that the existing public charging infrastructure is used only very little, and even if extended might well be used to only a limited extent. However, the conclusion cannot be drawn that a public charging infrastructure is thus not necessary. First, today's users of EVs in Germany have the advantage of being able to park and charge their vehicles at home. With the increasing interest in electric mobility, especially in urban areas, a dedicated parking place – not to mention charging station – might not be available in the near future for these potential users. These users would have to rely on the public charging infrastructure.

Second, the public charging infrastructure plays an important role in ensuring electric mobility, and allows also in the future for spontaneous use of the vehicle regardless of which kind of electric drivetrain it uses. This is a convincing argument for potential users of EVs.

Since the expansion of the public charging infrastructure would be costly, joint efforts between municipalities, utilities, operators of

electric car-sharing services and other stakeholders should be undertaken to prevent an uncontrolled growth of charging stations, and ensure instead that the needs of users of EVs are catered for.

Nevertheless, the provision of charging infrastructure at employers' premises should have priority, as the standing time of the vehicles in such locations is generally long enough for a full recharge of the batteries. Such provision even allows people without a charging facility at their residence to purchase an EV and to regularly charge it at work. This could be particularly interesting and relevant to potential users of PHEVs, since they are not fully reliant on charging stations.

6 Conclusion

The findings presented for private users of EVs in Germany provide a novel insight into the user structure, the motivation for the purchase of the vehicle, and the use of these vehicles in everyday life.

The results of the survey of early adopters of EVs show the users as a relatively homogeneous group of people. Thereby main findings from earlier stated preferences studies or smaller samples could be validated. Private users of EVs are predominantly middle-aged men tending to have higher incomes than new car buyers of vehicles with an internal combustion engine. EV users do not belong exclusively to the highly educated milieu, but at least half of them hold a college or university degree which is also above average for new car buyers. The results also show that the purchase is mainly motivated by the interest in the innovative vehicle technology and reducing the environmental impact. Overall, the respondents are very satisfied with their vehicle. For the majority of users the range of the EV is sufficient for everyday use, but for longer distances most of them make use of another conventional vehicle within the household. In general EV users are highly satisfied with the performance of their vehicles: 84% of private owners would recommend the purchase of an electric vehicle.

References

[1] European Environment Agency, *annual European Union greenhouse gas inventory 1990–2010 and inventory report 2012*, ISBN 978-92-9213-316-0 Luxembourg, Office for Official Publications of the European Communities, 2012.

[2] EU-Commission, *White Paper on transport: Roadmap to a Single European Transport Area – Towards a Competitive and Resource Efficient Transport System*, ISBN 978-92-79-18270-9, Brussels, European Commission, 2011.

[3] German Federal Government, *German Federal Government's National Electromobility Development Plan*, http://www.bmu.de/files/pdfs/allgemein/application/pdf/nep_09_bmu_en_bf.pdf, accessed on 2012-07-07.

[4] Deutscher Bundestag, *Gesetzesentwurf der Bundesregierung: Entwurf eines Gesetzes zur Bevorrechtigung der Verwendung elektrisch betriebener Fahrzeuge (Elektromobilitätsgesetz – EmoG)*, http://dip21.bundestag.de/dip21/btd/18/034/1803418.pdf, accessed on 2015-01-15.

[5] Electrive.net, *eMobility Dashboard Deutschland: Erstes Halbjahr 2014*, http://www.electrive.net/wp-content/uploads/2014/08/eMobility-Dashboard-Deutschland-2014-1.pdf, accessed on 2014-09-04.

[6] Deloitte Global Services Limited, *Unplugged: Electric vehicle realities versus consumer expectations*, http://www2.deloitte.com/content/dam/Deloitte/global/Documents/Manufacturing/gx_us_auto_DTTGlobalAutoSurvey_ElectricVehicles_100411.pdf, accessed on 2015-01-12.

[7] A.R. Campbell, *et al., Identifying the early adopters of alternative fuel vehicles: A case study of Birmingham, United Kingdom*, Transportation Research Part A, ISSN 0965-8564 , 46(2012), 1318–1327.

[8] M.K. Hidrue, *et al., Willingness to pay for electric vehicles and their attributes*. Resource and Energy Economics, ISSN 0928-7655, 33(2011), 686–705.

[9] R. Hagman, *et al., Strøm til biler (Electricity for cars)*, Oslo, Institute of Transport Economics, 2011.

[10] R. Ozaki and K. Sevastyanova, *Going hybrid: An analysis of consumer purchase motivations*, Energy Policy, ISSN 0301-4215, 39(2011), 2217–2227.

[11] A. Peters, et al., *Elektroautos in der Wahrnehmung der Konsumenten: Zusammenfassung der Ergebnisse einer Befragung in Deutschland*, Karlsruhe, Fraunhofer Institut für System- und Innovationsforschung ISI, 2011.

[12] O. Egbue and S. Long, *Barriers to widespread adoption of electric vehicles: An analysis of consumer attitudes and perceptions*, Energy Policy, ISSN 0301-4215, 48(2012), 717–729.

[13] California Center for Sustainable Energy, *California Plug-in Electric Vehicle Driver Survey Results – May 2013*, http://energycenter.org/clean-vehicle-rebate-project/vehicle-owner-survey/may-2013-survey, accessed on 2014-09-01.

[14] Accenture, *Plug-in electric vehicles: Changing perceptions, hedging bets – Accenture end-consumer survey on the electrification of private transport*, http://www.accenture.com/SiteCollectionDocuments/PDF/Resources/Accenture_Plug-in_Electric_Vehicle_Consumer_Perceptions.pdf, accessed on 2014-10-23.

[15] ECON Analyse, *Elbileiernes reisevaner (Travel behaviour of EV owners)*, ISBN 82-7645-857-2, Oslo, ECON Analyse, 2006.

[16] J. Rødseth, *Spørreundersøkelse om bruk av og holdninger til elbiler i norske storbyer (survey of use and attitudes toward EV in larger cities in Norway)*, Trondheim, Asplan Viak AS, 2009.

[17] Bundesministerium für Verkehr Bau und Stadtentwicklung (BMVBS), *Mobilität in Deutschland (MiD) 2008*, data set: http://daten.clearingstelle-verkehr.de/order-form.html.

Authors

Stefan Trommer studied Geography at the Humboldt University of Berlin. He is working at DLR since 2008 leading the team “Technology Acceptance and Evaluation”. In his research he focusses on the user acceptance of electric vehicle technologies and autonomous driving systems.

Julia Jarass holds a degree in geography and joined the Institute of Transport Research in 2011. Her current research interests include the characterisation of early adopters of electric vehicles and the influence of land use on travel behaviour.

Viktoriya Kolarova holds a Master of Science in Economic Psychology from “Freie Universität” in Berlin. She joined DLR in 2014. Her research focuses on qualitative and quantitative research on acceptance of new technologies in the field of passenger transport.