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Who will use electric vehicles?

## **Abstract**

Electric vehicles (EVs) are currently seen as an important means to make transport more sustainable; however, so far, only a few EVs are actually on the roads. This paper tries to identify likely early private users of EVs based on a narrative review of results from earlier studies by the authors. Two usage scenarios are analyzed: (1) the traditional model of car use where the EV is bought or leased by the household whose members drive the vehicle (“individual usage”), and (2) concepts where EVs are used as part of shared fleets (“collective usage”). Findings indicate that, for both scenarios, likely early users are highly educated middle-aged men. Those who live with their family in rural or suburban regions seem to be more interested in owning an EV; for those living in urban areas, carsharing might be an attractive alternative. Other likely user groups are also discussed in the paper.

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## 1 Introduction

Electric vehicles (EVs) are currently being strongly promoted as a possible future means of sustainable transportation. In surveys, significant shares of German consumers often indicate that they would be willing to use or buy an EV at some point in the future (e. g. Continental, 2011). However, results from publicly-funded projects like the German model regions for electric mobility show that consumers who have actually tried EVs in their everyday lives report mixed evaluations: Most of them rate EVs as easy to use and useful. While there is a smaller group which is really enthusiastic about the technology, a high share is not considering actually buying such a vehicle (Dütschke et al., 2012a). There are similar results for EVs in carsharing schemes: On the one hand, the biggest future potential for EVs is seen by the participants in the model regions in carsharing concepts and in concepts combined with public transport. However, it is not clear whether respondents would like to use such concepts themselves (Dütschke et al., 2012a).

In sum, EVs are evaluated positively in general and are seen as an alternative to conventional vehicles. But the weak diffusion of EVs (in January 2013, 7.114 electric cars were registered in Germany, KBA, 2013) – despite several promotion schemes – shows that there are still major challenges ahead. The needs of potential users have to be analyzed carefully in order to identify the consumer groups who are most likely to adopt EVs. Then it should be possible to develop and provide attractive products and services which meet these groups' needs.

In this paper we therefore take a closer look at the consumer groups likely to adopt EVs by considering two scenarios: the traditional model of individual usage and ownership, as well as models based on collective usage, i.e. sharing concepts. Our main focus is on battery-electric cars. However, we also refer to electric two-wheelers (electric bikes and e-scooters).

The next section outlines the reasons for analyzing these two scenarios followed by a short overview of current developments in the carsharing sector in Germany. Then we describe the methodology applied in this paper and the results. Before drawing conclusions, we discuss our findings in comparison to the results from recent studies by others.

## 2 Individual and collective usage of EVs

The usage of EVs contributes to sustainability on a local level as they drastically reduce local air pollution and noise, and could thus contribute significantly to improving the quality of urban life (Peters et al., 2010). Additionally, their batteries could help to balance supply and demand on the energy grid as more renewable energy is integrated. On a global level, EVs could reduce CO<sub>2</sub> emissions and the consumption of fossil energy resources. However, whether EVs are really more sustainable than conventional cars throughout their entire life cycle, including vehicle and battery production as well as disposal, depends on a number of factors. One of the major factors is whether and to what degree the energy for charging EVs is generated by renewable energy sources (cf. Helms et al., 2011). Moreover, the mileage of the vehicle and the mode of transportation replaced by the EV<sup>1</sup> are crucial for an assessment of its environmental performance.

EVs imply a lot of challenges in comparison to conventional vehicles from a consumer's point of view: Their range is far more limited (the average range of a battery-electric car is about 150 km), charging the battery takes hours compared to the minutes needed to fill a conventional gasoline tank, and prices for buying or leasing an EV are still very high (Peters & Wietschel, 2012).

Against this background of sustainability issues and technological challenges it has to be questioned whether it makes sense to use and offer EVs on the market in the same way that conventional vehicles are offered and used. EVs might be far more suitable and better able to realize their potential strengths if they were integrated into collective usage schemes, i.e. sharing concepts which offer transport modes and vehicles for different purposes. These concepts might be able to outweigh the limitations of EVs. For example, concerns about the limited range of EVs could be reduced if conventional cars were also available for longer distances. Moreover, the total cost and effort for the individual user could be reduced. At the same time, integrating EVs into sharing concepts would increase the mileage of each vehicle compared to private usage. This would enhance the EVs' environmental benefits and their profitability from a life cycle perspective.

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<sup>1</sup> If EVs replace conventional vehicles, this could have positive environmental impacts; however, if an EV is used instead of walking or cycling, this is obviously less sustainable.

However, using EVs as part of integrated mobility and sharing concepts challenges the habits of the majority of car users in two ways by requiring not only a change of technology, but also a change of ownership and usage. At the same time, EVs offered as part of carsharing could also present consumers with an attractive and innovative opportunity to test both sharing concepts and EVs. However, the development and implementation of integrated mobility and sharing concepts is a complex process which requires a targeted design and high investments for successful operation.

Therefore, for a sustainable and successful promotion of EVs, it seems relevant to analyze for which consumer groups these different ways of using an EV offer advantages and meet their needs.

### **3 EV market in Germany**

Although the EV stock in Germany is low, it is, however, currently increasing. In 2009 1,452 electric cars were registered in Germany, at the beginning of 2013 this number amounted to 7,114 electric cars (KBA 2013). Regarding new electric vehicle registrations in the years 2010 and 2011, Germany (2,984) ranged fourth after the U.S. (18,626), Japan (14,960) and France (5,322) in absolute numbers. In the U.S. and Japan financial support for the purchase of an EV is offered (between 5,000 und 9,500 € per vehicle) while the financial incentive in Germany is low and includes only a tax-reduction (NPE 2012).

The range of available EV-models in Germany is still limited (NPE 2012). At the moment (July 2013) there are 40 models (electric cars; including Plug-In-Hybrid vehicles and Range Extenders) available on the German market. Only three models of these are offered by German manufacturers, Mercedes Benz (SLS AMG), Smart (fortwo) and Opel (Ampera). Based on the current announcements it is expected that this number will rise up to 16 by the end of 2014 (Eckl-Dorna & Sorge 2013).

The charging infrastructure in Germany is under development as well. In 2012 there were more than 2,200 public and semi-public charging points and 12 fast-charging stations (NPE 2012).

## **4 Sharing concepts including EVs in Germany**

Carsharing providers in Germany recently reported rising demand: At the beginning of 2013, 270,000 consumers were taking part in carsharing. This is a rise of nearly 20 percent compared to the previous year. Roughly 6,700 carsharing vehicles are offered to these consumers (Bundesverband Carsharing 2012). While traditional carsharing schemes offer vehicles at pre-defined stations and require advance booking, a lot of new carsharing concepts are currently being developed and tested in field trials or about to be implemented. One concept does without pre-defined stations (so-called free-floating concepts); instead the vehicles can be left in any public parking space within a specific area. Often this is combined with no or only a small basic fee and spontaneous usage is encouraged. Examples of providers are “Car2go” by Daimler AG in Berlin, Hamburg, Ulm and Düsseldorf, and “DriveNow” by the BMW Group in Munich and Berlin. So far there are about 183,000 additional users and 4,550 vehicles registered for these new concepts in Germany (Bundesverband Carsharing 2013). Bicycle rental systems, like Call-a-Bike by Deutsche Bahn AG, are growing, too. EVs are integrated in conventional as well as the new carsharing concepts, for example in the fleets of Stadtmobil, Flinkster, cambio, car2go or Drive Now. Bicycle rental providers are beginning to include electric bicycles as well.

Members of carsharing associations usually do not use this as their main means of transport, but regularly use other modes like public transport or bikes as well. Therefore several initiatives are trying to develop comprehensive schemes combining several transport modes including vehicle sharing. Access to all transport modes and payment is facilitated by an overall system, often using a kind of ‘mobility card’.

Vehicle sharing is a market that is developing dynamically at the moment. However, like the overall market share of EVs, it is still a niche market so that it is not possible to make reliable predictions at present about the importance of sharing concepts in the future.

## **5 Research questions and methodology**

As pointed out above, so far, only a few EVs are on the roads in Germany. If EVs are supposed to gain a relevant market share, it would be helpful to know which groups are the most promising potential users, in particular with regard to

the different concepts of EV ownership and usage. In this paper we therefore focus on identifying consumer groups likely to

- i. either buy or lease an EV for individual usage
- ii. use EVs as part of sharing concepts.

We do this by combining expert expectations with results from qualitative as well as quantitative empirical studies surveying both potential consumers and those actually using EVs. For these analyses, we draw on our earlier work on this topic (i.e. Peters & Dütschke, 2010; Peters & Hoffmann, 2011; Wietschel et al. 2012; Dütschke et al., 2012a; Dütschke et al. 2012b). An overview of the empirical work reviewed in this paper is provided in Table 1.

Table 1: List of studies which provide the basis for the review in this paper

Study	Method, Sample, Design	Usage scenario and vehicle type
[1] Peters & Dütschke, 2010 and Peters et al., 2010	Expert interviews, $N = 8$ . Structured interview-guideline focusing, amongst others, on target groups and usage models for battery-electric cars.  Expert workshop, $N = 6$ . Structured format to identify most likely user groups by each expert individually followed by a group discussion.	Individual and collective  Focus on battery-electric cars
[2] Peters & Hoffmann, 2011	Focus groups: workshops with different target groups, $N = 41$ . Structured guideline for discussion focusing, amongst others, on the preferred usage of battery-electric cars.	Individual and collective  Focus on battery-electric cars
[3] Wietschel et al., 2012	Consumer survey: German car owners divided into four groups depending on their interest in EVs (actual users, likely buyers, interested, not-interested), $N = 969$ .  The study includes two further surveys (137 test-users of EVs; 210 consumers interested in electric mobility) and two qualitative studies (14 interviews with likely early buyers, 20 participants in group discussions)	Individual  Focus on battery-electric cars
[4] Dütschke et al., 2012b	Expert workshop, $N = 12$ . Structured format to identify most likely user groups by each expert individually and a joint review of a written summary based on workshop results.	Collective  Focus on all types of battery-electric vehicles (incl. two-wheelers)
[5] Dütschke et al., 2012a	Survey of test users of EVs. Longitudinal design with partly identical participants – $N = 835$ participants before starting to use the EV, $N = 781$ after up to three months of usage, $N = 690$ more than three months of usage	Individual and collective  Focus on all types of battery-electric vehicles (incl. two-wheelers)

## 6 Findings

In this section we present the findings from our review, first focusing on individual usage, second giving an outline on results for collective usage.

### 6.1 Who will buy or lease an Electric Vehicle?

A study of expert opinions (Study 1, Table 1) indicated that EVs are seen as being especially appropriate for use in urban areas where travelling is usually within a limited range. In particular, according to the experts, multi-vehicle households might adopt an EV to replace one of their vehicles. Regarding user attributes, EVs were seen as being attractive to those interested in new and innovative technology and / or the environmentally aware.

Table 2: Consumer groups likely to use EVs as identified in Peters & Dütschke (2010) and Truffer et al. (2000)

Consumer group	Description	Likely usage scenario
Technology enthusiasts	Main driver for interest in EVs is enthusiasm for technological innovation. Probably predominantly men who use the EV as an additional car. Joy of driving and image of EVs are likely to be important.	Individual
Environmentally aware	Sustainability issues are crucial for this group. Thus, driving a conventional car is in conflict with their personal values and more sustainable modes of transport (incl. bike and public transport) or vehicles with a more environmentally-friendly fuel or technology are preferred.	Individual and collective
Urban individualists	High need for mobility. Comfort and flexibility are crucial when choosing the mode of transport.	Individual and collective
Well-off consumers	EVs as something new and innovative that is also useful in everyday life.	Individual

More specifically, the expert workshop identified four private consumer groups as promising target groups likely to own or use an EV: the technology enthusiasts, the environmentally aware, the urban individualists and the well-off consumers (Table 1). According to the expert statements, the technology enthusiasts and well-off consumers might be more likely to buy or lease electric vehicles. For environmentally aware consumers and urban individualists, both owning an EV and sharing concepts could be attractive, depending on their specific needs and living situation. These groups and their characteristics largely corre-

spond to the findings of Truffer et al. (2000), who analyzed the characteristics of EV users in the 90s.

The results of Peters and Hoffmann (Study 2, Table 1), who discussed EVs with individuals representing these four consumer groups, confirmed that these groups might be likely to buy and/or use an EV. It is important to note that this study only addressed potential and not actual users, i.e. the participants had no experience with EVs and it is open to discussion how valid their expressed intentions are. These potential early users generally preferred the conventional model of owning a vehicle, also with regard to EVs. However, sharing concepts which allow a comfortable and convenient way of using EVs were also conceivable for many participants and were increasingly positively evaluated during discussions.

Study 3 (Table 1) combines several quantitative surveys as well as qualitative work in order to identify 'early adopters' of EVs, i.e. those most likely to buy EVs in the near future. Wietschel et al. (2012) come to the conclusion that the most likely buyers of an EV in Germany in the years to 2020 will be male<sup>2</sup>, aged between 40 and 50, and living in a suburban or rural area<sup>3</sup> with their families<sup>4</sup>. They are very likely to be highly educated, with above average income and two or more cars in the household. The likely buyers of EVs identified in this study work full-time more often than other groups.<sup>5</sup> Furthermore, these groups of actual and likely buyers of EVs express a higher willingness-to-pay compared to

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2 In the online survey of German car owners (Study 3, Table 1), there is a connection between sex and interest in EVs. The share of men rises significantly with rising purchase intention (Chi<sup>2</sup>-Test: significant deviation from a random and independent distribution,  $\chi^2=56.0$ ;  $df=3$ ;  $p<0.01$ ): 95 % of EV-users are men as are 91 % of persons with purchase intention and 82 % of interested persons without purchase intention. 68 % of the persons not interested are men, which corresponds to the share of men in the group of German vehicle owners (67.1 %, KBA (2011))

3 In the online survey with German car owners interested in electric mobility (Study 3, Table 1), 20 % of the respondents with purchase intention live in municipalities with less than 5,000 inhabitants (German average: 15 %). 21 % of persons with purchase intention live in cities with more than 100,000 inhabitants (German average: 31 %).

4 In the online survey with German car owners (Study 3, Table 1), there are more children in the households of electric vehicle users than in the households of the other groups (interested with and without purchase intention, not interested). The differences were tested by univariate variance analysis ( $F=3.1$ ;  $p<0.05$  bei  $df=3/965$ ) and Post-hoc-Scheffé-Test (all groups differ significantly with  $p<0.01$ ).

5 Survey with test users of EVs. Correlation .363, significant at the 5-%-level;  $N=34$ .

individuals not interested in EVs and / or without purchase intentions concerning an EV (Figure 1)<sup>6</sup> (Wietschel et al. 2012).

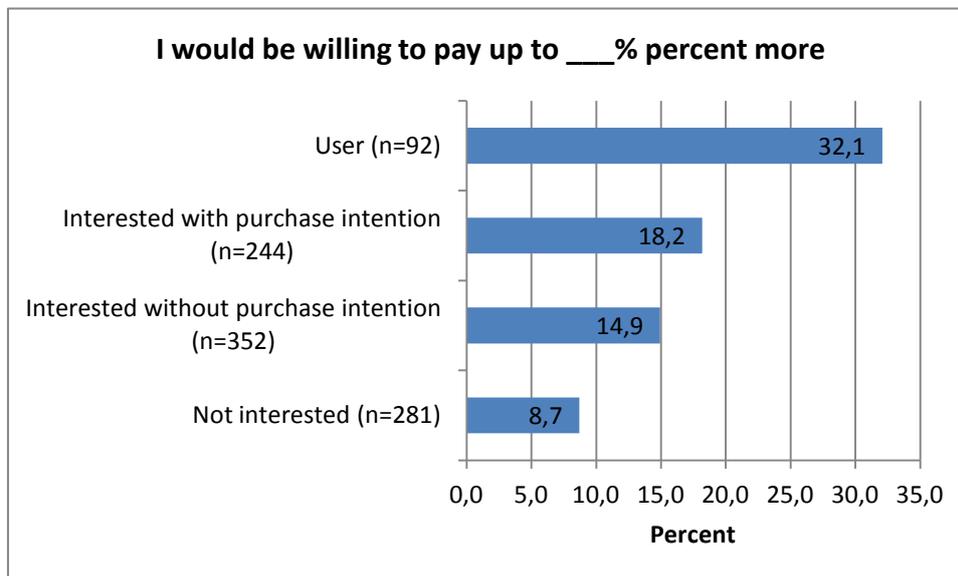


Figure 1: Willingness-to-pay for an EV of different consumer groups (data base: online-survey with German car owners; Study 3, Table 1)

The motives for buying an EV were discussed in the qualitative part of Study 3 (Table 1). The main motives were the environmental<sup>7</sup> and technical aspects<sup>8</sup> of the vehicles. The economic efficiency of EVs only plays a secondary role; a certain, though limited, price premium seems acceptable to participants due to the technical and environmental advantages of EVs. Thus, potential buyers are not primarily interested in economic efficiency, but the present purchase prices of EVs are still regarded as an important barrier to adoption.

Taking the results of studies 1 to 3 together, the expert studies and analyses of potential users suggest there are heterogeneous groups of likely buyers of EVs; the studies of actual users, however, indicate a more homogeneous group. In this context, it is important to keep in mind that the market for EVs is still in a

<sup>6</sup> Online survey with German car owners. The differences were tested by univariate variance analysis (df=3, F=45.9, p<0.01) and Post-hoc-Scheffé-Test (all groups differ significantly with p<0.01 with the exception of interested persons with and without purchase intention).

<sup>7</sup> Six interviewees mention the environmental impact as the main criterion for purchasing an EV. No other aspect is mentioned more often.

<sup>8</sup> The participants of the group discussions focus particularly on the acceleration of EVs.

very early phase, i.e. relevant consumer segments are likely to become broader and more heterogeneous in the future.

## **6.2 Who will take part in sharing concepts for EVs?**

The study of expert opinions (Study 1, Table 1) suggested that using EVs in sharing concepts could be attractive and useful for consumers who already combine various means of transport flexibly and individually according to their needs and purposes. Regarding the consumer groups shown in Table 2, such concepts might be especially attractive to environmentally aware consumers and urban individualists.

The participants in Study 2 (Table 1) stated that it is important for them to be able to fulfill their mobility needs comfortably and without excessive restrictions, costs or effort; this also applies to EVs. Thus, all groups also considered sharing concepts at least to some extent. At the end of the group discussions, especially participants belonging to the environmentally aware consumer group expressed interest in convenient sharing concepts and evaluated such concepts as more attractive than traditional ownership. Urban individualists and technology enthusiasts evaluated both types of concepts as equally attractive, while the well-off consumer group clearly preferred the traditional ownership model. However, as this study is a qualitative one, it is not possible to determine whether these results are robust.

An expert workshop of the “Themenfeld Nutzerperspektive” of the German Ministry of Transport identified several consumer groups as likely users for sharing concepts with EVs, including electric two-wheelers (Study 4, Table 1; for an overview see Figure 2). For 2020, potential markets for e-bike- or carsharing concepts were considered to be cities and towns where public transport is available while parking is scarce. In these locations, sharing concepts could help to extend the range of public transport at night or into areas with fewer public transport services. However, the experts expected interested consumers to primarily use either electric bikes or electric cars. Nevertheless, potential users of bikesharing are characterized in a similar way as potential carsharing users, i.e. living in towns / cities, frequent users of public transport and / or bikes, either not having a car of their own or sharing a car with other members of their household.

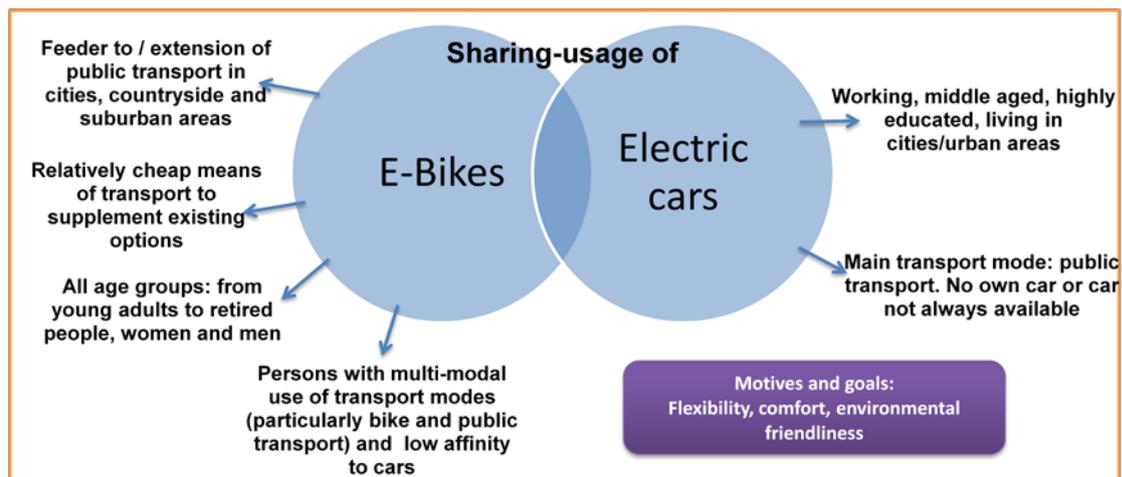


Figure 2: Overview of target groups for EV sharing concepts (Study 4, Table 1)

These potential user groups are expected to be heterogeneous with regard to age and gender. In addition, it was also discussed whether electric bikes could be used as a feeder service to public transport in more rural regions. In this case, it is expected that they will be mainly used by professional commuters and by older people who do not own a car.

Surveys of test users of EVs in the German model regions (Study 5, Table 1, long-term users) show that sharing concepts are rated very positively by the survey participants when asked about the future potential for EVs. 69 percent agree there is a high potential for EVs to be used in sharing concepts and 70 percent that EVs will become accepted as part of integrated mobility concepts (Table 3).

Table 3: Evaluations of future EV scenarios by test users (Study 5, Table 1)<sup>9</sup>

Do you believe that EVs will become accepted ...	Agreement	Disagreement
... in commercial traffic?	47 %	15 %
... in individual traffic, i.e. for private use?	58 %	5 %
... as part of vehicle-sharing concepts?	69 %	5 %
... as part of integrated mobility concepts, i.e. combined usage of different means of transport, like bus, railway and car-/bikesharing?	70 %	4 %

<sup>9</sup> The respondents evaluated the items on a six-point scale (1 = "does not apply at all" to 6 = "fully applies"). Agreement includes 6 = "fully applies" and 5 = "largely applies"; disagreement includes 2 = "does rather not apply" and 1 = "does not apply at all".

However, if these participants were asked for their preferred model of paying for the use of an EV, a majority of 58 percent prefers the traditional model of buying an EV. Only 7 percent can imagine paying for time and/or distance of usage. Similar to the results of Peters and Hoffmann (2011; Study 2, Table 1) presented above, this suggests that these new concepts are still unfamiliar to many consumers.

## **7 Discussion and integration into further literature**

To sum up, expert opinions and consumer studies allow some conclusions to be drawn about the characteristics of consumers who might be adopting EVs soon, either as buyers or clients of sharing schemes. The studies reveal similarities as well as differences between these groups. Typical for both groups are a high level of education, interest in environmental questions and openness for new technologies and / or innovative concepts. Moreover, the actual users and buyers of EVs are far more often men than women.

The place of residence is probably the most important difference between the group of potential individual users of EVs and the group of potential users of sharing concepts with EVs: Potential first buyers of EVs are thought to live in suburban or rural areas; potential users of EVs in sharing concepts are expected to live in cities. Regarding bike sharing systems, there might be some potential in rural areas, for example, as to provide a feeder service to public transport. However, so far, there is no empirical support available for this.

Some other recent studies have also tried to identify likely early adopters of EVs (Fornahl et al. 2011; Götz et al. 2011). Fornahl et al. (2011)<sup>10</sup> found similar groups – households with or without children living in rural areas – who might be interested in buying an EV. Their attitudes as well as their mobility behavior and the availability of private parking spaces seem to be important prerequisites. The purchase price, however, might be a barrier and thus, most of the families are not considering actually purchasing an EV at present. These findings are in line with our results – the men in these families are likely to have similar socio-demographic characteristics to those identified in our Study 3. Additionally, Fornahl and colleagues identified a group of urban individuals of 50 years and older who could imagine buying an EV as their next car purchase.

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<sup>10</sup> The target group of the survey are potential users or buyers of EVs and frequent and infrequent car users. Sample: 706 respondents.

They show a high willingness-to-pay and are frequent car users. This group resembles the segment of well-off consumers identified in our studies (Study 1 and 2).

Götz et al. (2011)<sup>11</sup> come to a partly different result; they conclude there are two groups of early adopters (EV-fans and cost-sensitive EV-proponents). Both live in metropolitan areas, have good access to public transport and rate public transport positively. Moreover, they are environmentally aware. The groups differ with regard to their valuation of running costs and their affinity with the technology. While “EV-fans” are less interested in the costs of vehicles, for the “cost-sensitive EV-proponents”, the running costs of a vehicle strongly influence their overall assessment of it. No statistical correlation with purchase intention regarding EVs was found for the socio-demographic variables of age, sex and education. Based on our results, we would expect these two groups to be more prone to take part in vehicle-sharing systems due to their urban place of residence and wide range of alternative travel modes. This difference might be due to issues of study design – we identified likely users of sharing systems based mainly on expert opinion (Study 1 and 4) and qualitative research approaches (Study 2). If users themselves are questioned in a quantitative approach, their preferences seem ambiguous (Study 5). This might be due to the current predominance of the traditional model of owning a car and uncertainties about the further development of sharing concepts. In the study by Götz et al. (2011), only potential new car buyers were included and no questions were asked about using an EV in sharing schemes.

A UK study (Anable et al. 2011) analyzing potential first buyers of EVs comes to similar conclusions as we do. Anable et al. (2011)<sup>12</sup> found that the typical potential first buyer is male and has an above average income. Concerning attitudes, openness to the EV technology is important and potential first buyers show high willingness-to-pay.

Hoffmann et al. (2012) and ifmo (2011) present information on potential first users of EVs in sharing concepts. Hoffmann et al. (2012) analyzed users of new mobility concepts with EVs – the majority of whom are male, highly educated and middle-aged, i.e. a similar socio-demographic profile as indicated by our

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11 Conjoint analysis with 1,487 potential new car buyers allocated by socio-demographic quotas.

12 Survey of 2,729 non-users of EVs in a two-wave design (information about EVs was provided between the two waves).

results for potential first buyers (Study 3, Table 1). Similar to our results (Study 1 and 4), these individuals are also described by Hoffmann et al. (2012) as frequent users of public transport. The study by ifmo (2011) indicates that especially younger consumer groups might be less interested in owning a vehicle and are therefore potentially more open to sharing concepts, thus pointing to changing values in society. As far as we know, no study has specifically analyzed (potential) users of e-bike sharing systems.

## 8 Conclusion

To sum up, other studies generally support our findings. Potential buyers as well as users of EVs in carsharing concepts are most likely to be male, highly educated and middle-aged. Their preferences for owning or sharing an EV may be related to their place of residence and – probably – their modal split. With further diffusion of EVs, user groups are likely to become more heterogeneous. In particular, older and well-off consumers have been discussed in this context as likely owners of EVs; younger individuals with limited income and a multi-modal mobility behavior are considered to be likely participants of sharing concepts.

An interesting question in this context is whether (potential) clients of sharing systems and (potential) owners of EVs differ from each other besides with regard to their place of residence and – possibly – their financial resources. It could be assumed that early purchasers will be individuals who are or who feel more dependent on their car. This dependency might be due to where people live as daily trips are usually longer for those living in more rural areas and public transport in these areas is often less developed. However, this aspect probably also has a more subjective component including affective and symbolic motives related to car use (cf. Steg, 2005). Thus, there might be a different level of affinity towards various modes of transport between (potential) clients of sharing systems and (potential) owners.

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