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Book Part — Accepted Manuscript (Postprint)

Electric car sharing as an integrated part of public transport. Customers' needs and experience

Suggested Citation: Kramer, Steffi; Hoffmann, Christian; Kuttler, Tobias; Hendzlik, Manuel (2014) : Electric car sharing as an integrated part of public transport. Customers' needs and experience, In: Hülsmann, Michael Fornahl, Dirk (Ed.): Evolutionary Paths Towards the Mobility Patterns of the Future, ISBN 978-3-642-37558-3, Springer, Berlin, Heidelberg, pp. 101-112, https://doi.org/10.1007/978-3-642-37558-3_7

This Version is available at:

<https://hdl.handle.net/10419/343421>

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This is an Accepted Manuscript of a book chapter. The final version published by Springer is available in *Evolutionary Paths Towards the Mobility Patterns of the Future* (edited by Michael Hülsmann and Dirk Fornahl) published on 08 October 2013, available online: https://doi.org/10.1007/978-3-642-37558-3_7 [ISBN 978-3-642-37557-6].

Electric car sharing as an integrated part of public transport Customers' needs and experience

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Word Count: 3.885 words (including footnotes and bibliography)

Version: Post-print, 26.03.2012

Electric car sharing as an integrated part of public transport

Customers' needs and experience

Steffi Kramer, Christian Hoffmann, Tobias Kuttler, Manuel Hendzlik

Abstract. The project BeMobility/ Berlin elektroMobil aims to investigate the benefits and draw backs of electric vehicles as part of the public transport system. Therefore about 40 electric vehicles (EV) were integrated into a public car sharing system in Berlin and research was conducted measuring users acceptance of this service. By utilising online surveys this service was tested for user friendliness, everyday usability and its modal integration.

The study revealed unique user groups whose travel patterns are multimodal and dominated by public transport. These sample groups can be characterised as environmentally friendly and open-minded towards car sharing and mobility concepts in general. Positive expectations and experience with EVs are related to quality and pleasure of driving whilst aspects of charging and costs are considered in a critical way. In order to cater for everyday mobility an integration of electric car sharing into Berlin's public transport system is perceived as sensible. This will provide the opportunity to compensating for limitations of electric vehicles.

1. Background

Challenges in transport are linked to emissions from combustion engines, limited fossil fuel resources and provision of physical space for transport infrastructure. There is a worldwide trend towards a further increase in the number of vehicles of which about 90% is due to road traffic. There is no single way to approach these challenges but there must be changes to travel behavior, mobility concepts and usage of fossil fuels in order to reduce CO₂-emissions from transport (Brake 2010). Integrated mobility concepts such as sharing concepts will play an important role in future urban transport. A greater share of fewer cars combined with public transport could lower traffic volumes and increase quality of urban life. These can be complemented by electric vehicles (EV), especially as they provide low carbon transport when using energy from renewable resources (Sperling and Gordon 2009).

Key benefits of electric cars for users have been widely discussed in media and can be summarized as "intersection of clean and fun" (Turrentine 2011). Limitations of electric vehicles are of less importance in a car sharing setting as users always have the opportunity to take alternative modes of transport.

E-Flinkster is the national brand for the car sharing concept of Deutsche Bahn (German Rail) that offers electric vehicles (Smart ED, Citroen C1, Citroen Zero, Toyota Prius Plug-In Hybrid) as part of Berlin's public transport.

“BeMobility - Berlin elektroMobil” is one of the projects in the Electric Mobility Pilot Region Berlin/Potsdam funded by the German government (German Federal Ministry of Transport, Building and Urban Development). Its aim is to combine electric vehicles and public transport, hence offering easy access to an integrated transport system. Usability is increased by providing associated services such as integrated information and offers. Successful cooperation between project partners from the energy sector, public transport, information technology, automotive industry, science and public services made best practice that could be adopted by other regions (Scherf and Wolter 2011).

Research was conducted as part of the project identifying customer needs of electric vehicles, car sharing and car sharing with EVs. This paper describes the socio-demographic characteristics of participants and their travel behavior in detail and presents the results of the surveys relating to expectations and experiences with EVs in car sharing.

2. Previous research

Research has been done on both supply and demand side of new mobility concepts. Maertins, Hoffmann and Knie (2004) suggest that the combination of public transport and private motorisation is able to offer tailored modal choice to the customers. Each mode is applied according to its strengths and hence overall efficiency is increased.

Research on supply side has concentrated on testing new products and its market potentials. On the other side environmental research and modal choice has often focussed on personal attitudes. Canzler and Knie (2011) combine users' acceptance of new technology (i.e. electric mobility) with a known setting (i.e. car sharing). Potential customers are identified as multimodal persons. That means that they use different modes of transport, regarding a private car as only one option in a modal chain. This type of pragmatic users can primarily be found in cities like Berlin.

Based on empirical findings this paper supports the approach of Canzler and Knie.

There are only few studies dealing with electric mobility from users' perspectives (e.g. Golob and Gould 1998, Turrentine 2011). The international MINI E trial involved consumer studies that primarily investigated the acceptance of the BMW Mini E as a substitute for privately owned cars. Therefore a group of people has been leased an electric car for several months. Data were collected at three points of time utilizing different methods such as travel and charging diaries, questionnaires and conjoint analysis (Turrentine 2011).

3. Research design

Research of the project BeMobility investigates the drivers and barriers that convince and withhold the public from combining different modes of transport including electric car sharing. Therefore users' perspectives are integrated into the

innovation process. A multi-methodical approach was applied and included both qualitative and quantitative methods (cf. Wolter, Hasse and Heinicke 2011).

This paper presents the results of the quantitative evaluation of the field trials in Berlin that were conducted between November 2010 and September 2011. Questionnaires are a useful tool for gathering comprehensive information about users. Using online surveys data were collected at three points in time – before usage of electric car sharing, after a short period of usage, and at the end of the field trial. Table 3.1 provides an overview of dates of field trials, number of participants and key topics of the three online questionnaires:

Table 3.1 Details of the quantitative study concept

T0 – before usage	T1 – after short period of usage	T2 – at the end of the field trial
16.11. – 05.12.2010	Field period 25.11.2010 – 20.04.2011	9.8.2011 – 5.9.2011
n = 311	Participants n = 160	n = 178
Key topics and standardised tools (extract)		
Expectations of EVs according to the Committee for Scientific Evaluation of the Model Regions (NOW 2011)	Mobility patterns (infas and DLR 2010)	Mobility behaviour (infas and DLR 2010)
Attitudes towards integration of EVs into public transport	Evaluation of user friendliness and everyday usability	Experiences with different aspects of electric vehicles in line with T0-questionnaire
Evaluation of pricing structure	Usage patterns of electric car sharing including travel purpose and destination	Evaluation of everyday usability
Mobility patterns according to the representative study of MiD - Mobility in Germany, Mobilität in Deutschland (infas and DLR 2010)	Evaluation of pricing structure in line with T0-questionnaire	Evaluation of pricing structure in line with T0 and T1 questionnaire
Attitudes towards environmental issues according to the representative study of Environmental Awareness (BMU 2011)	Evaluation of integration into public transport	Usage patterns of electric car sharing including purpose and destination
Evaluation of everyday usability	Socio-demographic characteristics (infas and DLR 2010)	Evaluation of integration into public transport in line with T0 and T1 questionnaire
Attitudes towards regenerative energy sources according to the MINI E Study (Krems et al.2010)		Preferences regarding renting locations
Socio-demographic characteristics according to MiD (infas and DLR 2010)		Car sharing routines in line with T1-questionnaire
		Socio-demographic characteristics (infas and DLR 2010)

Due to different settings in space and time the surveys do not present a panel situation. Each survey contains different respondents with 89 people having completed both T1 and T2.

Respondents to the surveys consist of customers of car sharing (Flinkster) and bike sharing (Call a Bike), both offered by Deutsche Bahn. Therefore results presented here are based on the opinion of a unique group that might be considered as open-minded towards innovative mobility concepts. Furthermore, as car sharing is usually used for purposes not occurring every day (Intermodi 2004) it is assumed that participants use different modes of transport hence practicing multimodality.

Due to the design of the study this paper will only give first impressions on car sharing with EVs but is not able to draw conclusions regarding a market potential of EVs in general.

4. Results

Results presented in the following chapter are based on questionnaires. They provide a useful source of information on the potential and real users of electric car sharing.

4.1 Socio-demographic characteristics of the samples

The findings in this study confirm previous research relating to the socio-demographic composition of car sharing customers. In all three study groups male respondents outnumber female ones (Table 4.1). In comparison, 87% of all E-Flinkster customers are male too. Further, respondents are highly educated, and often graduated from university. Rates of employment and self-employment are very high among participants, particularly in professional jobs. The age primarily ranges between 30 and 40 years whilst students and pensioners are represented below average.

Table 4.1 Sample Characteristics

Characteristics		T0	T1	T2
		Percentages		
Gender	male	87	94	87
	female	13	6	13
Qualification	university degree	60	74	68
	(self-) employed	89	94	90
Employment type	student	6	3	4
	pensioner	3	1	1
		Mean		
Age		39	38	39
Household size		2.3	2.1	2.2

Comments. BeMobility T0 – before usage of electric car sharing, n=311, BeMobility T1 – after a short period of usage, n=160, BeMobility T2 – at the end of

the field trial, n=178

Samples do not present the same persons

The first survey (T0) included attitudes towards environmental issues and regenerative energy sources. In summary, the sample population agrees to concepts saving the environment and are actively conserving nature themselves. For example, nearly half of them (T0: 44%) purchase electricity from renewable resources at home; in comparison, this applies to only three percent of the German population (BMU 2011). Seventy percent of respondents are willing to pay more for sustainable products. Consequently, sixty-nine percent of the first sample regard the source of energy for the electric vehicles as important. This refers to renewable sources of wind, solar and water in particular. More than 90 percent support their utilisation. Environmental concerns are an important reason for choosing sustainable modes of transport (T0: 63%) and car sharing with electric vehicles (T0: 77%) respectively.

4.2 Mobility patterns of the samples

Users' mobility routines were compared with the representative study of Mobility in Germany (infas and DLR 2010) and found to be very unique among the samples. Their modal choice represents their environmental attitudes described above. Compared to the Berlin population, car ownership and usage is below average and public transport has a great share in everyday travel (Table 4.2).

Whilst 61% of the Berlin population travel by car at least once a week (infas and DLR 2010), this applies to less than 50 percent of the participants. On the other side, up to 86% (T2) use public transport on a daily or weekly basis as opposed to 59 percent of the Berlin population. Cycling rates are above average too.

Results confirm the presumption that electric car sharing attracts mainly multimodal users who do not rely on a single mode of transport. This means they use different modes for different journeys often involving public transport.

Between 18% (T0) and 24% (T1) use more than one mode of transport every day. On a weekly basis the number of multimodal users rises to 67% at the second point of data collection (Figure 4.1). Eighty-five percent of these involve the use of public transport, mainly in combination with the bicycle.

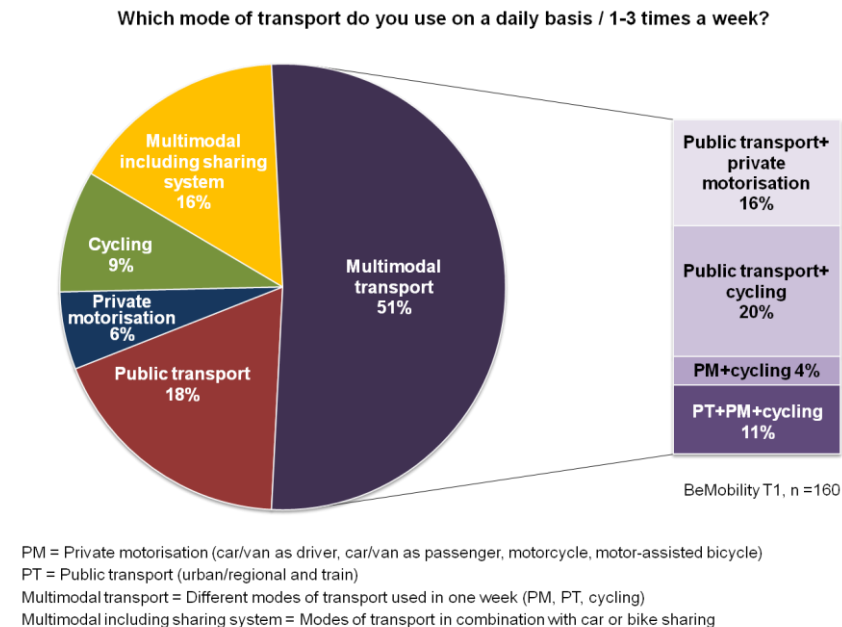
Table 4.2 Modal Split in comparison with the representative study of MiD

Mode of transport		T0	T1	T2	MiD
		Percentages			
Car as driver	Daily	21	14	10	31
	1-3 times a week	23	20	19	30
	1-3 times a month	25	24	33	16
	Less than once a month	21	24	21	8
	never	10	20	17	15
Public transport (regional)	Daily	51	54	60	35
	1-3 times a week	23	24	26	24
	1-3 times a month	20	16	10	18
	Less than once a month	5	6	3	11
	never	2	1	1	13
Bicycle	Daily	38	31	41	21
	1-3 times a week	23	20	21	19
	1-3 times a month	20	19	18	11
	Less than once a month	11	18	12	9
	never	8	12	8	24

Comments. BeMobility T0 – before usage of electric car sharing, n=311, BeMobility T1 – after a short period of usage, n=160, BeMobility T2 – at the end of the field trial, n=178

Samples do not present the same persons

Figure 4.1 Mode of transport (BeMobility T1)



4.3 Usage of electric car sharing

During the project more than 40 electric and hybrid cars (Citroen C1, C-Zero, Smart ED, Toyota Plug-In Hybrid) were deployed in car sharing. In a two year period nearly 3,000 bookings were made by over 1,000 customers. Frequency of usage was low with over half the respondents having used the vehicles only once or twice. Apart from technical specifications of the electric vehicle (i.e. range, charging) reasons for modest usage are the availability of vehicles, accessibility of the stations, and greater charges. If no electric vehicle is available or not suitable for the purpose of travel respondents would use conventional car sharing instead. The hybrid vehicles provide the opportunity to extend the limited driving range. On average they are used for about 127 km per booking whilst battery electric vehicles have an average booking distance of 28 km.

4.4 Expectations and experience of electric mobility in car sharing

The overall response to the electric vehicles was thoroughly positive. In each survey conducted during the study noise levels, driving pleasure as well as aspects of safety were evaluated positively. After a short period of usage (T1) open statements in the questionnaire include: “very silent”, “no motor noise”, “handling is intuitive”, “not as complicated as expected” and driving is a “special event”.

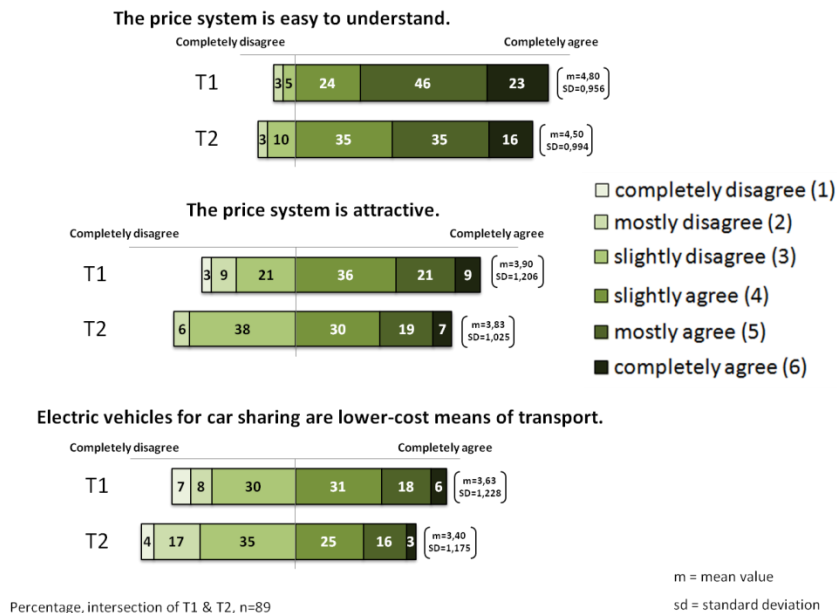
Negatively perceived aspects include costs for purchasing an EV, availability of recharging infrastructure at home or at the workplace, lack of flexibility and cargo space.

In a car sharing setting flexibility is constrained by the dependence on physical car sharing stations and limited driving range. The latter includes all aspects of the charging procedure that users face as they are required to recharge the vehicle at return. Both driving range and charging were criticised. However, electric car sharing is perceived as modern, useful and environmentally friendly.

4.5 Pricing structure

In order to increase acceptance of new forms of mobility and possibly initiate changes in existing mobility patterns low entrance barriers are key (Maertins, Hoffmann and Knie 2004). A central barrier for electric vehicles to enter the market is the cost of the battery. As a result electric car sharing is more expensive than conventional car sharing. The evaluation of the price system shows that while it is easy to understand, its attractiveness has reduced during field period (Figure 4.2). Although concerns about technical limitations of the vehicles predominate, current costs prevent their routine usage. It is possible that respondents of the first survey may not have been aware of the charges. In the final survey respondents were able to leave suggestions for improvement. Apart from reasonable charges they ask for cheaper charges per kilometer, more special offers and privileges for frequent users.

Figure 4.2 Attitudes towards pricing system



4.6 Integrated mobility concept

Integration into public transport is important for electric car sharing to be suitable for everyday use. In BeMobility three types of integration were implemented:

- Physical integration – car sharing that provides close links to public transport easing changing between means of transport.
- Integrated Information – travel information on different modes of transport was realized through a smartphone and web application called “BeMobility Suite”.
- Integrated offers – one ticket (“mobility card”) was introduced for a limited period of time that offered access to and usage of different means of transport (i.e. public transport, car and bike sharing).

Results of the surveys show that the majority of respondents agrees to the combination of different means of transport for their daily travel. They can benefit from flexible interchange, independence from parking space and time tables respectively. Efficient usage of different modes is seen as environmentally friendly and cost beneficial. These arguments tend to persist during the whole period of study; issues regarding independence from parking spaces and accessibility of car sharing stations are stressed more frequently after usage.

Visibility and spatial accessibility of car sharing increases demand. Nevertheless, 22% of respondents need 30 minutes or longer from their place of residence to the next car sharing station. Due to the limited number of electric vehicles, this expenditure of time applies to even 38% of respondents reaching an electric car sharing station. The majority of current car sharing stations is located at transport hubs and consequently, more than 60 percent of users travel to and from them by public transport. 71% of those who responded to the final survey are in favour of central locations with public transport accessibility. Sixty-six percent prefer locations in residential areas. A mixture of both concepts would make sense if the network of car sharing stations were to be extended.

In general, car sharing users ask for a dense car sharing network which extends over the borders of Berlin and is well connected with the public transport network. Availability of electric vehicles in residential areas, in rural areas and in other towns would improve the everyday usability of car sharing.

5. Discussion and conclusions

This study presented results of user surveys that were conducted as part of the evaluation of the project BeMobility/ Berlin elektroMobil. The research focused on user acceptance of new and innovative mobility services, i.e. electric car sharing.

The survey samples consist of people, who show a general interest in mobility services due to their membership with car sharing (DB Flinkster). They are characterised by being male, about 40 years old and highly educated. Respondents’ environmental consciousness is expressed in their travel behavior that can be described as multimodal. A high proportion of them use public transport and bicycle on a daily basis. They agree that electric car sharing is able to cater for their daily mobility needs when offered as part of public transport.

Results of the conducted surveys both before and after usage of electric car sharing show that positive attitudes towards electric mobility predominate. Current users of e-Flinkster are quite relaxed in terms of technical limitations of EVs. They are aware of the disadvantages of EVs but in an urban context and in combination with other modes of transport driving range and cargo space are less of an issue. Consequently, vehicles are only used when travel distance and purpose of travel match vehicle abilities. Usage frequency of electric car sharing is accordingly modest.

Due to the unique characteristics of the sample groups it is not possible to draw conclusions for the German population. However, the study has shown that electric mobility is an environmentally friendly add-on to conventional car sharing that attracts primarily current users of the system. Whilst advantages and disadvantages of electric mobility are mostly related to the vehicle itself, i.e. quality of driving, driving range, charging aspects, and cargo space, further remarks comment on car sharing in general. These are, for example, the useful integration into the public transport system and the limited flexibility respectively.

Further research in the field of user acceptance of electric mobility in car sharing is necessary in order to learn more about motivations and drawbacks of the users. Some changes to the current setting are necessary if users other than early adopters shall be addressed and if usage of vehicles shall be increased. First of all, demand for a greater availability of vehicles and a dense network of car sharing stations was identified. Special offers like the “mobility card” must be established over a longer period of time for changes in behaviour to come into effect. Further research will include spatial and seasonal analysis and a study on effects on traffic.

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List of figures

Figure 4.1 Mode of transport (BeMobility T1).....	9
Figure 4.2 Attitudes towards pricing system	10

List of tables

Table 3.1 Details of the quantitative study concept	5
Table 4.1 Sample Characteristics.....	6
Table 4.2 Modal Split in comparison with the representative study of MiD	8