BEMOBILITY: KEEPING CITIES MOVING
A CASE STUDY IN BERLIN

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ABSTRACT

Current figures show that almost every second household in Berlin, Germany, lacks access to a private vehicle: a rising rate. While benefits of owning a private vehicle are shared across 54% of the households [1], external costs are carried by 100% of the citizens who are affected by noise, fumes, congestion and occupied space. While nobody doubts the independence and comfort a car can create, the unfair distribution of the side effects and their increasingly threatening dimensions call for new, sustainable solutions in urban mobility.

The introduction of electric vehicles is seen as a future technology to reduce air and noise pollution, and also greenhouse gases when generated with renewable energy and intelligently linked with a smart grid. These advantages come at the cost of limited range and expensive batteries. The challenge is to compensate for these disadvantages in an introductory phase until economies of scales set in. Beside monetary incentives, such as direct subsidies or tax benefits, non-monetary incentives are also thought to be an effective way to boost electric mobility. They include the use of bus or high occupancy lanes, access to restricted city zones as well as reserved parking spots in inner-urban areas [2]. Another innovative mobility concept is. Although the idea of using rather than owning has been in place for nearly two decades, it is only now that new technological systems, product concepts and lifestyles are triggering new dynamics in this sustainable concept [3]. On average, one shared vehicle replaces 6.2 private vehicles, which also tend to be older and thus less efficient [4]. To a lesser extent, already profits from non-monetary incentives: some cities actively implement parking spaces in public space.

The project BeMobility is an approach that combines the advantages of both concepts [5]. Electric vehicles are introduced in an advanced approach creating multiple benefits [6]. The main aim is to integrate an e- scheme into the public transport system, so that it gains more flexibility. Short trips, e.g. for shopping, are carried out with e- while long distance travel and commuting are served by the rail and bus network. Additionally, the project will lead to insights on how infrastructure for e- can be implemented successfully [7]. It seeks to investigate the acceptance of charging facilities and the required density of the network.

1. BASIC MOTIVATION

The 'urban millennium' has commenced. The worldwide population dwelling in urban areas has surpassed the number of people living in rural areas – an extraordinary change of predominance after many thousands of years of agricultural societies. With many cities in developing – and to some extent newly industrialised – countries confronting rapid urban growth, local transportation systems are increasingly suffering from congestion, a lack of social-economic investment and issues of accessibility and questionable overall sustainability of existing infrastructure systems. New mobility products need to be developed urgently to mitigate the current situation and ease future problems arising now in rapidly developing cities.

On the other hand, cities beyond the rapid growth phase have already entered a phase of consolidation regarding their growth concerning motorised traffic. With many reversing measures, the phase can also be regarded as the correctional phase of the automotive age. The main motivation for this phase is deduced from the limitation of noise and particulate matter pollution as well as the revitalisation of occupied space and the avoidance of dividing urban identities. The reduction of climate changing emissions also stepped in as an increasingly important cause, being now considered as the main reason for sustainable policies. From the seventies onwards, German cities have seen pedestrian zones emerging in inner-city areas, regulations have been changed to allow reduced speed zones in housing areas, and the ecologically friendly alliance between bicycle usage and public transport has gained a stronger foothold in planning and policy processes [9].

While these measures are aimed to tackle the identified problems in a general context, inequities on the individual scale are often not recognised strongly enough. Figures from the latest consumer sample for Berlin show that 46% of the households in 2008 do not possess a private vehicle. This trend seems to continue in future: since 2005, the rate has increased from 42% [1]. With exception of 2009, the last five years have seen a decline in the number of annually registered vehicles [10]. All this takes place on an already low motorisation level in the German capital. With a motorisation level of only 320 vehicles per thousand inhabitants, Berlin has a much lower car density than the nationwide average of 500 vehicles [11]. While benefits of owning a private vehicle are hence shared across every second household, external costs are carried by 100% of the citizens who are affected by noise, fumes, congestion and occupied space.

Despite the independence and comfort a car generates for many, the increasing dimensions call for new, sustainable and fair solutions in urban mobility. The modern pragmatic use of traffic modes and the smartphone as the new social status symbol have created a new window of opportunity to test new solutions and technologies.

2. ELECTRIC MOBILITY

For several years now, a lively buzz has evolved around electric mobility. The electric vehicle (EV) is justifiably seen as a key technology to improve urban living conditions, to tackle global climate change and to gain more energy efficiency. These benefits come without losing the function of a status symbol and the fascination for the automobile itself. Boldly spoken, the technology will not only change individual motorised traffic – it also has the potential to change mobility as such [12]. To relativise the expectations, the current hype should be adequately placed between a long historic development and foreseeable future needs, making several years of a technological matureness process predictable.

First developments in electric mobility can be found in the 19th century. In fact, in the early stage of automotive development EVs were very competitive with their counterparts propelled by combustion engines. The historic climax of electric mobility can be seen in the early 20th century. At this stage, electric mobility produced a very healthy share of nearly 40% of the vehicle fleet in the USA. [13]. Despite these figures, the EV did not participate in the later rapidly developing automotive society. The technology dwindled to a niche industry if not diminishing altogether. Attempts to re-animate the success of the EV generally failed. Examples of such attempts are the actions of the DGRST (Délégation Générale à la Recherche Scientifique et Technique) followed by the involvement of the EDF (Electricité de France) from the mid sixties onwards [14], the development of the EV1 by General Motors in 1996 – its failure is critically viewed in a 2006 documentary film [15], as well as the VW Golf CitySTROMer test of the same year, calculating an efficiency of only 49% [16]. By the turn of the century, new technologies and a higher ecological motivation resulted in the development of a number of successful products such as the first full hybrid electric vehicle (HEV) series model in 2003 with the Toyota Prius, and the first battery electric vehicle (BEV) series model of a major automotive manufacturer in 2010, the Nissan Leaf. The first production series for a plug-in hybrid vehicle (PHEV) is yet to come with the Toyota PHEV Prius currently being run in its test phase.

As mentioned above, electric mobility is often considered as one of the more promising technologies to prepare for a post carbon-society. But there are several developments which have to take place before the technology can deliver these expectations. CO2 emissions depend heavily on the power mix of the energy provider the user chooses. Since the use of energy generated by coal power can lead to a far worse CO2 emission per distance than comparable conventional vehicles, the future EV will have to be powered by renewable energies to provide carbon-free mobility – an impossible preset since the technology is available on the free market. Electric mobility therefore needs to be interlinked with the energy grid to bring new dynamics into a sustainable energy supply. The key terms in this context are “vehicle-to-grid” and “load management”.

Since vehicle-to-grid (V2G) EVs are able to communicate with the power infrastructure, bi-directional loading technology can reverse the energy flow. Energy stored in the vehicle’s battery is then released back into the energy grid and thus supplies a small amount of the energy for the current demand elsewhere. So, in large numbers, EVs could serve as a virtual pumped-storage plant, storing energy in periods of low consumption, and supplying in periods of peak demand. With the rising proportion of renewable energies, the demand for power storage increases due to natural influences on the production process, e.g. during strong winds or the lack of them. Especially short term fluctuations in wind strength and sunshine are becoming a real challenge for the electric grid in regions with a high amount of renewable energy such as Northern Germany. Although these fluctuations can still be controlled by importing energy from less effected areas, the future need for storage options is essential. So far, pumped-storage hydropower is the only common technology in this field. As there is no sufficient storage capacity of this kind, and little room for expansion, the EV is seen as a potential new storage technology. The Association for Electrical, Electronic and Information Technologies (VDE) has calculated that 10% of Evs of the total vehicle fleet – resulting in approx. 5 mill – will provide as much power and storage capacity as all currently existing pumped-storage power plants together. This compromises 40 GWh. With costs of 3-5 Eurocent per stored day and kWh, the fictional fleet could generate revenue of several million Euros per year. An obstacle not to underestimate here is the short period of re-supply of the vehicle's battery, additionally constrained by the main purpose of its use. More obvious are the costs such wearing of the battery will have.

The Federal Environment Agency (UBA) therefore concludes that the use of the V2G-technology will be based mainly on load management [17]. Its principle is the regulation of power consumption to suit the production of renewable energies. In Northern Germany, at night time, wind generated energy already quite often exceeds demand. Consequently night time would be an optimal time to charge an electric vehicle, fitting well to consumer behaviour. The combination of both technologies can result in multiple benefits.

Together with the Frauenhofer IWES, the UBA has conducted an interesting simulation assuming a share of 100% renewable energies for the year 2050, with wind energy, photovoltaic and bio-methanol being the main sources. Further assumptions are made for the EV fleet: 50% of the annual traffic output in the simulation results from electric vehicles, with the fleet composed of 10 million BEVs and 15 million PHEVs. The total power demand is estimated with 50 TWh. 95% of the traffic output is produced between 6am and 8pm. Most of the consumed energy is predicted to be available for load management. Finally, it is presumed that 50% of the EVs are simultaneously connected to the smart grid. When regarding the current usage rate of 15% for private vehicles, this estimate seems realistic. When considering these estimates, the modelling of an optimised load management system came to the conclusion that 30% of the total battery capacity could be used for load management. The demand of the EVs amounted to 26% of the available overproduction, the rest being consumed by thermal heat pump and climate control technology [18]. The simulation showed that a carbon free energy market is theoretically achievable and that EVs could play an important role in future economy.

More immediate are the effects on noise and air pollution. With no particulate matter emitted other than that from tyre, brake and road surface wear, local pollution levels can be reduced directly with the rise of EVs in use. Although also immediately noticeable, the effects on noise pollution are far less effective. It is well known that with the logarithmical growth of the sound pressure level (SPL), a decrease in the traffic volume by half would lead to a decrease of just 3 dB. Also, the replacement of average strong noise emitters with less powerful ones has, in the case of multiple sources, a relatively low impact. Additionally, these benefits only take place as long as the engine noise is louder than the rolling noise. This is the case on most inner city roads, as the turning point where rolling noise becomes predominant is approximately at a travel speed of around 40km/h [19]. Under such conditions and especially where many intersections cause spot-like origins of noise, the EV can have a positive impact, even when its share of the total vehicle fleet is minor. A strong benefit of EVs is the reduction of noise and correspondingly air pollution for the occupants themselves. Without engine or transmission, both in-vehicle noise and emitters of particulate matter are practically removed, making EVs more comfortable for the user. Higher societal benefits with simultaneously lower investment costs can be achieved by electric mopeds and motorcycles, since their counterparts with combustion engines contribute disproportionately to the pollution of urban environments. In total, the short term societal benefits of electric mopeds are higher than electric cars making their promotion worthwhile.

For these reasons, many countries have set up programs to push the development of electric vehicles. The German Federal Government has set the ambitious goal of one million EVs on Germany's roads by 2020. This goal supposedly will make Germany one of the leading markets in electric mobility (compare table 1). "A technological turn of the tides”, as the Cabinet of Germany formulates it in its ‘Development Plan Electric Mobility’ (‘Entwicklungsplan Elektromobilität’) [23]. Several paths could lead to this goal: On the one hand, technological development could increase the limited range to an extent allowing a widely accepted utilisation. On the other hand, there is the possibility to use EVs in a context, which already allows a reasonable utilisation despite the limited range.

	vehicle numbers absolute, only cars, beginning of 2009	**EV numbers** absolute, only cars, beginning of 2009	**share of EVs of total vehicle numbers** in percent, rounded
Berlin	1 088 221	22*	0.002
Germany	41 321 171	1 452	0.0035
* additionally 50 test-vehicles of the *Mini e* type from BMW [20] and 100 *Smart ed* from Daimler [21]			

Table 1: The ratio between vehicle and EV numbers demonstrates the initial situation. (Source: Neumann 2009 [22])

Both paths do not necessarily exclude each other. In perspective of different mobility needs in urban and rural areas, efforts in both directions are needed. Also, the need to collect first experiences in a practical context, could make one path lead into the other. If seen this way, complementary benefits of both paths can be detected. The long range strategy demands a lot of capacities for basic research and, of course, an abundance of patience. The benchmark is set high by conventional vehicles: range, velocity and a convenient refuelling process form a technological vision of a high speed travel machine – suitable for long overland travel as well as short city trips [24]. The short term realisation of the second path could provide a market big enough to let economics of scale settle in.

3. CAR SHARING

Economically, operating EVs in a car sharing fleet might be more viable. While the basic principle of car sharing – as it has been first seen in the late eighties – was to divide costs and impacts by using instead of owning, the modern idea has shifted towards a consumer oriented mobility product with a unique flexibility. Three attributes characterising this trend are the instant access of vehicles, the open end of the booking time and the one-way option for the trip. Additional trends making car sharing more attractive are the limitation on usage costs without fixed costs, mobile accessible information on the availability and an easy booking system through information and communication technology (ICT).
Car sharing itself has many benefits on hand for both individual user and society. Benefits for the individual user can be lower overall costs and more flexibility with the free choice of car model. Dynamically rising numbers of car sharing customers prove that these utilities find a market. Also, municipalities profit from this concept by lower space consumption due to the reduction of private vehicles. Additionally, a long term change of habit to a life style with less vehicle kilometres leads to a more efficient transport system. Combined with the higher efficiency of the (in average more modern) car sharing vehicles, significantly less carbon dioxide is emitted into the atmosphere.

Only a few years ago, it was unthinkable that a traditional car manufacturer like Daimler would deliver the benchmark in innovative car sharing systems. With Car2Go, it now does exactly that in cities like Austin, Ulm and soon Hamburg. Furthermore, Daimler is planning an edition of the Smart model designed entirely for car sharing use [25]. Like Hamburg, Munich will see a modern car sharing scheme with vehicles provided by the local car manufacturer BMW. Peugeot has already moved in this direction with its Mu-concept. The bidding process for the new car sharing project in Paris, AutoLib, attracted several original equipment manufacturers (OEMs). [26]

In context with new mobility products like car sharing, a new mobility type has drawn attention: the so called “multi-modals” [27]. This type is characterised by the choice of multiple transport modes, for example the bike on a sunny day and the bus on a rainy day. The private vehicle – if existent – is only one of a few options considered. Obviously, the provision of reasonable mobility alternatives is a fundamental and basic condition for the development of a multi-modal travel habit. A reliable public transport and a safe bicycle network facilitate multi-modal behaviour. Since the service density of public transport rises with the size of the city, “multi-modals” can predominantly be found in large urban areas.

4. E-CAR SHARING AS PART OF PUBLIC TRANSPORT

By operating EVs in a car sharing scheme (e-car sharing), a higher usage rate of the vehicle can be achieved. While car sharing vehicles are used more than one third of the day time, private vehicles on the average are only used for approximately 10%-15%. The e-car sharing can thus provide higher efficiency and consequently levels the higher investment costs caused by batteries.

With the range of the available EVs usually lower than 200 km, the user must switch to other transport modes on longer distances. Here, the integration of e-car sharing in the public transport makes clearly sense. The public transport ensures long distance travel and commuting whereas the EVs increase the customers flexibility in short trips.
As mentioned above, a privately run car need not be powered with renewable energies nor connected to the smart grid. With the backing of municipalities, e-car sharing shows the potential to play an important roll in V2G-tehnologies. A fleet is more manageable for smart grid technology, as customer needs and storage capacity can be centrally directed and optimised.

Beside these long term benefits, the combination also incorporates short term effects regarding the introduction of EVs. In a rental system, many customers can experience their first contact with an EV and so gain a first input for their personal judgement on the EV. Car manufacturers, energy suppliers and governmental institutions also gain the opportunity to evaluate risks and chances.

Figure 1: EV-models in the study: Citroën C1, Smart ed and Toyota Prius PHEV (source: own image).

5. FIELD STUDY BEMOBILITY

The Federal Ministry of Transport, Building and Urban Affairs (German: Bundesministerium für Verkehr, Bau und Stadtentwicklung - BMVBS) has implemented the incentive programme “Förderprogramm Elektromobilität”. It is supported by the government with a budget of 130 million Euros. This program, compromising eight regions, concentrates on funding electric mobility in public space. The project BeMobility, located in Berlin, is part of this program. The main aim of BeMobility is the integration of EVs in public transport. The need for a diverse portfolio of shareholders is well documented with the list of partners: RWE, Solon, Vattenfall, and DB Energie are operating in the energy market. Bosch participates as a car supplier while Toyota is world's largest automotive manufacturer by sales and production. Contipark, DB AG, DB Fuhrpark, VBB and BVG are active in the transportation market. DAI Labor (Technische Universität Berlin) and HaCon deliver IT-solutions. Scientific partner is the InnoZ.

It is no coincidence that BeMobility is based in Berlin. As described above, figures prove that the city has, compared to other major urban centres in Germany, a reduced affection towards the private vehicle. A significant part of the population thinks and acts without the inclusion of car-related utilities in their personal mobility assessment. The use of various transport modes is often part of every day life making the population of “multi-modals” extraordinarily large in Berlin. Consequently, Berlin is the perfect sample for the development of car sharing. Here, in the late eighties, the first privately founded associations shared cars between a handful of members. Nowadays, Berlin citizens can choose from seven commercial operators.

5.1. Aim of the study

The predominant aim of BeMobility is to integrate EVs into public transport. It is therefore an example of the above described second path: the change of the usage context. In this project, usual car-travel patterns are not setting the benchmark – it is rather intended to demonstrate that existing EVs and charging facilities are already a feasible technology, when closely combined with public transport. So, a potentially long-lasting solution is tested in context with the complex problems individual traffic causes for municipalities. In the best case, economic viability of the concept can be proven.

5.2. Design of the test product

In order to integrate EVs into public transport, they are operated in an open car sharing modus, making them available to all customers of the car sharing company (in this case DB Flinkster). Only customers willing to participate in the survey are regarded as test-users. These customers can optionally test a package combining the car sharing membership together with a monthly ticket for the local public transport. While the flexibility of car sharing is purchased demand-orientated, the local public transport is paid by a monthly fee and will be regarded monetarily as cost-free in the personal mode choice. For long-distance travel, the customer can rely onto train services, which are made more attractive by including a discount card in the package. That way, the complementing attributes of the different modes are also monetarily transparent. Depending on the purpose of the trip, the user will choose the most suitable mode or combination of modes.

The vehicles integrated into the scheme are strongly dependent on what models the OEMs can momentarily offer. The currently available vehicles within the projects are: the Smart ed, the Citroën C1 (converted model) and the Toyota Prius (compare figure 1). While the first two models are driven entirely by battery power, the Toyota Prius is a plug-in hybrid which can drive the first 20 km on battery power, but will then switch to conventional propulsion. This vehicle is a test model, which is expected to be available in 2012. It is planned to extend the fleet composition with newly available models. In sight are the i-MiEV from Mitsubishi, the iOn from Peugeot, the C-Zero from Citroën and the Fiat 500 (converted model). With these inclusions the fleet will be extended from 18 to approximately 40 vehicles later during 2011.

It cannot be emphasised enough that the project constellation has led to the very unusual circumstance of having a vehicle from a large OEM tested in cooperation with a railway company. In this perspective alone, the project has fulfilled its aim of bringing public transport and EVs together.

Pedelecs are planned to be offered as well. Pedelecs are electrically supported bicycles, which assist the user only while peddling. This way the user has a pleasant experience similar to a strong tailwind. The level of electrical support is adjustable. However, in this case, the support will switch of at speeds above 25 km/h. This way the pedelec shares the same legal status as a common bicycle. Insurance and the wearing of a helmet are compulsory, which is essentially necessary for an innovative renting scheme. Many features such as the charging behaviour and the implementation of public charging facilities are similar to the EVs and will cause comparable reactions from the user. Pedelecs will also complete the intermodal product the project is aiming to test. Currently pedelecs are tested and based at the main railway station in Berlin and the EUREF-Campus in Schöneberg.

The car sharing stations in service are located at main public transport intersections. Three of the five long distance railway stations are already integrated in the scheme (Hauptbahnhof, Ostbahnhof and Südkreuz). Others are to be found near important subway or urban railway stations (compare figure 2). Furthermore, the district of Prenzlauer Berg will be covered with 10 to 20 e-car sharing stations during 2011, with several vehicles per station. All of the charging facilities deliver renewable energy. To ensure this to the test-users, the quality of the delivered energy is guarantied by neutral institutes.

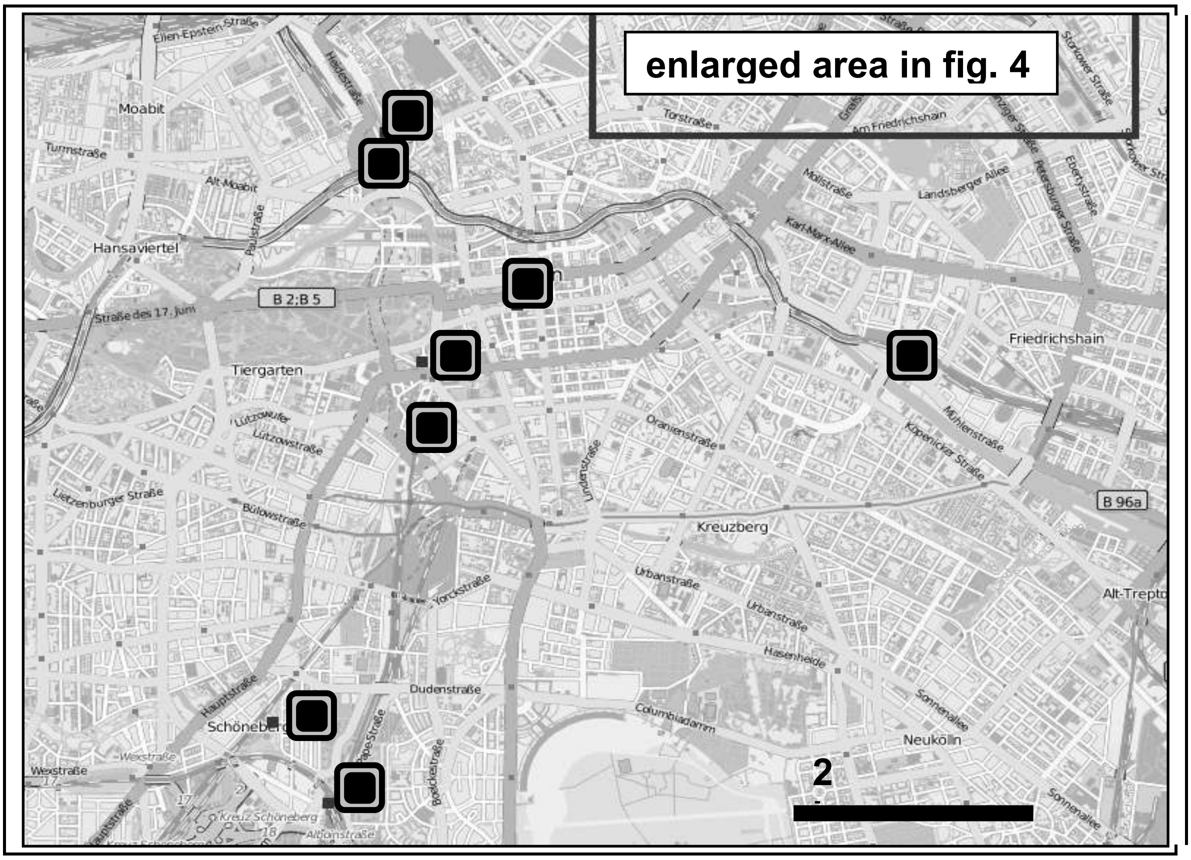

Figure 2: e-car sharing stations at central points in Berlin (source of map: www.openstreetmap.org)

Unfortunately, the current EV models have no common standard for power plugs and sockets. Therefore, publicly accessible charging facilities cannot be unvaryingly used for every vehicle model. Energy providers participating in the project also follow their own strategies regarding this emerging technology. Consequently, each type of charging station has a different routine for the customer recognition. While the charging stations from Vattenfall are accessible using NFC-technology and provide a socket option for CEE 7/4 "Schuko" and CEE Plus plugs, RWE has implemented a specific Mennekes plug which allows V2G-communication. Thus, identification simply is done by plugging in alone.
To integrate information, communication and pricing back-ends is a main challenge in a project such as BeMobility. In context with BeMobility, the Technical University of Berlin is developing a multi-platform web-application, the BeMobility Suite, providing the user with different types of information.

The focus here, is the routing assistance, which will have to live up to the aim of an intermodal service. The BeMobility Suite has to combine static and dynamic information of various modes for the project's route assignment. A trip could so combine for example a footpath, a bus-trip and an e-car sharing trip as parts of a suggestion for the best route. Currently, the project's application based on a mobile web-app can compare routes of different modes and find e-carscharing offers in range of public transport stops.

Information and communication technology (ICT) is necessary because of the duration of the recharging. While the conventional refuelling process currently might be a rare misfortune for the affected car sharing user, an empty or near empty battery will lead to a complex reorganisation of the user's trip. Therefore the current SOC and prospected recharging time must be transparent to the customer prior to the booking. As well as the provision of battery and routing data, there are several services which can make the use of e-car sharing more comfortable. The search of the nearest vehicle or charging station and other location based services are additionally provided by the BeMobility Suite.

5.3. Type of survey

The implementation of the product described above is evaluated by the accompanying research, focussing on the expectations and experiences of the test users. The research is strongly influenced by a user integrated research design. Therefore, the product design described above can itself partly be seen as a result of the survey. Unusual for the transportation sector, test users were identified based on typical mobility attitudes and not attributes. Approaches based on mobility attitudes have proved to be successful in recent traffic behaviour studies.

The first step of the accompanying research was the conduction of focus groups representing certain mobility types. The four mobility groups identified are derived from the previous Intermodi Study of the Wissenschaftszentrum Berlin (WZB) and are labelled as the 'ecologically motivated bicycle and public transport user', the 'public transport affine', the 'fun-oriented car-affine' and the 'pragmatic, highly mobile'. As early as late 2009, interviews have been conducted. In the first half of 2010, the first discussions within these groups took place. The results were used as an input for the specific product design.
The gathering of quantitative data began late 2010. The two main instruments for this step are the responses to the CASI-questionnaires and the indirect recording of user-data. The online-questionnaires are designed for a three-step survey process resembling the three phases before, just after and long after the first e-car sharing booking – last to record settled routines. The development of questionnaires is adjusted to other researches in electric mobility so that results can be evaluated in context.

The first phase has been completed with 311 participants answering. The second phase is currently about to be completed. The intermediate size of the study population is 159 (in late February 2011) with a size of 200 responding test-users intended. New users are identified within a regular period. The third phase is due to start mid 2011.

Additionally to the rather conventional instruments described above, a lead user identification and integration process has been conducted throughout the advanced field study. An interdisciplinary working group provided product suggestions for the ICT-solution based on a design-thinking process. The group incorporated students from the Hasso-Plattner-Institute of the University of Potsdam. Events displaying electric mobility to the public were used to document the thoughts of a specifically interested audience. Opinions of internet users discussing the topic in project-related online articles were raised with netnographic methods.

5.4. Findings

The findings show that the study participants resemble similar attributes to the average car sharing user. Therefore, the users do not represent a sound sample of the Berlin population but rather a group of interested test-users, often owning car sharing experience. This corresponds to the study design in focussing on the group of lead-users and early adopters.

The integration of lead-user and early adopter showed that a number of attributes of the product designs are regarded similarly throughout the mobility types. Flexibility is such an attribute. The relevance of other attributes is seen coherent. The discount for users combining public transport annual tickets is highly valued by public transport affine while fun-oriented car-affine users are slightly reserved regarding this design. The inclusion of the pedelecs finds lower approval rates from ecologically motivated bicycle and public transport users. These users seem to prefer their private bicycles. The fun-oriented car-affine showed a higher interest towards the selection between different EV models while the pragmatic, highly mobile type prefers innovative technologies.

The design of the test-product, as described above, can itself be regarded as a finding of the user integrating research method. Through pre-interviews and discussions in the focus groups two main product schemes were identified, one of which resembled the so-called “Berlin Mobile” product. An electric car sharing scheme closely interlinked with the public transport and long distant rail. This product has been mainly implemented as is described in chapter 5.2..

Slightly opposing the first product, is the second product design. The basic idea is that the customer can access the electric car whenever, wherever he or she sees it unoccupied. The concept is best described by the three most important requests for future car sharing: one way and open end ability as well as instant access to the car. The presence of EVs and charging stations in a high density throughout a defined area is the main necessity for this product scheme. It should create the same feeling of flexibility and freedom the customer might know from his or her own car.

Regarding the survey, the response rate of the first phase was especially good from males, family members, more educated and wealthier participants, pushing overall figurers in this direction. The study also attracted mostly new car sharing customers: 62% are car sharing customers since less than two years. This can be well explained by the dynamic growth of the product in recent years. While the motorisation rate of the respondents was equally high as the Berlin average, the average number of bicycles per household surpassed the local average by 30%. The ownership of an annual public transport ticket also excelled the Berlin average, coming in line with a more than average public transport usage. Also, a shift from a frequent to a rare use of the own private car can be made out.
Although the majority rates the expected prices for EVs as too high, and is thus repelled from buying such technology in the following years, the costs for the shared EV in the test-product are seen as acceptable and the product as attractive. In fact, a plus of 10% (0.34 Euro per hour of a Smart ed or similar EV) on the ordinary car sharing price is regarded as worthwhile. The possibility of free parking and access to traffic restricted zones were mentioned by over 70% of the test-users as reason for an additional price raise, while the access to exclusive lanes was rated much less attractive. Not even 50% of the test-users rated such a privilege as justification for an increased price. An overwhelming majority view the EV as an effective status symbol.

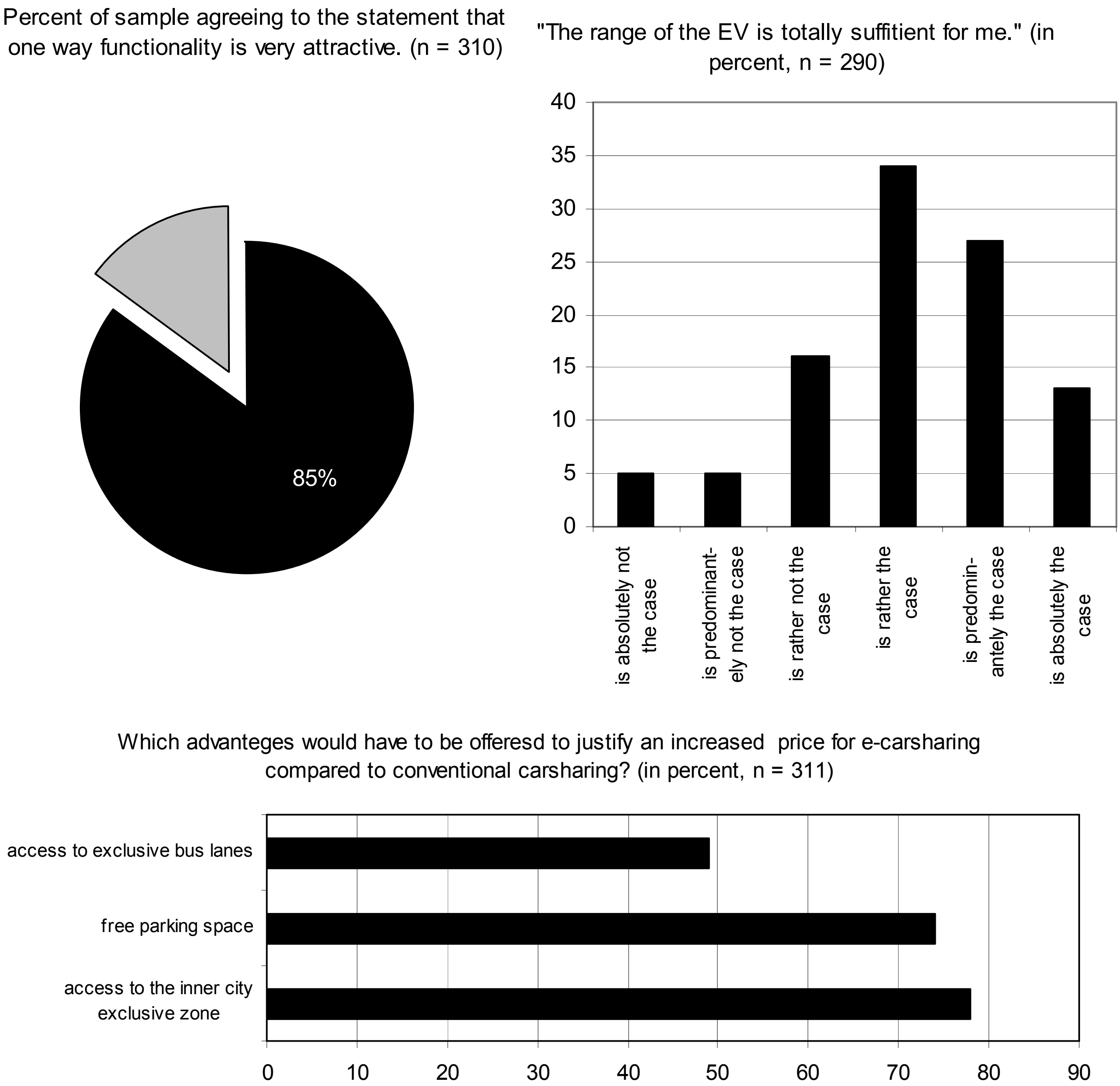

Figure 3: results of the survey, first phase

80% expect a one-way functionality and expectations are high on the vehicle's comfort and safety. Surprisingly, the limited range is considered by the majority as sufficient for daily needs (compare figure 3). Low expectations in the EVs maximum speed can be seen as a strong argument for the promotion of EVs within a city car concept. Operating such a system will benefit the image of public transport providers, as survey results show. The majority expected the consumption of renewable energy, with photovoltaic and hydrogen power being slightly more popular than wind energy.

During the operating phase, the driving periods of the EVs did not interfere with the charging periods in a negative way, so that a smooth operational service was possible. Problems occurred with the reliability of the EVs, with an unusually high maintenance necessary. Since two of the models are not jet produced in series and one is a readjusted model, the problem could potentially be teething troubles of an emerging technology. More specific for e-car sharing, a real problem can be seen in the availability of information on the SOC. Car manufacturers tend to be very restrictive when allowing access to their vehicle's own Controller Area Network (CAN-Bus). For a successful integration into a future smart grid, and also into the public transport, the availability of this type of information is a pure necessity.

6. OUTLOOK

The spatially inclusive and comprehensive coverage with e-car sharing stations in Prenzlauer Berg will evolve during 2011. It can be seen as an important step towards the spontaneous usage scenario. This area is known for its young and broad-minded population, who show great interest in innovative technological solutions as well as ecological topics. By far, the majority of the private vehicle holders in the area have no own parking, and therefore have to use curb side parking slots in public space. In recent years, the demand for parking space has risen in this trendy area. Beside motorised residents, a growing number of visitors add to the amount of car traffic. As a consequence, the council implemented a charging area covering most of the district and is very progressive regarding car sharing (compare figure 4). In this Berlin environment, the spontaneous usage scenario will find fertile ground.

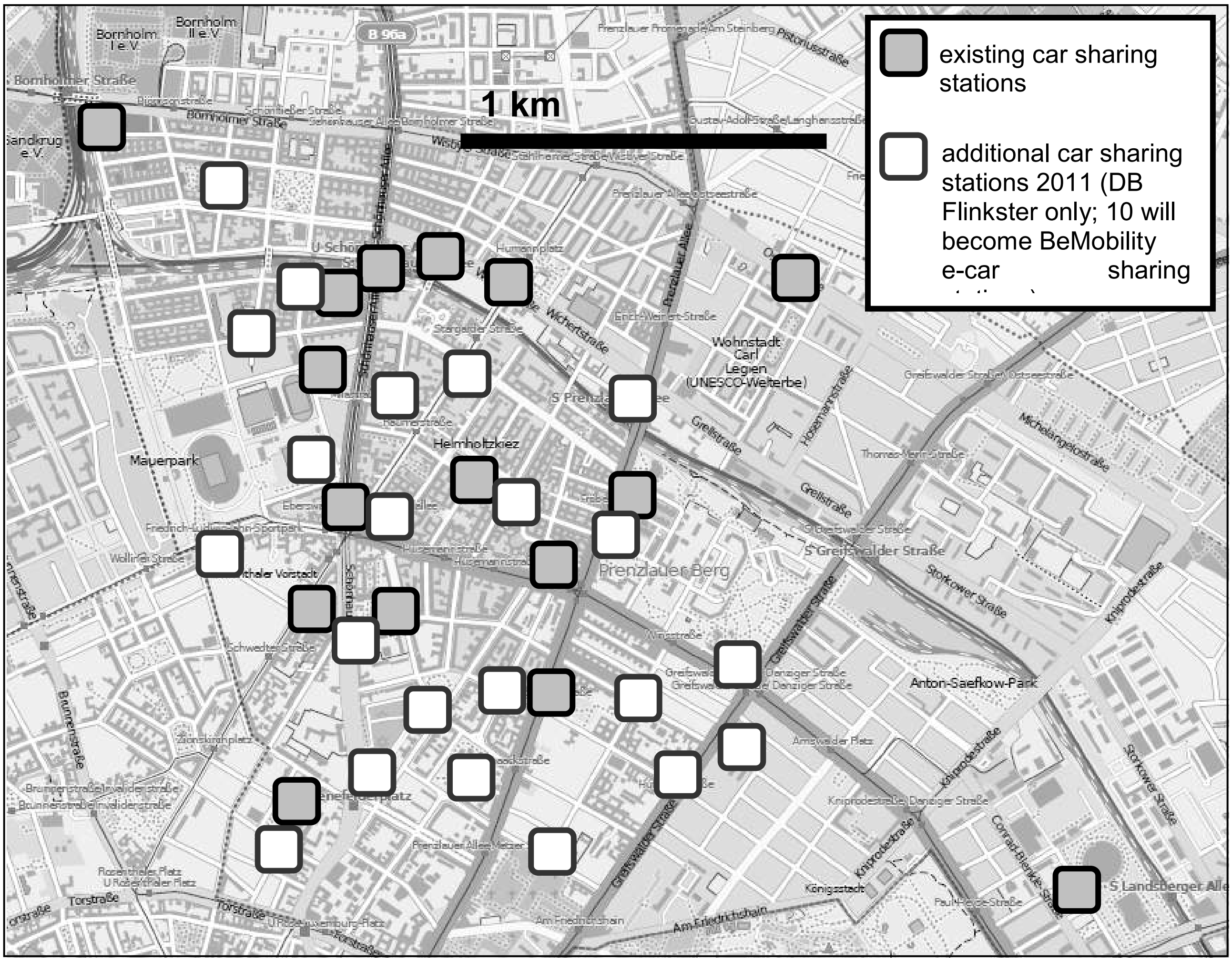

Figure 4: An example for the dynamic car sharing development: the map of existing and planned car sharing stations in Prenzlauer Berg, Berlin (source of map: www.openstreetmap.org)

With significant numbers of EVs operating in the e-car sharing scheme, the next test phase will have to embrace product developments of various key technologies, such as new energy systems, energy-efficient and smart housing, smart grids and smart networks. The theoretic construct of a smart grid solution with a decentralised energy production and storage, as well as an intelligent load management, will then be able to be tested on a bigger scale. The implementation and transfer of these technologies is the aim of the Intelligent City Forum, in which BeMobility is a local cluster partner.

As architect Georg Windeck has formulated it in his vision of an Electropolis 2.0 [29], “the production and application of sustainable technologies should not only address ecological necessities. It also has to formulate social ideals that are embedded in a larger framework of cultural and aesthetic aspirations. In the long run all technological efforts can only be successful, if we try to envision the urban environment we want Berlin to become, and postulate the goals that it materializes. If we fail to holistically address all aspects of urbanity, the individual technological improvements will remain isolated attempts that only react to isolated economical and ecological problems.” A statement directed not only to e-car sharing, but to any technology developed for urban mobility solutions.

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