CAR-SHARING WITH ELECTRIC VEHICLES: A CONTRIBUTION TO SUSTAINABLE MOBILITY?

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Abstract

Combining car-sharing and electric mobility results in a "circulus virtuosis" or in other words a profitable dynamic, because car-sharing and electric mobility are mutually beneficial. The operation of a car-sharing model with electric vehicles makes sense given these considerations even though it is still facing challenges. Apart from the costs, the integration of charging is the most critical success factor for the realization of the concept and its economic success. This paper discusses possible solutions for this problem which appear to be feasible and promising.

Keywords: *value chain, electromobility, mobility services sectors, electric vehicles, sustainable mobility*

JEL Classification: Q01, L9, L94

1. INTRODUCTION

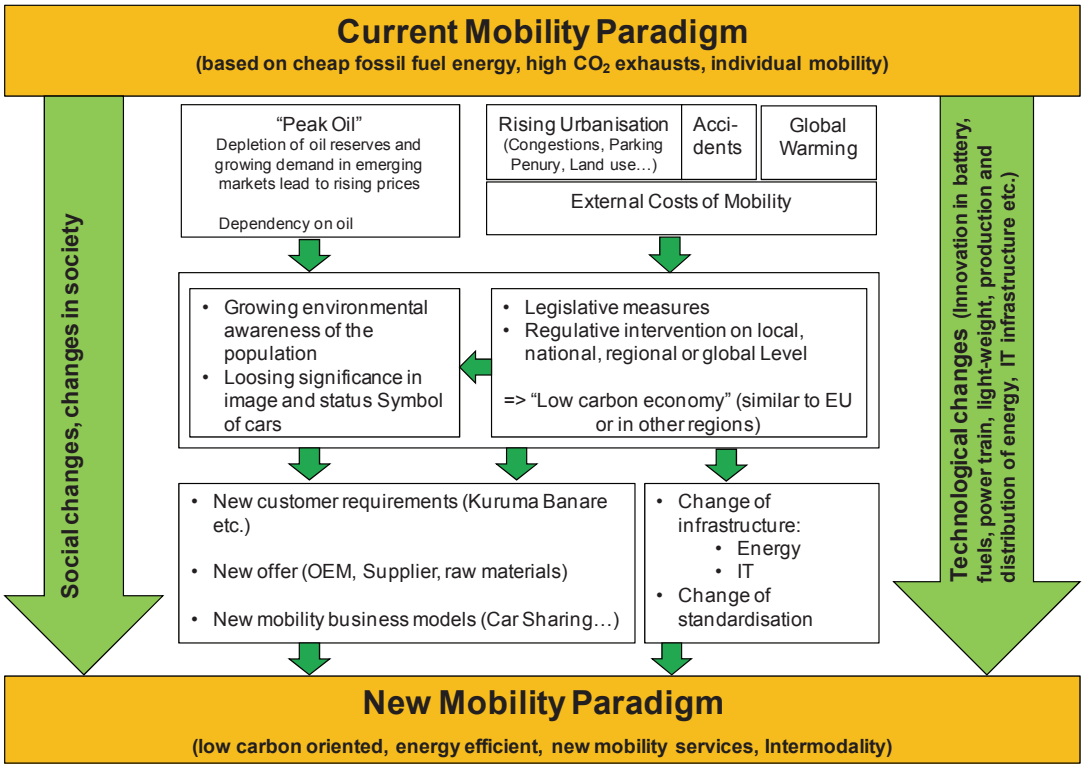
On a long-term basis the international automotive industry is regarded as a growth industry because individual mobility is considered a basic human need. However, the industry faces enormous global challenges. Increasing urbanisation, overloaded traffic infrastructures, global warming, pollution, scarcity of raw materials and the foreseeable shortages of oil are only some of the expected issues.[2] Governments around the world influence these developments through regulation at local, national and international levels.

Therefore, it is necessary for car manufacturers to adapt to these changing conditions redefining their business strategies. Accordingly, the automotive value chain will fundamentally change. This creates business models within new business areas, like the much discussed electromobility and mobility services sectors. The union of both concepts is the deployment of electric vehicles in car-sharing. Thus, the car manufacturers BMW and Daimler are considering the electrification of their car-sharing offers DriveNow and car2go. This is a promising mobility solution for many cities worldwide. This shows that the automobile industry drives innovative mobility concepts. The objectives of this article are to clarify how the connection of car-sharing and electromobility can make sustainable contributions to our future mobility. This article will especially analyse the economic side more in detail to explore whether it offers an interesting new business model and what the critical success factors of the model might be for industry and society. Lastly, approaches on how to face the economic viability of the business model will be discussed. To do so methodologically, secondary literature on global trends, electromobility, car-sharing, and electrical car-sharing will be reviewed in order to combine findings and draw conclusions whether this business model might be a promising strategic solution and how challenges could be tackled.

2. CHANGED ECOLOGICAL, ECONOMIC AND SOCIAL REQUIREMENTS

The international market changes require innovation across the board. Essentially, these factors can be identified as ecological, economic, social changes and technological innovations. The following figure shows a general idea of these influences, in terms of the new mobility paradigm.

Figure 1: Drivers of the new mobility paradigm



Source: own research

External costs can be identified as ecological drivers. This concerns not only the output of gases, which contribute to global warming, contamination or health issues, but also to emissions in the form of land-use or noise. Currently, these are estimated on the European level at 1.1% of GDP (€100 billion) for global warming, noise and air pollution and another 1.1% GDP (€100 billion) for traffic congestion.

The limits of, and dependence on resources (oil or other raw materials) also play an important role. This scarcity of resources logically affects the price. Thus experts estimate that oil prices will continue to rise in the future. For example, emerging countries will have an increasing demand. Consequently, the shortage of crude oil will affect the price of the fossil fuel based mobility.

External Costs and shortages of raw materials require governments to intervene. Through regulating costs and/or creating industry policies governments will help prepare businesses for a new mobility paradigm. For instance, the European Union plans to substitute taxation of work, with the introduction of a CO_2 and energy tax. Thus, governments enforce current regulations and will continue to raise the

price of mobility for customers. In this way, the ecological drivers affect the economic drivers directly.

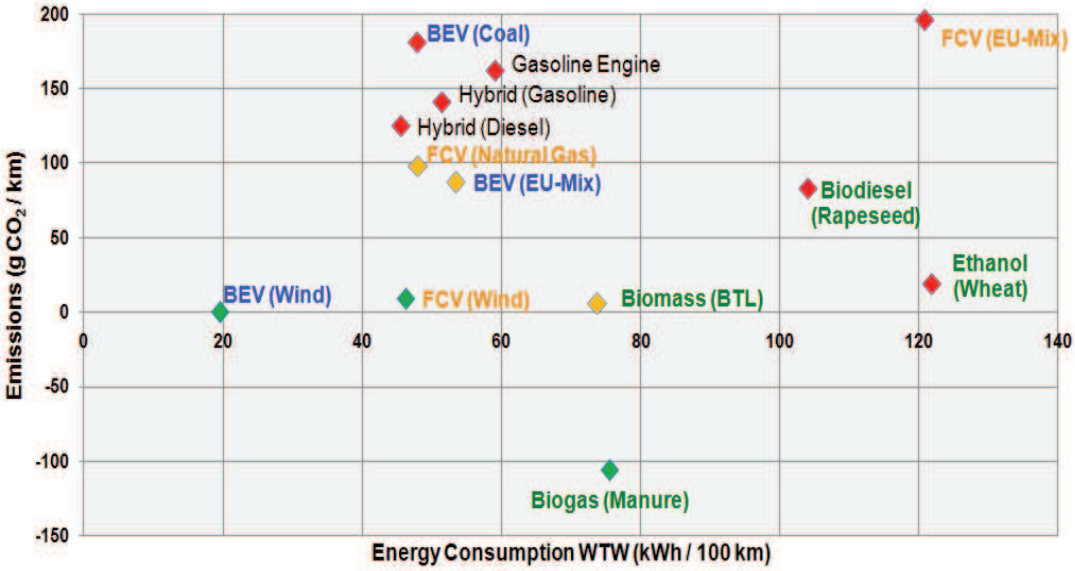
Besides the ecological and economic drivers there are also changing social conditions. While there is a large demand for automobiles in developing and emerging countries, the meaning and the prestige value of vehicles decreases while the needs of developed societies remain the same. The automobile as a solution for individual mobility is increasingly questioned. This phenomenon was already observed in the 1990's; for the first time in Japan under the keyword „Kuruma Banare", in English „demotorisation". A comparison of statistics by the German Federal Motor Transport Authority in 2009 showed that in Germany, the percentage of new vehicle buyers between 18 and 29 years old has decreased by half over the last ten years. The reason for the increasing lack of interest lies not only in the economic and ecological arguments mentioned above, but also in changing values of this generation in the triad markets (Europe, Japan and the USA). Collaborative consumption within "Peer to Peer Communities" is raising. The need to possess products like cars is replaced by services which are offered on the Internet. These services gain market shares and can be offered at an affordable price. The financial advantages, and affiliation with developing„Internet networks" ("Peer to Peer Communities) are increasingly important for today's young people. Smartphones, for instance, are more important status symbols than cars for many people. Furthermore, the purchasing power of young consumers will decline in the triad markets over the next twenty years. So it is expected that this generation will buy fewer cars. This is why future mobility needs will be addressed by car-sharing concepts, as well as other innovative solutions. For the manufacturers, it is crucial to consider these changes in international market environments in the development of new vehicles (e.g. electric vehicles) and mobility concepts (e.g. car-sharing).

3. CONTRIBUTION OF ELECTRIC VEHICLES TO SUSTAINABLE MOBILITY

Electric vehicles make permanent emission-free mobility possible. This is always true on a tank to wheel view. However, which energy source used for the production of the electricity is important and requires particular ecological considerations. The end result is represented by the CO_2 emissions. It

is crucial that renewable sources such as solar or wind energy are used, because this is the only way the electric option is reasonable. See the following figure.

Figure 2: Well-to-Wheel comparison of different drive systems: CO2 emissions and energy consumption (source: Own calculation after Concawe, European Council for automotive R&D, European Commission Joint Research Center (2007), Daimler Optiresource).



Also, energy consumption is an important factor. The Well-to-Wheel (WTW)[1] energy consumption is smallest with electric vehicles which are operated with renewable energies. The energy consumption could furthermore be seen as an indicator of price, due to the scarcity of crude oil and energy as a whole. The wide use of electric vehicles could provide enormous ecological and economic advantages in the long term due to lower emissions and high energy efficiency on a WTW basis.

Accordingly, governments will promote electromobility by monetary and regulatory incentives, for instance releasing bus lanes and priority parking lots. In France, for instance, large state-owned organizations like EDF, SNCF, RATP or La Poste are supporting the use of electric vehicles for professional

[1] To have a better understanding on the technical point of view and to better evaluate the different possibilities to fuel mobility the best is to analyse the energy path from primary energy to the wheel (Well-to-Wheel). First, you have to distinguish primary energy that can be fossil fuels (crude oil, natural gas, coal), renewables (sun, wind, biomass) or Nuclear (uranium). Primary energy is than transformed in final Energy (Gasoline, Natural Gas, Ethanol, Biodiesel, Biomass to Liquid, electricity, Hydrogen, compressed air etc.). This final energy is then transformed by a powertrain into movement (cf. Fournier, G. & Seign, R., 2009, p. 48.)

services[2]. It is estimated that almost 90% of the buyers are organizations. Electromobility will be beneficial on a long-term basis as taxation of energy and CO_2 emissions will enhance the near zero emissions effect stated in figure 2. In fact, the ecological advantages are converted by turning the external costs into economic incentives.

Moreover, it is expected that in the future, due to predictably rising fuel prices, electric vehicles will have lower operating costs than conventional automobiles, if they are operated with renewable energies. As consumer awareness of social responsibility rises, it could result in greater acceptance of electric vehicles, because of their lower noise, lower pollutants and cleaner operations.

With these advantages, electromobility will make a significant contribution to the future of sustainable mobility.

4. CONTRIBUTION OF CAR-SHARING TO SUSTAINABLE MOBILITY

As a result of the ecological, economic and social issues mentioned above, some consumers will change their way of consumption and be unwilling to invest money in a passenger car to satisfy his or her mobility needs. This was first studied in the 70s with the introduction of the concept of "collaborative consumption" using the example of car-sharing.[3] Predictably, the readiness of consumers to commit themselves over time to a product or to define themselves through property will decrease.[4] Nevertheless, the needs for advancement in mobility, sustainability and innovation continue to rise. The customer expects that his or her mobility needs will be fulfilled by new sustainable products offered by flexible ownership models in combination with reliable services. The needs of this growing customer base are only partially fulfilled by current business models and the limited product portfolios of car manufacturers. Consequently, few market players will be able to stay profitable with purely product-related revenues, or in other words, by selling vehicles only.[5]

[2] Lancement du plan national pour le développement des véhicules électriques et hybrides rechargeables

[3] cf. Felson/Spaeth 1978

[4] cf. Arthur D. Little, 2009, p. 64.

[5] cf. Arthur D. Little, 2009, pp. 2 ff.

The above mentioned challenges, combined with social and political pressures assure that individual mobility will change. Consumers will no longer require their own private car, but will be motivated to search for new means of mobility, that are fast, comfortable and environmentally friendly.[6]

Public transport is a part of this solution, but even an excellent public transport network cannot solve all mobility needs. To bring the traveller not only approximately, but exactly to his or her desired destination, is a problem which can hardly be solved economically. There are parameters which limit the effectiveness of public transport, for instance service to remote areas, long distances, the transport of handicapped persons, bad weather conditions and the transport of heavy or bulky objects. [7]

New mobility concepts will be necessary to meet future requirements and car-sharing is one suitable solution. The car-sharing concept is intended to fill the mobility gap between public transport, taxis, bicycles, car rental and private cars[8]. It offers the advantage and flexibility of a privately owned car, but without the associated fixed costs and obligations. This also makes the model attractive to new customer groups. The ecological and economic advantages of the mobility concept are as follows: [9]

- Less parking spaces or occupied areas are needed,[10]
- Parking search is simplified and traffic is minimized,
- Younger automotive fleets with less emissions,
- Vehicles are suited to the trip purpose,
- Reduction in private vehicle ownership, [11]

[6] cf. Beste, R. & Schwägerl, C., 2010, p. 31.

[7] cf. Mitchell, W. J., 2007

[8] cf. Millard-Ball, A.; Murray, G.; Schure, J. & Fox, C., 2005, p. 37.

[9] cf. Glotz-Richter, M.; Loose, W. & Nobis, C., 2007, S. 333 & Loose, W., 2010, pp. 73-92.

[10] This should deepen in the future as the Autolib car-sharing system in Paris shows after one year of usage that 53,3% of the users see Autolib as a substitution to the private car. Nevertheless still 46,1% see Autolib as a substitute to public transports. A potential of improvement is therefore still possible. Cf. CLCV 2012, p.

[11] In the scientific literature it is considered that between three and thirty vehicles are replaced by a car-sharing vehicle or rather will not be bought. The estimated CO2-reduction varies correspondingly and is furthermore dependent on the size of the fleet.

- Less passenger car use because of cost transparency and changed, mobility behaviour [12]
- Improved connections to public transport by Park and Ride promotions as well as intermodal [13] mobility concepts (e.g. RegioMobilCard in Freiburg or Yélo in La Rochelle),
- Easier integration of initial expenses of alternative drives by spreading fixed costs, and
- Possibility of decreased CO_2 emissions as well as compensation by service providers and users.

Additionally, the customer can always have access to current vehicles, has smaller or no parking costs and might actually see time savings if there is a high penetration of the service. [14] The stress level of the drivers is then reduced, which can be particularly high in large metropolises, such as Mexico City, Shenzhen, Beijing and Bangalore. [15]

To sum up, the volume of traffic and costs are reduced, without necessarily declining the frequency of the automobile use. The ease of private mobility is simpler and cheaper, since it requires no capital investment by the user. Finally, car-sharing models satisfy the social need for intensified consideration of environmental aspects. Thus car-sharing can be part of the solution to our future mobility and the sustainability needs.

Car-sharing with or without electromobility, can be realized in three different ways. The first, classical approach works with stations (e.g. public parking lots), at which the vehicles must be picked up and returned. Examples for these

[12] The high fix costs of the personnel vehicle owner motivate them even if it is actually unnecessary and there are enough alternatives to use their car. The transparent calculation per minute creates an strong incentive to reconsider his or her behavior and change (cf. Keegan, P., 2009). The Niches-project shows that car-sharing participants reduced their driven kilometers by 36% (cf. Niches+, 2010).

[13] Intermodality is defined as a multi-link transport chain where customers are carried with at least two various means of transport.

[14] cf. Bannister, A., 2005, pp. 29-33.

[15] cf. IBM, 2011-

are Quicar – Share a Volkswagen [16] and Flinkster, Deutsche Bahn, which use partial electric vehicles. [17]

The concept Autolib in Paris extends this approach. It provides stations where vehicles can be picked up and returned at a different station. But this approach requires high investment and a high critical mass of customers and vehicles. In Paris, it is configured with 3,000 electric vehicles and 6,000 parking lots at 1,000 stations. [18] However, even the operating company assumes the model only pays off after seven years. [19]

A third approach, which was selected by BMW and Daimler, differs from earlier approaches in that the vehicles, which are mostly conventionally driven, must be picked up and returned, not at stations but in a defined area. One way trips are possible since the vehicle can be parked at any point in a defined (central) area. The following figure shows the operational principle of such a car-sharing model.

Figure 3: Operational principle of the modern station-free car-sharing (source: Own representation following DriveNow, 2011 and Daimler, 2011).

[16] cf. Volkswagen, 2011, p. 8.

[17] cf. Flinkster, 2011

[18] cf. Niches+, 2010

[19] cf. Auto Motor und Sport, 2011

This principle combines the greatest possible customer benefits and flexibility with the smallest investment, but the provider must overcome great challenges in making the process work, which is described later.[20]

5. CONTRIBUTION OF CAR-SHARING WITH ELECTRIC VEHICLES IN SUSTAINABLE MOBILITY

Since car-sharing targets short term rentals and inner city traffic, electric vehicles are actually very suitable for use in a car-sharing fleet. The battery range is currently about 100-200 km and can be regarded as adequate. A car-sharing vehicle can go several days without charging, depending on the usage. car-sharing with electric vehicles can provide individual and emission-free mobility while matching the individual needs of the customers.

There are further strategic reasons for choosing electric vehicles. Their integration into the car-sharing fleet makes sense, because the integration will increase public awareness about the presence of electric vehicles as a new technology.[21] Since there is no lasting obligation, like car ownership calls for, the "per minute" fee structure allows the customers to gather experience with the electric car.[22] So, the acceptance will increase in the long run. But the still wide-spread fear of too short a range („range anxiety") will decrease. In addition, car-sharing with electric vehicles will lead to increased production and sales of electric cars. When the manufacturers benefit from large scale usage, it makes the vehicles less expensive. car-sharing can become an advertisement for electric mobility. Finally, conventional sales (for individual purposes) would benefit from wide scale usage and decrease the costs of the technology. More electric vehicles could be manufactured and their ecological, economic and social advantages would be multiplied.

This is an important point for the industry. With CO_2 reduction gained by widespread use of electric cars, the industry would more easily comply with government regulations. In the next ten years, approximately 300 billion euros will

[20] cf. DriveNow, 2011 und Daimler, 2011

[21] for more details: Lanzendorf, M., 2010

[22] cf. Rieckmann, T., 2010

be invested world-wide in CO_2 reduction, about 50 billion euros of investment will be in alternative powertrain engines, such as hybrid or electric drives.[23]

Another opportunity to consider is a concept called Vehicle-to-Grid. This is the integration of electric vehicles into the electrical power grid to form a virtual power storage station. In a grid with a high proportion of renewable energy sources but fluctuating energy production, the load can be stabilised by the storage, feeding and charging of electricity from electric vehicles. It is possible e.g. to use surplus power from renewable energy systems to substitute peak- loads. This electricity is normally provided by non-renewable power plants during peak load times. This process works by feeding stored "green" electricity into car accumulators that are docked into the grid. This is ecologically sensible. Depending on the country where it is implemented and on the business model, it can also be economically advantageous.[24] car-sharing operators could generate revenue even when the cars are parked.

Car-sharing offers an alternative to conventional selling or leasing of electric vehicles.[25] The institution Cetelem has recently asked 6000 European drivers in ten different countries how they view the future of the automotive industry in Europe. 36% stated they were ready to switch from ownership to leasing a car.[26] The electric vehicles are currently too expensive because of high research and development as well as high production costs. The Total-Costs-of-Ownership is still higher than that of a conventional vehicle despite lower operating costs. [27] Since electric car's batteries have a short lifetime, the residual value decreases rapidly. Car-sharing as a distribution form would be more attractive for customers. That makes strategic sense in order to increase production rates and finally create a large scale market.[28]

To sum up, it can be said that car-sharing using electric vehicles makes sense in many ways and is attractive for all parties involved. The contribution to the three pillars of sustainability is summarized in the following table.

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[23] cf. Oliver Wyman, 2009

[24] For more details see. Fournier, G.; Baumann, M.; Seign, R.:2010, , pp. 38-41

[25] cf. Reinking, G., 2011

[26] L'Observatoire Cetelem 2012, « La voiture électrique et les Européens », http://observatoirecetelm.com/medias/pdf/2012/obervatoire-cetelem-de-l-automobile-2012.pdf

[27] cf. Oliver Wyman, 2010

[28] cf. Reinking, G., 2011

Figure 4: The ecological, economic and sociological contributions of car-sharing with electric vehicles (source: Own representation).

Environment	Economic	Social
Less pollution impact	Fair use costs (internal + external costs)	Comfort without sacrifice
Smaller resources consumption (fuels, surface, time, human resources)		Improved use of time, decrease level of stress
High (energy) efficiency	New customer-oriented business models, development of new customer groups	Flexible ownership models, simple entrance to mobility services with small capital lock-up
Promotion of renewable energies	Smaller expenditures for mobility, for certain customer segments	Conscious, sustainable handling of mobility
	Product diversification for car manufacturers	Promotion of community thinking (Peer-to-Peer Community, Collaborative Consumption) by new technologies

Corporations would gain a competitive advantage through managing sustainability.[29] [30] This shows that the « triple bottom line » from Elkington[31] (3P = People, Planet and Profit) integrating sustainability in all economic, social and ecological dimensions, to generate more profit in the long term is possible. This could be a way for the automotive industry to survive in the long run[32] [33].

6. CAR-SHARING WITH ELECTRIC VEHICLES: A SUCCESSFUL BUSINESS MODEL?

Despite the multifarious advantages there are still challenges which have to be addressed. First, the diffusion and acceptance of the idea of car-sharing is crucial. Car-sharing is seen in a very critical light in many societies. A current study with young adults in Germany showed that 73% of them are aware of the current car-sharing service. However, only 6% are ready to use such a model.

[29] Shrivastava, P., 1995 and Story, D. & Price, T., 2006

[30] This goes also in hand with the concept of shared value with the focus on the connection between social and economic progress (Porter & Kramer, 2011).

[31] Elkington J. (1999), Cannibals with Forks. The Triple Bottom Line of 21st Century Business, Capstone Publishing Ltd, Oxford.

[32] D'Aveni R. (1995), Hypercompétition, Vuibert, Paris.

[33] Reynaud E. (2006b), « Stratégie et développement durable », dans Reynaud E. (Ed.), Le développement durable au cœur de l'entreprise, Dunod, Paris, pp. 203-228.

They are waiting for a better price-performance ratio and better service connections („No-Gaps Coverage").[34] If a high market penetration is reached, then the advantages of usage will contribute positively to a sustainable future in mobility. Nevertheless the many advantages of car-sharing combined with social acceptance will pave the way for the commercial success of such a service.

Moreover, the integration of electric vehicles into the car-sharing fleet will become more difficult. First the availability of renewable energies must be secured, which is an indispensable prerequisite for the efficient and ecological operation of the vehicles. Furthermore electric vehicles must develop a technological maturity and high reliability in order to find broad acceptance. Beyond that, they must exhibit controllable initial costs and an acceptable level of Total-Cost-of-Ownership. New business models must be developed which make car-sharing service with electric vehicles economically feasible and comfortable. This is a challenge, since charging the electric cars possibly leads to inconvenience and flexibility losses for the customer in comparison to conventional vehicles. Currently, the provider is responsible for refuelling the cars. Whether this model can work for electric vehicles, is questionable and will be examined in the next section as it is essential to the creation of car-sharing with electric vehicles and is identified as the most critical success factor for this business model.

Nevertheless, the political climate and regulations are very important factors for the success of such concepts. Predictably, success requires a charging infrastructure or at least the governmental support for such. Monetary (e.g. tax concessions, congestion charge or specific parking areas) as well as regulatory (e.g. release of bus lanes) incentives, are needed in order to compensate initial disadvantages of car-sharing compared to the private ownership of vehicles and the electric mobility in comparison to combustion engines. Otherwise, this innovation-bundle might perish. With the obvious advantages of car-sharing using electric vehicles, governments worldwide should take an active interest in promoting such concepts and create appropriate prerequisites for integrating this innovation into transportation networks.

[34] cf. Roland Berger Strategy Consultants GmbH, 2011, p. 22.

7. FACING THE MAIN CHALLENGE FOR ECONOMIC VIABILITY: CHARGING STRATEGIES FOR CAR-SHARING WITH ELECTRIC VEHICLES

The charging process differs significantly from conventional refuelling. This procedure takes several hours and requires a new infrastructure. The following illustration shows possible solutions for car-sharing providers and compares the pros and cons of the different alternatives for charging.

Figure 5: Solution options of the charging problem in the customer process of car-sharing with electric vehicles as critical success factor (source: Own representation).

	Option 1	Option 2	Option 3
	Provider owns charging points, customer charges	**Public charging points, customer charges**	**Provider owns charging points, provider charges**
+	easy process for provider	easy process for provider	high flexibility & comfort for customer
+	reliable infrastructure	no invest for provider	synergies with service processes for provider
-	reduced flexibility & comfort for customer	reduced flexibility & comfort for customer	high process costs for provider
-	high invest for provider	dependency on public infrastructure: no guaranteed space & possibly time limit for parking	high invest for provider

Since current conventional car-sharing systems (such as Zipcar) are not yet operating profitably, it cannot be expected that providers will be able to invest in both – currently higher priced electric vehicles AND charging infrastructure. Hence, option 1 and 3 will not be feasible in the near future.

For this reason, option two must be optimised so that providers do not have to invest in complex charging processes or in expensive infrastructure themselves while providing comfort and availability to the customer. In general, there are two different types of organizing charging infrastructure: centrally and decentrally. Following this typology, possible solutions how charging infrastructure might be organized to achieve this goal are discussed. In this discussion not only the view of car-sharing providers is taken but also other stakeholders such as the infrastructure operator and other electric vehicle owners are considered to ensure a realistic and comprehensive overview:

Decentral Concepts

a. "on-street charging"

This refers to classic roadside parking and simultaneous charging at specially marked parking spaces which are exclusively for electric vehicles. Here, a special charging infrastructure will be built and operated similar to parking ticket machines. Problems faced by this solution are urban integration (aesthetics, trip hazard) and the high likelihood that not more than one vehicle can be charged per parking space, e.g. over night. One advantage of this approach is certainly charging the visibility and the proximity to customers' homes, but it cannot be guaranteed that the parking space is available when needed. An example for this concept is car2go in Amsterdam.[35]

b. "swap charging"

Private users who have a private parking space with charging infrastructure (e.g. so called "wall boxes") could make their infrastructure available to others. This infrastructure could be rented out to overnight users. In addition to a possible permanent rent also dynamic models could emerge like booking platforms on the internet. For parking spaces this is already reality, for example through the service ParkatmyHouse[36]. For car-sharing however, this might lead to a complex booking and billing process.

Central Concepts

Nowadays the refueling infrastructure for conventional gasoline powered vehicles is centrally organized. Relatively big gas stations established themselves with a successful "cross selling" approach where not only gas but also many other products are sold.

It is expected that profit margins with selling electricity are far smaller than nowadays with fuel. In order to get a return on a charging infrastructure investment, additional revenues from other services might be necessary.

The combination of a continuous operation (24/7) and a service business (e.g., for a car park), the use of "free" resources (e.g. company car parks) or the installation of charging infrastructure in areas where a longer parking duration

[35] car2go (2012)

[36] ParkatmyHouse (2012)

is admirable (e.g. Park&Ride or supermarkets) seem very promising. Following, these concepts are briefly introduced.

a. E-Car Park (incl. service, "valet charging")

Especially in a car park the installation of charging infrastructure seems very interesting, because in combination with optimized logistics and a range of services, such as for private customers and / or companies (as well as car-sharing) a very high utilization appears possible. Electric vehicle owners without access to charging infrastructure might be dependent on such a service as well as car-sharing providers might consider such a solution (see for example DriveNow in San Francisco[37]). This can be very interesting for realizing additional revenue through vehicle-to-grid (V2G) solutions, where electric vehicles act as energy storage systems, e.g. to store abundant renewable energies. For this, a high utilization and hence a high availability of "the storage" is crucial.

The park operator may additionally offer so-called "valet charging" services, e.g. a provider picks up an empty vehicle from a customer in the evening and delivers it back fully charged in the morning. This could be interesting for car-sharing fleet managers who wish to reallocate their fleet or ask for additional services such as cleaning.

b. E-Company Car Parks ("overnight charging")

Large companies often have parking garages for their employees. These are usually very busy during the day, but in the evening or overnight, they are mostly empty. Charging capacity in these company car parks could therefore be used at least twice a day, during the day by employees with e-vehicles and overnight by private users or car-sharing fleets. For the company which owns the car park this offers additional revenue since they might have to invest in charging infrastructure for their employees, and for electric vehicle users this is an attractive alternative. However, it will be necessary to enable access to the infrastructure and to implement billing systems for this service.

c. E-Park&Ride ("park and ride charging")

In addition to parking garages especially "park and ride" facilities seem to be interesting locations for charging infrastructure. Here, cars usually park long enough to be charged in the meantime. Similarly to the concepts above, this

[37] DriveNow (2012)

concept appears interesting as mainly commuters use the parking and charging facilities during the day and utilization at night could be ensured through charging services. Additional services such as the mentioned valet-parking could bring in even more revenue to these parking operators.

d. eDepot ("depot charging")

Of course, other concepts for organizing charging infrastructure are possible. Sufficiently long parking times are an important prerequisite for economic operation. The above concepts are suitable for both AC load (duration approx. 7 h) as well as for DC loading (full charging time approximately 30min., however this is expensive and has complex technical requirements). Hence, further possible eDepots are malls, supermarkets, cinemas, private garages or backyards (e.g. operation through Property Management). These depots might be of interest for car-sharing customers if they consider charging the car during a booking to extend the range. Alternatively, companies could build up such a depot independent from a possible additional consumer profit to simply fulfill the operational requirement of charging (see car2go in Austin[38]).

A conclusion that can be drawn from this discussion is, that it is important to consider other stakeholders and be flexible when choosing a charging strategy. Conditions and offers might vary locally but overall, central concepts seem to face the challenge best and might be able to combine the interest of customers and car-sharing providers.

7. CONCLUSION

Public Company Accounting Oversight Board (PCAOB)Electromobility provides the advantage of emission-free and efficient mobility. It offers low operating costs and high innovation potential and is thereby a fundamental basis for sustainable mobility.

Car-sharing is one mobility form, which closes the gap between traditional transportation service options. It is advantageous in terms of ecological, economic and social concerns compared to other forms of individual transportation. In addition, the user does not necessarily have to forego any comforts.

[38] Lee (2012)

Combining car-sharing and electric mobility results in a "circulus virtuosis" or in other words a profitable dynamic, because car-sharing and electric mobility are mutually beneficial. The operation of a car-sharing model with electric vehicles makes sense given these considerations even though it is still facing challenges. Apart from the costs, the integration of charging is the most critical success factor for the realization of the concept and its economic success. This paper discusses possible solutions for this problem which appear to be feasible and promising. Especially centralized charging strategies seem promising as they might reconcile car-sharing providers' and customers' needs. Furthermore, car-sharing providers must solve open challenges with suitable new business models and appropriate consumer education. The doubts of the consumers concerning product reliability, price performance ratio and interconnectivity need to be overcome. Moreover, governments have to set appropriate framework conditions for this innovation as a part of a local transportation network. Without this support, the described "circulus virtuosis" turns into a "circulus vitiosus" – a vicious circle of high costs and complex processes. The Paris system is one example of a framework and set of conditions that seems to work well. Cities worldwide can learn from this. Car-sharing with electric vehicles could thus make an important contribution to our future mobility. Our mobility would become more sustainable in the economic, ecological and social aspects of daily life. It could also be a promising strategy for businesses and the automotive industry to cope with global challenges. But this innovation-package appears economically viable once the right internal and external framework conditions are given.

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