Mobility vs. Sustainability

Car Sharing as a Key Concept for Sustainable Mobility in Greater Lisbon

Vivian Felix Oberle

Department of Engineering and Management, Instituto Superior Técnico

Abstract

Individual mobility – not only expression of human needs, but also a prerequisite for the functional and economic capability of today's modern society. Spatial mobility and, subsequently, the choice of transportation mode, is of central significance in this regard. The passenger transport in many European cities, such as in Greater Lisbon, is nowadays still characterized by a predominance of automobiles, not only for reasons of constant availability and high flexibility. Cars are still an expression of status and prosperity, particularly in Southern European countries, as the evolution of the number of passenger cars in the European Union reveals. However, attached to individual car ownership are numerous negative ecological, economic and social side effects, such as noise pollution, land use, traffic accidents, cost of traffic congestions and not least the emissions of harmful greenhouse gases. To counteract the negative consequences of increasing road traffic, sustainable mobility concepts, closely linked to sustainable development, have to further shift into the focus of public interest prospectively. The property-less car usage, the so-called "car sharing," is seen by many authors to offer a highly promising approach to reduce these negative effects of transport mentioned, while preserving the individual mobility. Nonetheless, car sharing concepts are nowadays still far away from reaching widespread use in many European cities, like in Greater Lisbon as well. In order to depict a positive contribution for an increasingly sustainable, innovative and competitive environment in Greater Lisbon, car sharing is investigated from the point of view of sustainable development within the scope of the dissertation. The results demonstrate that an innovative and locally adapted car sharing concept could help to counteract the ecologically and economically unfavorable trend of increasing traffic volume in Greater Lisbon, while highlighting that social acceptance of shared car use is necessary, but alone not sufficient to push such a mobility concept towards a wider spread.

Keywords: Car sharing; Sustainable Development; Greater Lisbon; Mobility; Traffic

1. Introduction

Mobility is indisputably a prerequisite for the functionality and economic performance of the European Union. In fact, the road transportation sector was responsible for 82.6 percent of the total energy consumption in the EU in 2013 (Eurostat 2015b). Excessive use of automobiles, however, is accompanied by various negative consequences, including air and noise pollution, traffic congestions and accidents, as well as global warming. Consequently, a shift away to more sustainable mobility concepts is urgently required. In this context, so-called “car sharing” is seen by many authors as a highly promising approach to reduce the negative effects of transport, while preserving the benefits of individual mobility.

Nonetheless, car sharing solutions have still not become widespread in many European countries. Along this paper, the author analyzes if car sharing could be a key concept for sustainable mobility in Greater Lisbon. In particular, the paper aims at estimating, if shared car usage would have a positive impact on the struggle against the increasing traffic volume in the Portuguese subregion. For this purpose, a location specific car sharing concept is developed at the forefront, and its potential contributions to sustainability are assessed afterwards.

2. Background

2.1. Problem Analysis

Greater Lisbon is a Portuguese subregion, which includes the municipalities of Lisbon, Amadora, Cascais, Loures, Mafra, Odivelas, Oeiras, Sintra, and Vila Franca de Xira. Especially the municipality of Lisbon is daily facing an immense volume of road traffic, which rose by 60 percent from 1991 to 2001 (Emel 2005). The causes of the continuous rising volume of traffic in Greater Lisbon are manifold: population drift to the city, weak public transport system, increasing car ownership, and high proportion of short trips, to name but a few. The consequences are particularly serious, in terms of health (air and noise pollution), environment (global warming), and economy.

2.2. Sustainability

Sustainability, or sustainable development, is a concept that has different meanings at different application levels. A concept that is widely applied and accepted conceptualizes sustainability as the intersection of three overlapping circles, which constitute the social, economic and ecological sphere (compare Figure 1). Aim is to achieve sustainability goals in all three spheres, since sustainable development can only be implemented successfully, if they are considered together as part of the same effort (Hale, Lachowicz 1998).

For the purposes of this paper, the analysis and assessment of the car sharing concept will be based on this simplified conceptualization of sustainability.

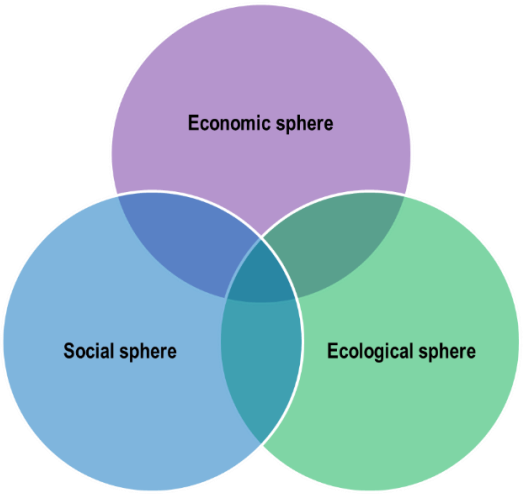

Figure 1. The three dimensions of sustainability (Weaver et al. 2008)

2.3. Product-Service System

A concept that may be linked to sustainability is the so-called “product-service system” (PSS). In the present time, manufacturers shift their focus from selling products only, to providing services. The combination of both, product and service, is able to add value to the customer. Tangible artefacts, the products, shift to the background, since they are often subordinate to the service elements (Cook et al. 2006).

Product-service systems can be classified in the following three categories (Yoon et al. 2012):

[1] *Product-oriented* PSS
The customer is the owner of the product but an additional service is provided.

[2] *Use-oriented* PSS
The service provider owns the product and sells its function.

[3] *Result-oriented* PSS
The service provider owns the product and the customer purchases the utility as an outcome.

Especially the characteristics of *use- and result-oriented* PSS have the potential to contribute to sustainable development (Manzini, Vezzoli 2003). For example, the service provider has an economic interest in keeping the products' operating costs low, since the profit mainly depends on the cost per unit of the service provided. This can only be achieved, if the amount of resources consumed and maintenance required is reduced, which promotes energy efficient and robust products.

2.4. Car Sharing

According to Millard-Ball et al. (2005), car sharing refers "to a service that provides members with access to a fleet of vehicles on an hourly basis". By definition, car sharing can thus be attributed to the category of *use-oriented* PSS, since the ownership of the product is retained by the service provider, who only sells the function of the vehicles. In the sector B2C (business to consumer), the following two business models have established themselves (Le Vine et al. 2014):

[1] *Station-based* car sharing
Fixed rental and return stations that provide additional services, such as kiosks and charging infrastructure for electric vehicles.

[2] *Free-floating* car sharing
Vehicles can be accessed and left in the operators' geographic zones (on-street parking).

Relevant literature shows that such a product-service system may have various positive effects on sustainable development, as represented in Table 1.

Table 1. Effects of car sharing

References	Effects on sustainability
(Briceno et al. 2005)	Car sharing programs are able to reduce the number of cars.
(Rabbitt, Ghosh 2013)	Car sharing can offer reductions of travel related CO_2 and can increase sustainable travel modes.
(Litman 2015)	Households that share a car can save money.
(Firnkorn, Müller 2011)	Car sharing can raise the city attractiveness.

2.5. Barriers Towards Car Sharing

Despite the potential contributions of car sharing to the three spheres of sustainability, the introduction of such a mobility concept involves several risks that need to be considered in advance. One of the main barriers of developed countries is for certain the shift towards "having a transportation need" opposed to "owning a vehicle". Thus, one of the main challenges is to encourage the population to use the offered service, which is naturally a prerequisite for a working business model. Nonetheless, there are other dares identified by the non-governmental global research organization *World Resource Institute* which are distinguished between potential users, infrastructure, and business side. These barriers towards car sharing are summarized in the table below.

Table 2. Barriers to car sharing (WRI 2015)

Category	Barriers
Potential users	Strong desire for car ownership
	Unfamiliarity with car sharing services
	Price sensitivity
Infrastructure	Insufficient public transport
	Insufficient cycling infrastructure
	Limited parking for car sharing
Business	High capital investment
	Limited access to capital
	Potential competition from taxis

3. Method

3.1. Online Survey

In order to be able to evaluate the feasibility of a car sharing concept in Greater Lisbon, it was first necessary to analyze the potential customers in-depth. For this purpose, a web survey was created and spread among the different faculties of the *University of Lisbon*. Following this approach, the survey's target group mainly consisted of students, professors, researchers, and other faculty workers, whereas the first group represented the biggest share. Further response from non-university individuals was obtained by distributing the survey on social networks. The survey consisted of 26 questions, 23 close-ended and 3 open-ended, and covered aspects such as awareness of car sharing, motivation to become a member, and mobility patterns.

3.2. Web Search

Web search made up the second pillar of the analysis, which was focused on the location Greater Lisbon. Relevant information, such as population density and local purchasing power, was obtained from the database of INE (Instituto Nacional de Estatística), the national statistical institute of Portugal, which is headquartered in Lisbon.

Additionally, it was necessary to investigate the local expansion of charging infrastructure in Greater Lisbon, in order to assess if car sharing based on electric vehicles would be feasible in the target location.

3.3. Sustainability Assessment

Based on the insights and findings gained through a literature and web review, an assessment tool, consisting of a set of indicators and an assessment matrix was developed. This tool was used to evaluate the car sharing concept according to sustainability indicators. To follow a pragmatic approach, the subsequent 3-level rating scale was considered adequate: +1 (improvement), 0 (no change), -1 (deterioration). Reference point for the evaluation was the expected evolution of the traffic situation in Greater Lisbon, in the absence of a car sharing service.

4. Results

4.1. Online Survey

The data of the online survey was generated using the online survey software *SurveyMonkey*. The sample consisted of 124 individuals, whereas nearly half of the respondents (48.5%) were students, followed by researchers (20.2%), professors (14.5%), faculty workers (10.5%), and non-university individuals (6.5%). Table 3 shows a brief overview of the most significant survey results.

Table 3. Online survey results

Would you use car sharing?	
Yes	59.4%
Not sure	32.7%
No	7.9%
What are the least attractive features for you?	
Vehicles not available	46.6%
Effort to get to the vehicle	29.3%
Price is too high	27.6%
Vehicles not clean	8.6%
Loss of independence	5.2%
How often would you use car sharing?	
Once a month	18.8%
Twice a month	17.8%
Once a week	13.9%
Twice a week	6.9%
More than twice a week	13.9%
N/A	28.7%
How long would you walk to a vehicle?	
1-5 min	18.8%
5-10 min	38.6%
10-15 min	26.7%
15-30 min	8.9%
N/A	6.9%
Would car sharing change your travel behavior (usage of sustainable transport modes)?	
Yes	49.0%
No	27.5%
N/A	23.5%

What is interesting on top of the data provided in the table is the fact that more than half of the survey

respondents either own a car (56.3%) or have a private car available in the household they are living (32.1%). These cars are mainly used for inner-city short trips to the university or workplace. Hence, most of the time vehicles are idle.

4.2. Web search

An adequate population density was identified as a fundamental prerequisite for success of car sharing. Thus, the web search firstly aimed at investigating the average population density of Portugal and its greatest urban areas. As Figure 2 reveals, Greater Porto and Greater Lisbon represent two urban agglomerations with very high population densities, which are significantly above the national average.

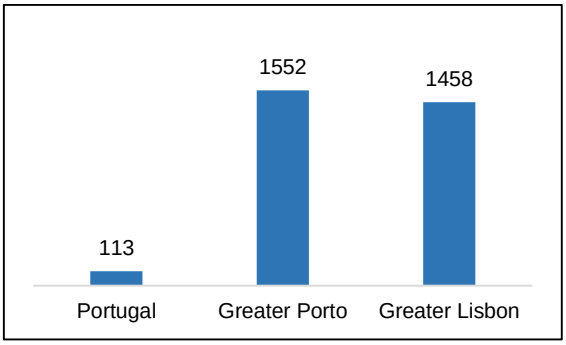

Figure 2. Population density (No./km2) by place of residents in 2011 (INE 2015)

Of particular interest in this context is the fact that the population density of the municipality of Lisbon, which is located in the Greater Lisbon subregion, is particularly high with 6,325 residents per square kilometer.

If the age structure of the target region is taken into account, the findings indicate that most of the individuals (30%) are between 25 to 44 years old (INE 2015). This result suggests that the car sharing target group is sufficiently represented in Greater Lisbon, since, according to mobilaro (2016), most of the car sharing users can be found in this age group. An additional target group car sharing providers recently discovered are students (mobilaro 2016). Once again, on this point too, Greater Lisbon offers an attractive location with 119,340 students enrolled in the academic year 2014/2015.

After gaining these positive insights, the charging infrastructure in the Portuguese region was analyzed, in order to be able to answer the question, if a car sharing concept based on electric vehicles would be feasible. It established that Portugal has set the objective of having ten percent of the traffic energy consumption coming from renewable energies by 2020 (MOBI.Europe 2012). For this reason, a nationwide electro-mobility initiative was launched in 2008, whereby a network of about 1,000 charging points was established (MOBI.Europe 2012). Especially densely populated regions profited from the initiative, as Figure 3 shows. The charging network in Greater Lisbon is very well developed, particularly in the municipalities of Lisbon as well as along the south coast from Oeiras to Cascais.

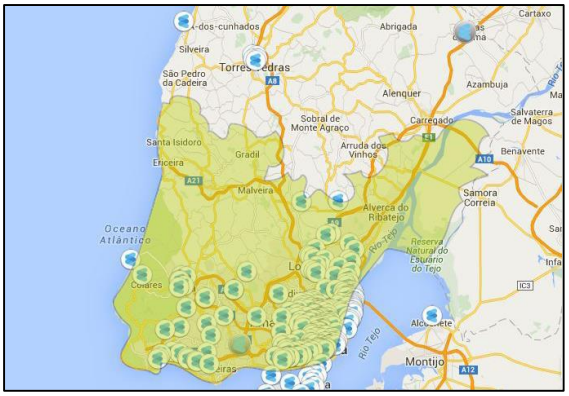

Figure 3. Charging network in Greater Lisbon (MOBI.Europe 2016)

4.3. Opportunities for Greater Lisbon

The previously conducted customer and location analysis reveals that the car sharing starting conditions in Greater Lisbon are positive on the whole. Surveys' respondents showed overall a positive attitude towards car sharing and especially the current mobility patterns (inner-city short trips) make shared car usage an attractive option. However, due to the relatively low number of survey participants further research would be necessary to reach definite conclusions about the social acceptance of shared car usage.

The site specific criteria, like the population density, the age distribution as well as the charging

network expansion clearly speak in favor of launching a car sharing service in Greater Lisbon. According to Millard-Ball et al. (2005), car sharing offers the highest potential in densely populated urban agglomerations with scarce parking, since car ownership gets less attractive in such areas. Residents have to walk to their cars, since parking without problems in front of the house is often not possible. Thus, they would also be willing to walk the same distance to a car sharing location (Millard-Ball et al. 2005).

5. Concept Introduction

5.1. Vehicle

Several vehicle scenarios were studied and characterized as a first step of the concept development, in order to identify the vehicle, which fits the local requirements of Greater Lisbon best. The focus here was on three cars that have already established in the fleets of existing car sharing providers: the *smart fortwo electric drive*, the *BMW i3,* and the *VW up!*. Basis for the final selection offered the so-called "weighted objectives method". Within the framework of this technique, criteria have to be selected at the forefront, in order to choose between different alternatives (van Boeijen et al. 2013). Since the development of a sustainable mobility concept is the overarching goal, the author selected criteria which reflect the three spheres of sustainable development best.

The analysis showed that the *smart fortwo electric drive* (compare Figure 4) fits the local requirements of Greater Lisbon best, and is the most appropriate vehicle to meet one major goal of the White Paper "Roadmap to a Single European Transport Area – Towards a competitive and resource efficient transport system" published by the European Commission in 2011. The document recommends the use of "smaller, lighter and more specialized road passenger vehicles". This appears particularly important in connection with the conducted online survey, where single person trips (29.5%) and 2-person trips (47.3%) to the university or workplace were the most common reason for travelling by vehicle in Greater Lisbon. Thus, in almost 80 percent of the cases a car with two seats, like the *smart*, would be a sufficient, and at same time resource saving vehicle.

Figure 4. *Smart fortwo electric drive*

5.2. Business Area

Once a decision has been reached on the car sharing vehicle, the exact business area was determined subsequently. Millard-Ball et al. (2005) have already identified several "success factors" that need to be given at a potential car sharing market. These characteristics include:

- *Parking pressure*
  Car ownership is less attractive in areas with a lack of parking space.
- *Ability to live without a car*
  Car sharing does not meet the entire mobility needs, a good public transport connection is thus required.
- *High density*
  High population density means a large customer group in walking distance.
- *Mix of uses*
  Business members may increase the utilization of the service since they use the cars during the workday.

Those conditions are obviously highly correlated. A lack of parking space is most likely given in densely populated urban areas, which have normally good connections to public transportation. Analyzing the location Greater Lisbon according to Millard-Ball's success factors comes to the conclusions that only three of the nine municipalities should be included in

the car sharing service area. As Table 4 demonstrates, Amadora, Odivelas, and Lisbon are the three communities with the highest population densities in the region. Furthermore, they are well connected to high speed public transportation, which is given by the subway in the present case.

Table 4. Service area characteristics (INE 2015)

	Population density (No./km^2)	**Population** (No.)	**Area** (km^2)
Amadora	7,397.7	175,136	23.7
Odivelas	5,758.1	144,549	25.1
Lisbon	5,090.4	547,733	107.6
Oeiras	3,769.6	172,120	45.7
Cascais	2,149.6	206,479	96.1
Loures	1,224.0	205,054	167.5
Sintra	1,193.3	377,835	316.6
Vila Franca de Xira	439.7	136,886	311.3
Mafra	278.4	76,685	275.4

Having determined the service area, an appropriate number of car sharing vehicles has to be estimated. As already established previously, there are two types of service strategies: *station-based and free-floating* car sharing. The online survey results reveal that potential users wish to have vehicles nearby in one to ten minutes walking distance. When they were asked about features that seem most unattractive in joining a car sharing service, 29.3 percent of the respondents have chosen the option "distance / effort to get to the vehicle". Thus, *free-floating* car sharing, which allows spontaneous access to parked vehicles may be a more appropriate strategy.

Transferring these insights into the distance calculator of the maps tool *google maps* shows that six minutes' pedestrian travel time results in a distance of 500 meters. Hence, two cars per square kilometer would be necessary to reduce the chance to walk more than 10 minutes. Talking into account the total service area of 156.4 km^2 thus implies a number of around 313 car sharing vehicles. However, random parameters such as customers' response and competitors' action have to be taken into consideration to get to a more accurate number.

5.3. Service Details

Having established that a free-floating car sharing service with around 313 *smart fortwo electric drive* would be an appropriate mobility concept for Amadora, Odivelas, and Lisbon, the precise rental transaction is described in this section. The main steps of the rental process are:

[1] *Pre-registration*
The pre-registration is done online, whereby the user most provide his / her name, address, and age. ID and driver license have to be presented to a service staff member in a local office. On this occasion, the user has the opportunity to acquire a smart card, which allows keyless access to the service vehicles.

[2] *Find*
After the pre-registration, the user is able to use the service autonomously without contacting staff members. To find vehicles within the operating zone, two different devices can be used – either a smartphone or a computer with internet access.

[3] *Book*
Having identified the nearest vehicle, the user can place a reservation over 30 minutes in order to get to the car. Other users do not have access to the car during this period.

[4] *Access*
After arriving at the vehicle, the user has two different options to access. The first option requires a smartphone with internet access. The provider's application has to be started, and the smartphone has to be approached afterwards to an in-vehicle validator located behind the windscreen. The second possibility for access is per smartcard.

[5] *Evaluate*
After entering, the user has to evaluate the condition of the car on an integrated user terminal.

[6] *Use*

Finishing the evaluation allows the customer to start the engine. The ignition key is electronically secured and stored in the vehicle.

[7] *End*

If the user wishes to end the vehicle rental, he has to put the ignition key into the intended position in the vehicle interior. Afterwards, he has to close the doors and to approach smartphone / smart card to the validator again. Vehicles can be parked costless in freely accessible locations.

6. Sustainability Assessment

For a better clearness, the results of the sustainability assessment were divided according to the three spheres of sustainability. The impact of the car sharing concept on these three dimensions is described hereafter.

6.1. Ecological Performance

The impacts of the elaborated concept on the ecological sphere of sustainability can be considered positive overall. Greater Lisbon is currently struggling with breaches of PM_{10} and NO_X levels measured at the traffic station *Avenida da Liberdade* in Lisbon (BUND 2014). A concept based on electric vehicles thus may help to counteract this trend by reducing these harmful emissions, which would have a positive impact on the quality of life of the people residing within the service area. Furthermore, car sharing users tend to lower their annual mileages, which should also contribute to a favorable evolution.

The CO_2 reduction potential of the concept is more difficult to assess, as several factors (e.g. country-specific energy generation, different life-cycle stages of the vehicle) have to be considered. According Daimler AG (2016), driving an electric-powered *smart* saves 28 percent of greenhouse gases compared to the gasoline-driven counterpart. However, this number is based on the EU electricity mix, and thus varies greatly from one country to another, depending on the share of renewable energies. It is interesting to mention that the share of energy from renewable sources in Portugal was steadily increasing from 2010 to 2013. This trend is likely to continue until 2020, which would result in 31 percent energy from renewable sources (Eurostat 2015a). Thus, a car sharing concept based on electric vehicles would be a great opportunity for Portugal to raise the share of renewables in transport. Further advantages that may come along with the introduction of the concept are:

- Reduced noise pollution
- Reduced land use
- Reduced resources and energy consumption

Transferring these insights into the initially described assessment tool resulted in an average value of 0.75. This suggests that the elaborated car sharing scheme would bring genuine ecological improvements.

6.2. Economic Performance

The economic performance of the car sharing concept can be further divided between provider and customer side. The contributions to the financial performance on the provider side, however, are hard to assess, but may potentially be very large: gaining access to the car sharing market in Greater Lisbon could be a major opportunity, since the competition is quite low. Currently, there is only one small car sharing operator, which serves exclusively inhabitants of Lisbon.

Potential cost savings on the customer side are easier to evaluate, since more and more information has become available. Individuals that decided to use car sharing exclusively can save much money on transportation, as a study of Carsharing-Experten (2016) has revealed. The experts considered two different used vehicle scenarios (small and large car), and calculated the costs per kilometer. At a low annual mileage of 5,000 kilometers car sharing clearly outperformed vehicle ownership.

To follow a holistic approach, economic changes to the municipality have to be taken into consideration as well. However, the changes in financial expenses in roadbuilding can hardly be estimated, but will most likely not change in the near future. Nevertheless, road congestions and accidents

may be reduced, since the overall traffic volume may be decreased by the concept.

The overall assessment of the ecological performance resulted in an average value of 0.3. Hence, the concept may also contribute to a favorable evolution of the economic sphere, but to a smaller extent.

6.3. Social Performance

The indicators that reflect the social performance of the concept are partially linked to the ones used to assess the ecological behavior. It was already established that trend changes regarding air and noise pollution may be achieved by the introduction of car sharing based on electric vehicles. Prevention / reduction of inner-city air and noise pollution would consequently have a positive impact on public health and well-being.

If additional aspects like the commonly good maintenance and low age of car sharing vehicles are taken into consideration, one further contribution to the social sphere can be identified: the risk of road accidents can be meaningfully reduced, which is of particular importance in Greater Lisbon, where many old and badly maintained vehicles can be seen on the roads.

Finally, other positive impacts on the quality of life in Greater Lisbon should be mentioned. Citizens who cannot afford a private vehicle would gain better access to individual, but nevertheless sustainable mobility. Especially job seekers may thereby raise their opportunities for access to employment, if a vehicle is needed for job searching and employment. During the concept development, special emphasis was placed on avoiding social disadvantages. Thus, cars may be accessed via smart card – a (costly) smartphone with permanent internet access is not required.

Assessing the overall contribution to the social sphere of sustainability results in an average value of 0.875, which reflects the highest (positive) value obtained in the course of the sustainability evaluation. Social improvements through the implementation of the car sharing concept in the Greater Lisbon region are to be expected in the foreseeable future.

7. Conclusions

In the framework of the present paper, the environmental impact of *free-floating* car sharing in Greater Lisbon was forecasted, based on a designed service concept, using a wide portfolio of sustainability indicators. It is found that a car sharing scheme based on electric vehicles may offer many advantages, like cost savings to members, reductions of travel related CO_2 emission, and an overall improvement of the quality of life in the region. The proposed service model may counteract the unfavorable trend of the increasing traffic volume, since the research revealed that car sharing members reduce their annual mileages, and increase their share of sustainable modes of travel. However, it should be emphasized that any car sharing system should be developed complementary to the public transport system, since car sharing alone is not sufficient to satisfy the variety of mobility needs. Hence, further investments into public transport, as well as into the building of cycle paths and sidewalks should be triggered in Greater Lisbon prospectively.

References

Briceno, Tania; Peters, Glen; Solli, Christian (2005): Using life cycle approaches to evaluate sustainable consumption programs. Car-shring. Norwegian University of Science and Technology.

BUND (2014): Soot-free Cities. A European city ranking on best practices on air pollution reduction from transport. Available online at http://www.sootfreecities.eu/city/lisbon.

Carsharing-Experten (2016): Kostenvergleich: eigenes Auto / Carsharing. Available online at http://www.carsharingexperten.de/infos/kostenvergleich-eigenes-auto-carsharing kostenvergleich, checked on 8/9/2016.

Cook, M. B.; Bhamra, T. A.; Lemon, M. (2006): The transfer and application of Product Service Systems. From academia to UK manufacturing firms. In *Journal of Cleaner Production* 14 (17).

Daimler AG (Ed.) (2016): Environmental brochure. smart fortwo electric drive. Available online at https://www.daimler.com/bilder/nachhaltigkeit/produkt/umweltzertifikate/englische/2243139-environmental-brochure-smart-fortwo-electric-drive.pdf.

Emel (2005): Plano de Mobilidade de Lisboa. Propostas para a Gestão da Mobilidade na Cidade de Lisboa no Contexto dos Diferentes Cenários de Futuro.

European Commission (2011): Roadmap to a Single European Transport Area – Towards a competitive and resource efficient transport system.

Eurostat (2015a): Renewable energy in the EU. Available online at http://ec.europa.eu/eurostat/documents/2995521/6734513/8-10032015-AP-EN.pdf/3a8c018d-3d9f-4f1d-95ad-832ed3a20a6b.

Eurostat (2015b): Sustainable development in the European Union. 2015 monitoring report of the EU Sustainable Development Strategy.

Firnkorn, Jörg; Müller, Martin (2011): What will be the environmental effects of new free-floating car-sharing systems? The case of car2go in Ulm. In *Ecological Economics* 70 (8), pp. 1519–1528. DOI: 10.1016/j.ecolecon.2011.03.014.

Hale, Monica; Lachowicz, Mike (1998): The environment, employment, and sustainable development. London, New York: Routledge.

INE (2015): Statistics Portugal. Instituto nacional de estatística. Available online at https://www.ine.pt/xportal/xmain?xpid=INE&xpgid=ine_indicadores&indOcorrCod=0001005&contexto=bd&selTab=tab2, checked on 4/1/2016.

Le Vine, Scott; Zolfaghari, Alireza; Polak, John (2014): Carsharing: Evolution, Challenges and Opportunities.

Litman, Todd (2015): Evaluating Carsharing Benefits. Victoria Transport Policy Institute. Available online at http://www.vtpi.org/carshare.pdf.

Manzini, Ezio; Vezzoli, Carlo (2003): Product-service Systems and Sustainability. Opportunities for sustainable solutions. [Paris]: UNEP.

Millard-Ball, Adam; Murray, Gail; Fox, Christine (2005): Car-Sharing: Where and How It Succeeds. Available online at http://onlinepubs.trb.org/onlinepubs/tcrp/tcrp_rpt_108.pdf.

MOBI.Europe (2012): MOBI.E. Available online at http://www.mobieurope.eu/the-project/ongoing-initiatives/mobi-e/, checked on 4/2/2016.

mobilaro (2016): Die Carsharing Zielgruppe. Available online at http://www.mobilaro.de/carsharing/4373-die-carsharing-zielgruppe, checked on 4/1/2016.

Rabbitt, Niamh; Ghosh, Bidisha (2013): A study of feasibility and potential benefits of organised car sharing in Ireland. In *Transportation Research Part D: Transport and Environment* 25, pp. 49–58. DOI: 10.1016/j.trd.2013.07.004.

Van Boeijen, Annemiek; Daalhuizen, Jaap; Zijlstra, Jelle; van der Schoor, Roo (2013): Delft design guide. Design methods. Amsterdam: BIS.

Weaver, Alex; Pope, Jenny; Morrison-Saunders, Angus; Lochner, Paul (2008): Contributing to sustainability as an environmental impact assessment practitioner. In *Impact Assessment and Project Appraisal* 26 (2), pp. 91–98. DOI: 10.3152/146155108X316423.

WRI (2015): Carsharing. A Vehicle for Sustainable Mobility in Emerging Markets? Available online at http://www.wri.org/sites/default/files/WRI_Report_Carsharing.pdf.

Yoon, Byungun; Kim, Sojung; Rhee, Jongtae (2012): An evaluation method for designing a new product-service system. In *Expert Systems with Applications* 39 (3), pp. 3100–3108. DOI: 10.1016/j.eswa.2011.08.173.