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Small and Light Electric Vehicles: An Analysis of Feasible Transport Impacts and Opportunities for Improved Urban Land Use

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Abstract: Improvements in battery technology have resulted in small and light electric vehicles (LEVs) appearing on the market in Europe since 2011—however, their market share is still comparatively low. Low energy requirements and small size can potentially contribute to sustainable mobility in terms of climate protection and reduced local emissions. Our study evaluates how three-wheeled and four-wheeled vehicles, categorised as L-Class according to Regulation (EU) No 168/2013, can contribute to more efficient use of space in urban areas. Evaluations of expert interviews, an extensive literature research, and analyses of the German national household travel survey (MiD) serve as the basis of the study. First, the substitution potential of trips through LEVs is explored using MiD data. Our findings show that between 17% and 49% of trips made and 6% to 30% of the distance covered by private trips can theoretically be substituted by LEVs. Thus, reorganisation of current land use offers potential and additionally, LEVs are an attractive and sustainable addition to other means of transport and contribute to achieving the climate protection goals of the transport sector. Due to the fact that technology application is restricted by travel behaviour and political support, our study discusses possible support by public bodies towards sustainable mobility. Here, the promotion of LEVs in combination with restrictive measures for cars is necessary.

Keywords: LEV; light electric vehicles; urban land use; urban mobility; small electric vehicles

1. Introduction

Cities today face problems resulting from increased mobility needs, which are often still tied to private car ownership and auto-centric transport infrastructures that have grown historically. This situation is compounded by urbanisation and population growth in many cities. Therefore, cities struggle with bad air quality, high noise emissions [1], a lack of space, and structures with low attractiveness for public spaces. Land used for transport infrastructure takes up a considerable proportion of the total area. For example, in large German cities, an average of 12% of land area is used for transport; in terms of residential areas, this figure is as high as 25% [2]. Furthermore, transport is accountable for a high proportion (25% in EU-28 2017 (including international aviation)) of greenhouse gas (GHG) emissions [3,4], 72% of which is due to road transport [5]. The European Commission estimates urban mobility to be responsible for 40% of all European road transport CO_2 emissions, which shows the importance of sustainable urban transport for climate protection [6]. In view of the Paris Climate Agreement 2015 to limit global warming to 1.5 °C, a significant transformation of the transport sector is required.

Different social transformation processes can be observed regarding social developments and mobility patterns, as well as the choice of mode and vehicle type. In connection with digitalisation, user-oriented and demand-oriented mobility services (e.g., car sharing) are becoming more popular in cities. A wide range of mobility services take into account the megatrend of individualisation, and push the necessity of car ownership, especially within the younger generation, into the background [7–9]. At the same time, owning a private car is still an important status symbol within the population, which is evident by the high share of car users in the modal split and the increasing motorisation rate in Europe [10,11]. Contrary to the current climate debate, figures from new registrations show that there is a trend towards large and heavy vehicles, such as sports utility vehicles (SUVs) [12,13]. Their negative contribution to climate protection appears to play a subordinate role in the purchasing decision, whereas comfortably getting in and out of the vehicle and a high level of safety for passengers seem to be the more important criteria.

A key element in urban mobility planning for many cities today is promoting ecologically, socially, and economically sustainable mobility options. Light electric vehicles (LEVs) below the United Nations Economic Commission for Europe (UNECE) M1-category can be an element in sustainable mobility concepts within urban and rural areas, if they replace conventionally sized passenger cars. Category M1 comprises vehicles that are designed and constructed for the carriage of passengers, with up to eight seats in addition to the driver's seat. Conventionally sized passenger cars usually belong to class M1 and are hereinafter referred to as "cars" in distinction to LEVs. LEVs require less energy and resources for production and operation than cars and occupy less space in stationary and flowing traffic. These characteristics make it worthwhile to investigate their use in urban areas in particular, as available space is scarce and strict regulations have been introduced to improve air quality (e.g., diesel bans) in some cities. LEVs are also well suited for mobility needs and the traffic situation in cities, characterised by low speeds and short trips. As a contribution to attractive urban neighbourhoods, LEVs offer potential for mobility chains that include local public transport (PT) and active modes such as walking and cycling. They can be integrated into modern PT concepts and sharing concepts or enable individual mobility. This could help to manage routes for which public transport is not suitable due to very low demand. LEVs may also be attractive for trips requiring the movement of heavy objects or where users are physically restricted. However, implementing LEVs as a mobility option requires rethinking in society and politics.

Whereas great effort is being made in research on topics such as alternative power trains, automated driving, and lightweight technologies for passenger cars in order to achieve climate protection targets, the vehicle itself remains mostly unaffected by existing concepts. The fundamentally different LEV concept currently receives little scientific attention. While LEVs have already reached a considerable market share in Asia, LEV sales in Europe are still very low [14]. In this respect, there are hardly any studies with a global perspective in relation to potential market penetration [15]. Research topics that have received more focus include: safety of LEVs [16–22], user requirements [23–25], and more rarely, cost optimisation [26,27]. In addition, several research vehicles are being developed, such as the Safe Light Regional Vehicle (SLRV) from the German Aerospace Center, the CityCar from the MIT Media Lab, and a vehicle for the older generation in the EU-funded SilverStream project [28]. Furthermore, since 2011, large original equipment manufacturers (OEMs) have produced different concept studies which, in most cases, do not reach series production. In terms of automation, startup company StreetDrone has developed a research vehicle for connected and automated driving [29]. Automated concepts, such as the Renault EZ-POD [30], can be important in the long term; however, vehicles that can be used in the medium and short term are highly relevant for a rapid transformation to more climate-friendly transport.

Given that LEVs are not widespread in terms of sales and research activities, our study examines the extent to which, and by what means, these vehicles can be used. Possible effects on transport through the implementation of LEVs in Germany are examined. In the following sections, an analysis of the general traffic potential is highlighted, showing the maximum substitutable potential of trips and mileage using data from the national household travel survey "Mobility in Germany (MiD)" 2017. Subsequently, possible optimisation of land use in urban areas is discussed, combined with the opportunities and advantages that come with the use of LEVs in this regard. In principle, LEVs are suitable for driving in both urban and rural areas. Depending on the area of application, vehicle requirements can vary, e.g., with regard to trip length or desired maximum speed.

Finally, recommendations for action and framework conditions resulting from expert interviews are put forward. For this study, the existing literature and statistics were analysed, complemented by interviews with experts from industry and research.

2. Definition of LEVs

The term light electric vehicle or LEV is currently not clearly defined and covers a wide array of different vehicles ranging from micro mobiles, such as eScooters, through to light four-wheeled vehicles. For this analysis, the focus is on LEVs with three and four wheels. According to European classification, these categories relate to L2e, L5e, L6e, and L7e (EU Regulation No 168/2013).

3. Materials and Methods

The content of our study was derived using three methods. First, an analysis was conducted of the substitution potential of LEVs using data from the "Mobility in Germany (MiD)" survey. Second, land use and potential savings through LEVs were analysed using literature research and analyses of existing data. Third, a discussion on framework conditions and recommendations for action was derived from expert interviews.

3.1. Quantitative Analysis: National Household Travel Survey "Mobility in Germany"

The usage potential was analysed using data from the "Mobility in Germany (MiD)" survey. The MiD is a nationwide and representative household travel survey of the German residential population. The MiD is a one-day survey with each participant reporting their mobility on a given day—namely, the survey day. The survey was conducted between May 2016 and September 2017. A total of around 316,000 individuals from 156,000 households participated and reported 961,000 trips on their respective survey days. A comprehensive overview of the survey design, sample characteristics, and survey results can be found in the MiD Outcomes Report [31].

In order to estimate the feasible transport impacts and user potential of LEVs in passenger transport in Germany, the following analyses were examined on the basis of the MiD 2017 dataset. First, the share of passenger transport trips and mileage that could be covered by LEVs was analysed. Second, the type of trips for which LEVs could be used was examined.

For the analysis, we selected three characteristic LEVs that represent different L-categories according to Regulation (EU) No 168/2013. We analysed which of the reported trips in the MiD survey these LEVs models can be used for. LEVs on the market are mostly developed and produced by startups and suppliers for original equipment manufacturers (OEMs). There are also small and medium sized companies that are well-known in the market segment such as Swiss firm KYBURZ, which produces LEVs for the Swiss Postal Service and other postal service providers around the globe. LEVs manufactured by OEMs, in contrast, are not widely seen on the market. In terms of passenger transport, the Twizy by Renault is the most famous LEV, and Renault is the only OEM with a series product (as of 2019). In addition, Toyota offers the iRoad and COMS models for car sharing services. Since 2017, several OEMs such as Seat, Honda, Toyota, and Citroen have published studies on LEVs.

Although the models evaluated in this study [32] comprise a wide range of vehicles, the analysis was limited to three characteristic LEV models with diverse vehicle characteristics: the EVT Trike (L3e), the Aixam eCity Pack (L6e), and the Microlino from Microlino AG (L7e). The vehicle characteristics, as shown in Table 1, were compared with corresponding data for each individual trip chain in the MiD. Only if all aspects and LEV model characteristics were applicable was it assumed that an LEV could be used on this trip chain. We took into consideration the following aspects:

- Is the battery range of the LEV sufficient for the distance covered?
- If the person is accompanied by others, does the LEV offer additional seats?
- If goods need to be transported, does the LEV have facilities that allow the transport of such items?
- Is the permissible maximum speed of the LEV consistent with the road infrastructure that was used on the trip chain? (Estimation based on the average speed on the longest trip of the trip chain).
- If a driving license is required for the LEV, does the survey participant have the appropriate driving license?
- Does the LEV have sufficient weather protection to enable its use even in unfavourable weather conditions?

If a trip chain meets all of the above requirements, we assume that an LEV can theoretically be used for those trips. However, trips need to cover a distance of at least 800 m, as shorter trip chains do not justify the time required to get ready and start a trip with an LEV.

Table 1. Vehicle and usage characteristics of various LEV models, suited primarily for passenger transport.

	EVT Trike	Aixam eCity Pack	Micromobility Systems Microlino
			
Range [km] [1]	70	75	140
Seats	2	2	2
Goods volume [L]	approx. 10	700	300
Maximum speed [km/h]	45	45	90
Driving license required	yes	yes	yes
Weather protection	no	yes	yes

[1] Estimated on the basis of information provided by manufacturers.

When evaluating this potential, four aspects need to be considered. First, it needs to be taken into account that this calculated potential would not be fully exploited in real life, because other aspects, such as personal preferences or willingness to purchase an LEV, impact mode choice. Second, the analysis refers to entire trip chains, not single trips. An LEV might be suitable for single trips of a multi-modal trip chain; for example, with sharing services, which is not considered here. Third, other criteria could be applied for determining the theoretical suitability of vehicles for single trips or entire trip chains; for example, weather protection might be of secondary importance for some users. Fourth, it should be noted that no conclusions can be drawn from the one-day survey data of the MiD 2017 on the travel behaviour of individuals and LEV user potential over longer periods of time. Consequently, no conclusions can be drawn from the MiD information about LEV user potential for single individuals from a longitudinal perspective. Overall, the analyses make it possible to quantify the share of reported trip chains for which LEV are suitable according to a defined set of requirements and trip chain specifications.

3.2. Potential of Rededicating Urban Spaces that are Currently Occupied by Cars

In order to demonstrate the potential of optimised land use in urban areas, a mixed-method approach was chosen, which combines the results of a literature search, statistical data on the use of urban areas, technical and statistical data on vehicles, and the results from expert discussions. Statistical data were mainly collected from three sources: figures provided by the German Federal Motor Transport Authority (Kraftfahrt-Bundesamt (KBA)); an overview of dimensions of available car models on the website automobiledimension.com; and various manufacturer websites. The data analysis was complemented by conclusions drawn from expert discussions that were part of an exchange dialogue “Strategiedialog Automobilwirtschaft Baden-Württemberg (SDA BW)”, a platform for institutional cooperation. An SDA BW working group "Land Use for Future Mobility" evaluated the issue of land use in several workshops with representatives from the state administration and local authorities, the automotive industry and transport companies, environmental organisations, and the sciences. The potential of LEVs was presented and discussed, among many other topics, within the working group. The discussion results are summarised in a recommendation paper, which is publicly available [33]. Additionally, they serve as a basis for land use potential presented in Section 4.2.

3.3. Qualitative Analysis: Expert Interviews

Recommendations for action were based on 15 expert interviews with stakeholders from industry, research, and public administration that were carried out between December 2018 and February 2019. They were partly conducted in person and partly via telephone. The interviews were guided interviews with an average length of one hour. The experts mostly consisted of vehicle manufacturers (7 interviews) but were also from federal state ministries (2), research (1), suppliers (3), and one importer of LEVs. Since the market for LEVs is very small in regard to European manufacturers, the circle of experts is also very limited. For this reason, the selection of experts was based on the available companies and, in terms of public institutions, on the geographical environment considered for the commissioned study. The selected manufacturers and suppliers range from small companies with a startup character through to OEMs. Interviewing the various stakeholders allowed a more comprehensive view to be generated. The questions covered three main content areas. The use, market potential, and manufacturing of LEVs were examined in order to derive recommendations for action. The third content area (manufacturing of LEVs) covered technical aspects such as component specifications. This last part is not considered in the presented analysis. Results of the discussions regarding recommendations for action are found in Section 4.3.

4. Results

The results show different aspects of LEVs in urban areas. In general, LEVs can be deployed in various applications. Like other modes of transport, they can be used privately; for example, for commuting. Furthermore, many models offer the possibility to transport goods, which makes them also feasible for shopping trips. LEVs can also be used in last or first mile trips in conjunction with public transport. This is one option for using these vehicle concepts in sharing systems. Like most bike sharing concepts, parking spaces can be set up in the vicinity of public transport stops to ensure seamless mobility when switching from an LEV to public transport. Even though commercial transport was also analysed for the study [32], this paper only focuses on passenger transport.

4.1. Feasible Transport Impacts and User Potentials of LEVs

The indicator for the transport potential of LEVs in this analysis is a theoretical substitution potential of the number of trips and the distance travelled. Our MiD data analysis indicates that up to between 17% and 49% of trips made, and between 6% and 30% of the distance covered by private trips, can theoretically be substituted by LEVs (see Figure 1). The theoretical substitution potential varies strongly between LEV models; in particular, battery range and maximum speed restrict the substitution potential.

The share of trips for which LEVs are suitable was analysed with regard to modes of transport that were used by survey participants. These modes were: by foot, bicycle, private passenger transport, and public transport (PT). LEVs are particularly sustainable for replacing private car trips. Figure 2 shows that LEVs compete with active modes and PT as well. LEV models with lower range and maximum speed have a particularly good substitution potential for active modes. While the EVT Trike could replace about 25% of trips by foot and more than 30% of trips by bike, those trips that are made by car only accounted for 11%. In contrast, the Microlino, which has a higher range and maximum speed, is better suited for substituting private motorised passenger transport (57%). However, this vehicle is also suitable on trips for which participants chose active modes; it could be used for 46% of trips by foot and 57% of cycle trips. A major reason why LEVs could not be used on more walking or cycling trips is that some of the vehicle models considered require a driving license. Not all participants who travelled by foot or by bicycle on the survey day have the appropriate driving license. Although trips with active modes are usually within the battery range of LEVs, no higher degree of substitutability is feasible because either a driving license is often required to use the LEV or trip chains by foot are shorter than 800 m.

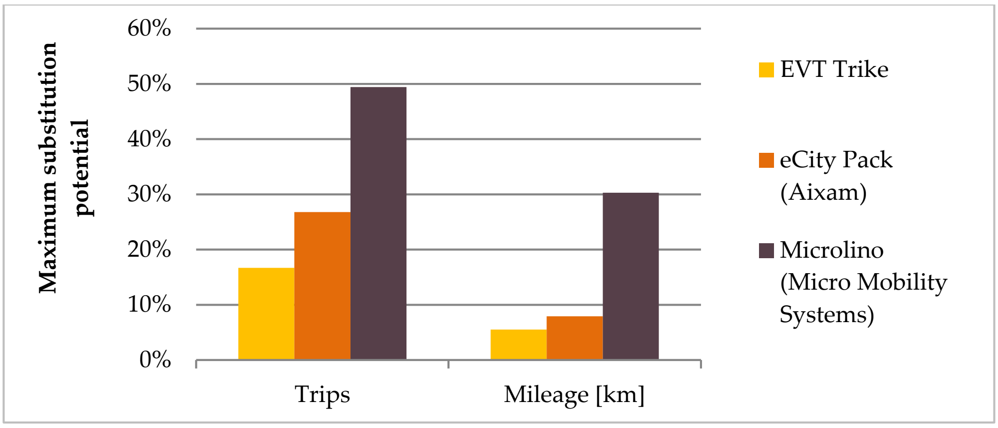

Figure 1. Maximum substitution potential for traffic volume and transport performance (DLR, own calculations based on MiD 2017).

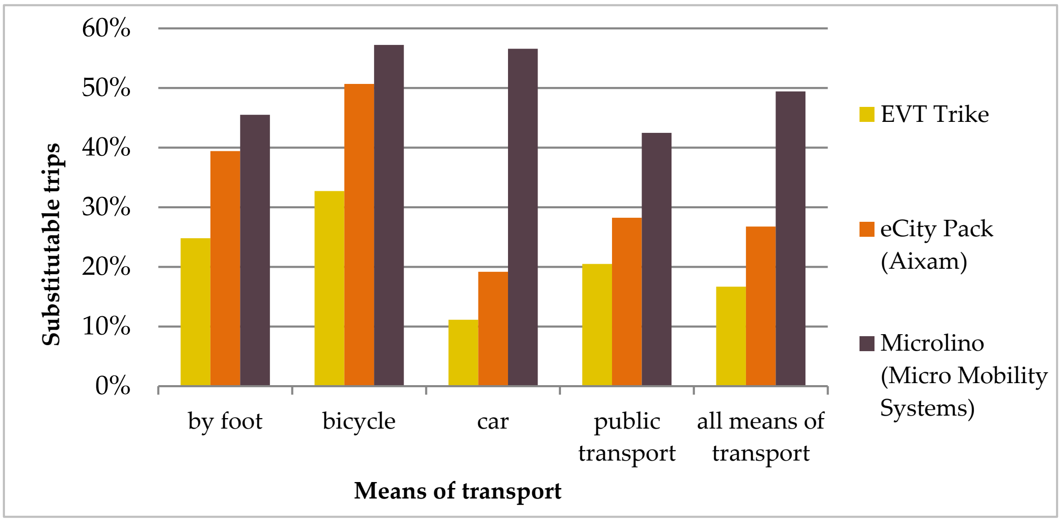

Figure 2. Replaceable trips depending on mode of transport of trips made (DLR, own calculations based on MiD 2017).

As the figures presented are derived by analysing the theoretical substitution based exclusively on trip characteristics, such as trip chain length or number of passengers, no conclusion can be drawn regarding user preferences. Hence, it is not possible to assess the most probable modal shift with this study. The analysis was carried out to provide the theoretical substitution potential of LEVs in order to be able to evaluate if more detailed studies are required. We hypothesise that there will be no large-scale replacement of active modes. If, as a scenario, fundamental changes in transport framework conditions were to take place and include both reducing privileges for cars and encouraging the use of LEVs, LEV usage might rise. We assume that promoting the uptake of LEVs by making car transport more unattractive, e.g., with high parking costs or tolls, would not reduce active modes of transport such as walking and cycling. Promoting LEVs with incentives (e.g., through purchase subsidies) might increase the attractiveness of buying an LEV instead of another form of transport such as electrically power assisted cycles (EPAC). This should be analysed in detail in further studies. If, in another scenario, the transport system were, in general, to stay the same, we agree with the interviewed experts in not expecting significant shifts from any type of mode to LEVs, as they have been available on the market for many years. Hence, absolute LEV numbers would probably remain low.

4.2. Optimising Urban Areas by Replacing Passenger Cars with LEVs

Some of today's problems related to cars, such as poor air quality or high noise emissions, could be solved by replacing the combustion engine with an electric drive. This can be implemented in car-sized electric vehicles (EV) as well as in LEVs. EVs have gained popularity in recent years albeit to a very low extent, when measured in absolute numbers, with market shares of 2.6% of global car sales and 1% of global car stock in 2019 [34]. Although EVs might help to address urban problems such as air quality by not emitting combustion engine related pollutants, other problems, such as scarcity of space and car-dominated cityscapes, remain unchanged. Additionally, the contribution of EVs towards mitigating global threats, such as climate change and scarce resources, is limited as long as energy and material consumption of the vehicles cannot be significantly reduced. Comparing different transport modes demonstrates the energy efficiency of LEVs as opposed to cars and the relation to other transport options such as EPACs or collective transport. EPACs are very energy efficient with 1 kWh/100 passenger kilometres [35], e-motorbikes require around 4.8 kWh/100 passenger kilometres [35], LEVs typically need 6–9 kWh/km for up to 2 passengers [32], and electric passenger cars 13–21 kWh/km for up to 5 passengers [36].

Although the energy demand of LEVs is relatively low, for sustainable operation it is important to generate the electricity for charging from renewable sources. The small amounts of energy and low charging power place relatively low requirements on the charging infrastructure. Charging at home, for example in combination with decentralized renewable energy generation, can hence be realized with comparatively little effort.

Analysis of the MiD reveals that the theoretical potential of replacing car trips with LEV trips is very high, at more than 50%. This suggests it would be beneficial to evaluate possible improvements in urban areas for a scenario with high LEV use. LEVs, with their small size and low consumption, have the potential to improve the quality of life in cities through the reallocation of areas used for cars. This is explained later in this section, following a description of the present situation. The focus is on the possible optimisation of land use in Germany, which includes potential improvements for the attractiveness of public spaces and health.

4.2.1. Present Situation—Urban Structures and Vehicle Trends

The aim of today's urban and transport planning in many European cities is to create people-oriented cities, with areas being divided up in such a way that the needs of various road users are taken into account. Many cities, however, still have cityscapes that have developed over time as a result of car-centric planning, prioritising cars not only when driving, but also dedicating a significant amount of space to stationary vehicles by providing public parking space for cars. Cars are still a dominant element in most cities, especially in terms of visual and acoustic aspects, with a significant influence on the attractiveness of spaces, health, and safety [37,38]. Although there has been a paradigm shift towards urban planning that is geared towards the needs of people, there is still a discrepancy between the desire for people-oriented cites and the resistance to change established transport patterns. This is demonstrated by Hansson (2020) [39] who shows that artefacts related to the green environment and the transport modes of cycling, buses, and walking are overrepresented in visual documentation of planned transport construction projects. This implies the idea of a sustainable transport system which is not in accordance with the predictable effect of the presented projects.

The reluctance to change personal behaviour towards more sustainable mobility is reflected by the global trend towards large cars, namely SUVs. In October 2019, SUV demand in Europe increased by 22% compared to the previous year, leading to the registration of nearly 500,000 SUVs, which represents a market share of 40%. This increase means that Europe is slowly catching up with the USA and China in terms of SUV market penetration [13]. In Germany, market share of SUVs and off-road vehicles (KBA classifies vehicles into different categories. The term "off-road vehicle" refers to vehicles usually described as SUVs such as the VW Tiguan or the Audi Q5) was 30% in 2019. Demand is specifically driven by the manufacturers, which is shown by the fact that SUVs and off-road vehicles were the most advertised segments [40] (p. 14) based on an analysis of Nielsen Media. Around half of all segment-specific advertising expenditure by German car companies in 2018 was spent on SUVs and off-road vehicles [41]. This means that the share for segment-specific advertising expenditure is significantly higher than the share of vehicles in new registrations and it suggests that the demand for more profitable models is being artificially pushed [41]. Overall, societal goals, such as a fair distribution of urban space and climate protection, are in conflict with business interests.

The average size of new vehicles is rising in Germany (see Figure 3). Not only is the growing share of SUVs contributing to this development, but also the evolvement of models in different segments over time. For example, the VW Golf, which accounted for almost one-third of compact class vehicle stock in 2019 in Germany [42], had a width of 1610 mm when it was introduced in 1974 [43], while the latest version measures 1790 mm in 2020 [44]. Average length of new vehicles increased from 4.34 m in 2008 to 4.44 m in 2017 while average width increased from 1.77 m in 2008 to 1.81 m in 2017 [45].

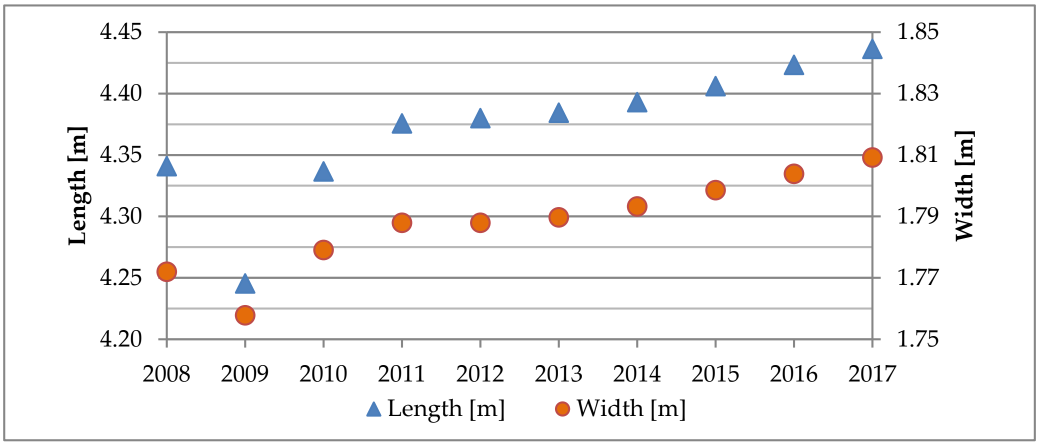

Figure 3. Length and width of new vehicle registrations in Germany [45].

In Germany in 2019, large cars, such as SUVs and off-road vehicle models, had an average projected rectangular surface on the ground (width without mirrors multiplied by length) of 8.6 m^2 and a maximum of 11.6 m^2 (Rolls Royce Cullinan) (based on: KBA, FZ11, manufacturer data). Accordingly, they take up a particularly large area of the space available in cities. In 2019, these vehicle types constituted a share of 13.3% of German passenger vehicle stock [46].

Some car park operators have reacted to the popularity of large cars by widening parking bays. For example, the company SWT [47] provides XXL parking bays in the city centre of Trier with a width of 3.5 m without extra charge. Another example is B + B, which operates a multi-storey car park in the city centre of Stuttgart with an XXL parking space share of over 30% [48].

4.2.2. Opportunities—Improving Urban Land Use

The pressure on space in many German cities is increasing, among other things due to significantly more and larger vehicles on traffic surfaces. In addition, new vehicle solutions (e.g., electric cargo bikes and electric scooters) demand space for driving and parking. This requires a restructuring of the public space with the aim of creating efficient and sustainable transport systems, as well as improving the safety and the attractiveness of public places [33].

Reducing the dimensions of motorised vehicles would allow urban spaces to be used more efficiently by rededicating the amount of space allocated to parking, even if the number of vehicles is kept constant. Coupled with the objective of reducing the number of motorised vehicles in private ownership, this can achieve far more effective results.

In general, LEVs occupy considerably less parking space than cars. In contrast to statistical data on cars, information on LEVs is scarce [49–51] and the variety of models is large, including three-wheel and four-wheel vehicles. Therefore, dimensions of typical four-wheeled LEVs are used instead of average values of the vehicle class in order to give an impression of size. The eCity Pack has a length of 2780 mm and a width of 1500 mm, the Microlino has a length of 2435 mm and a width of 1500 mm, and the Renault Twizy has a length of 2338 mm and a width of 1381 mm. Differences in size compared to cars are shown in Figure 4, showing a Twizy together with representative models of different car classes of small cars ranging from the Mercedes smart fortwo through to off-road vehicles such as the VW Tiguan.

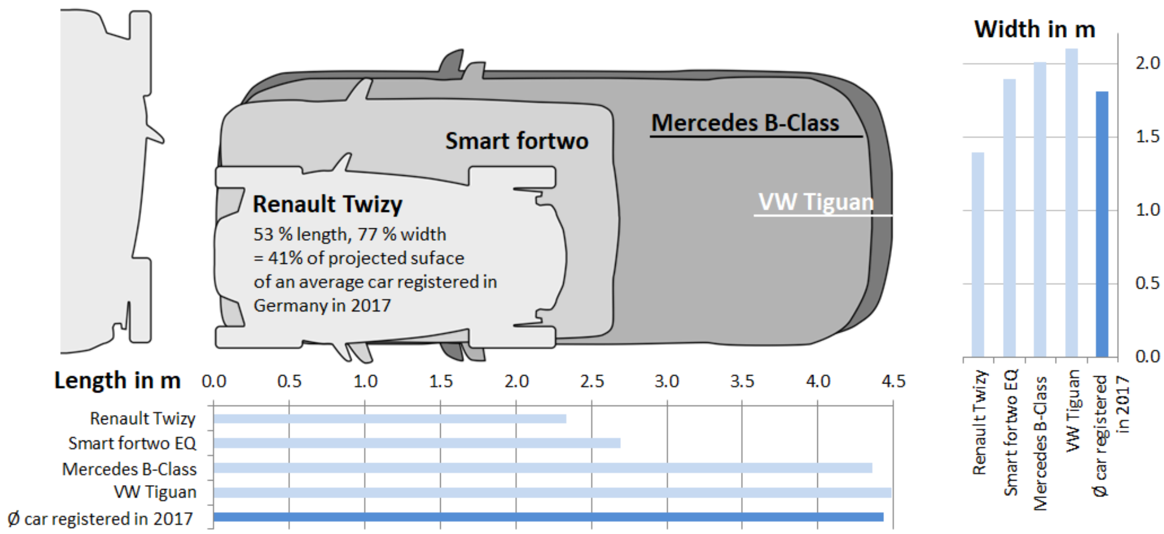

Figure 4. Comparison of different car and LEV dimensions.

The projected rectangular surface of a Twizy, for example, takes up only 41% of the space required for the average car registered in Germany in 2017 [45]. Depending on their size, up to three LEVs could be placed in one parking bay sized for a conventional car (see Figure 5). Considering that 90% of car drivers stated in the MiD that they were either alone in the car or had only one passenger, it can be assumed that a parking bay predominantly serves one or two persons. As LEVs usually provide space for up to two persons, this means that the average number of vehicle occupants per parking bay would not have to decrease if small LEV parking bays were to replace large car parking bays.

Statistical data regarding public or private parking space in cities are insufficient for a detailed analysis. Although very little data and few studies are available for a comprehensive analysis of available parking space (public and private) in cities, there are some approximations. An analysis from the German Association of the Automotive Industry (VDA) shows that public space is used for a significant proportion of the space allocated to residential parking (on average 33% in medium-sized and large cities) (Private parking spaces for new buildings also account for a certain amount of land used; this is, however, not considered in our study) [52]. Public parking areas, therefore, play an important role in car ownership. Replacing cars with LEVs would hence lead to considerable potential for alternative use of public space. In the following section, a qualitative analysis of potential connected to LEV use in urban areas is presented. Quantification of potentials in further studies could promote change towards sustainable use of space by revealing their full extent. However, it is also very important to test and evaluate new concepts in real-life test settings.

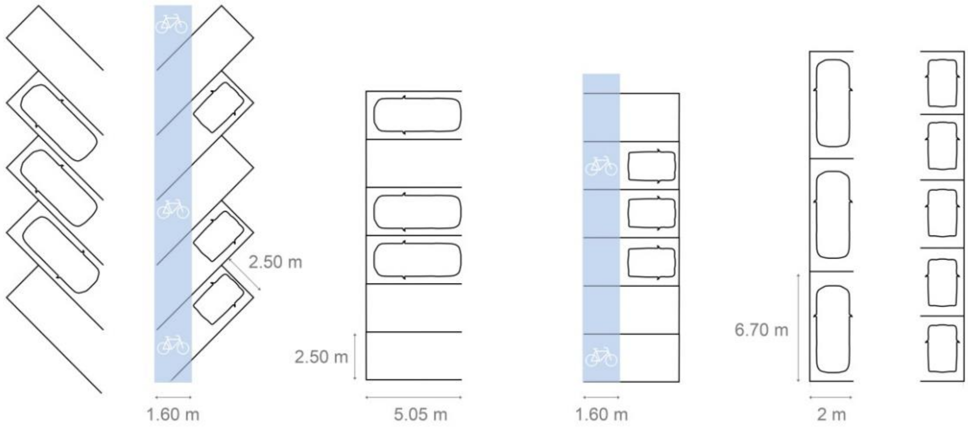

Figure 5. Possibility to reduce space allocated to parking by rededicating parking bays to smaller vehicles (The arrangement of the lanes for cyclists is only intended to illustrate that space for active modes can be allocated here and serves as a suggestion).

The following effects could be achieved by rededicating (reducing) space allocated to parking for passenger cars in order to make it available to other forms of use:

- More attractive public spaces;
- More room for sustainable transport modes such as walking, cycling, and PT;
- Reduced costs for the provision of public parking spaces;
- Reduced effect of urban heat islands;
- Possibility to deseal hard surfaces for rainwater infiltration;
- Fair distribution of public space.

In the following, we will discuss selected aspects of these effects.

Attractiveness and more room for sustainable transport modes. The quality and attractiveness of residential urban areas are impaired by stationary and flowing traffic due to their demands on space. Motorised individual and goods traffic compete, above all, with walking and cycling demands. Car-oriented cities prevent social interaction that could otherwise be promoted through more public squares, green space, outdoor gastronomy, or playgrounds [38,53]. Areas freed up by the smaller size of LEVs can provide room for active modes such as walking or cycling paths, or can be rededicated to open spaces for social interaction. The combination of providing more room for active modes and improving city design with attractive surroundings could encourage the use of public and active transportation [37], reinforcing the positive ecological effects of replacing cars with LEVs by promoting a modal shift.

In addition to the positive effects of rededicating parking space, LEVs may contribute to a more aesthetic and people-oriented cityscape by reducing the visual dominance of cars by taking up less optical space. The lower height of the vehicles offers less restricted visibility; for example, when walking on pavements alongside on-street parking bays. Smaller vehicles create an overall atmosphere that is more open; a more pleasant feeling of space (e.g., on sidewalks); and a more generous space for social participation. Furthermore, due to their generally smaller size, LEVs could improve safety for vulnerable road users. Larger parked cars reduce visibility for pedestrians crossing roads (see Figure 6). The inability to see other vehicles on the road due to parked vehicles has been found to be a major drawback of on-street parking [54,55].

Reduced effect of urban heat islands. Another threat to health is the phenomenon of urban heat islands. Factors affecting the occurrence and intensity of urban heat islands include the weather and geographic location; anthropogenic activities that lead to waste heat from vehicles, factories, and air conditioners (University Corporation for Atmospheric Research, 2011 from [56]); and the way cities are built. LEVs can contribute to a reduction in heat islands in two ways—first, they allow areas with high heat capacities, such as concreted parking bays, to be converted into green spaces, and second, they reduce heat emission from vehicles when they replace cars with internal combustion engines. Transportation is one of the main sources of anthropogenic activities, together with indoor heating and cooling (Soltani and Sharifi, 2017 from [56]).

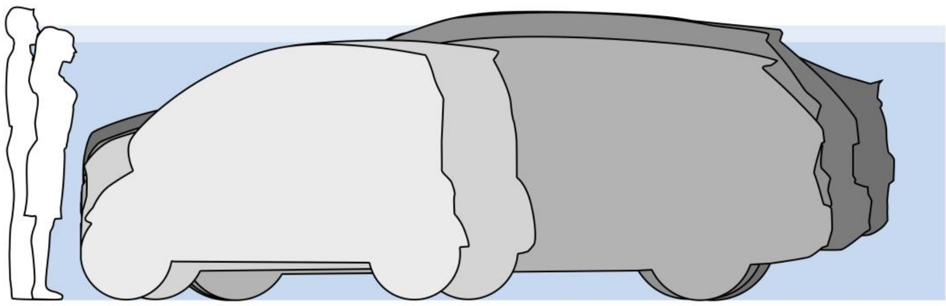

Figure 6. Height of different vehicle types depending on the eye level of women and men (50th percentile).

4.3. Framework Conditions and Recommendations for Action

Although LEVs could act as an alternative to increasingly large passenger cars, they are rarely bought in Germany today. Sales numbers from The Motorcycle Industry in Europe (ACEM) show that between 2013 and 2018, around 3500 electric quadricycles were sold [14]. This number only provides a limited insight because it contains four-wheeled vehicles and numbers from the members of the association. However, as data on the current number of LEVs in Europe are very heterogeneous and rather scarce, this at least provides an indication.

The very low market share is mainly due to framework conditions of the transport infrastructure that make using LEVs unattractive in comparison with cars or offer no incentives for LEVs. Examples of such framework conditions are: widespread speed limits of 50 km/h or above; parking infrastructure adapted to cars; very few parking bays reserved for small vehicles; and few car bans due to pollution in Germany. Additional reasons for the reluctance to buy LEVs include: safety concerns; a small variety of models; and relatively high prices compared to passenger cars [32]. When comparing prices of LEVs with battery electric vehicles (BEV) in Germany, it is very disadvantageous that the purchase of a BEV is currently subsidised by the federal government by up to EUR 9000 per vehicle, while LEVs do not receive any national subsidy. In some regions of Germany, there are subsidies for purchasing an LEV, but these are much lower and are often restricted to specific buyer groups, such as companies or municipalities.

There are currently a number of difficulties associated with using LEVs in many European cities and they face a number of barriers to their more widespread use. At the same time, transport system infrastructures and regulations mostly prioritise passenger cars over other transport modes. This includes:

- High speeds in cities;
- Low costs for car use (e.g., parking costs);
- No advantages for LEVs in flowing and stationary urban traffic (e.g., no dedicated lanes);
- No pollution charges or city toll, few entry restrictions for vehicles with high pollutant emissions.

In addition to global issues, such as climate protection, local urban framework conditions in particular are leading to pressure for action. Cities form the local level with a large scope for action. Different approaches can be taken to reduce land used by cars and minimise noise emissions. For the development of the LEV market, it is conceivable that measures such as speed limits (e.g., 30 km/h zones) could be put in place. Not only would this increase road safety, LEVs with a technical limitation to 45 km/h would also not hinder urban traffic, as is currently the case in most cities which have a maximum speed of 50 km/h. In Graz, for example, a speed limit of 30 km/h applies to all roads in the city except for priority roads. This applies to 80% of the road network [57]. Regulations in this respect can be laid down in noise action plans as well as in clean air plans. Effective measures to increase air quality in cities that have already been implemented in many European cities include driving bans (e.g., Milan, Italy; Vienna, Austria; Rotterdam, The Netherlands) and environmental zones. A congestion charge can also provide an incentive for LEVs through regulations such as discounts or free entry. Further amendments to the use of street space, such as shared spaces, are also conceivable. Measures such as parking space management can also be a major advantage for the use of LEVs. In Japan, for example, the need for proof of a private parking space certificate for the registration of cars in some cities has led to the registration of a large number of small vehicles (kei-cars). These are exempt from the obligation to provide such proof [58,59]. A car parking space in Japan can cost up to several thousand euros per month [60]. As a result, cities have a large toolbox of measures that could lead to the broader uptake of LEVs.

On the basis of expert interviews, a number of concrete measures were evaluated which could have a positive effect on the uptake of LEVs in cities. These measures are aimed at different target groups. In addition to the challenges and requirements of vehicle technology for manufacturers and general usage regulations, stakeholders at the municipal level were addressed in particular. Different types of policies were discussed regarding this. The results showed that a higher degree of LEV use would require significant changes to road traffic regulations and the allocation of land used by cars. Concrete recommendations for actions derived from the expert interviews include:

- **Reallocate traffic areas**
  e.g., designate parking bays to LEVs only;
- **Run pilot projects, e.g., sharing schemes**
  Test areas from single streets to larger traffic zones, in which, for example, a maximum speed of 30 km/h means that the slower LEVs use the same road infrastructure in a comfortable way;
- **Include LEVs in noise action plans and clean air plans**
  Future city tolls with reduced tariffs for LEVs;
- **Harmonise maximum speed limits for cars and LEVs**
  e.g., speed limit reduced to max. 45 km/h in inner city areas;
- **Improve LEV safety**
  e.g., by providing passive and/or active safety systems, reducing speed limits (reduced impact energy in the event of a collision);
- **Raise public awareness**
  Broader information/clarification of use (driving license, etc.).

In addition to a wide range of "hard" measures, "soft" measures should not be ignored. Accordingly, the public relations work and advertising done by manufacturers should focus more on highlighting LEVs and their benefits in order to influence purchasing decisions. In addition, changes in traffic behaviour often result from changes in a person's life situation; for example, relocation, children, starting vocational training or studies, taking up or changing employment. In these cases, the public should be aware of LEVs so that they can be considered as an option in transport decisions.

5. Conclusions and Outlook

The analysis shows the potential of LEVs to contribute to a sustainable transport system and thereby help to restructure urban areas towards people-oriented living spaces. However, acceptance in Europe, and especially in Germany, is still low and LEVs, unlike cars such as SUVs, lack a powerful lobby. Moreover, under current market conditions, no significant sales figures can be achieved without push and pull measures that reduce car use and promote the use of small sustainable vehicles.

As shown in the theoretically feasible substitution potential, there is a possibility that trips made by active modes could also be made using LEVs. In contrast to people changing from cars to LEVs, changing from active modes, such as walking or cycling, to LEVs would not be environmentally sustainable. Due to the fact that potential benefits would be compromised if LEVs were to replace active modes and PT on a large scale, appropriate measures should be taken to prevent this; additional research is needed in this area.

LEVs could complement sustainable modes, such as public transport and active modes. These modes constitute sustainable forms of mobility in most use cases. However, using these modes is challenging for some user groups, such as mobility-impaired people. Another challenge is providing sustainable mobility for long trips in areas or times with low travel demand. Distances may be too long for active modes and public transport might be unattractive due to low frequency. Providing high frequency PT in order to increase its attractiveness is not an adequate solution for areas and times with low passenger numbers, as it would be financially and ecologically inefficient due to low or zero occupancy rates. On-demand bus systems [61] are not suitable for sustainable solutions because it is almost impossible to bundle journeys when low passenger numbers are combined with dispersed origin and destination points. In these cases, LEVs could provide sustainable individual mobility.

Furthermore, it is possible that some people would be more willing to switch from car transport to another individual means of transport, such as an LEV, than to change their mobility behaviour more fundamentally. LEVs offer a high degree of flexibility in terms of routes and travel times compared to PT. In addition, compared to active modes, LEVs allow people to be mobile without physical exertion and, depending on the model, with the weather protection they are used to. Although LEVs are probably less ecological than public transport or active modes, they do have advantages over passenger cars.

Due to the increasing number of mobility alternatives, conflicts over land use arise when designing public space. Although the car is still the dominant means of transport, the pressure to change the mobility culture and thus, to rededicate traffic areas is becoming increasingly great. LEVs require less space than cars, especially when parking. Theoretically, LEVs have a great deal of potential to replace cars for private journeys and thus, make new use of space. Therefore, there is lot of potential for reorganising current land use because LEVs are an attractive and sustainable addition to other means of transport and they can contribute to achieving the climate protection goals of the transport sector. However, the share of LEVs is unlikely to increase significantly unless push and pull measures are put in place that simultaneously encourage the use of LEVs and discourage the use of cars.

The main obstacles at present are clearly still the high sales price and the safety of the vehicles (crash tests are not required for registration). In terms of further research, it would be interesting to examine holistic transport concepts and user acceptance. This requires a holistic approach with suitable areas for the coexistence of all forms of mobility, including walking, cycling, public transport, and LEVs, and new forms of mobility, including suitable vehicles.

Living on a planet with limited resources and worsening climate change requires fundamental shifts in many fields, including the need for reorganising mobility. Reducing trips and mileage, shifting to sustainable transport modes, and optimising transport technology require close interdisciplinary collaboration between many scientific fields, such as urban and transport planning, engineering, and social psychology. Developing technical solutions is important just as understanding societal aspects and fostering a willingness to change, from political and regulative levels down to individual behaviour. Further research is needed in order to find solutions for these challenges. If today's transport systems were to be reorganised, reducing hurdles for vehicles such as LEVs, they could be more successful and could become an important component in future systems.

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References

1. European Environment Agency. (Ed.) *Environmental Noise in Europe—2020*; Publications Office of the European Union: Luxemburg, 2020; p. 104.
2. Destatis. Bodenfläche Nach Art der Tatsächlichen Nutzung-Fachserie 3 Reihe 5.1-2018. Available online: https://www.destatis.de/DE/Themen/Branchen-Unternehmen/Landwirtschaft-Forstwirtschaft-Fischerei/Flaechennutzung/Publikationen/Downloads-Flaechennutzung/bodenflaechennutzung-2030510187004.html (accessed on 10 June 2020).
3. Eurostat. Greenhouse Gas Emission Statistics—Air Emissions Accounts. Available online: https://ec.europa.eu/eurostat/statistics-explained/index.php/Greenhouse_gas_emission_statistics_-_air_emissions_accounts (accessed on 16 April 2020).
4. European Environment Agency. Greenhouse Gas Emissions by Aggregated Sector. Available online: https://www.eea.europa.eu/data-and-maps/daviz/ghg-emissions-by-aggregated-sector-5 (accessed on 16 April 2020).
5. European Environment Agency. Greenhouse Gas Emissions from Transport in Europe. Available online: https://www.eea.europa.eu/data-and-maps/indicators/transport-emissions-of-greenhouse-gases/transport-emissions-of-greenhouse-gases-12 (accessed on 9 June 2020).
6. European Commission. Urban Mobility|Mobility and Transport. Available online: https://ec.europa.eu/transport/themes/urban/urban_mobility_en (accessed on 27 August 2020).
7. Deloitte. 2020 Global Automotive Consumer Study. Is Consumer Interest in Advanced Automotive Technologies on the Move? Available online: https://www2.deloitte.com/content/dam/Deloitte/us/Documents/manufacturing/us-2020-global-automotive-consumer-study-global-focus-countries.pdf (accessed on 8 July 2020).
8. Zong, W.; Zhang, J.; Jiang, Y. Long-term changes in Japanese young people's car ownership and usage from an expenditure perspective. *Transp. Res. Part D Transp. Environ.* **2019**, *75*, 23–41. [CrossRef]
9. Van Kampen, J.; Pauwels, E.; van der Mei, R.; Dugundji, E. Analyzing Potential Age Cohort Effects in Car Ownership and Residential Location in the Metropolitan Region of Amsterdam. *Procedia Comput. Sci.* **2019**, *151*, 543–550. [CrossRef]
10. INFAS Institut für Angewandte Sozialwissenschaft GmbH. Mobilität in Deutschland. Kurzreport. Verkehrsaufkommen—Struktur—Trends. Ausgabe September 2019. Available online: http://www.mobilitaet-in-deutschland.de/pdf/infas_Mobilitaet_in_Deutschland_2017_Kurzreport.pdf (accessed on 9 October 2019).
11. Eurostat. New Registrations of Passenger Cars by Type of Motor Energy and Engine Size. Available online: https://appsso.eurostat.ec.europa.eu/nui/show.do?dataset=road_eqr_carmot&lang=en (accessed on 15 April 2020).
12. International Energy Agency. *Global EV Outlook 2019: Scaling-Up the Transition to Electric Mobility*; OECD: Paris, France, 2019.
13. JATO Dynamics Ltd. Press Release: SUVs Make Up 40% of Total Car Registrations, as the European Market Records Its Best October Results Since 2009. Available online: https://www.jato.com/wp-content/uploads/2019/11/October-2019-Europe-Reg-Release-Final.pdf (accessed on 15 April 2020).
14. ACEM. Motorcycle, Moped and Quadricycle Registrations in the European Union—2010–2018. Available online: https://www.acem.eu/market-data (accessed on 8 March 2019).
15. Honey, E.; Lee, H.; Suh, I.-S. Future Urban Transportation Technologies for Sustainability with an Emphasis on Growing Mega Cities: A Strategic Proposal on Introducing a New Micro Electric Vehicle Statement. *WTR* **2014**, *13*. [CrossRef]
16. Edwards, M.; Seidl, M.; Carroll, J.; Nathanson, A. *Provision of Information and Services to Perform an Initial Assessment of Additional Functional Safety and Vehicle Construction Requirements for L7e-A Heavy on-Road Quads*; Transport Research Laboratory: Wokingham, UK; European Commission: Brussels, Belgium, 2014; Volume 3, pp. 139–152.

17. Robinson, T.L.; McCarthy, M.; Pitcher, M.; Gibson, T.; Visvikis, C. *Evaluating the Impact of Possible New Measures Concerning Category L Vehicles*; Client Project Report; Transport Research Laboratory: Wokingham, UK, 2009.
18. Sachs, C.; Burandt, S.; Mandelj, S.; Mutter, R. Assessing the market of light electric vehicles as a potential application for electric in-wheel drives. In Proceedings of the 2016 6th International Electric Drives Production Conference (EDPC), Nuremberg, Germany, 30 November 2016; pp. 280–285. [CrossRef]
19. Davies, H.C.; Bastien, C.; Nieuwenhuis, P.; Bailey, S. Challenges and Opportunities for Improving the Safety of Lightweight Vehicles. Available online: https://www.researchgate.net/publication/311494427_Challenges_and_Opportunities_for_Improving_the_Safety_of_Lightweight_Vehicles (accessed on 14 July 2020).
20. Devasurendra, K.; Perera, L.; Bandara, S. An insight to motorized two and three wheel crashes in developing countries: A case study in Sri Lanka. *J. Transp. Saf. Secur.* **2017**, *9* (Suppl. 1), 204–215. [CrossRef]
21. Harald, K.; Stefan, K.; Ernst, T.; Heinz, H.; Peter, L.; Wolfgang, S. Prospective Evaluation of the Collision Severity L7e Vehicles Considering a Collision Mitigation System. *Transp. Res. Procedia* **2016**, *14*, 3877–3885. [CrossRef]
22. Pavlovic, A.; Fragassa, C. General considerations on regulations and safety requirements for quadricycles. *Int. J. Qual. Res.* **2015**, *9*, 657–674.
23. Bauer, W.; Wagner, S.; Edel, F.; Stegmüller, S.; Nagl, E. *Mikromobilität. Nutzerbedarfe und Marktpotenziale im Personenverkehr*; Fraunhofer-Institut für Arbeitswirtschaft und Organisation IAO: Stuttgart, Germany, 2017.
24. Santucci, M.; Pieve, M.; Pierini, M. Electric L-category vehicles for smart urban mobility. *Transp. Res. Part F Traffic Psychol. Behav.* **2016**, *14*, 3651–3660. [CrossRef]
25. Kampker, A.; Gerdes, J.; Schuh, G. (Eds.) *Think Big, Start Small. Streetscooter the E-Mobile Success Story*; Springer: Berlin/Heidelberg, Germany, 2017; ISBN 978-3-662-54997-1.
26. Ma, Y.; Zhao, F.; Hao, H.; Liu, Z. Life-Cycle Cost Analysis of Low-Speed Electric Vehicles Using Different Kinds of Battery Technologies Based on Chinese Market. In Proceedings of the International Conference on Applied Energy 2019, Västerås, Sweden, 12–15 August 2019; p. 4.
27. Melo, S.; Baptista, P.; Costa, Á. The Cost and Effectiveness of Sustainable City Logistics Policies Using Small Electric Vehicles. In *Transport and Sustainability*; Macharis, C., Melo, S., Woxenius, J., Lier, T.V., Eds.; Emerald Group Publishing Limited: Bingley, UK, 2014; Volume 6, pp. 295–314. ISBN 978-1-78441-062-9.
28. John, R.; Kahrimanovic, E.; Otto, A.; Tavernini, D.; Camocardi, M.; Perelli, P.; Dalmasso, D.; Blaz, S.; Trojaniello, D.; Oleari, E.; et al. Light Electric Vehicle Enabled by Smart Systems Integration. In *Advanced Microsystems for Automotive Applications 2016*; Schulze, T., Müller, B., Meyer, G., Eds.; Springer International Publishing: Cham, Switzerland, 2016; pp. 201–215, ISBN 978-3-319-44765-0.
29. StreetDrone Limited. StreetDrone|Autonomous Urban Vehicles. Available online: https://www.streetdrone.com/ (accessed on 16 April 2020).
30. Groupe Renault. EZ-POD, A Robo-Vehicle Designed for Micromobility–Easy Electric Life. Available online: https://easyelectriclife.groupe.renault.com/en/outlook/markets/robo-vehicle-ez-pod-micromobility/ (accessed on 25 June 2020).
31. Nobis, C.; Kuhnimhof, T. *Mobilität in Deutschland—MiD Ergebnisbericht. Study from infas, DLR, IVT and Infas 360 on Behalf of the German Ministry of Transport and Digital Infrastructure*; FE-Nr. 70.904/15; BMVI: Bonn, Germany, 2018.
32. Brost, M.; Ewert, A.; Schmid, S.; Eisenmann, C.; Gruber, J.; Klauenberg, J.; Stieler, S. *Elektrische Klein- und Leichtfahrzeuge. Chancen und Potenziale für Baden-Württemberg on behalf of E-mobil BW*; e-mobil BW: Stuttgart, Germany, 2019.
33. Ministerium für Verkehr Baden-Württemberg. (Ed.) Effiziente Flächennutzung für die Mobilität der Zukunft. Available online: https://vm.baden-wuerttemberg.de/fileadmin/redaktion/m-mvi/intern/Dateien/PDF/200512_Empfehlungspapiere_TF_5_Fl%C3%A4chennutzung_final.pdf (accessed on 25 June 2020).
34. International Energy Agency. Global EV Outlook 2020. Available online: https://www.iea.org/reports/global-ev-outlook-2020 (accessed on 13 July 2020).
35. García-Olivares, A.; Solé, J.; Osychenko, O. Transportation in a 100% renewable energy system. *Energy Convers. Manag.* **2018**, *158*, 266–285. [CrossRef]
36. Allgemeiner Deutscher Automobil-Club e.V. (ADAC). Stromverbrauch Elektroautos: Aktuelle Modelle im ADAC Test. Available online: https://www.adac.de/rund-ums-fahrzeug/tests/elektromobilitaet/stromverbrauch-elektroautos-adac-test/ (accessed on 27 August 2020).

37. Nieuwenhuijsen, M.J. Urban and transport planning pathways to carbon neutral, liveable and healthy cities; A review of the current evidence. *Environ. Int.* **2020**, *140*, 105661. [CrossRef] [PubMed]
38. Umweltbundesamt (Ed.) Umwelt- und Aufenthaltsqualität in Urbanen Quartieren. Available online: https://www.umweltbundesamt.de/sites/default/files/medien/1410/publikationen/fachbroschuere_umwelt-aufenthaltsqualitaet_urbane-quartiere.pdf (accessed on 25 June 2020).
39. Hansson, L. Visual representation in urban transport planning: Where have all the cars gone? *Transp. Res. Part A Policy Pract.* **2020**, *133*, 1–11. [CrossRef]
40. Greenpeace e.V. Greenpeace-Report 2019: Ein Dickes Problem. Wie SUVs und Geländewagen das Klima und Unsere Städte Ruinieren. Available online: https://www.greenpeace.de/sites/www.greenpeace.de/files/publications/s02571_gp_report_suv_09_2019_es.pdf (accessed on 2 July 2020).
41. Buchenau, M.-W.; Fasse, M.; Hubik, F.; Kersting, S.; Menzel, S.; Murphy, M.; Rickens, C. Der SUV-Wahnsinn—Warum die Autoindustrie sehenden Auges in eine Falle tappt. Available online: https://www.handelsblatt.com/technik/thespark/klimaziele-der-suv-wahnsinn-warum-die-autoindustrie-sehenden-auges-in-eine-falle-tappt/24976708.html?ticket=ST-3781338-1m02yHMCeQvRacdigLtC-ap5 (accessed on 5 July 2020).
42. Kraftfahrt-Bundesamt (KBA). Bestand an Personenkraftwagen nach Segmenten und Modellreihen am 1. Januar 2020 gegenüber 1. Januar 2019 (FZ 12). 2020. Available online: https://www.kba.de/DE/Statistik/Fahrzeuge/Bestand/Segmente/b_segmente_inhalt.html?nn=2601598 (accessed on 13 July 2020).
43. Klaus Westrup. VW Golf I LS (1974): Käfer-Nachfolger im ersten Test; Auto Motor und Sport. Available online: https://www.auto-motor-und-sport.de/test/vw-golf-1-ls-1974/ (accessed on 13 July 2020).
44. Volkswagen, A.G. Der Golf, Golf Variant & Golf Alltrack. Available online: https://www.volkswagen.de/content/dam/vw-ngw/vw_pkw/importers/de/dialogcenter/brochures/golf-bq/golf_preisliste.pdf/_jcr_content/renditions/original.media_file.download_attachment.file/golf_preisliste.pdf (accessed on 13 July 2020).
45. Kraftfahrt-Bundesamt. Zahlen-Daten-Fakten 2015/2016/2017. Available online: https://www.kba.de/SharedDocs/Publikationen/DE/Jahresberichte/jahresbericht_2015_17_pdf.pdf?__blob=publicationFile&v=10 (accessed on 13 July 2020).
46. Kraftfahrt-Bundesamt. Personenkraftwagen am 1. Januar 2020 nach Ausgewählten Merkmalen. Available online: https://www.kba.de/DE/Statistik/Fahrzeuge/Bestand/Jahresbilanz/fz_b_jahresbilanz_archiv/2020/2020_b_barometer.html (accessed on 13 July 2020).
47. SWT-AöR. XXL Parken. Available online: https://www.swt.de/p/XXL_Parkpl%C3%A4tze-5-4429.html?_p_Menu.PK=4516 (accessed on 13 July 2020).
48. B + B Parkhaus GmbH & Co. KG. Tiefgarage Kronprinzstraße in Stuttgart. Available online: https://www.bb-parkhaus.de/parken/stuttgart/parkhaus/stuttgart-kronprinzstrasse/?cHash=0b46a29c48befbfbe8cab24375ba2230 (accessed on 13 July 2020).
49. Gicklhorn, K.; Ewert, A.; Brost, M.; Eisenmann, C.; Stieler, S. Light Electric Vehicles in Baden-Württemberg—Potential for Industry and New Mobility Solutions? In Proceedings of the 32nd Electric Vehicle Symposium (EVS32), Lyon, France, 19 May 2019; p. 10.
50. Brost, M.; Ewert, A.; Eisenmann, C.; Stieler, S.; Gicklhorn, K. Elektrische Klein- und Leichtfahrzeuge: Mobilitätskonzepte mit Zukunftspotenzial? *J. Mobilität Verk.* **2019**, 41–49. [CrossRef]
51. Ewert, A.; Brost, M.K.; Schmid, S.A. Framework Conditions and Potential Measures for Small Electric Vehicles on a Municipal Level. *WEVJ* **2020**, *11*, 1. [CrossRef]
52. Rikus, S.; Hoffmann, S.; Ungureanu, T.; Rommerskirchen, S.; Plesker, M. FAT-Schriftenreihe 271. Available online: https://www.vda.de/de/services/Publikationen/fat-schriftenreihe-271-parkpl-tze-in-st-dten.html (accessed on 13 July 2020).
53. Directorate-General for Environment (European Commission). Reclaiming city streets for people. Chaos or quality of life? Available online: https://ec.europa.eu/environment/pubs/pdf/streets_people.pdf (accessed on 25 June 2020).
54. Gitelman, V.; Balasha, D.; Carmel, R.; Hendel, L.; Pesahov, F. Characterization of pedestrian accidents and an examination of infrastructure measures to improve pedestrian safety in Israel. *Accid. Anal. Prev.* **2010**, *44*, 63–73. [CrossRef] [PubMed]
55. Biswas, S.; Chandra, S.; Ghosh, I. Effects of On-Street Parking in Urban Context: A Critical Review. *Transp. Dev. Econ.* **2017**, *3*, 1–14. Available online: https://link.springer.com/article/10.1007/s40890-017-0040-2 (accessed on 20 July 2020). [CrossRef]

56. Rupard, M. Urban Heat Islands: Causes, Impacts, & Mitigation. Available online: https://digitalcommons.calpoly.edu/crpsp/190/ (accessed on 10 July 2020).
57. Stadt Graz. Stadtgebiet Tempo 30 Ausgenommen Vorrangstraßen. Available online: https://www.graz.at/cms/beitrag/10320495/7765198/Stadtgebiet_Tempo.html (accessed on 15 May 2020).
58. Lipscy, P.Y.; Schipper, L. Energy efficiency in the Japanese transport sector. *Energy Policy* **2013**, *56*, 248–258. [CrossRef]
59. Fraunhofer-Institut für Arbeitswirtschaft und Organisation. *Standortanalyse Japan–Automobilindustrie und Zukünftige Mobilitätsinnovationen*; e-mobil BW: Stuttgart, Germany, 2018.
60. Aachener Zeitung. Tokio: Big in Japan: Der große Erfolg der kleinen Kei Cars. Available online: https://www.aachener-zeitung.de/ratgeber/auto/big-in-japan-der-grosse-erfolg-der-kleinen-kei-cars_aid-25756363 (accessed on 20 July 2020).
61. Gebhardt, L.; Brost, M.; König, A. An inter- and transdisciplinary approach to developing and testing a new sustainable mobility system. *Sustainability* **2019**, *11*, 7223. [CrossRef]