Diversification of the Bicycle Market and Consequences for Urban Infrastructure

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Abstract. Cycling and micro-mobility are booming all around the world. Covid-19 and other trends have led to a growing demand. The market is reacting by producing a wide range of different vehicle types, suitable for different usage requirements. Besides a huge variety of conventional bicycles, this includes different forms of electric bicycles, cargo bikes and electric kick scooters. Most of the vehicle types are legitimized to use the cycling infrastructure, although the specifications and riding characteristics differ significantly – from vehicle dimensions to speed levels and electric ranges. The market in the future will become more and more diverse and the current regulations and planning standards are, however, no longer up to date to cover the different demands and requirements. For this reason, the paper discusses how to deal with this heterogeneity of vehicle types and user groups in terms of infrastructure and legal aspects.

Keywords: Electric bicycles · Cargo bikes · Transport planning

1 Introduction

The bicycle industry has experienced dynamic growth in many countries within recent years. During the Covid-19 pandemic, cycling proved to be a guarantee for infection-proof everyday mobility. After easing the lockdowns in most countries, consumers shifted their focus on physical activities and resilient transport alternatives, setting the bike market in motion again. Bikes and e-bikes represented a safe, convenient and affordable alternative to public transportation [1]. The effect was that even Covid-19 impacts, that had negative influence within the beginning of the crisis, were then being recovered [2].

Besides this pandemic-lead growth of the bicycle market, many governments and municipalities are promoting cycling in order to achieve climate, environmental, and safety goals. This also led to increasing cycling shares over the last decade, mainly in urban areas [3]. The bicycle industry itself has accelerated this trend by producing a huge variety of bicycle types – from affordable city bikes for everyone to luxury models equipped with a strong electric motor and boxes to transport children or freight. On the one hand, this development entails new potentials for shifting trips from motorized transport to cycling. On the other hand, new challenges arise regarding appropriate infrastructure for the different types of bicycles.

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This paper sheds light on recent developments in the bicycle market, focusing on the German and European situation. It addresses the growing amount of different bicycle types and discusses their specific characteristics. The resulting opportunities for the mobility transition are analyzed, as are new requirements regarding infrastructure and regulation. Finally, the authors provide recommendations for redesigning road space and integrating the dynamics of the market into future transport planning and policies.

The findings are based on various research projects that have been carried out in recent years, supplemented by a literature research and analysis. Within the research project "project-mo.de", funded by the Hessian state program LOEWE, the infrastructural requirements of cargo bikes have been analyzed, using a mixed method approach, including on-site measurement of cargo bikes, traffic observations, expert interviews and a quantitative online survey. The research projects "LieferradDA" and "bike + business", both funded by the State of Hesse, also provided valuable insights on the needs and the actual driving behavior of cargo bike riders in a real operating process. Whereas the first project focused on delivery services of small retailers, the latter project promotes cycling in companies and provides participating companies with free electric bicycles. A quantitative survey of the participating companies and test riders provided information about the mobility behavior, the acceptance and the needs of e-bike users. In different study projects the desirable framework of micro depots and cargo bike concepts in urban areas have been identified through the calculation of delivery process data and expert interviews with courier, express, and parcel service (CEP) providers.

2 Development of the Bicycle Market

The European bike market has seen an enormous upswing in recent years. The development and sales of electric bikes is one of the major reasons for this growth. E-bikes were responsible for 23% of EU total bike sales in 2020, going up by 50% in some countries [4]. European cycling organizations developed a forecast showing that by 2030 e-bike sales could reach the number of 17 million bikes annually, which then could be as high as the sales of conventional bikes [ibid.].

In Germany, the largest bike market in Europe, sales in 2020 went up by 16.9% compared to the previous year, with 5.04 million units. Due to supply shortages the number was reduced in 2021, but with 4.7 million units still on a higher level than pre-Covid. 2 million electric bicycles (pedelecs, e-bikes, s-pedelecs) were sold, accounting for 43% of total sales. Compared to 2019, this is an increase of 68%. By the end of 2021, there were more than 8 million electric bicycles on the road in Germany alone [5]. Likewise, other countries see rising numbers for several years. In 2019, electric bicycles accounted for 51% of all sales in Belgium, 42% in the Netherlands, 39% in Austria, and 37% in Switzerland. Countries with the highest shares of speed pedelecs include Switzerland and Belgium [6]. Innovations in powertrain and battery technology as well as diversification of bicycle models contribute to the development. The following figure shows the development of the car and bicycle stock in Germany, including the share of electric bikes (Fig. 1).

Besides conventional and electric bicycles, cargo bikes experienced a strong increase in European bicycle capitals like Amsterdam, Copenhagen or Brussels, but also in German cities like Berlin or Frankfurt. Focusing on Germany, this significant increase in

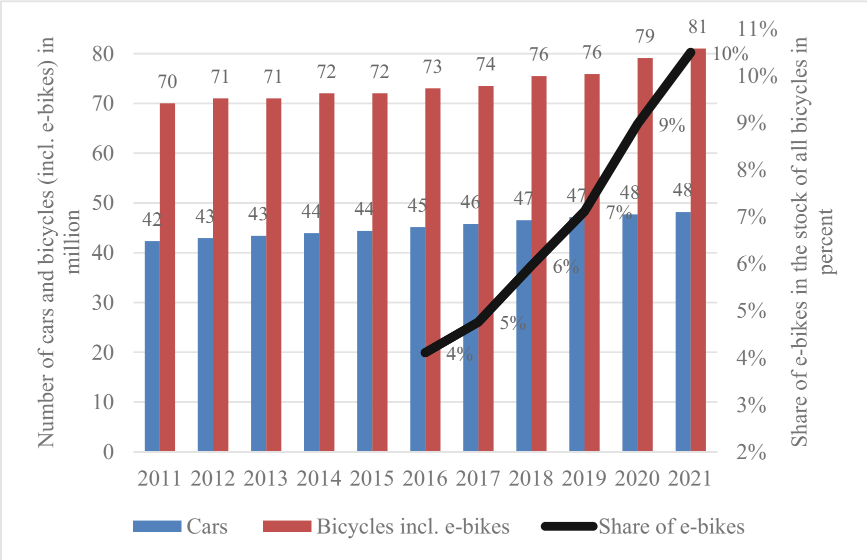

Fig. 1. Development of the stock of cars, bicycles and the share of electric bicycles in Germany [5, 7]

the number of cargo bikes has already taken place within the last few years. The number of cargo bikes sold in Germany rose from 60,100 in 2018 to 167,000 in 2021. Electric cargo bikes accounted for 120,000 units [5]. Triggered by a growing availability of cargo bike models there is a high modal shift potential in private logistics. Cargo bikes could replace 77% of all urban vehicle trips within the private sector and 50% for private and public services [8]. The transport of large or heavy objects is often mentioned as a reason for the necessity of private car use. However, this argument is most frequently used in relation to shopping trips. In this segment, trips for the procurement of everyday goods represent 85% of all trips. In many cases, the quantities purchased are quite small and can easily be transported by bicycles. For commercial delivery transport, the estimates on the shifting potential to cargo bikes range from 23 to 30% of all trips. A substitution of every fourth delivery truck trip could already mean a noticeable relief for urban traffic, as commercial transport often affect sensitive inner-city areas [8].

3 Types of Bicycles and Other Micro Vehicles

The diversification of the market leads to more and more different types of vehicles found on the roads. Already conventional bicycles can be divided into numerous model groups. In addition, for some time now there have been an increasing number of cargo bikes, different forms of electric bicycles, motorized scooters, mopeds, electric kick scooters, or other novel variants such as monowheels and airwheels.

3.1 Conventional Bicycles

As there are many different types of bicycles, the following is a categorization of those types by function. Road bikes, mostly designed for speed usage and characterized by their drop bars that curve downwards, are made for paved streets. Different categories are aero, cyclocross, triathlon, endurance or touring bikes. Similar to this are gravel bikes, but they can also handle off-road surfaces. Mountain bikes are more sporty vehicles with flat handlebars, characterized by usage in steep terrain. Hybrid bikes combine several functions of mountain and road bikes. They show an upright rider position, but have a flat handlebar and fast-rolling tires. Cruiser bikes are equipped with broad tires and best suited for short rides on paved streets. City bikes are designed to be low-maintenance, durable and affordable. Typically, they are efficient and driven on short tracks in urban areas. In addition to the aforementioned ones, there are other exotic types like fixed-gear and single speed bikes, tandems, folding bikes, bmx or recumbent bikes and trikes, which are more marginal groups [5, 9, 10].

3.2 Electric Bicycles

Electric bicycles differ from conventional bicycles both in terms of vehicle technology and vehicle body. The most widely used electric bicycle – the pedelec (pedal electric cycle) – is characterized as a bicycle with assistance from an electric motor when pedaling. The support ends at a speed of 25 km/h and it has a power limit of 250 watts. The pedelecs that electrically assist their users up to a speed of 45 km/h are called speed pedelecs, S-pedelecs or pedelecs 45. Although they look similar to the pedelec 25, they are classified as mopeds in some countries and require an insurance license plate. The third category, e-bikes, can be described as bicycles with an electric motor, which can be ridden without pedaling just by their electric drive. They can be further divided into different power classes. Such a bike requires an operating license and insurance. For speed pedelecs and e-bikes, the use of cycling facilities is generally not permitted in Germany and many other countries. Others, such as Finland, Italy and the Netherlands, allow exceptions to the ban on use. In general, the classifications and regulations differ from country to country. Major specifications and regulations for three different types are summarized in the following table, valid for Germany (Table 1).

3.3 Cargo Bikes

Especially cargo bikes offer great potential not only for transporting children and groceries, but also for different segments in the freight sector. A cargo bike can be a single-track or multi-track bicycle with or without an electric motor. Depending on the transported items, it can be equipped with boxes in different forms. The load possibilities differ depending on the type of construction, the vehicle dimensions (length, width, weight) and the loading area/box size. The number of cargo bikes is rising in both areas, private and commercial use. Figure 2 shows a selection of available models.

Table 1. Differentiation of selected electric bicycle types in Germany

	Pedelec	Speed pedelec	E-bike 20
Speed	Electric assistance up to 25 km/h	Electric assistance up to 45 km/h	Control via choke, up to 20 km/h
Max. Permitted engine power	250 W	4000 W	500 W
Insurance, vehicle registration, driving license requirement	No	Yes	Yes
Helmet compulsory	No	Yes	No
Minimum age	0	16	15
Cycling facility use in urban areas	Yes	No	Yes
Cycling facility use in rural areas	Yes	No[a]	Only with additional sign "e-bikes/mopeds allowed"

[a]The German city Tübingen has introduced an exception to allow speed pedelecs on certain bicycle paths with the approval of the state of Baden-Württemberg [11]

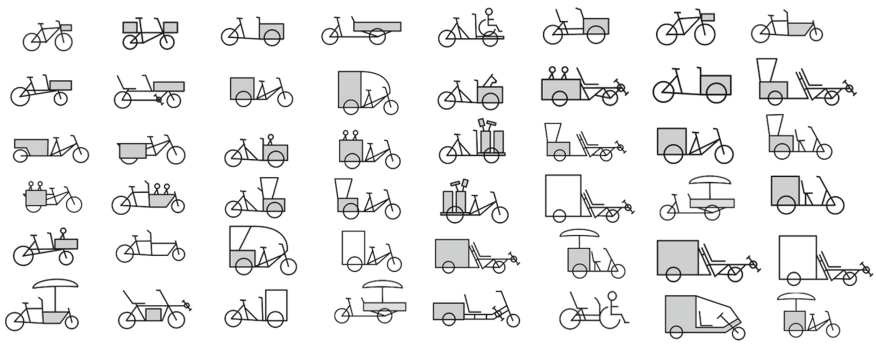

Fig. 2. Selection of available cargo bike models [12].

3.4 Other Micro Vehicles

Other vehicles subsumed under the term micro-mobility include one-wheeled vehicles, electric hoverboards, skateboards, and electric kick scooters, often called e-scooters. Their weight and maximum speed level differs which is relevant for safety requirements and regulatory measures. For example, e-scooters are usually equipped with a rechargeable battery and allow a maximum speed of 20 km/h. Their relevance for transport systems and road space issues has grown in recent years, mainly through their integration in sharing services. They are taken into account in this paper as they also use the cycling infrastructure to a high degree.

4 Characteristics and Implications for Transport Infrastructure

The specifications and appearances of the different vehicle types vary a lot – in terms of vehicle technology and vehicle body as well as driving dynamics and electric equipment. The following section summarizes fundamental characteristics which are relevant for the (re)design of road space and supporting infrastructure.

4.1 Speed

Due to their electric assistance, all electric bikes and micro vehicles travel at significantly higher speeds than conventional bicycles. Whereas the maximum speed can reach up to 45 km/h for the different types of vehicles, the actual travel speed on the road is much lower. Different studies show that the average speed of pedelecs is 2–4 km/h higher than that of conventional bicycles [13–18]. For speed pedelecs, the difference to conventional bicycles amounts to 5 to 9 km/h [13–15, 18]. For the cycle logistics sector but also for cyclists in general the higher speed possibility can mean a faster movement in cities and therefore leads to time savings.

However, it must be noted that the different speeds already occur with conventional bicycles and depends on the user groups. Cyclists with a racing bicycle are usually much faster than the ones with a usual city bike. Children and the elderly are often slower than the average. On the one hand, the different speed level possibilities allow each person to choose a pace suitable for his or her condition. On the other hand, this diversification of models and speed levels might cause problems on shared infrastructure, especially when there is no space to overtake safely.

4.2 Mechanical Effort and Electric Assistance

Electric bicycles and micro vehicles need a possibility to recharge the vehicle battery. If this is given, the electric motor resp. The battery capacity provide an extended driving range compared to conventional bicycles, and thus enable trips over larger distances with the same physical effort. Studies from Germany and the Netherlands show that the average trip length of a pedelec trip is at 6.1 resp. 5.9 km and with that 2.4 resp. 2.3 km longer than the one of conventional bicycles [19, 20]. The comparatively high average speed and the low mechanical effort also increase the potential for routes in the distance range of 15–20 km, making it a real alternative to cars, e.g. for commuting trips. As motorized vehicles account for 80% of all trips between 5 and 20 km in Germany – 73% in Switzerland, and 72% in the Netherlands – the modal shift potential is very high [19]. Electric bicycles can also relieve the burden on public transport, as they allow making journeys that were previously made by train or bus. In addition, catchment areas of public transport stops can be increased due to greater distances covered in the same amount of time.

The electric assistance also makes cycling possible for people with a lower level of physical fitness. It can maintain mobility for older or physically impaired people and promote mental benefits [21]. Further, electric bicycles make it easier to overcome natural obstacles, differences in altitude and headwinds which not only offers benefits for cyclists travelling alone, but even more for riders transporting people or goods in electric cargo bikes. As they enable the transport of larger loads with less effort, they offer great potentials for freight transport and are already used by the craft industry or delivery service companies.

4.3 Driving Dynamics

With a higher speed of the vehicles, the braking distance of bicycles and other micro vehicles increases. If considering cargo bikes, which usually have a higher weight, this effect is even intensified. This can lead to dangerous situations, especially at junctions or when passing by motorized vehicles parking in and out. Further, accidents are more likely to have severe consequences for the involved people. This relates to the kinetic energy of the vehicles, meaning that the faster and heavier the vehicles are the greater the consequence of a collision [22].

Further, electric bicycles and micro vehicles can accelerate stronger than conventional bicycles. As a result, they sometimes have an increased turning circle, making curves with a sharp radius a potential danger spot. Likewise, cargo bikes have a larger turning radius due to their longer wheelbase. Further, their high weight up to 250 kg can result in maneuverability that is more difficult. The special features of riding an electric bike, cargo bike or kick scooter, such as starting, accelerating, braking and turning, can lead to insecurities for older or inexperienced drivers [23].

4.4 Size and Dimensions

Cargo bikes tend to be longer and wider depending on whether they are single-track or double-track bikes and how large the loading area is. By examining 42 privately used cargo bikes it was possible to identify a dimensioning cargo bike which represents 85% of all cargo bikes in private usage, that is 2.60 m long, has a wheelbase of exactly 2 m, is 1.20 m high and has a 70-cm-wide transport box and 89-cm-wide handlebars [24]. Looking at commercially used cargo bikes, the measures differ, as larger models with a length of up to 3.40 m and a width of 1.20 m are common in commercial transport [25, 26]. These larger dimensions have several consequences for moving traffic as well as for parking, as it e.g. burdens a risk for collision on cycle paths and for improper use of side spaces.

4.5 Weight

Electric bicycles are usually significantly heavier than conventional bicycles and therefore not that easy to move. With cargo bikes, this challenge is even bigger. The heavier the vehicles are, the more difficult they are to handle. The vehicles cannot be easily lifted over obstacles. Especially for physically impaired people, it is often not possible to lift their vehicles over curbs or even stairs. This is why the type of parking facilities must also be taken into account as ground level and barrier-free possibilities play a key role for heavier vehicles. Double deck cycle racks, which normally are a nice parking solution for reasons of space, are often not accepted by pedelec users. Also, when riding a heavy cargo bike without electric assistance, it needs a higher human effort and can lead to a slower speed level.

4.6 Value

Nowadays, in Western cultures the relevance of the car as a status symbol is decreasing. On the contrary, customers' willingness to pay a higher price for a bicycle is increasing. In Germany, the average price people are willing to spend rose from 685 euros in 2019 to more than 1,000 euros in 2021 [27].

Even for conventional bicycles, the product range extends from low-cost models to expensive premium bicycles. However, electric bicycles and cargo bikes are usually much more expensive than comparable conventional bicycles. Accordingly, appropriate parking facilities with protection from theft, vandalism, and weather are of particular importance.

5 Recommendations for Physical and Regulatory Integration

Along with the diverse characteristics of the different micro vehicle types, new challenges occur in terms of physical integration and providing appropriate infrastructure for all users, but also reviewing and adapting the current legal framework, as it has a strong influence on the attractiveness and acceptance of transport modes, but also on road safety and urban development. All of the vehicles presented in Chapter "3 Types of Bicycles and other Micro Vehicles" are theoretically suitable for using cycling facilities. However, due to their specific characteristics they have different requirements for the infrastructure. Based on the mentioned research projects and analyses, the authors of this paper propose the following recommendations for the future integration of the different types of micro-mobility.

5.1 Network Expansion

Due to their higher speed levels and increased range possibilities, electric micro vehicles enable longer distances than conventional bicycles. This must be taken into account in network planning through the expansion of cycling facilities and developing a consistent cycling network, providing a potential to increase cycling shares. The requirement is not only limited to urban areas, but also include the countryside and hilly regions where the electric assistance makes cycling easier. This implies that network planning must not end at municipal boundaries, but should be done on supra-regional levels.

Especially tracks with a regional connection function offer great potential for a modal shift in commuter traffic. This includes e.g. cycle highways, which separate cyclists from other road users and provide fast, safe and attractive connections, often between cities and suburbs. Long-distance connections should play an important network function with corresponding feeder routes and be integrated into the regular cycling network. Cycle logistics companies can also profit from an extended network. Moreover, the potential for cycling in combination with public transport is enormous as catchment areas of stops are increasing due to higher ranges of electric micro vehicles. This implies an appropriate design of intermodal connections, bike-sharing schemes and take-on options.

5.2 Separation by Speed

The various speed levels, which can be achieved by the diverse range of bicycles and micro vehicles, must lead to a radical rethink of streetscape design. Depending on the spatial conditions and traffic network requirements, a street could be separated into parts with different speed limits. This approach was developed and piloted in several Dutch cities and could solve todays' issues of unclear regulations on who is allowed to use which cycling facility [22]. Local authorities should be more innovative and try out new solutions for the increasing diversification of vehicle types. This is explicitly desired, e.g. by the German Transport Ministry [28].

In general, physically separated cycle tracks from motorized transport and pedestrians represent the safest possibility, especially with regard to the diverse speed levels and the potential overtaking procedures. If separation is not possible, mixed traffic solutions can also be an option if the motorized traffic volume is at a low level and the speed limit is reduced to 30 km/h. The results of a Dutch study indicate that the risk of conflict between speed pedelecs and bicycles when using bike lanes is higher than between speed pedelecs and motor vehicles when riding on the roadway. However, the consequences of accidents with motorized vehicles on the roadway are likely to be more severe for speed pedelec users than with bicycles on the bike path [13].

Further, optional usage should be considered here. Besides the achievable speed of the vehicle, physical abilities and self-confidence of cyclists differ immensely. After all, slow and fast cyclists should be able to travel at their desired speed accordingly. These requirements are best met by separated cycling facilities. However, since high-quality cycle paths cannot be created in all road spaces, it should be ensured that the use of cycle paths is not compulsory and that motorized traffic adapts to the coexistence with cycling, e.g. by reducing speed, narrowing lanes and accompanying measures. Releasing road sections in a dual option solution has been proven a good compromise and led to a situation where fast cyclists rather used the carriageway and slow cyclists preferred to use the cycle path [29]. Mixing electric bicycles with pedestrians should be avoided in any case though. Mentioning the different possibilities, signage is an important aspect, providing clear information to road users who is actually allowed to ride where.

5.3 Adjustment of Cycling Facility Standards

All routes should be designed in a way that allows good use of the electric drive and the aerodynamics for the fastest possible progress. Checking the speed-dependent design parameters, such as safety distances to other modes and objects, curve radii, or stopping distances on wet surfaces, is mandatory. Due to the higher speed, greater dynamics and higher weight of electric bicycles and other micro vehicles, there is a need for non-slip surfaces without damage to avoid safety risks and loss of comfort. This also includes appropriate winter servicing.

For the integration of cargo bikes – considering their larger radii due to large wheel spacing as well as increasing vehicle widths and weights – wider bike lanes and paths are recommended. This would not only allow better maneuverability, but also benefit overtaking bicycles with different speed levels. Due to the increasing heterogeneity of vehicle types, a sharp increase in the number of overtaking maneuvers between cyclists and other micro vehicle users is to be expected. Therefore, higher widths of cycling facilities may become necessary. For overtaking maneuvers of two cargo bikes, for example, 3 m are necessary. At the very least, the widths should be such that a single-track bike can overtake a cargo bike. In order to avoid collisions in encounter traffic, markings are necessary in front of bends and crests.

Due to the increasing space requirements, additional space reserves and waiting areas for cyclists or e-scooter users should be considered. Besides the expansion of cycling facilities, infrastructural details must be checked and adapted to the requirements of the heterogeneous types of bicycles and micro vehicles. This includes skid resistance in curves and protection against leaving the track, gradients, obstacles like bollards and circulation grids, or waiting areas at intersections. E.g., existing waiting areas are often too short for cargo bikes [24].

5.4 Safe Parking Facilities

Although electric bicycles and micro vehicles need to be charged regularly, conducted surveys show that commuters rarely need a charging station in public spaces as they usually charge at home or at work. However, in order to promote electric two-wheelers as an alternative for tourist routes, charging facilities are particularly important for longer journeys and should be considered at places where a longer stay is to be expected, e.g. at restaurants, leisure facilities, or hotels.

Besides charging, the higher priced electric bicycles and cargo bikes also require safe parking facilities such as bicycle boxes. User-friendly bicycle boxes should include the following features: a roof for weather-protection, a burglar-proof material, secure lock function as protection against theft, lockers for additional luggage or clothes hooks, a device for a helmet as well as lighting via motion detectors [29]. As pedelecs and cargo bikes usually weigh more, a barrier-free access to parking facilities is also of particular importance. The higher weight, but also the frequent use by elderly people implies that high curbs or stairs should be avoided. This is relevant for both public and private space and could be promoted by the integration into parking space regulations and building laws.

To promote cycle logistics it is recommended to create dedicated parking and loading zones for cargo bikes in front of stores. This will not only be an incentive for companies and private users to use cargo bikes but would also prevent blocking sidewalks or bike lanes. Big data and digital applications offer new possibilities in this regard, not only for navigation, but also for the provision of information about free parking spaces within the framework of bicycle parking management.

5.5 Micro Depots for Cycle Logistics

Today, commercial traffic makes up approximately one third of the traffic within cities [31]. The current numbers for shipping volumes in Germany show 4.05 billion parcels delivered, rising much faster than previously expected [32]. Delivery transport is mainly conducted by 3.5-ton trucks, which often block bike lanes by unauthorized stopping in second row. The rising numbers have a direct impact on life in the city and affects municipal goals related to air pollution control, noise reduction, climate protection, traffic safety, and land redistribution. It increases the pressure to create a framework for more sustainable freight concepts, where cargo bikes come into play [31]. The use of cargo bikes for the last mile is not only environmentally friendly, as it can replace trips made by conventional delivery vehicles, but also economically beneficial for several applications.

To be able to deliver goods by bike on the last mile spaces are needed where the goods can be transferred from trucks to bicycles. Creating so-called micro depots at suitable locations in order to make optimum use of the created network should be one essential goal of sustainable freight concepts. Micro depots are mobile or stationary locations for the transshipment and intermediate buffering of transport goods, such as parcels, often in densely populated areas with a high volume of shipments. They also enable secure parking of cargo bikes when not used. They complement the existing logistics network of a service provider within the first or last mile. In the transport network, micro depots are located between the shipper or the recipient and the regional distribution center. Local transport services deliver suitable parcels to the micro depots from where they are further distributed to the end customer [33].

Real estate prices and limited available space makes the search for micro depots – especially in urban areas – financially difficult and time-consuming. Cities should support sustainable delivery concepts, e.g. by providing available land in municipal ownership. Collaboration between delivery service companies to jointly rent space or even bundle the distribution of goods can help to increase efficiency and reduce costs. Additionally, the threshold for people to connect with and take sustainable delivery for granted needs to be broken down.

Several infrastructural aspects have to be considered when developing micro depot solutions such as the space dimensions for accessing with trucks and bikes, storage, parking and transshipment, sanitary areas for the drivers, charging stations and necessary technical equipment. Suitable cargo bike models should be selected for the use of micro depots and be combined with the specific material flow, which differs by goods, shipment types and service types [34]. For future considerations, the combination of delivery by trams and cargo bikes is also a promising approach [35]. The specification of a clear legal framework as well as the support of innovative logistics concepts should facilitate the integration of bicycles into logistics processes.

5.6 Clear Legal and Regulatory Framework

The current legal framework allows some vehicles to use cycling facilities, while others are prohibited. In Germany, users of speed pedelecs and some types of e-bikes, for example, are not allowed to drive on cycle paths, even though high-class facilities such as cycle highways would offer an ideal connection for these types of bicycles as they allow longer distances and thus offer a high potential for substituting car trips. This might be the reason why speed pedelecs so far have not reached a similar boom as normal pedelecs.

Also for cargo bikes, several legal questions have to be solved. In Germany, a new traffic sign was introduced, offering an option to create parking areas for cargo bikes. Clarity is needed with regard to the use of footpaths for the last few meters when delivering a parcel or unloading groceries. These questions are closely related to the general design and (re)distribution of road space. There needs to be enough space to allow cargo bike users to stop without endangering other cyclists or pedestrians.

The use of and especially parking electric kick-scooter is also an area that has not yet been conclusively clarified. Currently, the municipalities are dealing very differently, especially with sharing services, which leads to uncertainties among providers and users. Due to the existing potentials – especially for the first or last mile in combination with public transport – there should be a uniform regulatory framework that does not restrict the use, but clearly regulates their assignment to the infrastructure.

Politics and authorities can make a significant contribution to the transformation of transport systems when they prioritize sustainable means of transport. In order to improve the conditions for electric bicycles, cargo bike logistics and other micro vehicles, it needs a carefully developed legal framework that is connected to the implementation of a high-quality infrastructure.

5.7 Public Relations and Mobility Management

Public relations and mobility management plays a decisive role for the consciousness and the actual mobility behavior of people. The communication of electric bicycle use appeals especially to technology-savvy groups of people and can encourage a direct switch from car to (speed) pedelec use. Also other user groups such as the elderly are more likely to stay on the bike with an electric assistance. Target-oriented measures are crucial to convince as many people as possible for sustainable mobility options. This includes information on the benefits of cycling, but also education and training with regard to electric bicycles, which is particularly important for people who are not yet able to master the additional power of electric assistance.

The higher purchase costs of electric bicycles and cargo bike can also be considered within the mobility management framework of companies and municipalities, e.g. by launching subsidy schemes, initiating leasing programs for bicycles or providing incentives for people using sustainable transport modes. This will not only create awareness among employees or other target groups. The use of bicycles, (speed) pedelecs or cargo bikes can be boosted by such measures.

6 Conclusions

With the increase in sales of electric bicycles and micro vehicles, new needs and challenges arise in road traffic. Electrically assisted or powered bicycles as well as other micro vehicles are associated with higher speeds, longer travel distances, and different riding dynamics. This has to be considered when creating bicycle networks, (re)designing road space and transport infrastructure, developing multimodal transport and logistics concepts, and adapting the legal framework.

More and more types of vehicles and user groups can be found on the roads and a lot of these are using the cycling infrastructure. It means that in the future, cycling facilities will not only need the capacity to accommodate the normal increases in cycling volumes, but that they have to be designed to accommodate all types of electric bicycles, cargo bikes and other micro vehicles. This is accompanied by heterogeneous demands and requirements from the users.

All the more important is a justice and future-oriented distribution of urban space, where much greater consideration is given to pedestrians and the different types of cyclists and micro vehicle users. There is a need for a value shift in politics and administration, no longer approaching transport planning from a car-centric perspective, but rather focusing on the value and quality of public space. Urban development aspects and the mobility needs must be connected and with that, the use of sustainable transport modes should be encouraged.

This includes the creation of consistent cycling networks, adjusted infrastructure related to moving and stationary traffic, intermodal connections to foster the combination of public transport and other modes, and logistics concepts encouraging more companies to switch to cycling. This paper shows that the opportunities to realize the mobility transition and make cities more sustainable are high, but several challenges to achieve the goals remain.

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