



A study under the Sino-German Urbanisation Partnership
Cycling (systems) in Germany and Europe

Impressum

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List of abbreviations

CO _{2eq}	Carbon dioxide equivalent
ECF	European Cyclists Federation
ECLF	European Cycle Logistics Federation
ERA	Empfehlungen für Radverkehrsanlagen
FGSV	Forschungsgesellschaft für Straßen- und Verkehrswesen
FöRi-Nah	Förderrichtlinien Nahmobilität
GDP	Gross domestic product
GIZ	Deutsche Gesellschaft für Internationale Zusammenarbeit
IoT	Internet of Things
MiD 2017	Mobilität in Deutschland
MIT	Motorized individual traffic
NRVP	Nationaler Radverkehrsplan
PBL	Protected bike lane
PT	Public transport

SME Small and medium-sized enterprises

StVO Straßenverkehrsordnung

VwV-StVO Allgemeine Verwaltungsvorschrift zur Straßenverkehrsordnung

1 Overview of the general situation of European (mainly German) cycling systems

While motorized transport has been the dominant consignee of transport planning for decades, the understanding of planning and the public interest have changed increasingly in recent years. “Fewer people accept [...] that the car has such prominence in the cityscape.”¹ In Europe, the bike is increasingly establishing itself as a climate-friendly means of transport, also on the ways of daily traffic.

1.1 Introduction

The German Society for International Cooperation (GIZ) awarded a study in the framework of promoting the exchange of experience and expertise in the field of sustainable and integrated urban development between Germany and China. In this study, cycling support, infrastructure, and technology in Germany and Europe will be described and concisely analyzed. Recommendations for the development of cycling in China are derived from this outcome.

1.1.1 Development of cycling systems in European cities

Utilization rate, user motivation, management, changes in transport pattern and its impacts

The general development of cycling systems in European cities is quite heterogeneous. While cities like Amsterdam or Copenhagen have decades of cycle-friendly planning experience, most of the bigger German cities just have started in the last two to five years to give cycling higher importance in city and traffic planning.

This fact reflects the utilization rate of cycling as well as the changes in transport patterns. Cycle cities like Copenhagen or Amsterdam experience substantial growth in the proportion of cycling compared to other modes of transport. The ratio of cycling in the modal split of Amsterdam, for example, was rising from 33 % in 1990 to 53 % in 2012. In 2017 48 % of the people who were going to work were going by bike. In Copenhagen, this was 41 %. All of this shows that supporting cycling in European cities takes a long time, in terms of improving infrastructure as well as this being accepted and used by the citizens. Since in Germany the cycling support is not as developed as it is in other European countries and cities, the proportion of cycling in most of the bigger cities (more than 500.000 inhabitants) is not as high as it is in those countries. However, it is growing.

In Europe and especially in Germany, the motivation for using the cycle as an everyday mode of transport varies. It is mainly driven by the current challenges of the cities (such as air pollution or traffic problems) and the social discourse about climate change but also by a growing awareness of health. However, there is also the increasing importance of time spent in traffic. While the

¹ Bundesministerium für Umwelt, Naturschutz, Bau und Reaktorsicherheit 2015, p. 1

problems in traffic management are still growing due to the ongoing growth of cars in the streets, the speed of different modes of transport equalizes. The faster cycling gets, and the more equal the travel time of different ways of traffic gets, the more people are willing to cycle.

1.1.2 Current challenges faced by European cities to become cycle friendly

European cities are currently facing different challenges to get more ecological, such as air pollution, climate change, or an ongoing growing of traffic density, causing a variety of problems in traffic management.

Traffic planning of the last about 70 years in most of the European countries and cities mostly aligned to motor vehicles to fasten it as well as make using it more comfortable. In the last about ten years, these aims changed due to the pressure to act caused by the challenges mentioned above. Public transport and more and more the bicycle are getting into focus on traffic planning, as a suitable mode of transportation to charge those challenges.

Not only is the number of cyclists increasing in many cities but also new types of transportation such as E-Scooter are now using the cycle infrastructure as well, and the bike itself is changing and therefore needs more space.

The increase in the required area is caused on the one hand in the rise of the speed spread. Unsafe and untrained cyclists ride at a speed between 12 and about 16 km/h while well-trained cyclists reach a speed of 20 km/h and more. In addition to this, there are pedelec cyclists that reach a speed of 25 km/h. These differences make more passing maneuvers necessary.

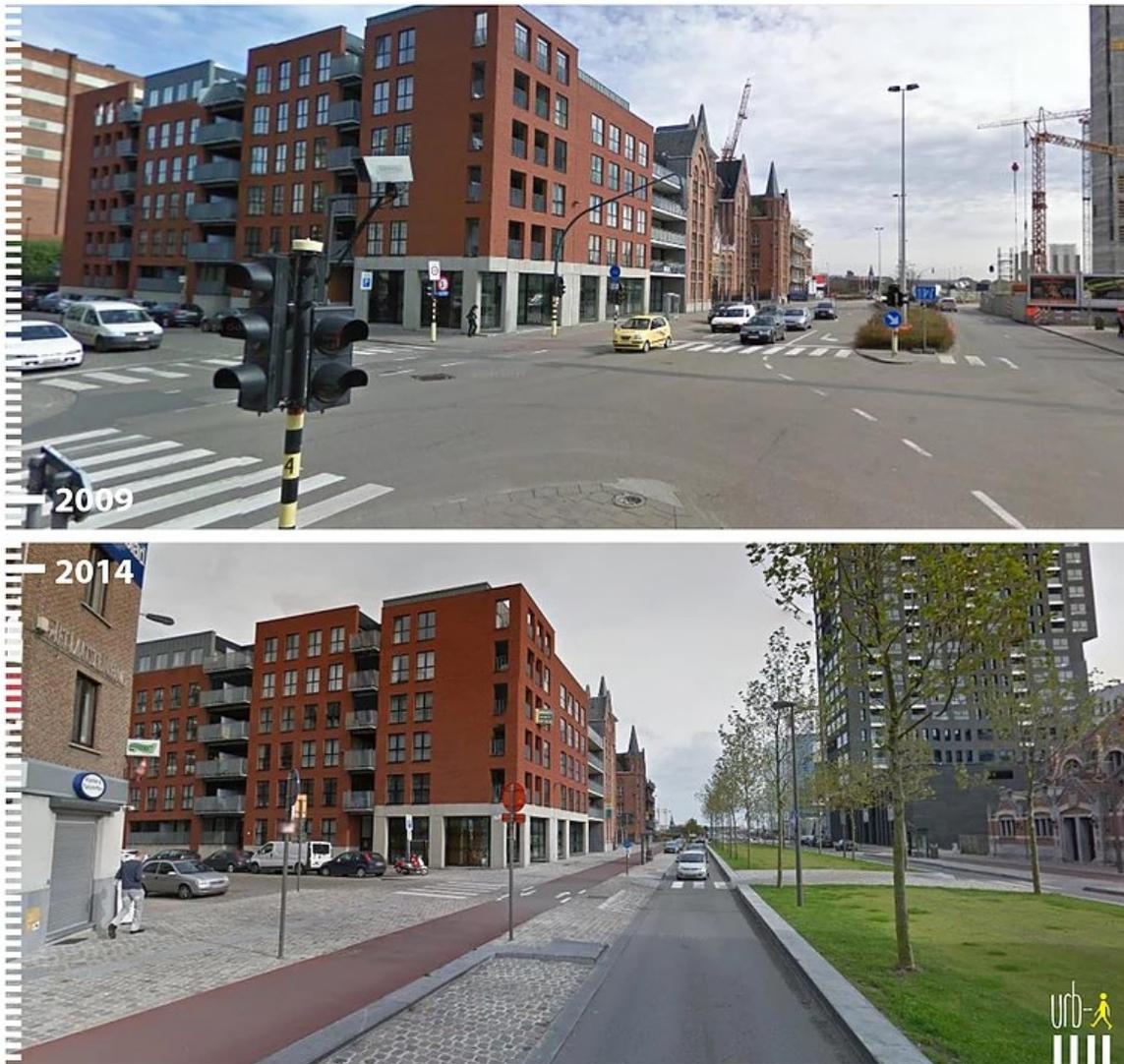
On the other hand, the diversity of cycles increases and with it the width of cycles. Cargo bikes are becoming more and more common sight in European cities, especially for the transport of children, not necessarily goods. However, cargo bikes are longer (up to 2,55 m without any trailers) and broader (up to 0.88 m and sometimes even a little more) than "normal" bikes. This is also reflected in the required widths of cycling infrastructure. At best, this should provide sufficient space for two cargo bikes to overtake. The problem, however, does not only apply to move cycle traffic but also to stationary traffic. The cargo bike requires more space even when stationary and also needs other types of parking systems.

Since most of the European cities are historically grown, although many of them had been destroyed in World War II, the biggest challenge most of the European cities are facing is the ongoing fight about the space ratio of streets. Many European cities were (re) build as car-friendly cities, and most of the inhabitants are used to the fact that much space in the cities is consumed by cars. The fight for urban space is additionally fueled by the steadily rising number of SUV registrations. Not only is the number of vehicles continuing to grow in many cities. These cars are also still getting bigger, with the SUV as the "tip of the iceberg".

The idea of more sustainable mobility now brings the need for changing those space ratios at the expense of automotive infrastructure (e. g. parking lots). The withdrawal of automotive infrastructure causes a high degree of displeasure on the part of the inhabitants and therefore often finds

no political support at the level of cities or districts in Germany. However, the change in space ratio for different modes of transport is without alternatives.

Illustration 1: Remodelling of Londenstraat (Antwerp) presented before (above) and after (below)



Source: urb-i.com

The reservations are still significant. Politicians fear for their votes and do not want to scare away their motor-vehicle affine voters. Owners of cafés, restaurants, and shops in the city centers fear a lack of costumers.

All in all, there are still many persuasions to be done on many points. However, the more useful examples there are, the easier this gets.

1.1.3 Future trends in European cities

The future trends for cycling in European cities are diverse. They range from protected bike lanes and cycle highways over green waves to cycle logistics.

Cycle Highways

Cycle Highways are the premium product for cycling in countries all over Europe. First and foremost, they are connecting cities and different districts of cities. The name highway is misleading though since one of the significant aspects of planning cycle highways is to integrate these sufficiently into the “normal” cycling system.

Illustration 2: Cycle Highway in Twente (on the left) and Nijmegen (on the right)

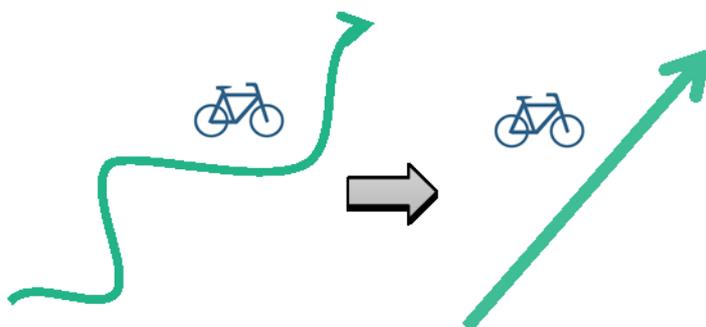


Source: Planersocietät

Essential requirements for cycle highways, beside the width, are:

- Direct and detour-free routing,
- As little as possible interference caused by motor vehicles or at junctions with motor vehicle traffic,
- High surface quality (asphalt or concrete),
- Slow pitched routing,
- Separation from foot traffic.

Illustration 3: Direct and detour-free routing



Source: Planersocietät

Protected bike lane

Protected bike lanes (PBL) are relatively common in bigger cities in North America. In Germany, protected bike lanes are a comparatively new phenomenon that is highly discussed. Osnabrück and Berlin were one of the first cities that inaugurated protected bike lanes in Germany.

The idea of PBL is to give cycling more space and to generate a sense of security by separating them from motor vehicle traffic, which is especially crucial for inexperienced cyclists. Since road safety is one of the most critical aspects, said by people if asked why they are not choosing the bike before the car, increasing road safety for cyclists (and the perceived safety) is essential for traffic planning.

Illustration 4: Protected bike lane in Berlin



Source: Planersocietät

PBL, therefore, can be a useful tool to achieve the goal of greater use of the cycle on everyday Routes.

Green Wave

For motor vehicles, the “green wave” is self-evident: Up until now, green waves have been geared exclusively to the speed of car traffic. Several projects in Germany have changed that. Whether it is statically or dynamically, the green wave for cyclists is gradually being introduced to cities all over Germany with Marburg as being the first city with a dynamic green wave controlled via Smartphone app.

Cycle logistics

Cities across Europe suffer not only from a general traffic problem but also from the significant increase in delivery traffic due to increasing online trade. Especially last-mile logistics are problematic since transporters are blocking the streets and cycleways and are inefficient in their usage. About 70 % of the delivery costs are incurred in the last 1.5 kilometers from the place of delivery. In 2013 a study showed that about 42 % of all motorized trips with goods transport have the potential to be shifted to the bike². All over Europe more and more transport service provider changes their vehicles from cargo trucks to cargo bikes.

Illustration 5: Cargo bike for transportation in cities



Source: Planersocietät

In the city of Gent, there are no more trucks allowed in the inner part of the city. All goods must be brought to hubs and from there are being delivered by some particular electric vehicle or by bike.

Seamless mobility and mobility as a service (maas)

To reach their destination, people are changing the means of transport more frequently and are choosing the best possible solution for their way and to its purpose: situational, ad hoc, pooled. Sometimes the car, occasionally public transport, sometimes the bike. Connected inter- and multimodal mobility, which will determine demand in the future, means developing integrated mobility concepts. The prerequisite for this is to think, organize and offer mobility no longer in different modes of transport, but along mobility chains. Individual means of transportation will no longer compete against each other, but instead, their use is intelligently interlinked. An increasingly networked, intermodal mobility goes hand in hand with ultra-integrated mobility concepts. Mobility will be mostly seamless in this way. Fluids and seamless transitions from one mode of transport to another – the vision of highly flexible, efficient, and uninterrupted mobility is becoming a reality through digital networking.

² ECLF 2013, p. 12

The bike has a large share in this. It is a perfect mode of transport for the first and last mile. Bike and ride, therefore, gain increasing importance in the mobility chains of people all over Europe.

Illustration 6: Seamless Mobility or Mobility as a service driven by digitization



Source: Planersocietät

1.2 Planning and regulations on cycling systems in Germany

The relevant cycling regulations in Germany are divided into legal regulations and those which standardize cycling infrastructure as state of the art. The legal regulations furthermore divide into those rules of law of the federal republic of Germany and those of the different states.

1.2.1 Overview of relevant cycling regulations in Germany

On the side of the federal republic of Germany, there is mainly the road traffic act “Straßenverkehrsordnung (StVO)” and administrative regulations with which it is accompanied (“Allgemeine Verwaltungsvorschrift zur Straßenverkehrsordnung (VwV-StVO)”).

On the part of the states, each of the 16 German states have their road law, which in most parts are equal but differ in some details.

Furthermore, the German research society of street and transportation (Forschungsgesellschaft für Straßen- und Verkehrswesen FGSV) developed Recommendations for cycle infrastructure (“Empfehlungen für Radverkehrsanlagen (ERA)”) which were updated in 2010 for the last time and are currently in the process of getting updated. Those recommendations form the basis of planning activities regarding cycle planning.

In detail, the German road traffic act provides a variety of different types of infrastructure for cycling. Since the bicycle is a vehicle in terms of the law, the common area for riding a bike should

be the roadway. In streets with a maximum speed of 30 km / h or less this should be usual. In particular situations and to gain safety for cyclists, it is possible to mark off protection lanes, which should only use by motor vehicles to evade.

Protection lane
(Schutzstreifen)



In all other cases and in terms of §45 IX StVO “traffic signs and traffic installations are only to be installed where this is mandatory due to the particular circumstances. [...] In particular, restrictions and prohibitions of flowing traffic may only be imposed if, due to the particular risk of the local conditions, a hazardous situation exists which substantially exceeds the general risk of impairment of the legal interests mentioned in the preceding paragraphs”. If such risks exist the following types of cycle infrastructure are available:

Common pedestrian and cycle path
(gemeinsamer Geh- und Radweg)



Separated pedestrian and cycle path
(getrennter Geh- und Radweg)



Independently guided cycleway ...



... or Cycle lane
(Radfahrstreifen)

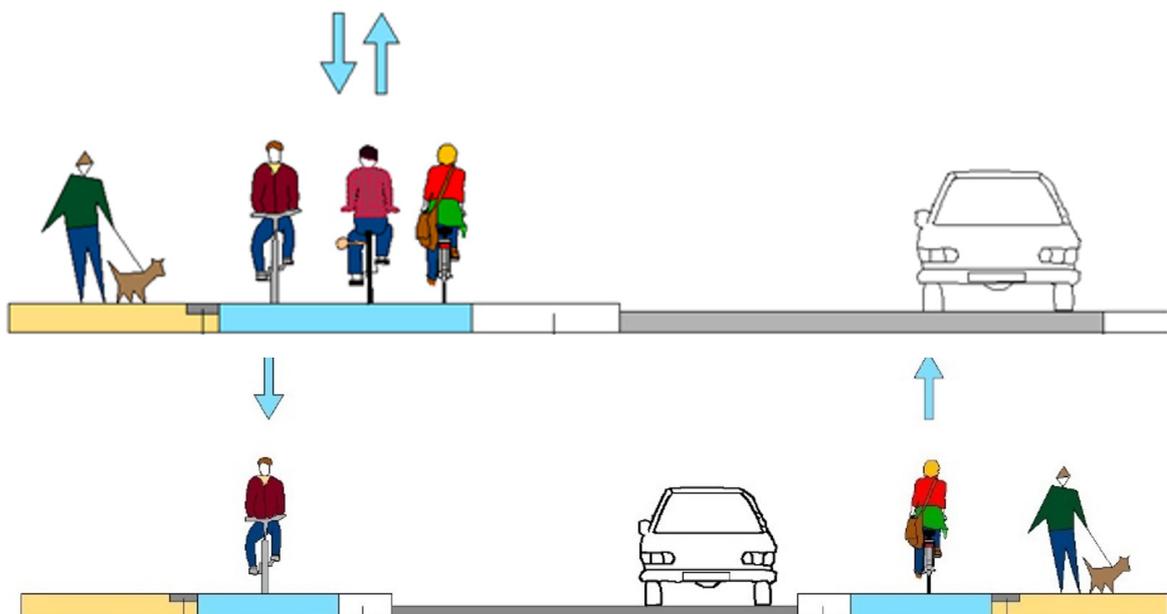


Cycle street
(Fahrradstraße)



Some of these types of cycle infrastructure are building subtypes or are subdivided to improve technical planning. The common pedestrian and cycle path, for example, is differentiated by location (is it an inner or outer city). All other cycleways (separated or independently guided) are differentiated whether or not it is conducted bi-directional and furthermore if it is guided on one side or both sides.

Illustration 7: For example, bi-directional cycleway on one side (at the top) and single directional cycleway on both sides (below)



Source: Planungsbüro Via eG

1.2.2 Technical planning regulations for cycle lanes and parking sites

The different types of infrastructure mentioned in the last chapter all have different quality standards after ERA. Those are:

Table 1: Width requirements for cycling infrastructure (regarding StVO and ERA)

Type of infrastructure		StVO and ERA			Cycle Highway	
		Width for cycling	Security separating strips for the roadway	Protection separating strips for longitudinal parking	Protection separating strips for oblique parking	Width for cycling
Protection lane		1,50 m	-	0,50 m	0,75 m	Not acceptable
Cycle lane		1,85 m	-	0,75 m	0,75 m	3,00 m
One directional cycle path		2,00 m	0,50 m	0,75 m	1,10 m	3,00 m
One sided bi-directional cycle path		2,50 m	0,50 m	0,75 m		4,00 m
Both sided bi-directional cycle path		3,00 m	0,50 m	0,75 m		
Common pedestrian and cycle path	Inner city	2,50 m (or more)	0,50 m			Not accepted
	Outer city	2,50 m				
Cycle street		4,00 m (4,50 m if there is bus service on it)		0,50 m	0,75 m	4,00 m (4,50 m if there is bus service on it)

Source: Planersocietät

For bicycle parking, there are no legal requirements in Germany, but there are quality features which are accepted overall. The following criteria are considered basic quality features:

- Excellent and secure grip on all bike sizes and types without any risk of damage to the bike or the cycle parking facility;
- Excellent accessibility for easy parking with sufficient freedom of movement;
- Adequate lighting and visibility of the cycle parking facility to theft protection as well as to improve the perceived safety;
- Adequate theft protection by the possibility of attaching one of the wheels and the frame, if the bike cannot be completely enclosed;
- Simple cleaning and safe operation due to bright design, sufficient height for roofing, avoiding sharp edges and danger of falling;
- Restrictions on people with disabilities should be avoided;
- Regular movement of “scrap bikes”

- Secure handling due to versatile leaning and connection options (e. g. by additional lower beams);
- Urban design compatibility in the form of restrained and straightforward shapes and colors as well as
- Staggering the offers as needed: for long-term parking at a train station or the office, weather-protected and locked cycle parking facilities should be offered, while short-term parking at a supermarket should suffice with simple stirrups.

Illustration 8: Different types of cycle parking facilities



Source: Planersocietät

1.2.3 Regulations for traffic behavior and safety

The regulations for traffic behavior and security are all prescribed by the road traffic act (StVO). As mentioned above, first premise of cycling in Germany is that vehicles (which include bikes) have to use the roadway and have to drive as far as the right as possible³.

“If you want to turn left with the bike you do not have to get into the lane when the road should be crossed from the right side of the road behind an intersection or junction. If you want to turn off, you have to let oncoming vehicles drive through, rail vehicles, a bicycle with an auxiliary engine and bicycles even if they drive on or beside the road in the same direction.”⁴

“On bicycles, only children up to the age of seven may be taken with by persons 16 years or older, if the children are seated in special seats and if wheel trims or similarly effective devices ensure

³ § 2 StVO

⁴ § 9 II StVO

that the children's feet cannot get caught in the spokes. Up to two children under the age of seven may be carried by persons aged 16 or over behind bicycles in trailers designed to carry children. The limit of seven years of age shall not apply to the carriage of a disabled child.”⁵

“Traffic signs and traffic installations are only to be installed where this is mandatory due to the particular circumstances. Danger signs may only be placed where it is necessary for the safety of the traffic because even an attentive road user cannot recognize the danger or cannot recognize it in good time and does not have to expect it. In particular, restrictions and prohibitions of flowing traffic may only be imposed if, due to the particular risk of the local conditions, a hazardous situation exists which substantially exceeds the general risk of impairment of the legal interests mentioned in the preceding paragraphs. Sentence 3 shall not apply to the ordering of

- protection lanes for cycling (sign 340),
- bike streets (sign 244.1),
- special trails outside built-up areas (signs 237, 240 and 241) or cycle lanes within built-up areas (sign 237 in conjunction with sign 295),
- 30-speed zone according to section 1 c,
- traffic-calmed business areas according to section 1 d,
- inner-local route-related speed restrictions of 30 km/h (sign 274) in accordance with § 1 I on roads of supralocal traffic (federal, state and district roads) or on other priority roads (sign 306) in the immediate vicinity of kindergartens, day-care centers, general schools, special schools, retirement and nursing homes or hospitals located on these roads”⁶.

Furthermore, the conference of transport ministers in Germany recently presented ad-hoc measures to amend the road traffic act and to promote cycling with it. These include among others that one-way streets in 30 km/h zones should in principle be opened for cycling in the opposite direction. The side-by-side use of bicycles shall only be prohibited if this obstructs traffic. The use of bike streets is to be simplified.

1.2.4 Comparison and assessment of German regulations in the framework of other European countries' laws

The bicycle is already defined as a vehicle in the Convention on Road Traffic⁷. A bike represents any vehicle “which has at least two wheels and is propelled solely by the muscular energy of the person on that vehicle, in particular by means of pedals or hand-crank.”⁸ Therefore, the cycle as a vehicle is under regulation as well as there are specific traffic rules for cyclists.

The convention thus states a list of equipment characteristics a cycle should provide such as an efficient brake or a red reflecting device at the rear. All European Countries signed the convention, but all these countries ratified it. The latter include France, Spain, and Portugal.

⁵ § 21 III StVO

⁶ § 45 IX StVO

⁷ United Nations 1968

⁸ Ibid., Chapter I Art. I (I)

In addition to these mandatory equipment characteristics, some countries such as the Netherlands and Germany have supplementary regulations to ensure cyclists' visibility or standards for accessories such as children's bicycle seats.

Cycle helmets are not mandatory in all European Countries. Malta was the first country in which cycle helmets became compulsory. That was in April 2004. In Sweden cycle helmets are only mandatory for children up to 15 years of age. All in all, the bicycle helmet legislation is divergent and differs from country to country.

In addition to the rules that apply to all public streets and under the Vienna Convention, cyclists are subject to specific rules defined in their national legislation. These national legislations differ in particular points, but may also alter more fundamentally from each other. For example:

- Cyclists have to keep to the right of the carriageway (in the UK and Ireland to the left) and give an appropriate arm signal when they wish to turn.
- Cyclists may not ride more than one abreast. Some countries however introduced exceptions to this rule (e. g. on cycle tracks)
- In Germany, it can be allowed for cyclists to ride contraflow in one-way streets
- Some national legislation provides that cyclists can only ride on a road after a certain age. In Switzerland, a cyclist must have at least the legal age to go to school before he can ride on a road. In Denmark, children under the age of 6 are not allowed to go by bicycle unless they are escorted by a person who is 15 years old or older. In Germany, children must be at least eight years old with the same provisions as in Denmark. In Poland, children over ten years must have passed a test to be allowed on the road.

Moreover, another special provision is making its way through Europe: Turning right at a red light for cyclists. The Netherlands is the pioneer here. Already in 1991, turning right at red for cyclists has been regulated by law. France followed by a clear margin in 2012. So did Belgium. In Denmark, a test phase was carried out between 2013 and 2015, which was finally completed successfully and therefore was declared a permanent arrangement in 2016.

It can, therefore, be stated that the regulations on cycling in Europe are based on the same principles, but that the details are different in the various countries, which cannot be described comprehensively due to their scope and complexity.

1.3 Financing cycling infrastructure and services

1.3.1 A general overview of the financing mechanism and instruments applied (public and private)

Germany has developed a national cycling support strategy. Already in 2002, the federal government took an important role as a moderator, coordinator, and initiator of cycle funding with the presentation of the National Cycling Plan (2002-2012) (Nationaler Radverkehrsplan NRVP). The "National Cycling Plan 2020 – Developing cycling together", which has been in force since January

2013 seamlessly follows the first NRVP and has developed it in terms of quality. Main topics are among others:

- The federal government attaches great importance to the support of cycling as part of a modern transport system in cities and rural areas and funds it with the NRVP.
- The federal government will continue to be involved within its responsibilities for cycling funding. This involvement includes the creation of infrastructure (e. g. construction of cycleways on federal streets which is a volume of 98 million euros per year), the development of the legal framework (e. g. StVO) and the support of model non-investment projects and measures (role model effect).
- The market for Pedelecs shows a particularly significant momentum. The development of this economic factor, which is not insignificant for German SMEs, will continue to be supported by the NRVP. The spread of Pedelecs also has an impact on infrastructure and traffic safety.

Besides the NRVP there are several more public financing instruments, either on the part of the federal government or the federal states. One of the most popular is the “Directive on the funding of climate protection projects in the community environment” (Kommunalrichtlinie). Its focus is not cycling, particularly but sustainable mobility overall. Nevertheless, cycling has an essential part in it. Funding for cycling experiences, for example:

- Construction of cycling facilities such as cycle lanes, protection lanes, cycle streets or gaps in cycle networks,
- construction of new bike paths,
- establishment of signposting systems for everyday cycling or
- the establishment of freely accessible parking facilities for bicycles.

The funding ratio is 40 % with a minimum benefit of 10.000 EUR and a maximum of 500.000 EUR.

Special funding is experienced by the cycle highways. The federal government funds cycle highways in the construction load of the federal states or municipalities with initially 25 million EUR annually. The corresponding law is in force.

Furthermore, there are federal states of the federal republic of Germany who has launched their funding. As an example, the following will shortly introduce the “Guidelines for promoting local mobility in cities, towns, and districts of the state of North Rhine-Westphalia” (Förderrichtlinien Nahmobilität FÖRi-Nah).

The FÖRi-Nah promotes short-distance mobility, which in terms of the guidelines is equivalent to non-motorized private transport and refers to individual mobility, preferably on foot and by bicycle, but also with other non-motorized means of transportation. Eligible are construction and development projects, fundamental renovations and other projects of short-distance mobility that are suitable

- to ensure safe cycling and pedestrian traffic;
- to shift individual motorized traffic to cycling and pedestrian traffic.

In doing so, networking with public transportation has to be taken into consideration.⁹ The maximum support may not exceed 90 %.

Direct private financing, on the other hand, is not entirely distributed in Germany.

1.3.2 Evaluation of interest for the public sector to invest in cycling infrastructure

The benefits of the public sector to invest in cycling infrastructure are divers. All kinds of fields have an advantage of investment into cycling support, which makes it attractive for the public sector to invest in cycling infrastructure as well as promoting the “system of cycling”.

“Supporting a shift away from motorized vehicle travel towards walking and cycling would also be expected to yield additional health, economic, and environmental benefits, including reducing traffic congestion, noise, and the emission of greenhouse gases.”¹⁰

Illustration 9: Fields benefitting from cycling



Source: Planersocietät based on ECF 2018

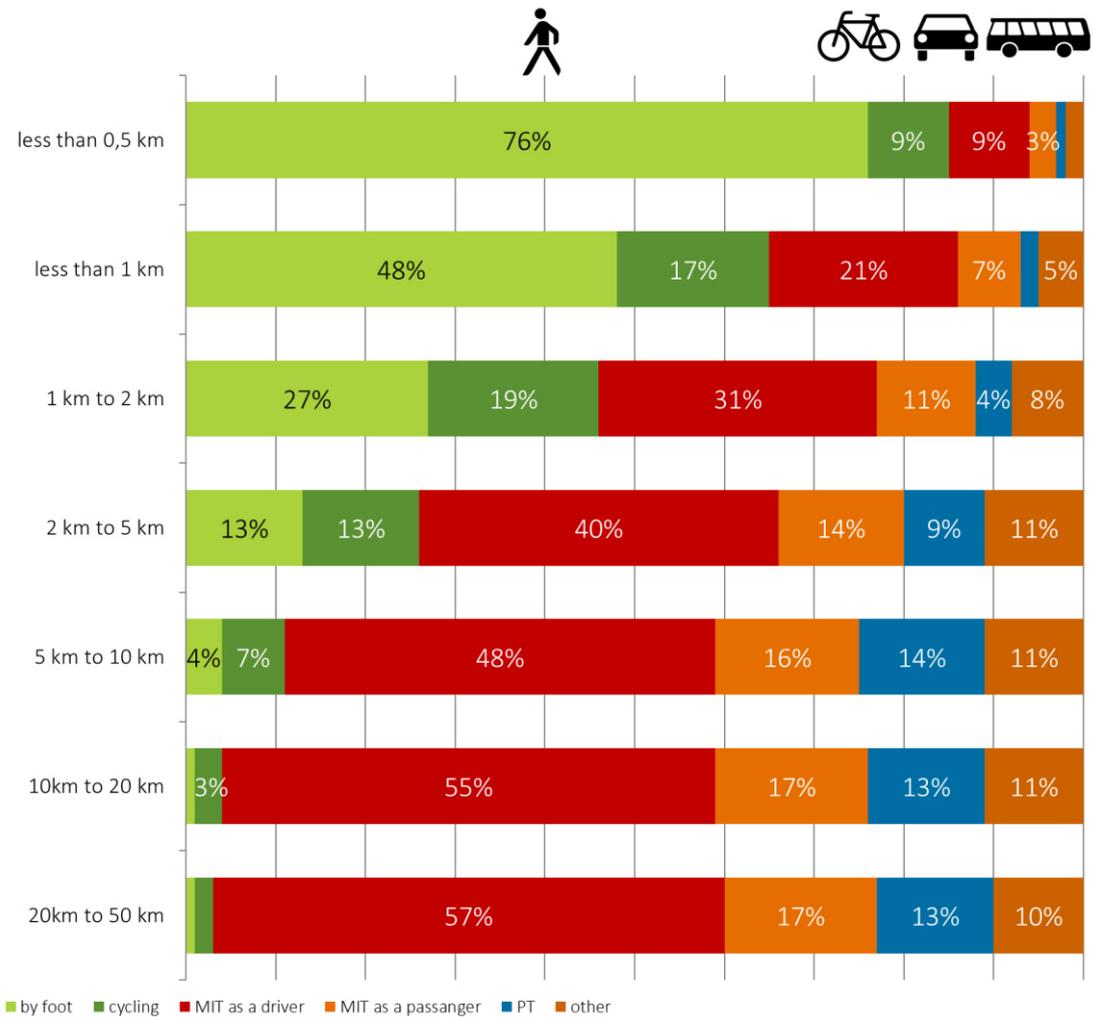
Environment and Climate

According to studies, cycling saves emissions equaling more than 16 million tons of CO_{2eq} per year in the EU alone. An average way in Germany according to the latest survey about mobility in Germany (MiD 2017) is 12.5 km long. Especially ways under 5 km but increasingly (due to progressive spread of Pedelects) ways up to 10 km, and more can be shifted from motorized individual traffic (MIT) to more environmental modes of transport such as public transport (PT) or in this distance class to cycling. The potential for a modal shift to cycling is immense and with the potential for climate protection. The Federal Environmental Agency estimates that 30 % of all car trips in metropolitan areas could be substituted for cycling.

⁹ Ministerium für Verkehr des Landes Nordrhein-Westfalen (2019)

¹⁰ Bundesministerium der Justiz und für Verbraucherschutz (2014)

Illustration 10: Mode of transportation choice by distance in Germany



Source: Planersocietät based on Data of MiD 2017

But not greenhouse gases alone are reduced but promoting cycling also reduces air and noise pollution. Cycling, therefore, protects not only the climate but also the environment in general.

Energy and resources

Most obviously, cycling can save much fuel. Already the current level of cycling in the EU corresponds to fuel savings of more than 3 billion liters per year. The value of these fuel savings is almost 4 billion euros, which can be spent otherwise.

Furthermore, the production of a bike is much less energy-intensive. The average weight of a car in the EU in 2017 was almost 1.400 kg while a bike rarely weighs more than 20 kg or 1.5 % of the weight of a car. Besides a less energy-intensive production, this means much fewer resources needed for its construction as well as that the resources used for construction are in most cases much more environmentally friendly.¹¹

¹¹ European Cyclists' Federation (2018)

Health

Cycling has many positive impacts on public health. Increasingly, physical inactivity worldwide is responsible for the increase in morbidity and mortality. The consequences of this are overweight and obesity, as well as secondary diseases, like:

- Cardio-vascular diseases,
- diabetes (type 2),
- breast cancer,
- colon cancer or
- osteoporosis.

Daily rapid walking or cycling can reduce the risk of developing adult-onset diabetes by 60 %, the risk of stroke by 30 % and the risk of a heart attack by 50 %. Furthermore engaging in moderate physical activity reduces the risk for Alzheimer's disease by 29 % and cognitive decline by about 26 %¹² and is also linked to lower the odds for developing depression to about 17 %¹³. The city of Copenhagen states that every cycled kilometer is the equivalent of DKK 0.99 in health care costs saved by the city, which includes increased productivity as well as reduced treatment costs¹⁴.

Furthermore, physical activity benefits children since they gain a higher concentration level. A study from Denmark says that the concentration level of children who are cycling or walking to school is 4 hours after arriving 8 % higher than of those children who are getting a lift by car.¹⁵

To push the modal shift also brings an improvement of air quality, as mentioned above. Air pollution is a significant health risk in the EU. The European Environment Agency stated in their "Air quality report" of 2018 that air pollution itself is the cause of more than 500.000 premature deaths. Most of them are attributable to PM_{2.5}.

Economics

All of this also has real economic effects: A study by the city of Copenhagen shows that the city profits 23 cents net from every kilometer traveled by bike instead of a car. A kilometer drove by car, on the other hand, costs 16 cents¹⁶. A study by the British National Institute (NICE) comes to similar conclusions. It puts the cost-benefit ratio for maintaining and developing cycle infrastructure at 1:11. This means that for every British pound invested in cycle infrastructure, eleven British pound results in health and social benefits¹⁷. In the Netherlands, the total economic health benefits of cycling are estimated at 19 billion EUR per year. In 2014 Macmillan et al. conducted a study about "The social costs and benefits of commuter bicycling" taking several variables such as commuting population growth, commute mode share, bicycling injury, or greenhouse gas emissions outcomes. The principal findings are similar to those of other countries: "in high-income,

¹² Guure et al. 2017

¹³ Schuch et al. 2018

¹⁴ City of Copenhagen 2017

¹⁵ Natur- og Biovidenskablige Fakultet ved Kobenhavens Universitet 2012

¹⁶ COWI 2009, p. 5

¹⁷ Beale et al. 2012

car-dependent cities such as Auckland, particular bicycle-friendly interventions will be crucial to turn patterns of declining commuter cycling into sustained growth that would meet climate and health goals” and “the intervention policies outweighed the harms, between 6 and 24 times”. “We estimate that these changes would bring large benefits to public health over the coming decades, in the tens of dollars for every dollar spent on infrastructure.”¹⁸

Social affairs

The yearly costs of owning and using a bike only amount to around 5 % to 10 % (for electric bicycles) to the price of owning and using a car. By providing a cheap transportation option, cycling can help to make jobs and participation in social life better access to all people regardless of their age, income, or social status. It also encourages gender equality. Research shows that women tend to benefit more from higher cycling levels. Since they are still taking care of most of the children’s and elderly mobility in families, they gain more free time if those can undertake journeys by bike independently and do not need a lift by car.

Besides that more people cycling and walking in the streets increase social control, which can help to create a higher level of perceived security.

Mobility

The value of congestion easing through cycling for the EU can be estimated at 6.8 billion EUR per year, while the total costs on congestion for the EU economy have been estimated at over 240 billion EUR per year which corresponds to a share of almost 2 % of EU GDP.

In Copenhagen, cycling improvements lead to 45 % less car traffic and faster public transport. In the Netherlands cycle, highways reduce the time spent in congestion by 3.8 million hours per year.¹⁹ So the traffic in the cities is positively influenced by the support of cycling.

Furthermore, cycling helps to create sustainable mobility chains. In the Netherlands, 44 % of train commuters use their bike to reach the train station from their home. People combining bike and train also use their car less.²⁰

¹⁸ Environmental Health Perspectives (2014), p. 342

¹⁹ FLOW (2018)

²⁰ Kennisinstituut voor Mobiliteitsbeleid (2018)

1.3.3 Evaluation of interest for private sector to invest into cycling infrastructure and services

As much as the interest for the public sector, the reasons for the benefit of the private sector vary and reach from financial goals over the health of the employees up to the image of a company.

From the financial side, there are different factors to consider. For once cycle tourism in Europe is a significant factor with an estimated number of 2.3 billion cycle tourism trips per year and a total economic value of about 44 billion EUR. In France, for example, cycle tourists spend almost 20 % more than the average for all tourists.

Not only in tourism cyclists spend more money than people arriving in any other mode of transport, but also people go shopping by bike. Customers using their bike to go shopping account for a total volume of consumption of 111 billion EUR. Cyclists visit local shops more regularly, spending more money than users of most other modes of transport. Per square meter cycle parking delivers up to 5 times higher retail than the same area of car parking²¹.

In Addition to direct monetary effects, cycling has a positive impact on the employees of a company. Different studies show that workers who use the bicycle year-round are superior in all requested health indicators to users of all other modes of transport²². It was found out that employees that cycle to work regularly have an average of 1.3 days less sickness absence per year. This means a gain of almost 5 billion EUR per year for employers around the EU.

Also, for many companies' cycling is a field of business. The value of the bicycle market in Europe was estimated at 13.2 billion EUR in 2016 and is expected to grow with an annual rate of 5.5 % until 2022. Moreover, it is a highly innovative industry, as well. Digitalization is increasingly influencing the market of cycling and opens up new fields of business. Bikesharing companies like nextbike or swapfiets whose business model is a cycle subscription that involves maintenance.

Also, besides all of that, cycling gives a company a "cool" and "hip" image, since cycling is more and more becoming the prototype of cool, relaxed, and sustainable urban mobility.

1.3.4 Examples of private investment including mode of operation

Cases of private investment into cycling in Europe are rather rare. Of companies like nextbike who are operating cycle sharing systems do invest in cycling infrastructure of cities by providing the necessary infrastructure for the rental. The mode of operation differs from city to city, in any case.

Other examples are "job bikes" or "employee bikes". Equivalent to a company car in Germany, there are different models of tax incentives for leasing a bike which is used on the way to work but can also be used in private. One model is the job bike by salary conversion. This means that the employer leases the bike and leaves it to the employee for professional and private usage. The employee serves the monthly installments from his gross salary. By that savings, up to 40 %

²¹ Raje et al. (2016), p. 3

²² Kemen (2016), p. 117

are possible compared to the classic purchase. The other model is employer-financed job bike, which means that the employer leases a bike, covers all the costs, and leaves it to the employee in addition to the already paid wages. The employee bike, however, ensures the use of a bicycle for official usage at any time.

One example of private investment into a concrete infrastructure project is the cycle highway of Enschede and Hengelo. The company Ikea wanted the cycle highway to be built to provide its employees as well as its costumers a quick and comfortable possibility to get to their Location by bike. They found that the health and performance of their employees are higher when they cycle to work. That is why the company supported the cities of Hengelo and Enschede to build the cycle highway and to get connected to it.

1.4 Technology supported cycling

Digitalization also reaches cycle traffic in very different characteristics. It includes innovations in the field of interlinking cycling with other modes of transportations, linking cycling with sustainable energy, technology of personal safety, technology of bicycles and accessories or transaction data which are especially helpful to traffic planners.

Technology for interlinking cycling with other modes of transport

The degree of interlinking cycling with other modes of transport differs. A rather low threshold is Bike and Ride, where the technology, however, led to a simplification. Cycle parking facilities can be booked and unlocked via smartphone or smart cards.

One step further is the project of switchh in Hamburg. For a monthly rate of 8.90 euros, the switchh card gives access not only to more than 2.500 bikes of the Bikesharing system StadtRAD Hamburg but also to the carsharing systems of DriveNow, Cambio and car2go. For the last-named there is a credit of 20 free minutes every month, using the Bikesharing system the first 30 minutes of each trip are free.

Illustration 11: Switchh point Berliner Tor in Hamburg

Source: Planersocietät

Technology for linking cycling and sustainable energy systems

A 90 meters long cycleway near Cologne is the first solar cycle path in Germany. It feeds about 16.000 kilowatt-hours of energy per year into the local power grid. That is about as much as four four-person families in Germany consume in one year. The 200-square-meter tile carpet also absorbs noise and does not need a winter service since the solar cells can generate resistance heat when they are self-powered. Black ice can thus be prevented. The structure of the soil is pimped, comparably to that of a mountain. "The dirt collects in the valleys, where the water that carries the dirt backflows, so we try to minimize the loss caused by filthy modules." The hilltops hold the tire. They are covered with corundum, an abrasion-resistant, and hard mineral. The valley has another function: "It absorbs the sound and prevents aquaplaning through its deep structures."²³ However, the technology still has its flaws and is not yet mature enough to become an integral part of cycle planning.

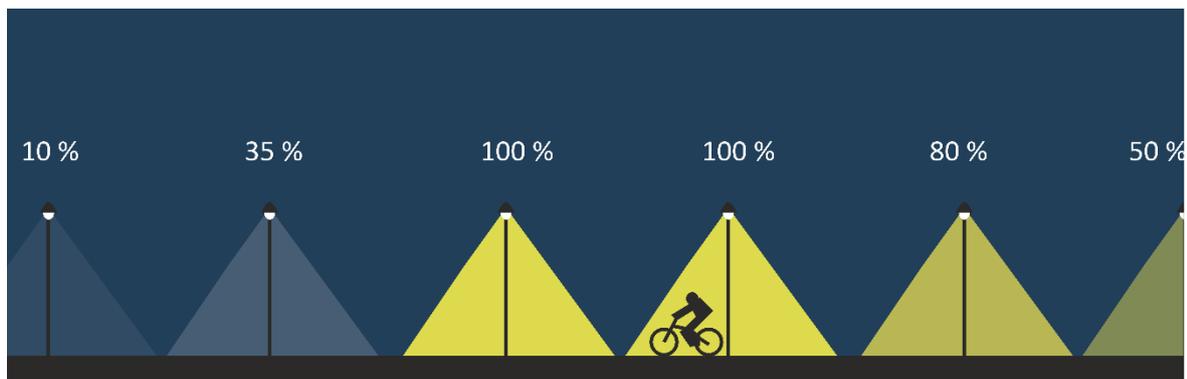
The technology of personal safety

Intelligent street lighting saves power and thereby protect the environment. But more than that it is also possible to increase the (felt) security by using them in outer city areas especially in sensitive areas such as nature reserves where social security is not as high as in inner-city neighborhoods.

²³ Spiegel Online (2018)

Safety in cycling could also be increased in the future as a result of digitalization. Cyclists and bicycles become a part of the Internet of Things (IoT) and thus of vehicle2x communication. With the help of smartphones or locator tags, bikes and travelers are in constant exchange with the digitized environment and especially the motor vehicle traffic. Autonomous vehicles can detect cyclists (and walkers) even better. In addition to or after the “turn-off assistant” (especially in trucks) accidents can be avoided particularly in the subsequent stages of automated driving.

Illustration 12: Intelligent street lighting



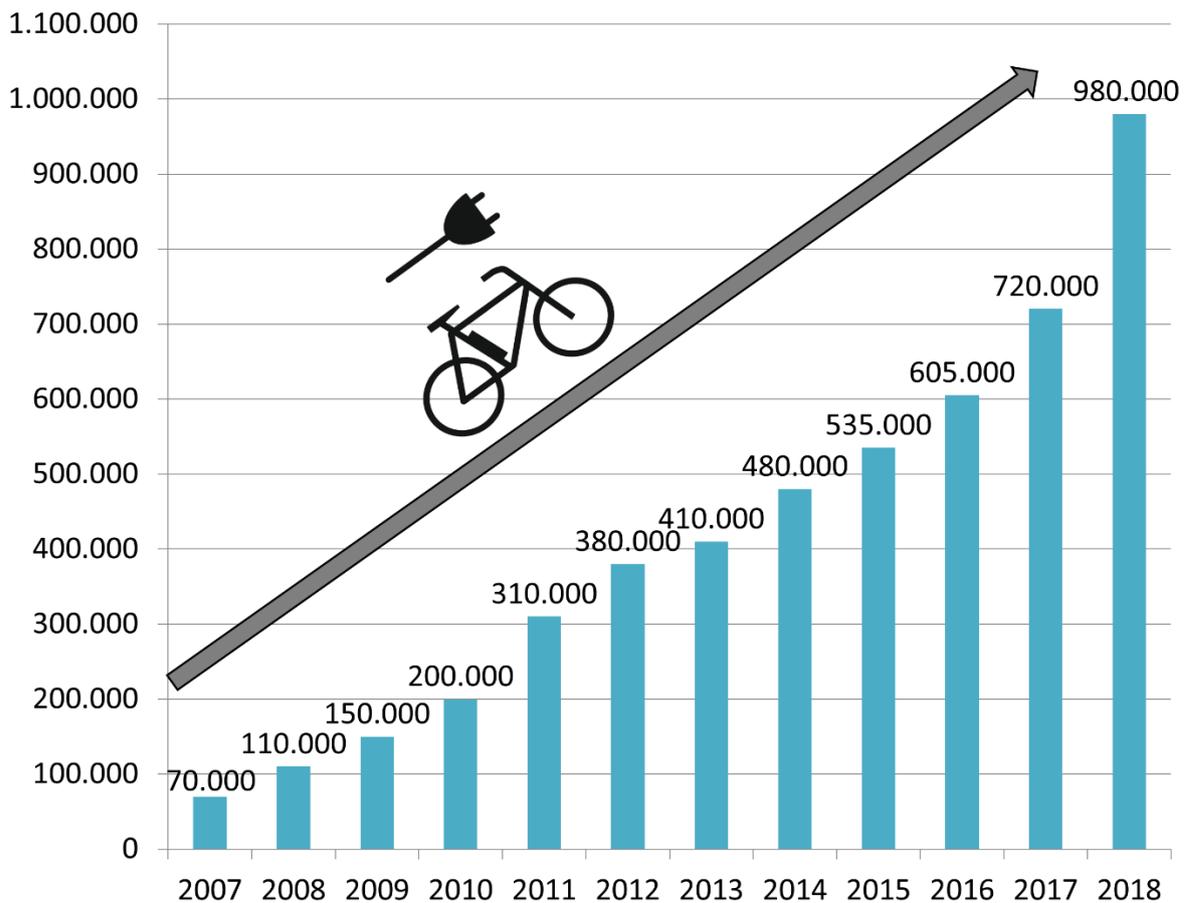
Source: Planersocietät

The technology of bicycles and accessories

Not only the flowing but also the stationary bicycle traffic is opened by digitization. Bicycle locks that can be locked or unlocked with a smartphone and that emit or can be tracked in the event of theft or can be opened for other users like private Bikesharing have arrived on the market. However, also, the rental of conventional rental bikes is further simplified by corresponding apps.

Finally, mobile phone providers have also become aware of the bicycle traffic market and, in cooperation with bicycle manufacturers, offer packages to secure bicycles. This involves installing a sim card into the bike, which, for example, sounds an alarm if the bike is removed from a predefined area and enables the owner to locate the bike via smartphone.

So, bicycles and accessories are becoming more and more digitized. This is also reflected in the sales figures for the bicycle industry. The market share of e-bikes in Germany in 2018 is already 38 %.

Illustration 13: Development of the sale of e-bikes in Germany

Source: Planersocietät by numbers of the Zweirad-Industrie-Verband

Transaction data

Motor vehicle traffic in most cities is wholly measured. Traffic models and real-time data more or less precisely simulate motor vehicle traffic. One of the biggest challenges of traffic planning is the definition of a cycling network since there is no such data. To define main routes and additional routes is rather hard because rarely traffic planners can derive those from data, but more likely only have qualitative data (e. g. through interviews or public events and public workshops). Telephone companies are starting to sell their transaction data to use them for traffic planning. However, these are usually not subtle enough to identify ways traveled by bike.

There are specialized apps like Bike Citizens, which provide not only a routing service but also track the ways the user takes. In collaboration with a city council, this data can be used for traffic planning. With the obtained data among other things, so-called heat maps can be created. These maps can be used to determine which routes are selected most frequently. Depending on the app, additional information such as travel and standing time, start – destination matrices, or the development of the day can also be displayed as time-lapse. Ultimately, this opens up a whole range of concrete application options, such as network planning, plant planning, prioritization of measures or the use of data in the context of evaluation and monitoring.

The problem with all these app data in Germany is not only data protection rules but furthermore the limited scope of the application and thus the question of its validity.

2 Case studies of European (especially Germany) urban cycling systems

The description of examples provides a brief overview of the city in general and the state and development of cycling in particular. To do so different cities of all sizes across Europe have been selected.

Illustration 14: Location of case study cities in Europe



Source: Planersocietät

Some of them have been promoting cycling for years, even decades. Some of them just recently started in the last years. An attempt is made to describe significant changes in the cycling system in the past, the changes in the modal split, and individual policies or financing models. Due to the wide variety of data that can be seen by the public, the representation differs in scope and depth in the various case studies. Furthermore, it is being tried to identify challenges and shortcomings in the current cycling system and to derive recommendations of improvements from that. At this point, it should be noted that to be able to make comprehensive and well-founded suggestions for improvement, the status quo should have to be examined in greater depth.

2.1 General situation and status of the cities' cycling system

Berlin

With around 3.7 million inhabitants, the capital of Berlin is the most populous and, with 892 square kilometers, the largest municipality in Germany. Hardly any other major city has as many green spaces as Berlin. The approximately 2.500 public green spaces with a total area of around 6.500 ha (about 7 % of the total area) offer inhabitants and tourists a wide range of recreational opportunities²⁴. This includes about 431.000 roadside trees, which is about 80 trees per kilometer of the city's streets.

Economically Berlin is prospering. With a GDP of 136.6 billion euros in 2017, it is the most significant urban economy in Germany and the fourth largest in the European Union. The GDP developed positively between 2007 and 2017 and rose by about 44 % (94.7 billion in 2007).

In earlier times the share of cycling in the modal split has risen rapidly. Was the share of cycling in 1992 only 7 % it nearly doubled to 13 %. Since then the growth slowed down to 15 % in 2018. The city of Berlin has installed cycle counting stations at neuralgic points all over the city in the last few years. The number of cyclists counted on those stations increased between 2016 and 2019 by about 16 %.

Nevertheless, the proportion of cycling is to be further expanded, according to the will of many citizens. In 2016 the initiative "Volksentscheid Fahrrad" (referendum bicycle) was founded and started a request for a referendum for a "safe and comfortable cycle infrastructure". On June 28th 2018 the house of representatives of Berlin resolved the "Berlin mobility act", which adopted the main objectives of the initiative in favor of cycling. The motivation of users differs. During a survey of the newspaper Tagesspiegel the enjoyment of cycling, the bicycle as the fastest mode of transport, cycling as a sports activity and doing something for its health is the most mentioned reasons for using the bike.

The biggest shortcoming and therefore challenging in the current cycle system lies within its infrastructure: of 1.713 km of main roads, only 56 % are covered with cycling infrastructure. Only about one-fifth of the main streets is covered by cycle infrastructure of 95 % or more. So, all in all, the cycle infrastructure network is a patchwork and therefore in many places not a high-quality experience for cyclists or is even worse unsafe in usage. This is also intensified since there is much fear due to aggressive behavior in road traffic which, among other things, is triggered through the "battle" of space for the different modes of transport.

At the administrative level, one problem is the absence of a concrete allocation of responsibilities or competencies in bicycle traffic planning. In general bicycle traffic planning lies within the scope of duties of the respective district's administrations. Often, however, financial and personnel resources are lacking. Also, a high level of coordination effort is required to plan cycle traffic beyond the boundaries of the urban district.

²⁴ Senatsverwaltung für Umwelt, Verkehr und Klimaschutz

In order to be able to make comprehensive and well-founded suggestions for improvement, the status quo should have to be examined in greater depth. Nevertheless, it appears that increasing the budget and the staff for cycle planning is impossible to avoid. Therefore, it may be helpful to “centralize” cycle planning as a scope of duty for the city of Berlin itself, not its district administrations. Berlin needs more cycle infrastructure and more space for cycling. For commuters’ cycle highways from the outskirts to the city center would be helpful.

Besides cycle traffic, in Germany the so-called “environmental alliance” (Umweltverbund), so the alliance of all modes of low-carbon transport (especially cycling, foot traffic and public transport), gets a higher status in Berlin. The solution approaches for the development of such an offer are therefore widely diversified and range from spatial planning measures to the de-attractiveness of motor vehicle traffic up to actions to make public transport, pedestrian and cycle traffic more attractive. The most crucial step to reach those goals were among others:

- The consistent concentration of settlement development on settlement exes along rail corridors.
- Measures to give priority to the modes of low-carbon transport: Increased consideration of the interests of low-carbon transport in comparison to MIT in the conception or revision of the circuit diagrams for traffic lights: target-oriented weighing to achieve the necessary balance of interests between public transport, pedestrian and cycle traffic.
- Improvement of the connection security in PT across modes of transport.
- The support of the combination of car, bicycle, and public transport use: construction of additional and extension of existing cycle parking spaces, expansion of the range of public rental bikes, development of carsharing.

The estimation of the financial framework for this transport policy up to 2025 was based on an optimistic and a pessimistic scenario. As a result of that, an average volume of 7.6 billion EUR is assumed for the optimistic benchmark scenario and around 6.6 billion EUR for the pessimistic benchmark scenario.

All in all, cycling needs a higher priority

- Significant changes in cycling system in the past
- Particular policies and regulations on cycling system compare with other cities
- Special financing modal on facilitation of the cycling system compared to other cities
- Chances and challenges of interlinking bicycle systems with different modes of low-carbon transport (e.g. walking, public transportation). (What are necessary planning steps and what to take into account for its operation? Which technology is used?)

A quick overview of the city		
Name of the city	Berlin	
Population size	3.7 million	
Economic development²⁵	GDP 2007: 94.7 billion EUR	GDP 2017: 136.2 billion EUR
Changes in modal split²⁶	The proportion of cycling 2008: 13 %	The proportion of cycling 2018: 15 %
Annual expenditure on cycling (per inhabitant in 2018)²⁷	4,70 €	
Challenges and shortcomings in the current cycling system	<ul style="list-style-type: none"> ▪ Low coverage of cycle infrastructure on main roads ▪ There is no concrete allocation of responsibilities or competencies in bicycle traffic planning, neither in the city nor in the respective district's administration ▪ Traffic safety, since many users have a fear of aggressive behavior in traffic 	
Recommendations for improvement	<ul style="list-style-type: none"> ▪ Increasing the budget and staff for cycle traffic planning ▪ Give cycling a higher priority ▪ "Centralize" cycle planning ▪ More cycle infrastructure and more space for cycling ▪ Cycle highways 	

²⁵ European Commission

²⁶ Mobilität in Deutschland 2008 und 2017

²⁷ Greenpeace 2018, p. 10

Cologne

The city of Cologne with about 1.08 million inhabitants is the most populated city in North-Rhine Westphalia and the fourth biggest in Germany (after Berlin, Hamburg, and Munich). The city of Cologne has an overall area of about 40.500 hectares. 29.3 % of it are green spaces (11.871 hectares), and another 4.9 % is water (1.964 hectares)²⁸.

Cologne has international significance as an economic and cultural metropolis. It is one of the world's most prestigious locations for the chemical and automotive industries and, together with some of its suburbs, is home to the headquarters and production facilities of twelve international automobile brands such as Ford and Toyota as well as numerous chemical companies such as Lanxess. Cologne had a GDP of 63.5 billion EUR in 2015, which was an enhancement of nearly 30 % compared to 2010 (49.6 billion EUR)²⁹.

Cologne has made some strong efforts to promote cycling. Several bicycle traffic concepts have been set up as well as the communication process "FutureBikeCologne", which was set up in 2018. Moreover, the efforts are beginning to bear fruit. Between 2008 and 2017 the modal split share of cycling increased by seven percentage points to now 19 %.

All of that, even though the cycling infrastructure in Cologne is still patchy and road safety, especially in the city center, is insufficient. The accident burden is comparably high, bending and crossing accidents are the most common accidents on main roads in Cologne. Furthermore, in many cases (planning) priority is still given to motor vehicle traffic. That is because cycling still lacks comprehensive political support. It is also because of that, that the funding for cycling is insufficient, with only about 2.80 EUR per inhabitant in 2018. In cycle-friendly cities like Utrecht or Copenhagen, the annual expenditure on cycling is more than 12 times higher.

Nevertheless, a big step towards a better cycling infrastructure and (hopefully) a higher share of cycling in the modal split are the different cycling concepts that contain several measures to improve cycling in Cologne. These concepts differentiate between two types of cyclists: the defensive "pleasure cyclists" and the offensive ones. Because of that, there has been a move to offer two networks to cyclists. The first one on main streets to offer an excellent network for fast, "offensive" cyclists and one network of urban cycle routes which is apart from the main streets and offer a qualitative network for everybody, especially "defensive" cyclists. The cycle concept for the city center states that a need for action is to be seen everywhere. The more important it is not to get lost in small measures on every corner.

The cycle concepts are already pointing out most of the measures needed to severely improve the cycle network and the cycling system in Cologne. The highest priority should have the closure of the cycle network. This includes the establishment of cycle highways that connect the city center of Cologne with surrounding municipalities on the one hand, and the overall closure of the cycling network (apart from main streets) on the other hand. The bicycle traffic concept already provides the traffic planners with a wide range of measures to do so. It also includes the redistribution of space on main streets in favor of cycling.

²⁸ Stadt Köln (2018)

²⁹ Ibid.

A quick overview of the city		
Name of the city	Cologne	
Population size	1.08 million	
Economic development³⁰	GDP 2010: 49.6 billion EUR	GDP 2016: 63.5 billion EUR
Changes in modal split³¹	The proportion of cycling 2006: 12 %	The proportion of cycling 2017: 19 %
Annual expenditure on cycling (per inhabitant in 2018)³²	2,80 €	
Challenges and shortcomings in the current cycling system	<ul style="list-style-type: none"> ▪ The cycling infrastructure network is still patchy ▪ The road safety for cyclists is not sufficient ▪ In many cases (planning) priority continues to be given to motor vehicle traffic ▪ Cycling still lacks comprehensive political support ▪ The funds to promote cycling are not sufficient 	
Recommendations for improvement	<ul style="list-style-type: none"> ▪ Establishment of Cycle highways ▪ Closing Gaps in the cycling network ▪ Redistribution of traffic areas 	

³⁰ Stadt Köln (2018)

³¹ Mobilität in Deutschland (2008 und 2018)

³² Greenpeace (2018), p. 10

Copenhagen

With its about 1.8 million inhabitants, Copenhagen is one of the most significant metropolia of northern Europe. In the city center of Copenhagen are some green areas. The water, however, is the element that defines the city. The urban area of Copenhagen is spread over several islands. The more substantial western part lies on the east coast of Zealand (Sjælland), the largest Danish island in the Baltic Sea and Denmark's largest island (except for Greenland). The eastern part of the city includes a collection of smaller islands so-called Holmen and the northern half of Amager. Copenhagen and Malmö in Skåne, Sweden, are only separated by the Öresund Strait.

Copenhagen is the major economic center of Denmark and is based mainly on service and commerce with a GDP of 111.8 billion EUR in 2016.

Cycling in Copenhagen is an essential form of transport and a significant, if not dominant, part of city life. The city offers numerous conditions for pleasant cycling: densely populated urban areas with numerous destinations at short distances, flat terrain, an extensive network of well-developed infrastructure, especially for flowing traffic, consisting of cycle paths along roads, mostly separated from the roadway, but also through green areas.

The consistent and since about 1973 continuous, since 1993 also very systematic support of the bicycle traffic, together with the meanwhile offensive public relations work of Copenhagen and whole Denmark, e.g., with the Cycling Embassy of Denmark, has founded the reputation of Copenhagen as possibly the world's best bicycle city. City and traffic planners and representatives of cycling lobby associations from all over the world repeatedly cite Copenhagen as an exemplary example of the preference for cycling.

Although the first cycle paths separated from the road were built much earlier, they did not become regular until the early 1980s. As in many other cities, planners suggested avoiding heavy traffic on main roads by creating routes on quiet side roads, but the effect on cyclists was small, and most cyclists could not be deterred from their more direct routes along major roads. The bicycle association's wish for delimited cycling facilities on direct road connections in order to make cycling competitive in terms of time and effort. This was the impetus for political decisions to build the first separate cycle paths along main roads as well as for the development of the first coordinated strategies to increase cycle traffic in the urban area.

Since the city started collecting systematic data in 1995, cycling has grown continuously from 30 % (1996) to 35 % in 2010 and 41 % in 2016 in terms of trips to work and education in the city of Copenhagen.³³

From the early 1980s until 2010 the length of the cycle path network in Copenhagen's urban area, on and independent from roads, has almost doubled to 397 km. In 2015 and 2016 alone 7 km of cycle tracks, 3 km of green cycle routes, 18 km of cycle highways, and 3.000 public cycle parking spaces were constructed. Between 2004 and 2017, the total investment in cycle infrastructure, traffic safety, cycle, and pedestrian bridges, and more amounted to 2.07 billion DKK.

³³ City of Copenhagen (2011 and 2017)

In 1996 the city of Copenhagen published the first “Bicycle Account”, in which the city collected data for ten key indicators for the first time. In addition to objectively ascertainable data such as

- urban funds spent on cycling infrastructure,
- the length of cycle path network,
- the means of transport chosen,
- the number of cyclists and
- accident data,

own surveys are carried out. The Bicycle Account provides an overview of the city’s plans and changes compared to the data in previous surveys. The city of Copenhagen has since created and published a Bicycle Account every two years, with significant enhancements in recent editions.

In 2001, Copenhagen published its first cycling strategy “Cycle Policy 2002-2012” to prioritize cycling in city planning. It highlighted the importance of cycling for the city and coordinated action programs that further improve cycling conditions. The city also promised to use the Bicycle Account to develop the objectives of the cycle policy. Among these objectives was the increase in the proportion of cycle traffic in the modal split from 34 % to 40 %, a 50 % reduction in the number of seriously injured or killed cyclists and objectives for comfort and travel times for which data are collected in the Bicycle Account.

The next development impetus came with the development of the 2006-2016 “Cycle Route Priorities Program”, which formed the basis for the planning of almost 70 km of new cycle paths and cycle lanes to be implemented within ten years. The extension of the network is prioritized by several different indicators:

- the number of cyclists,
- accidents,
- the sense of security that was raised in interviews,
- the situation in the network and
- the connection with other measures of the city.

On December 1, 2011, the city council adopted the new bicycle strategy “Good, better, best – The City of Copenhagen’s Bicycle Strategy 2011-2025”, which aims to make Copenhagen the world’s best cycle city. To achieve this goal, urban decision-makers have decided to focus on four main topics: city life, comfort, speed, and safety.

Another main objective of the strategy is to increase the proportion of cycling in commuting to over 50 %. The city uses the biennial Bicycle Accounts to identify critical issues that need to be addressed in order to increase the proportion of cycling and to derive plans for different actions to achieve the objectives. This includes extending cycle lanes to three lanes to allow side-by-side cycling with additional overtaking and increasing the sense of safety on cycle lanes while increasing commuter speed. The city is also planning to reduce travel times by adapting green waves to cyclists’ speeds and building additional bridges only for pedestrians and cyclists across busy roads, harbors, and canals. Furthermore, the city continues to try increasing safety by rebuilding several serious accidents rated junctions, redesigning school routes with safe infrastructure and speed reduction measures in car traffic. Finally, the strategy also aims to improve the chaotic conditions

for bicycle parking by increasing the range of cycle parking facilities, especially in and around railway stations.

A quick overview of the city		
Name of the city	Copenhagen	
Population size	1.8 million (capital region)	
Economic development³⁴	GDP 2010: 88.4 billion EUR	GDP 2015: 111.8 billion EUR
Changes in modal split³⁵	The Proportion of cycling 2008: - %	The Proportion of cycling 2016: 29 %
Annual expenditure on cycling (per inhabitant in 2018)³⁶	35,60 €	
Challenges and shortcomings in the current cycling system	<ul style="list-style-type: none"> ▪ so much cycle traffic that it is jammed up on cycle paths 	
Recommendations for improvement	<ul style="list-style-type: none"> ▪ Already an enormously high standard, still a possibility for improvement e. g. in the area of traffic flow, cycle infrastructure or cycle parking 	

³⁴ European Commission

³⁵ Mobilität in Deutschland 2008 und 2017

³⁶ Greenpeace 2018, p. 10

London

London is the capital of the United Kingdom and England. Today's administrative area with a total of 33 municipalities was created in 1965 with the founding of Greater London. In 2018 it had a population of 8.9 million³⁷, which represents about 14 % of the UK's total population. Around 3.3 million of them in the 13 city districts of Inner London. London is thus the most populous city in the European Union and, with around 14 million people in the London Metropolitan Area, the largest metropolitan region in the EU, ahead of Paris (12.1 million inhabitants).

About 47 % of London's 1.572 square kilometers is green space. There are about eight million trees in London, which is the world's largest urban forest and also inhabits 3.000 parks, 30.000 allotments, and about three million gardens.

The total volume of GDP in 2018 was 554 billion EUR, which corresponds to nearly one-quarter of the UK GDP³⁸. London has the largest GDP per capita (PPS) of all the regions in the UK and also has the largest GDP per capita among European cities. London's economy is more significant than that of other European countries such as Sweden or Austria. In the last years the GDP was increasing by about 38 % (2018 to 2010), but in the last years, the GDP started to decrease perhaps due to Brexit complications.

Between 1999 and 2017 the number of cyclists counted during daytime all over the city increased by 292 % (24.000 more trips in 2017 than in 1999). Between 2010 and 2012 alone vehicle counts across the city showed, that the number of cycles doubled. The modal split during peak hours in the morning as well as in the evening increased between 2007 and 2017 from about 15 % to about 37 % but overall is still at a low level of only 2.2 %. However, growth in cycling began to slow in 2012.³⁹ Because of that, the City of London Corporation assumes that further growth is only possible by a significant transformation in traffic infrastructure.

That is why in the last years London substantially increased the importance of cycling and walking in traffic planning. The bike-sharing system started in 2010, in 2015 plans for "Cycle Superhighways" were presented. By now eight of these Cycle Superhighways are opened, another three are planned. Transport for London, the organization that coordinates the transport system and transport planning since 2001, divided cycling infrastructure into "normal" cycleways, Cycle Superhighways and Quietways. "Quietways are continuous and convenient cycle routes on less-busy backstreets across London"⁴⁰. From summer 2019 on, new cycle routes, Cycle Superhighways, and Quietways are combined into one cycle network called Cycleways. Furthermore, the city of London awarded a 30 million-pound (about 33 million EUR) program called "Mini-Holland", in order to help three outer London boroughs to create a network of cycle routes.

The user motivation is similar to other cities all over Europe: it is faster than with any other mode of transportation, one can gain fitness while doing it, and it is more sustainable or more environ-

³⁷ Eurostat (2019)

³⁸ European Commission

³⁹ City of London (2018)

⁴⁰ Transport for London (2019)

ment-friendly. Nevertheless, analysis shows, that the dominant demographic profile of people using Cycle Superhighways as well as Quietways is white, middle-aged, high-income men.⁴¹

The measures and especially funding for supporting cycling started by mayor Boris Johnson are carried on by Sadiq Khan and will be at 169-million-pound per year in the years 2018 and 2019 and even 214 million in 2020 and 2021. This is despite the central government's complete withdrawal of the 700-million-pound annual operating grant for Transport for London.⁴²

However, there is still room for improvement. There are still many cycle paths that end abruptly. The biggest challenge is the mindset of the people. Costumer research of TfL shows that only 14 % of the people are getting ready to start cycling soon or are considering it. 66 %, on the other hand, are unlikely to cycle in the future. While most people agree that cycling is enjoyable (90 % of people who cycle, 72 % of people who do not currently cycle regularly). Difficult is that the proportion of people who agree to that is decreasing over the last years since in 2013 it was 95 % and 82 %. The most significant barrier to start cycling tends to be safety.⁴³ This tends to be an even bigger problem since casualty numbers show a decreasing number of cyclists in accidents.

In order to further promote cycling in London and to increase the modal split share of cycle traffic cycling in London still needs more space. To gain that it is imperative to redivide the streets and to turn driving lanes of motor vehicles into cycle lanes. The ongoing planning of Cycle Superhighways is proper and pursued further. Furthermore, it is necessary to promote cycling beyond making MIT more difficult and more expensive. Cycling right now is somehow exclusive only for parts of the society (middle-aged, high-income, white men). The natural strength of cycling is that it does not promote social segregation but can be used by all social groups (despite income, age, gender, etc.). This is what should be promoted and strengthened in London.

⁴¹ Ibid.

⁴² Ibid.

⁴³ Ibid.

A quick overview of the city		
Name of the city	London	
Population size	8.9 million	
Economic development⁴⁴	GDP 2010: 402 billion EUR	GDP 2017: 554 billion EUR
Changes in modal split⁴⁵	The proportion of cycling 2008: 1.6 %	The proportion of cycling 2017: 2.2 %
Annual expenditure on cycling (per inhabitant in 2013)⁴⁶	20 €	
Challenges and shortcomings in the current cycling system	<ul style="list-style-type: none"> ▪ Cycle paths still end abruptly ▪ The (perceived) safety of cycling is on a low level ▪ Cycling lacks reputation, even as an everyday mode of transport 	
Recommendations for improvement	<ul style="list-style-type: none"> ▪ Redividing streets to give cycling more space ▪ Pursuing the planning of Cycle Superhighways ▪ Large-scale public relations work to promote cycling 	

⁴⁴ European Commission

⁴⁵ Transport for London (2019), p. 25

⁴⁶ The Guardian (2013)

Munich

The city of Munich is one of the most liveable cities in the world and was ranked third place together with Vancouver (Canada) and Auckland (New Zealand)⁴⁷. Its population size is about 1.5 million and therefore the third biggest city (after Berlin and Hamburg) in Germany. The city has about 4.000 ha of green spaces, which about 13 % of its hole area. Munich is one of the economically most thriving cities in Germany and a still increasing GDP, which was at 104.2 billion EUR in 2015 (compared to a GDP of 81.9 in 2010).

Compared to pioneering cities of Europe such as Utrecht and Copenhagen, cycling support in Munich is a relatively new phenomenon. In 2009, for example, there was the first fundamental decision of promoting cycling (“Grundsatzbeschluss zur Förderung des Radverkehrs”), and it was updated in 2018. This basic decision contains principles, measures, and aims that should be realized by 2025. Achievements so far include:

- 1.200 kilometer of cycling network
- 61 cycle streets
- More than 28.000 cycle parking spots all over Munich
- Opening of more than 300 one-way streets for cyclists

The first successes could also be achieved regarding the modal split. From 2008 to 2017 the proportion of cycling rises by four percentage points (from 14 % to 18 %). Furthermore, the proportion of people who regularly use their bikes ((nearly)daily or one to three-time per week) rises. Already from 2002 to 2008 this proportion increases from 47 % to 49 %.

For the citizens of Munich, this is not enough. In march 2019 a petition started which aim it is to improve cycle infrastructure massively as well as to redistribute traffic space to create more space for cycling. Besides, a group of activists is formed who describe themselves as “citizens who are committed to volunteering, nonpartisan and independent.”⁴⁸ This group formulates a group of objectives like

- “A better pedestrian and cycle network
- Level, conflict-free and above all safe footpaths
- Wide, gap-free and above all safe bike paths
- A bicycle network from A to B without gaps for citizens of all ages (from 8-80)
- Suitable parking spaces and better general conditions for cyclists”

The motivation of people in Munich to ride bikes and to formulate these objectives is not only that most of the people enjoy riding a bike, but also that often it is faster, it is more sustainable, and it is affordable for everyone.

As can be seen in the forefront of the people, one of the biggest problems in Munich’s current cycling system is that it is still patchy. Not only there still are network gaps, but there is also a lot of cycle infrastructure that is not state of the art, not even speaking of high-quality routes. This also leads to the fact that road safety for cyclists is not sufficient.

⁴⁷ Archdaily (2019)

⁴⁸ R(ad)Evolution e.V. (2019)

Another big problem in Munich is that cycling, in many cases, still lacks comprehensive political support. For example, one cycle highways route is under discussion, because it could happen that along the road about 900 parking lots (for motor vehicles) have to be removed to generate sufficient widths for cycling in a cycle highway quality. The discussion shows that even though on many points, planners already try to give cycling more space but are thwarted by politicians.

Nevertheless, the efforts planners in Munich are currently going through are heading in the right direction. Establishing a network of cycle highways, closing the gaps in the cycling network redistributing the traffic area to give cyclists and pedestrians more space. More than that the city should give itself an annual budget for cycle funding.

A quick overview of the city		
Name of the city	Munich	
Population size	1.5 million	
Economic development⁴⁹	GDP 2010: 81.9 billion EUR	GDP 2015: 104.2 billion EUR
Changes in modal split⁵⁰	The proportion of cycling 2008: 14 %	The Proportion of cycling 2017: 18 %
Annual expenditure on cycling (per inhabitant in 2018)⁵¹	2,30 €	
Challenges and shortcomings in the current cycling system	<ul style="list-style-type: none"> ▪ The cycling infrastructure network is still patchy ▪ The road safety for cyclists is not sufficient ▪ In many cases (planning) priority continues to be given to motor vehicle traffic ▪ Cycling still lacks comprehensive political support 	
Recommendations for improvement	<ul style="list-style-type: none"> ▪ Establishment of Cycle highways ▪ Closing Gaps in the cycling network ▪ Redistribution of traffic areas 	

⁴⁹ Referat für Arbeit und Wirtschaft – Landeshauptstadt München 2018

⁵⁰ Mobilität in Deutschland 2008 und 2018

⁵¹ Greenpeace 2018, p. 10

Paris

Paris is the capital of the French Republic as well as of the Region Île-de-France. With about 2.2 million inhabitants Paris is the fifth biggest city and with more than 12.5 million people after London, the most significant metropolitan region in Europe. With a comparably small area of 105 square kilometers, Paris is with about 21.000 inhabitants per square kilometer the densely populated city in Europe.

The streets of Paris are lined with about 89.000 trees. The parks department “Direction des Parcs, Jardins et Espaces Verts de Paris” maintains about 2.437 hectares of green areas within the city limits, including the vast city forests “Bois de Vincennes” (995 hectares) and “Bois de Boulogne” (846 hectares) as well as the 14 inner-city cemeteries (92 hectares). In addition to the municipal facilities, the inhabitants and visitors of Paris have seven gardens and parks maintained by the state with a total area of 118 hectares at their disposal.

Economically speaking Paris is prospering. With a GDP of 709.2 billion EUR in 2017 which represents an increase of about 6 % compared to 2015 (671 billion EUR)⁵² the Greater Paris Region (Île-de-France) is the number one economy in Europe with a robust tertiary focus.

Since 2007 the bike-sharing system Vélib has been involved in the development of cycling in Paris and has actively contributed to reconciling Parisians with cycling and making Paris a more cycling-friendly city. Around 35 % of all cycling trips made in Vélib, which holds 15.000 bikes on 1.400 stations and has more than 280.000 subscribers.

The next big step towards a bicycle-friendly city was taken in April 2015, when the cycle plan “Plan vélo 2015-2020” was passed. The plan named an ambitious goal: 15 % of all journeys are to be made by bike in 2020, from only 5 % in 2014. To reach this goal the city of Paris will overall invest about 150 million EUR, among them:

- 63 million EUR for the development of cycle paths
- 30 million EUR to finance the “Paris at 30 km/h” program and the two-way cycling of all streets
- 7 million EUR for the creation of more than 10.000 cycle parking spaces
- 10 million EUR fund for the purchase of electric bikes and cargo bikes
- About 40 million EUR dedicated to bicycle facilities as part of public transport projects and the redevelopment of major roads, squares, etc. and the creation of a cycle express network

The city of Paris has been consistently expanding its cycling infrastructure for years. In 2007 the length of the cycle network was only at about 371 km. In 2014 it was already at about 700 km with the goal of bringing it to 1.400 km by 2020.⁵³ All this is accompanied by a high degree of public relations work to promote cycling. On Sundays, for example, some road sections such as the Seine Embankment or the route along Canal Saint-Martin are closed to motor traffic and only us-

⁵² European Commission

⁵³ Mairie de Paris (2014)

able by skaters, walkers, and cyclists in order to bring Parisians closer to active mobility as well as to show them the advantages of less motor traffic.

A big challenge for cycling in Paris is to increase the (perceived) safety for cyclists. Cycle traffic in Paris is often handled via combined bus and cycle lanes which have a width of about 3,00 meters. Since busses do not want to drive behind cyclists for longer distances, busses often pass cyclists, even though there is not enough space to securely do so. Increasingly, however, this is being deviated from in favor of road safety. The Champs-Élysées, for example, is currently being rebuilt with cycle paths on each side of the road in the direction of traffic. In other streets like Avenue de Flandres as well the road space is redistributed and safe paths are allocated for cycle traffic.

All in all, the city of Paris, driven by its mayor, makes many efforts to promote and improve cycling. However, especially in terms of cycle highways, Paris can still improve a lot.

A quick overview of the city		
Name of the city	Paris	
Population size	2.2 million	
Economic development (of Ile de France)⁵⁴	GDP 2015: 671.0 billion EUR	GDP 2017: 709.2 billion EUR
Changes in modal split⁵⁵	The proportion of cycling 2008: 3 %	The proportion of cycling 2014: 5 %
Annual expenditure on cycling (per inhabitant in 2018)⁵⁶	14 €	
Challenges and shortcomings in the current cycling system	<ul style="list-style-type: none"> ▪ Often combined bus and cycle lanes ▪ Still no continuous network ▪ Few cycle highways 	
Recommendations for improvement	<ul style="list-style-type: none"> ▪ Further redistribution of road space in favor of cycle traffic ▪ Realization of cycle highways ▪ Separation of cycling and public transport in order to increase road safety 	

⁵⁴ European Commission

⁵⁵ Mairie de Paris

⁵⁶ Self calculated after Mairie de Paris

Utrecht

Utrecht is a city in the Netherlands with about 343.000 inhabitants. It belongs to the province of Utrecht with an overall population of 1.3 million. Utrecht itself is the fourth-largest city of the Netherlands.

The province of Utrecht is the smallest in the Netherlands. Nevertheless, it is economically prosperous. Its GDP was at 67.3 billion EUR in 2017, rising since 2015 by about 7 % (63.1 billion EUR)⁵⁷, primarily from the tertiary sector. It is the most important location for Health & Life Sciences in the Netherlands as well as it is the second most important financial hub.

Like most Dutch cities, Utrecht has an extensive network of cycle paths. Also like in many other Dutch cities the bike is quite popular to get around in the city. Also, cycling continues to be massively funded and promoted. In 2018 the annual expenditure on cycling per inhabitant was by far the highest in comparison of the cities described: it amounted to 132 EUR⁵⁸. This is reflected in cycle traffic and cycle traffic planning. Utrecht wants to become a "world-class bicycle city"⁵⁹. In order to achieve this, the "Utrecht – we all cycle" action plan was established in 2015 as well as the "Road Safety Action Plan". "In this context, the bicycle is considered a primary means of transport"⁶⁰. Furthermore, cycle parking has a high priority in cycle traffic planning in the city of Utrecht. The reasons to promote cycling are manifold for the city. To be named:

- "Utrecht = 'Healthy Urban Living'
- The bicycle is clean, silent, economical
- We give the public space back to the user
- Cyclists represent value, health, liveability, spending
- Cycling in Utrecht is for 8-80 years
- Cycling provides a social meeting
- Cycling emancipates
- And it makes you happy"⁶¹

The Action Plan, therefore, has the goals to increase cycling among certain groups as well as to encourage the bike economy. The bicycle routes and paths are about to be considerably improved in the next years. All the paths are about to grow into a recognizable network since it is all painted in "striking red asphalt"⁶².

Additionally, it is planned to improve junctions in order to be more bike-friendly. Together with residents traffic lights which are unnecessary or can be set in a way that they are more bike-friendly, are identified. Ways are also searched for, which shorten or "at least sweeten"⁶³ waiting times. All actions undertaken in this framework are at a high level and would be seen as "fine-tuning" in most cities around the world.

⁵⁷ European Commission

⁵⁸ Greenpeace 2018, p. 11

⁵⁹ City of Utrecht¹

⁶⁰ Ibid.

⁶¹ City of Utrecht²

⁶² Ibid.

⁶³ Ibid.

This is also true regarding the modal split of Utrecht. 26 % of all ways are covered by bike. The modal share of cycling to work is even at 51 % and thereby higher than in Amsterdam (48 %) or Copenhagen (41 %).⁶⁴

A quick overview of the city		
Name of the city	Utrecht	
Population size⁶⁵	1.3 million	
Economic development⁶⁶	GDP 2015: 63.1 billion EUR	GDP 2017: 67.3 billion EUR
Changes in modal split⁶⁷	The proportion of cycling 2008: 21 %	The proportion of cycling 2018: 26 %
Annual expenditure on cycling (per inhabitant in 2018)⁶⁸	132 €	
Challenges and shortcomings in the current cycling system	<ul style="list-style-type: none"> ▪ Making cycling the logical choice for everybody 	
Recommendations for improvement	<ul style="list-style-type: none"> ▪ Already an enormously high standard, still a possibility for improvement e. g. in the area of traffic flow, cycle infrastructure or constructions and detours 	

⁶⁴ Bicycle Dutch 2018

⁶⁵ European Commission

⁶⁶ Ibid.

⁶⁷ City of Utrecht

⁶⁸ Greenpeace 2018, p. 10

Vienna

Vienna is the capital of Austria and has about 1.9 million inhabitants. It is one of the most prospering cities in Europe with a population growth of 13 % in the last ten years. In 2019 Vienna was ranked as the most liveable city of the world⁶⁹. Of its about 41.500 hectares, 45 % are green spaces (18.700 hectares) and another 5 % is water (1.900 hectares)⁷⁰.

Furthermore, Vienna has the highest value-added in Austria with a GDP of 93.9 billion EUR, which is about 20 % more than in 2010. All in all, Vienna shares about one-quarter of the total GDP of Austria.

As other cities in Europe cycle support is a rather new phenomenon in traffic planning. Historically Vienna is a city of public transport. In 2018 it had a share of the modal split of 38 % and was thereby the strongest mode of transport. However, in the last years, cycling is becoming more popular as well. From 2006 to 2017 the share of cycling on modal split went from 4 % to 7 %, which still makes it a peripheral means of transport. Moreover, for some years now (since 2014) it stagnates at this level. The motivation to bike, however, is similar to other cities all over Europe: it is fast, healthy, environmentally friendly, sustainable, and saves money.

Nevertheless, the efforts to promote cycling and thereby strengthen cycling as a daily mode of transport are significant. From 2000 to 2018 the length of cycling infrastructure increased by about 67 %. From 2010 to 2018 alone it increased by nearly 20 % to a length of 1.398 kilometers⁷¹. Only about 1 % of it is lead on a combined bus and cycle lane. The most common cycle infrastructure is the common pedestrian and cycle path and independently guided cycleways. Furthermore, there are about 46.000 cycle parking lots in Vienna. With its Urban Mobility Plan from 2014, Vienna has finally set the course for increasing climate-friendly mobility, with the aim that in 2025, 80 % of the ways should be made by modes of low-carbon transport.

In order to reach this goal, the Urban Mobility Plan lists measures in nine fields of action:

- Public space: sharing streets in a fair way
- Governance: Responsibilities and resources
- Efficient mobility through mobility management
- Sharing instead of owning
- Transport organization: a smarter way of managing mobility
- Transport infrastructure: the backbone of the city
- Business in motion
- Mobility needs innovation
- Together in the region

All of the measures must be subject to the three principles of traffic safety, barrier freedom, and gender mainstreaming and diversity.

⁶⁹ Archdaily 2019

⁷⁰ Stadt Wien 2018

⁷¹ Stadt Wien 2019

The biggest challenges and shortcomings of cycling in Vienna is the excellent developed public transport accompanied by a cycle network with occasionally significant gaps. The city itself makes clear that more cycling is an economic imperative. Apart from walking, no other means of transport is cheaper for the city. Cycle paths are comparatively affordable, and operating costs are low. Some studies show that only about one percent of the population can be classified as “strong and fearless”, which means they ride their bikes no matter what. About six to seven percent are self-confident road users who use the bike even if the infrastructure is not perfect.

On the other hand, two-thirds of the population can be reached with a complete cycling infrastructure network. However, here lies the problem. “Construction projects are delayed for years because of the hiccups for a few parking spaces.” says Ulrich Leth, Traffic Planning Expert at the TU Vienna. Maria Vassilakou (Green Party), the Vice-Mayor of Vienna and responsible for cycling, also criticizes the delays: “We are currently confronted with a situation in which every cycle path seems to lead to the end of the world. In this mood, it is difficult to advance cycling”⁷².

The situation of cycling in Vienna differs a lot to other European cities since it is in great competition with public transport. Nevertheless, it is without an alternative that the city has to close the gaps in the cycle network and adhere to the plan of redistributing the road space in a more balanced way (more space for cycling walking and PT).

A quick overview of the city		
Name of the city	Vienna	
Population size	1.9 million	
Economic development⁷³	GDP 2010: 78.1 billion EUR	GDP 2017: 93.9 billion EUR
Changes in modal split⁷⁴	The proportion of cycling 2006: 4 %	The proportion of cycling 2017: 7 %
Annual expenditure on cycling (per inhabitant in 2018)	-	
Challenges and shortcomings in the current cycling system	<ul style="list-style-type: none"> ▪ Lack of political support ▪ Large network gaps ▪ In high competition with public transport 	
Recommendations for improvement	<ul style="list-style-type: none"> ▪ Further redistribution of road space in favor of cycle traffic ▪ Realization of cycle highways ▪ Closing Gaps in the cycling network 	

⁷² Der Standard 2018

⁷³ European Commission

⁷⁴ Wiener Linien 2018

Vitoria-Gasteiz

Vitoria-Gasteiz, the capital of the Basque Country, has about 250.000 inhabitants. The economy consists mainly of the secondary sector, with a GDP of about 8.3 billion EUR. Famous economic enterprises are among others, Mercedes-Benz Espana, Michelin, or Gamesa Aeronáutica. In 2008 about 64 % of the city was blocked by and hold for cars. With the adoption of the sustainable mobility plan in the same year this ration changed to only 15-20 %. The remaining area was allocated to pedestrians and cyclists but was also converted to green areas.

Vitoria-Gasteiz has become the bicycle capital of Spain within a few years. 12.3 % of road users cycle every day. Moreover, the trend is rising. The car will play only a minor role here in the future.

Except for the old town of Gasteiz, which lies on a hill, the city is flat. A good condition for cycling, but only ten years ago there were nearly no cyclists to be found in the city. Only 3.4 % of the total traffic was cyclists. Meanwhile, it is over 12 % and in addition to that, every second goes to work on foot. That makes sense. The city is very compact. Around the old town, within a radius of 3 km, lives 89 percent of the population. People do not need a car since, within a radius of 500 m, they will find everything they need for everyday use: education, health, sport, and culture. After about 300 m they are already in the park or a green area. With that Vitoria-Gasteiz is a prototype for the "city of short distances".

The city has changed enormously over the past 30 years. The population grew from 130.000 to 240.000 inhabitants. However, the newcomers had different habits. They walked less often and preferred to get into their cars instead. The city superiors wanted to stop this development. In 2008, all parties signed the Sustainable Mobility Plan since 16.000 more apartments were to be built. At that time, parking cars blocked 64 % of streets and squares. Politicians found this undemocratic. They planned for them only 15-20 % in the street space. The remaining space was to be given to cyclists and pedestrians. In short, this means a city for people instead of cars.

The plans met with criticism because the interventions in the infrastructure were massive. Major access roads were restructured entirely. Retailers in the street were worried that sales were going down. However, the opposite was true. New merchants moved in, and cafés and restaurants emerged. But not only the active mobility was enhanced but also public transport. In order to make it easier for people to change trains, public transport was expanded. The number of bus lines was reduced from 20 to nine, the intervals were increased, and a tram was built. At the same time, parking costs for cars have tripled.

The city has invested 26 million euros over five years to implement its mobility plan. Part of this comes from an EU project that promotes sustainable transport concepts.

As a rule, the city has just 1.8 euros per inhabitant per year at its disposal to expand its cycling infrastructure. "That's very little," says Escudero. In the long term, many roads such as Sancho el Sabio Kalea are to be redesigned. However, the Basques did not want to wait until they had the money. That is why they painted the new concept on the street.

They only changed the signs, but the effect is enormous. What used to apply to motorists is now open to cyclists and vice versa. In other words, in large parts of the city, conventional streets were converted into one-way streets, cars were taken off a parking strip, speed 30 zones were introduced, and cyclists were given priority. While cars are only allowed to drive in one direction, cyclists can use both directions.

In this way, politicians have almost quadrupled the proportion of cyclists in the past seven years. Also, significantly more people are walking again, and the proportion of motorists in the city has fallen from 36 % to 25 %.

One of the most significant shortcomings right now is cycle parking. In summer, when everyone gets on their bikes, the many parking spaces in the city are barely enough. The city urgently needs to make improvements here. The number of bicycle thefts is also on the rise, and Gasteiz sees an urgent need to catch up with traffic regulations for both cyclists and motorists.

A quick overview of the city		
Name of the city	Vitoria-Gasteiz	
Population size	249.000	
Economic development⁷⁵	GDP 2010: 7.6 billion EUR	GDP 2016: 8.3 billion EUR
Changes in modal split⁷⁶	The Proportion of cycling 2006: 3.3 %	The Proportion of cycling 2014: 12.3 %
Annual expenditure on cycling (per inhabitant in 2018)	-	
Challenges and shortcomings in the current cycling system	<ul style="list-style-type: none"> ▪ The tremendous success in increasing cycle traffic at the beginning, but that stagnated ▪ Challenge of cannibalization effects between different modes of low-carbon transport 	
Recommendations for improvement	<ul style="list-style-type: none"> ▪ Cycle superhighways to get commuters on bicycles (because of the topography mainly in eastern direction) ▪ Construction of a system for bike parking (Utrecht can serve as a model) 	

⁷⁵ Eustat 2019

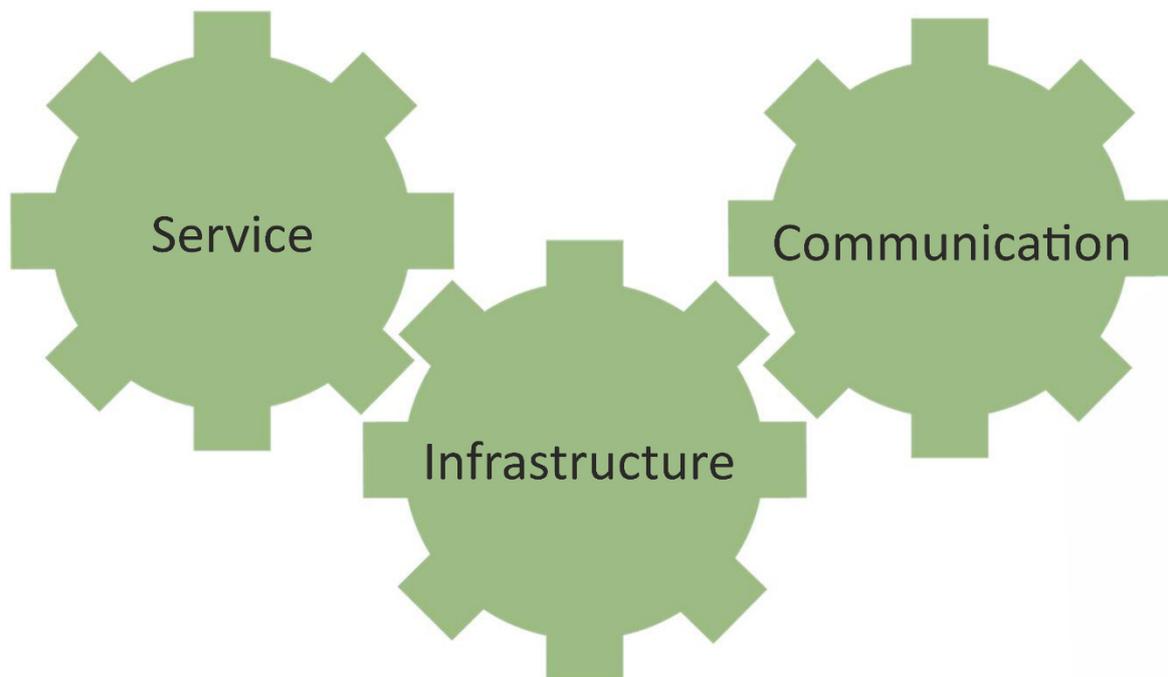
⁷⁶ Vitoria-Gasteiz 2015, p. 5

3 Recommendations for cycling systems in China

It is impossible to create a general guide with recommendations for promoting cycling. Cities are too different and require a separate, in-depth study. Nevertheless, some generally logical steps for the development of bicycle traffic support are tried to represent.

First of all, cycling should always be part of an integrated approach to mobility or traffic as well as city planning. The Emerald Cities Book⁷⁷, therefore, sets a good example. However, cycling still needs a further, more profound observation in order to develop cycling strategies, plans, and measures. In addition to this, cycling should be seen as a system, of which infrastructure is only one part.

Illustration 15: System of cycling



Source: Planersocietät

Cycling strategies can be developed at a national, regional or city level, and will typically include a medium to a long-term vision for cycling, whereby cities at the initial stage of developing a cycling strategy should consider existing national and/or regional level strategies or plans, when available.

⁷⁷ Calthorpe Associates 2018

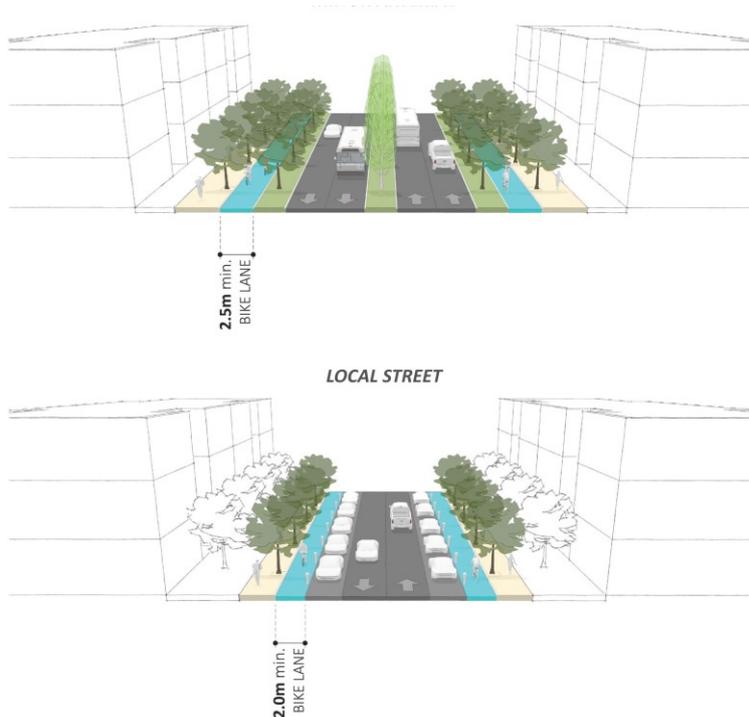
3.1 National or regional strategies

National or regional strategies usually have an emphasis on broad policies and programs, setting out a general framework for the development of cycling within the country or region, legally as well as financially. Furthermore, they often refer to the coordination of exchange of good practice, capacity building for local and regional authorities, and funding that is available for pilot projects, research, and awareness-raising campaigns. “National cycling strategies should set out the fiscal and legislative frameworks relating to cycling that have been adopted and may include details such as [the state of the art and design standards of cycling infrastructure], tax rates and fiscal incentives for commuting by bike”⁷⁸. A national strategy could include among others

- cycle traffic planning and conception,
- cycle infrastructure,
- traffic safety,
- communication,
- e-mobility,
- interlinking with other modes of transport or
- mobility and traffic education.

Regarding design standards, it is possible to orientate on the metrics of cycle lanes given in the Emerald Cities Book, although the minimum dimensions of cycle infrastructure should be verified to ensure safe and attractive handling of cycle traffic even with an increasing number of cyclists. Based on these, it seems questionable whether an infrastructure with a minimum width of only 2 meters is sufficient or will be sufficient in the future.

Illustration 16: Design of cycling infrastructure on different types of roads



Source: Calthorpe Associates 2018, p. 142

⁷⁸ European Commission 2019

It is highly recommended that generally valid recommendations for the construction of bicycle traffic facilities will be developed, which among other things will present the following contents in detail:

- network planning
- design basis
 - design parameters
 - Choice of cycle infrastructure
- Form of guidance on inner-city main streets
- Form of guidance on junctions
- Crossing facilities
- Cycling on access roads
- One-way streets with cycling in the opposite direction
- Cycling in areas of pedestrians

Besides unified design standards, the topic of funding is of exceptional importance in this context as long as it is not possible for the local authorities itself to realize a comprehensive financing model in order to implement and realize measures for cycle support. In many European countries, cities are categorized for the purpose of determining the level of funding required for cycling (e. g. starter, climber, champion). In the German NRVP, for example, the financial requirements for the different cities are described as follows:

Illustration 17: Financial requirements of cities for different areas of responsibility in cycling (in Euro per inhabitant)

	Infra-structure (Reconstruction / new construction and maintenance)	Infra-structure (Operational maintenance)	Sum (Column 1+2)	Cycle parking	Non-investiv measures (e. g. communication)	Further measures	Total sum
	1	2	3	4	5	6	7
Starter	5,00		6,10	1,10		0,50	8,00
	–	1,10	–	–	0,50	–	–
	12,00		13,10	2,50		2,00	18,00
Climber	8,00		6,10	1,10		1,00	13,00
	–	1,70	–	–	0,50	–	–
	12,00		13,10	2,50		2,00	18,00
Champion				0,10			18,00
	12,00	3,00	15,00	–	1,00	2,00	–
				0,80			19,00

Source: Planersocietät after NRVP

Basic quality design principles for cycle infrastructure and networks

There should be a national guideline for design principles for cycle infrastructure in order to guarantee a high quality of the cycle infrastructure and networks. These basic principles are:

- safety,
- directness,
- coherence,
- attractiveness,
- and comfort.

These requirements should be considered as objectives by all city types. They can also be used as criteria to assess the quality of cycling infrastructure. Where infrastructure meets these criteria, they are more likely to result in increased use of bicycles. The following sections outline the recommended basic quality design principles in more detail.

Safety

Safety is an essential requirement for any cycling infrastructure, although safety concerns are a significant barrier to cycling. Cyclists often feel vulnerable when moving in the same space as motorized traffic due to differences in speed, vehicle size, and the volume of traffic. There can also be a lack of understanding by people driving motor vehicles of the needs of cyclists. Therefore, elementary quality design principles aim to increase actual and perceived safety and include:

- Limit conflict between cyclists and other road users (other cyclists, pedestrians, or motorists):
 - Separate main routes for bicycles from pedestrian routes
- Reduce motor vehicle traffic volumes and speeds around cyclists, especially when road users mix
- Separate bicycles from fast and heavy motorized traffic to reduce the number of dangerous encounters – including separation on routes and especially at intersections
- Ensure conflict points at intersections and crossings are presented so that users are aware of the risks and can adapt behavior appropriately. Visibility of cyclists to motorists should be maximized at the approach to intersections
- Ensure cycling facilities are well lit
- Ensure cycling infrastructure is well maintained

Directness

The competitiveness of cycling with other modes of transport is essential. Nobody will ever take a bike when it takes much longer than any other mode of transport. Basic quality design principles for directness include:

- Ensure bicycle users have access to the most direct route
- Minimize overall travel time by considering factors such as detours, number of stops at crossings, traffic lights, and gradients

- Maintain constant speed of cyclists
- If possible, provide priority for people who cycle, over motorized traffic

Coherence

Routes should be coherent and accessible and should enable people who cycle to travel easily between their origin and destination. Cycle routes should also include connections with the public transport network. Basic quality design principles for coherence and accessibility include:

- Provide a continuous and recognizable network linking trip origins and destinations
- Ensure routes are well-signed throughout
- Ensure routes for cyclists are direct
- Provide consistent protection for bicycle users throughout
- Ensure interlinking with other networks/modes of transport
- Provide well-located and secure cycle parking (cycle parking)

Attractiveness

Most people say they are not using the bike because it is not safe if asked. So to encourage people to start cycling, it is necessary to make them feel safe. Furthermore, it is conducive, and if the infrastructure and routes are aesthetically attractive. Basic quality design principles for attractiveness include:

- Infrastructure and routes are aesthetically attractive and exciting to potential users
- Infrastructure is integrated within and fits into the local surroundings
- Considers the actual and perceived personal security of users
- Infrastructure is well-maintained

Comfort

The cycling experience should be enjoyable, smooth, and relaxed but also fast to maximize the comfort of people cycling. Basic quality design principles for comfort include:

- Ensure the cycling surface is smooth and well-maintained (drained and free of debris)
- Reduce discomfort through the appropriate selection of materials to avoid vibrations, shocks, and obstacles (asphalt)
- Minimize the need for interruptions in a cycling journey
- Minimize the need for complicated maneuvers
- Ensure adequate width and curve radii
- Avoid steep gradients
- Minimize impacts of noise, spray and headlight dazzle from other traffic

3.2 Local cycling strategies

Local cycling strategies should, therefore, take the national (and regional) strategy frameworks into account when developing city-level policies and proposals for specific cycling measures.

The process of developing a local level cycling strategy will vary but typically includes the following steps:

- Setting up a steering group or organizational network;
- Defining an overarching vision or strategy statement;
- Identification and understanding of target and user groups;
- Monitoring and determining the baseline situation in the city;
- Development of local design guidance based on existing regional or national and
- Determining the budget required for the implementation of the strategy and the potential sources of funding.

As mentioned above, local cycling strategies should be incorporated within other urban mobility or multi-modal strategies or plans at the city level.

Developing a cycle network

No existing city in the world starts from zero in cycle traffic planning. Therefore, when developing a cycle network, a city should expect to:

- Manage the existing roads and rights of way;
- Create new links within the existing cycling network to close any gaps; and
- Aim to create a network with an adequate level of service for cycle traffic.

In general, there are two types of cycling networks:

- **Utility network:** Connects destinations for functional and daily trip purposes, including shopping, work, education, etc. Connections should be as direct, and with as few as waiting times as possible as a utility, cyclists want to get from A to B as quickly as possible.
- **Recreational network:** Recreational routes can pass through urban areas/centers (and therefore also overlap the utility network), but the focus is on leisure cycling and insecure cyclists. They can include signed long-distance routes, signed tourist themed routes or a collection of nodes and interconnected links, enabling cyclists to determine their trip. Recreational cyclists are typically looking for a leisurely and attractive ride, which can allow them to explore an area, exercise or socialize.

It is necessary to name and present the relevant network points for cycling (sources and aims of traffic flow) such as dense living areas, educational institutions, business parks or interlinking points with PT (mobility hubs) to establish a utility network. The next step is to define a network concept (linear distance network) with

- Cycle Highways have a connecting function at a city or intercity level and connect villages, towns, and cities, either inside or outside urban areas.

- Main routes have a distributing function at the district level of the built-up area - providing the primary cycling connections between urban districts within major urban areas at along main streets for fast cycling
- Top local routes are also 'Distributors' at the district level of the built-up area but are providing the primary cycling connections between urban districts within major urban areas apart from main routes, mainly used by insecure cyclists (elderly, children)
- Local routes have an access function at the neighborhood level, which includes every street or track that can be used by cyclists, connecting all origins and destinations to higher level routes.

This linear distance network must now be reallocated at the actual road network. In particular, direct paths along main roads and paths in the secondary network are taken into account. However, especially for cycle highways creation of cycle infrastructure is often needed.

Cycling measures

There is a variety of measures cities have to realize in order to support cycling. As mentioned above, it is of great importance to see cycling as a system and therefore to support cycling not only regarding infrastructural measures but also by implementing "soft measures". So, cities have to realize the measures of different areas like

- Infrastructure for moving cycle traffic
- Cycle parking and associated infrastructure for bicycles and cyclists
- Information, communication, and promotion
- Encouraging conditions for fostering cycling
- Organizational measures und legal framework options for cycling
- Services products and supporting measures

Infrastructure for moving cycle traffic

A vital element of the cycle network development process is the selection of appropriate cycle measures that address gaps or challenges faced by a city. There is no single answer to which design solutions or measures should be implemented, but there are several crucial factors that cities should take into consideration in the decision-making process:

What is the route's function?

- Cycle highway, the main route, top cycling route or local route

What is the spatial environment?

- Inside or outside the urban/built-up area

What is the traffic situation?

- Intensity and speed of motorized traffic
- Road function – connector road, distributor road, access road
- Physical characteristics – available width, number of lanes, etc.

Cycle parking

People who cycle in a city need to have confidence that their bicycle will still be where they left it after they have finished their work, education, or other daily business. Hence, the provision of infrastructure for short-term parking and secure facilities in which they can leave their bicycle for more extended periods, are essential.

The bicycle must be safe, stable, level, visible and, if possible, weather-protected when parked near the home or at the destination of the bicycle traffic. The positioning, execution, and design of the systems determine their utility value and thus their acceptance by the users.

The following criteria are regarded as essential quality characteristics:

- excellent and safe hold of all bicycle sizes and types without risk of damage to the bicycle or the parking facility;
- excellent accessibility for easy parking and retrieval with sufficient room for maneuvers;
- adequate lighting and excellent visibility of the system to protect against theft and to improve the perceived safety;
- sufficient protection against theft by connecting one of the bicycles and the frame, if the bicycle cannot be completely locked in;
- easy cleaning and safe operation through bright design, sufficient clearance height when roofed, avoidance of sharp edges and danger of falling; restrictions on barrier-free access by bicycle parking facilities should be avoided;
- the regular removal of "scrap bicycles";
- secure handling due to versatile leaning and connecting possibilities (e.g., additional lower beam);
- urban design compatibility in the form of unobtrusive and straightforward shapes and colors; and
- Staggered offers according to need: for long-term parking at the station or workstation, weather-protected, and locked parking facilities should be offered wherever possible, while for short-term parking at the supermarket simple leaning brackets are sufficient.

Illustration 18: Parking guidance system for cyclists in the city of Utrecht

Source: Planersocietät

Due to the high acquisition costs for e-bikes, additional requirements arise when designing parking systems. The focus here is on protection against theft, vandalism, and weather. It is recommended equipping the system with a roof or providing lockable shared bicycle garages and individual bicycle boxes with simultaneous loading facilities. This accommodation is also advantageous because the relatively sensitive electronics are reliably protected from moisture. As the battery life is sufficient for the average pendulum travel, including smaller detours, charging is rarely necessary for everyday traffic or during the day.

Nevertheless, the provision of the possibility at selected locations is a service feature. Due to the built-in electronics and battery, e-bikes are usually heavier than standard bicycles. This is why e-bikes also have a high significance in terms of ground-level or barrier-free access to the facility.

Successful implementation of cycling measures

Through the preparation of city case studies and review of existing studies, the European Commission identified vital factors for a successful implementation of cycling measures in cities. First of all, it is necessary to undertake appropriate planning, which also needs political support. It is essential that the decision-makers of the cities, as well as the planners, have all the political support to ensure the necessary scope of action.

Furthermore, it is required to understand the different target groups. For this purpose, a variety of aspects must be taken into account, such as: For what purposes the bicycle is used? What kind of infrastructure is required for that type of usage? What are the expected bike traffic levels?

In order to be able to implement cycling measures, it is vital to secure finance. Building cycle infrastructure is much cheaper than building infrastructure for motor vehicles. Nevertheless, especially cycle highways can become very cost-intensive. To avoid delays, early clarification of the financing should, therefore, be sought.

This also applies to the maintenance of cycling infrastructure, which not only monetarily should be assigned to an institution or department of a city or region but also concerning the management. Not only the implementation of cycling infrastructure and associated facilities necessary but also the ongoing maintenance and management are, to ensure continued use.

Also, the collection, documentation, and communication of information on cycling in a city are vital. It provides the basis of evidence-based decisions for city authorities or traffic planners.

All in all, it is essential to draw up a comprehensive plan that puts cycling traffic planning on a sound footing. This should not only keep the details in view but also the big picture. Otherwise, there is the danger to get lost in all the small measures.

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