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Expert study on the state of the art

Bicycle-highways and Pedelecs

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1. Task and leading questions

The ELMOS project promotes the introduction of electric mobility as an integral part of urban transport concept in small and medium-sized cities in the southern Baltic area. The five participating cities are Karlskrona (Sweden), Malbork (Poland), Rostock (Germany), Trabki Wielkie (Poland) and Växjö (Sweden). Electric mobility shall be integrated into the urban transport system and particular completing the public transport.

Part 2 of ELMOS project deals with the previous experiences with bicycle highway projects and the expected synergies with the using of pedelecs in daily bicycle traffic. Leading questions are particularly “What are the features of bicycle-highways exactly?", “How do they get implemented in urban planning and building?” and “Where do best-practice cases exist?”. Answers will be included in the current best practice study based on appropriate researches by the company of PGV.

Creating good facilities for cycling is the prerequisite to any strategy for sustainable transport and to promote the use of pedelecs. On a long term level, creating a city with a high level of bicycle use can have positive effects both in terms of improved energy efficiency and improved public health in general. So called high speed bicycle tracks/cycling highways are especially developed e.g. in the Netherlands with advantages like reduced travel time, less car use and health improvements. They are fast, have few barriers on the way, often attractive and well integrated into surrounding infrastructure.

The cycling highways could also attract pedelec users, e.g. since the average speed is higher with pedelecs and the highways can provide more safe travels. Inventing them may therefore be one of the measures within the e-mobility (pedelec) strategies for the ELMOS forerunner cities, too. In order to consider them, however, the partners need more concrete information on what it means to plan and to construct them.

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2. Definitions

2.1 Bicycle highways

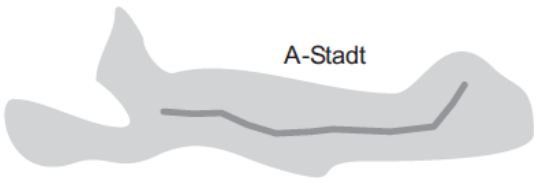
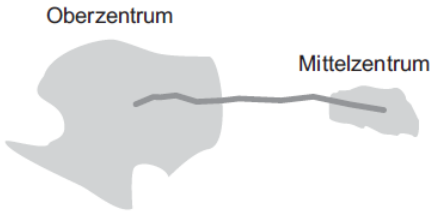
Bicycle highways are originally carried out in the Netherlands. They mean more than average continuous trafficable, detour-free routes with minimized time of waiting, primarily for usage in daily bicycle traffic. They are often separated from main roads, connecting for example the centers of small and medium sized cities or residential and working areas within cities.

2.1.1 Requirements on bicycle highways [1] [2]

Bicycle highways are mainly created on routes which promise a high daily bicycle usage. Along the route there should be a density of destinations like working areas or universities. It is important that there is a really high potential and high usage frequency to expect. The minimal recommended cyclists rate starts at about 2.000 per day.
The main target groups for using bicycle highways are commuting people, cycling from residential to working places or education (schools, universities). Because of the high usage bicycle highways need to be on a very high infrastructural level: Next to an adequate width, surface and traffic control should be better than the “normal” bicycle infrastructure level. Two bicycles should be able to pass each other without problems and the loss of time on intersections must be as short as possible.
The priority objective is to create a fast and safe trafficable route.
Furthermore it is recommended to integrate the bicycle highways into a bicycle or mobility strategy, including accompanying marketing and publicity.

2.1.2 Principle of connecting systems by bicycle highways [3]

Bicycle highways can have different characteristics. The use of bicycle highways depends mostly on the important ‘source-destination’ relations in everyday traffic (residential –work). Figure 1 shows potential applications as a function of settlement structures circumstances. These four types differ in their distances and in their local function. While one type only runs in between one city, another connects different cities with each other and might have a longer distance because of that (depends on the city-sizes).

	
Inner-city connection	Connection between a bigger and a smaller city

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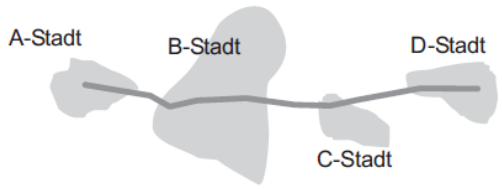	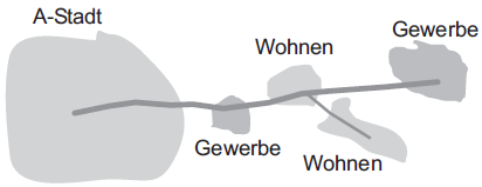
Connection between several cities	Connection between city and suburban areas or external workplaces

Figure 1 **Different bicycle highway types (German Road and Transportation Research Association (FGSV) (2013): Arbeitspapier Einsatz und Gestaltung von Radschnellverbindungen)**

2.2 Pedelecs [4] [5]

"Pedelec 25" denotes an across Europe nowadays mostly spreaded specific version of an e-bike, which is supporting the bicyclist by an electric drive during pedaling up to a speed of 25 km/h. It requires no compulsory insurance.

Usage of pedelecs: In Germany predominantly cyclists older than 60 years use pedelecs 25. Children and adolescents currently hardly use pedelecs. According to an advice from German experts pedelecs should not be used from children under the age of 14. For about 27 % of the users, the pedelec is the most frequently used mean of transport in daily routine as well as in leisure time. For 34 % it is the most frequently used mean of transport just in leisure time and for 4 % just in daily routine.
In the Netherlands every 5th sold bike is a pedelec. There are at the moment more than 1 million pedelecs on the streets.

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3. Initial situation and developments [6]

Bicycle-highways as a specific innovative form of cycling are still remaining in Germany in the implementation phase. The European capitals London and Copenhagen and especially the Netherlands are longer experienced with the design, construction and operation of bicycle highways. In the Dutch cities of The Hague and Tilburg for example, already in the late 1970s urban, partly intersection-free "Fietsrouten" were realized.

It is obvious that the conditions and design of bicycle-highways are always special and local. While a particular well-developed road-accompanying path or absolutely independent bicycle highway is observed in Copenhagen, London uses noticeable blue marks on the major roads.

The innovative development of bicycle-highways and pedelec use came up at a time of increasing multimodal transport behavior of the urban population. Therefore, the synergy of these two developments is a particularly attractive offer for cyclists in daily life and leisure cycling. The possible potential for the environment and climate protection seems to be considerable – for example, Copenhagen is going to carry out the vision as "Eco-Metropolis of the world".

3.1 The Netherlands [7] [8] [9]

In the **Netherlands**, the most extensive nationwide bicycle highway network exists at all (Figure 2). At the moment (Nov. 2013) 14 bicycle highways are realized all over the country. Most of them they are developed as radial networks connecting city centers and suburban areas. Above all there are much more bicycle highways in planning process.

- Total costs: Ca. 30 mio. € annual support
- Funding: nationwide support programme (Contribution on construction costs: max. 50% by the state (max. 1,5 mio.€/ route); remaining costs have to be funded by the municipality
- Route conditions:
    - many independent cycling routes (3,5 – 4,5 m wide in two way traffic)
    - asphalt colored in red
    - continuous illumination
    - preferable intersection-free solutions or synchronized progressive traffic lights
    - often parallel to motorways, canals or railway tracks

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The average use reaches up to more than 20,000 cyclists per day (working day). A higher structural investment is used to booster the use of bicycles as an alternative to motor traffic, which is often at the risk of congestion. The investments are accompanied by intense publicity and scientific evaluations.

- 2006: First bicycle highways were launched
- 2008: Start of the programme “Fiets filevrij”:
    - Supporting projects that effect reducing motor traffic
- 2013: 14 Bicycle highways realized

Evaluations have shown that the initiation of the bicycle highways sustained success:

- Up to 17% more cyclists on different routes after starting bicycle highway-program
- 8% increasing from car to bike (that was intended)

3.2 Great Britain [10]

Bicycle highways in Great Britain are implemented only in the City of London. The London Super Cycle Highways are in the realization process from 2010 to 2015. They consist of a radial system of 12 bicycle highways connecting suburban with central areas (Figure 3).

- Total costs estimated:
  converted 111 mio. £ (only 2010/ 2011)
- Funding: City of London, Transport for London (TfL), Sponsoring by Barclays (50 mio. £)
- Route conditions: Almost only one-way cycle lanes

The company TfL evaluated the bicycle highways after starting the first 2 routes in 2011 and found out a very satisfied user level. Cyclists feel safer through the new and better bicycle infrastructure. An increased usage was also documented on the analyzed routes (Figure 4).

3.3 Denmark [11]

In Denmark (Copenhagen) a meshed network (Figure 5) of bicycle highways is in the planning and partly in the realization process. All routes connect 18 municipals and different destinations in the area of Copenhagen on a prospective length of 300 km. 26 routes should be realized. The first route, the Albertslund route (length 17.5km) opened in April 2012. The estimated potential of the routes are about 52,000 commuters a day.

- Total costs estimated:
  up to 134 Mio. €
- Funding: Region of Copenhagen, 18 municipals, Danish Road Directorate
- Route conditions:
    - high and uniform quality throughout the route
    - following the optimum line as closely as possible
    - prioritization bikes before other means of transport whenever possible

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4. Practical experience in Germany [12] [13]

For the first time requirements and standards for bicycle-highways were formulated due the cycle traffic strategy in the **metropolitan region of Hannover-Braunschweig-Göttingen-Wolfsburg** (2006 – 2008) and a federal-statewide planning competition for bicycle-highways in **North Rhine-Westphalia** (NRW, 2013). Currently a working group of the **FGSV** researches on the national level.

The following criteria cite as the basis for requirements of bicycle-highways and are essentially identical across countries:

- Sufficient width: ≥ 4.0 m in two-way traffic
- Spatial separation from pedestrians
- Main road junctions with motor traffic:
- at best intersection-free solutions or
- if possible synchronized traffic lights or
- at least use of frequency controlled green-time extensions
- Secondary roads: giving preference at junctions
- Reduced waiting times: distance-related waiting time limits
- Sufficient condition of surface, less strong gradients
- Illumination, service facilities (e.g. bicycle pumps) and information boards and are obligatory.

Figure 6 and Figure 7 show different application possibilities. Those prospective solutions are from bicycle highway studies in the metropolitan region of Hannover-Braunschweig-Göttingen-Wolfsburg.

Several cities in Germany found out that cycling networks with a partial character of bicycle-highways already exist. Existing quiet side streets, independent bike path connections through the nature or riverine bicycle routes sometimes without separation between pedestrians and cyclists, partly offer benefits of faster daily connections, even without the classification as a bicycle-highway.

Bicycle-highways are planned and implemented according to prevailing opinion as an integral part of local or regional cycling networks or mobility strategy. Inter-municipal cooperation is the rule.

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5. Best practice (Germany)

For the ELMOS participating cities are interesting practical experiences of three regions or cities in Germany, which are briefly presented:

5.1 City of Göttingen, Lower Saxony [14]

The bicycle highway Göttingen will be the first nationwide to go straight through the center of a city. The route connects next to the city center the university the train station and several residential and working areas (Figure 8) This trial route will be used to investigate which demands are placed on the infrastructure by cyclists on electric bikes and whether, through the provision of electric bikes, the willingness of commuters to change over from car to bike increases.
The project is funded by the City of Göttingen and the University of Göttingen, which are supported by an e-mobility-program called “Electro-Mobility Show Case” from the Federal Ministry of Transport, Building and Urban Development.

Facts:

- Approx. 130,000 inhabitants; about 15.000 employees and 25.000 students working nearby the bicycle highway
- Length: about 4 km (extensions possible)
- Route conditions:
  - 2 km as a four meter wide cycle way
  - 1,5 km as a bicycle path (intended for cycle use only, use of other vehicles must be approved, e.g. residents)
  - 0,5 km on a bus lane
- Special conditions:
  - Synchronized traffic lights
  - Special design
  - Cleaned preferably in winter
  - Battery charging facilities along the route (train station, big workplaces)
- Cost: about € 1.1 million for two parts
- Evaluations: several inquiries of acceptance

Timeline:

- 2009 - 2011: first route and feasibility studies during the cycle traffic strategy in the metropolitan region of Hannover-Braunschweig-Göttingen-Wolfsburg
- March 2013: Start of the detailed planning
- June 2013: Start pretesting for the research project
- Autumn 2013: Completion of the 1st section
- Spring 2014: Presentation Intermediate Results of the Research Project
- Autumn 2014: Completion of the 2nd section
- Spring 2016: Presentation of the Research Results

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5.2. District of Herford and Minden-Luebbecke with five cities, North Rhine-Westphalia [15] [16]

The Federal state of North Rhine Westphalia (NRW) arranges a competition on bicycle highways in 2013. The communes are invited to present their planning and the government announces them to support the further planning and realization process. The cities of Bad Oeynhausen (general coordinator), Herford, Löhne, Minden and Porta Westfalica, situated in north-east NRW syndicate for the competition, planning a route between these medium sized cities. The route connects all city centers and all bordering train stations across totally 67 km. The final route definition hasn't been completed yet, so there are some alternatives included (Figure 9).

Facts:

- Five cities with 35 – 80.000 habitants each; extension possible
- Length: about 67 km (incl. alternatives)
- Route conditions:
  - 36 km as a four meter wide cycle way (not along streets, independent)
  - 7,5 km as a four meter wide cycle way (along streets)
  - 19,5 km as a bike path (intended for cycle use only, use of other vehicles must be approved, e.g. residents)
  - 4 km bicycle lines on streets (3 m wide)
- Special route conditions:
  - preemption for the bicycle highway as often as possible, even for independent ways crossing main roads
- Total costs: up to 20 Mio. €, depending on the chosen alternative
- Funding basically promised (Federal State in case of winning the competition)

Timeline:

- September 2012: agreement on the basic standards for bicycle highways in NRW
- January 2013: public offer of a reward for the competition
- May – July 2013: intensive planning process for completing the competition components
- November 2013: official announcement of the winning regions

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6. Pedelecs and bicycle highways[17] [18] [19] [20]

Bicycle highways like longer distance and high speed routes for bicycles attract pedelec users in special.
In Figure 10 is shown that pedelecs are faster than all other means of transport during peak times up to a distance of 9.8km. It is especially faster than using a car because of the possible use of direct ways and less traffic-jam waiting times. During this study “traffic-revolution-pedelec” issued from the Leuphana University Lüneburg in 2012 it is concluded that the pedelec journey times are favorable because of compensation of slopes and headwind and for sure faster (re-) directions. Moreover the physical intense is much lower.

Dutch and Belgium evaluations point out important specifications of pedelec usage:

- Average route distance: 10 – 15 km
- Pedelec-users are up to 20% faster than normal cyclists; the average speed of pedelec users is about 18,7 km/h
- Bicycle highways can increase the average speed up to another 20% (incl. waiting time)
- Zone of attraction (habitation – workplace) of pedelec-user is up to 100% bigger
- In the Netherlands an average extension on cycling ways of working commuters is proved. From 6,3 km (normal bike) up to 9,8 km (pedelec)
- considerable distance increase between habitation and destination
- e.g. Flandern: 44% respondents think about covering distances over 20 km daily using a pedelec

The grown number of pedelecs leads to the question, whether this has implications on the standard dimensions of cycling ways. Studies from the Mecklenburg-Western Pomerania government in 2011 have shown that this is not negliable. Pedelecs are faster than normal bikes and more people can reach higher speeds while cycling. Because of that it might be important to specify cycling infrastructure.
Most important results are:

- The normal width of cycling ways is often not enough for overtaking. It is required to overtake slower (normal) cyclists, for that reason the standard sizes of cycling infrastructure should be increased. Without sufficient width to overtake on cycle paths, safety risks for cyclists and pedestrians may rise by cyclists overtaking on the footways.
- Joint ways with pedestrians might be not suitable, because of higher speed levels. An opening of pedestrian ways should be considered only in individual cases.
- The use of two-way cycling paths (except for high standard bicycle highways) should be out of question.
- While planning the space requirements for cyclists and pedestrians should be on one of the first tasks. They must not get the remaining space after planning for the motor traffic.

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Bicycle highways and pedelecs are an ideal combination. Therefore it should be mandatory to install special infrastructure for pedelec users like battery charging facilities or special parking spaces for pedelecs.

7. Summary

In summary, the following findings can be stated so far:

1. **European Countries**: Here can be found already partially realized, but different examples of bicycle-highways: a) radial networks in London, b) more meshed networks in Copenhagen, c) nearly extensive radial distribution networks between different cities in the Netherlands.
2. **Germany**: On the national level there are planning hints by the German Road and Transportation Research Association (FGSV) being in process, which shall include recommended standards for the optimal design of bicycle-highways. The publication hasn't been issued yet. Single projects of bicycle-highways are in planning or realization.
3. **Federal state of North Rhine-Westphalia**: In NRW a statewide competition for regional bicycle-highways is still in process. In the five administrative districts of the state, the winners and their following plans and realizations will be supported financially.
4. **Further German Cities and Regions**: On the (inter-)communal level bicycle-highways are under specific local conditions, especial for financial support and partnerships, planned or already under construction: e. g. Bonn, Göttingen, Kiel, Rostock, Ruhr area. Its population is starting at 130,000 habitants, the length of the bicycle-varies from 4 to 85 km.

The most important points from this study for small and medium-sized cities are:

- Realizing bicycle highways should presuppose a good initial position on cycling (bicycle culture).
- Bicycle highways are not a single strategy. They must be integrated into a complete bicycle-strategy combined with adequate public relations.
- The distance of bicycle highways is not essential. More important are a high destination frequency and an expected high user level.
- Bicycle highway criteria depend on the cities / regions situations. A very good infrastructure level (more than the normal level) is necessary, but reasonable compromises are possible.

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8. Attachment

Figure 2 **Existing and planned bicycle highway in the Netherlands (http://www.fietssnelwegen.nl)**

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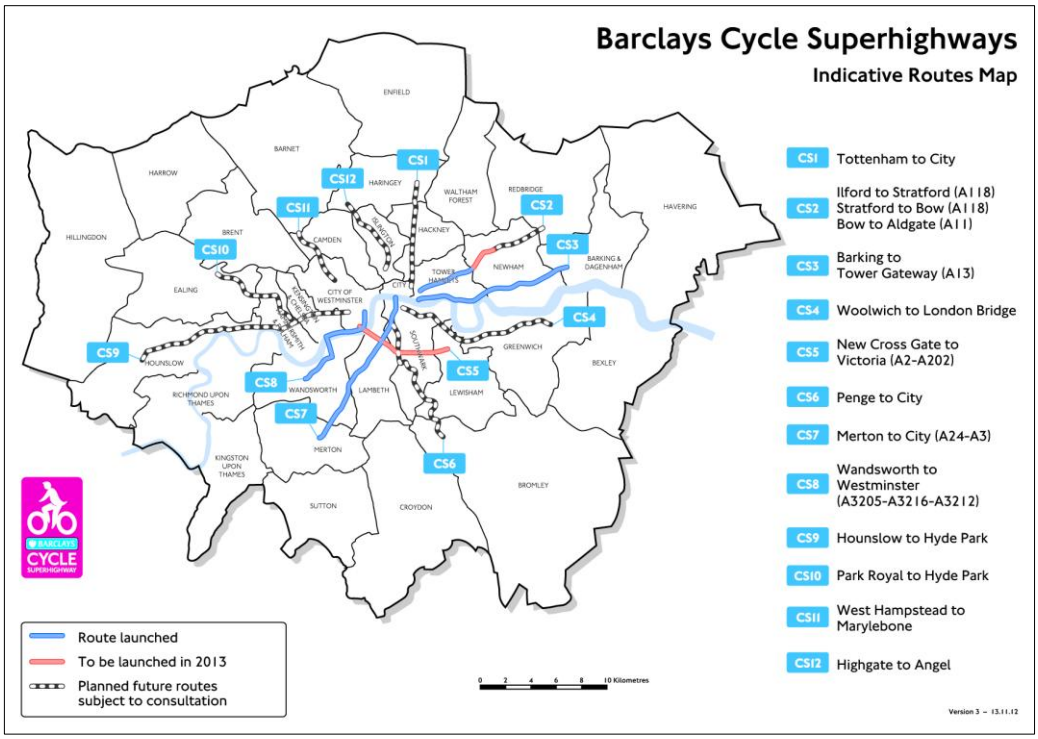

Figure 3 **Radial system of bicycle highways in London (www.tfl.gov.uk/roadusers/cycling/11901.aspx)**

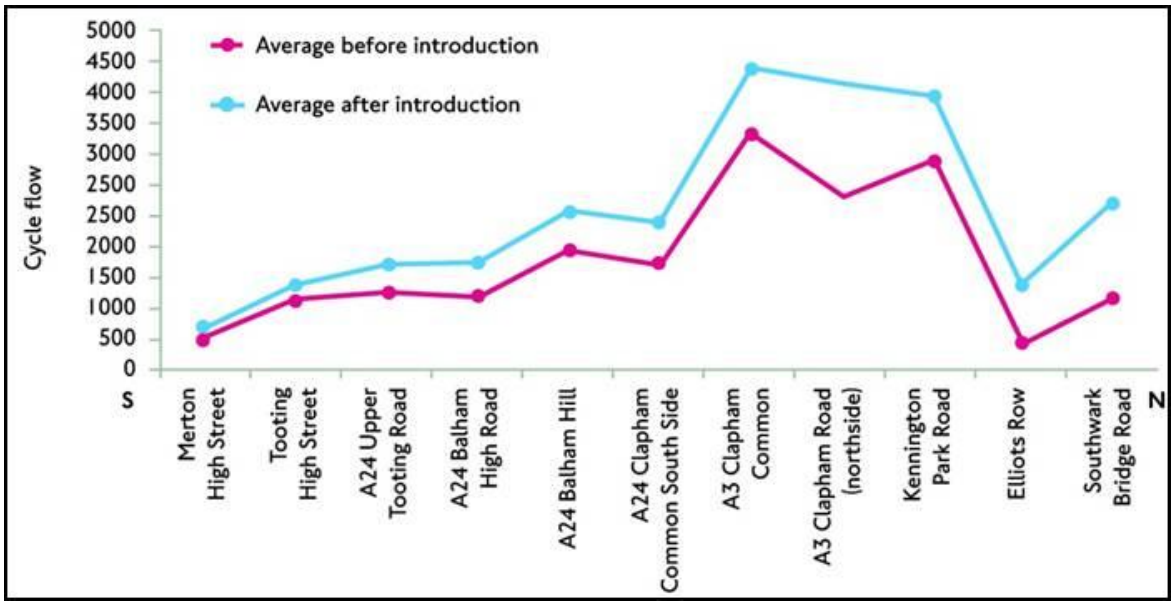

Figure 4 **Cycle flow 07-19.00 along BCS7 (www.tfl.gov.uk/roadusers/cycling/11901.aspx)**

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Figure 5 **Cycle Super Highway network Copenhagen (www.cykelsuperstier.dk)**

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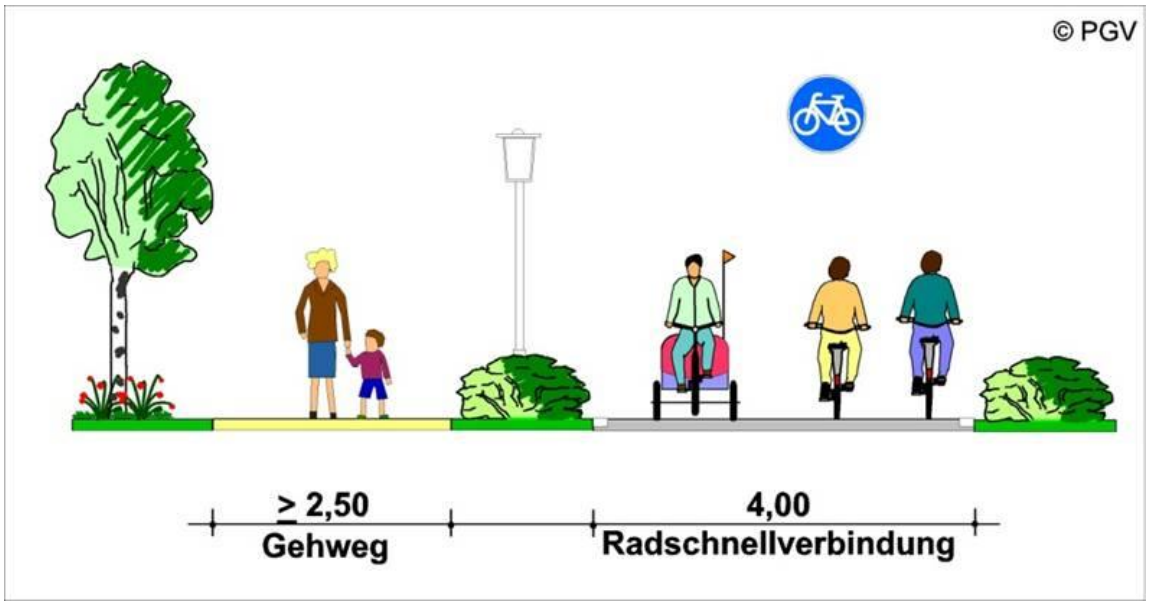

Figure 6 **Bicycle highway solution: Cycle track, not road-accompanying, independent track, two-way-direction**

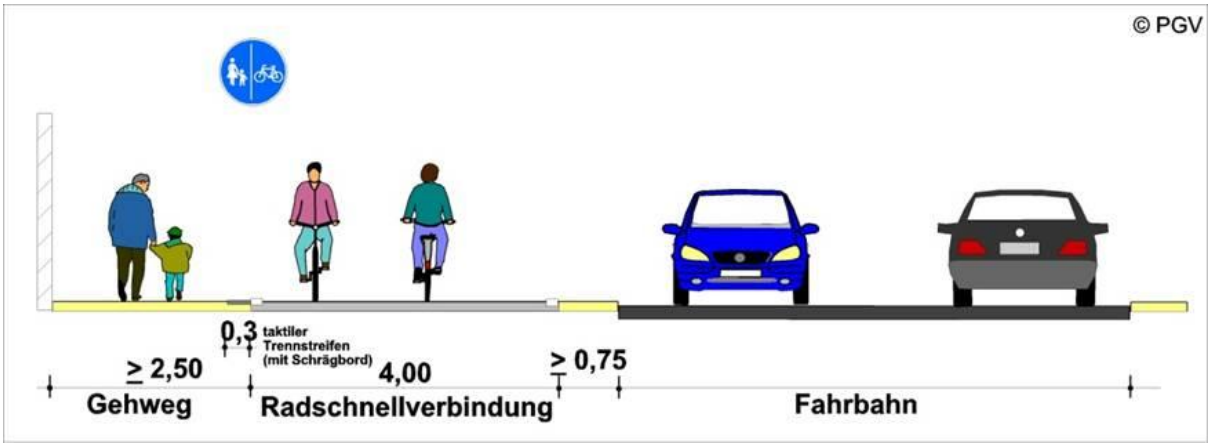

Figure 7 **Bicycle highway solution: Cycle track, road-accompanying, one side only, two-way-direction**

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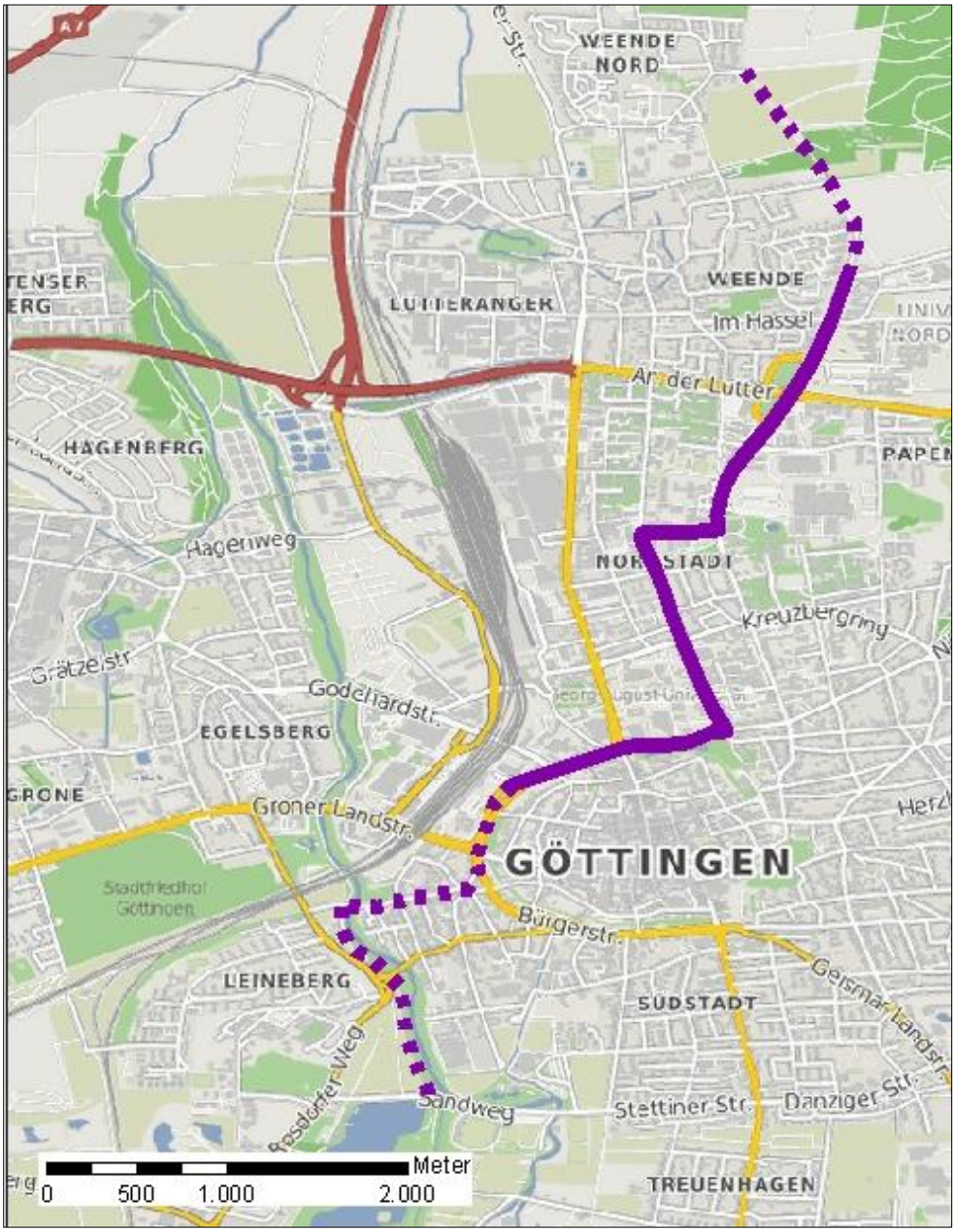

Figure 8 **Course of the bicycle highway Göttingen**

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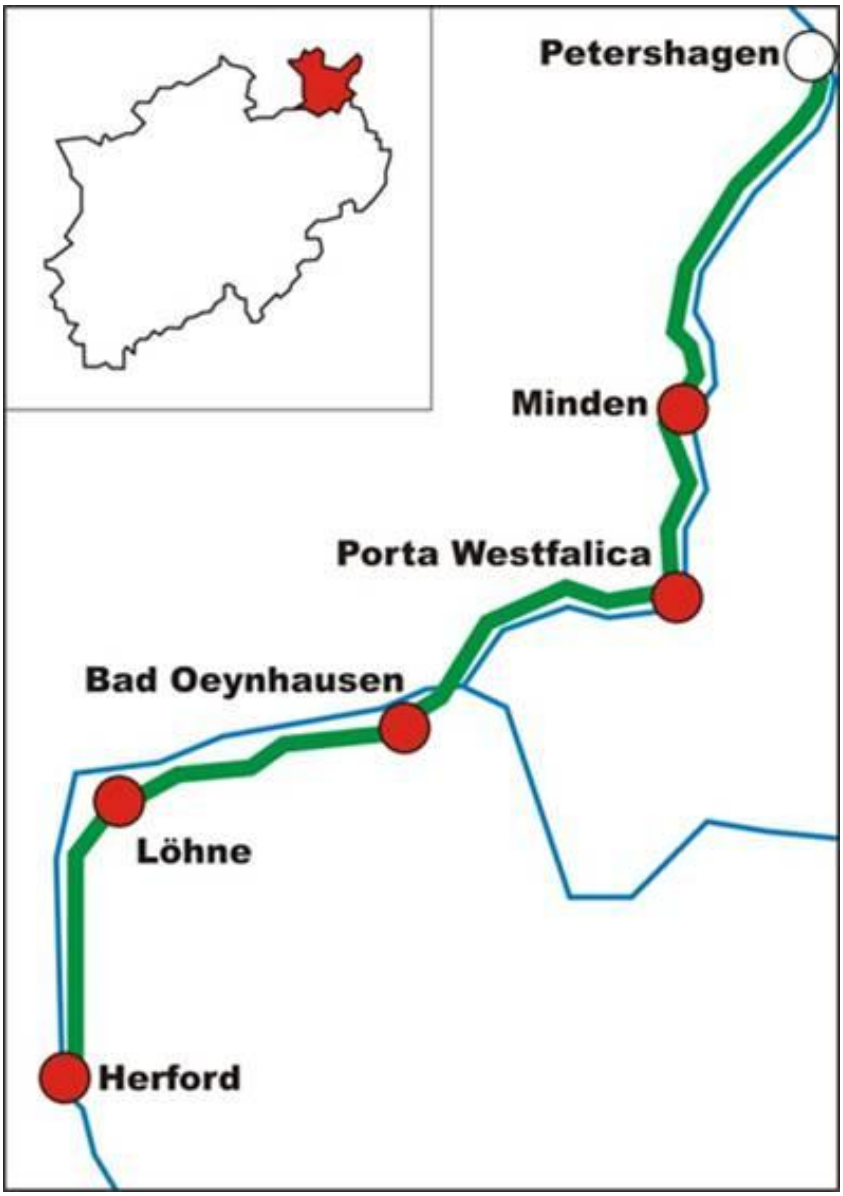

Figure 9 **Generalized course of the bicycle highway OWL**

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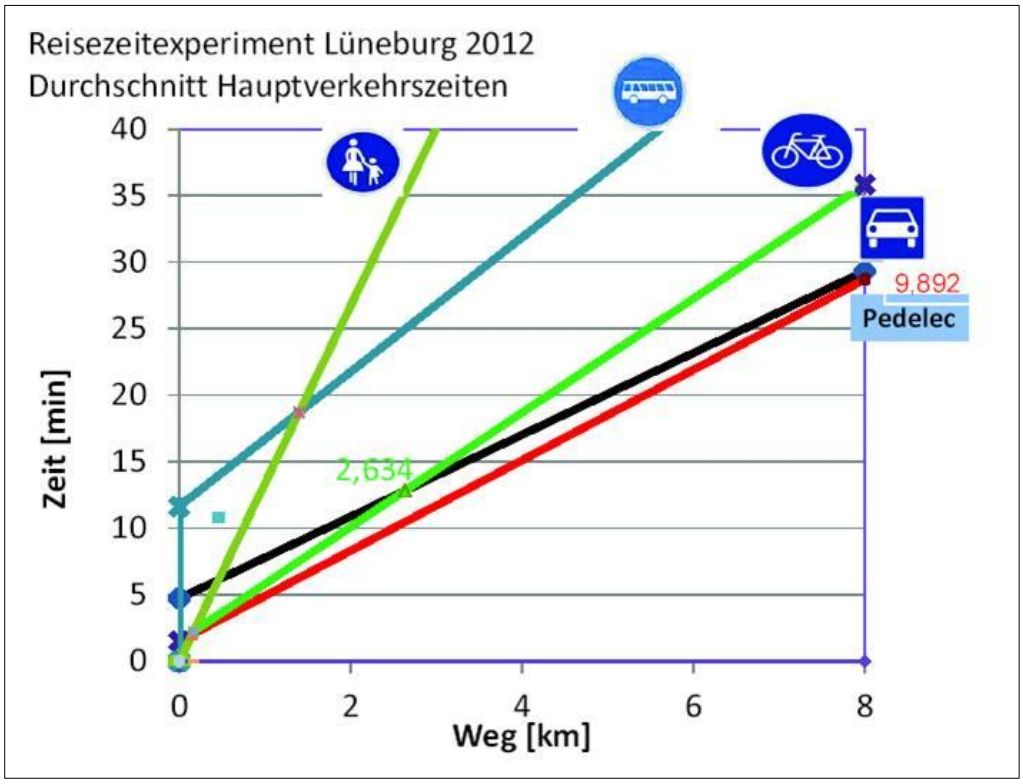

Figure 10 **Comparison between different means of traffic during peak-time (Pez, Peter (2012): Verkehrsrevolution Pedelec)**

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