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TECHNICAL POTENTIAL AND USER REQUIREMENTS FOR THE IMPLEMENTATION OF ELECTRIC CARGO BIKES IN COURIER LOGISTICS SERVICES

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ABSTRACT

In urban areas, the vast majority of courier logistics deliveries consists of small shipments over short distances. In order to minimize harmful ecological, social and economic effects, a mode-shift from combustion engine vehicles to electric cargo bikes has been suggested by the German Federal Ministry for the Environment. This article shows a technical substitution potential between 19% and 48% of the mileage carried out by combustion engine vehicles, based on goods volumes and shipment distances. The general user anticipation regarding this implementation seems to be favorable. Electric cargo bikes seem compatible with a messenger's job organization. However, electric range and purchase price are still seen as critical issues.

Keywords: cargo bikes, urban freight, courier services, electric mobility

INTRODUCTION / OBJECTIVES

Commercial transport is already today contributing 20% to the total of transport emissions in cities and urban areas. Within commercial transport, an important role is played by so-called CEP services: courier, express and parcel deliveries. Due to changes in shopping habits and delivery structures, they show a disproportional growth rate in Germany, growing twice as fast as GDP and 1.4 times faster than the entire logistics industry's growth rate.[1]

Within a project funded by the German Federal Ministry for the Environment, Nature Conservation and Nuclear Safety, as part of the National Climate Initiative, 40 electric cargo bikes (see Figure 7) are currently being tested by courier companies in eight different German urban areas over a period of two years, starting in summer 2012. It is the purpose of this project to analyze to what extent electric cargo bikes can contribute to the reduction of CO_2 emissions of urban deliveries, mainly by replacing trips of combustion engine cars or vans.

Due to the high number of vehicles used and the long term of the project it is possible to gain unprecedented density of data on user needs, acceptance and behavior in relation to electric cargo bikes. This contribution summarizes the first findings of the project: based on extensive empirical research in the form of a questionnaire handed out to the drivers and cyclists involved, shipments and routes are analyzed for their appropriateness for use by electric cargo bikes (technical potential). At the same time the social requirements toward a successful implementation of these vehicles are evaluated from a messenger's perspective (user requirements).

The German CEP market

About 2,850 companies in Germany are specialized in CEP services, using at least 211,000 combustion engine vehicles to carry out 2.45 billion deliveries in 2011 with €17.8 billion turnover[2]. In the following, the focus is on the courier segment within CEP services. For businesses active in this field, the term 'courier (logistics) company' will be used whereas actual drivers are referred to as 'messengers'. Courier services comprise the smallest and highest-priced segment of the CEP industry, offering a permanent personal accompaniment of the shipments, high reliability and flexible services[3]. In 2011, 238 million courier deliveries, (10% of the German CEP market) generated €3.85 billion of turnover (22% of the German CEP market).[2]

Despite the fact that a majority of courier deliveries comprise small and light-weight goods, the most commonly used mode of transportation are cars or light commercial vehicles. This combination of small units being transported by car, often over short distances with high frequencies of braking and acceleration, causes harmful environmental (i.e. local and GHG emissions), social (i.e. congestion) and economic (i.e. week capacity utilization, low reliability) consequences for urban residents and businesses.

One approach to solving these problems is the introduction of electric vehicles and, specifically, the introduction of electric cargo bikes. So far only a few of these vehicles have been able to be used by courier services in longer term field testing. The following research reflects on the opportunities and limitations experienced during the first phase of a large-scale empirical research study conducted in Germany, where 40 electric vehicles could be used by courier logistics services in different urban set-ups. Based on the findings of the accompanying empirical research and analysis, this research contributes to a better understanding of the potential substitution of car trips in the context of urban freight transport by electric cargo bikes. Electric mobility is seen as one key measure to fulfill national and international energy and climate policy targets[4]. Especially in urban areas, commercial vehicles tend to be older – due to higher competitive pressure – and hence more environmentally harmful [5]. Electrically-assisted cargo bikes could be a low-threshold form for electric mobility with high suitability and a quick amortization in urban freight transport, especially for point-to-point courier deliveries.

Historic overview of cycle freight

As using bicycles and cargo bikes for urban freight is in no way a new idea, a short look at the historical development is helpful. These vehicles were a common and accepted means of urban freight transport from the beginning of the last century until the rapid spread of automobiles in the 1950s and 1960s. Whereas companies' internal transport was continuously dominated by combustion engine vehicles, a renaissance of bicycle messengers began in the 1970s in New York City and from the mid-1980s onward also in major German cities. Determinants for this change can be found in structural changes such as the rise of a post-Fordist knowledge- and services-based society which brought a stronger division of labor. Furthermore, the demand side has undergone changes as well, i.e. the growth of an ecological movement. Seven of the eight courier logistics companies that provided data for this work were founded between 1988 and 1992, which signifies this renewed boom phase for freight transport by bicycle. Especially small and light-weight deliveries inside dense urban areas were assigned to bicycle messengers. However, this industry was once again challenged by the digital revolution 10 to 15 years ago. Many small-sized goods such as documents, photographs or tickets could be sent by email and needed no longer to be delivered physically. Consequently, the number of bicycle messengers decreased in most courier companies and the average size and volume of the shipped goods increased. More recently, many urban courier companies diversified their services and found new markets, e.g. the medical sector, law firms and the public sector.

Recent academic and practical studies

Limited material is available about the possibilities of bicycles in urban goods transportation, even less for (electric) cargo bikes[6]. Currently about 9% of German CEP companies employ bicycle messengers and about 100 companies in total are mainly specialized in transporting freight by bicycle[7]. Among the few studies rough estimates of about 0.5% bicycle share can be found for the goods movement inside the German city of Kassel[8]. Maes and Vaneslander[9]

see messengers on bicycles as a feasible link to bigger logistics chains, improving efficiency and reliability for the last mile of deliveries. Another study combines electric vehicles (including a tricycle) with an urban consolidation center in order to replace diesel trucks on their regular delivery tours[10], reducing the total distance driven by parcel by 20%. A first structured potential analysis of cargo bikes in urban freight was done in 2009 by Transport for London (TfL). General advantages of cargo bikes were seen in terms of purchase cost, running cost, parking costs and congestion charge area, low driver training requirements and low environmental impact. Disadvantages were expected in terms of security, limited range and payload and driver fatigue[11].

Despite the still low market shares of (electric) cargo bikes in urban freight, some CEP-companies have already conducted small-scale field trials, testing different types of cargo bikes (i.e. 2-, 3- or 4-wheeled, non-electrified or electrified). Among them are UPS (in several German cities), DPD (Hamburg), Messenger (Berlin), Outspoken Delivery (Cambridge) or Gnewt Cargo (London). More models of (electric) cargo bikes are approaching market maturity, partly from start-up specialists as well as from established bicycle manufacturers. Furthermore, the general awareness of media and a broad public is rising. Publicly funded projects like 'CycleLogistics.eu' raise awareness of cargo bike transportation, specifically towards local administrations and private customers[12].

These newly developed vehicles, in combination with the search for lower emission transport options, have contributed to the promotion of electric mobility and the expansion of the current niche market of electric cargo bikes. Implementing these vehicles in urban freight combines several initiatives to reduce harmful characteristics that are typical for this sector, as mentioned by Browne et al.[13], such as modal shift, vehicle engine design, matching vehicles to load, use of vehicles powered by non-fossil fuels, use of bicycles and loading time restrictions for other vehicles.

Potential for a new type of vehicle?

It is yet to be found out what share of courier logistics deliveries and mileage could technically be performed by electric cargo bikes. This technical potential is the first relevant determinant for a sustainable electric cargo bike usage and therefore corresponds with the first part of this research. It is assumed, that a high percentage of trips and mileage could technically be substituted by electric cargo bikes given the constraints of shipment distance and goods weight and volume.

Secondly, the messengers' needs and expectations concerning the practicability of this mode of transport for their day-to-day work need analyzing. As electric cargo bikes are currently targeting a commercial market, messengers can be seen as user pioneers. Due to the mostly freelance and therefore autonomous job organization, it is important to understand individual messengers' anticipations and usage requirements to determine possible social constraints towards the diffusion speed of this logistics innovation. This includes users' perception of the suitability of different vehicle components. It is assumed that especially battery size and purchase price are posing limiting factors to a wider spread use of electric cargo bikes as often described in literature[14].

DATA COLLECTION

Eight German courier and express logistics companies provided data for research. All of them are among the three biggest market players in their home cities which are (in rank of size) Berlin, Hamburg, Munich, Düsseldorf, Leipzig, Bremen, Nuremberg and Mainz. The database provided contains all trip data for one year of business (May 2011 to April 2012) for all modes of transportation, except for 2 companies who applied a regional filter (metropolitan area) before transferring the data. All companies use different modes of transportation, at least bicycle and cars. As the participating companies are different in size, the quantities of delivered trip data records differ (ratio biggest to smallest company concerning trips: 9.7:1). However, the data is being analyzed unweighted and is seen as a representative sample of the German urban courier market, following DablancsErro: Origem da referência não encontrada remark on the relative independence of urban goods movements towards local urban characteristics.

While all companies offer a broad range of services (i.e. overnight deliveries, warehousing, value-added logistics), point-to-point deliveries remain the core business model and are the object of analysis in this study. Only point-to-point-deliveries are considered, as they promise the lowest risk of errors in the data analysis due to bundling strategies (decrease in mileage) or trips prior to pick-up and after delivery (increase in mileage). All deliveries were routed using equal settings (i.e. fastest trip, low priority to motorways for bicycles etc.), thus generating 752,334 shipment distances (3‰ of the German courier services market) for further analysis. For mapping the companies' spatial extension, a core business area was defined as at least 1 pick-up or 1 delivery per week per zip code.

117,198 cases contained processable information concerning type, volume or weight of delivery. Therefore the universe for the substitution potential calculation was narrowed to this sample. Information about types of goods was partly manually coded into a new variable assessing whether the specific goods are feasible for a 2-wheel electric cargo bike, having a load rate of up to 100 kg (with no parcel more than 25 kg) and a cargo box with a volume of 78cm x 48cm x 47cm (176 liters).

An online questionnaire was sent out via the CEOs of the courier and express logistics companies to all freelance or employed messengers that were actively working for one of the eight companies, in total 590 messengers. Between June and September 2012, 188 questionnaires were filled in completely (general response rate: 32%, individual company response rate ranges from 16 to 52%). This sample comprises roughly 8‰ of the German messenger workforce.

The trip data records as well as the questionnaire data were analyzed and visualized using Microsoft® Excel 2010, IBM® SPSS Statistics 19 and ESRI® ArcMap 10.0.

TECHNICAL POTENTIAL: WHAT SHARE OF COURIER DELIVERIES COULD BE MADE BY ELECTRIC CARGO BIKES?

Spatial network and lengths of courier deliveries

The analyzed structure of courier logistics deliveries in eight German cities is clearly concentrated in inner city areas. Half of the shipment distances – independent of their mode of transportation – are below 4.7km. The possible maximum payload of the used vehicles and actual shipment weight often differs, as car messengers frequently transport goods that are feasible by bicycle or cargo bike as well. To calculate the potential for electric cargo bikes to take over courier shipments, two limiting factors were taken into account: shipment distance and weight/volume of the goods.

The possibility of applying electric cargo bikes to courier services depends on the existing structure of delivery origins and destinations and the used transportation modes. It is most likely that electric cargo bikes target a niche market between classic inner-city bicycle deliveries and longer-distance transportation by combustion engine vehicles. Figure 1 maps the courier companies' core business areas, both for deliveries with (car messengers) or without (bike messengers) combustion engine vehicles. Also displayed are the city perimeters, covering urban areas between 892km² (Berlin) and 98km² (Mainz).

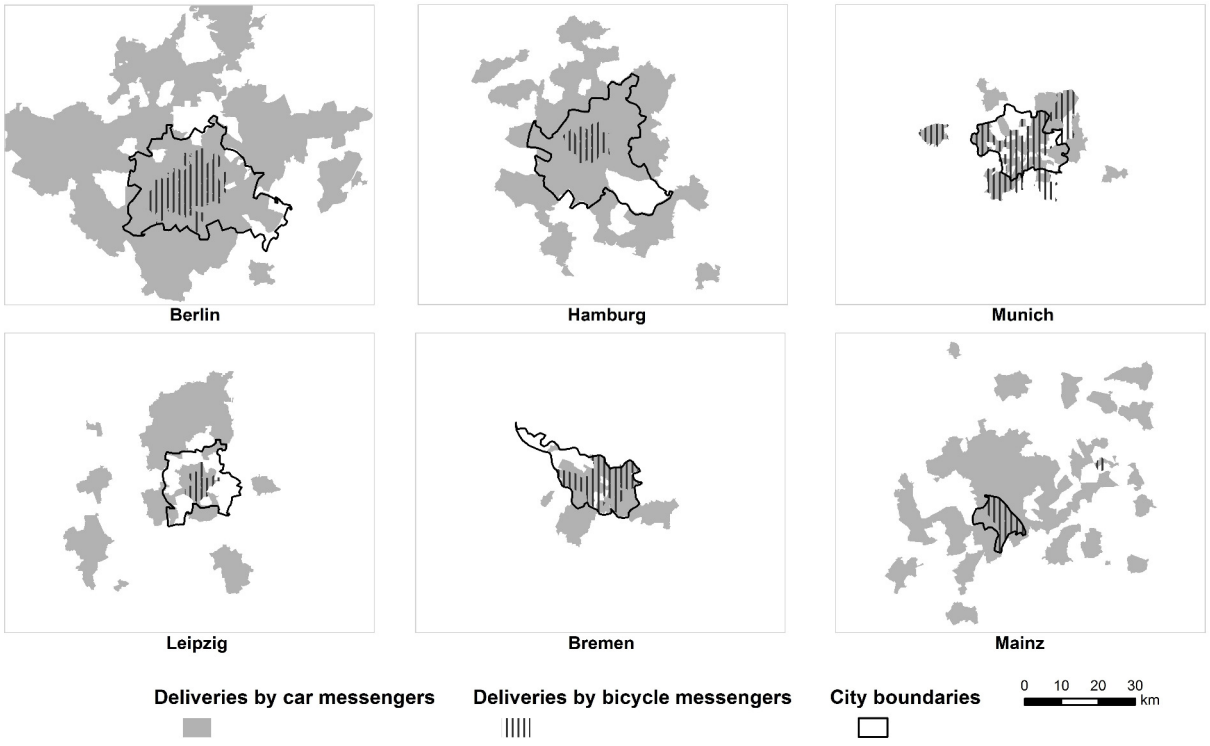

Figure 1 – Core business areas of 6 German courier logistics companies (2 further companies provided data with a regional filter applied to their metropolitan areas and were therefore not included for visualization)

The area covered by bike messengers ranges from 48km² (Leipzig) to 382km² (Munich) with a mean of 170km². Bike messengers are mostly working inside city premises. In Munich, the wider spread of bicycle deliveries is due to messengers using public transportation or living in neighboring towns of the metropolitan area. A ratio of approximately 5 km² per associated bicycle messenger can be found in Berlin, Leipzig and Bremen and Mainz. However, this number differs in Hamburg where one associated messenger statistically covers 2 km². In Munich, this number is 14 km², underlining the more disperse coverage of bicycle messengers.

Car messengers are active in a bigger area, ranging from 320km² (Bremen) to 3,459km² (Berlin) and a mean of 1,466km². The area statistically covered by one car messenger is 18km² in Hamburg, 31km² in Munich, approximately 40km² in Berlin, Leipzig and Mainz and 53km² in Bremen.

Despite the wider areal spread of car deliveries, both bike (99%) and car (82%) trips are mostly carried out inside the city perimeter. Even the companies in Leipzig and Mainz, having a more disperse business area, still make 51% and 44% of their car trips inside the city.

Although it is yet to be found out whether the covered areas of electric cargo bikes show a significant difference compared to bicycle and car deliveries, one can assume that viewed from the visual spread of the two shown modes of transportation, a niche positioning in between seems reasonable. Electric cargo bikes are likely to enable messengers to cover greater distances without fatigue.

Besides the spatial network of courier trips, it is also important to consider the lengths of the shipments. As opposed to express and parcel deliveries, the courier sector is characterized by a high share of short-distance trips to bridge the last mile of shipments. Figure 2 shows the distributions of shipment distances both for all available data collected from 8 companies (n≈752,000) and a selection of trip data records from Berlin (n≈117,000). This selection also contains information on the goods' weight and volume and was therefore used for further analysis. Both distributions are generally comparable, being positively skewed and leptokurtic. Due to the extensive size of Berlin and its polycentric character, shipment distances are longer than in other German cities, especially distances between 5km and 30km have a higher share. Mean distance of the selected sample in Berlin is 9.1km and 8.5km for all companies.

In order to calculate a substitution potential for electric cargo bikes, a maximum shipment distance of 10km (for Potential 1) and 20km (for Potential 2) was set, according to qualitative statements of messengers and the courier companies as well as the limitations in electric range of about 60-100km, depending on battery size and usage.

Setting 10km (20km) shipment distance as the only limiting factor to the implementation of electric cargo bikes, 72% (92%) of the trips and 40% (70%) of the generated trip distances (base: all cities) would be substitutable.

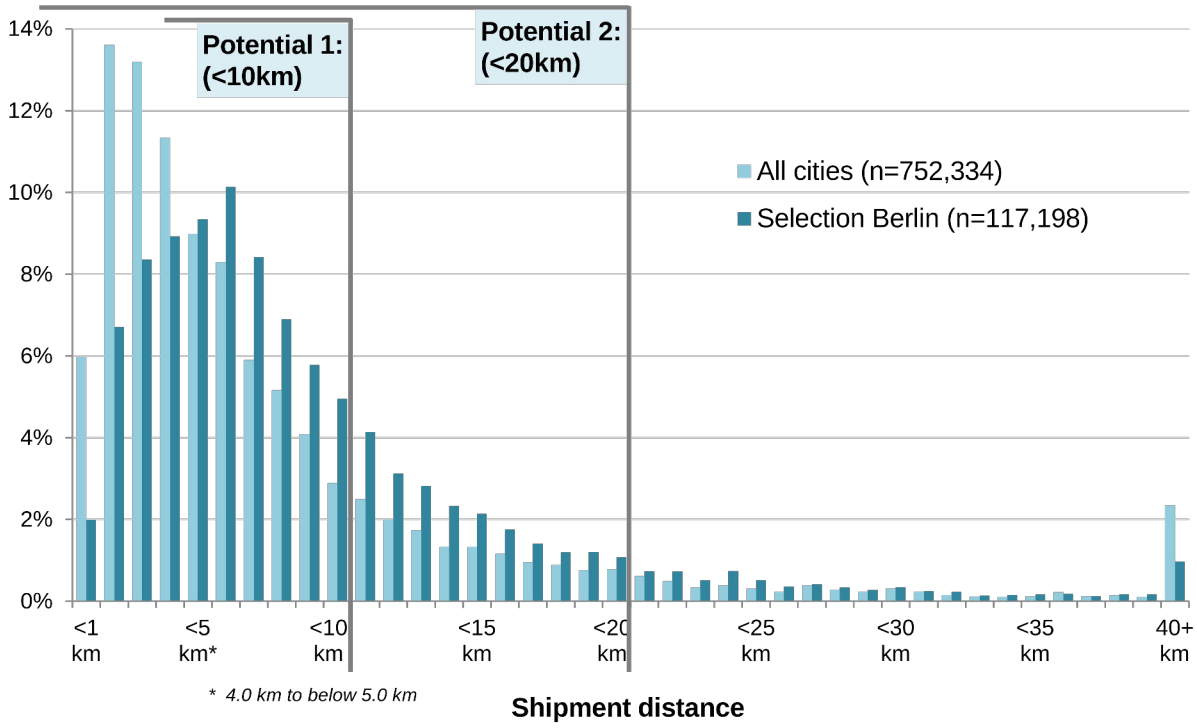

Figure 2 – Distribution of shipment distances of courier logistics deliveries

Constraints concerning goods' weight and volume

To facilitate a meaningful technical potential for electric cargo bikes in courier services, the goods weight and volume have to be taken into account. If only weight and volume were the limiting factors, 89% of the goods would still be feasible for transportation by a 2-wheel electric vehicle offering a cargo box with a volume of 176 liters. Typically-used terms employed by courier companies to classify these sizes of goods in Germany are "15 grey cartons" (i.e. for flyers or serial letters), "3 copy cartons" (each of them containing 2,500 sheets of standard paper) or "one standard packing case".

The technical substitution potential combines dimensions of both distances and weight/volume and was derived from the Berlin selection of trips (see Table I). Between 66% and 83% of these deliveries could be done by electric cargo bikes. This corresponds to a range of 36% to 62% of substitutable mileage.

Table I – Technical substitution potential (n=117,198)

	Substitutable deliveries	Substitutable car deliveries	Substitutable mileage	Substitutable car mileage
Potential 1: Shipment distances < 10km & feasible goods only	66%	42%	36%	19%
Potential 2: Shipment distances < 20km	83%	68%	62%	48%

& feasible goods only				

These calculations consider all modes of transport. In order to achieve a positive environmental impact, it is important that there is also potential for substitution of trips currently done by combustion engine vehicles with electric cargo bikes. To gain a better understanding of this question, a mode analysis was conducted and displayed in Figure 3. It shows that electric cargo bikes can take over both bike as well as car trips, as these two vehicle types have a shared market, especially for shipment distances below 15km. Both modes have a peak shipment distance of less than 6km. Between 42% and 68% of the car trips (see Table I) could be replaced by electric cargo bikes, thus saving between 19% and 48% of the distance travelled by combustion-engine vehicles for courier logistics services.

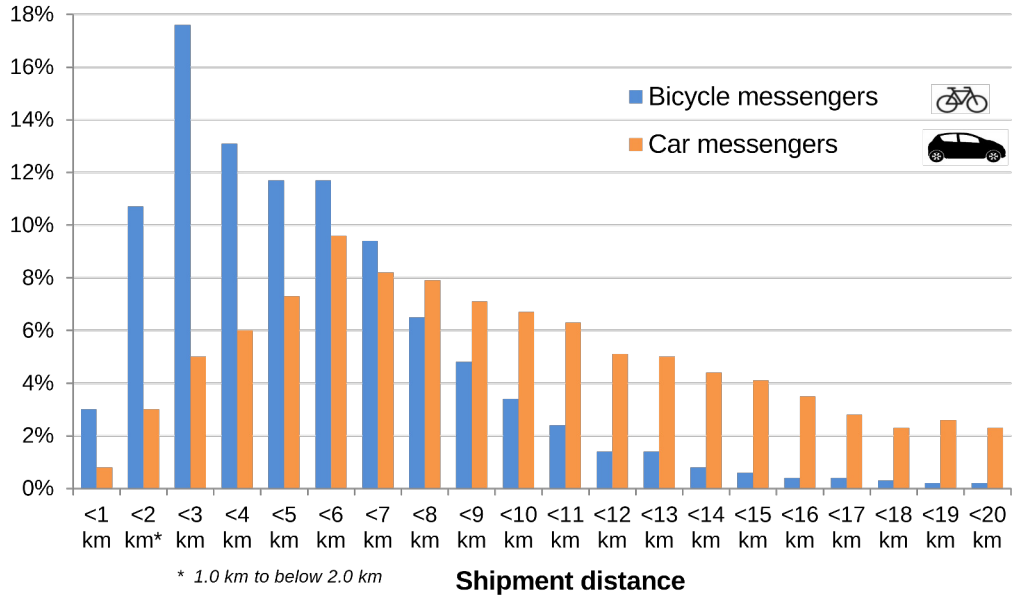

Figure 3 – Modes of substitutable trips (n=117,198)

USER REQUIREMENTS: WOULD USING AN ELECTRIC CARGO BIKE CHANGE A MESSENGER'S JOB?

Messengers' current vehicles

The CEP market is an employment-intense industry. There are different assessments about the total number of employed/freelance persons within Germany differing between 188,000Erro: Origem da referência não encontrada and 254,000[2]. The employment structure

is complex and depends on subcontractors or franchise systems both between the courier companies (often called switching centers) and the individual messengers and between the courier companies and nationwide network operators. Estimates for the couriers within CEP services put the number of car messengers in Germany at about 19,000 and the number of bike messengers at about 4,500-5,000[15].

Messengers can be seen as pioneers of commercial vehicle usage. In order to assess their perspective on electric cargo bikes, it is important to understand their recent vehicle usage in a job situation. Certain framework conditions like charging possibilities, ownership status of the vehicle or daily routines could influence the willingness to change to a different mode of transportation. The analyzed sample is mainly (93%) male and contains both veterans and beginners of the business: 35% have been working as a messenger for more than 10 years, 13% started not more than a year ago.

Respondents were asked about their currently used mode of transportation on duty. 52% stated a vehicle without combustion engine (thereof: 86% bicycle, 8% cargo bike and 6% electric cargo bike), grouped as *bike messengers*. Despite the fairly high rate of messengers that have already used an electric cargo bike for their work during the last year (9%), only 1% own an electric cargo bike (7% own a regular cargo bike).

48% of the respondents stated a combustion engine vehicle as their favored mode of transportation (thereof: 66% mid-sized car / light commercial vehicle, 20% small-sized car and 14% SUV / transporter), grouped as *car messengers*. The engines of car messengers are mostly powered by diesel (64%), followed by gasoline (25%) and CNG/LPG (10%). Mean vehicle age is 6 years.

The most common form in German courier logistics as well as in the sample (91%) is to use self-owned vehicles. One of the 8 companies operates its own fleet of cars. Consequently, about 6% of the drivers park their vehicle at the establishment site after duty, the rest park close to home in private or public parking spaces.

52% of the messengers visit the location of the establishment at least once a day, over a third of the messengers even several times a day. This would appear to indicate that the necessary recharging periods for electric cargo bikes are easily adaptable to the everyday routines.

For most messengers (94%) it is possible to bundle several deliveries. For 29%, it’s their own responsibility to bundle deliveries, another 21% get multi-deliveries from the dispatcher. The most common amounts of deliveries bundled are up to 3 packages, only 13% are able to bundle more than 3 shipments on a regular basis. The usage of cargo bikes could raise this number.

Messengers’ general anticipation of electric cargo bikes

Following Figure 4, messengers see a high potential for electric cargo bikes in their actual urban surrounding. This type of vehicle is also seen as a contributor to environmental protection. It could most likely substitute logistics tasks of both car and bike messengers, yet

it's unclear which vehicle mode is more feasible for substitution. About half of the sample strongly agrees/agrees that electric cargo bikes will generally prevail in courier logistics services. There is, however, an information deficit about available models and usage options.

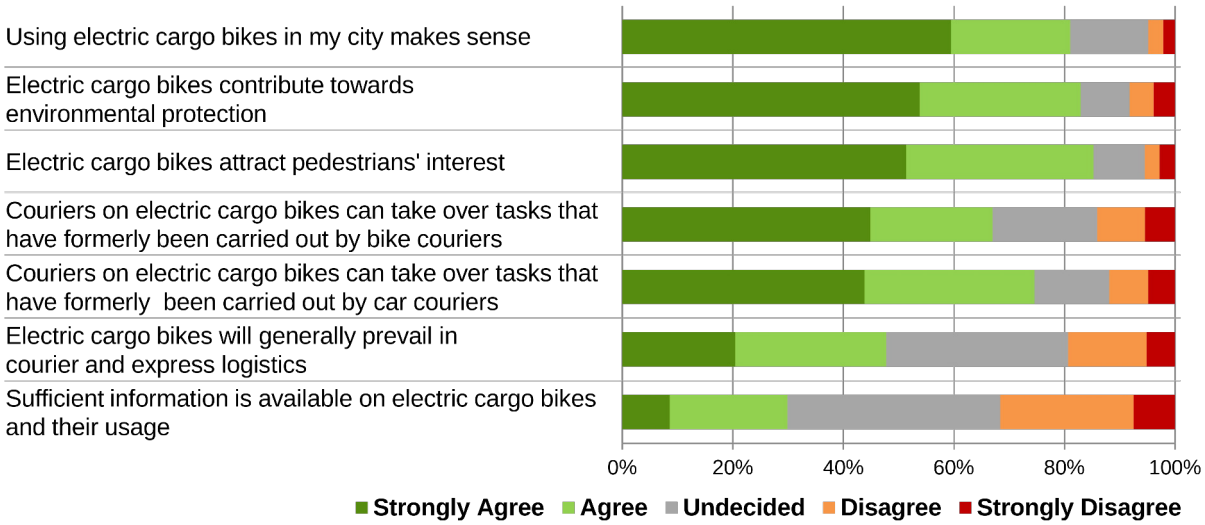

Figure 4 – General assessment of the usability of electric cargo bikes (n=188)

Messengers' assessment of job-related indicators

Besides their opinion on general statements concerning electric cargo bike diffusion in courier logistics, the possible impact on the messengers' personal job status was assessed, as one possible driver for changing to another vehicle type could be dissatisfaction with current job features. Therefore, messengers were given 11 job-related aspects and asked about their importance and their satisfaction with these items on a 5 point scale. Figure 5 displays the share of items that were rated as important/very important (x-axis) and satisfied/ completely satisfied (y-axis). Furthermore, messengers stated their anticipation as to what extent these aspects would change when using an electric cargo bike on duty instead of their current vehicle. Improvement/reduction of satisfaction is displayed as triangle/circle symbols.

The most important job-related factors are flexibility / time management (importance: 86%), contact with clients (68%), variety from day to day (68%), contact with people (62%) and amount of income (60%). All of these aspects besides the amount of income (satisfaction: 30%) were seen as quite satisfactory (between 76% and 84%). The satisfaction with most job-related items would remain constant with a modal shift towards electric cargo bikes. Slight reduction of satisfaction is expected for the flexibility / time management, slight improvement is expected for the possibility of taking exercise while working and the image of

the job. A strong improvement is only seen for the usage of innovative technologies. However, this item is of least importance to the respondents.

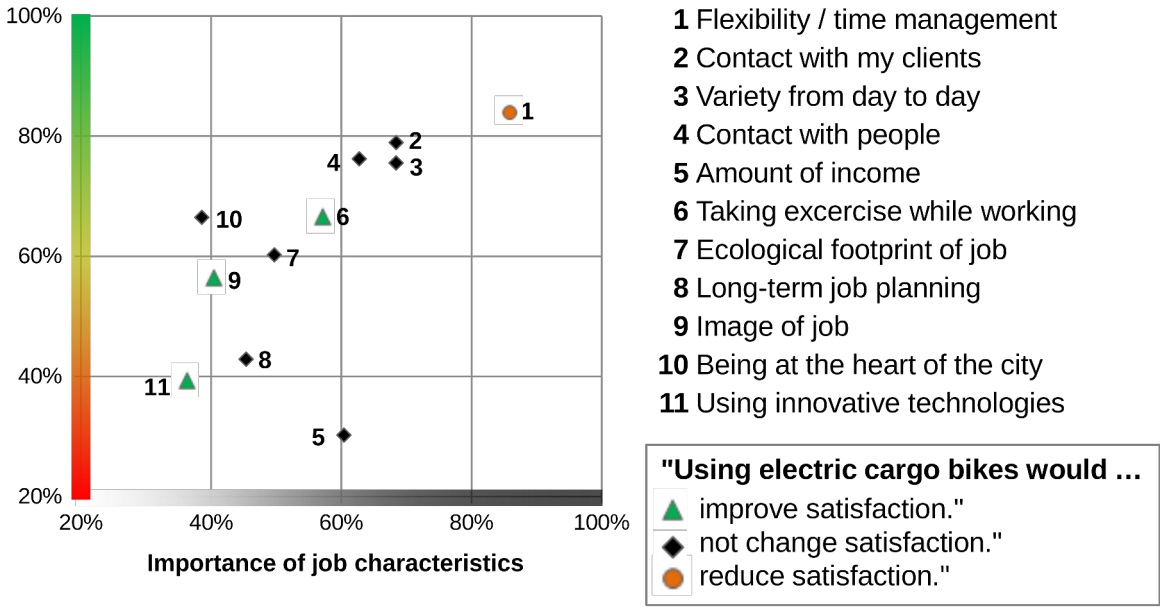

Figure 5 – Importance of (x-axis) and satisfaction with (y-axes) job characteristics; symbols signify possible change in satisfaction with job characteristics when using electric cargo bikes instead of current vehicles (n=188)

Messengers were asked if they would consider using an electric cargo bike instead of their own vehicle. 57% of the messengers showed interest in trying out this type of vehicle during the funded pilot project for a limited time (up to 2 years). Almost one fourth of the remaining messengers could generally think of using an electric cargo bike in their daily routines. Therefore a total potential target group of 68% of the asked messengers could be determined.

Messengers' requirement towards vehicle characteristics

In a further step it was investigated which vehicle-specific characteristics are of importance for the previously identified target group of messengers interested in electric cargo bikes. In addition, those aspects were rated in their anticipated practicability (operationalized as "having no doubt" about a specific feature, e.g. speed).

A feature that is considered of high importance for driving comfort but at the same time results in a potential obstacle for the acquisition of an electric cargo bike is the bike's electric range, often directly correlated to the bike's purchase costs (see Figure 6). This problematic can be seen as a barrier to a quick diffusion among messengers. For the important aspect of handling while driving, the majority of the respondents voiced no concerns, as they also saw no obstacles in the similarly important aspects of theft protection and vehicle safety. Payload is of mid-range importance and was most likely considered as sufficient. There are no doubts

about a positive perception both from customers and peers; however, these items are of limited relevance for the messengers' decision to use electric cargo bikes on duty.

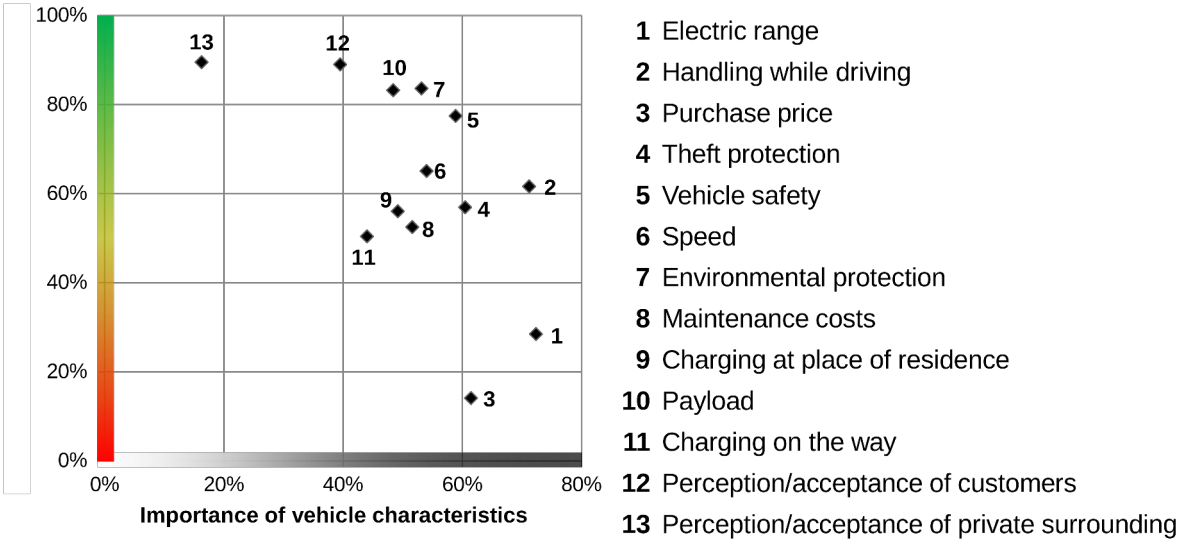

Figure 6 – Relevant characteristics of electric cargo bikes (n=127)

CONCLUSION AND OUTLOOK

It was shown that between 19% and 48% of the mileage of courier logistics services currently done by combustion engine vehicles could be substituted by electric cargo bikes. Short and medium distance (below 15km) shipments in central urban areas, especially, are relatively unpopular for car messengers due to a high risk of congestion and therefore incurring of losses. Electric cargo bikes seem to be a particularly appropriate mode of transportation to penetrate this market, which is nowadays nearly evenly shared between bicycle and car messengers. So from a technical viewpoint, electric cargo bikes can be attested a high potential in commercial transport.

Generally, the interviews of the project show that German car and bike messengers' overall anticipation of electric cargo bikes is positive. A majority sees this vehicle type as highly competitive for delivery tasks in their specific urban surroundings, which include 7 of the 15 biggest German cities. It is most likely that this logistics innovation will have its greatest potential in core areas of these cities, successfully facing problems like congestion and limited access areas due to environmental zones or deliver period restrictions. Although most messengers have had no previous practical experience with electric cargo bikes, two thirds can imagine using this vehicle type for their job. Besides that it should be taken into account

that not only willing adopters, but also new personnel could be attracted if electric cargo bikes come to be seen as a competitive mode for urban freight transport. In order to achieve logistics innovations, more information is needed on available vehicle models and their usability.

Implementing an electric cargo bike only creates a slight influence on the way messengers organize their job. On the one hand, messengers expect a slight reduction of flexibility, which could be a critical issue as flexibility is seen as most important feature of the job. On the other hand, they expect an improvement in their jobs' image and a better possibility to have on-the-job exercise, and they generally welcome the idea of using innovative technology equipment. Further studies are needed to narrow down and describe the target group of possible users of electric cargo bikes. An in-depth comparison of answers given by car messengers and those by bike couriers appears to be promising; however more upstream determinants like social status might also play a role in structuring attitudes and willingness towards electric cargo bikes. In line with most other current research, electric range and purchase price are seen as the main problems of the newly developed vehicles. These doubts of a pioneer user group like messengers could slow down quick electric mobility diffusion in the cargo bike segment.

To achieve an even better assessment of the substitution potential, the clients' perspective could help. This paper is only concerned with the technical characteristics of a shipment (distance and weight/volume). Insufficient stakeholders' acceptance is likely to limit this potential, at least in the early phase of electric cargo bikes' diffusion. An example for this would be the transport of sensitive medical commodities (i.e. blood samples). Furthermore, there is a need to take into account the logistics structure of the courier companies and their ability to change.

Generally, though, despite being still at the beginning of the project, it has become apparent already that electric cargo bikes like the example displayed in Figure 7 do hold the potential of finding high acceptance within the messenger community. With its high number of test vehicles and cities involved, this project offers a unique opportunity to evaluate a wide range of user needs, expectations and behavior towards electric cargo bikes. At the same time, the long duration of the project allows in-depth insight into these aspects beyond first enthusiasm or skepticism. It will be possible to compare messengers' anticipation and their actual usage patterns several months later. It is going to be interesting to find out during the coming years to which extent the electric cargo bikes will allow the bundling of deliveries, to substitute car trips and to significantly contribute to CO_2 emissions reductions of urban commercial transport.

Figure 7 – Example of a 2-wheel electric cargo bike being used for courier logistics services in Berlin (photo credit: Amac Garbe for DLR)

ACKNOWLEDGEMENTS

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