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Electromobility For City Logistics – The Solution To Urban Transport Collapse? An Analysis Beyond Theory

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Abstract

Congestion within cities is a major problem of urban transport already, yet further traffic augmentation is expected over the coming years. Especially the distribution of goods within cities is responsible for a high percentage of emissions and noise of the overall emissions in towns. Furthermore, and in line with its Whitebook for Transport, the EU aims for achieving almost CO2-emission free city logistics by 2030.
Electromobility is considered as one of the technologies that shall contribute to the realisation of this target. Yet little is known about user needs and user acceptance in regards to electromobility for city logistics. It is the aim of this research to contribute to closing this gap as it is essential for a successful introduction of electromobility for city logistics. As methodology empirical research is applied with a focus on the assessment of user behaviour, expectations and needs. Furthermore, whereas up to now most projects related to electromobility for city logistics are based on round-table deployment, this research is based on a multiple agent approach: By the use of extensive interviews, an in-depth analysis of user needs, user expectations and user acceptance of drivers of vehicles, purchasers of vehicles and customers of city logistics will be possible.
The findings of this reflect current limitations of electromobility for city logistics. Furthermore, the findings contribute to support governments in developing steering tools for the use of alternative energies for vehicles.

Keywords: city logistics; electromobility; FEV; LCV; multi agent analysis; urban deliveries

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1. Background and motivation

1.1. Scope of Research and Objectives

Within the coming years it is expected that the percentage of our global population living in cities and urban areas will rise from 50% today to around 70% (UN 2010). Already today though it is a common problem in most cities that roads are congested, usually around the rush hour, but often also during the normal working hours. These congestions are in part caused by individual traffic, including commuters on their way to work and back home. A substantial amount of traffic though is deriving from inner urban logistics. In Berlin up to one third of the traffic volume is due to commercial transport (SenStadt 2003). These include deliveries by all sorts of logistics providers, ranging from the shops own logistical services, to express services or integrators (e.g. DHL, TNT, UPS, FedEx), freight forwarders or mail (Menge & Hebes 2011).

It is to be expected that, with the predicted growing number of inhabitants of urban spaces, urban logistics will augment in the coming decades (SenStadt 2011). With its augmentation traffic-related emissions are bound to rise, unless vehicle technologies, and especially engine technologies, are changing (European Commission 2011). One option of change discussed widely in recent years, is to move away from the currently widely-spread use of diesel engines and fuel powered vehicles to electromobility for logistic vehicles used in cities. The technologies developed for logistics so far vary from hybrid to fully electric vehicles, from "add-on packages" for already used vehicles to entirely newly developed cars, vans, lorries and trucks (Aftabuzzaman & Mazloumi 2011). Despite all these technologies and vehicles developed, little is known so far about the impact on users and their acceptance of these technologies. First test, accompanied by thorough research, can contribute to better understanding user needs and expectations towards electric vehicles. This knowledge is important in order to ensure that further developments as well as accompanying political and organisational measures enable and support a successful introduction of electric vehicles for city logistics, in order to achieve a reduction of emissions caused by urban logistics.

Based on a research project run in Berlin in cooperation with DHL and the freight forwarder Meyer & Meyer the impact of electromobility on urban logistics is reflected and the expectations as well as the experience of the various involved stakeholders is analysed. Based on this example first conclusions can be drawn of the advantages and challenges of electromobility for urban delivery concepts by means of transfer. The research is closing with an outlook on opportunities and limitations of electromobility for logistics in cities and by reflecting in how far this new technology can contribute to a reduction of transportation related emissions in urban areas.

1.2. Case study – Berlin

With 3.4 million inhabitants and covering an area of more than 890 km², Berlin is one of Europe's cities on the forefront of encouraging the search for new and alternative transport technologies. One of the topics supported in this context is the implementation of electromobility. Several organisations and initiatives within the area of Berlin and Brandenburg have been involved in a series of trials regarding the usability of electromobility. Whereas most of them focus on the applicability of fully electric or hybrid engines on passenger cars, the test-series analysed here is one of the very few run in regards to logistics services in urban areas. This pilot project is supported by the initiative "Modellregion Berlin-Brandenburg", an initiative backed up by the German Federal Ministry of Transport Building and Urban Development. The project started in summer 2010 and was scheduled for ending in autumn 2011.

The project itself consists of two logistics providers – DHL and the freight forwarder Meyer & Meyer - which test-run fully electric vehicles (FEV) for urban distribution services in Berlin. Whereas DHL has equipped three vans (Iveco EcoDaily Electric, up to 3.5 t gross vehicle weight) with batteries for a potential range of 70 km, the freight forwarder Meyer and Meyer utilizes two smaller lorries (with a gross vehicle weight of up to 8 tons) which were converted into FEVs. The lorries are powered by two 700 kg batteries which allow for a range of almost 170 km without recharging. All vehicles are tested over the period of an entire year. The CEP provider DHL operates the vans for its delivery routes in two residential areas of Berlin each of them with their own high street offering a full range of shops and businesses for daily requirements, including department stores and shopping malls. Meyer & Meyer, the freight forwarder, operates their lorries within the city centre of Berlin for deliveries to a branch of a major textile retailer whose delivery ramp is located inside an underground parking lot.

The research methodology to accompany the trials run in Berlin is based on a systemic approach. Therefore, and in order to reflect in how far electric vehicles are a real alternative to classic fuel engines, not only the vehicles technical adeptness is taken into account. Furthermore, a strong emphasis is put on the reactions of the multiple stakeholders of urban logistic services: During the months of the pilot phase they were interviewed in order to capture their experience and perception of the FECs. The stakeholders involved were:

- Drivers
- Shift managers
- Customers of deliveries
- Neighbors to customers of deliveries

Drivers and shift managers were interviewed at two points in time of the project: at the very beginning of the pilot project and "ex post", i.e. prior to the delivery of the vehicles, they were interviewed in t_0, (see *Figure 1: Timing Of Interviews And Questionnaires*) as well as after a test-period of the vehicles of a minimum of seven weeks in order to ensure a habitualisation. Therefore, this second period of interviews, t_1, took place in summer 2011. Also interviews with customers of deliveries and neighbors took place in t_1, in summer 2011, following a minimum of three months of the test-run in order to generate valid and reliable feedback.

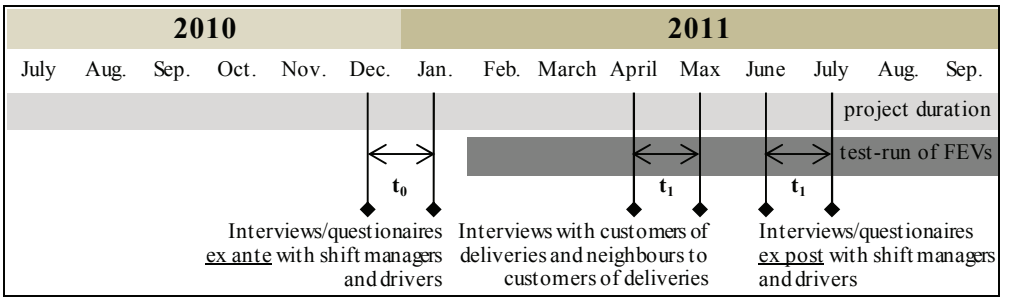

Fig. 1. Timing Of Interviews And Questionnaires

It was the central aim of the empirical research to investigate the user behavior, the perception of the vehicles and their use as well as the vehicles' acceptance. For this purpose interviews were run in the form of personal interviews based on questionnaires with open questions, complemented by multiple-choice questionnaires. In addition to the interviews drivers were observed by the researching staff and routes of the vehicles were logged in a logbook. *Table 1: Research Methodologies* gives an overview on the research techniques applied.

Table 1. Research Methodologies

	Observation period (number of questionnaires)	
	t_0	t_1
Shift managers	Interview (3)	Interview (3)
drivers	Questionnaire (10) Logged routes (24)	Questionnaire (9) Observation through researchers logged routes (20)
Customers	-	Interview (34)
Neighbors	-	Interview (26)

Generally the interviews focused on qualitative rather than quantitative feedback. Interviewed customer and neighbors had a very heterogeneous background, including men and women in nearly equal parts and covering various professional backgrounds as well as all age groups. All questionnaires offered the interviewees the possibilities of remaining anonymous in order to ensure maximum openness and support of the interviewees during the poll.

2. What we know – State of the Art

Electric vehicles are not a new invention. First FEV were built back around the beginning of the last century (Sperling 1995). The use of electricity for vehicles could not be vastly established though. In very specific fields, e.g. the delivery of dairy products to households in the early hours of the day in the UK, electric vehicles could be established. Only during the last years, in search of alternative energy sources to fuel, electricity was "rediscovered". In the meanwhile several Original Energy Manufacturers (OEM) developed electric Light Commercial Vehicles (LCV). The market still appears to be very limited though and electric vehicles for logistic services are not wide spread (Lieven et al. 2011, Trommer et al. 2010). As a consequence not much is known on how the use of electric engines impacts logistical services and commercial transport in general and in urban areas in particular. Research related to the field of the use of electric vehicles for Courier and Express Parcel Services CEPS and logistic services so far covers the combination of FEVs and urban consolidation centers in London (Browne et al. 2011) as well as the intermodal combination of light rail and electric distribution vehicles (Arvidsson 2010).

Within the project presented here the focus was on the use of FEVs for inner-urban CEPs as well as deliveries. Despite the fact that on a macro level these transport services only account for a relatively small share of traffic, their contribution to the dense urban traffic is of interest, even more due to their very specific routing patterns: Given their relatively short routes in metropolitan areas – CEP services drive distances of an average of less than 60km per day – they seem to be a field of use very adapt for a

move to electric engines instead of fuel or diesel motors. Furthermore, such a switch to electric vehicles for CEP services could therefore contribute to a reduction of emissions in the most sensible areas, the densely populated inner urban parts of towns, often characterized by schools, kindergartens, hospitals, etc., as inner urban deliveries impact the entire urban community (Menge & Hebes 2011). Stakeholders considered of imminent importance to the project therefore not only were the drivers of the FEVs and their shift managers but also the customers of the deliveries and the neighbors of these deliveries.

3. Stakeholders of City Logistics

Urban communities are of complex structures, involving many players and stakeholders ranging from citizens to merchants and businesses, the towns administration, its politicians and service providers, as well as tourists or organizations representing various interest groups. Within this project the focus was on groups of imminent involvement in the use of delivery vehicles.

Drivers were the most obvious group, as the vehicles are the most important tool of their work. The drivers participating in this pilot project were very experienced drivers who have been working in urban distribution for several years. The average drivers' age involved in the project was 33.9 years, some of them though having had a different career prior to joining the CEP segment as a driver. They are all very familiar with the area and the routes assigned to them. When interviewed at the beginning of the pilot, most of the drivers had a clear understanding of characteristics of traditional fuel systems and alternative fuel systems such as bio-fuel. The knowledge of plug-in-hybrid technologies, full- and mild-hybrid technologies as well as Battery-electric vehicles (BEV) was limited though (*see Figure 2: Drivers' Experience With Alternative Engine Technologies, Period t_0*), often the technologies not known to the drivers. Despite this lack of knowledge of the technologies and no previous driving experience with such vehicles, all drivers showed a very positive attitude towards the project and were keen on testing the vehicles.

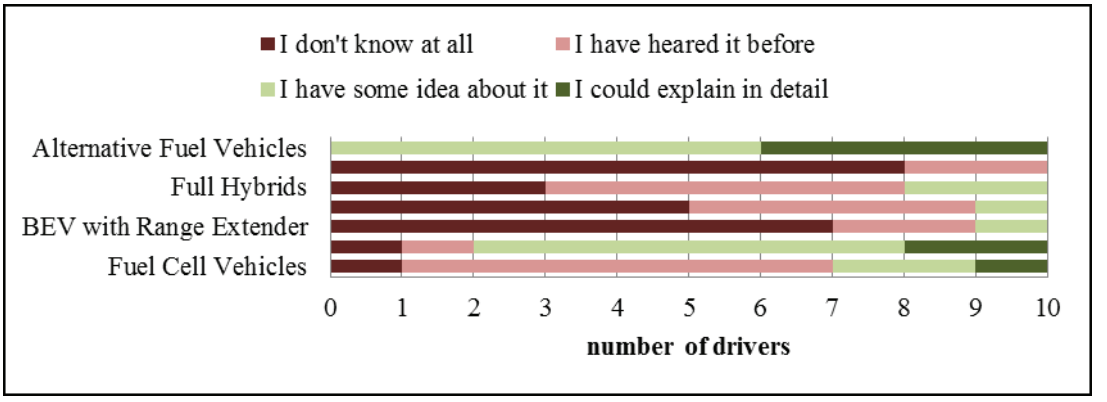

Fig. 2. Drivers' Experience With Alternative Engine Technologies, Period t0

4. Analysis of Findings

The results from the pilot project in Berlin can be divided into two main fields of insights: ”hard factors”, factors related to the technical usability of FEVs for urban logistics and “soft factors”, those related to the general stakeholders’ acceptance.

As far as the **technical usability, the hard factors** of FEVs for urban logistics is concerned, the Berlin pilot has proven that these vehicles are a valid alternative for the currently used fuel and diesel powered delivery vans and lorries as the battery range proved to be sufficient for the routing patterns of both service providers. Some initial concerns of drivers and shift managers regarding the risks related to the FEVs’ high voltage batteries did not last long. Also other aspects, such as the ease of use of cockpit instruments as well as the space in the driver’s cabin where considered satisfactory or even positive on average. However there are some issues, especially in the CEP segment, which pose future challenges such as the space at disposition for the transportation of goods (see Figure 3: Drivers’ Feedback). The battery size and its weight reduce the payload, and as a consequence drivers perceive the vans as too small.

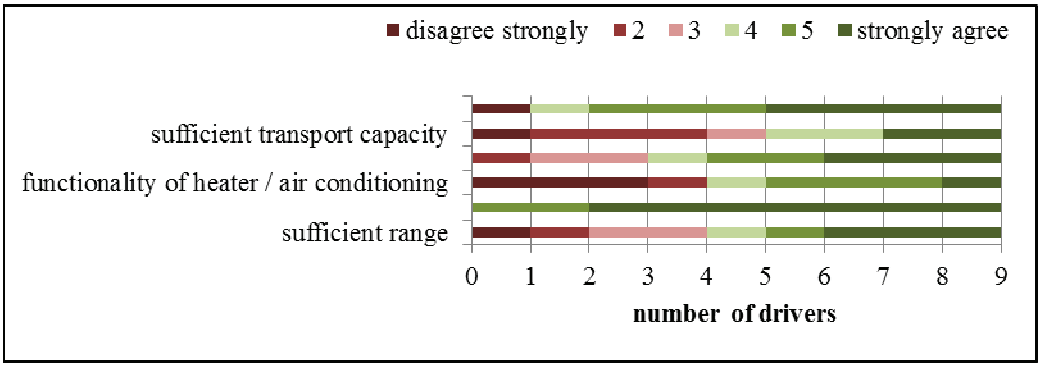

Fig. 3. Drivers’ Feedback

The pilot project also showed that, despite concerns voiced at the beginning of the tests, the currently existing infrastructure did not cause major challenges or obstacles to the use of electric vehicles for urban deliveries: Whereas at the beginning (t_0) shift managers voiced the opinion that a public infrastructure enabling the recharging of the vehicles would be required, later interviews (t_1) where more ambiguous. Public recharging opportunities were only of interest in specific cases, namely:

- should the usual overnight recharging should be forgotten
- during unavoidable longer halts during delivery routes and routes to remote locations
- in places where fast-charging facilities were provided

As far as lorries are concerned their route pattern includes longer distances for deliveries and both shift-managers as well as drivers mentioned the fact that limitation of mileage would result in a limitation of the use of electric vehicles unless recharging facilities were provided. The pilot project reflected therefore, that the strongest challenge from a technical perspective for a move to alternative energy resources results from the distribution pattern of the potential user, i.e. delivery service company.

As far as the **soft factors, aspects related to the general acceptance of stakeholders** are concerned, the results of the research are more complex: All involved drivers and shift managers agreed on the fact that they felt that the reduced emissions, namely noise and exhaust emissions, were an appreciated improvement to the vehicles and especially the **drivers’** reactions were generally very positive and

enthusiastic. As far as the positive impact on emission is concerned, it is to be expected that a change to FEVs for urban deliveries hold the potential of contributing to an emission decrease. According to the survey, CEP services had to stop between 30 and almost 50 times a day on their delivery routes. With emissions of traditional diesel fuelled engines increasing especially during the engine start and during acceleration processes, a considerable effect is to be expected on the overall emissions within a city centre. Only in a few cases the drivers felt that, when driving slowly, electric vehicles were causing so little noise, that pedestrians could overhear them, thus causing a security issue.

Table 2. Shift Managers' Feedback

Shift managers	*Acceptance of FEVs in period t_1*	*Expectations towards changes of regulations*
CEP	• Attitude towards the concept of FEVs very positive over all • „no difference to traditional fuel and diesel powered vehicles“ • Expectation for the future: wider spread use of electric vehicles, additional recharging stations in public areas and intensive use of renewable energy sources for electric vehicles	• Bus lanes should be open to electric vehicles in order to avoid traffic jams • Electric vehicles should have relaxed delivery times for deliveries within pedestrian areas
Meyer & Meyer	• „positively surprised“ • „amazing noise reduction“ • Very appropriate for use in Berlin, but not for entire fleet • Current battery range limits use of electric vehicles • Expectation for the future: FEVs won't fully replace fuel and diesel powered lorries, hybrid technology is an interesting alternative	• Bus lanes should be open to electric vehicles in order to avoid traffic jams • Special ramps for electric vehicles should be introduced at shopping centres and shopping malls • Electric vehicles should have relaxed delivery times for deliveries within pedestrian areas

Generally it is to be said that both, shift managers (see Table 2: Shift Managers' Feedback) as well as drivers, gave a positive feedback in regard to the use of electric vehicle particularly for CEP services and all drivers stated that the FEVs "elate" them. None of them comes to a negative conclusion. Eight of nine drivers agree that driving a FEV is fun. Whereas CEP drivers expect a wider spread use of FEVs in the future though, delivery truck drivers were a bit more hesitant: according to them, hybrid technology is an appropriate propulsion system for delivery trucks. They feel the limited driving range is inhibiting the full replacement of traditional engines by electric engines. Both parties expect that regulations should be amended for electric vehicles: they should be allowed to use bus lanes and relaxed delivery times for pedestrian areas should be implemented for them.

Similarly positive to drivers' and shift managers' reactions was the interviewed neighbors' and customers' feedback: Especially the reduction in emissions – noise as well as exhaust emissions - were appreciated. Their acceptance went to the extent that they were supportive of the idea of battery charging points in public (see Figure 4: Acceptance Of Battery Charging Points In Public Spaces). As interviews and questionnaires revealed, many CEP drivers combine stops for several customers by parking their

vehicle in one location and carrying the parcels by hand to their final destination. As a consequence dedicated centrally located parking bays vehicles could be recharged, at least partly recharges would be feasible, if dedicated parking bays with recharging facilities were available. Therefore customers and neighbors where asked during the interviews, whether they would accept such dedicated parking bays as they might take up currently publicly available parking space.

It is to be said though, that observations in connection with the electric vehicles for CEP services revealed that existing dedicated delivery van parking bays are often not used for various reasons: on one side these bays often require parking in reverse, maneuvers which pose the risk of accidents in the dense inner urban traffic and which, moreover, cost too much time for CEP service drivers. On the other hand these parking bays often are occupied by cars or other unauthorized users. Therefore, despite the fact that these dedicated parking bays may add flexibility to the use of the electric vehicles, as the shift managers pointed out, their practical use is limited due to everyday business. The use of these bays could be enhanced though by enlarging the loading zones to make forward parking easier for CEP drivers and by stricter controls of parking offenders.

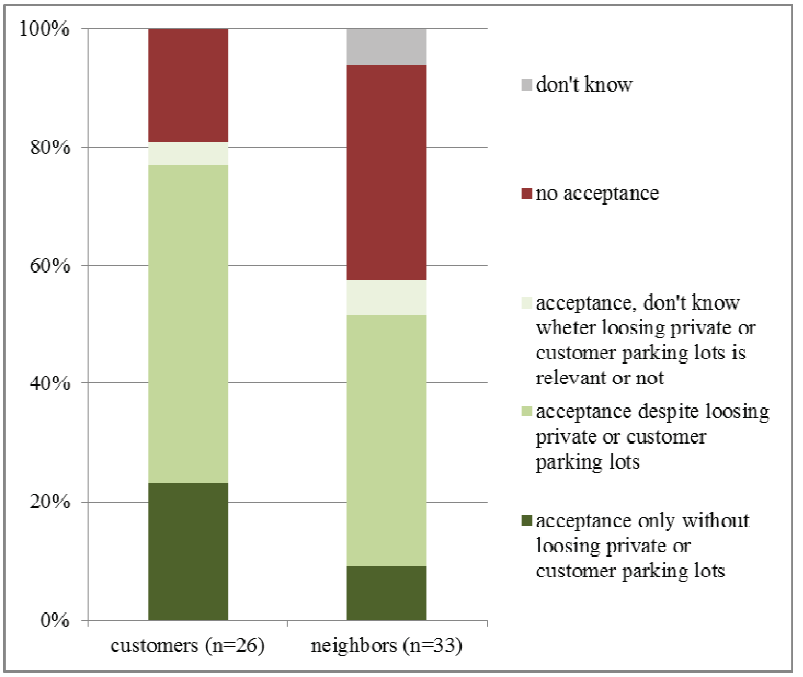

Fig. 4. Acceptance of Battery Charging Points in Public Spaces

All in all it can therefore be summarized, that generally speaking FEVs are a valid alternative to traditional combustion engines for CEP urban services. In regards to lorries and their use for deliveries, actual battery ranges still limit the use of FEVs. Hybrid technology is considered an attractive alternative though. Recharging facilities in public spaces and en route would be welcome by the delivery service providers, in order to add flexibility to the use of FEVs. The current infrastructure did not limit the pilot project though. Most customers would be prepared to power supply stations as long as they don't block the front windows of their shops. Nighttime deliveries are already part of current practice for freight forwarders and CEPs customers would not appreciate them. A relaxation of access to pedestrian areas

would be welcome though.

5. Transferability

The vehicles tested were CEP service vehicles and small lorries, thus being representing a very specific case of inner urban logistics. Companies like those involved in the project are to be found in all urban areas though: freight forwarder and CEP services. The general setting of this pilot suggests therefore that results are transferable to other major urban areas in Germany and western agglomerations as such. It would be important though to bear in mind, that Specific results related to user acceptance and behavior identified in the Berlin project may vary between different locations and have to be analyzed and taken into consideration.

The routing patterns identified in this project of both the CEP services as well as the one of the freight forwarder though are likely to be found in other towns as well. Some companies operate routing patterns which may include further specific characteristics such as e.g. the UPS pattern, which is always set up in a way that it exclusively contains right turns and avoiding any left turn. Despite these details the basic characteristics outlined remain unchanged: relatively short daily distances that need to be covered, frequent halts, sudden changes to the original route due to customer calls coming in on short notice. Furthermore, it can be assumed that also other services with similar traffic structures will profit from the advantages of electric engines to the same extent as the services in Berlin, in particular the reduced noise and exhaust emissions. As a consequence findings of the pilot project in Berlin can be transferred to other delivery companies but also to other services within urban areas. This could be food and beverage delivery services, health care services, facility management services, pharmaceutical and medical transport services, etc. (service-related transport, Hebes et al. 2011).

Despite the limited number of vehicles tested it can be assumed that the validity of the use of electric engines for urban logistic services experienced in Berlin is transferable to other cities.

6. Conclusions and outlook

The period of almost a year over which the pilot project was accompanied gave some valuable insights into the usability of electric vehicles for commercial transportation in cities. The vehicles range is still limited and investments are high compared to traditional vehicles. Despite these aspects, all stakeholders agreed that electric vehicles can contribute to a reduction of noise as well as of local emissions of the last-mile-distribution. Furthermore the trial reflected that even though knowledge of electric vehicles was limited at the beginning of the trial phase, drivers became enthusiastic about the new technology. All in all, user acceptance was very high, which is an important requirement for the successful introduction of electric vehicles. These high levels of user acceptance were complemented by the positive feedback of customers and neighbors who confirmed that they perceived the electric vehicles as a contribution to an improvement of inner-urban transportations systems. As an outcome it can therefore be concluded that this pilot project of FEVs for urban delivery services in Berlin has shown that electric vehicles are an appropriate alternative to traditional combustion engines.

The approach chosen, a systemic analysis based on a qualitative empirical research, which takes into consideration all directly but also indirectly involved stakeholders, is a valid approach for analyzing such a pilot project.

For further investigation it would be interesting and important, to add the following dimensions to the qualitative approach of the current research: On one side it would be useful to add a quantitative analysis. This could be done in the form of further test cases in other cities, with other forms of services or in Berlin with additional vehicles. Generally it is to be said though, that such a quantitative approach would

require a more wide spread use of electric vehicles, preferably FEVs as well as hybrid engines, in the context of commercial services in urban areas. This requirement for a higher number of vehicles at disposition for trials still poses a challenge though. Despite the fact that the first vehicles have entered line production, they are not wide-spread yet.

On the other side, apart from the quantitative analysis, a longer term observation would be of interest as this would allow to gain insights into the usability of electric vehicles for commercial purpose on the long run: e.g. how do they cope with extreme temperatures which can be encountered in Berlin winter periods and how reliable is the functionality of batteries and engines over longer terms.

All in all it can therefore be said that the pilot project is an excellent first step into understanding whether electric vehicles in urban commercial services will find the necessary acceptance of all involved stakeholders so they can contribute to improving the traffic situation in cities.

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