

Yielding a Treasure: A Transition Management Approach to Electric Urban Freight Vehicles in Germany

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Abstract

The market for battery electric freight vehicles is outperforming the market for battery electric passenger cars in Germany, although it has received much less stimulation by policies. This manuscript aggregates the companies' strategies to successfully employ electric freight vehicles; summarizes and compares policy options to further support successful business models; and discusses whether transition management is a suitable approach to consolidate the existing innovation potential in the intrinsically-driven electric urban freight transport market.

Keywords: BEV (battery electric vehicle), Germany, policy, truck, incentive

1 Introduction

Germany aims at becoming an international electric mobility lead supplier and lead market with one million electric vehicles on its roads by 2020 – these are the targets communicated by the German federal government regarding electric mobility. According to the expert council, the German National Platform for Electric Mobility (NPE), Germany is on track in becoming a lead supplier, with about 29 series of electric vehicles offered by the end of 2015 [1]. However, the efforts in establishing a lead market are lagging behind: only half the planned number of electric vehicles will be registered by 2020, in the case where no further actions are taken [1]. The expert panel rates Germany to be rather in the middle field of transforming to a lead market. Other benchmarks confirm this assessment [2, 3].

This imbalance between the different levels of achieving the goals is not surprising, when evaluating the rationale behind the electric mobility targets. The German government acknowledges the contribution of electric vehicles in reducing the traffic's carbon emissions [4]. However, the emphasis in fostering electric mobility is to support the country's car manufacturing industry, as the sector forms one of the most important pillars of the German economy: the automotive industry generates one fourth of Germany's total industrial turnover and one fifth of Germany's exports [4]. An analysis of the electric mobility policies of six jurisdictions reaches a similar conclusion, that Germany's primary focus is industrial policy [5].

According to transition management theory, a shift towards sustainable mobility is a complex transition process, which requires more than a technological change, as reflected in the German car manufacturers' electric vehicle models palette. Further, cultural, regulatory and infrastructure factors need to be adapted or newly established in order to drive the change process [6].

Interestingly, the market for battery electric freight vehicles (FBEVs) has been outperforming the market for electric passenger cars, although it received much less stimulation, compare Figure 1. For example, one out of each 932 vehicles in the class of 2- to 6-ton payload – which corresponds approximately to trucks of 5 to 12 ton gross weight – was an electric truck by January 1st, 2015, while only one out of 2,434 passenger cars had an electric drive-train [7].

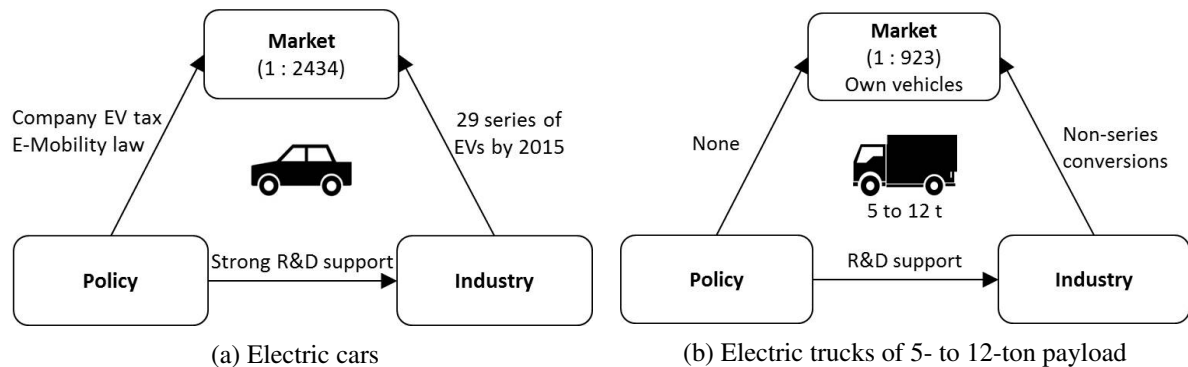


Figure 1: The impact of electric mobility policy on industry and market

However, the attention of the administrative support was mainly directed to higher-priced electric passenger cars, since this is the most important segment in the German car manufacturing industry:

- In order to stimulate the electric passenger car market demand, an electric mobility law was adopted in 2015, which allows municipalities to grant traffic privileges to electric vehicles up to 4.25 tons, such as free parking or the usage of bus lanes. While implementing such privileges is discussed controversially by the municipalities, medium duty (or heavier) FBEVs are excluded from the advantages by law [8].
- In contrast to the strong support for research and demonstration projects for electric passenger cars in electric mobility pilot and showcase regions, research projects on electric urban road freight transport are few and fragmented.
- German car manufacturers have started the series production of 29 electric car models [1], in a market environment with a relatively low demand. At the same time, only a hand full of medium duty truck types are individually converted to electrical versions, in Germany. Due to the missing alternatives, logistics companies who were eagerly interested in the new technology, became importers of FBEVs from China¹, commissioned the conversion of used diesel trucks into electric versions², or even became involved in an own freight BEV development³.

In conclusion, electric urban road freight transport might be a hidden treasure, which has not received much attention yet. The current paper analyzes the case of electric urban road freight transport in Germany in order to answer the questions:

1. Why is urban road freight transport a successful niche for deploying battery electric vehicles (BEVs) and how do freight transporting companies support deploying BEVs?

¹City Express Logistik: DFM

²UPS: P80-E

³DHL: StreetScooter and Schenker: electric trailer

2. Which policy measures are recommendable to further advance the use of electric urban road freight transport?

The two questions aggregate findings from our earlier research as summarized in sections 2 and 3. Based on the results, we discuss in section 4 whether a transition management approach might pose an adequate methodology to yield the hidden treasure of electric mobility in urban road freight transport; and if it could support Germany in reaching the goal of becoming a lead market.

2 Profitability strategies of companies

In order to derive an initial overview on the parameters that influence the adoption and competitions of FBEVs in urban freight transport, our earlier work reviewed use-cases in Germany [9]. The goal was to understand the motivation of companies to utilize FBEVs and to achieve an overview on supportive factors for FBEVs in the companies. A qualitative multi-case study approach was chosen to empirically explore the recent phenomenon of BEV usage for urban freight transport purposes in Germany.

All companies that utilized electric vehicles and electrically supported vehicles – such as electric freight cycles – and that took part in government-funded projects in the period of 2012 to 2013 in Germany were invited to participate in semi-structured interviews whereby fifteen companies participated. An analysis identified four main motivations of deploying electric freight vehicles: in five cases, the main objective of the companies was to test whether the FBEVs can technically replace conventional freight vehicles, while keeping a similar operational pattern. Otherwise, three companies tested new concepts to understand whether an adjustment of the operational profile would lead to a better exploitation of the strength of the BEVs. To five companies, the emission reductions or the image gain in communicating to customers were the most important drivers for deploying FBEVs. Two companies reported that their main motivation was to achieve cost-reductions by utilizing the FBEVs. In all cases, the companies reported that the FBEVs were technically fit to replace conventional vehicles on certain pre-selected daily trips. In summary, the study suggests that the main drivers for deploying FBEVs were the vehicles technical suitability, emission reduction and with it the possibility to advertise the company's green credentials. However, the main barriers reported were the poor model availability and that only in about half of the cases the companies expected the FBEVs to be a financially viable alternative.

For this reason, the study additionally assessed the measures that the companies applied to raise the competitiveness of their FBEVs. The companies carried out several measures that were aimed at increasing the productivity of the FBEVs, by either reducing the total cost of ownership (TCO) or increasing the profit generated by utilizing the FBEVs. In order to validate and enhance the results, a content-analysis of a report on 57 field studies of FBEVs schemes in seven countries of the North Sea Region [10] was carried out. 18 specific profitability measures were identified, which can be classified into three segments as visualized in Figure 2.

Companies that claimed that their BEVs could be operated profitably, combined strategies to i. reduce the investment into the vehicles and supplies, ii. to increase the utilization of the vehicles and iii. aimed to raise the revenue of deploying the vehicles by gaining more customers, or by exploring new business models and generating a different customer group.

The majority of the identified profitability measures (14 of 18) were implemented by FBEV-utilizing companies themselves. The most important measure when purchasing a FBEV, was to replace conventional vehicles by small and hence lower-priced electric vehicles. Examples are electric quads or battery-electrically supported cargo cycles (SubEVs, 32%). Some companies started to equip their BEVs or charging stations with solar roofs, in order to reduce the dependence from external energy suppliers and charging infrastructure (Solar roof, 5%). Communication of the environmental advantages of the emission-free delivery was the most important measure in acquiring or maintaining customers (Communication, 61%). Once a specific FBEV was purchased, the companies aimed to extend the mileage of the

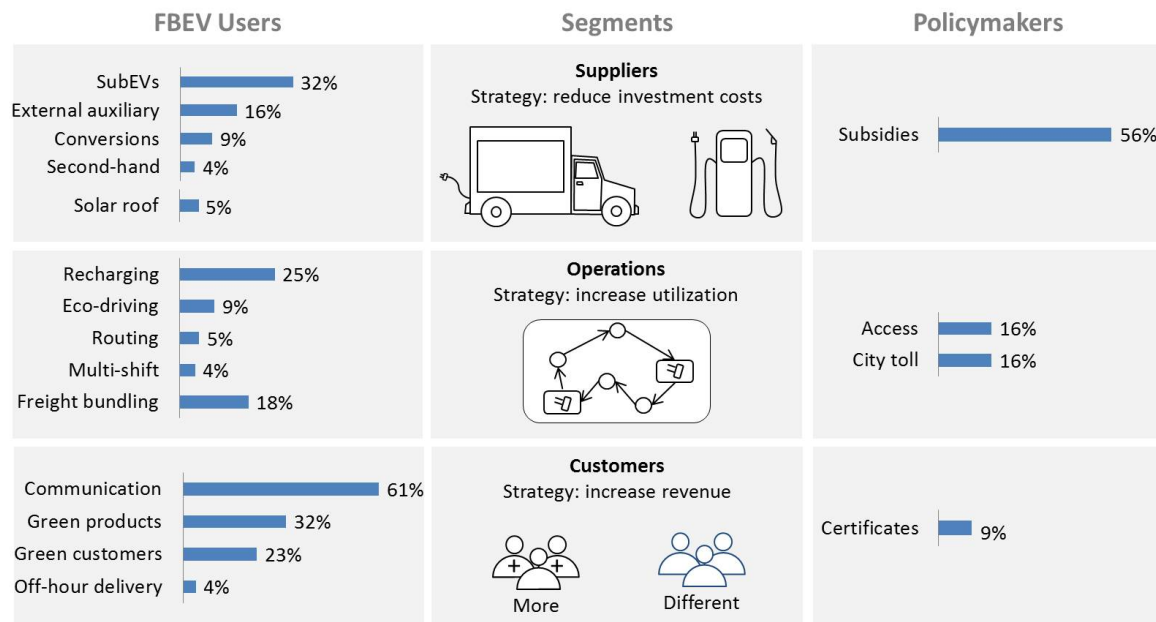


Figure 2: Identified profitability measures in 57 North-European field studies (2013)

FBEVs, in order to increase the productivity of their FEBVs. To reach this aim, the companies most often recharged the vehicles in-between the trips (Recharging, 25%). Due to the BEVs' lower operational costs compared to diesel vehicles during the phase of high fuel prices in the past years, the literature generally suggests to increase the mileage of FBEVs, in order to compensate the higher purchase costs [11, 12, 13]. Figure 2 indicates that first companies applied intermediate recharging to deploy FBEVs in multi-shifts (Multi-shift, 4%), leading to the operation in a combined day and off-hours delivery (Off-hours, 4%).

The companies reported on only four policy measures that supported the adoption of their FBEVs. Financial subsidies, in the form of tax reductions or purchase price subsidies, were utilized by over half of the companies, including German companies. Apart from financial subsidies, three further policy measures were named, but those only were available to a few companies outside of Germany. Although it is possible that not every policy measure was mentioned by the companies, this analysis shows the lack of political support for FBEVs, considering the ambitious goals of the European Commission to achieve a virtually emission-free city-logistics by the year 2030 [14] and the importance of the urban freight transportation segment for the local air quality [9]. A literature review revealed that an overview on and rating of policy measures that support the adoption of electric urban freight vehicles was lacking. Hence, the next section pursues to answer the question of which policy measures are available and suitable to support the adoption of FBEVs in Germany.

3 Policy options to support electric freight vehicles in Germany

Fiscal measures are often suggested in the literature as the key to overcome the total cost of ownership gap of FBEVs. The only policy measure to support FBEVs implemented in Germany, at the beginning of the study in mid-2014, was to exempt electric vehicles from the annual vehicle tax – a symbolic but negligible financial subsidy. In order to derive recommendable policy options, two analyses were carried out. Firstly, we generated an overview on possible supportive FBEVs policy options, including fiscal and non-fiscal measures, and invited two stakeholder groups to rate the measures. Secondly, we researched how the TCOs of FBEVs develop, when applying the companies' measure to recharge the vehicles in-between trips, in order to extend the vehicles' utilization. The study gives interesting answers to the question which fiscal policy options are recommendable in order to increase the utilization of FBEVs.

3.1 Rating of freight BEV policy options

Possible policy options were collected by reviewing scientific and gray literature on policy measures, and analyzing implemented policy options in Europe [15]. The detected policy options were clustered according to the scheme of Hood and Margetts [16] into the categories “fiscal”, “legal”, “communication” and “organization”. Subsequently, 18 German experts of two stakeholder groups (policymakers and freight BEV users) rated several criteria regarding the measures in an Online-survey. The results were evaluated through statistical analyses, and the discordance between the ranked results between the groups was analyzed. An excerpt of the results is depicted in Figure 3, Table 1 briefly explains the utilized abbreviations.

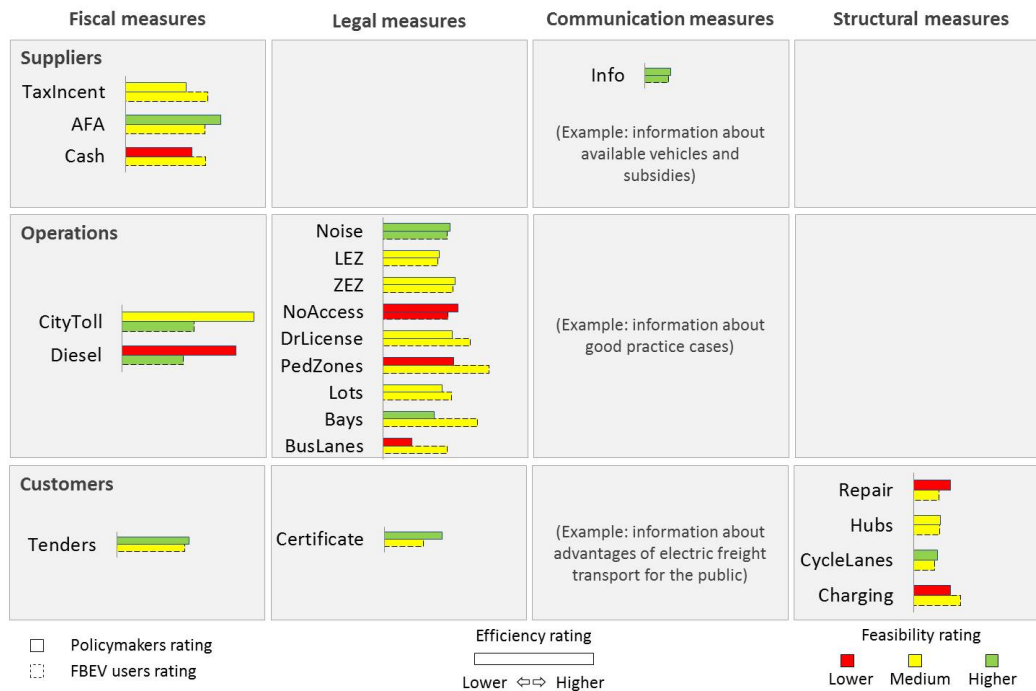


Figure 3: Rating of the efficiency and feasibility of policy options by two stakeholder groups

Figure 3 shows that both policymakers and freight BEV users on average rate fiscal and legal measures to be more efficient than communication or organizational measures. However, compared to FBEV users, policymakers underestimate the efficiency of legal measures, such as access permissions. Especially, the analysis of differences in the ranking of measures holds valuable insights: as a measure-related example, the policymakers rank the policy option to abolish the current diesel fuel subsidy of €0.219 to not be socially feasible, while FBEV users rank the measure as one of the most feasible options (although they dislike this measure the most, when being asked directly). This example highlights the complexity of the matter, and shows that it is important to rate policy options with independent criteria and by different stakeholder groups.

The study suggests that recommendable policy measures supporting FBEVs differ from general electric mobility policy recommendations, since these often aim at supporting electric mobility in passenger transportation. As an example, the policymakers ranked the effectiveness to offer free and/or privileged parking lots higher than to offer privileged loading bays, in order to support FBEVs. This estimation was opposite to the rating of the FBEV users, who ranked the loading zones as a more appropriate policy option to support freight EVs. Hence, a clear distinction between the requirements of the different transport segments is essential for choosing suitable measures.

Abbreviation	Explanation
<i>Communication measures</i>	
Info	Virtual or physical information on FBEVs, costs, subsidies and advantages
<i>Legal measures</i>	
Access	Access privileges to areas restricted to heavy trucks above 7.5 tons
Bays	Allow FBEVs to use privileged loading zones in inner city areas
BusLanes	Allow FBEVs to drive on bus lanes
Certificate	Certify transport companies with ecological fleets
DrLicense	Allow FBEV drivers with class B license to transport a payload comparable to conventional 3.5 ton diesel vehicles.
LEZ	Low emission zone for freight vehicles of 3.5 tons and above
Lots	Free and/or privileged parking for emission-free vehicles
Noise	Access privileges for BEVs into low noise zones or at nighttime
PedZones	Entry into pedestrian zones for emission-free with city logistics approach
ZEZ	Access privileges for emission-free vehicles into zero emission zones
<i>Fiscal measures</i>	
AFA	50% fiscal depreciation in year of purchase
Cash	Purchase price subsidy
CityToll	FBEV exemption from city toll
Diesel	Abolish subvention of diesel €0.219
TaxIncent	Company tax incentive of €100 per kWh (up to 20 kWh per vehicle)
Tenders	Demand freight EVs in tenders requiring goods transport
<i>Organizational measures</i>	
Charging	Setup of charging infrastructure on company compounds
CycleLanes	Cycle infrastructure improvement, facilitating freight transport with cargo cycles
Hubs	Space for micro-consolidation centers for freight EVs to operate in the near range and recharge the battery during loading of freight
Repair	Support the setup of BEV repair and service workshops

Table 1: Excerpt of identified measures

Further, the study suggests that the municipalities' goal of implementing emission-free transportation policies should drive the choice of the measures: Is it desired to achieve high emission savings (environmental goal – choose effective measures)? Should the most efficient measures be chosen (budget-driven decisions – choose efficient measures)? Are other stakeholder groups strong and do they need to be considered (choose socially feasible measures)? Should the policy be implemented as soon as possible (choose short-term measures), or rather pave the way for a more sustainable future (choose structural measures that often need a longer planning horizon)? Depending on the answers to these questions, different measures are recommendable.

3.2 Fiscal support of purchase vs. operation of FBEVs

Figure 2 indicates that the policy measures available to most FBEVs users were fiscal subsidies, which reduced the purchase price of the vehicles (compare Figure). In the Netherlands, for example, BEV-buyers can claim an “environmental allowance” of 36% of the purchase price, limited at a maximum of €50,000 when purchasing an BEV [17]. Purchase price subsidies of €3,000 are currently discussed for commercially used EVs in the beginning of the year 2016 in Germany, in order to overcome the slow market-uptake of EVs. At the same time, Figure 2 indicates that freight transporting companies aimed to increase the utilization of FBEVs, in order to benefit from the comparably lower operational costs of the vehicles and to decrease the TCO gap. TCO calculations in the literature also suggest to increase the mileage of freight EVs in order to compensate the higher purchase costs [11, 12, 13]; although the authors mention that the more frequent battery replacements, which become necessary when increasing the utilization, can impair the cost advantages. Furthermore, the operation of conventional vehicles has become increasingly attractive in the past year, due to the attenuation of the oil and hence fuel prices.

This leads to the question of how the current diesel price development and the potential subsidies impact the total cost of ownership of EVs, when they are operated at higher average daily mileages.

To answer this question, we developed a calculation model that takes into account the implications of battery degradation and battery replacement at high mileages [18]. The TCOs of three medium duty FBEVs of 5.5 tons, 7.5 tons and 12 tons were calculated and compared to the TCO of a comparable conventional vehicle, utilizing a numerical simulation approach. The fuel price projection of the baseline scenario is based on the International Energy Agency (IEA) World Energy Outlook 2012 that is similar to that utilized by Brokate and colleagues [19]. The results suggest that none of the vehicles are more competitive than the conventional diesel vehicles, even though increasing the mileage leads to a reduction of the cost gap for two of the three vehicles.

The aforementioned subsidy of €3,000 would additionally slightly reduce the gap, if no other parameters changed. However, when recalculating the TCO of the vehicles by including a €3,000 subsidy and applying a recent diesel price of €0.95 (€0.80 excluding VAT/GST, March 2016), all three FBEVs become more expensive with an increasing utilization. Figure 4 depicts the changes in the cost-developments between the baseline scenario, and the scenario utilizing the current diesel price including the potential €3,000 subsidy for the 12-ton vehicle. Despite the subsidy, the lower diesel price leads to a larger cost gap in the TCO calculation at any mileage in the current diesel price scenario. At higher mileages, the cost differences increase further.

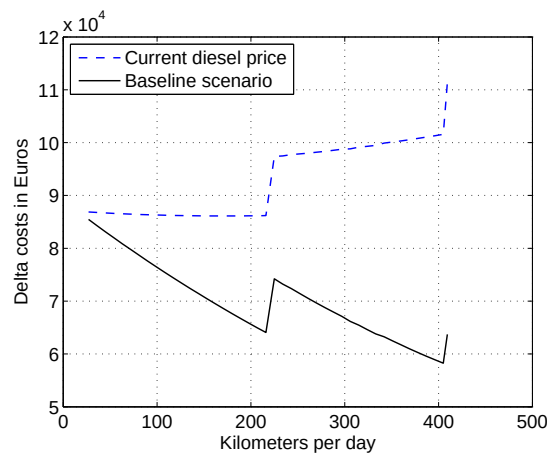


Figure 4: TCO development for different scenarios

The sensitivity analysis in our study [18] suggests that the slope of the curve in Figure 4 is most sensitive to the diesel consumption and diesel price of the compared conventional vehicle. Further important factors are the energy consumption of the FBEV and the energy price, and to a smaller extent the purchase price and warranty of the FBEV's battery.

This analysis shows that only a high purchase price subsidy would significantly reduce the costs gap between medium duty FBEVs and comparable conventional vehicles. However, if the current diesel price prevails, all three in [18] exemplarily calculated medium duty FBEVs would become less competitive the more they are utilized. Increasing the per-kilometer costs of the conventional vehicle is the most effective leverage to reduce the comparable operational costs of FBEVs and hence increase the competitiveness of FBEVs. Possible fiscal options are, i.e. to waive the tax advantages of nearly €0.22 for diesel fuel at filling stations, or to implement a city toll for conventional freight vehicles. At the same time, the per-kilometer costs of FBEVs could be reduced by subsidizing proprietary (fast-) charging infrastructure, or reducing tax and environmental charges for the energy to recharge FBEVs. This study suggests that these fiscal options are an important leverage for fostering electric mobility in urban freight transport for larger electric vehicles. Eventually, the advantages of emission-free FBEVs with respect to the local air

quality and noise emissions are increasing, the more diesel-driven kilometers are replaced by FBEVs.

4 Discussion

We utilize a transition management approach to analyze the electric mobility-related actions taken in Germany. The aim is to embed our findings into an overall methodology and discuss whether transition management could pose an adequate methodology to yield the hidden treasure of electric mobility in urban road freight transport. The transition management method is applied for example in the Netherlands, in order to manage complex transition processes, such as towards sustainable mobility [20]. The transition management scheme was suggested to guide innovations that emerge in niches on the micro level; broaden technology-centered policies on the meso level and unite the fragmented support by an overarching vision on the macro level [21, 22].

Today's electric vehicles are technically adequate for certain applications in urban freight transport, since the tour planning and fleet mix of companies allows choosing suitable trips [9, 23, 24, 25]. In section 1, we highlighted that relative to the numbers of vehicles, twice more EVs are registered among freight vehicles than among passenger vehicles. In section 2, we reported that FBEV users are intrinsically motivated to use EVs, either by the prospect of short-term or future cost reductions; the desire to reduce the negative impact of freight transport on the environment; or the option to utilize their sustainable transportation as a differentiation criteria in the communication towards their customers. Hence, a "bottom-up" movement can be observed on the micro level for electric mobility in urban freight transport. This presents a prerequisite for applying a transition management scheme.

On the macro level, the transition management approach suggests to establish an overarching, long-term vision. On a European level, the European Commission has defined two goals for the transport in urban centers by 2030: "*Halve the use of 'conventionally-fuelled' cars in urban transport by 2030*" in passenger transport; and "*achieve essentially CO₂-free city logistics in major urban centres by 2030*" in freight transport [14]. These goals aim at a reduction of the traffic's greenhouse gas and other emissions. On a national level, the German federal government has formulated two goals which are highly present in the media: to have one million electric vehicles on the roads by the year 2020 [1] and to reduce the greenhouse gas emissions by 40% until 2020, compared to the 1990 levels [26]. These goals lead to a focus on the passenger transport sector: in order to replace larger quantities of vehicles and to reduce greenhouse gas emissions, the passenger car market is the most important leverage: passenger cars make 83% of the licensed vehicle stock [7] and emit, as an example, 77% of the traffic's greenhouse gas emissions in Germany's second largest city, Hamburg [27]. At the same time, heavy duty vehicles over 3.5 tons are responsible for 45% of the traffic's nitrogen oxide (NO_x) emissions in Hamburg [28] and considerably contribute to other air pollutants such as particulate matter, as well as noise [29]. Nevertheless, a national vision for the development of the (urban) freight transport is not broadly communicated. Despite the lack of a national vision, cities are increasingly focusing the freight transport segment on air quality and noise action plans. However, fostering electric mobility in urban freight transport is often not yet a major focus in these plans, and existing attempts are fragmented.

With existing prerequisites on the micro level and an implemented vision on the macro level, the transition management approach suggests to subsequently take action on the conceptual level – the meso level: to develop sustainable policies and practices, by bringing together experts and stakeholders to form networks and to implement experiments. After the completion of a so-called 'transition-round', the achieved results are evaluated and the long-term goals and the next steps are adjusted. According to the transition management theory described in [20], several transition-rounds are necessary and four development phases can be identified as i. pre-development; ii. take-off; iii. acceleration and iv. stabilization. The barriers encountered when implementing a sustainable innovation may change over the phases, hence an identification of the phases is important [20].

A review of the German practice shows that the German government is following a similar strategy. A network of industrial players, scientific experts, political decision makers and NGOs was established and several umbrella schemes to support experiments were implemented, i.e. in the electric mobility pilot and showcase regions. The schemes facilitate the exchange between the experiments and a group of experts, the National Platform for Electric Mobility, which is evaluating the advances in reports and counseling the German government. According to their latest report, Germany already completed the first market preparation phase in 2014 and entered the market uptake phase, lasting until 2017, and is followed by a mass market phase [1]. The phases correspond to the aforementioned phases i. to iii. of the transition management model. While the market preparation phase was mainly characterized by investments of €1.5 billion into development and pilot projects [30], the current phase sees the adoption of the electric mobility law for electric passenger cars and light commercial vehicles, as well as a debate on purchase price subsidies to support the market launch. Results from electric freight mobility are thematically discussed within commercial transportation groups and tracks. Commercial transportation comprises both segments, commercial passenger and commercial freight transportation

However, companies that desire to deploy FBEVs are facing technological, regulatory, or infrastructure barriers that suggest that the developments and the support for electric mobility in commercial freight transport is lagging behind the commercial passenger transportation segment. As examples, the FBEV-model variety is very limited compared to passenger EVs, and only expensive non-series vehicles are available (technological barrier); in Germany, freight EVs above 4.25 tons are excluded from the electric mobility law [8], that foresees a labeling of EVs as a legal basis to grant privileges (regulatory barrier); while the build-up of a public charging infrastructure is often named as the most important enabler to support electric passenger mobility, supporting a (fast-) charging infrastructure at companies has received far less attention; and wide cycle lanes that allow a feasible operation of bulky and fast cargo cycles are scarce (infrastructure barrier). Such factors often obstruct new sustainable technologies, and were an initial reason for suggesting a transition management approach in the Netherlands [31]. The results presented in this study highlight the importance of clearly separating the segments of commercial freight and commercial passenger transport, since prerequisites, requirements and barriers differ.

The current study contributes to the body of literature by applying the transition management approach to the electric urban freight transport segment in Germany. We conclude that transition management is a viable method to analyze the current development phase of electric freight mobility. The method provides a suitable approach to consolidate the existing innovation potential in the intrinsically-driven freight transport market by suggesting the creation of a common vision for a sustainable urban freight transportation on the macro level. This would offer a guideline to the existing fragmented efforts and locally initiated projects. A best practice of bundling local efforts in a concept is provided by the Netherlands. Here, 8 larger and 18 smaller municipalities have signed a so-called “Zero Emission Urban Logistics Green Deal” with interest groups, freight companies and the federal ministry, to maximize emission-free urban freight transportation in their municipalities until 2020 [17]. Furthermore, this study suggests that electric urban freight mobility is in a different development stage than commercial passenger transportation. Hence, the financial subsidies discussed to support the uptake of electric passenger transportation are only one policy option that is required for supporting the electric freight transport segment. While fiscal incentives in the form of purchase price subsidies certainly are highly welcomed by companies, this study shows that it is important to simultaneously improve the ratio of the per-kilometer cost benefits of electric vehicles compared to diesel vehicles, in order to not only subsidize the purchase, but also support the operation of FBEVs. Especially, the effect of legal policy measures to support FBEVs are underestimated by policymakers. Extending the German electric mobility law to freight vehicles and implementing local privileges for FBEVs are valuable instruments to support and enhance the existing innovation potential of freight transporting companies. Structural measures, such as proprietary company charging infrastructure and cycle lanes that are suitable for cargo cycles would further support the adoption of electric mobility in urban transport.

Despite the advantages of electric mobility for the urban air quality and noise emissions, the support of electric freight mobility has a limitation: the number of freight vehicles is relatively small compared to the numbers of passenger cars. Supporting the adoption of electric mobility would only make a small contribution in the electric vehicle statistics, even if a larger percentage of freight vehicles would have an electric drive train. A further diminishing factor on the statistics is that transporters might be replaced by even more sustainable cargo cycles. Hence, supporting FBEVs would only have a minor impact on the German target to achieve a market leadership with one million EVs on the road by 2020. In formulating a vision for a sustainable freight transport segment, this disadvantage might be avoided.

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