Optimising the acceptance of electric vehicles for urban logistics with evidence from France and Germany

Verena Ehrler, Pierre Camilleri

Recherche Transports Sécurité

ARTICLE ORIGINAL / *ORIGINAL ARTICLE*

OPEN ACCESS

DOSSIER / ISSUE

Pratiques logistiques et enjeux du transport de marchandises : une comparaison franco-allemande

Logistics practices and freight transport challenges: a French-German comparison

Optimising the acceptance of electric vehicles for urban logistics with evidence from France and Germany

Optimiser l'acceptation des véhicules électriques dans le domaine de la logistique urbaine : une comparaison franco-allemande sur la base de projets pilotes

Verena Ehrler, Pierre Camilleri

Summary So far, electric vehicles have not become a wide-spread alternative for the long-time dominating diesel vehicles in urban logistics. If this is to be changed, it is important to identify logistics applications for electric vehicles which are not geographically limited, to understand what improves user acceptance and how to measure the attractiveness of electric vehicles for users. The aim of this research is to contribute to answering these questions, based on evidence from France and Germany. For this purpose, findings from empirical research carried out in the form of pilot studies and surveys in Germany is analysed as the basis for the identification of user acceptance.

By means of a basic model data from research in France is analysed, in order to identify, in how far incentives, technical and market developments contribute to an improved attractiveness and hence spread of electromobility for urban logistics. Findings from the German pilots and the French data are combined and compared. In a comparative analysis it is discussed whether the thesis can be confirmed, that electromobility is or will be a valid alternative for urban logistics in general.

Keywords urban logistics, electric vehicles, freight transport, comparison France-Germany

Verena Ehrler (auteur référent) (✉)
German Aerospace Center (DLR)
Institute of Transport Research
Rudower Chaussee 7
12489 Berlin, Allemagne
&
Univ Gustave Eiffel, IFSTTAR, Univ Lille,
F-59650 Villeneuve d'Ascq, France
verena.ehrler@dlr.de

Pierre Camilleri (✉)
camilleri_pierre@hotmail.fr

Résumé Jusqu'à présent, les véhicules électriques ne sont pas devenus une alternative largement répandue aux véhicules diesel qui dominent depuis longtemps la logistique urbaine. Pour faciliter un changement rapide vers les véhicules électriques, il est important d'identifier les applications logistiques qui ne sont pas limitées géographiquement, de comprendre les aspects qui améliorent l'acceptation, et de mesurer les avantages des véhicules électriques pour leurs utilisateurs. L'objectif de cette recherche est de contribuer à des réponses à ces questions, en se basant sur des projets réalisés en France et en Allemagne.

Dans la recherche présentée, les résultats des études pilotes et d'enquêtes en Allemagne sont analysés comme base pour l'identification de l'acceptation par les utilisateurs. Au moyen d'un modèle de base, des données issues d'une enquête en France sont analysées, afin d'identifier dans quelle mesure les incitations, les développements techniques et commerciaux contribuent à améliorer l'attractivité et donc la diffusion de l'électromobilité pour la logistique urbaine. Les résultats des projets pilotes allemands et des données françaises sont combinés et comparés. Dans une analyse comparative, il est discuté si la thèse peut être confirmée, que l'électromobilité est ou sera une alternative valable pour la logistique urbaine en général.

Mots-clés logistique urbaine, véhicules électriques, transport de marchandises, comparaison franco-allemande

The megatrend of urbanisation is reflected in an augmenting population density in urban areas. As a consequence, urban logistics become more and more complex and dense as road space available in these urban areas is limited, often shrinking due to more parked vehicles. With more people living on the same space, requiring more movements of goods, services and refusals, emissions of urban logistics are an ever more pressing issue that needs to be addressed to avoid suffocation of city centres, as statistics of air quality data show (WHO 2016).

Reçu le 27/06/2017 accepté le 17/02/2021 en ligne 22/09/2021
https://doi.org/10.25578/RTS_ISSN1951-6614_2021-09

Electric vehicles for urban logistics are therefore considered as an alternative which might contribute to a reduction of local emissions, thus limiting the impact of the augmenting urban commercial transport on air quality. Electric vehicles for urban logistics are not new though, they have been used before. First electric vehicles were already built during the first half of the 18th century. In London as well as in New York, electric taxis were used by the turn of the century. One of the most prominent uses of electric vehicles for urban commercial transport, and in particular urban deliveries, is the milk float, operated in the United Kingdom. These vehicles, equipped with batteries (BEV) were wide spread and the biggest group of electric delivery vehicles until their replacement by combustion engines began in the 1980s. It is not possible to give an encompassing list of electric vehicles used for urban logistics in the past, as there are too many examples.

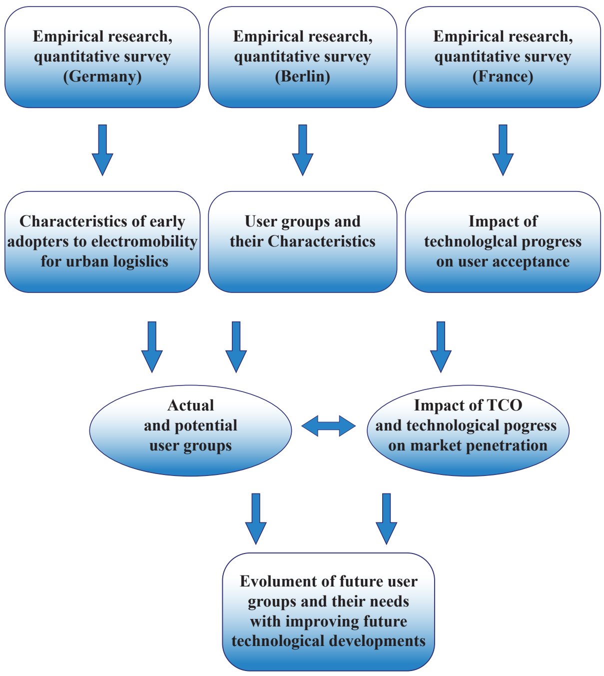
Fact is though, that electric engines for vehicles could not find sufficient spread and were replaced by combustion engines. The last decade has witnessed a significant increase of interest in electric vehicles though, which manifests itself through a strong support by governments and councils, and for the first time their use is accompanied by research in order to systematically evaluate their impact. Concomitantly, major car manufacturing companies have shown an active involvement in the electric vehicle markets.

So far, electric vehicles are used in local, geographically limited logistics. The number of vehicles produced for these applications is rather small and it is difficult for OEMs to reach attractive economies of scale. Therefore, electric vehicles have not become a wide-spread alternative for the long-time dominating diesel vehicles in urban logistics. If this is to be changed, it is important to identify logistics applications for electric vehicles which are not geographically limited, to understand what improves user acceptance and how to measure the attractiveness of electric vehicles for users. The aim of this research is to contribute to answering these questions. For this purpose, findings from empirical research carried out in the form of pilot studies and surveys in Germany is analysed as the basis for the identification of user acceptance. Furthermore, by means of a basic model it is analysed in how far incentives, technical and market developments contribute to an improved attractiveness and hence spread of electromobility for urban logistics. Based on these analyses, it is discussed whether subsequently the thesis can be confirmed, that electromobility is or will be a valid alternative for urban logistics in general.

1. Methodology and Structure of Paper

In the following, findings from pilot projects [1] carried out in Berlin in 2015 and 2016 within the project framework "Schaufenster Elektromobilität" ("electromobility window") are described. Within these pilot project logistics providers from the parcel delivery and courier industry (Hermes Logistics, DHL and messenger) as well as a logistics provider to a wholesaler for electric goods (Obeta) were accompanied and analysed whilst using electric vehicles instead of combustion engines in parts of their fleet. Structured expert interviews were held with drivers, disposition as well as decision makers before and after the introduction of the electric vehicles. This approach allowed to gain insights into user expectations, into perceived advantages and obstacles and subsequently into the users' acceptance. Furthermore, two quantitative surveys were carried out during which user expectations and experiences were captured. The first, "Pakt II", provided data for the analysis of 1165 users of electromobility for commercial transport in Germany. The survey was carried out between 2014 and 2015 as an online survey and focused on so-called "early adopters", early users of the (re)introduced electromobility. The second survey, which was part of the "Smart e-User"-project, focused on the identification of user groups and their characteristic within the user community of electric vehicles for commercial transport in Berlin and its agglomeration. Over 340 businesses were contacted out of which over 120 agreed to participate in the survey. 56 of these contacts answered to the questionnaire, supplying information on their fleet structure, ownership of vehicles, touring development behaviour, touring patterns, including e.g. average route length, longest route, average number and length of stops, shift patterns as well as user expectation towards electric vehicles. The paper analyses by means of a model how changes to the characteristics of vehicles, taking the findings of these surveys and further 20 empirical research in France into account. It is reflected in particular, how battery capacity and purchase incentives impact total costs of ownership (TCO) and the attractiveness of electric vehicles for potential users.

These data and insights allow to describe the potential user groups of electric vehicles for urban logistics and the motivational aspects that can lead to an optimised acceptance of electric vehicles for urban logistics. As the analysis were carried out in a comparable format in Germany and in France, the paper discusses in how far the thesis can be confirmed, that electromobility is or will be a valid alternative for urban logistics in general. The paper closes with a summary of the findings. The logical structure of the paper therefore is presented as follows:



1. The projects referred to are the projects „Smart e-User – concept for electromobility for urban logistics" and "DISLOG Electric vehicles for efficient urban distribution logistics"; for further details: http://www.emoberlin.de/de/schaufenster/projekte/gueterverkehr/ or to www.dlr.de/vf

2. Findings from pilots and surveys

2.1. Early adopters of electromobility for commercial transport

Analysis of early users of electric vehicles for urban commercial transport has shown that it is mainly the purpose of a trip that characterizes this group, rather than the fact that the organisations belongs to a specific commercial sector. Especially organisations which need their vehicles for service trips (assembly and repair) are to be found within this group of early adopters (see Figure 1).

When it comes to reasons what motivates these organisations to try the use of electric vehicles within their fleet in such an early state of the market development, it is primarily the avoidance of emissions which users mentioned. Furthermore, it is worth mentioning that the early users of electromobility which participated in the survey were content with their experience even if their electric vehicles were not technically able to meet all their daily requirements. So user satisfaction could be reached even if distances which needed to be covered were beyond the range of the electric vehicles which made it necessary for the users to keep the electric vehicle as additional vehicle in their fleet, so they could use conventional combustion engines when longer distances needed to be travelled, or they had to adjust tours or routing to the range of their electric vehicles (Frenzel et *al.* 2015; SEU 2016).

Figure 1. Early adopters of electromobility for commercial transport

Variable	Standard users	Heavy users	Small distance users	Green sport car users
Trip purpose	Services (assembly, repair), other services	Services (assembly, repair), other services, transportation of materials	Services (assembly, repair), other services	Services (assembly, repair), other services
Range of daily trip length	30-60 km	70-130 km	10-40 km	25-120 km
Deployable radius	< 50 km	/	/	/
Vehicle types	Cars, light duty vehicles up to 3.5t gross-vehicle weight	Cars, light duty vehicles up to 3.5t gross-vehicle weight	light city vehicles, cars, light duty vehicles up to 3.5t gross-vehicle weight	cars
Vehicle power (only to separate sport and luxury cars)	/	/	/	> 200 PS (147KW)

(Source: Frenzel et *al.* 2015)

These findings were confirmed within the pilot projects, where expert interviews were held with drivers, decision makers and disposition staff: ranges and loading capacity of vehicles available in the market at the time of the projects (2014 to 2016) were insufficient for covering the users' needs, both courier and parcel deliverers as well as the logistics provider to the electric wholesaler, yet there was willingness to adjust to the limitations of the vehicles and particularly drivers and decision makers described the day-to-day use of electric vehicles as a positive experience due to the limited emissions. These limited emissions were perceived as positive for the image of the logistics provider toward third parties. They were also perceived a relief and improvement for the workplace of the drivers though, as mainly noise emissions but also fumes of diesel engines add to the stress experienced by delivery drivers. Supporting ICT was mentioned by all involved partners as a needed and desirable support in planning and optimizing routings, both for static touring as well as for ad-hoc routing.

Generally, the aspects of user acceptance from early users of electromobility can be categorized into two classes, which, based on the Herzberg's two factor-theory, can be described as follows: hygiene factors – factors which need to be fulfilled by electric vehicles in the future in order to find a wider-spread use and acceptance of electric vehicles for urban logistics – and motivators – characteristics of electric vehicles which are perceived as an additional incentive for shifting from combustion engines to electromobility. The requirements for a wider spread of electromobility for urban deliveries, based on the pilots and surveys of early adopters, can therefore be summarized as follows:

Table 1. Hygiene factors and motivators for the use of electric vehicles for urban logistics

Hygiene factors	Motivator
Electric vehicles for urban deliveries need to offer sufficient loading capacity for the purpose of their usage	Well-to-wheel emissions for electric vehicles are below levels for vehicles with combustion engine
Total cost of ownership (TCO) for electric vehicles needs to be at the same level or below as for combustion vehicles with the same loading capacity	Stress reduction and relaxed atmosphere experienced by drivers of electric vehicles due to reduced noise emissions and driving characteristics
Ease-of-use of handling of vehicles	Automatic gearbox
Ease-of-use of charging of vehicles	Low emission levels – fumes and noises
Comfort of electric vehicles is comparable to those of combustion engine equipped vehicles (this refers in particular to heating, ventilation and air conditioning)	"Green" image of electric vehicles
Range of battery corresponds to range requirements in daily use of vehicle	Being ahead of anticipated future restrictions for vehicles, e.g. expected and now realised restrictions for diesel powered vehicles in urban areas

3. Electric vehicles for urban logistics - actual and potential user groups

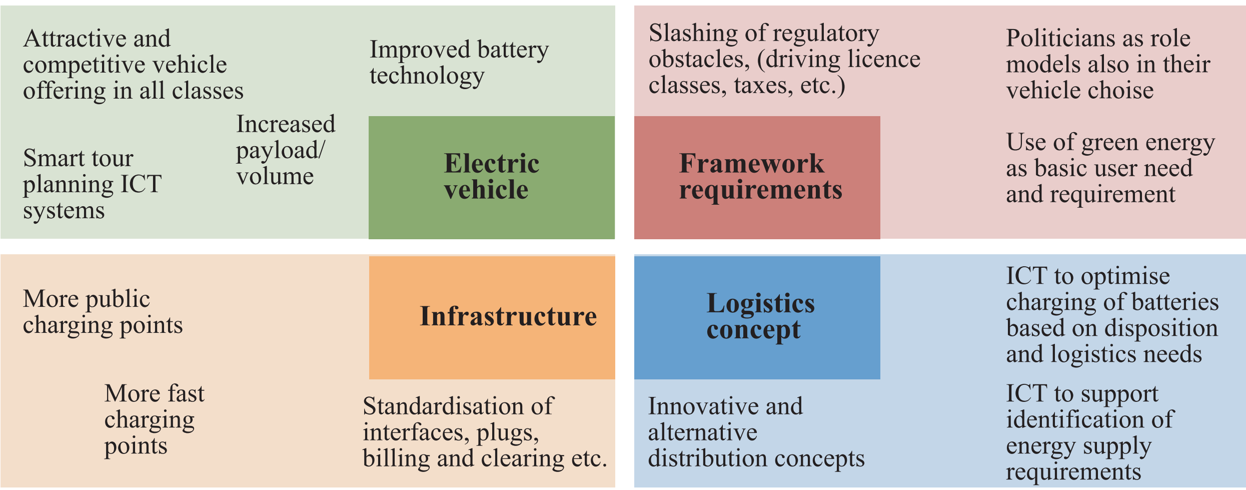
The surveys and pilot projects carried out within the electromobility project-frame "Schaufenster Electromobilität" have confirmed the relevance of reduction of emissions as decision driving factor for early users of electromobility. Beyond these motivational aspects, the projects served as a basis for identification of characteristics of user groups which, given the actual offering of electric vehicles in the markets, are most adapted for an instant shift to electromobility. Typically, urban logistics providers with the following qualities are particularly suitable for such a shift (SEU 2016):

– Range: the maximum length of tours should not exceed 100km, to ensure that battery capacity is sufficient, regardless of actual weather conditions
– Routing, tours and holding times: It is important that breaks and holding times within the tours of the vehicles are long enough to provide for sufficient time for charging the batteries
– Planning of routings: in particular static routings are suitable for the use of electric vehicles, with limited exposure to seasonal variations.
– Loading capacity: requirements toward loading capacity should be in line with the current vehicle offering, taking into consideration that the batteries still contribute significantly to the weight of the vehicles.

Particularly parcel delivery, urban couriers, and service providers meet these characteristics favourable for a swift shift to electromobility. This affinity and suitability is further confirmed by the following consideration of TCOs. The following analysis also confirms the importance of the offering of vehicles in the market and its impact on the spread of electromobility for urban logistics, as the current range on offer is resulting in financial and technical limitations to an augmented market penetration.

Beyond these findings, the surveys held and data analysed showed, that electromobility is more than the exchange of a propulsion technology. Shifting urban logistics to electric vehicles requires developments in the area of infrastructure (charging points, public and private; standardization of interfaces, plugs, billing and clearing systems), logistics concepts which are adjusted to the specific requirements of longer "re-fuelling", i.e. charging times, as well as regulatory and energy providers related framework developments (see Figure 2). All these areas need to be developed jointly, in a systemic approach, with the involvement of all stakeholders, including OEMs, decision makers, drivers and municipalities if a sustainable solution and a swift shift is to be realized.

Figure 2. Requirements towards a shift to electromobility for urban logistics (Ehrler and Lobig, A. 2016)



4. A dynamically evolving market: actual spread of electric vehicles and future perspectives

Business users, especially in urban freight, have long been identified as privileged targets for electromobility (Brunel and Perillo 1992; Lee, Thomas, and Brown 2013; Taefi et al. 2015). This is due to the low average speed in urban environments, regular routes, relatively short distances, the fact, that many companies' have their own parking ground, and the possible benefits from an environmentally friendly image, which is becoming more and more relevant for businesses. As a consequence, the market for commercially used electric vehicles is slightly ahead of the one for private cars, as can be seen in Figure 3. The difference is not significant though

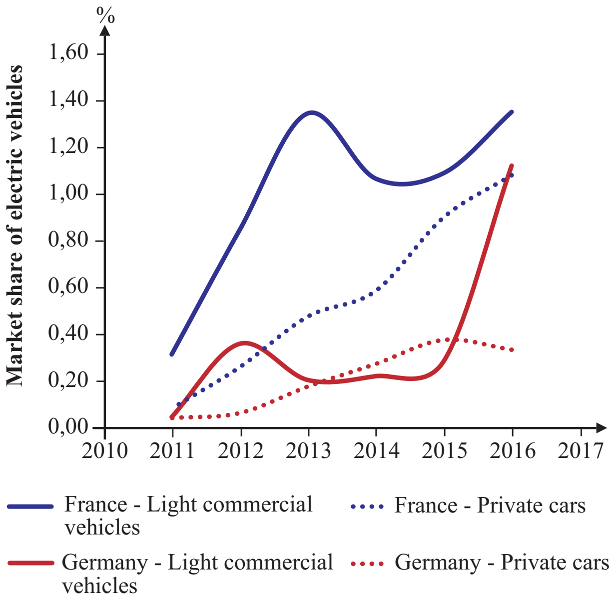
Several elements can be noticed for the spread and use of electric vehicles in general. All electric vehicle markets are growing. It can be observed that the private car market is growing more regularly than the light commercial vehicles' one (LCV, less than 3.5 tons gross weight). It may be due to the fact that the LCV market is essentially driven by big companies in mail and parcel activities. La Poste, for example, has purchased more than 5500 Renault Kangoo Z.E. since 2011, when DHL even decided to produce its own electric vehicles in its subsidiary StreetScooter (2380 new electric vehicles since 2015 (EAFO, 2017)). This explains the exponential growth of the last two years. It is interesting to notice that these mail and parcel delivery activities meet the majority of specificities stated above, especially a great regularity of the trips and own possessed premises.

Sales of electric vehicles in the French markets are clearly higher than in the German markets. This is not a surprise, as electric vehicles have been much more incentivized in France than in Germany: there has been an environmental bonus for battery electric vehicles successively up to 5000€ (2010), 7000€ (2012), 6300€ (2016) and currently 6000€ for the purchase of a battery electric vehicle. In Germany, national incentives of 4000€ have been introduced recently in June 2016, paid half by the car manufacturer, and half by federal subsidies. In addition, the vehicle is exempted from the annual circulation tax for a period of 10 years (with an order of magnitude of 170€ per year). Local incentives can add up, for example in Paris companies can profit, under specific conditions, from an additional bonus of 3000€ for LCVs (growing with the size of the vehicle up to 9000€ for electric trucks).

It is an interesting point to notice that both countries have a big automotive industry, and that most of the electric vehicles sold in 2016 are from national brands, in all vehicle categories (BMW i3 and StreetScooter Work in Germany, Renault Zoé and Renault Kangoo Z.E. in France) (EAFO,2017).

Still though, the offering of vehicles is limited and the scarcity of the offer manifests itself in the concentration of sales on only few vehicle models. In the private car market, in Europe and in 2016, the three most-sold models represent more than 60% of the market share, while the three most-sold electric LCVs score even higher with almost 75% of the market share. The offer is focused on small vans, even if new bigger van models are about to enter the market (for instance the VW e-Crafter, Renault Master or StreetScooter Work L).

Figure 3. Evolution of market shares of electric vehicles in the private car and light commercial vehicle market for France and Germany



5. Investigating range and costs: assessing the impact of incentives and technological evolution

This section explores how the evolution of the technology will affect the market and the typical user by investigating range and costs, two crucial characteristics of the vehicle. They are interesting to investigate jointly, as they are exerting antagonist forces: who wants much range must pay for it, who wants a cheap vehicle must accommodate with a lower range. The battery capacity is what links the two characteristics together.

Thus, the equilibrium is moving with the price per kilowatt-hour of battery, which is dropping thanks to technological improvements and scaling. Nykvist and Nilsson (2015) have observed until now an 8% yearly drop in battery prices.

5.1. Modelling intra-day variations with a gamma distribution

When a total cost of ownership (TCO) needs only the average driven distance to be computed, the range constraint has to be explored by accounting for the irregularity of the trips. For this purpose, the variability of the daily driven distance has been modelled. The main assumption is that the daily driven distances for one specific user follows a Gamma distribution. This law has already been used to evaluate range constraints (Greene 1985) and energy use (Lin et *al.* 2012). More sophisticated laws also have been used for private vehicles in a similar manner as for this model (Tamor, Gearhart, and Soto 2013; Barter et *al.* 2015).

Because of the lack of GPS data to generate distributions, the daily uses of the vehicles were reconstructed from partial data. This has been done through an optimization algorithm, applied as follows: (i) Representing the daily driven distance variations with a gamma law parametrized with the mean of the distribution and 1/k, where k is the shape parameter (1/k, proportional to the excess kurtosis, characterizes the tail of the distribution); (ii) representing the variations among the individuals, by assuming that the parameters are themselves independently distributed according to gamma distributions and (iii) searching for the 2*2 parameter sets of the latter distributions, which optimize the fit to the observed marginal data. In the present case, the objective function that has been minimized is the following:

$$\Delta = smax_i(\,\delta_i) \text{ with } \delta_i = smax_j\left(\sqrt{n}\cdot\left|\overline{F_i}(x_j) - F_i(x_j)\right|\right)$$

Where:

– $\overline{F_i}$ and F_i are respectively the empirical and modelled cumulative distribution functions of the studied parameter i .
– n is the size of the sample
– $smax$ is a smooth maximum function defined as

$$\forall x \in \mathbb{R}^n, smax(x) = \frac{\sum_i x_i\, e^{10 \cdot x_i}}{\sum_j e^{10 \cdot x_j}}$$

Data stems from the "Survey on the uses of light commercial vehicles" conducted in 2010-2011 by the Service de l'Observation et des Statistiques (SOeS), the French environment ministry's statistics service. The model is applied on subsets of the database. Vehicles being used for freight transportation have been extracted, vehicles that are only driven for private purposes have been removed and only vehicles bought after 2009 (two years before the year of survey) have been taken into account. At last, vehicles of under 2.5 tons gross weight (and between 3.2 and 3.5 tons respectively) were extracted from the database, which leaves 648 vehicles (593 vehicles respectively), operating all over France.

For these vehicles, the following three parameters have been used to set up the model: annual driven distances, frequency at which the vehicles are driven over distances of more than 80 kilometres, and frequency at which they are driven over more than 150 kilometres a day. By lack of equivalent data for the German use of LCVs it was assumed that the driving patterns are similar, thus it will be impossible to see the impact of the use differences on the market potential.

5.2. Applying a simplified decision model for each generated use pattern

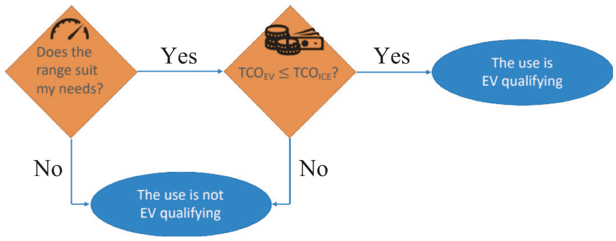
As we investigate range and cost, we consider that business users choose whether to switch to the electric vehicle or not under two conditions presented in Figure 4. The range constraint has been defined as follows, allowing only one day per year where the range is exceeded, with the cumulative distribution function of the distribution of daily driven distances:

Range constraint is satisfied

$$\Leftrightarrow \; F_r(range) > 1 - \frac{1}{Working\ days}$$

The TCO has been estimated over a time span of 4 years, and includes vehicle and infrastructure purchase, fuel costs and battery rental costs. Fuel consumptions are randomly distributed to simulate differences between a use on highways and in cities. Resale values have been assumed equal for electric and diesel vehicles, which is a conservative assumption (as electric vehicles cost more) that might be more representative of the computations of risk averse companies rather than early adopters. Detailed numerical assumptions are given in the Annex.

Figure 4 : A simplified decision model to discriminate, given a vehicle use, EV-qualifying vehicles based on the range and the comparison of Total Costs of Ownership.

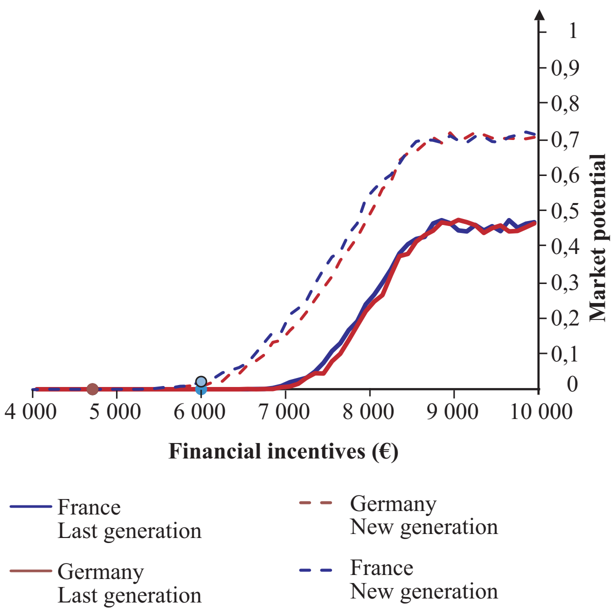


5.3. Summing up to a market potential

Summing up the number of EV-qualifying uses gives an estimation of a possible market share potential, depending on the context and the vehicle specifications. This is of course not a precise market forecast, as the mechanisms are very simplified and several constraints and opportunities are not taken into account, as charging difficulties, social and regulatory factors etc. But the model offers the advantage of underlining the dynamics affecting the convergence of supply and demand.

6. The potential of electric vans of the last and new generation, in France and Germany – a comparison

Figure 5. Small vans' market potential as a function of the actualized financial incentives, in Germany (red) and France (blue), for the last (full line) and the upcoming (dashes) van generations. Dots represent the situation with current incentives.



In Figure 5 the small vans' market potentials for electric vehicles are represented, with vehicle specifications representing the last generation (representative from the electric vans that came to the market since 2011, with around 22kWh batteries) and the upcoming electric van generation (representative of the vehicles that has been announced by several car manufacturers for the coming year, with around 35kWh batteries). The dots represent the current and near future market potentials, given the current incentives in France and Germany. 22kWh enable real trips of around 80 kilometers, and 35 kWh around 120 kilometers (depending on the consumption, and the weather conditions).

First, it can be noticed that the market potential has a strong and non-linear link with incentives. The threshold-effect may be exaggerated though, because of the simplicity of the decision model and the uniformity of parameters like the number of days on which the vehicle is used, or the time span over which the total cost of ownership is computed. However, we observe that in France, we are on the edge of being financially competitive with diesel vehicles. Local additional incentives or advantages in terms of image or work conditions may be enough to persuade businesses. In Germany, because of the lower incentives (and in the event of stable support), only the next generation of electric vehicles should be attractive enough to open the market for a larger group of potential users. In Germany the slightly higher diesel price for businesses compensates the high electricity price, so the energy markets have not much impact on the compared competitiveness of electric company vehicles.

To explain the high maximum size of potential markets, despite their relatively limited ranges (around 80 and 120 kilometres), it is important to keep in mind that the majority of the vehicles is not used for transporting freight for a third party, but only for own account, hence the small distances.

The market is likely to grow moderately in the beginning, while the incentives are not entirely absorbed, contrary to the usual exponential growth of many innovations. But as has been shown in the first part of this research, companies need time to discover and to adapt to the new processes required by electric vehicles.

7. Different battery capacities for different users

Figure 6. EV Market Potential (with the most recent battery technology, and in the French market), as a function of the average daily driven distance for three different battery sizes.

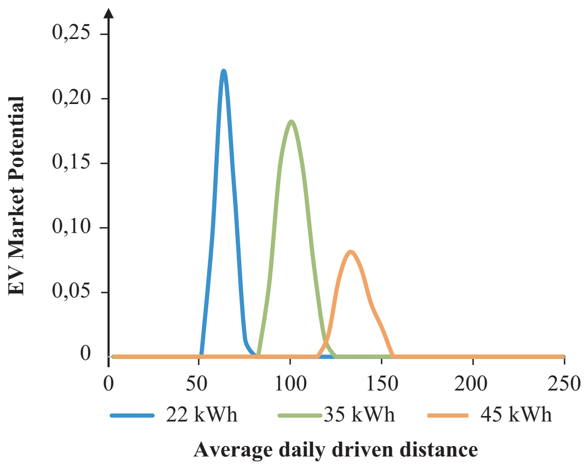


Figure 6 clearly shows that electric vehicles are likelier to be profitable when they are driven frequently and used a lot. Electric vehicles are not attractive for users who only use the vehicle seldom. For this reason, ... different battery capacities are of interest for different users. So, the broadening of the offer will multiply the market potential for electric vehicles, and for most companies, frequency of the trips might matter more in the future than their actual average distance. More frequent drivers may benefit from a bigger fuel displacement and so be able to amortize the large battery capacity. The fact that the heights of the peaks are decreasing indicates that the costs for additional range are superior to the savings realized by replacing fuel.

The peak of the 22kWh battery (order of magnitude of the current battery capacities) corresponds to current use patterns of postal and parcel delivery services, which is why the use of electric vehicles instead of combustion engines is so attractive for them.

Finally, we observe in Figure 6 that additional battery still costs more on average than the savings it can allow through fuel displacements. But as the price drops, there may be a turning point on the prices of batteries, at which the offer for batteries offering long range EVs, or heavier EVs become competitive at once. One other constraint that must be kept in mind, which has not been investigated by this model but which will also evolve, is the charging constraint. Today, it can be a problem if the charging time is too long or if the required charging power is too important for the current network (especially for big fleets). This problem will be more acute if battery sizes increase, meaning either longer charging times or higher power for charging. Innovations and technological progress need also to progress on this matter. A positive element for the environmental assessment of these bigger batteries is that the economic equation favours the user that is indeed using the whole capacity of his vehicle, assuring to limit the production of unused battery capacity.

8. Exploring bigger vans

Figure 7. Market potential for electric 3.5t gross weight vans, with former battery technology (full line) and new battery technology (dashed).

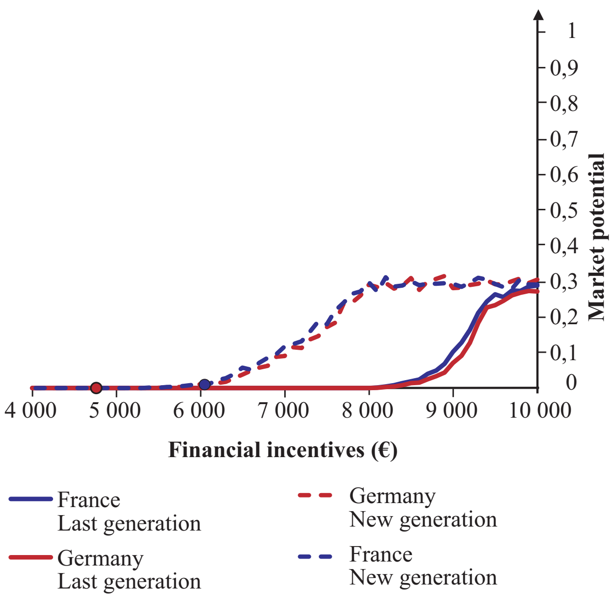


Figure 7 explores the market potential of a 3.5 tons gross weight van, with a 42kWh battery (around 120 kilometres of range). It explains why the market has been so scarce in this segment until now: the energy consumption requires a battery-size that make the vehicle uncompetitive because of its weight, size and cost. However, the technological evolution has a significant effect on the competitiveness, and here again it looks like the technology is close to being competitive in France (and a bit less in Germany). The future will tell, as such vans are currently entering the market.

9. Conclusion: how will the ideal user profile evolve with technologic improvements?

Preceding results show that the number of incentives and price of batteries have an important impact on the competitiveness and ideal user profile for electric vehicles. Instead, national energy markets have almost no impact on the market potentials, as the more expensive electricity in Germany is compensated by a slightly higher diesel price.

The results also prove that the ideal user will not necessarily be the user that is driving the less, but the user who is driving the more regularly and who drives the maximum granted by the battery size on a daily base. This points towards the necessity of a broad offering of battery sizes to suit a broader range of potential users. Offering other battery sizes will have a multiplying effect, as each battery size addresses different user profiles.

It has been shown that postal services are, with today's offer, close to optimal use conditions for electric vehicles, so it is no mystery that some big companies are forerunners in the electric vehicle market.

The heavier the vehicle, the more difficult it is to have a viable electric offer on its segment. But the reduction of the battery prices may anyway enable to have low range middle-sized trucks in the future, which are interesting for urban delivery rounds.

Based on these findings the thesis can be confirmed, that electromobility is or will be a valid alternative for urban logistics in general, once developments for batteries allow a competitive offering on the basis of TCO considerations.

Analyses have also shown though, that beyond the vehicles and the battery technology, it is important to develop integrated solutions for urban logistics of electric vehicles, which take into consideration the complex requirements of evolving urban logistics in connection with electromobility as alternative propulsion.

Annex: Numerical assumption used in the model

	General
Study Period (years)	4
Discount rate (%)	7
Number of working days	254 business days

	Diesel Small van	Diesel 3.5t van	Electric Small van	Electric 3.5t van
Purchase price (€)	16.900	31.700	22.050	35.750
Mean consumptions (L or kWh /100km)	Distributed from 5.76 to 8.14	Distributed from 10 to 15	Distributed from 15.75 to 26.4	Distributed from 25 to 47
Battery sizes (kWh)	n.a	n.a.	22,35 or 45	42
Infrastructure (€)	n.a.	n.a.	2000 amortized on 8 years	
Residual Value (€)	Equal in € between electric and diesel vehicles			

n.a. is for not applicable

	France	Germany
Incentives (€)	6000	4000 + 170/year
Diesel prices (€/L)	1.035 (after VAT deduction)	1.132
Electricity prices (€/kWh)	0.0728	0.1285
Daily driven distances of small vans	Gamma distributed with parameters: 1/k ~ Γ(1.1285 ; 6.4e-3) Mean ~ Γ(1.987 ; 40.271)	Same use as in France is assumed
Use of 3.5t vans	Gamma distributed with parameters: 1/k ~ Γ(7.498 ; 4.5e-3) Mean ~ Γ(1.117 ; 115.339)	Same use as in France is assumed

k is the shape parameter of the gamma distribution

	Last generation battery	New generation battery
Battery Rental (€/year)	nkWh / 22 . (512 + $d \cdot 0.01794$) (based on current rental rates)	nkWh / 22 . (512 + $d \cdot 0.01794$) . 0.926 (based on 8% decrease between 2011 and 2017)

d is the annual driven distance in kilometers, nkWh is the capacity of the battery

Bibliography

1. Barter, Garrett E., Michael A. Tamor, Dawn K. Manley, and Todd H. West. 2015. 'Implications of Modeling Range and Infrastructure Barriers to Adoption of Battery Electric Vehicles'. *Transportation Research Record: Journal of the Transportation Research Board* 2502 (October): 80–88. doi:10.3141/2502-10
2. Brunel, Philippe, and Thierry Perillo. 1992. «La Voiture Propre ». *Économie et Statistique* 258 (1): 89–94
3. EAFO, European Alternative Fuels Observatory. 2017. Accessed March 24. http://www.eafo.eu/
4. Ehrler, V., and Lobig, A. 2016. "DISLOG" Electric Vehicles for Efficient Urban Distribution Logistics – Final Workshop Presentation and Report'. Berlin
5. Frenzel, Ina, Julia Jarass, Stefan Trommer, and Barbara Lenz. 2015. 'Erstnutzer von Elektrofahrzeugen in Deutschland'. https://core.ac.uk/download/pdf/31017693.pdf
6. Greene, David L. 1985. 'Estimating Daily Vehicle Usage Distributions and the Implications for Limited11 Range Vehicles'. *Transportation Research Part B: Methodological*, Special Issue Economic Models 12 of Automobile Demand, 19 (4): 347–58. doi:10.1016/0191-2615(85)90041-4
7. Lee, Dong-Yeon, Valerie M. Thomas, and Marilyn A. Brown. 2013. 'Electric Urban Delivery Trucks: Energy 14 Use, Greenhouse Gas Emissions, and Cost-Effectiveness'. *Environmental Science & Technology* 47(14): 8022–8030
8. Lin, Zhenhong, Jing Dong, Changzheng Liu, and David Greene. 2012. 'Estimation of Energy Use by Plug-In Hybrid Electric Vehicles'. *Transportation Research Record: Journal of the Transportation Research Board* 2287 November): 37–43. doi:10.3141/2287-05
9. Nykvist, Björn, and Måns Nilsson. 2015. 'Rapidly Falling Costs of Battery Packs for Electric Vehicles'. 21 *Nature Climate Change* 5 (4): 329–32. doi:10.1038/nclimate2564
10. WHO, World Health Organization. 2016. WHO Global Urban Ambient Air Pollution Database (Update 2016)
11. SEU, Abschlussbericht Verbundprojekt: „SMART E USER" (Final Report of the Smart E-User Project). 2016. Berlin. http://www.logistik.tu-berlin.de/fileadmin/fg2/Forschung/Smart_e-User_Abschlussbericht.pdf
12. Taefi, T. T., Jochen Kreutzfeldt, Tobias Held, Rob Konings, Richard Kotter, Sara Lilley, Hanna Baster, et *al.* 2015. 'Comparative Analysis of European Examples of Freight Electric Vehicles Schemes'. In *Proceedings of Dynamics in Logistics: Fourth International Conference*. http://www.researchgate.net/profile/Richard_Kotter/publication/276274106_Comparative_Analysis_of_European_examples_of_Freight_Electric_Vehicles_Schemes._A_systematic_case_study_approac_with_examples_from_Denmark_Germany_The_Netherlands_Sweden_and_the_UK/links/55548fa508ae6fd2d81fc0e5.pdf
13. Tamor, Michael A., Chris Gearhart, and Ciro Soto. 2013. 'A Statistical Approach to Estimating Acceptance of 37 Electric Vehicles and Electrification of Personal Transportation'. *Transportation Research Part C:* 38 *Emerging Technologies* 26: 125–134