Possible charging strategies for the use of electric vans by urban freight companies

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Abstract

Electric light commercial vehicles have low market shares in Europe. However the market is growing and traditional barriers of cost, range, and supply are being progressively removed. The question of the charging constraint, which we define as the necessary adjustments to cope with the charging needs, will be met by more and more companies that want to mitigate low operational flexibility due to the limited range of battery. The present article aims at investigating these constraints among urban freight companies. Building upon 39 interviews, three charging strategies are identified and discussed in light of the companies’ specificities. Nighttime charging is found to be mandatory for every use case, however it is a sufficient condition only for a few specific freight activities. Companies that need flexibility have high expectations on fast charging, which can be an enabler if it is fast enough. A third charging strategy, integrated charging, consists in charging the vehicle between the trips when it is parked, provided there is the appropriate charging infrastructure. This strategy can be rewarding but it is more complex. Some use cases where it can be enforced with minimal process changes are presented.
Introduction: why focus on the charging constraint?

Many cities are facing pollution issues and looking for solutions to improve air quality. The transport sector, among others, is a big contributor of major pollutants, including particle matters and carbon monoxides, and is, therefore, a sector of prime interest in the strive for cleaner air. If in many major cities, the general trend is to push more and more cars out of the cities (Nieuwenhuijsen and Khreis, 2016), the traffic for urban freight transportation, although a significant contributor to the cities’ pollution (Dablanc, 2008), cannot be shut down without negative impacts on the commercial and business activities. Electric vehicles (EVs) appear as a potential solution, a compromise between environmental impact and accessibility to city centers. In what follows, by electric, we mean battery electric vehicles, excluding hybrid vehicles.

One among the major constraints for the commercialization (from a car manufacturer’s point of view) and the use (from a company’s point of view) of EVs is the high cost of the battery, which results either in very short-ranged or expensive but longer-ranged vehicles. So both the vehicle supply and the markets are still low but rising (electric vans represent 0.1% of the fleet in the EU).

A constraint related to limited range can only be defined together with a charging behavior. If the vehicle is not charged during the day, then the battery capacity defines the allowable daily traveled distance. If it is fully charged between every trip, the range then defines the maximal allowable trip distance. At last, if we allow charging during the trip, then virtually every distance can be covered (but possibly with much waiting time). This naturally raises the question of the acceptability and operational possibility of such charging events for freight operators.

Dong and Lin (2014) show with stochastic modeling how important an impact the charging behavior can have on the possible use of EVs. For example, based on data on private vehicles from the Seattle Metropolitan Area, the authors show that the number of drivers for which an EV would satisfy at least 95% of the trips would raise from about 35% with only home charging, to about 75% when one daily charging event is possible and to more than 90% when the vehicle can be charged between every trip (‘charging everywhere’ scenario). On the other hand, (Axsen and Kurani, 2008) show that for the U.S. private market, approximately half of the
households buying cars may have difficulties to access a charging infrastructure at home. This shows how critical the charging constraint is.

The aim of this paper is to explore and discuss how well nighttime and daytime charging fit into the current processes of urban freight transportation companies. Results are mainly based on semi-open interviews. First, the context will be outlined in the introduction by short descriptions of the electric van market and of the publicly accessible charging infrastructure in Europe. Then, in the second section, we present the methodology, which is inspired by the diffusion of innovation theory. In a third section, three possible charging strategies are discussed and their specificities outlined, to finally finish with a discussion of the results and a conclusion.

I. The context of electric vans and publicly accessible charging stations in Europe

In Europe in 2016, electric passenger cars registrations outnumber electric light commercial vehicles (LCVs) by a factor of more than seven (around 15 million passenger vehicles and 2 million light commercial vehicles, figures for EU, EFTA, and Turkey (ACEA, 2017)). The shares of electric vehicles are approximately the same for the two markets, small but growing, with 0.57% for passenger vehicles and 0.48% for LCVs in average in Europe in 2016 (EAFO, 2017).

Norway is the leading country in electromobility, with more than 15% of electric market share for new private cars in 2016 (close to 30% if counting plug-in hybrid electric vehicles). The difference with the electric LCV market is striking: the same year, the latter hardly reached 2%. This difference can be explained by different taxations for private and business conventional vehicles, affecting the competitiveness of electric competitors. For the other countries where interviews have been conducted, electric LCV market shares lie at 1.4% for France, 1.1% for Germany, and 0.5% for Sweden. Electric LCVs for urban freight remain a niche market.

Postal companies are among the biggest customers of electric LCVs. The French company La Poste has bought 5,000 electric vans, between 2011 and 2015. The Deutsche Post DHL Group, in Germany, uses a growing fleet of more than 2,500 electric vans, bought since 2014. It launched its own production in 2014 through a subsidiary company Streetscooter.

The figures also highlight that the market is overwhelmingly composed of small vans. Indeed, the supply of bigger vans is very scarce. It basically boils down to converted
conventional vehicles\(^1\) (such as the Gruau Electron II on the basis of a Fiat Ducato). However, several larger electric vans are about to reach the mass market, with (among others) the marketing of the Renault Master Z.E.\(^2\) or the Ford Work XL\(^3\) announced for end of 2017 and 2018.

Surveys about the use of EVs point toward an extensive use of private charging points for private users and company infrastructure for business users (Frenzel et al., 2015). It is confirmed by the fact that in Europe, the number of EVs is almost four times as important as the number of publicly accessible infrastructure (Global E.V., 2017). Privately owned infrastructure has typically a power between 3 kilowatts and 7 kilowatts. However, publicly accessible charging infrastructure is often considered as an effective support for reaching a mass market (Sierzchula et al., 2014; Lutsey, 2015) and existing offers are already used by current EV-owners (Frenzel et al., 2015). According to Schroeder and Traber (2012), the costs for installation (material costs and grid reinforcement) of charging infrastructure at home is about €500 (US$580), while public slow charging infrastructure ranges from €3,000 for 3.6 kilowatts to €6,000 for 7.3 kilowatts (US$3,500 to US$7,000), and public 50-kilowatt fast charging infrastructure costs around €55,000 (US$64,000).

In Europe, around 120,000 publicly accessible charging positions are listed on (EAFO, 2017), among which around 13,500 offer fast charging (power strictly superior to 22 kilowatts and up to 120 kilowatts). The number of publicly accessible charging stations, normal and fast, has continuously risen since 2010 in Europe (see Figure 1).

\(^1\) Converted vehicles are not taken into account in the counts of the European Alternative Fuels Observatory.
A comprehensive review of public charging programs can be found in (Hall and Lutsey, 2017) for instance, and the high diversity of networks is outlined. Only a few initiatives will be mentioned here. In cities, mostly slow chargers are installed, but not only. Paris seizes the opportunity of its self-service shared EVs system Autolib’ to propose 800 additional slow charging positions reserved for private vehicles. 270 points of semi-quick chargers (22 kilowatts) were also implemented on 90 stations (network called Belib’). The business model favors short charges, with a very cheap first hour (0.25€ or 0.29$ per quarter hour), and very expensive following hours to ensure the maximum use of the stations. At last, five fast charging stations complete the proposed infrastructure.

Oslo is covered by approximately 2000 publicly available charging stations, of which half are operated by the municipality. Among these, 11 are fast charging stations (80% of the battery capacity in 30 minutes) and 22 semi-quick chargers. For the customer, semi-quick charging fares 10c€ per minute, and fast charging 25c€ per minute. With a ratio of 15 EVs per charging position, the chargers in Norway are among the most crowded. The pace of installation of the charging positions has been overtaken by the development of the EV market (the municipality of Oslo confirmed this in an interview). This is one more hint towards the usefulness of publicly accessible charging infrastructure and its support of the EV market uptake.

4 According to Chargemap (www.chargemap.com).
For charging stations outside of cities, fast charging stations are often installed on highways for a corridor-based approach, such as in France with the installation of 200 fast charging stations along highways in the frame of the TEN-T European project Corri-door. Some companies (such as IKEA) are also installing slow charging infrastructure on their parking facilities as a way to attract customers, and some car manufacturers are installing infrastructure by themselves (for instance in their sales network).

At last, many cities and countries support the installation of private infrastructure. In France for instance, the program Advenir offers financial support, and a so-called right to a socket has been introduced to facilitate the installation of infrastructure in collective housing (Code de la construction et de l’habitation - Article R136-2, 2014).

In what follows, we will use “public” in the sense of “publicly available” for the sake of simplicity.

II. Methodology

Thirty-nine semi-open exploratory interviews have been conducted with transport companies, transport trade groups, and diverse stakeholders in freight and electromobility (see below). The interview questionnaire was based on the theory of diffusion of innovations, from which a first paragraph will briefly introduce some elements.

A. Inspiration from the theory of diffusion of innovations

The interview questionnaires were designed to explore the factors impacting the possible use of EVs by urban freight companies, through five attributes which influence the adoption rate of an innovation, defined in the theory of diffusion of innovations (Rogers, 2010):

- **Relative advantage**: the degree to which an innovation is perceived as being better than its precursor.
- **Compatibility**: the degree to which an innovation is perceived as being consistent with the existing values, needs, and past experiences of potential adopters.
- **Complexity**: the degree to which an innovation is perceived as being difficult to use.
- **Observability**: the degree to which the results of an innovation are observable to others.
- **Trialability**: the degree to which an innovation may be experimented before adoption.
Because of our focus on charging strategies, all attributes are not equally relevant. For example, the charging behavior is believed to have only a marginal effect on compatibility and observability of the whole EV system. On the other hand, we add a **perceived risk** attribute, defined in (Bauer, 1960) as “a combination of uncertainty plus seriousness of outcome involved,” as another attribute of interest.

This gives us an analysis grid with four parameters: **relative advantage**, **complexity**, **trialability**, and **perceived risk**. The investigation lacks an important item about the relative advantage: interviews did only provide limited information about the costs of the charging solutions. To give some insights on costs, simple computations are made to assess the cost differences between a reference and more sophisticated charging strategies. However, these computations do not give information on the cost competitiveness of the whole EV system, which is very dependent on uses and vehicle specifications (Camilleri and Dablanc, 2017).

**B. Interviews**
The argument builds onto semi-open interviews that have been conducted in Germany (15), Norway (14), Sweden (9) and France (3), of which 19 were with transport companies and 8 with freight and retail trade groups. Some companies were already using or preparing to use electric vehicles (8), while others were not interested yet (11). In addition to that, 12 exploratory interviews were conducted with municipalities or administrations, research project leaders, one software developer and one charging infrastructure operator. The detail of the activity of the interviewed organizations is given in Table 1. We call “couriers” the transport companies the main activity of which is end-to-end transportation. “Mixed goods, post, and parcels” are companies transporting general goods, post or parcels. The frontier between these activities may be thin, as companies, or even single drivers, may mix both, so the activity that seemed to be their main activity in terms of time spent has been chosen. At last, there probably is a bias towards the companies favorable to the use of EVs, as the latter may have been more willing to answer positively to my solicitation. On the basis of these interviews, an exploratory analysis has been conducted on the link between possible charging strategies, current activity, and current organization of the companies.
In addition to the interviews, blog articles concerning electric vehicle charging have been consulted on the French blog automobile-propre.com\textsuperscript{6}.

<table>
<thead>
<tr>
<th>Company activity</th>
<th>Number of interviews</th>
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<tbody>
<tr>
<td>Couriers</td>
<td>6</td>
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<tr>
<td>Mixed goods, post, parcels</td>
<td>6</td>
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<tr>
<td>Food and Beverages</td>
<td>4</td>
</tr>
<tr>
<td>Newspapers</td>
<td>2</td>
</tr>
<tr>
<td>Automobile parts</td>
<td>1</td>
</tr>
<tr>
<td>Hauliers associations</td>
<td>4</td>
</tr>
<tr>
<td>Retail associations</td>
<td>2</td>
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<tr>
<td>Electromobility associations</td>
<td>2</td>
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<tr>
<td>Municipalities and public administrations</td>
<td>6</td>
</tr>
<tr>
<td>Researchers and experts</td>
<td>4</td>
</tr>
<tr>
<td>Fleet management software developer</td>
<td>1</td>
</tr>
<tr>
<td>Charging infrastructure operator</td>
<td>1</td>
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</tbody>
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Table 1 Activity of the interviewees

III. Exploring three possible charging strategies

Throughout the interviews, three possible charging strategies have been identified, and are discussed in this section: charging only during night time, fast charging during long trips (with specific breaks) and integrated charging in-between trips. To make the link between the characteristics of each charging solution and the specificities of the companies’ operation, an ‘ideal’ company profile is identified for each scheme.

A. Charging only during nighttime

\textit{A mandatory practice, which offers alone limited flexibility}

Charging during nighttime seems absolutely mandatory in every charging strategy. All companies that were using or planning to use electric vehicles were using their own infrastructure, on the company premises or on private grounds. No company was relying on

\textsuperscript{6}http://www.automobile-propre.com/borne-de-recharge/
public infrastructure for overnight charging. In (Frenzel et al., 2015), 69% of business users declare using charging stations on company premises daily, 92% are using them more than once a week. Four interviewed companies were having night shifts, expecting at least semi-quick charging in order to have full batteries at the beginning of the night operation. For all these reasons, the possibility of charging at night seems to be the first enabler for the use of electric vehicles. Charging overnight on private infrastructure will be our reference strategy.

In our interviews, no company was ready to give up any trip that was currently made with conventional vehicles. Electric vehicles, if adopted, are required to fully cover every trip currently made. For companies with irregular or unforeseeable activities, the risk of a loss of opportunities is unacceptable. Therefore, relying only on nighttime charging only suits a few specific companies.

**Possible difficulties for installing charging infrastructure**

For companies with suitable activity patterns (as presented in the next paragraph for instance), this scheme is easy to put into place. It is, in fact, even easier than refueling a conventional vehicle as there is no need to go to a specific place for charging. Being able to have its own infrastructure is also an asset compared with other alternative fuels, like natural gas or hydrogen.

The complexity is met upstream, during the planning and installation phase. It is mainly linked to organizational issues (parking location of the vehicles, private use of vehicles, etc.) and to technical installation difficulties. First, charging infrastructures need a proper access to the electricity network, requiring sometimes expensive additional building works to overcome grid access restrictions. This is especially a problem for large fleets (as for postal and parcel delivery companies). UPS has experimented upgrade works in London, with the support of the European project Frevue (Nesterova et al., 2013), for an additional access for 50 trucks. Fire safety regulations can also lead to investments in expensive equipment.

Among the organizational issues, the use of the vehicle outside of business activities by hired drivers (typically for commute) may increase installation difficulties. Implementing a charging infrastructure at a driver’s home may raise legal issues (as it imposes on the driver the responsibility of charging outside of working hours). The workforce turnover may also question the installation of infrastructure in a place not directly linked to the company. Independent carriers are less subject to this difficulty as they own their vehicle.
More generally, if parking is on public space, infrastructure installation is not always possible. Sometimes, a solution is to change the parking location, but then it may be to a suboptimal location or may result in significant additional costs for the parking premises. An independent driver (operating one vehicle) had, for instance, a private parking space 15 minutes’ walk from home but preferred to park on the street in front of his home to avoid the time loss.

At last, some new processes may be needed. Supervision of charging processes is important, as a charging failure results in the immobilization of the vehicle for the whole day. Charge management enables to reduce the power needs (by not charging all the vehicles simultaneously), in order to make savings on the electricity bill or to allow an increased number of charging positions. Finally, the cooperation between fleet and infrastructure management, two departments that are not used to working together, is an additional obstacle for large companies, as one of them points out.

**Historical postal companies have the ideal profile for overnight charging only**

Historical postal companies have been identified in the interviews as the ideal organizations to charge their electric vehicles only during nighttime. First of all, postal companies have their vehicles parked in specific premises overnight, and often inherit many logistics spaces, including in the heart of cities. The very density of their deliveries means that the delivery rounds are, if not identical, very similar from one day to another, so the risk of a loss of opportunity is low. The historical companies also hire a fair amount of their drivers (which is less true for express companies), and the use of the vehicle is exclusively for business activities. This is important, as small independent carriers appear to diversify their activity when the opportunity arises, even if their main activity is for postal or parcel distribution.

While adequate electric vehicles for postal distribution (small vans) do exist on the market, there is a scarce supply of larger vans for parcel deliveries, with poor supply and low choice from car and truck manufacturers. However, the organization of the latter are also favorable to the use of electric vehicles with only overnight charging, and it is probably a matter of time before these companies invest in electric vehicles, as postal companies already started to do. It is therefore not a surprise that postal companies (La Poste, Deutsche Post DHL Group) are today’s biggest customers for electric vans.
**An organizational change in favor of electric vehicles is complicated**

It would be theoretically possible to introduce a share of EVs in some companies’ fleets to cover only the smallest trips, while having conventional vehicles to cover the rest of the trips. This *mixed-fleet* solution, which looks promising, has a low acceptability for many companies. According to three interviews, reasons for that include the lack of appropriate tour management software. Also, independent drivers are not willing to give up the longest trips, as they are usually the most rewarding. Swapping vehicles between drivers is not feasible either. Indeed, meeting with another driver and switching shipments from one vehicle to the other is too cumbersome.

This illustrates the resistance of companies to process changes. However, some examples show concessions in favor of electric vehicles. The best example is a courier company, which in the frame of the Frevue project guaranteed to its subcontracted drivers a regular activity during the experimentation, thus changing the daily activity with no other purpose than enabling the use of EVs.

**B. Fast charging during long trips**

*Fast charging is an enabler for many uses, especially for independent drivers, provided there is a high quality of service*

Limited battery capacity does not allow to do the longest trips for companies with irregular uses if there are no additional charging possibilities. Fast charging during the trip is one solution and acts as an enabler. It is implied that the driver does not carry out any activity for his company while waiting for the vehicle to be charged. Current business users of electric vehicles are 11% to use charging stations installed on highways or national roads more than once a week, and 25% more than once a month, more frequently than private users (Frenzel et al., 2015).

The need for fast charging has been raised spontaneously by many companies in our interviews. This is not a surprise, as except maybe for additional trip planning, fast charging would not require many process changes to the current refueling practices. For a company declaring daily distances around 250 kilometers (155 miles) daily, “even with 300 kilometers (186 miles) of range, [their future capacity to use electric vehicles] depends on fast charging stations.” However, charging time expectations are very high, reaching or exceeding today’s most advanced technologies, as for instance Tesla’s superchargers (but batteries of vans do not currently support such charging powers today).
To put this solution into context, the cost of one charging operation is estimated: with 50 kilowatts of charging (estimation of today’s most common fast charging solutions), the waiting time for 100 additional kilometers (around 60 miles) on the highway (27.5 kilowatt-hours for a van\(^7\)) is 33 minutes and has a cost of around €15 (around US$17)\(^8\). Based on Tesla charging rates (which are somewhat low compared with what is found in the literature, as in (Schroeder and Traber, 2012)), charging would cost €5.5 (US$6.4). This gives a total cost of around €20 (US$23), which is high compared with the same costs when charged from a private infrastructure, or even the costs of the fuel consumed by conventional vehicles. It points towards a punctual utilization of fast charging, and in line with the companies’ perception on the use of fast charging.

In that example, waiting time has higher costs than the service, which explains the insistence of the interviewed companies on the rapidity of the service. So the quality of service is central to the interests of freight transport companies in fast charging. In line with what (Morganti and Browne, 2016) call queue anxiety, the risk of wasting time waiting at the charging station or reaching the station strongly penalizes fast chargers’ acceptability.

**The use of fast recharging leads to a high dependence on service operators**

The geographical coverage of the stations is a concern, outlining again the risk of the loss of opportunities. One company specifically outlined (and disapproved) the risk of dependence on charging infrastructure operators. The company would be helpless in the face of a drop in quality of service (for example because of an increasing demand due to the fast growing EV market). The problem of the reliability of charging infrastructure is regularly put forward by private EV-drivers on the automobile-propre.com blog\(^9\). This problem may greatly reduce the acceptability of en route fast charging solutions (and generally all solutions based on publicly accessible charging).

**Small independent drivers, even with mostly urban activities, need fast charging solutions**

Fast charging seems essential for independent drivers. Indeed, even when the major part of their activities takes place in urban areas, the need for some interurban trips has been expressed during the interviews. One independent driver, for example, carries meal trays and has very regular

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\(^7\) Official Renault Kangoo Z.E. range estimation, at 110 km/h (68 mph), at 20°C (68°F) and with 400kg of load.

\(^8\) For lack of a better, value of time of bus drivers’ taken from (Quinet, 2014): 27,6 €/h (32,1$/h)

rounds, but even if long trips are “not the rule,” they happen “two or three times in a month, to carry furniture, or whatever.” Fast charging would allow them not to give up the most rewarding long trips.

For the independent drivers that are urban couriers (they perform end-to-end transportation inside one metropolitan area), it is to be noted that current electric vans don’t fit their needs, this time not because of the vehicle size but because of the available range. Indeed, even for regular days driving only in urban areas, couriers can cover distances of 300 kilometers (186 miles) a day.

In one interview with a courier company, however, a manager told us about one independent driver who bought an electric van on its own initiative, limiting himself to urban trips, and with the use of integrated charging, as presented in the next paragraph. The company also provides bike deliveries and seems to focus on transportation in the dense city-center.

C. In-between trips integrated charging

*Integrated processes can lead to substantial benefits*

A third charging strategy is to charge the vehicle each time it is parked, between the trips, provided there is adequate charging infrastructure (during lunch, during deliveries, between shifts, etc.). The main difference with the previous scheme is that the stop is not aimed at charging the vehicle, and the driver carries on his normal activity instead of waiting for a certain amount of charge. In that case, the charging event is *integrated* into the companies’ processes.

In a context of limited choice in battery capacity (as it is the case today), integrated charging may enable to operate an EV despite a range too low. No user relying on integrated public charging has been met, but some have been mentioned by fleet managers during the interviews. It is not self-evident that if there is a supply in the right battery capacity, this scheme will still be attractive.

The benefit of this additional daytime charging is to be found in the possibility of having a smaller battery. An order of magnitude of the savings can be derived by using, for instance, the monthly rental rates of the battery for small vans (based on Renault Kangoo Z.E. rates). If the company can ensure a daily charge of one hour at a 7-kilowatt charging infrastructure, the economic gain by reducing the battery size of 7 kilowatt-hours is around €300 (US$350). The same charging at a power of 22 kilowatts leads to potential savings of €925 (US$1074) per year and per vehicle. These simple computations assume that there are no service costs associated
with this charging (only electricity costs), for example, if the charging occurs on own infrastructure. We can see that these gains can be substantial, even for moderate powers. The assumption of one hour in the day is arbitrary but not unrealistic, it could be a lunch break, or six ten-minute stop at delivery areas equipped with charging infrastructure.

**Integrated charging requires tailor-made solutions**

This solution offers limited flexibility and requires regular uses, to ensure that daytime charging can be integrated into everyday activity (or it needs that irregular uses be covered with fast charging). One solution that seems of interest is charging during lunch time, even if it may require some organizational changes. It is not uncommon that each driver chooses the time and the place where they want to eat for example (provided they make a real break for lunch, not just a sandwich while driving).

Companies have numerous organization possibilities, depending on their strategies and the transported goods (Beziat et al., 2015) and each organization has different possibilities to integrate charging events. One specific use case seems ideal: companies with several shifts, where vehicles are operated successively by different drivers during the day. This is often the case for companies with night urban deliveries, taking maximum advantage of their fleet by delivering general goods (in our interviews, mostly parcels) during the day. These companies are able to charge in between the shifts: the vehicles are coming back to the premises, where they are parked for some time (there is a change of driver), and sometimes loaded with new freight. There is a real chance to charge the battery during these changes, with very few inconvenience, as this organization is on a regular daily basis.

Urban delivery activities that need some time to load or unload the vehicle may also have the potential for integrated charging. Inductive charging may actually be especially relevant for this case (close to *opportunity charging*, when the vehicle is not parked but stopped for a short period of time, for example, at a traffic light (Lukic and Pantic, 2013)), indeed the more charging events in the day, the more any lost minute to plug-in the vehicle is penalizing. To our knowledge, no city has deployed a charging infrastructure network on delivery areas.
IV. Discussion and conclusion

In this paper, we explored, based on interviews with freight companies and actors in the electric vehicle and urban freight ecosystem, three possible charging strategies that would promote the use of electric vehicles. At the end, what will the future of charging look like for business users?

Cost and flexibility appear to be crucial characteristics of the transport companies’ evaluation of the relative advantage of EVs. The flexibility of conventional vehicles is hard to reach, whatever charging strategy is used. Therefore, EVs need to be cost-competitive compared with conventional vehicles in hope of a market uptake. These factors are precisely the ones identified as leading to a high rate of subcontracting in urban freight (Harnay et al., 2014).

The different charging solutions appear to be complementary rather than in competition. The probable medium-term outcome will be a compromise between the lower flexibility of integrated charging and the higher cost of fast charging to compensate. The interviews also revealed a lower acceptability of solutions requiring process changes. One hypothesis that this raises is that many companies may wait for an easy solution to be competitive, before looking into more sophisticated optimization possibilities. Therefore, experimentation occupies a central role to speed up process transformation. Most interviewed companies that were actually using electric vehicles were in an experimentation phase.

The issue of public intervention is salient in this topic, and the results confirm the usefulness of both the support to private infrastructure installation and the development of a publicly available charging stations network for freight companies. Demand-driven charging infrastructure installation is particularly relevant to help companies who are not able to install their own infrastructure or to support innovative integrated charging organizations. An original example is the city of Amsterdam (Vertelman and Bardok, 2016), which strategy consists of installing infrastructure upon request of the user.

In the case of supply-driven infrastructure, for instance, fast charging on highway corridors or inductive charging on delivery areas, the geographical coverage is of prime importance to limit perceived risk and operational usability. The presence of a high-quality offer specific to business users may be relevant, limiting further the perceived risk.

Guessing the future charging behavior is subject to one big unknown: technological progress. There is a race between improvements in battery capacity and charging possibilities.
We already observe today that both are evolving quickly. Battery prices are dropping at a fast rate (Nykvist and Nilsson, 2015), while the amount of charging positions is growing and charging power is increasing. For instance, the car-manufacturer consortium Ionity has announced a network of 400 very fast charging stations, up to 350 kilowatts, by 2020\textsuperscript{10}. We also see new solutions appear to overcome the difficulties of access to the electricity network. Stationary batteries, which can accumulate energy at low power when no vehicle is connected but can re-deliver it to high power, allow flexible charging solutions without adding a big load to the network and are especially promising for fast charging as experimented in Oslo\textsuperscript{11}.

**Acknowledgement**

We thank Jens Klauenberg from the DLR, Jardar Andersen from the TØI and Sönke Behrends from Chalmers University, for their hospitality in their respective laboratories. This research work was supported by Renault, by the French Institute of Science and Technology for Transport, Development and Networks (IFSTTAR), and by research grants from the German Academic Exchange Service (DAAD) and from the the MetroFreight VREF Centre of Excellence in the framework of a PhD research (supervised by Dr. Dablanc).


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