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Zero emission city logistics: current practices in freight electromobility and feasibility in the near future

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Abstract

This paper examines the feasibility of using electric powered vehicles in urban freight transport from a carrier's perspective, including their attitudes towards electric freight vehicles (EFVs) and all relevant elements affecting this business case, such as: technological features, existing restricting and promoting policies, financial and non-financial incentives, type of operations, urban settings and logistics organization. We look at the business cases for different truck sizes, varying from small vans to large trucks, in relation to the logistics requirements. This contribution combines the relevant urban freight transport solution directions: technology (both for the vehicle and the supporting IT), logistics and policy. The attitudes of the different EFVs user groups are also taken into account. Only if all these elements support each other, a feasible case can be possible at this moment. We look at the current business case and make conclusions on where it is necessary to act in the near future in order to increase an uptake of electric freight vehicles. For this analysis we use the data collected from current demonstrations that are actually running in the European FP7 project FREVUE, which includes over 100 electric-powered vehicles in the cities of Amsterdam, Lisbon, London, Madrid, Milan, Oslo, Rotterdam, and Stockholm. This data includes operational, attitudinal and financial data for the before situation in which conventional vehicles were used and for the first year(s) where electric vehicles were operated.

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Keywords: electric freight vehicles; city logistics; electromobility; electric vehicles business case; attitudes towards electric freight vehicles

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1. Introduction

Freight transport and logistics in cities are recognized to be large contributors to the GHG emissions and to contribute to a set of specific urban area problems (congestion, air and noise pollution), directly affecting the life of urban residents (see Civitas Wiki, 2015). Specific policy packages on the European level are dedicated to address these problems, supporting both optimisation of the logistics movements within city areas as well as looking into the introduction of the new technologies into the traditional city logistics processes. The European Commission aims to decrease CO_2 emissions as well as tackle air and noise pollution by encouraging the use of alternative fuels. To improve air quality and decrease local emissions the EC has policies in place to decrease sources. Next, several cities are aligning with the Commission's strategic guidelines by granting electric delivery vans and trucks access to environmental zones or by exempting them from certain fees or taxes (see also AIT, 2014).

The use of zero emission vehicles is considered as one of the directions on how to reduce the negative impacts from transport in cities while maintaining an efficient urban freight transport system. The use of EFVs is one of the most promising technical solutions existing at this moment as it does not produce local emissions (from the tailpipe) and – depending on the way electricity is generated – has huge potential in reducing CO_2 emissions (see for example Quak and Nesterova, 2014). The mass introduction of the electric freight vehicles in the daily operations did not happen yet. The transition from conventionally powered diesel vehicles towards electric vehicles in urban freight transport did not appear be an easy one due to the insufficient technology maturity and not yet proven business case. For a literature review on this topic, i.e. electric freight vehicles in city logistics operations, we refer to FREVUE deliverable 1.3 'State of the art of the electric freight vehicles implementation in city logistics – Update 2015' (Nesterova and Quak, 2015).

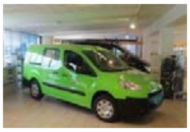
This paper further examines the feasibility of using electric powered vehicles in urban freight transport from a carrier's perspective, including their attitudes towards electric freight vehicles (EFVs) and all relevant elements affecting the business case. Through FREVUE project demonstrations we look at the business cases for different truck sizes, varying from small vans to large trucks. This contribution combines the relevant urban freight transport solution directions: technology (both for the vehicle and the supporting IT), logistics and policy. The attitudes of the different EFVs user groups are also taken into account. Only if all these elements support each other, a feasible case can be possible at this moment. After introducing the FREVUE project (section 2), the paper provides a summary of the main findings from the state of the art study (Nesterova and Quak, 2015) on electric freight vehicles in city logistics (section 3). Section 4 provides the first results of surveys on the attitude towards electric mobility in urban logistics. The last section takes the results of the demonstrations and the other sections in account and summarizes these findings in a business model canvas. The research methods used to collect data are described in FREVUE deliverable 1.1 the central assessment framework (FREVUE, 2014).

2. FREVUE introduction

Recent years have shown an increasing number of trials and demonstrators running EFVs in daily city logistics operations. In some cities EFVs are penetrating more and more specific niche markets. Running services and new demonstrations are continuously delivering new results on the performance of the electric freight vehicles in urban logistics. For this analysis we use the data collected from demonstrations that are currently running in the European FP7 project FREVUE. FREVUE demonstrates the use of EFVs in city logistics operations in eight European cities. The project is co-funded by the European Commission under the Seventh Framework Programme, Theme 7 Sustainable Surface Transport. It answers the call "Demonstration of Urban freight Electric Vehicles for clean city logistics". Within the project the demonstration of EFVs is organized, covering a variety of urban freight applications that are common across Europe including different types of goods, various logistics systems, vehicle types, climates as well as diverse political and regulatory settings that exist within Europe.

Below we present the status of demonstrations within eight FREVUE cities as for August 2015, provided with some illustrations (table 1).

Table 1. FREVUE demonstrators (and some examples of vehicles in the particular demonstration).

Amsterdam 	In Amsterdam three companies and the municipality are involved in the FREVUE demonstration: Heineken's logistics service provider is using a 12 tons electric truck Ginaf to supply hotel, cafes and restaurant establishments in the city center; UPS uses six retrofitted large electric vans (which looks like the typical UPS van form the outside); and TNT recently started operating 5 large retrofitted electric vans based on Fiat Ducato chassis for their express deliveries. In addition to subsidies the municipality of Amsterdam has taken complementary policy measures to make EFVs use more attractive. Those privileges are exemptions on traffic codes/regulations/rules, such as parking on sidewalks to load/unload, driving into roads that are only for pedestrians, etc.
Lisbon 	In the demonstrator the Portuguese postal company CTT uses 10 small electric vans (type Renault Kangoo ZOE) for post and parcel operations in Lisbon. EMEL uses five small electric vans for maintenance of the on street parking and charging point infrastructure. The Lisbon local authorities look at supporting policies for EFVs and already uses some EFVs for waste collection and gardening and city maintenance.
London 	For FREVUE UPS has 16 retrofitted EFVs with a changed powertrain and refurbished old vehicle running in London. These EFVs replaced existing roundtrips of diesel vehicles of 75 kilometers a day, fitting perfectly into the daily range of the EFVs. In the other London demonstration Clipper uses two EFVs of ten tonnes for the operation of the consolidation centers in London. These EFVs make two roundtrips per day between the large consolidation center in Enfield (10 miles north of the London city centre) and the smaller one at Regent Street in central London.
Madrid 	The Madrid demonstration includes three operators and an UCC (Urban Consolidation Center). Currently four electric vehicles are running: two Renault Kangoos (TNT and SEUR) and two larger vans for Pascual (Iveco Daily and Mercedes Vito). Regarding an UCC, after a search for an available suitable the location local authorities have found an old market for fruit and vegetables in the southern part of Madrid that was empty. A part of this old market is reconditioned to make it suitable for an UCC, including charging infrastructure for the EFVs. The use of the UCC is offered for free to the operators in the FREVUE project, except for some really minor costs, e.g. the costs for cleaning, some maintenance issues, etc.
Milan 	The Milan demonstration is slightly delayed due to several technical and legal barriers when trying to get a French--authorized EFV with temperature controlled box to operate in Italy. A logistics operator, specialized in temperature controlled distribution of pharmaceutical, diagnostic and biomedical products to pharmacies, hospitals, third party distributors, nursing homes and patients, will operate two EVs in the demonstration.
Oslo 	In the Oslo demonstration Bring uses subcontractors to deliver and pick up parcels. The company is operating 4 EFVs (Peugeot Partners) of the 6 planned. These are replacing existing conventional vehicles. The logistics concept is as follows: in the morning deliveries are made and in the afternoon pick-ups are done. Basically, the routes start at home, to the post office, to the Bring customers, doing pick-ups, to the post office and then back to home. Four different post offices are used to start 4 different EFVs operated routes at this moment.
Rotterdam 	In Rotterdam the Binnenstadservice's local franchisee RoadRunner uses a Nissan eNV200 for its deliveries. TNT just started operating 4 large electric vans and UPS operates 4 large electric vans. Next, Heineken operates one large 19 ton electric truck Hytruck. The city of Rotterdam is preparing a study in cooperation with the local grid operating company to determine the spatial distribution of business vehicles (trucks and vans) and derive the overnight charging requirement if all vehicles were electric. Next, the city is examining ways to include promoting zero emission logistics in the procurement of goods and services.
Stockholm 	Originally one demonstration was planned with a construction consolidation center (CCC) and EFVs carrying construction materials from the CCC to the construction sites. After one year as the capacity of the electric vehicle was too limited for all construction deliveries, the electric van (Mercedes Vito) that was used to move materials from the CCC to the construction sites accompanied by two conventional trucks with hybrid cranes. Now Stockholm is examining the possibility for an UCC to deliver goods in the city centre using electric freight vehicles.

3. Business case for battery electric vehicles in city logistics

The purchase price of EFVs remains significantly higher compared to the conventional vehicles and operational advantages for now remain limited. Therefore business case for the EFVs is not yet evident and changes are required not only in vehicle technology but also in operational practices. Looking deeper at technology performance, operation, economics and policy support we are defining the elements that are critical for the EFV business case and on which one can act to further improve business case for EFV in city logistics.

3.1. Technology

It is still a case that technological performance and reliability of the vehicles depends a lot on the specific vehicle type or model. Though, so far, the majority of vehicles used in FREVUE do perform excellent from a technical point of view, two failure cases were recorded:

- One of the Madrid demonstrators has reported frequent failures of the batteries because of which the vehicle had to be stopped for about 6 days.
- One of the Amsterdam/Rotterdam demonstrators also experienced technical problems with the vehicle.

In general, the increased insights in the EFV maintenance show that, when operating well, the regular maintenance of the EFVs requires fewer efforts compared to internal combustion engine vehicles (ICEVs). That is because EFVs have fewer moving parts than ICEVs and do not need regular oil changes, as regenerative breaking allows for less break wear. At the same time, almost in all cases where problems occurred, there was a lack of available resources for quickly solving technical issues with the vehicles (Pelletier et al, 2014). Therefore an important problem that gains a larger focus today: lack of efficient and competitive manufacturer support in case repair is needed, in comparison to the quick support by existing dealer-networks for conventional vehicles. Otherwise no problems or issues were reported by FREVUE demonstrators and all vehicles performed as was promised by the manufacturers.

The vehicles in FREVUE are running for only short periods now (between a few months to about two years), but based on these observations as well as on the extended knowledge on batteries received from other real life implementation cases we can say that the small and medium EFVs are no longer ‘trial’ products as these were in the early 2000s, but are reliable vehicles. As availability of the heavy EFVs remains extremely limited, they are still falling into the ‘trial’ category. In general, the attitude towards the issue of the limited range of EFVs has changed and there are more and more companies running EFVs in daily operations which are perfectly fine with the EFVs’ range.

Four charging methods can be distinguished: in-house charging, public charging points, inductive charging and battery changing. FREVUE vehicles as well as the majority of the commercial EVs described in other demonstrators are charged overnight on company grounds. The running FREVUE demonstrations showed that in some cases the existing power grid is not sufficient to actually charge the EFV fleet during the off hours at the depot. For example, the London demonstration showed that it was necessary to upgrade the power grid in order to charge the 16 EFVs all at once and run the sorting machine at the depot at the same time during the night. Grid upgrades are expensive for commercial vehicle fleets and are non-scalable. In case of UK, these upgrades (owned by the power-network company) have to be paid by the end user regardless of who is the owner. This is contradictory, because it requires a logistics service provider to make an investment in a network it does not own. Therefore for the London demonstrator that was difficult to develop full technical and economic understanding of power infrastructure upgrade alternatives on a full life cycle NPV basis. Next, the process of obtaining landlord permission for the necessary infrastructure upgrade works has proved to be more complicated than anticipated (in this case) because of multiple levels of ownership involved. Most other cases show that some investments are necessary for charging infrastructure and sometimes in the grid (for example in Rotterdam), but these investments are limited in comparison to grid investments that we saw in the London demonstration. These insights from FREVUE (extended with experience from other publicly availably demonstrator reports) result in the following elements influencing the EFV business case and presented in table 2.

Table 2. Technology factors influencing EFVs business case.

Possible extra cost	Potential benefit
High vehicle/battery repair cost	Lower maintenance cost
Vehicle replacement cost	
Additional charging infrastructure cost	
Grid upgrade cost	
Landlord permission cost	

3.2. Operations

From the operations point of view there is a common understanding that EFVs are suited for urban logistics. Nowadays the focus is more on finding out for which kind of operations within urban logistics practices EFVs are the most suitable and beneficial. The delicate nature of supply chains needs to be taken into account. In any case the adjustment of operational processes or routes was necessary in the majority of cases and as FREVUE demonstrators have illustrated – the use of EFVs requires at least more intelligent journey planning.

FREVUE demonstrations (e.g. Amsterdam/Rotterdam demonstrator) provide good examples of logistics (re)organisation via direct replacement of ICEVs by EFVs. Simply replacing a conventional vehicle with an electric vehicle seems to be the easiest way to use electric freight vehicles in urban freight transport operations. Though, most of the times this is not an optimal solution, as the logistics organisation was designed for ICEVs. However, some routes have the characteristics that perfectly fit EFVs, i.e. parcel or post deliveries. Usually, these trips cover short distances, have a high drop density and start from depots close to cities. FREVUE examples of Lisbon, London and Oslo show that this is indeed the case. Replacing an ICEV can be done by operators if the roundtrips that were performed fit the limitations of EFVs, especially the limited range of an EFV compared to an ICEV.

From the demonstrations we learned that in many cases replacement does not mean that there are no additional efforts. For example, the use of an EFV requires more intelligent planning. In the case of Rotterdam the EFV replaces a conventional vehicle on a route. However, during or after this fixed roundtrip planners used to plan pickups for the conventional vehicle, whereas for the replacing EFV this results in issues with the vehicle range. So in planning extra variable pickups after the fixed roundtrip to this vehicle, the EFV had an extra constraint. Another FREVUE example where the EFVs also replaced existing ICEV roundtrips is London demonstrator. There, the challenge with EFVs is the following: the vehicles have very tight routine at the depot, such as washing and fuelling, loading and unloading. With the ICEVs this routine is easy and fast. With an EFV there is less flexibility as these have to be planned at a charging location, where it should be for about 8 hours. All daily operational and maintenance activities including, there is only 4 hours of idle time left for a vehicle which is too short for charging. So operations at the depot have to be planned around the charging of the vehicle. As a result the vehicles are charged at the time that most electricity is used (e.g. the sorting machines, as this process also takes place in the late evening/early night).

In cases where replacement of the vehicles is not possible due to e.g. range issues, another way to use EFVs in city logistics operations is to make use of a hub. Most parcel and postal companies already make use of a dense hub network, which makes these types of operations very suitable for the use of EFVs in the last mile. Several examples exists in FREVUE where hubs are introduced as a starting point for city logistics operations with EFVs: Urban consolidation centres in Madrid and London, Stockholm Construction Consolidation Centre In two cases to find anaffordable and suitable location or warehouse to “host” and UCC was not that easy. The lack of evidence about potential UCC cost savings and other benefits make some companies reluctant to invest in the early stage investigations. It was also reported that the transshipment of goods from conventional vehicles to EFVs at the (micro)hubs results in extra handling, which add to the transport costs. The choice of the relevant ICT application which would be beneficial for UCC operation in a broader context was reported as a difficulty. In the case of Stockholm EFV capacity was not enough in order to cover the growing volume of goods carried and demonstrator shifted back to the usage of conventional vehicle.

Considering the above-described insights from the FREVUE project, the possible impacts on the EFVs are identified in table 3.

Table 3. Operational factors influencing EFVs business case.

Possible extra cost	Potential benefit
Transhipment costs of goods from ICEVs to EFVs	

3.3. Economics

Looking into the total cost of ownership (TCO) of EFVs compared to the ICEVs the main conclusions remain the same over last years: on the one hand the purchase price of EFVs is higher and on the other side energy and maintenance costs are (or could be) lower than for conventional vehicles. For example, smaller vans (less than 3.5 tonnes) are more expensive than conventional vans with an order of magnitude about twice the procurement price. Larger vans (between about 3.5 and 7.5 tonnes) that are often retrofitted show an order of magnitude about twice to four time the procurement price of a comparable conventional vehicle. Trucks (more than 7.5 tonnes, up to the 19 tonnes truck that is used in Rotterdam demonstration in FREVUE) can be as much as four/five times more expensive in procurement. The FREVUE demonstrators have confirmed that the availability of EFVs varies: in general the market for smaller vans is reasonably well developing (EFVs smaller than 3.5 tonnes), whereas larger vans or trucks are often tailor-made or produced in smaller batches. As reported in FREVUE periodic reports, EFVs larger than 3.5 tones are not yet a proven technology and big OEMS are not providing them to the wider market (e.g. Rotterdam and Amsterdam demonstrators). Small companies seeing opportunity in it try to take a leadership role, but have problems in assembling EFV because of lack of financial resources as well as lack of experience. Therefore, most of the vehicles used in the category of larger vans are retrofitted vehicles. For example a Rotterdam demonstrator changes the powertrain and refurbishes the old vehicle, whereas an Amsterdam/Rotterdam demonstrator makes use of retrofitted vehicles on a new Ducato chassis.

Another difficulty reported to the procurement of large vans is that production of the batteries takes place when the producers have enough orders to produce them all together which can cause delivery delays (Amsterdam demonstrator). Suppliers of equipment reported that they were not licenced to import some engine parts necessary for battery production. These procurement difficulties are translated into the extra procurement costs.

Other cost items where some difference compared to ICEVs is seen is:

- Even though regular maintenance costs reported so far for EFVs seem to be significantly less (20–30% lower) than for ICEVs (Pelletier et al, 2014; TU Delft, 2013, German cases), the main problem is that if the vehicle breaks, the repair cost become extremely high.
- On top of the high purchase price, transport operators working in the extreme weather conditions or within supply chains with specific requirements often have to invest into additional heating or cooling systems of the vehicle.
- Hiring of additional drivers is reported as a potential additional cost of EFVs compared to ICEVs there should be a certain investment in training of drivers: both on operation of EVs and related to its eco-driving.

Table 4 summarises the possible impacts for the business case.

Table 4. Economic factors influencing EFVs business case.

Possible extra cost	Potential benefit
Higher purchase price	Lower operational costs
High vehicle repair cost	Lower maintenance costs (20–30%)
Vehicle replacement cost	
Installation of additional heating/cooling equipment if necessary	
Training of drivers/additional hiring of drivers with specific skills	
Additional procurement costs	

3.4. Policy and procurement

Since the EFVs in all categories are more expensive in purchase, an active role of local authorities is often expected to make the business case more feasible. One of the FREVUE partners for the London demonstrator reports “public sector levers such as policy (e.g. Ultra Low emission zone) are strong allies in building the case for EVs”.

In FREVUE demonstrators three instruments are used in cities to promote the uptake of EFVs. First are the purchase or other subsidies. Most of the FREVUE vehicles are partly funded from the project. Some local authorities have subsidies available for the procurement of EVs, for example in Amsterdam. Some of the FREVUE demonstrations use favourable taxation schemes like no congestion charge for EFVs, no parking fee, or no road tax are another financial instrument that local authorities use to make the business case more attractive for EFVs. Second, some of the instruments focus more on electric vehicles rather than on EFVs. For example, carriers do often not pay parking fees when making their deliveries with EFVs. Finally, supportive policies such as entering (low)emission zones, use of bus lanes, parking at non loading areas, wider time access restrictions, and possibilities to enter pedestrian zones can result in operational advantages (as is demonstrated in the Amsterdam demonstrator).

The evaluation of eight transport companies operating between one to four EFVs in the city centre of Amsterdam proved that policy exemptions can have a positive effect on the logistics operations especially in terms of time savings which results in the cost savings. The evaluation showed that time savings is achieved by: reduction in time necessary to find a suitable location for (un)loading; reduction in walking time of the driver from parking to the delivery address; better planning and/or more deliveries during the time-window period and as a result fewer vehicles are necessary in the city center.

Another direct effect of the exemptions that was mentioned by several operators was the decrease in stress for the drivers, better performance and fewer mistakes. Examples of advantages of parking privileges are: the anxiety of drivers for fines disappears which makes them more relaxed and able to deliver a better service to the receiving clients. Without the parking privilege and when no legal place is available to unload a double parking is often necessary to make a delivery. Attitudes of drivers in passenger cars result in delivery men to be more in a hurry and not receiver-friendly. Therefore free parking exemptions result in a reduction of stress for drivers and nuisance by (un)loading vehicles for the other traffic. Finally, the observation was made that for the customers from HORECA the image of the brewery delivering the goods at cafes in environmentally friendly way was also beneficial.

Experience from other FREVUE demonstrators has shown that certification is another issue where regulatory support is necessary. This is the case both for EFVs that are developed in small batches, for example the Cargohoppers, but also the larger trucks as for Heineken. The requirements are strict: all vehicles, as these are often tailor made or specifications slightly differ in batches, have to be tested to get a certificate. These extra certification costs add to the already high prices. No certifications based on standard components are yet allowed.

Another issue, following from the FREVUE demonstration in Milan, is that a vehicle that is approved for one country is not automatically allowed on the road in another European country. The partner who provided the vehicles for Milan is French and the vehicle has a special certification to circulate in France but, in Italy this is not legitimate. As a result, the already limited supply of these electric refrigerated vehicles in Italy is made even smaller.

Table 5 summarizes the impact of different policies on the EFV business case.

Table 5. Policies influencing EFVs business case.

Possible extra cost	Potential benefit
Extra certification costs	Purchase subsidies
	Favourable taxation schemes
	No parking fees
	Operational advantages

4. Attitude towards battery electric vehicles

Being less noisy and more environmentally friendly both from local and global emissions point of view than conventional vehicles, electric vehicles are usually very well perceived by the general public. However, to encourage a large uptake of EFVs, different stakeholders including drivers, logistic operators, grid managers and customers all have an important role to play in this process. In FREVUE the survey for different groups were carried out and some of the early findings are presented below for the following groups of actors:

- Drivers, based on 47 returned questionnaires
- Logistics operators (including fleet managers), based on 31 returned questionnaires
- Customers (including both senders and receivers), based on 24 returned questionnaires.

4.1. Drivers

During the survey conducted prior to the deployment of EFVs, most of the drivers said they do not think the EFV would make much difference to them compared to the conventional vehicles. There was a lack of interests in general to these EFVs. However, after running the vehicles for a few months, in most cases the drivers are happy with EFVs because of the improved technological features that make maneuvering and parking easier in the city centres as well as standing out for their appearance. Amsterdam demonstrator reported that the drivers were all very enthusiastic after they have driven the EFVs for the first time. The gadgets in the truck (e.g. regeneration, dashboard with other metric system etc.) have proven popular. They have also found that the power that the vehicles generates when it is accelerating and the silence of the vehicles has proven to be an advantage with the vehicles rather than an issue.

In terms of range anxiety, the survey has indicated that the operational routine plays an important part. Drivers are not concerned about range issues if there is a stable and predictable daily delivery environment which they know their vehicles will be able to cope. These operational factors include distance, routes, number of stops and weather. However if there is a long delivery distance and a variable delivery environment, drivers are usually very worried about running out of battery. Two FREVUE drivers from Oslo demonstrator have reported that they are constantly worried about battery due to the cold weather there and long daily delivery distance (around 200km).

For other factors such as comfort, reliability and safety, most of the drivers reported that they do not think there are noticeable difference comparing to conventional vehicles. Some of the drivers did report the reluctance of using air condition/heater on the vehicle because of the concerns that it might drain the battery faster.

4.2. Logistic operators

The responses from logistic operators to the EFVs have been largely positive with no or few problem reported. However there is a mixed responses when asked whether they think EFVs are a viable option for replacing ICEVs. The top four concerns include the characteristics of EFV and their business needs, high capital expenditure, infrastructure availability (including the availability of charging facilities and grid capacity) and lack of suitable EFVs on the market, especially for the vehicles with more than 3.5t gross vehicle weights. Most of the operators did report that at the current state EFVs cannot replace all ICEVs in operation, however for the category of under 3.5t they are a serious contender if the route and daily operation can be optimized to suit the characteristics of EFVs. Some of the FREVUE operators have committed of taking more EFVs as a part of their business because of the success they had with the FREVUE trials.

When the operators were asked what the most important factors is to consider for future EFV procurement, economic considerations came on top, followed by running cost and reliability. This means that although main strength of EFVs continues to be its environmental performance, if there is going to be a large uptake, the key issue to be addressed is still its business case. This also reflects on the preferable incentives to have to encourage more uptake of EFVs, where government subsidy or tax exemption to cover the additional cost of buying EFV was voted on top, followed by the discount on road charging or toll and then priority of EFVs on street.

4.3. Customers

The survey with customers (senders and receivers) which include both senders and receivers have received low response rate, probably due to survey fatigue or a lack of interest or incentives in this topic. Hence bias might be present in the results. Nonetheless, most of the respondents show a good awareness of EFVs and most of them are concerned about environmental rated issues such as global warning, air pollution and traffic noise hence they are very supportive of replacing ICEVs with EFVs.

The customers have claimed that they will have positive attitude towards delivery companies and retailers who are using EFVs, and they would take “green delivery” as one of the factors when choosing a delivery company. Most of them confirmed that they would always choose an EFV over ICE for delivery if the price is the same and they are given the option from a delivery company.

However, when asked whether they are willing to pay extra to get their goods delivered by an EFV, only about 25% said yes. For most of the customers although the awareness of the impacts from goods vehicles to the environment is improving, but the most important factor to get their goods delivered is still the price and on time. Based on the results we think it would be difficult to transfer the high cost of EFV to the customers without providing extra services.

What we also found out is that most customers are not certain if their goods are delivered to them by an EFV or ICEV. If a logistic operator want to harvest the positive corporate image from using EFVs, they will need to find a better way to communicate this to their customers.

5. Potential business cases for small, medium and large vehicles

Table 6. Business model Canvas for operators using EFVs – changes positive (+),negative (-) or neutral (0) compared to ICE usage.

Key Partners	Key Activities	Value Proposition	Customer Relationships	Customer Segments
Closer cooperation with cities (0), energy networks (0). Maintenance: fewer knowledgeable service men available (-) New manufacturers and dealers, requires more effort than normal relationships, and OEMs are usually smaller and less professional than for ICEs (-)	• Vehicle charging time (-), costs (+) • More time efficient delivery because of the privileges (+) • Low vehicle utilisation rate and more difficult to plan due to range (-)	Hardly changes: most customers want low emission deliveries, but willingness to pay is very limited at this moment (0)	No changes	Customers including zero emission criterions in the procurement (+), although hardly used – at this moment – in practice
	Key Resources	**Value proposition for society**	**Channels**	
	• Ownership of the vehicles: fewer lease options (0) • Fuel costs vs. electricity (+) • Procurement cost (-) • Charging infrastructure at depot (-)	Reduction of emissions (+) Less noise nuisance (+)	Low nuisance (stench, smell and emissions): interesting for outdoor cafes	

Cost Structure	Revenue Streams
Investment costs: cost in purchase of the vehicle; cost in purchase of charging point and telematics (-) Operating costs (0) or in case of exemptions (+) Less fuel costs; less maintenance cost (+)	No changes (0), except if: subsidy for the vehicle purchase (+), or for charging point purchase (+), zero emission in procurement (+) Non-monetary revenue stream: more sustainable

Above confirms that finding a feasible business case for use of EFVs in city logistics operations is still a challenging issue. Using the line of reasoning as developed in Quak et al. (2014), where we adapted the Osterwalder’s business model canvas to a city logistics context, we see that using an EFV in city logistics mainly affects the cost-side, and hardly any effects are noticed in the revenue-side for the logistics operators. On one hand investment costs increase due to higher vehicle prices, reorganisation of planning, use of extra locations, etc.. Costs advantages also occur due to the use of electricity instead of diesel, which can be considerable sometimes up to 80% in cost savings due to using electricity instead of diesel and some other advantages that are illustrated in table 6. At the moment the use of EFVs usually does not result in extra revenues as most customers do not want to pay more for zero emission deliveries, although some FREVUE demonstrations (e.g. city of Amsterdam) do examine possibilities to include zero emission deliveries as favorable in the procurement of products or services. However, if there are no extra revenues, it is important to find ways to make the business case feasible in the cost-side.

Tables 6 presents a business case set up and effect of changes; and how these influence the business case for logistics operators in using EFVs, between positive (+), no effect (0) and negative (-). Obviously, the magnitude of these changes differs per operator, and per EFV type as well. In general we saw that the extra costs for larger EFVs are higher than for smaller EFVs (see section on 3.3). These changes follow from the sections 3 and 4 of this contribution and are summarized in Table 6's business model canvas, more details can be found in these sections.

6. Conclusions

A wide uptake of the electric freight vehicles in city logistics practices is currently slowed down by several factors characterising the electric freight vehicle market and infrastructure:

- Techno12logical performance and reliability of the vehicles still depends a lot on the specific vehicle type of the model;
- Lack and high cost of efficient manufacturer support in case repair is needed;
- Development of the ICT support is necessary for further optimisation of EFVs integration into daily practices of transport operators;
- Limited production and availability of, especially, heavy duty electric freight vehicles;
- Need in the infrastructure investment/adaptation.

The purchase price of EVs remains significantly higher compared to the conventional vehicles and current operational advantages provided by this environmentally friendly technology are not sufficient for the positive business case of the EFVs. Therefore, operators keep searching for new forms of ownership of the vehicles and successful business models Finding a feasible business case for use of the EFVs is considered as a challenging issue, an active role is still often expected from local authorities. At the same time, at the policy level there is now an understanding that non-monetary incentives are also very important as they are giving operators of EFVs long term competitive advantages.

Finally, there is a confirmation of positive social attitudes towards EFVs: they are in general very well perceived by the general public and receive positive feedback from drivers. Undoubtedly, environmental performance of the EFV is one of its main strengths, though, with the appearance on the market of freight vehicles running on other alternative fuels and strengthening of EURO standards for ICEVs, this competitive advantage of EFVS might reduce in the future.

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