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Possibilities and barriers for using electric-powered vehicles in city logistics practice

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Abstract

This paper discusses the current developments, as well as the barriers and opportunities for using electric freight vehicles in daily city logistics operations based on the experiences from a number of running demonstrations. This paper discusses results from other studies and demonstrations that were published on electro mobility in city logistics in the last three years, as an update of an earlier state of the art review. Next, we present recent narratives based on the more than 100 electric freight vehicles (EFVs) deployed in the European project FREVUE and the experiences of TransMission in using four battery electric Cargohoppers to perform their urban deliveries in Amsterdam. Over the years the attention shifted from a focus on the limitations of EFVs in comparison to conventional vehicles, such as the limited range, towards the question how to better adapt the operations to deal with the EFV characteristics. Although, the business case for using EFVs, in comparison to conventional vehicles, is still suffering from high vehicle purchase price and uncertainty about its residual value, the use of EFVs in daily operations shows that in the majority of cases the current generation of EFVs have a good technical performance. Companies using EFVs are generally satisfied with these vehicles. Obviously still a number of barriers has to be levelled, but large scale EFV usage seems more feasible than before.

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Keywords: electromobility; electric freight vehicles; zero emission; city logistics; FREVUE

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1. Introduction

Urban freight transport is a serious contributor to local emissions (i.e. NOx, elemental carbon and organic carbon) affecting the urban air quality and to global emissions (i.e. CO2) affecting global warming. Poor air quality is a pressing problem in many urban areas as it directly affects the health of people and as a result the life expectancy of citizens. World Health Organisation states that poor air quality is a serious health risk. Next to that, many European cities are not meeting the agreed European standards for air quality (Directive 2001/81/EC), which can result in penalties. Therefore, it is not surprising that one of the major short term concerns for local authorities is to improve local air quality. On the longer term, the European Commission formulated the ambition to make urban freight transport emission free by 2030 (EC, 2011).

Albeit that urban freight transport has these effects, it is of major importance to sustain urban life by providing both the supply of all goods (including the necessities of life) and the removal of all waste from the locations where people concentrate, i.e. the cities. Therefore it is necessary to continuously examine the possibilities of how to reduce the negative impacts while maintaining an efficient urban freight transport system. The use of zero emission vehicles could be one key element. One of the most promising technical solutions existing at this moment is the electric powered vehicle: it does not produce local emissions (from the tailpipe), and – depending on the way electricity is generated – has huge potential in reducing CO2 emissions (see for example Quak and Nesterova, 2014).

However, the transition from conventionally powered diesel vehicles towards electric vehicles in urban freight transport is not an easy one. This paper examines the barriers and opportunities to use electric freight vehicles in city logistics operations. We first provide a short description of the sources we used to identify current barriers and opportunities as well as the direction these barriers and opportunities are moving (in comparison to an earlier review presented in Nesterova et al., 2013). Specifically we introduce FREVUE, a large European demonstration project of electric vehicles in city logistics and the case of Cargohopper in Amsterdam. The remaining part of this paper examines the trends and current state of implementation of electric vehicles in urban freight transport based on information received from recent demonstrations, trials and daily operations. Finally we define what are the main strengths and weaknesses in the business case of electric freight vehicles in city logistics.

2. Electric freight vehicles in city logistics operations

Zero-emission city logistics operations, although often still in the form of small scale demonstrations rather than large implementations, are performed more and more in practice. This contribution examines the barriers and possibilities that arise when actually using EFVs in daily operations. This contribution is a continuation on the state-of-the-art study on electric freight vehicles from 2013 (see Nesterova et al., 2013), where we identify the trends and changes that occurred the last two years. For this, we use three main sources: i) we review the recently published results (2013-2015) from the projects and demonstrations that include freight electro mobility in city logistics, ii) we present the first insights from FREVUE (Project acronym VALIDATING FREIGHT ELECTRIC VEHICLES IN URBAN EUROPE) and iii) we discuss the case of the four electric Cargohoppers operated by TransMission in Amsterdam. These main sources are introduced in more detail in the following paragraphs.

2.1. Overview of the reviewed projects and demonstrations (2013-2015)

We selected relevant projects and demonstrations to be included for the review based on a set of specific criteria, i.e.: i) papers or reports that are published between 2013 – 2015 presenting from the field of electric powered vehicle implementations in city logistics or other relevant research papers on electro mobility and city logistics, ii) reports and articles are written in English and focusing on implementation of EFVs, and iii) projects and research that focus only on electric freight vehicles such as trucks and vans. This resulted in a review of the following projects and the corresponding deliverables, papers and reports: C-Liege, e-mobility NSR (2011-2014), ENCLOSE (2015-2015), LAMILO (2011-2015), Molecules (2011-2014), Pelletier et al. (2014a and 2014b), SELECT (2012-2015), SMARTFUSION (2012-2015), STRAIGHTSOL (2011-2014), Taefi et al. (2014), and Tide (…-2015).

2.2. FREVUE 'Freight Electric Vehicles in Urban Europe'

The FREVUE project demonstrates the use of electric freight vehicles (EFV) 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 127 EFVs is organized, covering a variety of urban freight applications that are common across Europe. This includes:

- Goods deliveries (including food, waste, pharmaceuticals, packages and construction);
- New logistics systems and associated ICT;
- Organisation with a focus on consolidation centres to enable minimalisation of trips in urban centers;
- Vehicle types (from small car-derived vans to large 18 tonne goods vehicles);
- Climates (from Northern to Southern Europe);
- Diverse political and regulatory settings that exist within Europe.

Below we shortly present the eight cities and the demonstrations that take place there within the FREVUE project:

Amsterdam: In Amsterdam three companies and the municipality are involved in the FREVUE demonstration: i) Heineken's logistics service provider is using a 12 tons electric truck (Ginaf) to supply hotel, cafes and restaurant establishments in the city center, ii) UPS uses six retrofitted large electric vans (which looks like the typical UPS van form the outside), and iii) 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: The Portuguese postal company CTT uses 10 small electric vans (type Renault Kangoo ZOE) for post and parcel operations in Lisbon. Next, EMEL uses five small electric vans for maintenance of the on street parking and charging point infrastructure. The Lisbon local authorities are the third FREVUE partner in this local demonstration. The municipality looks at supporting policies for EFVs and already uses some EFVs for waste collection and gardening and city maintenance.

London: For FREVUE UPS has 16 EFVs running in London. These are all retrofitted vehicles, this implies: a changed powertrain and refurbished old vehicle. These EFVs replaced existing roundtrips of diesel vehicles. The replaced roundtrips are less than 75 kilometers, so these do not exceed the daily range of the EFVs. In the other London demonstration Clipper uses two EFVs of ten tonnes for the operation of the consolidation centres in London. These EFVs make two roundtrips per day between the large consolidation centre in Enfield 10 miles north of the London city centre and the smaller one at Regent street.

Madrid: The Madrid demonstration includes three operators and an UCC (Urban Consolidation Center). The operators active in the Madrid demonstration are: TNT Spain, SEUR (both parcel deliveries) and Pascual (dairy products). Currently four electric vehicles are running: two Renault Kangoos (TNT and SEUR) and two larger vans for Pascual (Iveco Daily and Mercedes Vito). The local authorities decided to use an UCC in the FREVUE demo. After a search for an available suitable location, they found an old market for fruit and vegetables that was empty. Part of this old market is reconditioned to make it suitable as UCC (in the southern part of Madrid), 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 electric freight vehicle with temperature controlled box vehicle to operate in Italy. A specialized logistics operator, i.e. Eurodifarm, specialist in the 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 Oslo Bring is the logistics company running the FREVUE demonstration. Bring uses subcontractors to deliver and pick up parcels. The company plans to operate 6 vehicles in the FREVUE demonstration, from which 4 are already operating. These EFVs are replacing existing conventional vehicles. The EFVs deployed are Peugeot Partners. 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.

Rotterdam: In Rotterdam the Binnenstadservice's (see Van Rooijen and Quak, 2010) 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 also active in FREVUE preparing a study in cooperation with the local grid operating company to: determine the spatial distribution of business vehicles (trucks and vans); derive the overnight charging requirement if all vehicles were electric; combine this spatial distribution of demand with the grid capacity; explore the possibilities of local energy production and storage in a pilot.

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 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), as the capacity of the electric vehicle was too limited for all construction deliveries. Now Stockholm is examining the possibility for an UCC to deliver goods in the city center using electric freight vehicles.

2.3. Cargohoppers in Amsterdam[1]

From Amsterdam we present also another case that is not part of FREVUE. The transport company TransMission operates four electric freight vehicles, the so-called Cargohoppers. In order to perform logistics operations in Amsterdam with EFVs, TransMission developed for distribution a small truck-trailer combination, the Cargohopper 2. This vehicle is developed by order of TransMission and follows from the development of the early Cargohopper 1 that looked like a small road train (that was used in Utrecht). The first version of Carohopper 2 was deployed in Enschede. Lessons from these vehicles were taken in account, and as a result the Cargohopper 2 that runs in Amsterdam is, among other things, about 750 kilogram lighter, than the comparable version in Enschede.

Before implementation of the electric Cargohoppers, TransMission served Amsterdam from its depot in Almere (about 28 kilometers from the city center of Amsterdam) by six conventional vehicles, that either delivered pallets or parcels. In the new situation TransMission uses one large truck to transport all goods for the environmental zone in Amsterdam (i.e. the city center) to a micro-hub that is owned by removal firm (Van Deudekom) close to the city center. The search for this micro-hub turned out to be very challenging (as is discussed later in this contribution). After the depot was adapted to the requirements of the Cargohopper, TransMission performed its city logistics operations as follows: one big (conventional) truck brings pallets and parcels from Almere to the micro-hub. In the hub all goods are cross-docked to four Cargohoppers that combine parcel and pallet deliveries. The Cargohoppers make deliveries and pickups in Amsterdam and return to the micro-hub. From there a large truck brings the goods to the depot in Almere.

3. New insights into freight electro-mobility: changing focus in the discussions about EFVs in city logistics

Last years show an increasing number of trials and demonstrators running EFVs in daily city logistics operations. In some countries and, more specifically, cities (e.g. London, Amsterdam, Rotterdam), EFVs are penetrating specific niche markets more and more. Running services and new demonstrations are continuously delivering new results on the performance of the electric freight vehicles in urban logistics. Technologies and business environment are not standing still so new success factors and barriers are emerging. In this section we are looking into the new

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[1] The information presented follows from a site visit to TransMission's Logistics Decoupling Point in Amsterdam (4-12-2014), an interview with TransMission's director P. Tjalma (29-1-2015) and the website (www.cargohopper.nl).

trends resulting from the recent electro-mobility research and results comparing it to the situation reported in FREVUE's state of the art review performed in 2013 (see Nesterova et al., 2013).

Nesterova et al. (2013) have indicated that the first massive trials / demonstrators of electric freight vehicles were undertaken more than 20 years ago. The main challenges faced then by operators in implementation of EFVs in city logistics were: high procurement costs, limited range of vehicle models, little or no after sale support and long waiting time for spare parts, low performance of the lead-acid, nickel – cadmium and ZEBRA battery technologies, limited mileage range, low vehicle speed and limited payload. In short, these early EFVs were far from perfect and were not a serious alternative for internal combustion engine vehicles (ICEV) in city logistics operations. The development of more reliable and better performing batteries was considered crucial for all types of electric vehicles to become (more) competitive to conventional vehicles.

FREVUE's state of the art review defined a list of challenges and success factors for EFVs uptake relevant to demonstrators, trials and initiatives implemented before 2013. Two years later, there is more knowledge available on technical, operational performance of the EFVs as well as their economics. There is a shift in the attention focus in the discussions of what are the most critical success factors and barriers for wider deployment. We show how the field evolved over the last two years. Therefore the following sections present a follow-up (so complementary) to the state of the art review performed within FREVUE in 2013, showing the changes and trends structured according to the elements that were used introduced in Nesterova et al. (2013): technical performance, operational performance, economics, environmental performance, and policy and governance.

3.1. Technical performance: from focus on range to the importance of aftersales support

Back in 2013, it was reported that the range of EFVs is usually not larger than 100 – 150 kilometres. The range promised by the manufacturer was often not reached, although new(er) vehicles have a higher real range. Whether the range is a limiting factor depends on the logistics operations. Technical issues observed included: failing batteries (and limited or late) support, equipment availability issues, relatively long charging time and the necessity to adapt charging infrastructure for fleet needs. The rapid improvement in the technology was mentioned as a reason for waiting to acquire EFVs. The limited availability of standard vehicles and vehicle types (especially for larger vans and trucks) was also mentioned as a factor that is seen as a barrier for EFVs implementation.

Today, technological performance and reliability of the vehicles still depends a lot on the model of the vehicles used. Some companies are very happy with the vehicles deployed and based on this experience decide to increase the share of the EFVs in their fleet. They report that EFVs have an exclusive advantage of excellent acceleration and high torque, are comfortable to drive in, are fast and flexible in urban traffic. The opposite cases also exist, where operators got really disappointed in the technological performance of a particular EFV type which further unmotivated them to continue using EFVs. The latter part is closely related to another problem that gains a larger focus today: lack of efficient manufacturer support in case repair is needed (in comparison to the quick support by existing dealer-networks for conventional vehicles).

In general, the increased insights in the EFV maintenance show that, when operating well, the regular maintenance of the EFVs requires less efforts compared to ICEVs. That is because EFVs have fewer moving parts than ICEVs, 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). As Ninh et al. (2014) report, there are "only some garages where they know technical specifications of EFVs in order to fix them". As EFVs are still relatively new product and only limited EFVs are used per city (certainly in comparison to ICEVs) the availability of technical parts, next to the availability of skilled servicemen, to perform the repair quickly is not always guaranteed. Therefore, in majority of broken-down cases reported repair time is very long – sometimes up to several months (Ninh et al., 2014; TU Delft, 2013). As a result, companies experience limited flexibility as there not always schemes providing a back-up service available yet. Few available cases have shown that retrofitted vehicles experience more technical problems than new mass produced electric vehicles (Baster et al., 2014).

Next, we noticed that the attitude towards the issue of the limited range of EFVs has changed. There are still remarks on insufficient range of EFVs. Of course, from the improvement of the EFVs range everyone will gain, but, currently, the latter concern also comes from the fact that companies through trial and demonstration processes are trying out to see to which kind of businesses and operations EFVs fit best. At the same time, there are more and more companies running EFVs in daily operations which are perfectly fine with the EFVs' range. First, those who do not require high range in their operations and secondly those who have adapted their daily routines to the available range. As Taefi et al. (2014) summarize, "whether or not an application is successful is largely case-specific and depended on if the performance of the EV complies with the intended transport use for this vehicle". In any case, it is now confirmed that factors temporary reducing available range are: extreme temperatures, driving style (e.g. rapid acceleration and high driving speed) and hauling heavy loads (see e.g. Pelletier et al, 2014; Vaicaityte et al., 2014; ENCLOSE, 2014). Taefi et al. (2014) also state that "the range listed by EV manufactures is based on measurements according to the New European Drive Cycle, which compared to real life energy consumption in urban last mile delivery do not give a reliable indication of the expected range". This disparity of declared and real range is confusing for transport operators in the beginning of the operation of EFVs.

More knowledge on the batteries is available now: lithium-ion batteries used typically in current EFVs should last around six years (Pelletier et al, 2014). At the same time, typical battery warranty lengths for electric trucks have been reported as being in the three to five years range (Pelletier et al, 2014). Battery health can be influenced by the way they are charged and discharged, where frequent overcharging or frequent discharging to very deep levels can affect battery lifespan, just as keeping the battery at high states of charge for lengthy periods (Pelletier et al, 2014). Therefore, with time, the stability of the battery range becomes problematic (Taefi et al., 2014). Multiple experiences show that only 80% of the marketed battery capacity is actually usable. There are also considerations to take the battery recycling policy of manufacturer into consideration (Vaicaityte et al., 2014).

Basically, four charging methods are deployed: in-house charging, public charging points, inductive charging and battery changing. In-house charging is the most common for the companies operating EFVs and public charging is usually seen as a positive supportive factor that provides operator with ability to charge when necessary in between tours. Charging time varies largely depending on the type of electric vehicle supply equipment and type of battery. Some cases were reported (Taefi et al., 2014; FREVUE demonstrators) where in-house charging infrastructure was over-loaded by the high capacity needs during simultaneous charging of several EFVs. Taefi et al. (2014) reports that other charging related issues appear, such as: "solutions to ensure charging in case of power outage are necessary; implementation of a smart grid and load management for large electrical fleets; charging plugs being too damageable and only specially trained staff being able to handle a plug". In some cases improvement of the cable bound charging process was described as of a high importance: currently the cable can be unplugged by anyone, even while the vehicle is still charging (TU Delft, 2013, German cases). On the EU level, EU-wide standardisation of grid-to-vehicle technology is currently on-going and is very well perceived by the operators.

Improvement and sometimes standardisation of the software inside the EFVs as well as connecting EFV with a grid is an emerging issue gaining attention. There is a clear need in the improvement of the ICT support of EFVs operations in different application areas. As noted by Taefi et al. (2014), "the introduction of an electric vehicle has resulted in some less optimal information processes due to the fact that the long distance transport (by regular truck) and short distance transport (by electric truck) were no longer in one pair of hands". Conducted demonstrations have illustrated that, for example, dispatching software available today is not yet ready to manage electric vehicles (needing to take into account the remaining (and predictable) battery level) (Taefi et al., 2014; TU Delft, 2013).

Technical insights from FREVUE. So far the vehicles used in FREVUE do perform excellent from a technical point of view. No problems or issues were reported and all vehicles performed as was promised by the manufacturers. Obviously, the vehicles are running for only short periods now (between a few months to about two years), but based on these observations we can say that the EFVs are no longer 'trial' products (as these were in the early 2000s), but reliable vehicles.

The FREVUE project 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 UPS EFVs (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. 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. Next, the process of obtaining landlord permission for the necessary infrastructure upgrade works has proved to be more complicated than anticipated (in this case). That is largely because there are 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.

3.2. Operational performance: fine-tuning urban logistics operations to EFVs

FREVUE's review from 2013 concluded that EFVs demonstrate both positive and negative operational performance characteristics compared to conventional vehicles. Because of their environmental performance and reduced noise level they are often permitted in larger geographical areas and wider time windows in cities where any of those restrictions exist. Some technological features, like an acute turning range, steering circle and improved visibility facilitate the manoeuvring of the vehicles in dense city areas. At the same time, charging, load capacity, maintenance and the need to adapt logistic concepts for the usage of EFVs were seen by operators as the main existing operational challenges. Not all freight operations were considered suitable for using EFVs, which is particularly the case for the long-haul operations and operations requiring large loading capacity. In terms of the range, the payload and overnight charging, current EFVs performance levels are good enough for the city distribution operations.

Today majority of these conclusions remains the same. The common understanding is that EFVs are suited for urban logistics. Though, focus is more on finding out for which kind of operations within urban logistics practices EFVs are most suitable and beneficial. Electric freight vehicles have already been tested for many urban freight transport tasks: post and courier delivery, pizza delivery, garbage collection, cash managing company, on-line supermarket, etc. Agreement is that in general, light electric freight vehicles are best suitable for "duty cycles in (sub-)urban areas involving a low daily driving range and a relatively low load capacity" (ENCLOSE, 2014). Combined to limited payloads, this makes them best suited for last mile deliveries in compact cities involving frequent stop and go movements, limited route lengths and low travel speeds (Pelletier et al, 2014, ENCLOSE, 2014). Ninh et al. (2014) additionally refer to the size of the company: "in some companies, EFVs might fit well in their business, because they deliver small parcels and use small ICE vans anyway. Than it would not be a big problem for them to switch to EFVs with the same size. For bigger companies, which transport large amounts of goods every day to the inner city, it would be hard for them to pay more for the labour cost in order to switch to smaller vehicles".

As mentioned before, satisfaction with a range is really case specific with some operations within city logistics being more suitable for the currently available range than others. From one side, as stated by Leal et al. (2014), "the low range (in average 100 km) of the electric vehicle is not an obstacle to the reliability of the urban freight transport business: the travel distance is often known in advance and the travel routes can therefore be optimized to fit the range of the electric vehicles". From another side, as Baster et al. (2014) conclude, "when a distance travelled by ICEs in company is higher than the range proposed by EFVs, this decreases the flexibility for the business – as in need for additional vehicles at the longer routes, they simply cannot serve them". Currently transport operators using EFVs are finding their ways in adapting their routines to the available vehicle range.

In any case, the adjustment of operational processes or routes was necessary in the majority of cases. Taefi et al. (2014) state that "direct substitution of conventional commercial vehicles with EVs does not fully exploit the strengths of EVs, hence often leading to operation that is simply not profitable". Therefore, adaption of logistics concepts is necessary in order to achieve the profitability of the EFV business case. On the level of the urban planning, two main combinations of measures are currently being implemented: consolidation of supply (deployment of EFVs in combination with urban logistics centres) and consolidation of demand (combining deliveries to one area from multiple suppliers).

Operational insights from FREVUE and TransMission. FREVUE demonstrations provide good examples of logistics (re)organisation via direct replacement of internal combustion vehicles (ICEs) 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 EMEL, UPS and CTT 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 RoadRunner (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 for UPS. There, the challenge with EFVs is the following: at UPS 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 vehicles are running form e.g. 8 am to 6 pm vehicles, so then these are away from the depot. Then between 6-10 pm the vehicles are washed and fuelled / charged. Next, the conventional vehicles are 4 hours idle and from 2 am these are off for inbound logistics operations again. These 4 hours are too short to charge the EFVs fully. 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).

Another way to use EFVs in city logistics operations, in cases where replacement of the vehicles is not possible due to e.g. range issues, is to make use of a hub. Several examples exists where hubs are used as a starting point for city logistics operations with EFVs.

TransMission: in order to make deliveries in Amsterdam, TransMission needed a location where it could cross-dock deliveries from the conventional vehicles to the Cargohoppers. The search for a hub at the right location (i.e. south east of Amsterdam, at the route from Transmission's depot in Almere to the city centre of Amsterdam) took over two years, even though the local authorities were very helpful in and during this search. Many warehouses and locations were examined, but very often issues like opening hours, available space, etc. did not match TransMission's requirements to operate its four Cargohoppers. By coincidence, the directors of TransMission and Van Deudekom (a removal firm with a depot at the right location and some empty space), have met. And even more important: there was a click. After a search of over two years, and being close to abandoning the entire plan of making zero emission deliveries to Amsterdam, the hub was found. Van Deudekom allowed for the necessary changes in the warehouse (e.g. charging infrastructure, adapting docks to the Cargohopper) and in 2014 the Cargohoppers started operating in Amsterdam. Cross-docking at this microhub enables TransMission to have operational advantages (combined parcel and pallet networks) in Amsterdam and a consolidated flow between the microhub and TransMission's existing warehouse in Almere that can be performed by a big truck.

Madrid's Urban Consolidation Center (UCC) in FREVUE: the local authorities redeveloped an unused market place to an UCC with facilities for charging and cross-docking for the FREVUE demonstrators in Madrid. This facility enables the carriers to operate in Madrid with EFVs at low costs, as the use of this UCC is, except for some services, free for them. This UCC is used for cross-docking deliveries and pickups from EFVs to conventional vehicles (and the other way around) and charging the EFVs. There is no bundling of loads between the users of this facility.

Stockholm's Construction Consolidation Center (CCC) in FREVUE: the CCC has a temporary structure, it will be moved during the 15 years of construction development. The city of Stockholm owns the CCC and an operator, who won the tender, runs the operations. Since the city owns the land on which construction takes place, local authorities could require the use of the CCC in the building regulations (the city is also a developer itself, and from that role it can also require the use of the CCC by builders). All vehicles carrying limited volume (i.e. less than about 5 euro pallet places) that deliver to the building sites have to unload at the CCC. When construction started most deliveries from the CCC to the actual construction sites were transported by the EFV. However, in the beginning of 2014 the volume of goods at the CCC increased and the electric van was getting to small for delivering all the goods. The smaller parcels and packages were then fitted on the crane vehicle instead, as this vehicle was driving with larger volumes between CCC and construction sites anyway. A suitable electric powered crane vehicle was not found, so the remaining of this demonstration continues using conventional vehicles. The CCC still operates satisfactorily, but at this moment without EFVs. Stockholm local authorities examine the possibilities for an UCC to supply the city center to test EFVs there.

3.3. Economics: searching new forms of ownership and successful business models

The purchase price and total cost of ownership (TCO) for EFVs are significantly higher than for conventional vehicles. That is explained by the high battery cost and limited production volumes of these vehicles. Nesterova et al. (2013) state of the art report states that in the longer term it is expected that EFVs will become more competitive, incorporating savings from the improved operational performance, reduction in purchase prices due to the massive production and associated environmental benefits. Currently, as operators are usually more focused on short term benefits, the wider uptake of electric vehicles is difficult. The fact that the second-hand market and residual value of EFVs are not yet clearly known holds back some of the operators in their purchase decision. Leasing and financing companies are also reluctant to invest due to these uncertainties. Battery leasing or swapping options are regarded as potential options to reduce vehicle purchase and operational costs. These main conclusions remain the same two years later: on the one hand the purchase price is higher and on the other side energy and maintenance costs are (or could be) lower than for conventional vehicles. On top of the high purchase price, transport operators working in the extreme weather conditions often have to invest into additional heating or cooling systems of the vehicle.

Energy saving has been up to now considered as one of the main competitive advantages of the EFVs. At the same time, some counter-arguments start to appear. TU Delft (2013, German cases) reports that “the price of electric energy is influenced by the shutdown of nuclear reactors, additional renewable power plants and further construction of the power grid. Therefore these factors need to be closely monitored as profitability of EVs is influenced by the price of electric energy” (TU Delft, 2013). Pelletier et al (2014) indicate that commercial EFVs will also have to compete with other fuel alternatives such as compressed natural gas, in which case the business case can be harder to make. Further significant improvement in ICEs efficiencies is expected in upcoming years which could also reduce “the environmental” advantage of EFVs.

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), the main problem is that if the vehicle breaks, the repair cost become extremely high. That is the case, because of the high price of small repairs as well as because “EVs technique is not as well developed as ICEs and still only very few people are trained and educated to repair EVs” (Ninh et al., 2014).

Hiring of additional drivers is reported as a potential additional cost of EFVs compared to ICEVs. This happens, because an EFVs driver has to have a different set of skills, e.g. identification with technology, understanding the need for an economic driving style and an ability to communicate advantages of EVs to customers (TU Delft, 2013, German and Danish cases). In any case, there is an agreement that there should be a certain investment in training of drivers: both on operation of EVs and related to its eco-driving. Investment into the additional charging infrastructure might be of an interest if the company wants to have a large EFVs fleet. This can reach several thousands of US dollars (Pelletier et al, 2014).

More discussion appears on what is possible to improve the EFVs business case. Taefi et al. (2014) make an overview of options available to reduce the TCO of EFVs: i.e. reduction of capital investment (e.g. purchase price subsidy), increase in vehicle range (e.g. implementing slow and quick charging, implementing battery changing system or installing solar panels on the roof of the vehicle), increase of the EFV turnover (by communicating the green image, benefiting from additional privileges provided by local authorities), further decreasing the operational expenses (charging off peak hours allowing for reduced electricity rates). Also, some companies, for example, Greenway in Slovakia, start offering EFVs leasing services.

Economical insights from FREVUE and TransMission. The procurement process of the demonstrations within FREVUE project has illustrated that that the availability of smaller electric vans is relatively good. Several large manufacturers produce EVs for this segment. For the larger vans comparable to e.g. the Iveco Daily, the availability of vehicles is limited. Most of the vehicles used in this category are retrofitted vehicles, for example UPS changes the powertrain and refurbishes the old vehicle, whereas TNT makes use of retrofitted vehicles on a new Fiat Ducato chassis. The Cargohopper 2 is an example of a vehicle in this category that has been completely developed for TransMission. Trucks are relatively scarce in electro mobility. In FREVUE two of Heineken’s logistics service providers are using an electric truck at this moment (one 19 ton truck and one 12ton truck), which will be increased to seven trucks in total. . Articulated vehicles are not available at this moment at a feasible price (not as full EV, but also not as plug-in hybrid). The FREVUE demonstrators have confirmed that the availability of EFVs varies: in general the market for smaller vans is reasonably well developing, whereas larger vans or trucks are often tailor-made or produced in smaller batches. This translates into the extra procurement costs: smaller vans are more expensive than conventional vans with an order of magnitude about twice the procurement price and (retrofitted) larger vans show an order of magnitude about twice to four time the procurement price of a comparable conventional vehicle. Trucks can be about four / five times (or more) as much in procurement. Demonstrators also confirm cost advantages of EFVs, such as the use of electricity instead of diesel, tax reductions, and subsidies.

Finding a feasible business case for use of EFVs in city logistics operations is still a challenging issue. Following the line of reasoning as described in Quak et al. (2014), we see that using an EFV in city logistics mainly affects the cost-side. 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 discussed in the following sections. On the other hand, the use of EFV usually does not result in extra revenues as most customers do not want to pay more for zero emission deliveries. Therefore it important to find ways to make the business case feasible.

One of these examples where operational advantages were found is the case of the Cargohoppers in Amsterdam. In the baseline scenario when all deliveries were made by conventional vehicles TransMission runned two networks in Amsterdam: one for parcels delivered by vans and one for pallet-loads (or bigger) delivered by trucks. These networks overlapped geographically. In the new situation all deliveries are brought to the micro hub where further sorting is done in the four Cargohoppers. The networks that were separated are combined in this new situation and as a result TransMission needs fewer kilometres (both in Amsterdam and in the trips from the depot in Almere to Amsterdam and back): an operational advantage!

3.4. Environmental, social and attitudinal impacts: confirmation of positive trends

Undoubtedly for now main strength of EFVs continue to be its environmental performance, manifested in reduced CO2 emissions and almost absent tailpipe and noise emissions compared to the ICE. For the full picture well-to-wheel emissions need to be considered and therefore certification of the electricity supply is important. Being less noisy and more environmentally friendly than conventional vehicles, EVs continue to be very well perceived by the general public and receive positive feedback from drivers in most of the initiatives. Though, as mentioned before, with appearance on the market of freight vehicles running on alternative fuels and with the strengthening of EURO standards for ICEVs this competitive advantage of EFVs reduces in the future.

Some companies look at their experiences with EFVs as on a clear opportunity , e.g. “the early implementation of electric mobility in courier and express services gave as a head start over the competition to learn about the new electric vehicle technology and the processes that need to be tailored in the daily workflow” (TU Delft, 2013, German cases). Baster et al. (2014) report that “the green image is perceived as a future investment and not as an investment which can provide profit today”. Companies report that utilisation of eco-friendly vehicles helped them to strengthen the relationship with existing customers and gain new ones. Though, majority are still more reluctant, focusing on the financial case of the EFVs. As was summarised by one transport operator: “about 98% of its customers are looking at the price and delivery service. So if price is a bit higher, because the company is driving EFVs, very few customers would be interested in it” (Ninh et al., 2014).

Training is necessary in order to familiarize drivers and general transport operators with the technical and operational particularities of the vehicles in order to achieve better results from the vehicle performance. After utilizing the EVs for some time, the drivers report to be very positive about the EVs performance and comfort. Some are saying to be proud in driving a vehicle that does not pollute. From TransMission we learned not all drivers are suitable for driving EFVs, as they do not succeed in conscious driving.

3.5. Local policy and governance structure: to a more integrated city management approach

Supportive government policy is still of a high importance for the wider uptake of EFVs. Initially financial subsidies were largely used. Nowadays there is an understanding that non-monetary incentives are also very important, as financial ones are not sustainable on a longer term. A better way to support the mass adoption of the alternatively fuelled technology is to give them a long term competitive advantage.

Variety of instruments are available for the local policy makers: financial incentives that aim to reduce an upfront costs of electric vehicles and charging equipment (e.g. purchase subsidies and all forms of tax exemptions) and prioritized access initiatives (e.g. access to high occupancy lanes; exemption from road tolls; extended delivery time window; exemption from maximum weight restriction; preferential parking, etc.). However, the main question for the local policy makers today is not only which instrument to choose, but also how to choose the right instrument and apply it in the way that intended effects are maximized and that there is a maximal space for unanticipated effects (van der Steen et al., 2014). Moreover, in case of financial support through the preferential taxation of the EFV, it is recommended that the value tax being put on a vehicle should not aim to encourage a specific vehicles “technology”, such as electric vehicles, but should be depended on the level of pollution produced by specific fuels (Baster et al., 2014). This way vehicles reducing pollution in the most cost effective way are chosen.

Policy insights from FREVUE and Transmission. 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. In FREVUE demonstrators three instruments are used cities to promote the uptake of EFVs:

- Subsidies/purchase – in FREVUE many of the vehicles are partly (i.e. a part of the extra costs compared to a conventional vehicle) funded from the project. Some local authorities have subsidies available for the procurement of EVs example e.g. Amsterdam.
- Some of the FREVUE demonstrations use favorable 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. Some of these instruments focus more general on electric vehicles rather than EFVs. For example, carriers do often not pay parking fees when making their deliveries, so there is no actual operational advantage for EFVs if these vehicles do not have to pay a parking fee.
- 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. At the same time some environmental zones do not apply to vans and as a result in these cities there is no operational advantage for electric vans at this moment (see for example Rotterdam, Madrid).

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.

4. Main strengths and weaknesses determining EFV uptake

Despite of the increased availability of vehicles and information about the EFVs on the market as well as technological progress that is made, main strength of the EFVs continue to be of environmental and social value. The main weakness that makes the EFV business case still problematic, is the lack big manufacturers producing the large vehicles and providing support via the dealer-networks, as well as the high battery prices. Operational specifics is more and more integrated into the daily routine of the companies neither representing a big challenge or operational advantage. The opportunities lie in the improvement of the vehicles technical performance and specifically in the increase of the vehicle payload, in order to increase its attractiveness. Finally, main threats are related to the increased environmental performance of the vehicles running on the alternative fuel. Table 1 illustrates the main strengths, weakness, opportunities and threats in more detail.

Table 1. SWOT of EFVs compared to ICEVs

Strengths	*Weaknesses*
Low fuel costs	High procurement costs
Efficiency of operation in case of government support	Limited loading capacity
Good environmental performance	Limited, unreliable and expensive after-sales support
No noise from vehicle	No better revenues (limited number of customers paying more) for EV deliveries
Positive acceptance by public	Grid issues with large fleet
	Limited availability of vehicles
Opportunities	*Threats*
New(er) vehicles have higher range	Unclear regulation regarding certification
Well-fitting to the specific niches	Better environmental performance of vehicles running on alternative fuels
Availability of public charging points	Low oil prices, and increasing energy prices
Innovative vehicle/battery leasing schemes	
Decrease in battery price	

5. New insights into freight electro-mobility: changing focus in the discussions about EFVs in city logistics

In this paper we discuss the current tendencies in the implementation of the electric freight vehicles in urban logistics. Results from FREVUE and the case of Cargohopper in Amsterdam are combined with reviewed trials and running activities. Where EFVs in the early years received mainly criticism about the limited range, now transport operators are shifting their attention on how better adapt their operations to deal with the smaller range. EFVs are perfectly fitting the requirements of urban logistics, especially within small and medium sized cites. Currently, focus is on defining which kind of activities in city logistics can benefit most from the EFVs case. The business case, for operators, for using an EFV is still suffering from high purchase price of the vehicle and uncertainty about its residual value. Though, accepting for now these two factors, companies are trying to find ways on how to improve the TCO of their vehicles by acting on other cost elements. At this moment, local authorities' support is still a critical factor for the successful wide spread of the EFVs. However, there is a growing understanding that even though financial incentives are currently the most powerful in order to support the market uptake of the vehicles, in the long term a more integrated city management approach is necessary. The focus is shifting towards more non-monetary measures and general support of the less pollutant vehicle technologies. Lack of qualified and reasonably priced aftersales support, necessity to develop new ICT concepts both for in-vehicle and for vehicle-grid connection and absence of proper certification mechanisms are reported as challenges for this moment.

Having summed up these: the demonstrations show that the current generation EFVs have a good technical performance (next to the obvious good environmental performance). In general, companies using the EFVs are satisfied and often look at opportunities to deploy more EFVs. Obviously still some barriers have to be levelled, but the solutions to do so are far from insuperable, as also noted in this paper.

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