Comparative Analysis of European examples of Freight Electric Vehicles Schemes.

A systematic case study approach with examples from Denmark, Germany, The Netherlands, Sweden and the UK

Tessa Taefi[1], Jochen Kreutzfeldt[1], Tobias Held[1], Rob Konings[2], Richard Kotter[3], Sara Lilley[3], Hanna Baster[4], Nadia Green[4] Michael Stie Laugesen[4], Stefan Jacobsson[5], Martin Borgqvist[5], Camilla Nyquist[5]

[1]University of Applied Sciences Hamburg, Germany,
[2]Delft University of Technology, The Netherlands
[3]Northumbria University, Newcastle upon Tyne, UK
[4]FDT - Association of Danish Transport and Logistics Centres, Aalborg, Denmark;
[5]Lindholmen Science Park AB, Gothenburg, Sweden

Abstract: eMobility is a hot topic, in the public policy area as well as in business and scientific communities. Literature on electric freight transport is still relatively scarce. Urban freight transport is considered as one of the most promising fields of application of vehicle electrification, and there are on-going demonstration projects. This paper will discuss case study examples of electric freight vehicle initiatives in Denmark, Germany, the Netherlands, Sweden and the UK and identify enablers and barriers for common trends.

1 Introduction

The issue of e-mobility deployment for freight vehicles has so far not gained substantial attention despite electric freight fleet city distribution being most mature in North America, and to some extent in Europe. A number of studies and pilot tests have been conducted in Europe, as private initiatives, within regional or federal projects and European Union's framework programmes. Using findings and research gathered for the *North Sea Region Electric Mobility Network* project, this paper discusses electric freight fleet vehicle pilot initiatives in Denmark, Germany, The Netherlands, Sweden and the UK.

2 Background

With dwindling fossil resources, concerns for climate change, urban air pollution and public health concerns, the deployment of electric vehicles (EVs) is becoming more central. Within the EU, the road transport sector produces 20% of the total CO_2 emissions and is the only major sector where CO_2 emissions are still increasing. Cars and vans (up to 3.5 tons) contribute to 15% of EU's road CO_2 emissions; trucks and busses produce approximately 25% of the road CO_2 emissions (European Commission, 2012). The EU's 2011 *White Pape*r supports research and outlines a long term strategy for transport development. The European Green Cars Initiative (including long distance truck innovation) follows the European Green Vehicles Initiative, with the objective of energy efficiency of vehicles and alternative powertrains. Regional initiatives include the Interreg IVB programme's *North Sea Region Electric Mobility Network* project (forum for Clean Urban Freight Logistics Solutions). Other project examples include:

- ELCIDIS (Electric Vehicle City Distribution) project trialling hybrid electric trucks and electric vans for urban goods distribution in Europe;
- CITELEC (the European Association of cities interested in electric vehicles) disseminate the idea of electric mobility.
- FREVUE (Freight Electric Vehicles in Urban Europe) project is running urban freight EV demonstration projects in Amsterdam, Lisbon, London, Madrid, Milan, Oslo, Rotterdam and Stockholm.
- Deutsche Post DHL's pilot project deploying electric delivery vehicles in its fleet in Bonn city centre and the surrounding region (Cars 21, 2013).

There is increasing guidance for and research into fleet EV usage, including vans (EV20 et al, 2012). A report by Element Energy (2012) outlines the total cost of ownership of low and ultra-low emission plug-in vans (fully electric, hybrid, hydrogen, under 3.5t gross weight). The results highlight the '*strong potential for ultra-low emission vehicles in the light commercial vehicle market in the medium term, as rising fuel costs and falling battery and fuel cell costs cause ownership costs to converge. They also highlight the short term cost challenge for EVs, where high battery costs (particularly in larger vans) are likely to restrict widespread deployment beyond fleet trials and early adopters without strong policy support.*'

3 Methodology

A comparative case study methodology aims to compare multiple subjects. As a cross-country study, the aim here is to identify, analyse and explain similarities and differences across countries whilst identifying key issues and trends (Yin 2009). Issues seen as most relevant as enablers and barriers to introduce new transport technologies successfully (University of Antwerp, 2012; Binsbergen et. al., 2013), namely Environmental Factors, Technical and Logistics Factors, Financial and Regulatory Factors, Energy Supply and Infrastructure, ICT factors and Human Factors, were identified and applied consistently by researchers in their respective countries as a common analytical framework to the case study examples. The method of data collection has been based on secondary data collection, largely internet based searches. The information gathered was analysed to draw out the important and active actors in the adoption of EVs. Semi-structured telephone interviews and e-mail correspondence were used for data validation and verification.

4 Results

4.1 Environmental Factors

The performance of the electric freight vehicles in terms of tailpipe and noise emissions is a strong focus for their application where local air quality and noise are perceived most problematic, i.e. in city centre shopping areas. The environmental performance of EVs means that their application in residential areas, such as garbage collection and home delivery of packages, are emerging markets for electric freight vehicles. Many initiatives and involvement in EV experiments are driven by companies' awareness and anticipation of regulations for less environmentally-friendly vehicles becoming more restrictive in the future. It is difficult to assess the total environmental benefits for cities because reducing emissions depends on the extent to which conventional urban freight transport can be replaced by its electric counterparts, let alone the issue of upstream emissions depending on electricity source. Reducing local air pollutants were named as benefits throughout the cases, though without detailed calculation of emission savings. Calculations of CO_2 emissions reductions are summarized in Table 1.

Table 1: CO2 emission reduction calculated in cases

UK	Germany	Denmark	Netherlands
5- 12 tons per truck and year[1]	35 - 70 percent[2]	36 percent	1-2 Megatons p. a. in 2050

[1] Office Depot, Sainsbury's, Speedy Hire, Tesco

[2] Project colognE-mobil

The more silent operation of the EVs was perceived positively by residents, passengers and drivers[3]. For the operation of EVs in park and cleaning public spaces, EVs were perceived advantageous with regards to noise though human and animals didn't notice the vehicles until they were close by[4]. A warning indication was recommended in pedestrian areas[5].

4.2 Technical and Process and Logistics Factors

The limited operating range and payload (due to the heavy batteries) of EV batteries is a strong factor determining the application of freight EVs. The required range and payload is company-specific, depending on customer density, customer demand and weight or volume of goods. Freight transport in urban stop-and-go traffic with a limited kilometre range and cargo capacity is an important first market for EVs. The EVs are energy efficient and recuperate energy when braking in stop and go traffic. The cases confirm the technical compliance of EVs to the daily driven kilometrage on a significant amount of urban tours as can be seen in table 2. However, for the Netherlands and German examples, the limited operating range of electric trucks caused less flexibility in planning trips, or restricted ad-hoc tour planning and hence caused less efficient operations. The ability to charge in between tours is a positive factor if the range is lower than the required mileage. Companies charged or quick charged[6] whilst new freight was loaded, or installed solar panels on the roof of the EVs[7] to extend the range. While the inner city mileage of the EVs was often sufficient, the stability of the battery range was reported as problematic: The kilometre range declined over time through battery ageing, when carrying heavy loads, as well as in winter due to electrical consumers like heating, lights and ventilation[8]. Furthermore, the range listed by EV manufacturers 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. The reliability of the EVs was dependant on the model; certain prototypes and conversions were judged as reliable[9], while others[10] were reported as insufficient.

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[3] colognE-mobil; DHL Germany; Meyer&Meyer Germany; United Parcel Service Germany
4 colognE-mobil
[5] Effenberger Bakery
[6] Joeys Pizza service and City Express Hamburg, Tesco and Sainsbury's London
[7] Cargohopper, the Netherlands
8 DHL recorded an increased energy demand in winter of 30 to 60%.
[9] UPS Germany (conversion of 15 year old UPS truck); DHL (Iveco E-daily); Hermes (Mercedes Vito E-cell); Joeys Pizzy (eScooters);Nappy every after (Bradshaw EV)

Once the EVs were stable, the low maintenance needs due to less movable parts was highlighted positively[11]. However, in many case studies throughout all countries a low quality in aftersales services was experienced, with lack of repair shops, limited know how for repairs, low availability of spare parts lead to longer repair times and loss of money. Substantial truck manufacturers are not yet being strongly involved.

Table 2: Average mileage reported in freight transport cases.

Country	Mileage in freight transport cases
UK	Used only 25% of full battery charge per working day[12].
	Adequate for courier services with micro-consolidation hub[13].
	Localized journeys below 25 km[14].
Germany	EV range sufficient[15]; 11,000 km on average per year[16].
	Chose profiles with high density of stops and low parcel volume[17].
	Not suitable for courier services with 200 km per day[18].
	Low daily, reoccurring mileage[19].
Denmark	EV range described as more than suitable[20].
Netherlands	Maximal tour length of all cases in Amsterdam was 80 km.

4.3 Financial and Regulatory Factors

The cost competitiveness of electric trucks compared to conventional trucks influences the large-scale implementation of EVs. Case study companies calculated the 'total costs of ownership' (including costs of investment for EV and charging infrastructure, costs for energy and other costs such as vehicle tax, insurance, service and maintenance, repairs and environmental charges) as key financial indicator for profitability. Due to high investment costs, EVs are more expensive unless they reach a daily high mileage. Table 3 shows grant subsidies or exemptions in the the countries.

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[10] UPS: Modec. In the Netherlands it was felt that the vehicles were sensitive to failures, in particular converted vehicles.

[11] The costs for service and maintenance are 20 – 30 % lower than for conventional vehicles, (DHL Germany). Lower maintenance costs were also reported in the UK (Enterprise Mouchel, Sainsbury's, UPS).

[12] UPS, parcel delivery, London

[13] Gnewt Cargo ltd., delivery services, London

[14] Melrose and Morgan, food delivery London

[15] Hermes Logistics, parcel delivery

[16] DHL, parcel delivery

[17] UPS, parcel delivery

[18] City Express Logistics, courier services

[19] Effenberger bakery, transport on-own-account

[20] Seas-NVE of Frederiksberg municipality, postal delivery.

Table 3: Cost factors, subsidies and exemptions of electric vehicles.

EV		Subsidies and exemptions			
Cost factors	Costs compared to CV	UK	Germany	Denmark	Netherlands
Investment	2- 3 times higher	20% up to £8,000	In projects up to 50%	None	50% of difference up to € 40,000
Charging infrastructure in depot	Depends on technology	No subsidy	No subsidy	No subsidy	No subsidy
Energy	Half price	None	None	None	Amsterdam: Free public charging
Taxes	Exemptions:	Road fund license, Van benefit charge (5 years)	Vehicle tax (10 years)	Sales tax up to € 7,500 (until 2015)	Vehicle tax
Service & maintenance	Depending on EV model	None	None	None	None
Environmental charges	Exemptions:	Congestion charge (London)	None	None	None
Parking	Exemptions:	Free or reduced	None	Free, e.g.. in Copenhagen	Free in Amsterdam
Driver's license	Exemptions:	Class B until 7.5 t	None	Class B until 7.5 t	Class B until 7.5 t

The environmentally friendly image of EVs is a soft financial factor that cannot be easily quantified. 'Green credentials' were mentioned by companies as a positive influence on deciding to use EVs. UK case examples reported benefits with taking the lead with EV delivery[21]. In Germany, positive and extensive press coverage served as a commercial measure for gaining new customers[22]. Companies in the Netherlands stated that the EV operations are not cost competitive compared to the regular vehicle operations but believe that an EV has a strong promotional value, which may pay off by attracting new customers who appreciate sustainable transport solutions[23].

For electric trucks to be a viable alternative a combination of the following factors must be present: daily distances travelled are high as the electric trucks' maximum range is 100 miles (but the battery energy constraint is not binding); low speeds or traffic congestion are prevalent in the route area; customer stops are frequent/numerous (meaning the electric engine is more energy efficient), gradients or other factors exist which cause increased expenditures of energy; the purchase price is reduced by tax in-

21 Gnewt Cargo Ltd, Sainsbury's, Brewers, Speedy Hire Melrose and Morgan
22 Effenberger bakery, City Express Logistik, Meyer and Meyer, Joeys Pizza delivery
23 Technische Unie

centives; increase on taxes for CVs (yearly vehicle tax, purchase tax, mineral oil tax). EVs do, however, have a higher depreciation value.

4.4 Energy Supply and Infrastructure Factors

Recharging EVs is an important issue determining the use of EVs both in terms of its charging availability and flexibility. The recharging techniques mostly discussed are slow charging, fast charging, battery swop stations and inductive charging. The most common way of charging for the case studies was to slow charge the vehicles over night at company premises. However, in-house charging infrastructure and infrastructural challenges have been faced by the freight delivery companies in Germany[24]. The in-house charging infrastructure had to be adapted several times; it was overloaded by the high capacity need of the e-trucks. Other charging related issues found were that the implementation of a smart grid and load management for large electrical fleets is not yet clarified; solutions to ensure charging in case of power outage are necessary; and charging plugs were too damageable and only specially trained staff could handle the plug, which caused problems with replacement drivers and training issues. Quick charging outside the company's premises would be an option, if quick charging would not reduce the batteries' life span. However, logistic processes and tour planning would need to be adapted (Schönewolf 2011: 7). The limited number of charging spots outside the cities and lack of battery swapping for larger vehicles was criticized in Danish cases[25]. The charging public network in London was welcomed by companies, allowing them to park and charge during lunch, extending the kilometre range[26].

4.5 Information and communication (ICT) Factors

The European Commission (2007) highlights that the efficiency of urban freight distribution can be increased with the help of ICT systems, in particular through better timing of operations, higher load factors and more efficient use of vehicles. Throughout the case studies here, the need expressed by companies for ICT solutions were ambiguous, depending on

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[24] DHL, UPS

[25] TRE-FOR A/S and the Danish Energy Agency

[26] Melrose and Morgan, Gnewt Cargo ltd.

the area of business and amount of EVs used[27]. 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, i.e. the short distance transport with an electric vehicle was outsourced[28]. Mainly in larger fleets with dynamic scheduling the dispatching software should take into account the remaining (and predicted) battery level, to maximize the dynamic scheduling of EVs and capitalize on the low operational costs[29].

4.6 Human Factors

Human factors include the behaviour and attitude of EV users including electric truck drivers, electric truck customers and the general public. The perceived performance of EVs by users greatly determines the willingness to accept and use EVs; therefore human factors are a highly relevant for EV implementation. In some cases, the drivers reported an initial rejection of the vehicles; training of drivers was important and led to a high level of acceptance. After utilizing the EVs for some time, the drivers were very positive about the EVs, especially “the impressive acceleration”, having the comfort of an “automatic gear-box”, fail-safeness and the silent operation. It was observed that drivers identify with ’their’ EV and work more than before [30]. Electric scooters proved to have strong advantages for the delivery staff[31].

The visibility of electrical delivery vehicles is high, making them a good means of communicating the advantages of electric mobility to the public. Communicating EVs to passengers and customers was highlighted as a positive aspect in the UK and Germany in several cases[32]. The limited

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27 In Sweden, the market for urban freight transport and distribution does not express a need for ICT solutions.

28 Delta Stadsdistributie (Netherlands)

29 DHL and City Express Logistik (Germany)

30 DHL, UPS, Meyer &Meyer, City Express Logistik (Germany).

31 Joeys Pizza Service: “they do not stink, are silent and passengers do accept the eScooters, when squeezing into corners for parking”.

32 “My job did become more communicative. I talk to customers and pedestrians during the day a lot, their feedback is overwhelmingly positive. At the end of the day I feel affirmed instead of stressed: usually an express driver does receive mostly negative reactions during the day, for example because of a slow delivery, due to the traffic congestion, or when parking in the second row and hindering the traffic”(City Express Logistik).

range of the vehicle was judged an advantage in two cases[33], as drivers need to drive in a moderate and energy efficient way; a considerate driving style increased the range by 30%[34]. A considerate drive style includes among others gentle acceleration and using recuperation when ing[35].The drivers' behaviour, alongside as the ambient temperature and loaded weight, is an important when discussing factors that influence the maximum range.

5 Conclusion

Our comparative analysis of freight EV initiatives has revealed that enablers and barriers for start-ups and wider application of freight EVs are generally similar in these countries. The different country cases indicate that many EV applications are good experiences, although whether or not an application is successful is largely case-specific and dependent on if the performance of the EV complies with the intended transport use for this vehicle. The cases suggest EVs are used for many types of transport activities in urban areas, transporting grocery products, beverages, textiles, furniture, parcels to gardening and waste. This shows potential for the wide implementation in urban transport, but the cases also indicate major conditions that are required to achieve this extensive use of EVs.

A key factor is the technical performance of the EV, although the required operating range is company specific and satisfying in many cases although there is a shared interest to increase the range to enable a higher utilization rate of the vehicle and, hence, improve its competitiveness to CVs. Increasing the range refers to improving the batteries performance, stability and reliability, particularly highlighted by case study examples in Germany and Denmark, with harsh winter conditions. The loss of pay load due to the heavy weight of the batteries was a universal problem across the case study examples. Although it affects the competitiveness of the EV negatively, it is not considered critical, since adapted regulations regarding driver license and qualifications can largely compensate its impact. One of the largest barriers experienced by all country cases was the lack of quality in aftersales services, i.e. a lack of spare parts and the limited knowledge for repairs.

A major observation throughout the case studies is the concern that operating an electric freight vehicle is not profitable, although it could be in the

33 City Express Logistik (Germany), Nappy ever after (UK)
34 DHL
35 Sainsbury's

near future. Companies consider their involvement in EVs as a way to explore the use of electric transport, prepare for future policy and to get a frontrunner position in the transport sector regarding sustainability. Their involvement in electric freight transport is strongly driven by companies' ambitions to have environmentally sustainable operations, and hence a "green" image with soft financial benefits. Operating an EV is considered an opportunity to showcase sustainable ambitions and possibly attract new customers. The cases suggest that to stimulate the use of electric freight vehicles, major incentives are needed to compensate the existing disadvantages of EV use, for example subsidies to compensate the high initial investment costs and granting privileges to these vehicles (e.g. exemption of time window delivery restrictions and privileged access to city zones).

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