The Future of Sustainable Urban Freight Distribution – A Delphi Study of the Drivers and Barriers of Electric Vehicles in London

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Abstract

The use of electric delivery vehicles in urban applications is a viable solution proposed by government and academic research to enable the logistics industry to achieve the carbon emissions reduction targets set in the UK for 2050. This paper examines the multi-dimensional drivers and challenges of the use of electric freight vehicles as a primary means for the decarbonisation of urban freight transport. A theoretical framework closely linked to disruptive innovation is established to demonstrate relationships and is empirically examined through a mixed research approach of observation and a two round Delphi survey analysis. The findings suggest that (i) electric vehicle use is driven by urgency to improve city logistics, (ii) prevention of adoption is primarily cost and vehicle performance, (iii) there were notable differences in expert stakeholder perceptions of motivators and barriers. Implication included the prioritisation of targets for policy and practice to resolve.

1 Introduction

The use of electric delivery vehicles in urban applications is a viable solution proposed by government and academic research to enable the logistics industry to achieve the carbon emissions reduction targets set in the UK for 2050 and further abate the impacts of climate change. As electric vehicles (EVs) are being increasingly introduced to improve the sustainability of city logistics, this research assesses the use of EVs in the development of city logistics as a primary means for decarbonised urban freight transport. The research will assess the drivers and barriers to its implementation in the delivery fleets of supply chain operators in London.

Improving the environmental sustainability of logistics has an overwhelming international importance given the threats and serious environmental impacts of global warming and climate change [1]. Growth in freight transport and emissions are expected to continue to grow globally as a result of economic growth [1]-[3]. Since freight transport is primarily fuelled by diesel and accounts for 20 percent of the total GHG emissions emitted by the transport sector [3], [4], the UK is currently in alignment with EU objectives and is at the forefront with its policy to reduce emissions between 80-95% from 1990 levels by 2050 [5], [6].

Electricity is a primary option for alternative fuel to substitute oil as an energy source for propulsion in transport [1]. Electric commercial vehicles, which are driven by a battery powered electric motor and are charged from mains electricity, are known to have 0% tailpipe CO_2 emissions and overall emissions, and are estimated to be approximately 40% lower than conventional diesel fuel depending on the electricity generation source [7], [8]. Given these advantages and the applicability of the technology in urban commercial freight fleets [7],[9], an investigation to assess the drivers and barriers affecting the vehicle technology's widespread use in cities is useful from a regulatory, transport industry and business management research perspective.

For commercial use, electric vehicle technology is currently limited to vehicles up to 12 tonnes and typically suited to operate from a single point of distribution with a limited delivery range [9]. Nonetheless, their urban applications are being encouraged and demonstrated throughout London in combination with other city logistics initiatives such as urban consolidation centres (UCC) [10].

The aim of this research will be to assess drivers and barriers surrounding the use of fully battery electric vehicles in decarbonised urban road freight transport fleets in the United Kingdom. Specifically, in order to meet this aim, this research plans to evaluate the perceptions of key stakeholders involved in the implementation of electric commercial urban freight vehicles in London and to develop a customised framework for commercial electric vehicle use that delineates the primary drivers and key challenges for market commercialisation in London.

2 Literature review and research framework

2.1. Drivers for EV Use in urban freight transport

On a global scale, freight trucks currently cause about 23% and light duty vehicles 40% of the global transport energy consumption and greenhouse gas (GHG) emissions [2], [11].With the EU objective set to reduce CO2 emissions by 80-95% by the year 2050, with respect to 1990 level, decarbonisation transport systems and substituting oil as a transport fuel will also follow this same timeline [1].

At an international level, technical analysis such as the EU Roadmap 2050 [12] and guidelines have sought to confirm that these global targets are technically possible for the transport sector. It identifies that the decarbonisation in the transport sector requires mass application of electric vehicles, hydrogen fuel cell vehicles as well as biofuels – all which will require a significant improvement in performance and cost.

The UK has taken the agreed stance of the EU to drastically reduce its GHG emissions aiming to reduce CO2 emissions by at least 80% by 2050 are set out in the Climate Change Act 2008 [6], [13], [14]. Transport emissions in the UK are known to be 21% of the total UK domestic emissions [6]. With freight contributing to 24% of this total [14], decarbonising transport must also contribute to the solution.

To meet carbon budgets for 2050, the CCC, [15] estimated that 90% reductions are required in the transport sector compared to 1990 levels. Further investigations by Hickman, Ashiru and Banister [16] have looked at the optimisation of policy packages to achieve effective implementation of the ambitious carbon reductions in the transport sector. Ultimately, it is an elimination of the dependency on oil that will enable freight transport decarbonisation.

Use in improving city logistics

Electrification of road freight transport in urban environments or urban logistics is also explored in an emerging discipline known as city logistics. WBCSD (2001) stated that freight movement used 43% of all transportation energy and slow-moving freight vehicles were a significant cause of congestion on highways [3].

2.2. Barriers against EV use in urban freight transport

What are the limitations to Electric Vehicle technology? Major automakers involved in electric vehicle development cite that a breakthrough in battery technology is still, a century later, required for EVs to be commercially viable. Amongst the descriptions to the barriers to implementation, the studies by the EC (2011) describe that key components of electric vehicles, particularly the batteries, on-board power management and systems for vehicle-grid interaction and infrastructure impacts will require support in research and in integrated demonstration projects.

The limitation to EVs lies in its dependence on batteries, which are heavy, and limit the distance range that can be travelled by a freight vehicle [9]. Current applications of electric vehicles are city cars and urban delivery vehicles up to 12 tonnes [7], [17]. The distance range of EVs has improved to where it now can travel in excess of 250 miles and EV are frequently used for van-based home deliveries. Small delivery vehicles, such as those made by Smith Electric Vehicles are currently used by a number of UK companies [9].

The primary drawback for EV technology is that their capital cost is much higher than that of a conventionally fuelled vehicle[9]. Freight Fleet [17] states that the lithium-ion battery backs have been used in Smith Electric vehicles for only 3 years and it is difficult for managers to set resale values without any historical data. With secondary markets, a small business owner in London who generally would not be able to realise cost benefit of new £60,000 EV may be able to take advantage of a £15,000 van that saves potentially £5,000 in fuel, tax and congestion charges [17].

- Competition and organisational decisions - A complex stakeholder network and a lack of knowledge to achieve EV market uptake remains as a limiting factor for use in urban road freight transport. When considering the cost and benefit of adopting an environmentally friendly new technology or new type of equipment, Bae, Sarkis and Yoo [18] have considered optimal levels of adoption and documented a gap within the academic literature. In their model and experiment, they began to fill a gap in analysis for specific organisational investment and adoption of green practices, particularly within a transportation investment perspective.

- Elusive business case for sustainability - The business case to quantify the financial advantage for adopting the use of new technology is another limiting factor preventing haulage firms from investing in freight EV. The business case for sustainability remains elusive in that strategic models merely cover intangible effects of a firm's reputation rather than linking sustainability directly to a company's financial performance [19].

- EV technology as a disruptive innovation -Electric vehicle technology is a disruptive innovation [20]. The concept of a disruptive technology is defined as an innovation that brings to a market a very different value proposition that had been previously available - resulting in worse product performance, at least in the near term [20]. This framework presents a suitable way of looking at the barriers EV technology for commercial transport as Cooper [21] expands upon in developing a strategic marketing plan for such disruptive innovations that affect the dimensions of consumer decisions.

3. Research Methodology and Method

3.1. Research Strategy

The two primary sources of data collection methods chosen were:

- Observation as participant: The observation of EV use in the field produced primary descriptive observations of the activity of urban freight delivery using electric vehicle. The role of the observer as participant followed a journey of a single day of freight deliveries using an electric vehicle to deliver goods in Central London. Following the observation task, an observational protocol was used for the observational data collection and detailed notes were recorded within 24 hours of the field session.

- The Delphi Method: The primary data collection method of this research employed the Delphi Method. This technique aimed to uncover drivers and barriers to implementation of electric vehicle in urban freight distribution in London to gain a clear picture of the dynamics of the freight electric vehicle market and seek to understand the opinion of a panel of expert stakeholders in a structured manner.

The advantage of this technique in this research is to conceptualize or invent the future by a group of specialists, stakeholders or operators affecting the use of fully electrified vehicles for urban freight distribution.

3.2. Data Collection Process

Rather than exploring multiple locations or a larger geographic area for data collection, a focus on a specific urban environment – London was chosen where evaluation research can take place of existing electric freight vehicle fleets.

Delphi panel members were sought from a range of key stakeholders to canvass a wide range of opinion – industry advisers, governmental policy makers, electric vehicle fleet operators and academic researchers. Based on guidance by methods set out by [22], a nomination worksheet was used to identify candidates in relevant disciplines or skills to be included in the Delphi study:

- Specialist practitioners or consultants in the field of EV and urban freight.
- Government or local authority officials responsible for electric vehicle research and deployment in UK/London
- Academics as identified in the literature review with speciality in EV and city logistics.
- Logistics Operators with electric vehicle delivery fleets in London.

In order to have representation from each broad category of stakeholders, at least one representative in each category and a minimum total of 8 panellists for the study was desired. All nominees were treated as a single panel with their categories being validated during the panellist response section of the first questionnaire. A profile of the Delphi respondents, including their self-reported expertise level is provided (Table 1).

Respondent	Stakeholder Group	Expertise Score
1	Consultant	4
2	Consultant	4
3	Consultant	2
4	Consultant	4
5	Local Authority	4
6	Government	4
7	Academic	4
8	Operator	5

Table 1: Profile of Delphi respondents

Delphi Rounds

Due to the risk of participants losing interest in the study [23], two rounds were conducted in this Delphi approach. The second round feedback responses and sought to gain insight on the future landscape of using EV in urban deliveries for reduced carbon in freight transport. The Delphi 2 questionnaire was designed to rank the most frequent responses by the panellists to identify the most important drivers and barriers [24], [25] to the use of EV for urban freight distribution.

4. Findings and Analysis

4.1. Observation Findings

The observation was conducted on a vehicle depot of a fashion logistics provider that delivers into Central London using a 12t capacity Newton electric vehicle. The observation phase yielded the following list of drivers and barriers:

Drivers: City logistics and congestion, green / environmental image, adequate charging for depot-based operation, savings on congestion charge.

Barriers: Overall cost of the vehicle, charging requirements interrupts multi-shift use, need for larger vehicle options, reliability issues during early ownership, extra care required for pedestrians.

4.2. Delphi Findings

A total of 7 out of 8 panellists (87.5% response rate) responded to the Q2 round. In round 1, consultant panellist 3 was self-identified with an expert score of two out of five, the lowest of all selected panellists. All other panellists had scored themselves with a four or higher out of five.

Summary of responses

For each of the top factors identified by the group in Round 1, the panellist was asked to rate the factor from 1 to 5. The rating responses for all Q2 panellists and scores for each factor are provided in Table 2.

Drivers	**Average Score**
1. Cost savings from fuel cost	4.43
2. Low carbon emissions / zero tailpipe emissions	4.29
3. Traffic congestion leading to greater restrictions on freight distribution / use of consolidation centres	4.14
4. Reduction in whole life costs	4.00
5. Cost savings within Low Emission Zones / Congestion Charge	3.86
6. Cost savings from reduced maintenance	3.86
7. Ability and incentives to use out of hours	3.43
8. Enhanced public environmental image	3.57
Barriers	**Average Score**
1. Overall cost of vehicle	4.71
2. Vehicle range and battery performance	4.29
3. Battery design – weight	4.14
4. Payload capacity	4.00
5. Time required to recharge	3.83
6. Lack of larger vehicle options needed for urban freight operations	3.57
7. Reliability issues with freight EV	3.50
8. Low noise with potential increase risk to pedestrians and cyclists	2.57

Table 2: Q2 responses and rating analysis

The drivers identified in the initial observational data collection phase explored EV use in the distribution operations of light freight retail distribution operation. As the literature review had highlighted, use of electric vehicles for light freight and delivery of small scale retail goods at short distances is the most feasible logistics market for EV [5], [7]. The data collected from the observation of a depot-based delivery scenario for light goods fashion retailers ascertained further drivers and barriers from a successful operation of EV using the largest available electric 12t vehicle on the market. Close examination of the drivers as seen in the benefits a single operator highlighted the perceived importance of having a green image in the current marketplace and the value of a firm's environmental appearance in today's competitive market.

The extra care required for pedestrians were also a valuable insight uncovered in the observation stage. Throughout the literature review, low noise was cited as a marked benefit of EV suggesting that improvements to urban operations and city life using EV. The risk associated with low noise of EV is as an important issue – which was rated in Q2 and ranked at the bottom of the importance list. Pedestrians typically rely on being able to hear vehicles before they cross busy roads and small passageways in Central London. Observing the low noise in operation of the EV in operation raises a point for public safety. This important finding suggests that if EV were more prevalent in London, pedestrians require more attention at zebra crossings and equally drivers have to increase their level of awareness as the risk for accidents from the use of EV could increase.

5. Discussion, Contribution and Conclusion

The most important Delphi-rated issue was the cost of the vehicle which was cited in the literature [9], [17]. In February 2012, a 'carrot' incentive of an £8,000 grant for plug in vans was made available by DfT for fleet operators [26]. This aimed to be a catalyst to the fleet operators who, as confirmed in the research findings, found the overall costs of purchasing the vehicle prohibitive. The government introduced the grant to supplement part of the cost of purchasing an electric freight or service vehicle. While this is an encouraging stride for support of low emission technology, further assessment of the impact of the increase in uptake will be important research over the course of the scheme.

The inter-related issues of vehicle range & battery performance, payload capacity and battery design and weight were highly rated by the Delphi panel at #2, #3 and #4 in the barrier rating list. This is consistent with the literature as well as the observational data, in highlighting the view that R&D is the essential force for a low-carbon urban freight transport option. Pure EV requires higher capacity batteries to achieve market acceptance [27].

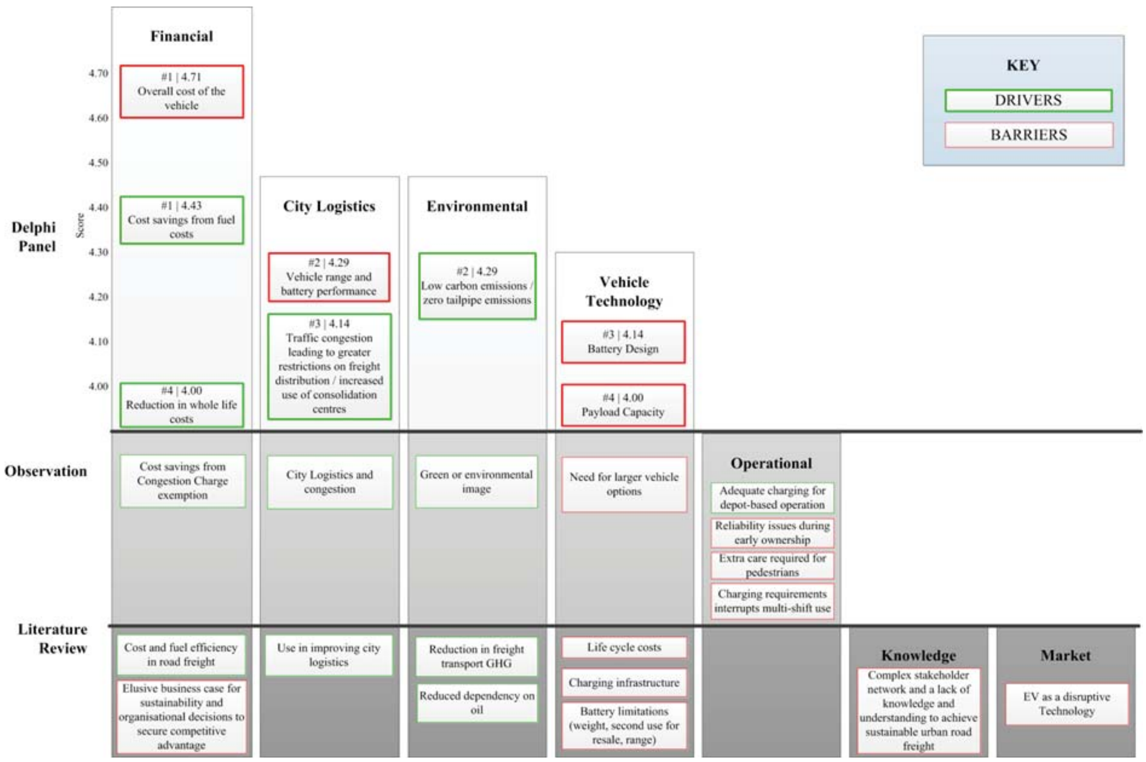
In this research, costs were identified as the primary barrier to EV. Cost benefits are achieved over the whole life, but the initial costs of the vehicle remains as a primary deterrent. Thus, in addition to tax benefits, policy needs to be introduced further incentives and grants that will allow logistics businesses to achieve a sound business case to decarbonise delivery fleets. Otherwise, other collaborative leasing and subscriptions models will need to be made available to increase freight EV uptake [28].

Operationally, EVs offer a significant opportunity to improve urban logistics systems and help to deliver a low carbon freight distribution solution. The ways in which key stakeholders respond, to the barriers and drivers alike, will impact the way in which businesses operate under increased pressures to reduce carbon emission levels from urban goods distribution.

There are a number of avenues of future research. The assessment of market disruption of freight EV as potential disruptive innovation could be more fully assessed in further research. The market opportunity freight EV presents as a disruptive innovation could provide valuable inside for R&D firms proposing to address the most important barriers to EV identified in this research.

Recommendations for further enquiry include the progress made on whole life cost analyses to further inform the key barriers identified research. This would include costs – purchase, leasing fuel, battery ownership, service maintenance and repair and driver training costs. Equally, the battery technology improvements and implications could provide further insight into this specific technological barrier explored in this research. The variables identified as key in the Delphi could be used to develop a quantitative (Structural Equation Modelling) piece of work and a broader geographical assessment.

Figure 1: Customised framework for primary factors affecting EV use in urban freight



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