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Socio-technical experiences from electric vehicle utilisation in commercial fleets

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HIGHLIGHTS

- Operations of +100 electric vehicles (EVs) in commercial fleets during 18 months.
- EV usage increases with gained experience but external factors influence operations.
- Practical experience boosts the general attitude towards EVs and user confidence.
- Fleet suited for electrification prior to public charging infrastructure expansion.

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ABSTRACT

Commercial vehicle fleets are in many ways an attractive entry for electric vehicles into the transport system. In total, 174 electric vehicles have operated in commercial vehicle fleets and gathered socio-technical data over a period of 18 months, resulting in 302,000 all electric kilometres. This paper presents two perspectives regarding electric vehicle operations in commercial vehicle fleets – the functionality perspective, illustrated by the vehicle actions, and the user perspective that addresses the implementation of the task. The socio-technical analysis has resulted in four major findings. With time, the overall usage and the driving distance between charging occasions increase. It is not the passage of time that has influenced this behaviour but it may be explained as the result of accumulated experience. Swedish winter conditions show regression in usage, foremost due to users not familiar with the range reduction caused by the heating system. The need for public charging has been shown to be modest, which in an introductory phase with limited development of charging infrastructure, makes commercial vehicle fleets favourable to electrify over private vehicle fleets. According to deployment strategy, the different user groups' ability to incorporate the electric vehicles in their daily activities has been explored and this paper shows large potential for substituting traditional internal combustion engine vehicles within commercial vehicle fleets. Electric vehicles have been made available through a technology procurement scheme and have generated both kilometres and experience, which has come to increase the understanding of the usage of electric vehicles in commercial vehicle fleets.

1. Introduction

The transport sector is often considered to be a difficult sector to unleash from fossil fuel dependence. Today, transportation accounts for 27% of the world's total energy use, contributes to 28% of the global energy-related greenhouse gas emissions and is 98% dependent on fossil fuels [1]. Compared to other stationary energy sectors, the transition to renewable fuels moves more slowly [2]. The European Commission has specifically targeted the urban transport with the goal to halve the number of fossil-fuelled cars by 2030 [3]. Electrification of the powertrain is an energy-efficiency-improving measure [4] and the number of electric vehicles in European urban areas is increasing [5]. The growth in installed capacity of non-hydro renewable power generation, i.e. geothermal, solar, wind, biofuels and renewable municipal waste, continues concurrently [6]. The high initial capital cost of the electric vehicle constrains mainstream diffusion. Several barriers may hinder the introduction of new transport technologies, for example in the work of Banister [7], but an initial deployment in commercial

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vehicle fleets would reduce multiple aspects of financial risk. Commercial vehicle fleets are governed by several policies, public fleets more than private. Procurement is a requirement for all public organisations but it is also a policy instrument for gaining the interest of private actors, who respond to a consumer-driven demand for greater corporate responsibility. For the European Union member states the Clean Vehicle Directive [8] and the Energy End-use Efficiency and Energy Services Directive [9] regulate public procurement of vehicles with strict energy efficiency requirements and with the aim to reduce the environmental lifecycle impact.

The European Commission emphasises the role of technology procurement to ensure rapid uptake of new energy efficient vehicle technologies in its White Paper on Transport [10]. Technology procurement aims to accelerate a market introduction of new innovative technology [11]. At this stage, consumers often perceive the market as fragmentised. During the development of the technical specifications for the procurement, existing innovative technology is inventoried and forms the foundation for concrete requirements. As the characteristics of the innovative product have been identified, actors may consider converging. Technology procurement is expected to create a market pull, by enlarging an emerging market, compared to a laissez-faire introduction [12]. Technology procurement is also recognised as an effective policy measure for reducing the electric vehicle purchase cost [13] as well as being identified as a catalyst for demand-driven expansion of charging infrastructure [14]. On a local government level, technology procurement may function as a non-market based local public policy instrument, complementary to national policies. In addition to national energy and climate policies, local public policies, such as procurement policy, are influential when it comes to the acquisition of new vehicles in public bodies and may ultimately influence the local energy and transport systems.

Public and private actors may collaborate and share framework agreement. A specific case of a public–private technology procurement of electric vehicles is the Swedish National Procurement of Electric Vehicles and Plug-in Hybrids scheme, initiated in 2010 and coordinated by the City of Stockholm and the utility company Vattenfall. The technology procurement scheme aims to facilitate market introduction and market expansion of battery electric vehicles (BEVs) and plug-in hybrid vehicles (PHEVs) in Sweden.

This paper will introduce the National Swedish Procurement of Electric Vehicles and Plug-in Hybrids and aims to present the experimental socio-technical findings from the operation of the 174 associated electric vehicles over an 18-month period. Using a socio-technical approach accounts for the effects of both technical data as well as user data. The need for a socio-technical research approach has been emphasised in other studies in order to achieve an energy and carbon-efficient transport system [15,16]. Electric vehicle operations at Swedish, i.e. Nordic, electricity market conditions may imply significant reductions of carbon dioxide (CO_2) from the transport sector. Opportunities achievable for this fleet are investigated. There are many studies of potential electric vehicle users [17,18] but little has been written about actual electric vehicle users. This paper aims to increase the understanding of the usage of electric vehicles in commercial vehicle fleets.

2. Materials and methods

A standard method for evaluating electric vehicles is using equipment to gather the technical data of interest. This approach allows the vehicle and its components to be analysed. Unlike traditional studies, this paper includes the user perspective and collects data from multiple sources to achieve an interdisciplinary socio-technical comprehension of electric vehicle operation. The user perspective is provided by the employees of organisations participating in the National Swedish Procurement of Electric Vehicles and Plug-in Hybrids scheme, which operates the vehicles in their daily activities.

The vehicle logbook reports information about driving distance and charging conditions (current and location) but also encourages the users to provide personal remarks, for a certain trip and/or share her/his general thoughts regarding operating an electric vehicle. User engagement has a proven, positive effect on the dissemination of sustainable energy technologies [19]. Therefore, user remarks concerning the data collection and method have been considered and have contributed in the method development process, which is described and published in [20]. The possibility to retrieve a user perspective is greater when the users submit their own travelling data, compared to automatic collection.

The electric vehicle users responded to web-based questionnaires, three in all, when coming into the scheme and then they repeated that exercise again twice with approximately a year in between. Questionnaires are a widely used research method since the method has the possibility to analyse the outcome from a large number of respondents to a relatively low cost [21]. The outcome may be studied either statistically or quantitatively. This paper will analyse questionnaires from electric vehicle users quantitatively in order to express the respondents' general opinions regarding electric vehicles and will study how this has varied with time. It was mandatory for all vehicles participating in the scheme to submit at least one questionnaire per round. The problem with low return rates otherwise associated with questionnaires was therefore avoided. A more detailed presentation of the carried out questionnaires are found in Section 5.2.

In addition to the vehicle logbooks and user questionnaires, interviews were carried out to corroborate the socio-technical interpretation of the collected data. Interviews are a common qualitative research method and may be more or less structured depending on aim and topic of the research [22]. The main difference between structured interviews and semi-structured interviews is the level of standardisation. Structured interviews are conducted by using a strict interview guide with a specific set of questions. Semi-structured interviews are more flexible, since the main reason for using the method is not to generate standardised answers but instead achieve an in-depth understanding of the respondents' view of a certain topic. However, the flexibility is jeopardising the possibility to make static comparisons between the different respondents, which is a disadvantage of the semi-structured interviews compare to the structured. To compromise the standardisation of the interview process may be considered as compromising the reliability of measurement. Nevertheless, the semi-structured interview encourages the respondent to complement the questions with own reflections, or even elaborate of the topic, which gives an insight to what the respondent sees as relevant to point out and discuss [23]. Using questionnaires, a method with a high level of standardisation and carried out without any interaction, semi-structured interviews were considered an appropriate complement, thus it gave the respondent a possibility to add information otherwise not captured by using the other data methods. In this paper the semi-structured interviews provided more in-depth information, foremost regarding user remarks submitted through vehicle logbooks. The interviews were initiated with specific questions regarding a particular subject or issue, such as an interesting remark in the vehicle logbook, and were then followed by more open-end questions to gain additional user comments and experiences. The results from approximately 30 interviews have been used to triangulate the findings in the socio-technical data collection and have contributed to the general understanding of how the vehicles have been used and operated.