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# Mobility behaviour of companies in urban areas: A triangulation approach to explore the potential for BEV

Heike Flämig[1], Christian Matt[1], Kerstin Rosenberger [1], Marcel Steffen[1], Sören Chr. Trümper[1] and Jutta Wolff[1]

[1]*Hamburg University of Technology, Institute for Transport Planning and Logistics, Hamburg, Germany*

**Abstract.** For a holistic view on commercial mobility traditional mono-method approaches are not sufficient. The purpose of this paper is to give a better understanding of the benefits of triangulation in the mobility research context. It is shown that the combination of multiple methods can help to cope the challenges of commercial mobility understanding. One major finding is that the differences between subjective and objective opinions can be revealed by the mixture of quantitative and qualitative data.

## 1 Introduction

The share of commercial vehicle operations in inner-city traffic is 36 per cent [1, p.433]. The value is derived from the empirical study ‘Commercial Traffic in Germany’ (Kraftverkehr in Deutschland). In addition, other national figures provide varied but limited information. There is structural data on the company, e.g. the economic sector, and driving related data, e.g. mileage. Latest logging devices deliver a huge amount of vehicle data collected and analyzed in various research domains to show spatio-temporal dynamics. However, to better understand and predict a company's mobility behavior and pattern, more information about the motives of the way of moving are necessary.

The hypothesis of this paper is that obtaining this information could help to identify the measures to transform the potential share of e-mobility in the exercise of the profession into a real share. Commercial fleets are identified as important early adopters of battery electric vehicles (BEV) and a facilitator for this new technology [2,3,4]. Commercial mobility is understood as the traffic generated through the exercise of a profession.

Following Denzin [5, p. 82], for such a purpose several methods have to be combined to gain an in-depth understanding of the whole phenomenon. He calls "the combination of methodologies in the study of the same phenomena" triangulation. [6, p. 297]

## 2 Data basis and methodologies

The underlying research project "Wirtschaft am Strom" (WaS) aims to gain comprehensive insight into the contextual factors and the real mobility behavior of companies exemplified for the Hamburg region (Germany). The focus is on commercial mobility with battery electric vehicles (BEV) of less than 3.5 tons all-up weight.

The chosen triangulation approach consists of questionnaires, repertory grid interviews and geospatial-based trip data.

Firstly, a questionnaire-based online survey was carried out; questioning 360 companies that have acquired 795 publicly funded battery electric vehicles [7]. The data collection covers companies' structural and organizational characteristics, ranges of activities, procurement behavior as well as vehicle fleet characteristics and mobility patterns.

Secondly, a sub-sample of 66 players from 41 companies was further investigated with in-depth interviews [8]. Data were collected using the repertory grid technique based on the Psychology of Personal Constructs of American psychologist George A. Kelly [9]. In the mean of the repertory grid technique mobility alternatives represented the elements used in order to identify the intrinsic

constructs of test persons shaping their ways of valuing mobility alternatives. Repertory grid tests were conducted with users of a mobility alternative (driver) and with decision-makers.
Thirdly, 161 of 795 project-BEV (26 of the 41 companies interviewed) were equipped with a data logging device that collects trip data such as GPS-based movement and energy data on a per-trip basis to explore their mobility behavior, energy consumption and charging patterns.

## 3 Findings

The method mix allows a more realistic substitution potential estimation by analyzing motivations and relativizing subjective perceptions on objective conditions measured by data logging. Some examples are given below.
In the literature [10] range is identified as a major barrier to procurement of BEV. Related to the maximum daily mileages of the BEV, the estimation and driving behavior are close to each other. The figure for the average daily mileages of BEV for commercial purposes in the ratings by the users is higher than they actually are. For further studies about BEV potential, this aspect is important when working out interviews or questionnaires.
One assumption of the research was that commercial vehicles charge out of work hours, because charging is unproductive. The data logging show times and locations for charging (infrastructure) and the specific electricity demand at each charging location. It is conspicuous that charging took place at noon with a duration of up to 5 hours. However, the logging data cannot explain why. Therefore, it is necessary to gather more information of the determinants of decision for mobility behaviour.
The triangulation of data between constructs showed with the repertory grid technique, data logging and land use data make deviation between ‘subjective’ assessment of mobility alternatives and ‘objective’ driving behavior explicit. One example from one interviewee, both a driver and a decision-maker: the rating result of BEV worked out with the repertory grid technique reflected self-sufficient, independent, additional working time rather than driving to gas station. The logging and land use data of this interviewee show that gas stations for conventional vehicles can easily be reached en route without detours.

## 4 Conclusion

The core of our work was to identify determinants of commercial mobility, which influence the share of BEV on the total fleet. It was shown, that a mix of personal motives, land use data, observable driving patterns and context factors help to explain mobility behavior of corporate players comprehensively. By linking all the survey data, the validity of the results can be maximized. By doing so, in particular subjective perceptions can be relativize by objective circumstances. In fact, the researcher has to be the mediator between the object and methodology of research, the sources of knowledge - here the company or interviewee - and the research community to avoid uncertainty and misinterpretations.
By analyzing data, it becomes obvious that the empirical approaches show different sources of uncertainty. For example, trip data can only be interpreted correctly if manufacturers share sensitive technical information and if the overall vehicle architecture is known. By comparing trip data and questionnaires results, it became evident that the corporate players did not evaluate all parameters precisely. Moreover, a comparison to interview results revealed a discrepancy between subjectively reported and objectively collected data (e.g. by spatial analysis with GIS). It is found that the assumed driving behavior of the interviewees differs from their real driving behavior with the BEV.
The triangulation approach used, combining questionnaires, repertory grid interviews and geospatial-based trip data, make it obvious that the single Germany-wide survey on a company's mobility behavior is insufficient to fully understand and describe their mobility patterns. To come to comprehensive design recommendations for policy and planning as well as for service providers and OEMs regarding environmentally sound mobility, extended explorations are necessary that incorporate individual and company-specific decision criteria. By doing so, conclusive efficient and effective accompanying measures for the implementation process can be proposed to increase the share of BEV on the total fleet.

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