# Integration potential of alternative truck drive systems in transport companies: A case study of overhead contact line trucks

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## Abstract

In recent years, the importance of alternative truck drive systems for transport companies has steadily increased, driven by factors such as global climate targets, rising diesel prices, and $CO_2$ emission costs. However, most alternative drive systems are at a different stage of development, making the transition challenging and lacking transparency for transport companies. Therefore, the goal of this study is to develop a new method for evaluating the integration potential of alternative truck drive systems in the fleets of transport companies. To validate the developed method, we applied it to overhead contact line trucks (O-trucks). Over a period of four years, data was collected during the real-world operation of O-trucks as part of a German field trial. This data served as the basis for applying the evaluation method. The results show that, depending on the operational profile, the O-trucks demonstrated an integration potential of 61% to 75% compared to a diesel truck at 72%. In the long term this potential can be increased in the long term, subject to overhead contact line expansion.

## Introduction and Motivation

In Germany, the transport sector significantly contributes to greenhouse gas emissions, accounting for approx. 20 % (Umweltbundesamt, 2023). A practical approach to reducing greenhouse gas emissions in road freight transport is transitioning to environmentally friendly energy sources or alternative drive systems (Hilgers, 2016). These include natural gas trucks, fuel cell trucks, and electrically operated trucks that are either charged at stationary points or utilize dynamic charging options, such as overhead contact line infrastructure.

However, each of these alternatives is at a different stage of development, making the transition challenging and lacking transparency for transport companies. Additionally transport companies are lacking knowledge on alternative drive systems (Mohammed et al., 2020). Therefore, an assessment method can help transport companies to evaluate the integration potential of alternative drive systems in their fleet in advance or during trial operations. The aim of this work is to develop a methodology that allows determining the integration potential of trucks with alternative drive systems into the fleet of transport companies considering not only cost but additionally operational and technical aspects of the implementation as well as the acceptance by relevant involved stakeholders like drivers and fleet managers.

To develop the evaluation method, the following three research questions were defined:

- Which factors influence the integration potential of alternative truck drive systems from the perspective of transport companies?

- Which method is suitable for evaluating the integration potential of alternative truck drive systems by transport companies?
- How high is the integration potential of an O-truck in the fleet of transport companies?

## Development and application of the evaluation method

The development of the evaluation method builds on established approaches from three key research areas: decision-making methods in transportation planning (FGSV 2010), acceptance measurement methods (Davis, 1985; Davis et al., 1992; Frambach and Schillewaert, 2002; Venkatesh et al., 2003), and methods for the economic evaluation of commercial trucks in road freight transport. These three research areas were combined through a utility analysis and expanded into a comprehensive method for evaluating the integration potential of alternative drive systems in transport company fleets. Following the structure of a utility analysis, the developed evaluation method is divided into three interrelated levels: evaluation criteria, sub-objectives, and target areas. At the most detailed level, 80 evaluation criteria were identified. These criteria are each assigned to one of ten overarching sub-objectives, which in turn are assigned to one of four main target areas: Vehicle, Operations, Costs, and Acceptance

The goal of the evaluation method is to determine the overall fulfilment degree, which reflects the integration potential as a measure of how well alternative drive systems meet the requirements of transport companies. The overall fulfilment degree considers both objective vehicle criteria (e.g., range) and subjective evaluation criteria (e.g., user-friendliness) that influence successful integration. The integration potential is quantified on a scale from 0 % to 100 % and is divided into four zones for better interpretation.

The developed evaluation method was afterwards applied to O-trucks, the most advanced dynamic alternative drive systems (Boltze, 2020; Linke et al., 2022; Schöpp et al., 2022, 2021). Over a four-year period, data was collected from the first real-world operation of O-trucks across five different use cases using a mixed-methods approach, combining qualitative and quantitative methods. Based on the collected data five different use cases of the field test O-trucks were evaluated. Furthermore, to explore the future integration potential of O-trucks, future scenarios were derived.

## Results

The evaluation of the O-Trucks has shown that the evaluation method developed works. The findings reveal that O-trucks already demonstrate a promising integration potential, with an average overall fulfilment degree of approximately 70% across the use cases. In comparison, the diesel reference truck achieves a slightly higher fulfilment degree of 72%. This minimal difference, combined with the low variance in the fulfilment degrees across different use cases, highlights the O-truck is a viable alternative to diesel trucks under diverse operational conditions for transport companies.

By considering potential future scenarios considering more advanced O-trucks and an expanded overhead contact line infrastructure, our evaluation demonstrated that the integration potential of O-trucks could increase to 88%, while that of diesel trucks is expected to decline.

## Conclusions

In summary, this work demonstrates that an evaluation method based on a utility analysis allows for determining the integration potential of alternative drive systems by transport companies. The method is particularly suitable for alternative drive systems that represent a technological innovation and differ significantly from the use of a diesel truck.

Further research is needed regarding the consideration of O-truck advancements and a possible expansion of the overhead contact line system. In addition to continuous review and adjustment of the assumptions made in future scenarios, more extensive acceptance studies will be required as the technology becomes more widespread.

Furthermore, there is the possibility of applying the method to other alternative drive systems e.g., battery electric trucks or fuel cell electric trucks to compare the integration potential of different alternatives. Applying the method to trial operations could reveal the integration potential early on and provide transport companies with a basis for deciding on a possible switch to the alternative drive system.

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