Evaluating the potential of an electronic road system in the early market phase

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Abstract

The electrification of trucks, along with the integration of renewable energy sources, holds significant potential for reducing greenhouse gas emissions in road transport (Plötz et al., 2019). However, the adoption of electric trucks has been hindered by technological and practical limitations of current battery technology, leading to barriers such as limited driving range, lack of charging infrastructure, high investment costs, and reduced payload. To overcome these challenges, Electronic Road System (ERS) technology has emerged as a promising solution. ERS provides electricity to vehicles while they are in motion, increasing driving range for battery-electric vehicles and reducing fuel consumption for hybrid-electric vehicles (Chen et al., 2015; Gustavsson & Lindgren, 2020).

The implementation of an ERS network entails substantial costs and risks. However, exploratory studies conducted in the United Kingdom and the Netherlands suggest that nation-wide adoption and implementation of ERS infrastructure could be financially feasible (Ainalis et al., 2020; van Ommeren et al., 2022). The user base of the ERS network plays a critical role in achieving financial feasibility by spreading the large capital investment among as many users as possible. The initial implementation of ERS infrastructure is unlikely to be a full-scale deployment. Starting with a smaller-scale development can help reduce capital investment and mitigate risks. Nevertheless, even the initial network must be sufficiently extensive to enable potential users to experience the benefits of ERS adoption.

Determining the optimal configuration for an initial ERS network in the early market phase presents several uncertainties. Infrastructure developers must address questions regarding the geographical location, minimum infrastructure requirements, and the choice between creating a dense, interconnected network or a few long corridors. Furthermore, there is limited understanding of the general market potential of different ERS network configurations and the factors influencing it, despite the crucial role of a large user base in the success of ERS technology. Therefore, this study investigates the effects of different ERS network design configurations on the market potential of ERS technology during the early market phase.

To address the research question, a quantitative scenario analysis is conducted. Four network configurations are developed based on two design philosophies: Dense and Sparse. The Dense design philosophy involves an ERS network serving a relatively small geographical area,

offering flexibility to potential users with a wide variety of routes. However, this design may not support longer routes in the early market phase. In contrast, the Sparse design philosophy consists of one or more long corridors of ERS infrastructure, enabling longer routes but providing limited flexibility to users. The market potential of each configuration is determined by applying three market conditions to a dataset comprising all freight transport flows within the Netherlands. These conditions filter out trips that would not be attractive enough for vehicle operators to invest in ERS-compatible trucks. Specifically, trips are not considered part of the market potential if they require very long detours to utilize the ERS network, involve a relatively short percentage of the trip within the ERS network, or require very long trips to or from the ERS network. As parameters related to these conditions lack certainty, a sensitivity analysis is performed to examine the impact of different market condition parameters. Additionally, a post hoc analysis provides insights into the required revenue for financial feasibility.

The study's results highlight significant differences between the Sparse and Dense design philosophies. A Sparse ERS network captures a higher market potential in terms of total kilometres travelled, while a Dense network captures a higher market potential in terms of the total number of trips using the network. The average distance travelled per trip in a Sparse network is nearly double that in a Dense network. Expanding a Sparse network requires significant extensions as they do not synergize with the existing network, while a Dense network allows incremental growth that synergizes with the existing infrastructure.

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