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Electrifying public transport bus fleets

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Battery electric buses are considered a well-suited technology for the electrification of road-based public transport. However, the transition process from conventional diesel to electric buses faces a number of challenges such as the limitations in travel range and charging times of batteries. This study provides a methodology for planning depot charging battery bus fleets and their charging infrastructure. It reveals that a mixed fleet of different types of electric buses could be advantageous dependent on the operational characteristics of the bus route.

Commercial fleets, such as public transport buses, are seen as a starting point for the introduction of electric vehicles. Battery electric buses have been successfully tested in several international projects and, with decreasing battery system costs, have become increasingly competitive compared with buses running on conventional fuels. However, reduced operational performance of electric buses is still a major barrier for the transition process.

The process of designing battery electric bus systems differs from that of designing diesel bus systems. The study proposes a framework for the strategic planning of public transport bus fleets. It is based on the input data from bus operators which, together with additional information, is used to evaluate alternative fleet composition and scheduling.

The study addresses strategic electric bus planning by focusing on 'Electric Vehicle Scheduling Fleet size and mix Problem with Optimization of Charging infrastructure' (EVS-FMC), minimising the total cost of ownership (TCO) of electric vehicle fleets. It outlines a customisable framework for the strategic planning of electric bus fleets based on a grouping genetic algorithm (GGA) with incorporated mixed-integer charger optimisation. The objective is to minimise the TCO of the entire bus system. The TCO is the main decision criterion for investment alternatives. It consists of initial investments in vehicles and charging infrastructure, and the operational costs within a defined time.

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Electrifying public transport bus fleets

The strategic planning framework was applied to real-world case studies of electrification in two different cities – Aachen (Germany) and Copenhagen (Denmark). Fleets comprised two electric bus types, one based on lightweight but with a strictly limited range and the other on a higher range bus. The results showed that the lightweight bus offers a more energy efficient mode of transport, although the deadheading (a trip with no passengers) distance increases. The energy savings range from 27 % to 32 %. However, limited range requires additional vehicles which, together with the need for several charging phases, result in additional driver costs due to deadheading.


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An operation of a mixed fleet using both bus types can reduce the TCO, depending on the characteristics of the bus route. The TCO of a mixed bus fleet was calculated to be between €2/km and €3/km. Therefore, the TCO is strongly dependent on operational characteristics. Bus routes with increased peak vehicle demand seem particularly beneficial for the operation of depot charging battery buses.

The proposed methodology could be used in feasibility studies to evaluate electrification options for bus networks that have so far only focused on the technical feasibility of original diesel bus routes. In contrast, the EVS-FMC enables a joint technical and operational analysis. Adjustments of vehicle schedules are considered and monetised with a TCO calculation so that a reasonable balance of charging infrastructure investments and operational adjustments can be determined.