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Passenger impacts of implementing electric buses in Denmark using smart card data

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Abstract

Electric buses have been implemented in several Danish cities over the last years replacing conventional diesel buses. Previous studies have shown that electric buses can increase passenger satisfaction through increased comfort levels. Such results suggest that there could also be an effect in terms of increased ridership, however no studies have so far analysed this in details. This study will analyse the development in ridership over a 5-year period, covering cities in Denmark, which have replaced conventional diesel buses with electric buses. The study compares selected cities, which have made such replacement city-wide, to selected cities in a control group in which no changes were made. In addition, the study will include Odense and Aalborg as cases, which includes a city focusing on light rail, and one on the first full Bus Rapid Transit (BRT) system in Denmark, hence also considering explicitly notable changes to level of service. The analysis will be based on primarily Rejsekort data, and the results will compare ridership trends across cities dependent on the type of buses and level of service, thus providing insights on the effects of implementing electric buses in terms of passenger ridership.

1 Introduction

Electric buses are being deployed in great numbers around the world replacing conventional diesel buses. This has a number of environmental benefits such as reduced CO2 emissions, local air pollution and noise. In addition, electric buses might have positive passenger impacts considering that they can be more comfortable than diesel buses due to less rapid accelerations and decelerations, less vibrations and less engine noise. Previous studies have shown that comfort is one of the most important parameters for passengers in terms of passenger satisfaction, equally important as service levels (1), and that comfort is a key parameter for using electric buses (2). Furthermore, the environmental aspect has been highlighted by passengers as reason for choosing public transport (PT) in general (3) and electric buses in particular (2), and it is an aspect that increases user satisfaction (4). Hence, the implementation of electric buses might have a positive influence on actual PT ridership. However, to the knowledge of the authors no studies have focused on the impacts on ridership of substituting conventional diesel buses with electric buses. Hence, this study will contribute to existing literature by analysing in detail the passenger impacts of implementing

electric buses as replacement of conventional diesel buses. This will be achieved through using a large-scale dataset of passenger trips based on Rejsekort data covering a 5-year period from 2018-2023.

2 Background

Electric buses have replaced diesel buses in many Danish cities since 2019. The transition process happens gradually when tendering contracts are re-negotiated, and often happens on a municipality level. Hence, some entire city areas have had electric buses implemented simultaneously, whereas others continue using conventional, old buses. This allows for comparing the ridership trends in different cities over time before/after introducing electric buses. We thereby compare ridership trends across cities of similar characteristics, which are served by either electric or conventional buses. In few cases tendering only affects certain bus lines in a city, thus resulting in service within city areas being a combination of electric and conventional buses. This will also be taken into account in the analysis. Finally, the city of Aalborg implemented a full Bus Rapid Transit system (BRT), which opened in September 2023. This special case of electric buses with a notably improved level of service will also be included in the analysis as a special case.

3 Approach and data

The study is based on smart card data (*Rejsekort*), which is a tap-in-tap-out Automated Fare Collection (AFC) system covering the entire country of Denmark with detailed OD-information including transfers. This data cover approx. 41% of trips conducted in PT in Denmark (2021, Movia), whereas the remaining passengers use monthly cards or other types of tickets. The study utilises data from 2018 to 2023 and focus on eight cities which had electric buses implemented during this period, two cities where electric buses only served the key lines (and in combination with light rail), and a control group of 10 cities that have continued using only conventional diesel buses, cf. Table 1. All cities have been selected such that no other major changes of the PT network took place in the given period. Note however that Aalborg had a full BRT system implemented during the study period with a notable increase in level of service. This corresponds to a further improvement in terms of both being electric and having notably reduced travel times for passengers, and is thus part of the analysis as a special case.

All electric buses (inauguration year)	Combination	Conventional buses only	City Characteristics
Roskilde (April 2019), Slagelse (June 2021), Næstved (April 2022)		Hillerød, Helsingør, Køge, Holbæk	Cities in the Greater Copenhagen Region
Esbjerg (December 2021) Kolding (June 2022) Horsens (March 2023) Fredericia (June 2023)		Herning, Vejle, Randers, Silkeborg, Viborg, Holstebro	Provencial Cities
Aalborg (August 2022)	Odense, Aarhus		Larger cities

Table 1; List of cities included in the study, their city type, and which type of buses they are using.

4 Results

The study analyses in detail the development of PT ridership using smart card data over the five year period across both the focus cities and the cities in the control group. The analysis will compare the ridership trends for cities with change to electric buses to that of the cities in the control group. In addition, the analysis will cover cities, which implemented electric buses partially. The analysis will include focus on Aalborg, which had electric buses implemented in combination with the BRT system. Hence, this will ensure analysis of also implementing electric buses in combination with notable service improvements. Light rail will also be covered indirectly through analysing the effects in Aarhus and Odense (which had light rail implemented during the study period).

In addition, aggregated passenger count data from the PT agencies will be analysed, and the official Danish National travel survey (TU) (5) will be used to analyse the development in overall market share of PT (and car, bicycle, walk) on a city-level for entire Denmark.

* *The project runs until 2025, hence the results to be presented in 2024 will be preliminary and might only cover a subset of the selected cities.*

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