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ZERO EMISSION BUSSES IN GERMANY'S PUBLIC TRANSPORT

Insights of the Accompanying Research on e-Buses for the German Federal Ministry for Digital and Transport

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Executive Summary

We present insights of the first phase of the accompanying research on electric buses (e-buses) for the the Federal Ministry for Digital and Transport (German: Bundesministerium für Digitales und Verkehr (BMDV)). We focus on the holistic evaluation of the technological and operational readiness of the deployed e-bus systems in Germany including issues such as availability, winter performance and range of e-buses in an operational environment. The basis for our investigations is data from transport operators receiving funding either from BMDV or the federal ministry for the environment (BMUV). We also take a glance on the market situation of e-buses in Germany, which has experienced substantial change during the last two years and is facing even more dramatic changes in the next four years due to regulative measures such as the CVD and the largest subsidizing initiative for e-buses in Germany so far.

1 Introduction

The BMDV has been subsidizing buses with alternative drives for years. Since 2015, the Electric Mobility Funding Directive has promoted not only research and development projects, but also the procurement of buses and the necessary charging infrastructure for operation. In total, nearly 380 buses were funded so far. In addition, BMDV also promotes the procurement of fuel cell buses via the National Innovation Program Hydrogen and Fuel Cell Technology.

The National Organization for Hydrogen and Fuel Cell Technology (NOW GmbH) is a state-run program company that coordinates and implements support programs for BMDV and advises the ministry. As part of the bus promotion, NOW GmbH coordinates all activities of BMVD.

The aim of the accompanying research is, on the one hand, the detailed analysis and evaluation of buses in use with alternative drives, including usage-specific data and taking into account the requirements for infrastructures, economic issues, operation and acceptance topics. On the other hand, a decision-making aid is to be provided in support of the transport companies or the transport authorities. This should provide assistance in the selection of the correct overall concept for electrically driven buses in the respective network. The developed software tool is designed as an aid and criteria-based initial assessment in the evaluation of different bus concepts for own operation.

In addition, the Federal Government has created a platform for the exchange of information and experience between transport companies, manufacturers, research institutions and the federal ministries involved with the working group “Innovative Drives Bus”, which was jointly initiated by BMDV and BMUV.

2 Market development

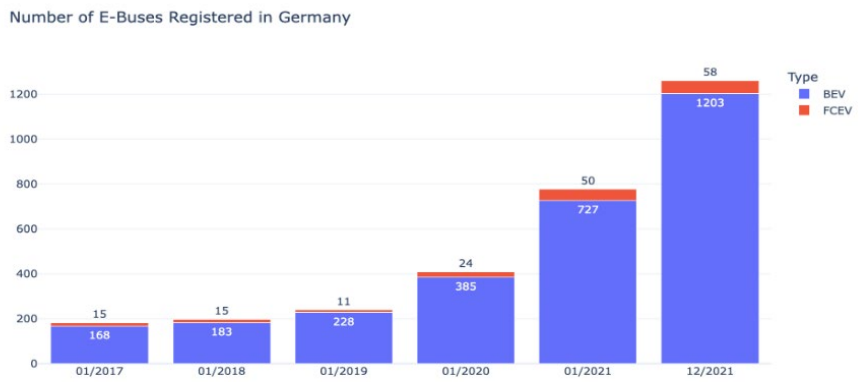

Figure 1: Registration numbers of buses with alternative drives in Germany according to drive type [1]

Approximately 80,000 buses (alle technologies including diesel) are operating in Germany. More than half of that are used in regular service. In total, there are currently 1,203 battery and 58 fuel cell buses in Germany as of December 2021 (see Figure 1). The last years have seen a substantial increase in these numbers, e.g. the number of battery buses has more than tripled within the last two years. We expect this trend to become even stronger, driven by regulative measures like the CVD and additional subsidies by the BMDV. In fact, current applications for subsidies suggest that the number of zero-emission buses may grow by a factor of more than four in the next five years. In addition to the promotion of BMDV, this is also due to the activities of the BMUV.

3 Database for accompanying research

In total, nearly 380 electric buses supported by BMDV alone will be examined as part of the accompanying research. Figure 2 shows a project overview from BMUV and BMDV. In yellow and orange all battery electric, in red all trolley bus and in blue all hydrogen bus projects are marked. The black circles represent a project in which the data is not yet complete. The full project overview was published in September 2021.

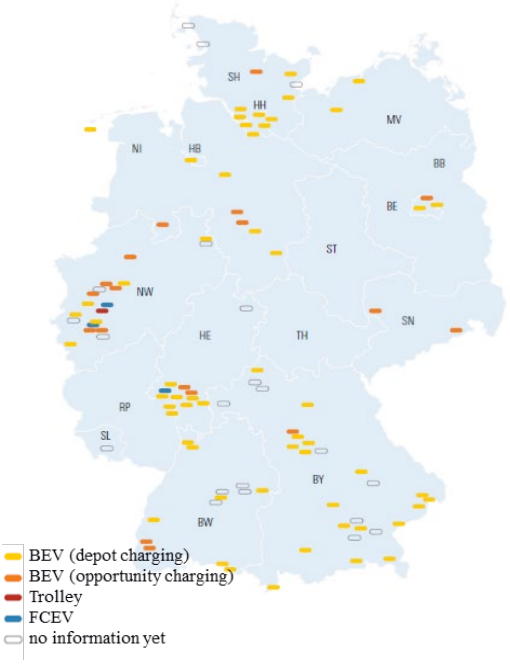

Figure 2: Map of Germany with BMUV and BMDV funded e-bus projects [2]

4 Technical evaluations

In the course of the accompanying research several technical performance indicators have been monitored. As an example we give some first insights into availability data as well as an analysis of energy consumption with respect to temperature. [3]

Availability

Data is available for 18 transport operators using battery electric buses (Figure 3). The overall average availability

among them is 87%. This is a significant increase with respect to availabilites of 72% for depot chargers and 76% for opportunity chargers in 2016. It is noteworthy that several of the reasons for low availabilities in the first period of the evaluation were not BEV-specific defects, but more general problems that we expect to typically occur during the introduction of a new vehicle type.

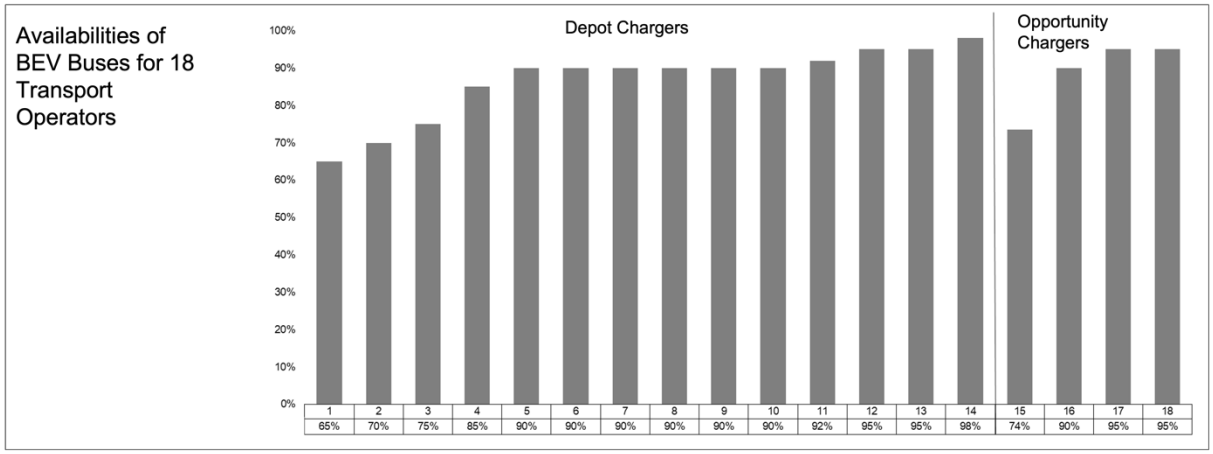

Figure 3: Availability of BEV buses currently part of the data monitoring [3]

Energy consumption

Figure 4 shows as an example the energy consumption of the 12m battery electric bus used at VAG in Nuremberg from March 2018 to July 2019. It should be noted that the vehicle is equipped with a fully electric heating system. Accordingly, the influence of the heating period on the energy consumption can be recognized. If the existing consumption values are sorted according to the average daily temperature, the typical "bathtub" curve on the right in Figure 3 results in consumption that is over 80% higher at temperatures below 0 °C and one third higher consumption at temperatures above 30 °C compared to the energetic "sweetspot" at 15-19 °C average outside temperature.

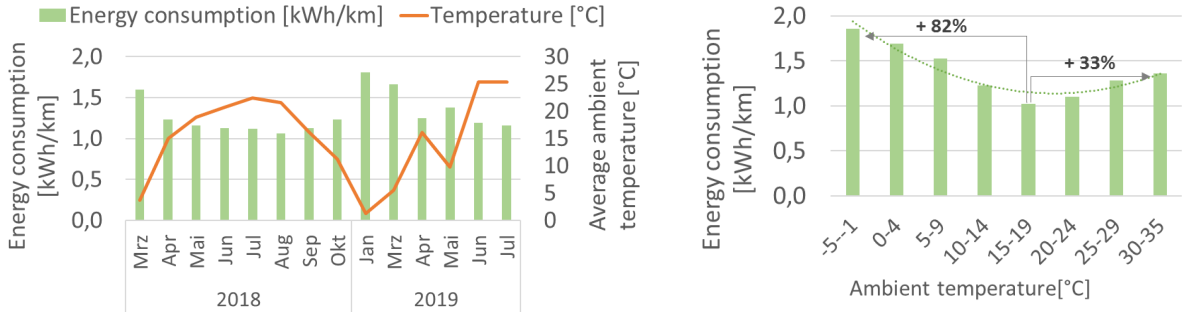

Figure 4: Energy consumption (green) in relation to average outside temperature (red) [3]

5 Conclusion and outlook

The market overview shows that the e-bus market in Germany is growing extremely. This is supported to a great extent by federal support measures. In addition, the EU has issued a CVD, which requires quotas for alternative drive systems for new registrations from 2021 onwards. Thus, from August 2021 in Germany 45% "clean" buses must be procured [4].

Our evaluations show that the battery buses already meet the expectations and can be used in regular operation. For bus operators, however, the question of which technology should be used individually remains exciting. Here the accompanying research can provide an important contribution.

Acknowledgments

[1] Publication of the Federal Motor Transport Authority, Flensburg, September 2019

[2] M. Faltenbacher et al., E-BUSES IN GERMANY – First experiences from the Accompanying Research on e-buses from the German Federal Transport Ministry, unpublished, NOW GmbH, Berlin, 2021.

[3] M. Faltenbacher et al., Abschlussbericht Programmbegleitforschung Innovative Antriebe und Fahrzeuge: Innovative Antriebe im straßengebundnen ÖPNV, Berlin, 2022 (to appear)

[4] Clean Vehicle Directive, EU Commission, Brussels, 2019

Presenter Biography

Oliver Hoch is Programme Manager Electromobility at the National Organization for Hydrogen and Fuel Cell Technology (NOW GmbH) since 2017. He is responsible for the topics "battery electric drives in buses and rail vehicles" in the electromobility team. He studied Environmental Engineering/ Regenerative Energies at the University of Applied Sciences (HTW Berlin) from 2009-2014 graduating with a M.Sc.

Christopher Borger works as a Data Scientist at NOW GmbH in Berlin. He finished his PhD in computational mathematics in 2020 at Otto-von-Guericke University in Magdeburg after receiving his master's in mathematics at TU Munich in 2016. His current work focuses on applying mathematical methods to analyse real life data of buses subsidized via NOW.

Steffen Schulze works as Programme Manager Electromobility at the NOW GmbH since 2020. He is responsible for battery electric drives in buses in the team electromobility. He studied Mechanical Engineering with the majors in Energy and Production Engineering at RWTH Aachen University from 2012-2021 graduating with a M.Sc.