



1 *Implementation of electric buses in Hamburg.*

ROUTE IMPLEMENTATION FOR ELECTRIC BUSES

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Background

Increasing prices for fossil fuels, the desire to become independent of the turbulences on international commodity markets and the requirement of protecting the local environment as well as the global climate are motivations for many transport operators to consider the introduction of fully electric city buses.

For many transport companies, electromobility is no unknown territory. Trams and even trolleybuses have been used in cities for more than 100 years. If the passenger figures are not sufficient, however, trams and trolleybuses cannot be operated efficiently and their introduction is obstructed by high infrastructure investment costs. In addition, many cities have reservations about the introduction of catenaries in view of the cityscape. In total, the interest in electric buses with energy storages for catenary-free operation has increased significantly.

Initial situation

Due to the current developments in electric energy storage systems and power electronics, concepts for fully electric city buses have become feasible – even if they did not seem realizable a few years ago. Except for a small number of niche applications, fully electric buses have hitherto been based on a linear energy supply via catenaries. Today, concepts can be realized which include the regular recharging of energy storage units on vehicles without the need for catenaries. The feasibility of these approaches depends on the characteristics of the route or the network, including

- the length of the route,
- the cycle time and organization of breaks,
- the elevation profile,
- passenger load as well as
- travel speed.



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Range of Services

Following the principle »recognizing perspectives by distinguishing the possible from the impossible«, the Fraunhofer Institute for Transportation and Infrastructure Systems IVI offers consulting services for the implementation of fully electric city buses.

Based on comprehensive knowledge and experience in electric storage and propulsion technologies, bus routes and route networks are analyzed with regard to the possibility of a stepwise implementation of battery buses. Concepts for linear energy supply via catenaries and inductive charging are also taken into consideration. The concept for a stepwise implementation of electric city buses is designed for a short-term or middle-term time frame.

The analyses are unbiased to the result. It is also possible to conclude that a route is currently or in the near future not suitable for the introduction of electric city buses. The risks related to the introduction of a certain technology are always clearly communicated.

Issues relating to energy efficiency, environmental impact and costs are also included in the services.

Scope of the Work

In a first step, the **route characteristics** relevant for the propulsion concept are recorded. If the initial rough analysis shows that a route or a network could be suitable for the operation of battery-powered city buses, a detailed **calculation of the energy and performance balances** is carried out using efficient simulation tools. For vehicle modeling in general, and the modeling of the drivetrain in particular, configurations can be made both regardless of the manufacturer and manufacturer-specific, depending on the customer's requirements.

The result includes statements on the suitability of a route for battery-powered buses as well as information regarding

- the necessary size of the energy storage,
- the performance requirements and
- possible changes in the operations process.

In a third step, the requirements for the electric energy storage and the drivetrain are compared to technologies which are either already available or will become realizable in the near future.

The results provide decision support for transport operators and can be used for the definition of specifications.

Implementation Concept

The implementation concept for fully electric city buses includes statements on their gradual procurement and entry into service as well as information on

- workshop equipment,
- the training of workshop staff,
- the training of drivers and
- regulations and safety risks.

Selected References

The Fraunhofer IVI has detailed many implementation concepts for different cities and transport providers, including

- Berlin (BVG)
- Düsseldorf (Rheinbahn AG)
- Cologne (KVB AG),
- Hamburg (Hochbahn AG, Fig. 1),
- Bonn (SWB-Verkehr GmbH),
- the entire bus network of the Munich region (MVV GmbH),
- the entire bus network of Aachen (Aachen Municipal Administration).

- 2 Urban public transport network.
3 The Fraunhofer IVI's fast charging electric bus.