Promoting Electric Public Transport

TROLLEY Project

Summary Report Feasibility Study: Network Extension in Salzburg

THIS PROJECT IS IMPLEMENTED THROUGH THE CENTRAL EUROPE PROGRAMME CO-FINANCED BY THE ERDF.

Example of planned network extension

Business Analysis (Feasibility Study)

To meet the focus on „efficiency enhancement", the Salzburg AG and the Hallwang municipality authorized the investigation of a trolleybus network extension into the surrounding area. As since trolleybus line 4 was successfully extended to Hallwang Mayrwies in 2007, the question was raised whether further extensions of the network into the agglomeration would make sense.

Starting point of the investigation was a general comparison between the diesel bus and trolleybus systems. Based on these findings, concrete use cases were applied to shed light on the effects of network extensions, including extension of the trolleybus network within the municipality Hallwang from Mayrwies to Esch. Then the impact on the environment, passenger volumes and economic viability could be investigated. The results of a passenger and citizen survey conducted in Hallwang could be used to gain information on acceptance of the trolleybus service and its network extension.

For a system comparison between diesel bus and trolleybus, the impact on the environment is also relevant. Trolleybus operation has the advantage that it is locally emission-free. As the Salzburg AG operates their trolleybuses with water-generated power, no emissions are produced for power generation either.

The analysis shows that the extension of the trolleybus line broadens the PT services offered. It thus makes public transport services more appealing and helps win new customers. It also reduces car volumes and their negative effect on the environment. Broadening the service offer involves additional costs. These can partly be offset by the additional revenue generated.

Variants of Technical Organizing

The principal purpose of this project is the development of a solution for the power supply of trolley bus lines across open land track sections.

The measurements during the test journeys served the determination of the bus data as input data for the simulation, as an energy-based line analysis and for verification of the simulation, as well as for the inclusion of the geometrical data of the bus network.

Bus parameters and the extension section to Esch

The parameters for the simulation were determined on a test track in urban areas at a maximum of 50 km/h and without gradient and were used unchanged for the simulation on the extension track section. The bus manufacturers have yet to address the following questions:

- Is the maximum performance uphill also available for a longer time of up to 2 min.? In town, the speed range for the maximum performance during acceleration is already exceeded after approx. 5 seconds.
- Does derating uphill start at the same speed and does it have the same magnitude as on a straight line?

- Can the back-fed electricity become as big as the fed-in electricity or is it limited beforehand? Without limitation, regenerative feedback electricity of up to 500A would flow when braking at a stop downhill.
- When braking downhill, is the pneumatic brake switched on? In the simulation, this is not considered.

Simulation of trolleybus networks

With the complexity of electric grids like that of a Trolley bus network, the influence of the numerous parameters and the interaction variety of the variable consumers, if at all, is at most only qualitatively predictable. In order to gain a quantitative idea, too, it makes sense to make use of a computer simulation. The analytical focus is on the preparation of energy balances and network losses (overhead contact system (OCS) losses, braking resistors), the review of the capacitive limit of the electrical network and its stability and the support of the planning process for proposed route extensions. It should be pointed out that, although many time-related parameters are received because these contribute on many different ways to the energy balance, the software is not supposed to issue traffic forecasts, etc.

Planning and optimization of a track extension

The extension section has special requirements. It concerns an overland route (between the stop Schmiedbauer and the stop Rechl) with gradients of up to 9%. The track section length amounts to 3 km.

It is now a matter of obtaining an energy consumption evaluation as well as an appraisal of the network stability for various versions with the help of the simulation. Here, the positioning of new substations, possible energy stores and the contact wire cross section to be used is by choice. Attention is paid primarily to a stable power supply (particularly in regard of further extensions) and to the height of the regularly appearing power peaks in the planned substations in order to determine the necessary transformer output.

On the sections downhill from Esch to Mayrwies, large outputs can be recuperated. Hence, attention will be paid on the pages to follow also to the energy lost in brake resistors and to options for the reduction of these losses. For the simulation, there is the assumption that braking only takes place electrically.

Analysis of Variants

The analysis of variants has been carried out for catenary cross-sections (Fahrdrahtquerschnitte) of 80mm², 100mm² and 120mm².

In **Variant 1** the existing mobile infeed station is replaced by a stationary substation. This corresponds to the conventional intuitive approach for network expansion. It is predictable that the voltage drop towards the planned terminus in Esch is problematic owing to the special requirements. This is confirmed by the results of the simulation.

In **Variant 2**, in order to reduce voltage drops towards the track section end, the planned substation is moved to the gradient-intensive part of the new section. By positioning the substations in the power-requiring area of the track section, overhead contact system (OCS) losses are meant to be reduced.

Variant 3 is now a combination of the two preceding variants. There are two substations that are newly erected. One of them (substation Mayrwies) replaces the existing mobile substations as in variant 1, while the other one (substation Esch) in turn is positioned midway on the slope of the upgraded line, as in Variant 2.

It strikes immediately that the voltage drops are very low between the two newly positioned substations and also towards the end of the extension to Esch, the voltage on the bus is always more than 540V.

Because of the additional substations, the voltage drops are more favorable in the track section course all together than in Variant 2, and there is no especially high drop between substations 16 and substation Mayrwies. This affects the network losses. Also, the peak loads are distributed better; now between three substations instead of two. In particular, the subnetwork is better decoupled from the power feed of the substations 16 which is thereby subjected to a lower additional load by the planned new stretch. This becomes clear from the independence of the overhead contact system (OCS) cross section from the peak loads in the substations 16.On the sections downhill from Esch to Mayrwies, large outputs can be recuperated. Hence, attention will be paid on the pages to follow also to the energy lost in brake resistors and to options for the reduction of these losses. For the simulation, there is the assumption that braking only takes place electrically.

Summary

According to customary planning, one would break down the network into about 3 km feeder segments and have it supplied by the substation without nevertheless finding a concrete estimate for the necessary performance capacity of the transformer installed in the substation. In this manner, trolley networks grow in a natural manner. Variant 1 complies with this intuitive approach.

Expected voltage drops were able to be determined by specific simulations (particularly on the critical points), as were power consumptions, network losses (overhead contact system (OCS) losses, brake resistors) and transformer variables. Also, the effect of energy stores can be estimated. On this occasion, beside the reduction of the losses in brake resistors, the contribution of energy stores is to be emphasised particularly to the network stability between feed-in points and to the reduction of the load peaks in the substation. The comparison of the influence of substations and energy stores on the electric grid has shown that it is most sensible to refrains from operating these in a mutually exclusive manner but rather top operate them side by side.