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Center for Sustainable
Future Mobility (CSFM)

RailPower - Power and Energy for the future railways: Calibrated Simulation of Railway Networks

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1 Introduction

The electricity consumption of the transportation sector is expected to rise. This results primarily from the electrification of private cars and secondarily from an increasing number of passengers and freight in public transport. The RailPower project aims to provide [1]:

- a comprehensive view on the electric energy needed by the railway
- coordination of local renewable generation with the optimal charging of Electric Vehicles (EVs) at the train station [2].

This requires an accurate calibrated simulation of a railway network [3], which is part of the RailPower project and in the following described.

2 Methods

The calibration uses energy counter data, which logs the vehicle's energy consumption and GPS data each second of nearly each regular train run. These data were evaluated to determine the following values for each vehicles type:

- Driving resistances
- Engine efficiency and mechanical-power independent consumer (incl. comfort systems)
- Vehicle and location acceleration and breaking behavior
- Energy dissipating brake usage probability.

These values were determined with the following two approaches:

1. BigData, which simulates the train runs based on energy counter data trajectories and uses this for reconstruing the calibration values.
2. Evaluation of acceleration-sensor measurements during train runs and combining them with energy counter data.

3 Materials

For the two approaches, the following given inputs were needed:

- Energy counting data: For energy billing reasons, almost all trains of the Swiss Federal Railway have installed an energy measuring device. It records the power consumption of the entire train (i.e. at the pantograph) each second, georeferenced by the corresponding GPS coordinates.
- Technical data: Digital railway infrastructure description, with the precise position of the slopes, curves and stations, along curvilinear coordinates and vehicle type and specific information.
- For approach 1: Simulation tool (minoTraction, developed between 2010 and 2012 by Michael Nold). It is a tool which can simulate trains on a very high detail level, including several engine details and vehicle control parameters. It also enables the simulation of varying speed profiles of existing train runs for this calibration.
- For approach 2: Mobile high-level acceleration sensors (MSR 165, with 1600 Hz sampling). During calibration, vehicle-specific control parameters could be reconstructed for the simulation due to the high solution and accuracy of the used sensor (e.g. brake control).

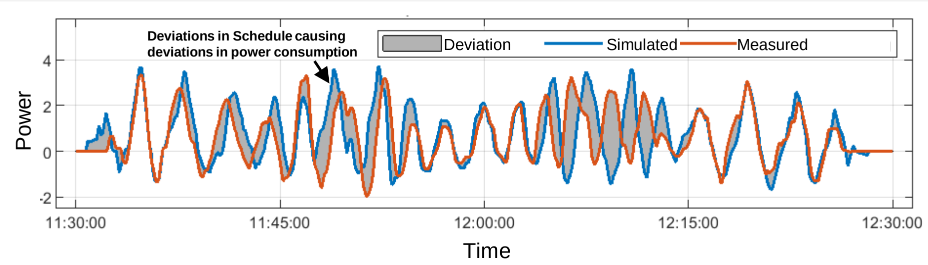
4 Results and discussion

The train-run data of two weeks were available for calibrating the simulation tool for the considered railway line. With the calibrated tool, the total power consumption of one day could be estimated with a deviation of only 4 %.

The values of the single hours had particularly stronger deviations:

- During peak traffic times, there was a standard deviation of 27 %. This is because delays and varying delay-depended driving styles are not included until now. The model uses the average values determined by line-specific data (e.g. vehicle and location-specific acceleration and breaking behavior). Delays and their impact on driving styles are not estimated.
- During the very early morning and evening off-peak hours. the deviation between the simulation and the measurement in the hourly power consumption is less than 1 %.

The second wise simulation and estimation are possible as long there is no delay from the schedule. Deviations from the schedule cause time shifts in total power consumption.



Simulated and measured power consumption of a railway feeding section.

5 Conclusion and outlook

The described calibration makes a precise simulation of the total power consumption possible (in the test case: single hours <1% deviation). This high accuracy was possible due to the compressive calibration, which includes all impacts for the vehicle power consumption and driving-style-depending influences. This makes it possible to estimate how much energy is required for the railway and available for other modes.

However, delays and other deviations in the schedule can create substantial deviations in power consumption because of shifts in departure/arrival and changing driving styles. With delays in the model, it is possible to estimate in a short time frame (e.g. second- or minute-wise) how much energy is needed.

Stochastic influences and timetable effects (e.g. delays) will be investigated in the following work packages of the project.

References

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