

## EFFECTS OF IMPLEMENTING WEATHER DATA IN LIFE CYCLE COST CALCULATION OF PASSENGER TRAINS WITH ALTERNATIVE POWERTRAINS

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**Summary:** Railway vehicles with alternative drivetrains are increasingly entering the rolling stock market. There are strong developments, specifically in the application of fuel-cell electric multiple units and battery-electric multiple units. There is little experience with the energy costs associated with operating these vehicles. Hence, energy demands are often assessed during decision-making processes regarding a certain powertrain technology. Power and energy demand for traction of these trains are often determined by applying longitudinal simulations. To account for the required energy demand for heating and cooling, the majority of studies use a static heating and cooling load. This is usually derived from the specifications of the European regulatory framework EN 50591, which provides parameters for a range of predefined weather conditions across different climate zones.

This is useful for design cases such as the dimensioning of drivetrain components. However, when evaluating energy consumption, for instance, as an input parameter for operational expenditures (OPEX) calculations embedded in a Life Cycle Cost (LCC) analysis, the standard EN 50591 might not serve this purpose well. Furthermore, its rather static approach does not allow for considering emerging business models related to the now highly dynamic electricity market. Here, electricity cost issues can be addressed with time-sensitive trades, e.g., at the intraday market. These new technological and economic developments urge us to progress towards a more sophisticated acquisition of vehicle energy consumption. To achieve this, we propose a model chain that automatically integrates local weather data into the energy assessment of multiple units with alternative drivetrains.

We present a geodata model that generates driving profiles based on timetables, geodata of the railway network, and station locations. It parses track parameters from OpenStreetMap and samples elevation profiles from a digital elevation model (DEM). This serves as the foundation for simulating traction energy demand. To determine the energy needed for heating and cooling, weather data along the route is sampled based on the vehicle's location and time, as determined by the timetable. The sampled weather conditions are fed into a thermal car body model, which outputs the thermal power requirements. We compare the resulting energy requirements of this approach with those obtained using the specifications of EN 50591. We demonstrate the implications for OPEX cost planning by executing and comparing LCC analyses for fuel-cell electric and battery-electric multiple units.