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Traction solutions for non-electrified regional railways: A model-based comparative assessment of energy use and greenhouse gas emissions

Non-electrified regional railways require replacement of diesel traction to meet increasingly strict emissions regulations. Due to the relatively low utilisation of regional lines, complete electrification is often not economically viable. Therefore, solutions are being sought in advanced catenary-free propulsion systems and alternative low-carbon fuels. Given the range of available propulsion system technologies, energy carriers, and their production pathways, it is essential to understand the overall energy demand and GHG emissions attributed to each alternative. This information is crucial in policy decision-making and long-term planning of energy efficient and low- or zero-emission regional railway transport.

This research proposes a comparative analysis of implementations of various (hybrid) propulsion systems combined with prominent low-emission energy carriers while including commercially mature and novel technologies and energy carrier production pathways. The analysis adopts a bottom-up approach, with direct fuel and/or electricity consumption estimated via a simulation model that captures high complexity of new propulsion systems and relevant factors influencing direct energy use. Proposed method is applied in the real-world case of regional rail passenger transport in the Netherlands using energy carriers, pathways and emission factors relevant to European and Dutch contexts, providing the railway undertaking and policy-makers with new essential information for planning future rolling stock and infrastructure investments. Additionally, provided estimates of primary energy use and GHG emissions can benefit future research, especially in comparable cases when detailed vehicle, infrastructure and/or operational parameters are unavailable.