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Regional non-electrified railway networks require replacement of diesel traction to meet increasingly stringent emission reduction targets. Since full electrification of these networks is often not economically viable due to their low utilization, battery-electric multiple units (BEMUs) are recognized as a potentially suitable long-term solution, offering zero-emission trains operation while requiring only partial tracks electrification. One of the main challenges when introducing BEMUs is determining an optimal electrification layout, i.e. the location and the length of electrified track sections while taking into account the vehicles' and infrastructure technical characteristics and constraints alongside the requirements related to maintaining current timetable and quality of service. Present research formulates this as an intermittent partial electrification network design problem and develops an optimization framework that integrates high-fidelity BEMU simulation model in deriving a cost-optimized network electrification configuration. The proposed method is demonstrated using the existing non-electrified regional railway network in the Netherlands with the rolling stock and transport services of Arriva as a case. The obtained solution provides about 30% lower capital costs compared to the conventional continuous partial electrification approach, and about 3.5 times cut in these costs compared to the fully electrified network. Additionally, further costs reduction is observed by increasing the maximum current absorption limits at standstill and by introducing flexibility in terms of operational margins.