Abstract:

This study explores the smart-charging potential for residential electric vehicles (EVs) in the Netherlands to reduce electricity peak demand and maximize renewable power consumption by 2030. The study uses the mixed-method approach by combining quantitative optimization modeling with comparative case analysis with actual data for the households in the Netherlands, solar generation, and EV charging patterns.

The model considers a 100-house residential area with 50 solar-equipped houses and 20 EV-equipped houses, 50% with smart-charging infrastructure. The findings confirm that smart charging substantially enhances the performance of the power grid: electricity peak demand declined by 16%, renewable power consumption increased by 13.3%, and the curtailment of renewable power declined by 61.5% compared with non-smart charging scenarios. Further, smart EVs consumed slightly less cumulative energy (2,642 kWh) than non-smart EVs (3,139 kWh), encouraging improvement in the efficiency of the EVs. The study findings reiterate that the synchronization of the charging schedule with solar generation hours enhances the power grid's stability and reduces fossil-fueled electricity consumption during the evening peaks.

Even though the model used is simplified and lacks specific power grid attributes like congestion or transformer loading features, the results confirm that smart-charging large-scale implementation may comprehensively support national decarbonation targets and be in line with the EU's 2050 climate-neutrality target. Overall, smart EV charging offers an effective and scalable flexibility solution to support renewable power accommodation, flatten the peaks of demands, and enhance the sustainability of future power systems.