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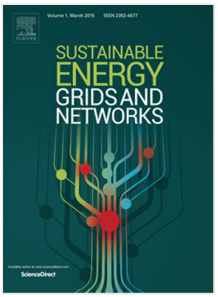

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Integrating Multi-Domain Distributed Energy Systems with Electric Vehicle PQ Flexibility: Optimal Design and Operation Scheduling for Sustainable Low-Voltage Distribution Grids

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Abstract

Electricity and transport sectors have to be decarbonised in order to mitigate climate change effects leading to increased penetration of distributed energy systems (DES) and electric vehicles (EV) which can threaten the security of distribution grid operation. Proper design and operation of such systems are crucial if the adverse effects on the grid are to be avoided. Moreover, EVs represent a high load and should not be considered merely as passive assets since they can provide various flexibility services for maintaining the grid stable. This paper presents a multi-domain optimisation framework for minimising carbon emission in low-voltage distribution grids with high share of distributed energy resources and electric vehicles. The framework determines optimal EV flexibility usage (both active and reactive) while satisfying electric and thermal building demands, and maintaining the distribution grid in the stable operation. The model was applied to a real low-voltage Danish distribution grid where measurement data is available on hourly basis in order to determine EV flexibility impacts on carbon emissions, as well as the benefits of optimal DES design. The influence of EV reactive power control on the grid operation, in addition to coordinated charging, is analysed. Results showed that when the system can be optimally designed, emissions decrease by 64% and additionally 32% with proactive EV integration, whereas EV reactive power control enables integration of larger EV amounts and provides significant voltage support without affecting the user comfort.

Keywords: AC power flow, distributed energy systems, electric vehicles, MILP, multi-domain optimisation, reactive power control

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