

Renewable Capacity Investment Planning under Distribution Grid Hosting Capacity Uncertainty: a CVaR-based Approach

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Abstract-

Electricity distribution grids have been identified as a potential bottleneck for the rapid rollout of renewable generation due to insufficient hosting capacity and barriers to its expansion. This paper assesses the implications of relaxing hosting capacity (HC) calculation criteria for investment decisions in new renewable generation at a specific network bus. Additionally, the potential of combining HC relaxation with the hybridisation of renewable generation technologies is quantified. To this end, a model that maximizes investor returns under constrained grid capacity conditions is developed. The methodology accounts for uncertainty in HC, renewable resource availability, and market prices. The investor risk is represented via Conditional Value-at-Risk, thereby accounting for tail-risk exposure under adverse conditions. The case study demonstrates that relaxing the HC calculation criteria unlocks additional electricity grid's capacity to absorb more energy, thereby incentivising higher levels of installed generation capacity to maximise investor profits. Transitioning from a contingency-restricted static HC to a dynamic HC definition enables a 65% increase in energy injection and raises average investor profits by 64%, without putting at risk the security criteria for the network operation. Combining HC relaxation with hybridisation increases the optimal generation capacity by 127% and average investor profits by 75%. Sensitivity analyses are performed to assess the robustness of the proposed methodology. The findings highlight the strategic value of relaxing HC calculation criteria as a mechanism to release untapped capacity in electricity distribution grids, while maintaining robust investor profitability.

Index Terms- Conditional Value-at-Risk; Distributed generation; Distribution grids; Flexible connections; Hosting capacity

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