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GUEST EDITORIAL

Guest editorial: RES hosting capacity in distribution networks

Decarbonization policy leads to an increasing trend of integration of renewable energy sources (RESs) in distribution grids. The high penetration of RES in distribution grids creates technical challenges such as reverse power flow and congestion, voltage rise, frequency excursions, and lack of inertia, which significantly impact various aspects of power systems and limit the introduction of more RES. These challenges necessitate advancements in the design, operation, management, and control of distribution networks to ensure efficient and reliable integration of RES.

This Special Issue addresses these challenges and explores methods, technologies, and solutions to investigate the RES hosting capacity of distribution grids and improve their penetration level. The issue features a collection of high-quality research papers that offer valuable insights into enhancing the hosting capacity of distribution networks with RES integration.

1 | PAPERS IN THE SPECIAL ISSUE

In this Special Issue, we have received 14 papers, all of which underwent peer review. Five of the 14 originally submitted papers have been accepted and seven have been rejected or referred to other journals.

The accepted papers in this Special Issue cover a wide range of topics, highlighting the diverse approaches and methodologies employed to improve the integration of RES in distribution grids. The papers address the following key areas:

'***Photovoltaic hosting capacity improvement based on the economic comparison between curtailment and network upgrade***': This research paper investigates the economic trade-off between curtailment and network upgrade for improving the hosting capacity (HC) of distribution networks with fluctuating distributed generation, specifically focusing on Finnish climate and load patterns. The study utilizes real-time load and photovoltaic (PV) generation data to simulate the performance of three Finnish distribution networks. The results show that curtailment is a low-cost option to increase the HC, providing a rise of 13% in rural regions and 7% to 8% in suburban and urban regions. However, curtailment compensation costs eventually surpass upgrade costs, making network upgrades a practical option once the HC level reaches 118%, 106%, and 97% for rural, suburban, and urban regions, respectively. The paper concludes that curtailment can serve as a short-term solution to relieve network violations and defer network investment, while network upgrade offers a larger headroom for HC increase in the long run, albeit with higher costs and resource requirements.

'***Hosting Capacity Enhancement of Hybrid AC/DC Distribution Network Based on Static and Dynamic Reconfiguration***': This paper presents a model for enhancing the Hosting Capacity (HC) of hybrid AC/DC distribution networks by incorporating static and dynamic network reconfiguration, reactive power control of Voltage Source Converters (VSCs), and mesh operation capability. The proposed model maximizes the RESs HC while considering technical constraints and uncertainties using stochastic programming. Simulation results demonstrate the effectiveness of the model, showing that dynamic reconfiguration with mesh operation and the inclusion of QVSCs (reactive power control in VSC) leads to the highest HC improvements. The study highlights the advantages of hybrid AC/DC networks in increasing the HC and provides a flexible model for various studies related to network planning and optimization with RES integration.

'***A Single-Ended Protection Method for Flexible DC Distribution Grid***': This paper undertakes the study of a single-ended protection method for flexible DC distribution grids in response to the inherent intermittency of RESs and the challenges they pose to grid operation. The adoption of modular multilevel converter (MMC) based flexible DC distribution grids is motivated by their advantages of flexible operation, high power supply capacity, and reliability in addressing renewable energy integration challenges. However, the rapid rise of fault currents during short circuit in the DC side of these grids, caused by the discharge of submodule capacitance in MMC poses a safety threat to the DC system. To overcome the limitations of protection relying on line boundaries, this paper introduces a novel single-ended protection method that is independent of line boundaries. This research is of significant importance as it addresses the critical issue of fault protection in flexible DC distribution grids, ensuring the safe and reliable operation of renewable energy-integrated grids while considering economic costs and engineering applicability.

'***Conditionally Constrained Compound Sub-gradient Method for Distributed Energy Coordination***': This paper presents a Conditionally Constrained Compound (CCC) sub-gradient method for distributed energy coordination in the context of distributed optimization algorithms. The research

addresses the optimization problem of complex distributed multi-energy input systems and focuses on consistency optimization, which requires individual decision variables to become consistent. By utilizing a compound sub-gradient method distributed among agents, the proposed method offers a solution for distributed energy resources (DER) systems. The study analyzes the DER model transformation and identifies energy storage transformation as a crucial factor. Through a time-based representation and an iterative compound step ladder algorithm, the proposed method demonstrates its effectiveness in complex distributed new energy access applications. The convergence rate results highlight the method's performance and utility in solving the optimization problem of distributed energy coordination.

'***Power System Wideband Oscillation Estimation, Localization, and Mitigation***': This paper focuses on power system wideband oscillations and their impact on power system stability. The study begins by examining the propagation of oscillations and typical events caused by them. It then discusses methods for estimating the oscillation model, including both model-based and data-driven approaches, highlighting the benefits and challenges associated with each technique. The paper also explores oscillation localization techniques, such as DEF (Distributed Energy Flux) and mode shape analysis, which enable accurate identification of the source of wideband oscillations using real-time measurements from different locations. Additionally, various mitigation measures are compared, including FACTS (Flexible AC Transmission Systems), PSS (Power System Stabilizers), damping controllers, and converters. The paper concludes by emphasizing the need for further research on wideband oscillations and presenting future directions for investigation.

2 | SUMMARY

These papers contribute to the body of knowledge surrounding the RES hosting capacity in distribution networks and offer practical solutions for the integration of RESs. Each paper brings unique perspectives and methodologies, showcasing the diversity of approaches adopted to tackle the technical challenges associated with high RES penetration.

We hope that this Special Issue will serve as a valuable resource for researchers, practitioners, and policymakers interested in advancing the integration of RESs in distribution grids. The findings and methodologies presented in these papers will contribute to the ongoing efforts to improve the HC of distribution networks and pave the way for a sustainable and decarbonized energy future.

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DATA AVAILABILITY STATEMENT

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