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## Editorial

# Planning and Operating Power Systems to Proactively Respond to Climate Change

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The rapid growth in the proportion of renewable-energy generation, such as wind and solar power, has significantly heightened the power system's dependence on climate. Global climate change will profoundly impact various aspects of the system, including renewable-energy resource potential, power-system planning and operation, and electricity markets. The Intergovernmental Panel on Climate Change (IPCC) has pointed out that as climate change accelerates, extreme weather events will continue to become more frequent and severe. This trend will further intensify the impact of climate change on power systems. Reports from the North American Electric Reliability Council and the US Department of Energy have emphasized the urgent need to increase the resilience of power systems in response to climate change.

In recent years, extensive research has been conducted both domestically and internationally on the interactions between climate change and resource potential, renewable-energy power forecasting incorporating climate change, and extreme weather monitoring and prediction. These efforts have yielded multiple breakthroughs. However, research on how the planners and operators of renewable-energy power systems can proactively respond to climate change remains inadequate: ① There is a lack of systematic and in-depth fundamental theories and methods for analyzing and optimizing the supply–demand balance in renewable-energy power systems under climate change; ② conventional risk-assessment methods for power-system operation struggle to address high-penetration

renewable-energy scenarios in the context of climate change; and ③ the strategies and defense systems available for power systems to cope with extreme weather impacts are insufficient.

Understanding the potential impacts of climate change on renewable-energy resources is a prerequisite for the use of high-penetration renewable-energy power systems to address climate change. In this issue, Feng et al. from the China Electric Power Research Institute used Coupled Model Intercomparison Project Phase 6 (CMIP6) datasets to analyze global trends in low-output wind-power events. Their findings reveal a concerning increase in the frequency and duration of such events, particularly in East Asia and South America, highlighting a fundamental risk to power-supply adequacy in future wind-dominant systems.

The evolving uncertainties of high-penetration renewable-energy power systems under climate change and our understanding of them form the basis for system planning and operation. Liu et al. from Tsinghua University establish a systematic framework for addressing decision-dependent uncertainties (DDUs)—that is, uncertainties influenced by system planning and operational decisions—and apply it to develop new supply–demand matching methods. By clarifying the theoretical foundations of DDUs, their work provides a basis for developing smarter and more reliable planning and scheduling methods in systems with high shares of renewables and demand response.

System-planning methods must also account for the new characteristics of high-penetration renewable-energy power systems under climate change. Yang et al. from Xi'an Jiaotong University introduce a coordinated planning model for transmission, renewables, and energy storage. By defining renewable-energy power-flow density, their method offers a novel way to track and optimize clean energy pathways, ensuring that clean energy is effectively delivered to both internal and external loads. At the microgrid level, Liang et al. from the Hong Kong Polytechnic University present a tri-level interconnection planning approach for hybrid alternating current (AC)/direct current (DC) microgrids. Their framework, which incorporates dynamic converter efficiency and a data-correlated uncertainty set for solar power, significantly reduces interconnection costs while ensuring robust operation.

Risk assessment for high-penetration renewable-energy power systems under climate change has become increasingly critical.

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Hu et al. from Chongqing University propose a fully analytical method for real-time dynamic reliability evaluation. By avoiding computationally intensive simulations for every contingency, their approach enables rapid risk assessment—a crucial capability for system operators managing the high variability of renewables. Focusing on system defense, Liu et al. from Shandong University develop a method using machine learning algorithms to rapidly identify critical lines that could trigger cascading failures in hybrid AC/DC systems. This allows for proactive measures to be taken to protect the system against widespread outages.

This special issue aims to systematically organize and present major emerging engineering challenges at the intersection of climate/weather, power systems, and renewable energy, as well as global representative and pioneering academic advances. We hope to inspire more research teams to actively engage in this field, driving power systems toward proactive responses to global climate change. We extend our gratitude to the contributing authors for their scholarly work, to the editors for their stewardship, and to the reviewers for strengthening the articles' rigor through constructive critique.