Towards Next-Gen Power and Energy Systems

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I. Background and Topic Description

Driven by the proliferation of distributed energy resources (DERs), modern power grids are undergoing a revolutionary transformation in how electricity is generated, traded, delivered, and consumed. While new opportunities to exploit DER flexibility are created, power grids are not fully prepared for the forthcoming challenges: the uncertainty and variability from renewables, the lack of understanding of electrochemical mechanisms of battery storage, the reduction in the system-wide inertia, and the massive sensor measurements susceptible to malicious cyber-attacks, etc. Such negative impacts are likely to be reinforced due to the climate change-induced extreme weather events that have been witnessed more often in recent years. Therefore, invariant to any paradigm changes, the reliability of power and energy systems remains the most fundamental but increasingly challenging requirements to meet.

The latest advances in tackling this challenge have seen rising interest in using cross-discipline knowledge, spanning control theory, optimization, game theory, learning theory, geometry, economics, physics, and electrochemistry. This highlights several vital issues that hinder current power and energy system operation, including but not limited to: (i) frequency and voltage stability margin under high penetration of renewables; (ii) scalable computation under risk of uncertainty; (iii) degradation-aware battery storage operation; (iv) economic incentive compatibility of emerging technologies; (v) data susceptibility to malicious cyber-attacks. In attempts to answer the above questions, combining classical techniques in power and energy system analysis with cutting-edge data-driven approaches has huge advantages in dealing with the inherent system complexity and is thus favored in many real-world scenarios. Moreover, the broad potential applications will also boost the development of new theories and tools.

The goal of this invited session is to bring together researchers working on next-gen power and energy systems to exchange ideas and recent progress. It is the hope of the session organizers and contributors that more discussions can be stimulated and more research problems can be formulated through the interactions.

II. Keywords

Distributed Energy Resources; Low-Inertia Power Grid; Net Zero; Carbon Neutrality; Energy Economics; Cyber Security; Data-Intensive Computation.