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Grid Reliability and Resilience Enhancement through Advanced Modeling and Autonomous Grid-Forming Control for Photovoltaic Systems

Abstract.

Today's electric grids are rapidly transitioning toward having an increasing proportion of generation from inverter-based energy resources such as solar, wind, and battery storage devices. These changes pose major challenges because there is no established body of experience for operating electric grids that are comprised of traditional synchronous generators as well as those of numerous and diverse inverter-based distributed energy resources. As a consequence, many research questions on the control and operation of large-scale inverter-based distributed energy resources and their effect on the stability, reliability, and resilience of the electric grids have been raised. To address some of these questions, the ***goal*** of this project is to develop advanced dynamic modelling and control frameworks for distributed solar photovoltaic (PV) systems to enhance the stability, reliability, and resilience of the electric grids. The approach is to: 1) develop an autonomous, robust, grid-forming control framework for distributed solar PV to provide aggregated grid reliability and resilience services, including frequency and voltage regulation and transient damping and stability improvement; 2) develop a high-fidelity, low-computation-cost, dynamic modelling framework for aggregating large-scale distributed solar PV systems; and 3) conduct real-time simulation and hardware-in-the-loop testing to validate the stability, reliability, and resilience enhancement of electric grids with distributed solar PV resources using the proposed control and modelling frameworks. Findings resulting from the project will provide generic, easy-to-implement modeling and control techniques that can be used to study the impact of solar PV on the electric grids and develop new advanced control systems for solar PV and other inverter-based resources to enhance the stability, reliability, and resilience of the electric grids. The project results will provide useful tools for electric utilities, such as the Nebraska Public Power District (NPPD), to study various problems related to the grid integration of solar PV and other inverter-based distributed energy resources.