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Award Abstract # 1653922

CAREER: Risk-Aware Power System Operations with Significant Wind Power Penetration

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ABSTRACT

Wind power has been integrated into the nation's bulk power systems at a rapidly increasing pace. Due to its intermittency, volatility, and uncertainty, wind power generation has posed grand challenges for power system operations and planning. This project aims at addressing key challenges in wind power integration, including reserve procurement, wind power ramps, and involuntary wind power curtailment. The research of this project will produce the following: 1) a systematic approach for risk assessment and quantification of wind power ramps; 2) an early alarm system for large wind power ramps induced by extreme weather events; and 3) cost-effective operational protocols for acquiring reserves from generation and transmission resources of power networks. The research outcomes will be integrated to develop new multidisciplinary courses to enrich the curriculum of wind engineering program at the National Wind Institute, and to engage undergraduate students in research through design and experimental projects at a dedicated wind power research laboratory that is to be established as an outcome of the project. The project outcomes are expected to impact power system operations by enhancing the operator's situational awareness of wind power ramps, and by improving the reliability, security, and efficiency of bulk power systems and the wholesale electricity market. The integrated research and educational activities will contribute to training qualified engineers

and researchers who can contribute to a thriving and sustainable wind energy industry.

The project research seeks fundamental breakthroughs in wind power ramp risk assessment and curtailment reduction to enable efficient utilization of increased wind power capacity in bulk power systems. Motivated by a key observation that large wind power ramps exhibit tail behaviors dictated by generalized Pareto distributions, a systematic method for quantifying wind power ramp risk is developed, based on which the adequate amount of reserves can be determined in a rigorous manner. Along a different path, preliminary studies using real-world data from Mesonet and dispersed wind farms reveal that Mesonet measurements indeed contain critical signatures of large wind power ramps induced by extreme weather events (fronts, thunderstorms, icing events, etc.), which state-of-the-art wind power forecasting systems may fail to capture. With this insight, a Mesonet-based early alarm system will be designed to enhance the power system operator's risk awareness with respect to large wind power ramps. Further, an innovative concept of line transfer margin will be developed from a congestion risk-limiting viewpoint, which facilitates reduction of involuntary wind power curtailment by suppressing congestion risk and by improving the deliverability of reserves. These line transfer margins can be easily pre-computed by using basic statistical information on nodal wind power generation together with the flow distribution factors of power networks. The research encompasses several innovative and nontraditional approaches, including risk quantification of wind power ramps using extreme value theory, wind power ramp events detection through networked data analytics, and exploratory study of dynamic reserve zoning from a graph-theoretic perspective.

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Abedi, Sajjad and He, Miao and Obadina, Diran "Congestion Risk-Aware Unit Commitment With Significant Wind Power Generation" *IEEE Transactions on Power Systems* , v.33 , 2018 10.1109/TPWRS.2018.2831677 Citation Details

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