Advances in Assessing and Projecting Water-Dependent Generating Capacity at Risk across the United States

Sean Turner (sean.turner@pnnl.gov) and Nathalie Voisin (nathalie.voisin@pnnl.gov) (Pacific Northwest National Laboratory, Richland, WA, USA)

Background/Objectives. Hydroelectric and thermoelectric power generating technologies rely on natural, fresh surface water to fill reservoirs, drive turbines, and supply coolant. These water-dependent generating technologies account for more than half of United States power generating capacity. Understanding the performance and vulnerability of these resources during drought is a key requirement in support of simulation studies seeking to determine reliability of electricity supply for the power grid of present and future. PNNL is engaged in selection of research projects that aim to characterize and model possible impairment and derating of power generation during drought, as well as explore potential hydropower plant operating strategies for maintaining reliable generation.

Approach/Activities. PNNL is combining hydrologic simulations with water management observations and theory, data analysis, and statistical modeling to study and simulate the impacts of drought on individual power plants across large power grids. Our large-scale hydrological and water management modeling capabilities include empirically-derived, weekly-resolution reservoir operations obtained by analyzing historical reservoir operations across approximately 700 dams located throughout the United States. These operations allow for realistic river flow and reservoir storage simulations over large regions during prolonged hydrological drought. Since we aim to inform grid-scale power simulations, our drought impact models can project generation across hundreds of individual plants throughout large power grid regions with spatiotemporal coherence that reflects realistic, widespread effects of drought on interconnected regions.

Results/Lessons Learned. Recent projects and associated findings include a study of 30 reservoirs throughout Texas supplying water for thermoelectric plant cooling, in which we demonstrate a threat of future droughts compromising up to one fifth thermoelectric generation supply to the Texas grid. We have also created hydropower generation datasets for various water years covering the entire Western Interconnect, finding that weekly (rather than monthly) parameterization of hydropower can significantly improve power grid simulations. Ongoing and future studies include a retrospective analysis of the 2020/21 drought in western United States and its impacts on hydroelectric power production, in which we hope to characterize the effects of drought on both generation and flexibility. We are also improving and extending our hydropower generation datasets to cover the entire conterminous United States with weekly-resolution targets for a range of different power system models. In work aimed at addressing the potential value of forecasts for hydropower producers, we are examining how enhanced operations at various dams located throughout the United States can mitigate the detrimental effects of drought on generation and flexibility.