Stochastic Water Distribution Network Operation Considering Power Distribution Network Constraints (EGSR_8)

Anna K. Stuhlmacher, Johanna L. Mathieu

Department of Electrical Engineering and Computer Science, University of Michigan, Ann Arbor, MI

The electric power grid faces resiliency challenges due to increasing levels of intermittent and distributed renewable energy sources. The water distribution network (WDN) and power distribution network (PDN) are spatially and temporally coupled through the power consumption of water pumps and storage capabilities of water tanks. By jointly optimizing operation of the water and power distribution networks, we can ensure that WDN power usage does not exacerbate the violation of constraints in PDNs with high penetrations of distributed energy resources. We formulate a chance-constrained optimization problem to schedule water pumping subject to PDN constraints while managing water demand uncertainty. In addition to an optimal pumping schedule, we also determine optimal parameters of a control policy that can be used to compute real-time control actions to compensate for water demand forecast error. The resulting problem is nonlinear and nonconvex, and so conventional solution approaches for chance-constrained problems do not work. We heuristically apply a scenario-based method and investigate the performance of the control policy in ensuring water demands are met and both WDN and PDN constraints are satisfied despite uncertainty. Through case studies with a detailed model of a coupled WDN/PDN, we find that the scenario-based method provides feasible real-time control actions for most realistic scenarios; however, there is no guarantee that the full range of realistic scenarios can be satisfied at the desired confidence level. Future work will explore alternative solution approaches including convex relaxations and approximations of the formulation.