Instantons and Risk-aware Optimization and Control Challenges in Energy Transmission Systems

Michael Chertkov*[1]

[1]Los Alamos National Laboratory (LANL) – T-4, MSB213, Los Alamos, New Mexico 87545, United States

Abstract

Today's energy systems, such as electric power grids and gas grids, already demonstrate complex nonlinear dynamics where,
e.g., collective effects in one exert uncertainty and irregularities on other. These collective dynamics are not well understood and are expected to become more complex tomorrow as the grids are pushed to reliability limits, interdependencies grow, and appliances become more intelligent and autonomous. Tomorrow's will have to integrate the intermittent power from wind and solar farms whose fluctuating outputs create far more complex stress on power grid operations, often dependent, e.g. in providing fast regulation control, on the gas supply. Conversely, one anticipates significant effect of the wind-following gas fired turbines on reliability of the gas grid. Guarding against the worst of those perturbations will require taking protective measures based on ideas from optimization, control and statistical physics. In this talk we introduce a few of the physics, optimization and control principles and phenomena in today's energy grids and those that are expected to play a major role in tomorrow's grids.
We illustrate the new science of the energy grids on examples: (a) discovering most probable (instanton) configuration in power and gas grids (b) discussing an efficient and highly scalable Chance Constrained Optimal Power Flow algorithm providing risk-aware control of the power transmission system under uncertainty associated with fluctuating renewables (wind farms); (c) describing effect of the intermittent power generation on reliability and controls of the natural gas operations.

*Speaker