Author(s): Chengda Ji, Yue Shen, Elijah J Pivo, Pengcheng You, Dennice F Gayme, and Enrique Mallada

Organization(s): Johns Hopkins University

Email Address: chengdaji@jhu.edu

Title: Optimal Distribution System Resources Coordination in the Presence of Uncertainties

Abstract: The increasing penetration of distributed energy resources within distribution networks brings both challenges and opportunities for utilities. On the one hand, these distributed energy resources introduce uncertainties, e.g., high day-ahead demand and price forecast errors, that can jeopardize system reliability. On the other hand, the additional flexibility introduced by controllable loads and energy storage systems across multiple heterogeneous feeders can enable utilities to decrease costs by taking advantage of price differences (arbitrage) between day-ahead and real-time prices and generate revenue by participating needs in ancillary service markets. In this work, we present an optimization framework to achieve both of these benefits by coordinating the distributed resources over a radial network for joint participation in the real-time and multiple reserve markets. We deal with uncertainty in three ways. Chance constraints are adopted to deal with the uncertainties associated with the demand and solar generation forecast errors. A scenario-based optimization technique is imposed to manipulate the uncertainty from the price prediction. Finally, we solve the problem in a receding horizon manner to obtain a trajectory of the optimal energy and ancillary service markets participation strategies that are updated based on the currently available predictions. The approach is illustrated on a real-world circuit using several trace-driven simulations. The performance is quantified in terms of the utility's net cost, i.e., the net energy procurement cost minus the revenue from the ancillary markets, and the computational complexity. We investigate the sensitivity of the solution to system parameters by further studying the techno-economic trade-offs associated with reducing uncertainty. Specifically we quantify the effect of forecast quality on the economic benefits (utility's net cost) and computational complexity, under various solar penetration levels.

Key words: