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Holistic planning of a virtual power plant with a nonconvex operational model: a risk-constrained stochastic approach

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Abstract-

This paper presents a novel approach for the investment planning of a virtual power plant trading energy in an electricity market. The virtual power plant comprises conventional generating units, renewable generating units, storage units, and a set of flexible demands. In order to maximize its expected profit, the virtual power plant has the possibility of installing new conventional, renewable, and storage units. Such investment decisions are made under the long-term uncertainty associated with future production costs of the conventional generating units, future consumption levels of the flexible demands, and future energy market prices, as well as the short-term variability of market prices and renewable production levels. In addition, the effect of generation and storage operation on investment decisions is precisely characterized by a detailed nonconvex formulation. The resulting model is cast as a scenario-based two-stage stochastic programming problem wherein the conditional value-at-risk is used to represent the risk aversion of the owner of the virtual power plant. Numerical results from several case studies show that the virtual power plant can significantly increase its expected profit by expanding its generation and storage assets. Moreover, neglecting nonconvex operational constraints generally results in over-investment in conventional generating units. The moderate computational effort required to solve instances with up to 45 candidate assets backs the practical applicability of the proposed approach.

Index Terms- Co-optimized generation and storage investment decisions; Nonconvex operational model; Risk; Stochastic programming; Virtual power plant planning

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