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Prescriptive Energy Scheduling in Two-Stage Markets: an Iterative Learning Approach

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Energy scheduling is typically conducted as a two-stage procedure that comprises day-ahead and real-time stages. Particularly, day-ahead decisions are made under uncertainty, which then affects real-time decisions, as operators must constantly maintain power balance. For that, it is commonplace in the energy industry to predict renewable energy production and power load, which are then used to plan energy dispatch ahead of time. However, forecasting models are often developed independently of the sequential decision-making process, which can result in sub-optimal day-ahead solutions. While scheduling methods based on stochastic programming have been developed to incorporate the influence of day-ahead decisions on real-time decision problems across different scenarios, they have been criticized for undermining key market characteristics and the computational burden during operations. To bridge the gap, we design a value-oriented point forecasting approach for sequential energy dispatch problems with renewable energy sources. During the training phase, we align the training objectives with the decision value, aiming to minimize total operational costs. The estimation of forecasting model parameters is set up as a bilevel programming problem. With certain mild assumptions, we reformulate the upper-level objective into an equivalent form utilizing the dual solutions from the lower-level operation problems. In particular, we design a novel iterative learning method tailored for the defined bilevel program. Within this iterative framework, we demonstrate that the upper-level objective is locally linear regarding the forecasting model's output, which then serves as the loss function. Through numerical experiments, it is shown that the proposed method provides reduced operating costs compared to the widely utilized sequential decision-making scheduling framework. Simultaneously, the method attains a performance level akin to two-stage stochastic programs, while offering greater computational efficiency.

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