Impact of Forecasting Accuracy on Predictive Optimal Control of Active and Passive Building Thermal Storage Inventory

This paper evaluates the benefits of combined optimal control of both passive building thermal capacitance and active thermal energy storage systems to minimize total utility cost in the presence of forecasting uncertainty in the required short-term weather forecasts. Selected short-term weather forecasting models are introduced and investigated with respect to their forecasting accuracy as measured by root mean square error, mean bias error, and the coefficient of variation. The most complex model, a seasonal autoregressive integrated moving average (SARIMA), shows the worst performance, followed by a static predictor model that references standard weather archives. The best prediction accuracy is found for bin models that develop a characteristic daily profile from observations collected over the past 30 or 60 days. The model that projects yesterday's patterns one day into the future proved to be a surprisingly poor predictor. We test the predictor models in the context of a predictive optimal control task that optimizes building global temperature setpoints and active thermal energy storage charge/discharge rates in a closed-loop mode. For the four locations investigated in this article—Chicago, IL, Denver, CO, Omaha, NE, and Phoenix, AZ—it was determined that the 30-day and 60-day bin predictor models lead to utility cost savings that are only marginally inferior compared to a hypothetical perfect predictor that perfectly anticipates the weather during the next planning horizon. In summary, the predictive optimal control of active and passive building thermal storage inventory using time-of-use electrical utility rates with significant on-peak to off-peak rate differentials and demand charges is a highly promising control strategy when perfect weather forecasts are available. The primary finding of this paper is that it takes only very simple short-term prediction models to realize almost all of the theoretical potential of this technology.
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