ENERGY STORAGE AND PEAK LOAD PRICING FOR MORE EFFICIENT DEFERRABLE DEMAND MANAGEMENT

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Overview

Our previous research has shown that distributed storage capacity at load centers (e.g., deferrable demand) can lower total system costs by smoothing out and flattening the daily dispatch profile of conventional generating units. The main savings in cost come from the displacement of conventional generation by wind generation and from reducing the amount of installed conventional generating capacity needed to maintain operating reliability and generation adequacy at the peak system load. However, the full capacity of deferrable demand will not be used to reduce the peak system load when the price arbitrage between the peak and off-peak periods is too small to cover the round-trip inefficiency of the storage. In terms of the total system costs, this situation is inefficient (Cuomo, 2014). The reason is that the system operator determines the optimal dispatch by minimizing the expected cost of current operations and ignores the potential for reducing the peak system load and saving the associated capital costs.

Methods

This paper presents a mechanism for augmenting the nodal prices during peak load periods to reflect the capital cost of a peaking unit. Since the modeling framework treats load and potential wind generation as stochastic inputs, it is possible to determine the probability that a predetermined (high) net load is exceeded. We study alternative mechanisms for this surcharge, including one method that multiplies this probability by the capital cost of a peaking unit and to add the product to the offer prices submitted into the wholesale market. We combine a theoretical framework, formulating a stochastic maximization of the total welfare from the point of view of a social planner (Lamadrid et al., 2015), and a network reduction (Allen, Lang, and Ilic, 2008) alongside specific placement of Renewable Energy Sources in connected nodes that may have congestion. The optimization uses CPLEX to find a solution via a Newton Raphson approximation. For the statistical analysis, we use a dataset that comes from the Eastern Wind Integration and Transmission Study (NREL, 2010), and has data for wind with forecasts and realizations in 15-minute time steps.

Results

Our preliminary results show that, including the capital costs savings of reduced peaking capacity and costs of the thermal storage, the higher operational incomes can provide an additional revenue stream to conventional generators, therefore partly eliminating the rationale that capacity markets are needed to provide missing money; and the management of the deferrable demands shifts from a mixed role of providing support for uncertainty of renewables and energy shifting to a predominant role of shifting energy from cheap to expensive periods.

Conclusions

We find that, with the move to a predominance of gas turbines, there are reduced incentives to manage deferrable demand efficiently by narrowly focusing on the marginal cost of production. This outcome is likely to be inefficient in the long run, leading to a much higher peak capacity installed, with spare usage over the year. Peak system load management can correct some of these challenges. However, it requires changes in the regulatory structure and the incentives faced by operators of the transmission and distribution system.

References

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