The Economic Value of Distributed Storage at Different Locations on an Electric Grid

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Executive Summary

The objective of this article is to analyze the system benefits of distributed storage at different locations on an electric grid that has a high penetration of renewable generation. The chosen type of distributed storage modeled is deferrable demand (e.g., thermal storage) because it is relatively inexpensive to install compared to batteries and could potentially form a large component of the peak system load. The advantage of owning deferrable demand is that the purchase of energy from the grid can be decoupled from the delivery of an energy service to customers. Consequently, these customers can reduce costs by shifting their purchases from expensive peak periods to off-peak periods when electricity prices are low. In addition, deferrable demand can provide ramping services to the grid to mitigate the uncertainty of renewable generation. The primary economic issue addressed in this paper is to determine how the storage capacity is allocated between shifting load and providing ramping services. The basic economic tradeoff is between the benefit from shifting load away from the peak to reduce the installed capacity needed for adequacy, and using storage capacity for ramping to reduce the amount of conventional reserve capacity needed for operating reliability.

The analysis uses a new form of stochastic, multi-period Security Constrained Optimal Power Flow (the **M**atpower **O**ptimal **S**cheduling **T**ool, **MOST**) that minimizes the expected system costs for energy and ancillary services over a 24-hour horizon. For each hour, five different levels of wind generation may be realized and these are treated as different system states with known probabilities of occurring. This model uses a reduction of the New York State and New England grid to simulate the hourly load on a hot summer day, treating the potential wind generation at different sites as stochastic inputs. The model determines the expected amount and location of conventional generating capacity dispatched, the reserve capacity committed to maintain operating reliability, the charging and discharging of storage capacity, and the amount of potential wind generation spilled.

The results show there are major differences in how the deferrable demand at two large load centers, Boston and New York City, is managed. A much higher proportion of the storage capacity at Boston is used to shift load compared to New York City because the day/night price differential is larger in Boston. However, from the perspective of long-run economic efficiency, this is not efficient. The potential savings in the capital cost of installed generating capacity from reducing the peak system load is much larger than the benefit from providing more ramping capacity to dispatch more wind generation and displace conventional generation. The overall conclusion is that some form of critical peak pricing is needed for long-run efficiency.

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