Estimating Arbitrage Profits for Storage Resources in Nodal Electricity Markets: A Decision Tree Method

Benjamin P. Fram, NHH, Department of Business and Management Science

Abstract

In this paper, we formulate an optimal strategy for an operator of a stand-alone utility scale storage resource, such as a battery, maximizing arbitrage profits in a wholesale electricity market with ex-ante pricing. A new price is revealed to the operator periodically and we assume that the revealed price also signals the price for the next time interval and by extension, the future price trajectory for the remaining decision time horizon.

The storage operator's options include: charge (buy power), discharge (sell power), or stay idle. The storage operator's decision is contingent on the revealed price and on the operator's expectation of the future prices at that instant. We employ this approach to obtain revenue distributions of storage resource operators in 856 locations in the wholesale power market managed by Midcontinent Independent System Operator (MISO). These revenue distributions quantify the range of risk-reward tradeoffs available to a potential investor in a utility scale storage facility.

We highlight several key findings from our analysis results. First, there is a strong, positive correlation between price volatility at a given node and expected profitability. Second, we find no relationship between expected arbitrage profitability and generator fuel type. Instead, we find that the most profitable locations are clustered in so-called "narrowly constrained areas" (NCA), i.e. sub-regions of the MISO where insufficient power transmission infrastructure causes frequent network congestion and high price volatility.

Finally, the results of our sensitivity analysis on storage resource charging capacity show that expected arbitrage revenue increases with the storage capacity at a diminishing rate and there are limits to arbitrage opportunities during a normal power delivery day. These findings have important implications for potential investors in storage plants and policymakers who wish to encourage development of storage resources.