ENERGY STORAGE BEYOND ARBITRAGE – HARNESSING THE EXCESS ENERGY OF WIND POWER PLANTS

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Abstract

High efforts to promote and expand renewable energy systems (RES) in Europe have led to fundamental changes in the electricity sector. Demand minus volatile generation from renewables (the residual load) tends towards zero in few moments during a year and could also become negative at times in the foreseeable future, which would force RES to shed generation. This is where storage devices, which are often considered to be indispensable elements of future energy systems, could produce relief, but they are currently suffering from low wholesale electricity prices and small price spreads in particular. Consequently, the traditional field of application for storage systems, energy arbitrage, often fails to trigger investment in those technologies. Hence there is a strong interest to employ them for additional purpose in order to generate extra revenues.

This paper aims to explore options of deployment of battery energy storage systems (BESS) when operated jointly with a wind power plant (WPP). Thereby the BESS is used in three different ways in order to maximize net revenues of the wind-storage system: (1) to reduce forecast errors of the WPP and thus reduce payments for balancing energy; (2) to provide ancillary service (negative control energy) to the grid; and (3) harness excess energy of the WPP by shifting production in moments of low corresponding value of energy to moments of high values.

To achieve this, the BESS must operate in both the (day-ahead) spot market and the control energy market. The optimal dispatch strategy of the BESS is obtained from a two-stage linear optimization model:

- In a first step dispatch of the BESS is optimized for the upcoming period (day) considering day-ahead spot market prices for electricity only. This first optimization leads to a scheduled dispatch of the BEES.
- Subsequently, the second step of optimization takes into account the forecast error of the WPP and the control energy that has to be delivered by the wind-storage system and gives the actual dispatch of the BESS.

Both steps of the optimization model assume perfect foresight and the wind-storage system to act as a price taker. Finally, resulting net revenues from storage deployment are calculated according to the actual dispatch of the BESS using historical data for forecast errors of a WPP and balancing energy prices, spot market prices, control energy calls and control energy market prices.

The calculation is based on data from the year 2014 of the Austrian spot and control energy market and was performed using the example of an existing 20 MW WPP in Austria. The linear optimization model was implemented in Matlab using Yalmip and a Gurobi Optimizer.

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