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Optimizing operation of wind-hydropower hybrid systems on a day ahead energy market

Jakub Jurasz (1), Alexander Kies (2), and Jerzy Mikulik (1)

(1) AGH University, Management, Engineering Management, Poland (jakubkamiljurasz@gmail.com), (2) Frankfurt Institute for Advanced Studies, Goethe University Frankfurt, Ruth-Moufang-Str. 1, 60439 Frankfurt, Germany

The inherently variable weather driven nature of wind energy sources makes their integration into the power system a complicated and demanding task. Over recent years, several approaches have been proposed, investigated and analyzed in order to overcome the problem of varying energy supply from wind turbines. Among them are: wind speed/energy yield forecasting, coupling wind parks with battery banks or using bulk energy storage (pumped storage hydroelectricity) as an intermediary between wind power sources and the power system.
In this paper, we investigate the concept of coupling a run-off-river power plant with pondage with a wind park. Similar ideas were already thoroughly investigated from the perspective of, for instance, solar-hydro hybrids. However, the body of literature available on such systems operating on a day ahead energy market is relatively small. It is worth mentioning that such a solar-hydro hybrid itself is a very interesting combination, albeit quite different from the one proposed here since it does not offer any form of direct storage for available wind energy surpluses. The variability of wind energy has to be compensated by an adequate and optimally sized operation of a run-off-river power plant with a reservoir. Although, sudden and not predicted by forecast drops of wind generation can be in such situation substituted by hydropower the not forecasted over generation has to be curtailed.
The main assumption is the proposed hybrid operating on a day ahead market maximizing its profit from sold energy due to a price variation during peak and off-peak periods, where unmet scheduled energy delivery/dispatch is penalized Several constraints are including: mass balance, water turbine power curve or allowable flow rate changes. In our analysis, we have used both deterministic (as a benchmark) and stochastic (considering wind generation and flowrate forecast uncertainty) models. Obtained results indicate that thanks to the proposed dispatch algorithm, two objectives can be achieved simultaneously:
i) the profitability if compared to wind hydro alone is increased
ii) curtailed/rejected wind generation is minimized
iii) water retention increases and wind power variability impact on the power system is minimized.