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Probabilistic energy storage sizing for reducing wind power forecast uncertainty (extended abstract)

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A novel method is proposed for designing an energy storage system (ESS) which is dedicated to reducing the uncertainty of the short term wind power forecast. The investigation focuses on the statistical behaviour of the forecast error and the state of charge (SOC) of the ESS. This approach gives an insight into the influence of the forecast conditions on the distribution of SOC. With this knowledge, an optimised sizing of the ESS can be done with a well defined uncertainty limit.
One-year power output data measurements and two types for forecast were used for this study. In addition, different forecast quality degrees are simulated based on the persistence approach. With the forecast data, empirical probability density functions (pdf's) of the SOC are generated which is the base of the proposed method.
This approach can lead to a considerable reduction of the ESS and provides important information about the unserved energy. This unserved energy is the remaining forecast error or uncertainty. As a consequence, the proposed probabilistic method permits the sizing of the energy storage system as a function of the desired remaining forecast uncertainty.

Five main conclusions can be derived from this study:

- Large ESS capacities are needed to reduce wind power forecast errors
- Permitting only small quantities of unserved energy, requirements for ESS are reduced drastically
- Persistence scenarios Tx1 (for power) and Tx2 (for energy) are valid for ESS sizing as they represent to a large extent statistics of real world forecasts
- The proposed sizing method performs well for 24-h forecasts with both, persistence and real world data
- Bias correction (MOS) improves model precision and reduces ESS capacity requirements

It could be demonstrated that forecast errors from the persistence scenarios can be used for ESS sizing. The sizing method is verified with real world forecast data. Especially for 24-h forecasts, the method presents relatively low errors which is interesting for day-ahead forecasts in electricity markets. Finally, model output statistics (MOS) such as the proposed online bias-correction revealed a great value for ESS sizing. Estimations are more precise and statistic parameters resemble more those from persistence scenarios.
From the case study it can be seen, that large capacities of energy storage are needed to compensate wind power forecast errors. On the other hand, only permitting amounts of unserved energy in the range of 5% may reduce the required ESS size by up to 50%.

Interpolating the results, sizing surfaces can be obtained, giving an estimation of the unserved energy for every combination of reduced energy and power ratings. One example is given in Fig. 1. Here a reference system of 1 MW and 24-h forecast is assumed, which represents 100% forecast error compensation in case of forecast scenario Tx1. Values of unserved energy are normalised by the maximum, which is equal to ETR_0 in this case.

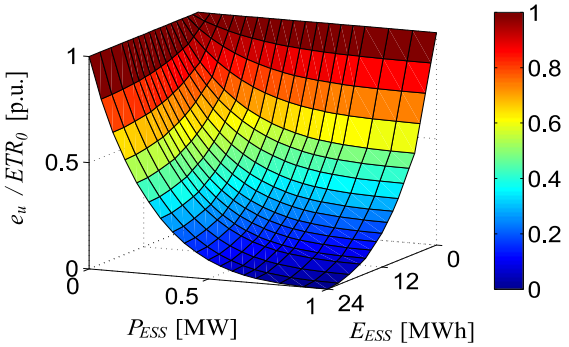

Fig. 1. 2D-interpolation of unserved energy, normalised with ETR_0 as a function of ESS size, reference case of 1 MW installed power and 24-h Tx1 forecast.