Stochastic Modeling of Wind Power Production

by

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Abstract

The prominence of renewable energy, such as wind, has significantly increased over the past years. According to the Global Wind Energy Council, installed wind capacity doubled since 2007. However, wind energy development can be hampered by its natural high capacity volatility. More accurate forecasts can help reduce operation and maintenance costs of the supporting thermal generation power plants and ensure system reliability by meeting the power demand.

Short-term wind power forecasts typically are based on the statistical time-series analysis. One of the simplest short-term wind power prediction methods is the persistence forecast. The persistence model is based on the assumption that the wind power would stay nearly constant for the next few hours. Surprisingly, it is extremely hard to improve on this simple model for a short-term power prediction. The persistence forecast is costless and often used as a baseline. In this paper, we analyze wind power time series and suggest an alternative relatively simple algorithm for the short-term forecasting of wind power production. The technique provides over a 30% decrease in the root mean square error (RMSE) over the persistence forecast for up to few hours ahead wind power prediction. The forecasting model is not computationally expensive and can be implemented by any wind power supplier.

The model allows a stochastic capacity planning for a wind farm with a storage. We consider a model for a storage device with dissipation. The dynamics of the system with a battery is described by a stochastic differential equation, where energy dissipation is taken into consideration. We derive the exact solution of the equation for stored energy. The solution allows to obtain an explicit expression for the system capacity.

Key words: Time series analysis. Stochastic differential equation. Wind farm capacity.

1 Results

The analysis is based on an additive daily decomposition of the wind power production. Autoregressive moving average (ARMA) model is used to predict the irregular remainder. The sample autocorrelation and sample partial autocorrelation functions of the irregular remaining component suggest ARMA(10,0) model for 1 min data. The analysis of the corresponding residuals confirms the result. Running blind tests on real 1 min wind power datasets, we demonstrate that the model significantly improves the persistence forecast. The obtained ratio of the persistence RMSE to the proposed algorithm's RMSE is over 1.5. The model allows to perform a stochastic capacity planning for a system with a dissipative storage device.

2 Conclusions

Wind power generation can be decomposed into the daily component and the remainder. The irregular remainder can be modelled as AR(10) process. The error analysis of the model indicates that the optimal results are obtained based on ten days of wind power generations. There is no significant improvement observed if more than 10 days of historical generations are taken into the model. It concludes that a memory length of the wind power is nearly ten days. The algorithm allows a wind farm capacity planning.