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Statistical power curve modelling: Which power curve for what application?

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Short Abstract

All statistical models for the conversion of meteorological variables to power generation, employed either for simulation or forecasting purposes, have their parameters estimated with a Least Square criterion - or equivalents. However, the basic assumption for the use of such criterion, which is that explanatory variables e.g. wind measures or forecasts are error-free, is obviously not true in practice. The paper discusses alternatives approaches for power curve estimation, based on the minimization of different criteria. The interest of using such or such approach depending on the intended application, i.e. point or ensemble forecasting, is discussed.

Extended Description

So far, there exists a wealth of rival and complementary approaches to the modelling of conversion of meteorological variables to wind power. These models are consequently used for simulation or forecasting purposes. Whatever the considered approach, it is assumed that the criterion to be minimized for model estimation is a Least Square (LS) criterion - or equivalent. The aim of the present paper is to discuss the relevance of this LS-criterion (and of others) depending on the intending application.

From a statistical point of view, using a LS-criterion derives from the assumption that a noise component is present in measured power data only, and that measures (or forecasts) of meteorological variables e.g. wind speed or direction, are error-free. However, it is commonly accepted that this is not the case in practice. A possibility for circumventing this assumption is to use a Total Least Square (TLS) criterion. In such case, the contribution of the noise components in both power and meteorological variables are accounted for in

model parameter estimation.

The case-study of a Danish wind farm is used as a basis for discussion, whose power curve is to be modelled with the Wind Power Prediction Tool (WPPT) from wind speed and power data. These data consist of hourly wind speed measurements from a meteorological mast at the level of the wind farm over a 10.000-hour period, and in simulated power measures. The 'true' power output is obtained by passing the wind speed data through a theoretical power curve. Then, the simulated - but realistic - power data are generated by adding a noise component to both the wind speed and 'true' power data. This semi-artificial dataset dataset allows us to evaluate the regression estimated from the various approaches against both the 'true' power curve and simulated measurements.

It is demonstrated that using a TLS-criterion leads to a more accurate model of the 'true' power curve, while using a LS-criterion permits to minimize error measures such as the Normalized Root Mean Square Error (NRMSE) evaluated against measured data. The latter criterion may then be more appropriate for the point forecasting application (as it is done today), since NRMSE minimization is often seen as an objective by forecast users. However, for applications such as ensemble forecasting, one is mainly interested in the 'true' power curve model. The TLS-criterion should then be considered. The interest of both criteria for other applications is similarly discussed.