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Studying non frequent wind events for energy applications

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Wind energy is a fast growing industry for the last decades. This trend is a result of both the rise of energy demand and the production cost using conventional sources. Two basic issues related to wind conditions and energy conversion, is site assessment and power prediction in short (1-3 hours) and long (1-5 days) periods. Both are highly depended on wind variability (e.g. ramping effects) and extreme conditions (e.g. gusts or winds exceeding the operational limits). The operational limits are affected by both high and low wind speeds as the cut-in threshold is about 3 m/s while the cut-out is around 25 m/s. For this reason, risk analysis techniques are necessary to ensure the viability of a project and maximize production. The uncertainties associated with the wind fields are considerable for the entire wind speed probability distribution. Low wind speed persistence will lead to periods characterized by low or no energy production that may affect the operation of the electricity network. Uncertainties related to wind speed variability affect the energy production while higher winds affect energy generation, wind turbine structural design and safety.

In this work, different approaches for the study of events related to both the lower and upper tail of wind speed probability distribution will be presented, based on the event's intensity, duration and frequency as well as the wind turbine's general characteristics. The application of such methodologies for the specification and extrapolation in time of these events, require several years of data. To overcome this restriction, a multi-parametric approach based on statistical tools and the Extreme Value Theory principles is employed. The study is focused on the estimation of extreme environmental conditions return periods using a ten-year/hindcast dataset. The obtained results show that the outputs of the methodologies tested, converge with respect to both low and high wind conditions.