Impact of Weather Regimes on the Wind Power Ramp Forecast in Portugal

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***Abstract*— Short-term forecasting and diagnostic tools for severe changes of wind power production (power ramps) may provide reliable information for a secure power system operation at a small cost. Understanding the underlying role of the synoptic weather regimes (WR) in triggering the wind power ramp events can be an added value to improve and complement the current forecast techniques.**

This work identifies and classifies the WRs over mainland Portugal associated with the occurrence of severe wind power ramps. The most representative WRs are identified on compressed surface level atmospheric data using principal component analysis, by applying K-means clustering. The results show a strong association between some synoptic circulation patterns and step variations of the wind power production indicating the possibility to identify certain WRs more prone to trigger severe wind power ramps thus opening the possibility for future development of diagnostic warning systems for system operators' use.

***Index Terms* — Large-scale integration, Meteorology, Pattern recognition, Power generation meteorological factors.**

I. Introduction

THE wind power capacity installed in Portugal had a high increase rate in the latest years, becoming the second largest renewable energy source. By the end of 2013, Portugal had 4.4 GW of installed wind power out of 17.8 GW of the operating capacity in the Portuguese power system. During 2013 the wind generation reached 11.8 TWh contributing with 24% of the total electrical supply [1] what constitutes the second highest wind energy penetration in the world, only surpassed by Denmark. The rapid growth of variable wind generation poses a serious challenge to the transmission system operators (TSOs) since, at any time: 1) balance between power supply and consumption must exist to ensure stability of the power system, and; 2) the supply/demand balance must be achieved at a minimal economic cost.

Wind power production forecasts play an important role and are nowadays extensively used by almost all TSOs [2, 3]. TSOs with high amounts of wind generation - by far the most relevant of the renewable variable sources - normally receive wind generation forecasts, which are usually calculated for the next 24 hours (day ahead) and refreshed every 6 hours. Due to unit commitment constraints and the technical limitation on power ramping of some power units [4] the wind forecasts are particularly relevant for the TSO in the 1-6 hr. time-horizon [5, 6]. This information is particularly relevant for the system operator when strong variations on the wind generation are expected, since the power fleet may lack the flexibility required to balance those wind power ramps [7] or that balancing may be obtained at very high costs in the reserves market.

This work aims to: a) understand which atmospheric conditions over Portugal are more associated with wind power ramp events within a 1-6 hr. time-horizon; and b) present the development of a diagnostic tool for detecting future wind power ramp events using synoptic data obtained from a numerical weather prediction (NWP) model coupled with multivariate statistics. This methodology of ramp diagnostic may be used at a later phase as part of a forecast tool to support the TSO operational decisions, namely aiding to keep the reserves committed due to wind fluctuations at minimum values and thus reducing the overall wind integration costs.

Section II describes the different forecast approaches and the added value of wind power ramp detection for the TSO. In Section III, a brief background on relevant atmospheric circulation in the Euro-Atlantic region is presented. Section IV describes the input data and the methodology developed. Section V presents and discusses the link between large scale circulation and wind power ramp events in Portugal. Finally, in section VI some conclusions are provided.

II. Use of Wind Power Ramps Detection on the Power System Operation

A comprehensive review of short-time wind power forecasting literature is beyond the scope of this paper and may be found in several review papers, e.g. [8, 9]. The common approach for wind power forecasting is based on the use of single point time series, i.e., forecasting the value of the wind power (and its confidence interval) for a given future time-horizon using either probabilistic models [10, 11], numerical weather prediction models (NWP) or by combining both [9]. Single point time series forecasts present high errors and according to [12], an improved solution to forecast wind generation can be obtained by providing spatial NWP forecast information to the TSO. This is justified by: a) the capacity to assess the spatial changes in the meteorological fields

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