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CONSTRUCTION OF AGGREGATED SCENARIO TREES FOR THE DAY-AHEAD PREDICTION OF WIND POWER

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Abstract: In this work, we present a method for constructing a multistage scenario tree based on an ARMA wind speed prediction and its absolute error. This method will be used to assist system actors for the day-ahead management of the grid. Furthermore, a comparison between different trees regarding the length of the historical data as well as the evaluation of the tree for days with much different wind behavior is going to be presented in the full paper.

Keywords: ARMA, prediction, scenarios, trees, wind

I. INTRODUCTION

Electricity grids evolve rapidly due to the integration of Renewable Energy Sources (RES). Although wind energy contributes to a high extent to this emergence of environmental friendly power generation, the stochastic nature of wind raises difficulties concerning the management of electrical networks. The integration of wind energy into the power system brings up unique challenges for system operators and planners. In this context wind speed prediction becomes a factor of great importance.

II. APPROACH

In order to surpass the challenges that the system actors are facing due to the integration of wind power, we establish a scenario tree which aims to assist system actors (Transmission System Operators, Distribution System Operators, providers) during the day-ahead management of the grid (electricity market aspects, reserve allocation,…).

Our first step is to predict wind speed for the day-ahead with an ARMA model and calculate its absolute error (difference between the measured value and the predicted one). The parameters of the ARMA model are chosen based on the historical dataset that is used and using the well-defined AIC criterion [1]. With an ARMA model we simulate the error equal times to the number of scenarios we need. A big fan of scenarios is created thereafter by adding the simulated errors to the output of the prediction model. The fan of scenarios is then reduced to a desirable size according to an algorithm that merges those scenarios with the smallest distance between them. This procedure aims to create a smaller and more efficient scenario tree which at the same time is representative of the initial fan of scenarios [2]. The scenarios of the reduced tree are also followed by their new probability of occurrence. The reduced fan of scenarios is then converted into a multistage tree by a backward algorithm which indicates which scenarios are closer to each other, at the stage under investigation, and merges those scenarios into one by adjusting the corresponding probabilities [3]. A study on the impact of the historical dataset's length on the volatility of the simulated scenario trees is then carried out, by examining the distances between the different scenarios. The procedure is repeated for various days with different wind behavior.

III. CONTRIBUTIONS

The contribution of this work would be in the direction of improving the constructed multistage tree by experimenting on the different behavior of wind for days with specific characteristics. Furthermore, the effect of the length of the historical data on the quality of the prediction is examined both for the ARMA prediction tool and the scenario tree.

IV. FIRST RESULTS

Rooted mean square error (RMSE) will be used in this study for the evaluation of the prediction tools. The prediction results will also be compared to the persistence model, which is a simple model that assumes the predicted value to be the same as the last measured one. Persistence is widely used in the bibliography for the evaluation of the prediction, as it gives good results for short term predictions. In fig. 1, one can see the RMSE for the different studied cases, which indicates better prediction for larger in length datasets. More specifically, it is clear that till the 10^{th} predicted hour the longer datasets result in smaller errors while the persistence model is outperformed for the whole prediction time horizon. Those results agree with the ones presented for one month data by Torres et al. [4]. After the 10th hour, the results change but still the longest dataset provides better results. In the full paper, day-ahead prediction will also be studied for different days in order to compare them and investigate if a generalization of the results regarding the dataset's length can be applied.

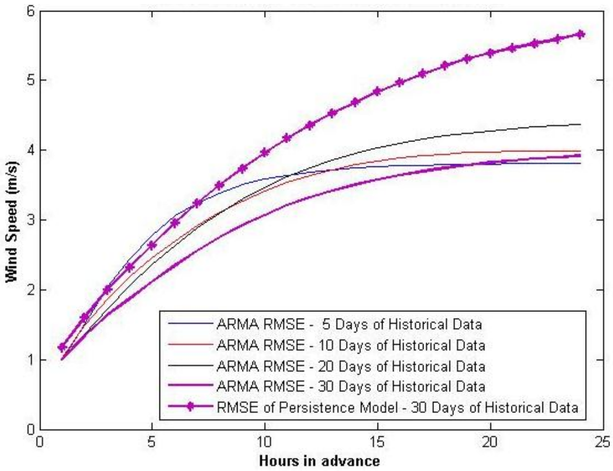

Figure 1: Comparison of the RMSE errors for different length of historical data

In figure 2, one can visually see the transformation of a big fan of scenarios, based on the prediction and its error, into a reduced fan of only 8 scenarios and then into a multistage scenario tree (for 4 time steps). The final multistage scenario tree will include the accompanied probabilities of the new transformed scenarios, in order to maintain as much information as possible from the original fan of scenarios. Table 1 shows the probabilities of each branch of the final multistage scenario tree for our case.

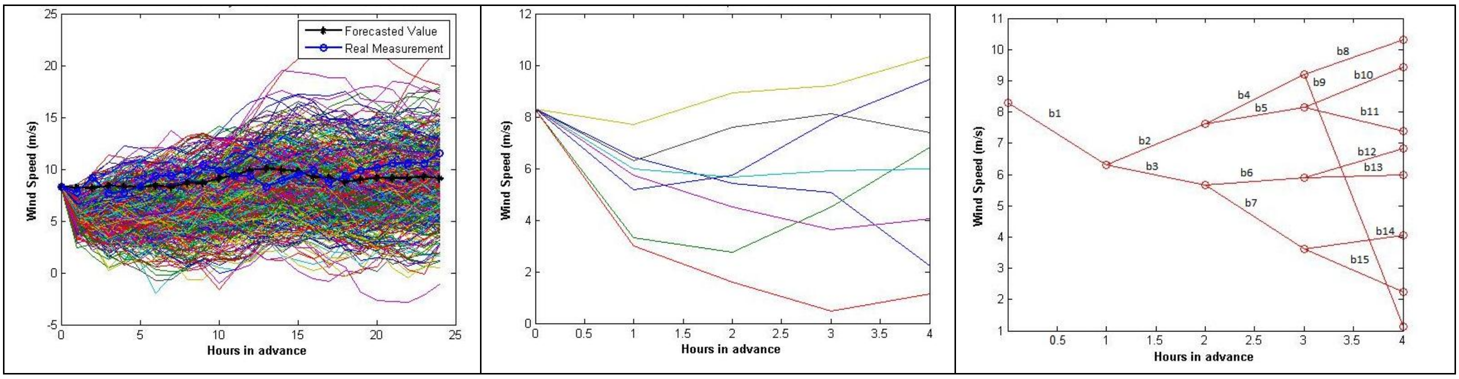

Figure 2: Transformation of a fan of 500 Scenarios into a reduced one of 8 scenarios and lastly into a multistage scenario tree

Table 1: Associated probabilities at the branches of the multistage scenario tree

Branch	1	2 - 3	4 - 5	6 - 7	8 - 9	10 - 11	12 - 13	14 -15
Probabilities	P_1=1	P_2=0.244	P_4=8115	P_6=0.3466	P_8=0.0229	P_{10}=0.8788	P_{12}=0.004	P_{14}=0.0435
		P_3=0.756	P_5=0.1885	P_7=0.6534	P_9=0.9771	P_{11}=0.1212	P_{13}=0.996	P_{15}=0.9565

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