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► **To cite this version:**

Simon Camal, Andrea Michiorri, Georges Kariniotakis. Forecasting Extremes of Aggregated Production from a RES Virtual Power Plant. Proceedings of the Wind Energy Science Conference 2019, EAWE - European Academy of Wind Energy, Jun 2019, Cork, Ireland. hal-02158589

**HAL Id: hal-02158589**

**<https://hal.science/hal-02158589>**

Submitted on 18 Jun 2019

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Keywords: Probabilistic Forecasting, Virtual Power Plant, Extreme Values.

## Forecasting Extremes of Aggregated Production from a RES Virtual Power Plant

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Transmission System Operators (TSOs) expect Renewable Energy Sources (RES) to participate to the provision of Ancillary Services (AS), in order to substitute conventional dispatchable power plants. A promising solution to ensure a sufficiently reliable provision of AS by weather-dependent RES is to aggregate dispersed plants into a Virtual Power Plant (VPP), so that the total production shows reduced uncertainty. Most AS markets operate at short-term horizon, typically for the day-ahead, and require that the service shall be provided with a minimal frequency of underfulfilment (i.e. reliability close to 100%). Therefore a Wind-PV-based AS offer must be based on an accurate forecast of the production uncertainty. A probabilistic forecasting model of the aggregated Wind-PV production based on machine learning has been developed in [1] and proved reliable down to the 1%-quantile of the production distribution. However for rare events (quantiles below 1%), the reliability of state-of-the-art machine learning models is known to deteriorate, mostly because of their lack of generalization on unobserved data [2]. We propose here two models specifically designed for a better forecast of the extremes of the distribution: the first model is based on the Extreme Value Theory (EVT) [3], and the second model is based on a quantile regression by a Deep Neural Network (DNN).

The EVT extrapolates extreme production levels from a collection of observations over a threshold, which is used to generate a probabilistic forecast following a Generalized Pareto Distribution. A specific challenge is to assess which inference method (Maximum Likelihood, L-Moments, Bayesian) is the most adapted to the problem of aggregated production forecast. The motivation behind the use of a DNN is to capture regular patterns of interdependence between energy sources at different spatio-temporal scales, which could not be detected by tree-based machine learning models such as Quantile Regression Forests, and explain the multiple conditions leading to very rare production levels.

We evaluate our forecasting models on a VPP of 200 MW comprising Wind, PV and run-of-river hydro plants in operation in France and Germany, with 2 years of data available. We find that the EVT and DNN approaches show improved reliability on the lowest quantiles when compared to a state-of-the-art machine learning model (Quantile Regression Forest).

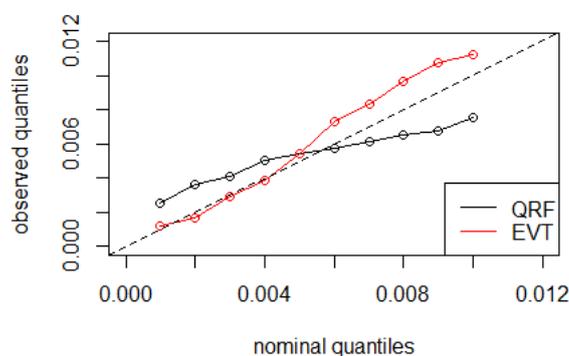


Figure 1: Reliability Diagram for forecasting model EVT and QRF (state-of-the-art)

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[1] Camal et al., *IEEE Transactions on Power Systems* **33-6**, p.6155-6170 (2018)

[2] Matos et al., *PMAPS 2016*, p.1-7 (2016)