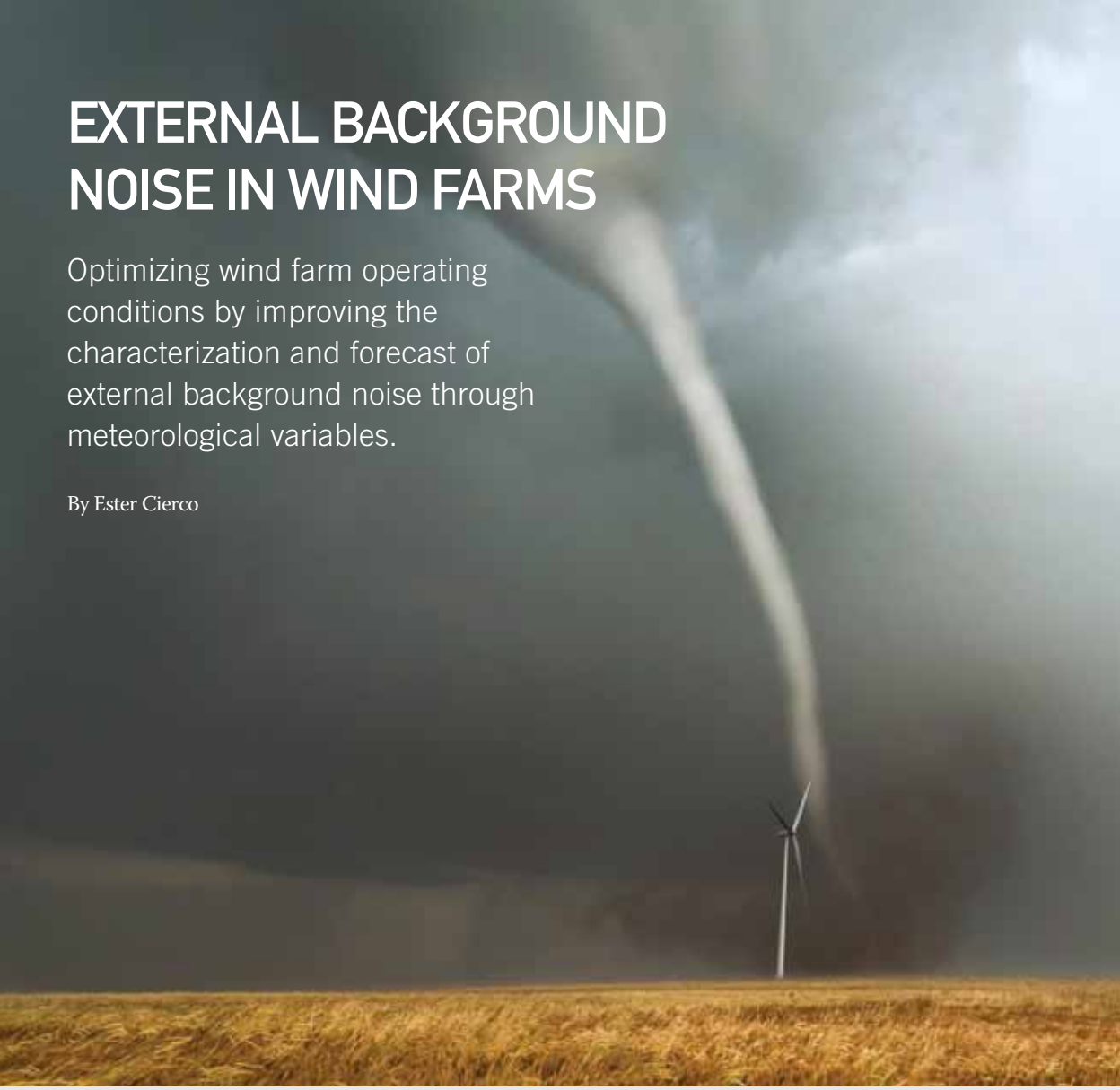

EXTERNAL BACKGROUND NOISE IN WIND FARMS

Optimizing wind farm operating conditions by improving the characterization and forecast of external background noise through meteorological variables.

By Ester Cierco

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NOISE IS OF INCREASING CONCERN to wind farm operators and standards in this field are becoming stricter. More and more, noise impact studies of noise generated by wind farms located near populations are taken into account. As a result, accurate vibro-acoustic studies are increasingly in demand to meet these requirements. Nevertheless, they do not seriously take into account the importance of external background noise in the contribution to the overall noise. Furthermore, background noise evaluation is often a poorly defined task, which does not take into account the different periods of the year, for instance. In practice, most current acoustic studies lack a long-term background noise prediction and it is virtually impossible to foresee it accurately. SOME-ECO (SOund MEteorological Environmental COrrelation) is a pioneering project whose goal is to improve the characterization and forecast of external background noise in wind farms by taking into account meteorological variables in order to optimize the wind farm operating conditions.

Under the leadership of ICR (Ingeniería para el Control del Ruido, S.L), a leading engineering company in vibro-acoustics, with the support of AEMET (the Spanish meteorological agency), the

main target of SOME-ECO is to make accurate long-term noise predictions in a particular environment with certain characteristics. For this purpose, SOME-ECO attempts to correlate external background noise with meteorological variables such as temperature, wind speed and relative humidity. Unlike current background noise measurement regulations, which do not comprehensively take into consideration the effect of these factors, SOME-ECO takes them into account in its calculations. Then, by knowing the influence of these variables and quantifying the correlation of short-term levels of background noise with their equivalent long-term values, SOME-ECO attempts to be able to make noise predictions based on these factors.

One of the most frequent choices to date is to define large safety margins in the prediction of background noise to account for its possible variations over time. However, this methodology is often inefficient and prevents the optimization of the financial return of the wind farm initial investment. Since current regulations do not specify the duration of the background noise measurements, they are usually carried out over short periods of time between 2 and 7 days. These short-time measurements prove to be insufficient and large safety margins are defined, instead of making accurate noise predictions based on the characteristics and the meteorological variables that influence the wind farm location.

SOME-ECO is reformulating the current methods for predicting external background noise and provides, for the first time, representative information that guarantees more realistic forecasts of background noise from representative variables of the site. The project seeks to optimize the installed power and the operating strategies of a wind farm. To do so, this study has two main phases to follow up: a first step that consists of generating a model by correlating external background noise with meteorological variables and a second step which is the noise prediction itself, from the generated model and short-time measurements of the studied location.

CREATING A MODEL: CORRELATION OF THE BACKGROUND NOISE WITH METEOROLOGICAL VARIABLES.

The first objective of SOME-ECO is to create a model by correlating background noise with climatic variables that are specific to a particular place for a period of one year. The purpose is to provide accurate and representative data on the contribution of meteorological variables to external background noise at different periods of the year and at locations with different characteristics.

To do so, ICR will analyze the behavior of atmospheric pressure, temperature, wind speed, wind direction and relative humidity among other things in five different representative areas of measurement. The 5 chosen locations are 2 urban areas and 3 rural areas. This work procedure allows to learn about the evolution over time of every variable separately and to study how they contribute jointly to external background noise by means of multidimensional data analysis. As a result, different models are obtained depending on the studied location (Figure 1). Other variables, such as the day of the week, the period of the year, may be included as well in the model.

As shown in figure 2, a seven-day evolution of four variables (rain, temperature, wind speed and

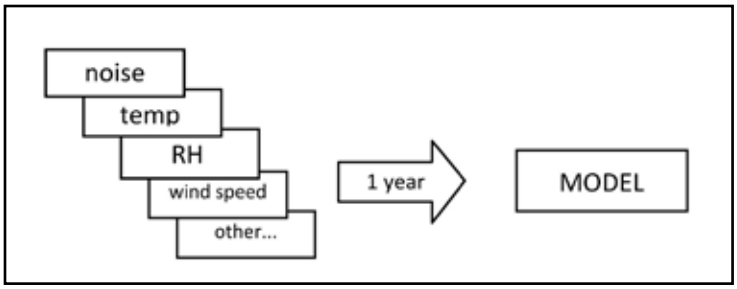

Figure 1: Diagram of the Model generation.

relative humidity) and background noise. Climatic variables measurements come from meteorological stations data and noise measurements are made at the same location in third octave bands, from 20 Hz to 10 KHz. The graphics below show the variables evolution with values every 10 minutes at a particular site. With regard to noise, it shows the equivalent continuous level every 10 minutes (Leq_{10min}) in global value (from 20 Hz to 10 KHz). Horizontal axis represents the UTC date and time.

Considering the measurements that have been used to date, they do not take into account the dependence relationship existing between climatic variables and background noise. However, SOME-ECO intents to correct this by providing representative data of this relationship at different periods of the year, on different days and at different times of the day depending on the climatic conditions of a particular site. The following expression presents such relationship:

$$S(t) = f(t, x_i) + e(t),$$

where $S(t)$ represents the SPL over time, $f(t,x_i)$ is the function that relates, linearly in the simplest case, the N variables x_i taken into account, where i=1,...,N, and $e(t)$ is a stochastic variable with a probability distribution function which depends on the site.

To sum up, the main purposes of this phase of the study are:

- Providing statistical analysis of the correlation between the equivalent level of external background noise and the meteorological conditions at a particular location (atmospheric pressure, temperature, wind speed and direction, relative humidity among other).
- Further exploring the factors that contribute to the generation of external background noise.

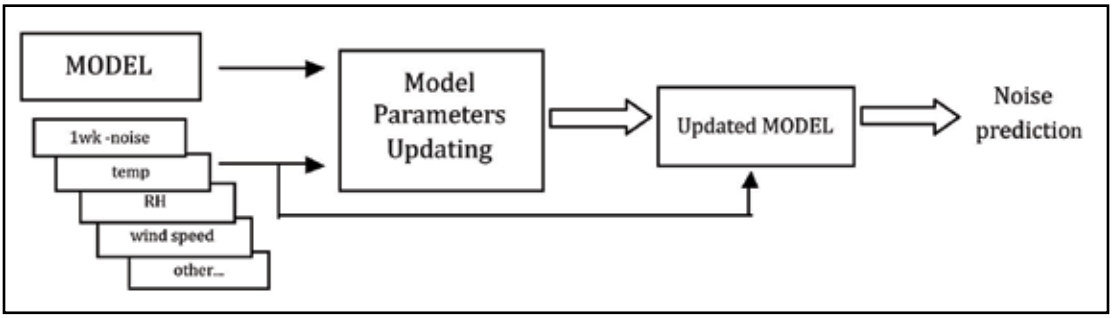

Figure 2: 7-day evolution of meteorological variables and SPL (Sound Pressure Level).

- Quantifying the relationship between meteorological variables and background noise according to different periods of the year and different times of the day.

PREDICTING EXTERNAL BACKGROUND NOISE FROM SHORT MEASUREMENTS

The goal of this phase of the study is to enable long-term predictions, which were impossible to carry out to date due to lack of experimental data.

Making one-year measurements is an unfeasible task in terms of economic costs as well as time costs. In practice, measurements are made during a period equal to or less than one week. The current standards that regulate the measurement of external background noise do not clearly specify the period of time at which measurements should be done. Since results obtained in one-week measurements may not be representative of the background noise at a particular site, noise prediction has to be made. In SOME-ECO, this prediction is made from the model generated in the previous step. Figure 3 shows a diagram of the prediction phase, which makes up the second phase of the project.

This phase starts with the updating of the parameters of the model depending on the characteristics of the location and the noise measurements made. Then, the noise prediction is made from the updated model

Figure 3: Diagram of the 2nd step.

and the meteorological variables of the studied site. Prediction will be as accurate as the model and the data are.

SOME-ECO seeks to correct inaccuracy in long-term noise predictions since this inaccuracy leads to establish large safety margins so that the

condition of low noise is usually activated in a wind turbine. As these predictions are based on the resulting data of studying several meteorological variables and their relationship with background noise, the first step of the project and the model updating are essential to perform a good prediction.

APPLICATIONS

SOME-ECO is aimed at wind farm construction companies and operators. The results of the research may be very useful at different stages of a wind farm project, such as the site-searching phase or during the operational phase after the wind turbines have been installed.

During the wind farm site-searching phase, SOME-ECO can be very useful for assessing the feasibility of a site on the basis of the long-term background noise predicted by SOME-ECO.

The main objective at this stage is to provide a background noise prediction much more accurate than establishing a large safety margin. This enables the client to weigh up the feasibility of a specific urban or rural site and its particular characteristics.

During the operational phase, SOME-ECO seeks to prevent from the need of periodic noise studies resulting from inaccurate noise predictions. ICR goal is to provide representative data that reveals the behavior of background noise. This will enable to avoid prediction errors caused by noise variations and provide the client with an accurate noise long-term prediction.

The knowledge of this data will help in saving time in detecting problems due to unexpected noise variations and saving money in applying solutions for these noise problems. Additionally, it will enable to optimize the initial investment, the installed power and the operating strategies of the wind farm.

With SOME-ECO, wind farm operators and construction companies will obtain an understanding of the effect of meteorological variables on external background noise in order to obtain a correct definition of external background noise at different times of the year and in different climatic conditions.

SOME-ECO is reformulating the current methodology for background noise long-term definition and provides, for the first time, representative information that guarantees more accurate forecasts of external background noise at potential wind farm sites. For this purpose, it studies deeply the correlation between noise and several meteorological variables, as well as the characteristics of the site. The ultimate goal is to optimize the financial return of the initial investment in a wind farm, as well as to adjust the installed power and the operating strategies.