

## Summary

Many countries such as France, New Zealand, UK, Italy use background noise to limit the noise of a wind farm. For this reason **background noise assessment** is a key process in the planning of a wind farm. Usually therefore every possible receiver must be measured to determine which is its level of background noise. For this reason it would be useful to have a **background noise map already at the beginning of the planning process**, in such a way to check as early as possible what is the situation of impact.

Creating a reliable background noise map is pretty complicated since you should be able to evaluate all sources of noise on a very large area. What is less complicated is to evaluate only that part of noise that depends on wind. Estimating winds at receivers height on a large area can be done with a **computational fluid dynamics (CFD) model** of the wind in the area.

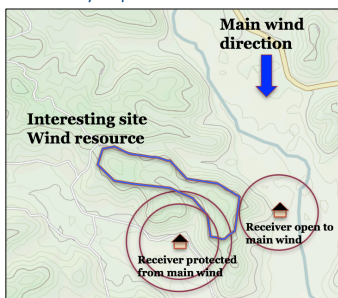


Figure 1 - Difference between two receivers equally distant from the wind farm site. One is more protected from N-wind and therefore more sensible to noise.

## Objectives

The objectives for this study are:

- > **Have an idea** of noise background even in absence of on-site noise measurements.
- > **Increase the quality** of the definition of the layout identifying which receivers should be kept at higher distances.
- > **Reduce cost** of noise preliminary assessment by extending the background noise campaign to sites that were not measured.

## Introduction

In the early stages of a wind project we study all the elements that help move the project forward smoothly. The four most important elements that need to be analyzed preliminarily are: **the wind resource map, the constraints map including noise, the connection to the network, the possibility of transporting and mounting**. It is surely convenient to have already at an early stage a noise constraints map in order to avoid planning the turbines in disturbing areas. The problem encountered in the execution of a constraint map of noise usually depends on the limited information on background noise of the area. We classify the sources of noise into two main categories: noise sources independent from wind and sources whose intensity depends on the wind [1]. A formula to describe it is the following:

$$L = 10 \cdot \log_{10} \left( 10^{\frac{L_{WR10} + 10 \log_{10}(V_w)}{10}} + 10^{\frac{L_{NWR}}{10}} \right)$$

Figure 3 - Equation used to correlate noise parameter for wind related noise and non wind related noise.

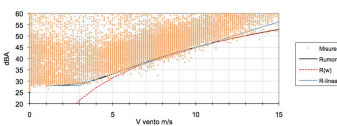


Figure 3 - Measurement of noise and wind at a 7 meters distance. The  $L_{WR10}$  parameter is 45.

The meaning of this value is simple: in the absence of wind independent noise this value identifies the noise that we would have at 10 m/s. Clearly one of the major uncertainties of this logical process is the need to **establish a correlation between the wind at the receiver and the wind at turbines height**. The CFD software give a more accurate modeling of the correlation between the high winds and the wind on the ground because they consider the second and some following terms of the Navier-Stokes equations. This allows identifying in particular the areas of macro turbulence.

\* $L_{WR10}$  = Noise parameter for wind related noise. The meaning of this parameter, as expressed here, is the noise that we would have at 10 m/s in absence of non wind related noise [dB].

\* $L_{NWR}$  = Noise parameter for non wind related noise [dB].

The result can be seen in **Figure 3**. The experience of identification of noise in many installations showed that  $L_{WR10}$  is typically in the range 40-60 decibels.

## Experimental Design

We therefore performed a wind mapping using **Windsim** in the whole area with the aim to identify winds at receiver level. After this calculation we were able to compare the result with some measured points where we collected the data. During this process it is important to analyze all parameters involved in the dependence of the noise from wind. The **wind direction** would completely change the speed ups in all the area. The second parameter that identifies the wind is the **frequency distribution**. In a generic site the frequency distribution follows the so-called Weibull distribution. Another parameter that influences the conversion of wind into noise is the presence of **structures** like vegetation, shape of the houses, on the structures and it is peculiar to each point the territory. Since this aspect is too peculiar for every receiver we disregard it. The fourth parameter that influences this conversion is the **air stability**. The measurements on the site are shown in **Figure 4**.

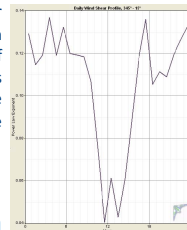


Figure 4 - The power law exponent change between night and day

## Results

### Generation of the Background Noise Map

The CFD software creates a map of wind at 2 meters height. The result is shown in **Figure 5** and **Figure 6**. The receivers of the site are also shown. **This map allows us to indicate which zones have lower noise in comparison to others**. It also gives a numerical measure of noise.

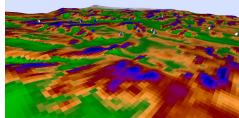


Figure 5 - Background noise 3D map for 10 m/s, North wind, night.

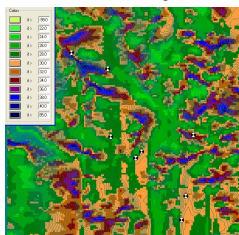


Figure 6 - Background noise map for 10 m/s, North wind, night.

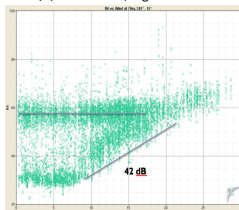


Figure 7 - Model of the measurements of one receiver. In addition to the not wind related noise there is a clear noise at around 55 dB given by cars.

### Noise Measurements

This is a description of the process that we have used to **identify  $L_{WR10}$  parameter** from the measured data. We measured the noise data with meteo stations that remained on site for one month. The sensor is at 1.5 meters height. It is protected from rain. At the meteo station there's a rain sensor. Measures during periods of rain are cancelled from the data. The noise point are  $L_{Aeq}$  sampled on 1 minute while the wind is sampled on 10 minutes. For this reason the wind data are then extended on the one minute sampling simply putting 10 times the same value. We consider this procedure more reliable than the other procedure which would be to average the noise on the 10 minutes.

### Comparison between Noise Model and Site Measurement

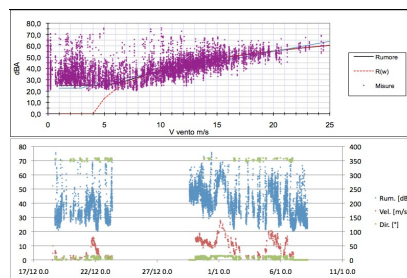


Figure 8 - Model of the measurements of one receiver. In addition to the not wind related noise there is a clear noise at around 55 dB given by cars.

We are interested in knowing **if the numbers given by the noise map are reliable or not**. For example the point in the **Figure 8** has a clear model. We have done a model of background noise of every point. If we now compare the coefficient  $L_{WR10}$  and the noise coming from the calculation we find a very poor correlation. if we instead chart the noise from the map, vs. the lowest level of measured noise around 15 m/s a correlation emerges, as shown in **Figure 9**.

## Next Steps

- **Identify** if roughness map, which usually describe vegetation, influence the noise map and can help to identify  $L_{WR10}$ .
- **Create** a relationship between wind at mast and wind at the receiver with a wind modelling software.

## Conclusions

SR International is therefore proud to introduce this approach that is **useful in a preliminary stage to assess qualitative maps, and identify key receivers** that should be kept more distant. In **preliminary and operation stage this innovative methodology can acquire information in order to extend the background noise campaign to sites without extensive site measurements**. Detailed background noise measures, based on above, have to be performed just on sensitive target. The effort for such analysis is a little lower than an energy assessment and is worth to highlight that in case of simultaneous energy assessment, considering the same Windsim modeling, the additional cost impact is negligible.

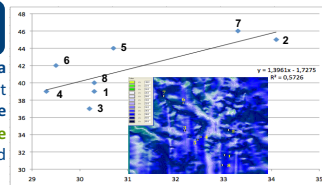


Figure 9 - Correlation between model and measurements.

## References

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2. Kathryn M. B. Haugen, International Review of Policies and Recommendations for Wind Turbine Setbacks from Residences: Setbacks, Noise, Shadow Flicker, and Other Concerns, Minnesota Department of Commerce: Energy Facility Permitting, October 19, 2011
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