

Noise Map of Wind Farms

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Abstract: - Noise generated by wind turbines is a problem that is caused controversy in the field of renewable energies. In some regions and countries there is legislation about it and companies comply with the legal procedure. Both in these cases and when there is not any regulation about the noise of the wind farms, noise maps of this type of renewable energy is need. We have developed a software to make a noise map of a wind turbine or a wind farm and we have done field tests in a wind farm of Spain. In this paper the software and some results of measurements are presented. We also propose some solutions to mitigate the noise.

Key-Words: - Noise, wind farm, wind turbine, map, renewable energy.

1 Introduction

A wind farm is a group of wind turbines in the same location used for production of electric power. Normally the wind farm is connected to the electric system and supplies energy to it.

A large installation consists of several wind turbines, turbines with the same power or not, distributed according to the local wind conditions, which have been designed to work towards the windward (upwind or weather side) and require a system to control orientation of the chassis and of the blades (if they are variable), or towards the leeward (downwind or lee side), without any such control.

The frequency of sound (Hz) is the number of sonic waves that pass through a given position in one second, or the number of times per second that the sonic pressure varies in a complete cycle of compression and expansion.

The decibels, dB, is a dimensionless number that relates the level of sonic power with the reference power, equal to $1 \cdot 10^{-12}$ W/m², and it is equivalent to:

$$dB = 10 \cdot \log_{10} \left(\frac{\text{measured power}}{\text{reference power}} \right)$$

2 Noise from the wind turbines

Until recently, many of the problems that have occurred by the noise generated by the wind turbines have been due to little emphasis on the design phase of these turbines to achieve low noise emissions.

In a brief way, wind farms can be built with criteria to non-generate a large environmental impact caused by noise, taking into account certain aspects:

- Wind turbines must be located at an adequate distance from human settlements.
- The moving parts of the wind turbine should be designed, manufactured and assembled, taking into account criteria for minimizing noise.
- In the case of blades, attention should be paid to their aerodynamic design, reaching a compromise between the aerodynamic effectiveness and the generated aerodynamic noise.
- Noise levels should be supervised by the legislation to monitor and set limits achievable with these noise levels.
- The appropriate location (away from areas with high population density and special topographical features) should be considered by those who promote the project of a wind farm but must be controlled by state authorities who are dedicated to the

determination of the soil use and management.

3 Regulations

The noise reduction is intended to comply with the local, regional and state regulations (and in Europe European regulations also) for maximum noise levels, and obviously for the welfare and health of the people who live in the affected areas.

In Spain there is no specific legislation (about the level of noise from wind turbines of wind farms can emit) for all the country but only in some regions. However, there is a "Law of Noise" (Law 37/2003 of 17 November. 18/11/2003 BOE), which does not establish values, simply providing definitions and deadlines for the execution of noise maps.

Anyway, reference labels that are taken into account in Spain and other European countries are shown in the next table:

Dominant use	Sound Level (dBA)	
	Day	Night
Health and Education	45	35
Residential	55	45
Tertiary	65	55
Industrial	70	60

Table 1. External Receiving Levels

At European level, the directive 2002/49/EC of the European Parliament and Council of June 25, 2002 on the assessment and management of environmental noise, provides in Article 5 the use of additional indicators of noise in certain special cases, including "when the content of the low frequency noise is high," and "when quiet areas in the open field are affected". This legislation is binding since July 18, 2004.

4 Simulation

To recreate the performance level of mechanical and aerodynamic noise of a wind farm an application has been developed, having designed its interface simple and friendly for the user.

The software allows the selection of the model from a list of commercial wind turbines, whose data

obtained from the catalogues provided by manufacturers are already included in the program.

Since the main purpose of the program is to obtain a map of the noise produced by one or more wind turbines, it is worth noting that not all manufacturers provide data of the sound levels of their products (turbines), and those that are provided are approximate values. Therefore, for models without data of noise, this has been estimated by approximation models of wind turbines with similar characteristics, interpolating data of diameter of the blades and wind speed at rated (or nameplate) power.

If a wind turbine has a rated power of 1000 kW, that tells you that the wind turbine will produce 1000 kilowatt hours (kWh) of energy per hour of operation, when running at its maximum performance (i.e. at high winds above 15 metres per second (m/s)).

If a region has, for example, 1000 MW of wind power installed, that does not tell you how much energy the turbines produce. Wind turbines will usually be running 75 per cent of the hours of the year, but they will only be running at rated power during a limited number of hours of the year.

In order to find out how much energy the wind turbines produce, you have to know the distribution of wind speeds for each turbine.

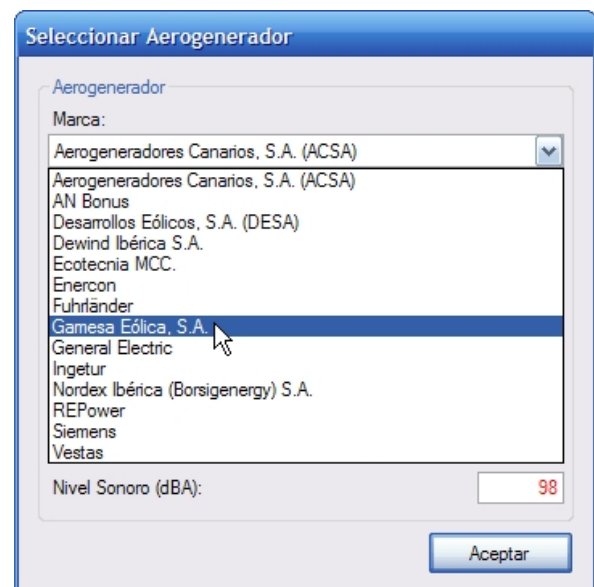


Fig. 1. Selection of models

An example of the data for wind turbines is shown in the next table:

Model	Rated Power (kW)	Approx Axis Height (m)	Rotor diameter (m)	Area swept by Blades (m ²)	Wind Speed at Rated Power (m / s)	Sound Level (dBA)
ACSA A27/225kW	225	31.5	27	573	13.5	98
ACSA V47/660kW	660	45.7	47	1735	13.5	101
AN-Bonus 1MW/54	1000	-	54	2290	15	104

Table 2. Models of Wind Turbines

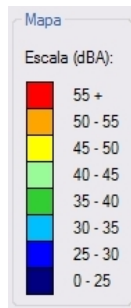


Fig. 2. Scale of Colours

The result is shown as noise map, distinguishing noise intervals based on a scale of colours defined in the work area.

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The result of the calculation of the program is represented in the workspace on the selected image as a background and semi-transparent. Thus, we will see what places the noise impact is greater.

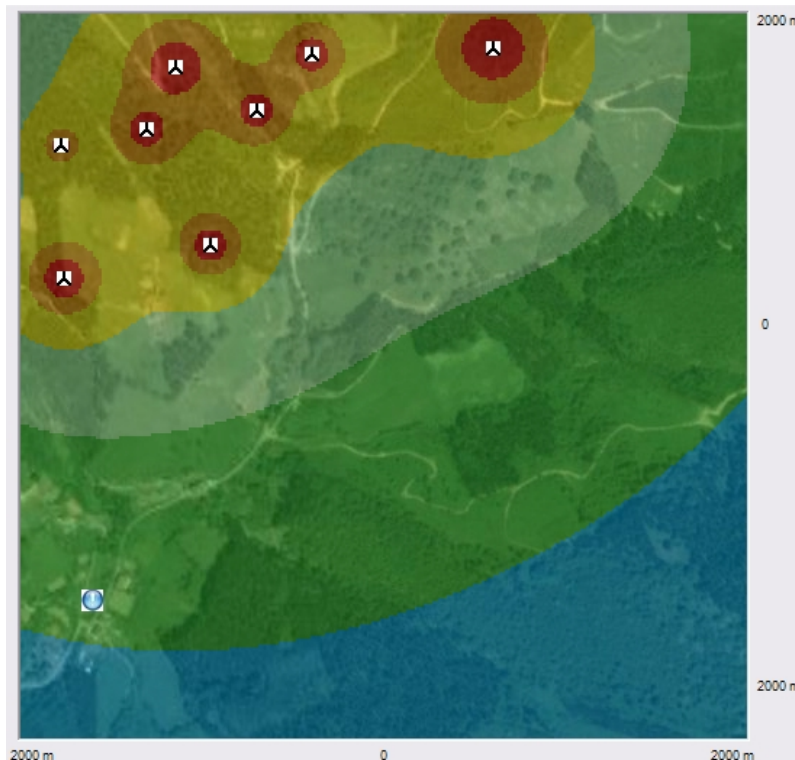


Fig. 3. Results

5 Proposed solutions

One of the first solutions that we propose to control the noise level is to build wind farms away from population centres.

This solution can be satisfied either by putting the wind turbines in areas where the concentration of population is as low as possible, either carrying wind to the coast, in what is called off-shore wind farm.

Moreover, other solutions are:

- Improving the surface of the blades.
- Increase the height of the gondolas through the study of structures or constructive configurations more efficient.
- Create natural screens for attenuation of noise.

6 Conclusions

Faced with the growing energy demand, the society is looking for answers not harmful to the environment, such as renewable energies.

After studying the morphology of the devices, it leads to the following conclusions:

- The noise that is perceived from a distance on the wind turbine of 50 meters is mainly due to aerodynamic component of the turbine.
- The noise due to electrical generator or the gears that are in the gondola of the wind turbine has been successfully tackled by the manufacturers, since it is almost negligible, except when some wind turbines rotate to make better use of wind energy (in these cases, the noise is appreciable from thousands of meters).
- The component due to electronic noise that is at the base of the wind turbines is practically inaudible from a distance of 15 meters.

Thus, we have verified after the field test made on the wind farm that the company "Eólicas de Euskadi" has on Mount Oiz, that the noise was clearly perceptible to over 1 kilometre away.

In other points located at the same distance the noise was mitigated and masking part or all of it by the trees that surround this wind farm. We also saw that the sound produced by the trees when they move their branches by the effects of wind mitigated or cancelled the noise emitted by the wind turbines.

Acknowledgements

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