Wind Turbines Acoustic Measurements

Amelia Trematerra [1, a)], Gino Iannace [1, b)]

1. *Department of Architecture and Industrial Design – Università della Campania "Luigi Vanvitelli" – Borgo San Lorenzo 81031 Aversa (Italy)*

[a)] *Corresponding author: liatrematerra@libero.it*
[b)] *gino.iannace@unina2.it*

Abstract. The importance of wind turbines has increased over the last few years throughout the European Community. The European energy policy guidelines state that for the year 2020 20% of all energy must be produced by alternative energy sources. Wind turbines are an important type of energy production without petrol. A wind speed in a range from 2.5 m/s to 25.0 m/s is needed. One of the obstacles to the widespread diffusion of wind turbine is noise generation. This work presents some noise measurements of wind turbines in the South of Italy, and discusses the noise problems for the people living near wind farms.

INTRODUCTION

The European energy policy guidelines state that by the year 2020 20% of energy production will not be from fossil fuels, but by alternative sources (wind, solar, geothermic). There are many wind farms in different parts of the world, with the size of the blades and the height of the towers increasing according to the need to produce more energy. The reason of this success is due to economic subsidies, sale of white certificates, investment banking, strong wind speeds and accessibility of the sites. Initially, wind farms were built far away from residential areas, but wind industry investments have created a significant expansion of wind farms, with the wind towers now being built nearer to towns, creating a series of problems, including noise pollution, to the local residents. When wind towers are working, they generate an annoying noise. One of the limits to the expansion of wind farms is the noise generated by the rotation of the blades. The authors have studied the noise produced by some wind farms in the South of Italy, on mountains at about 1.000 metres above sea level. This location is very good for the installation of wind farm since the wind speed is not variable over time, with the range being between 2.5 m/s – 25 m/s. Figure 1 shows a wind map [1] with different colours to indicate the average wind speed. Furthermore, Figure 1 shows where the acoustic measurements were carried out, with the South of Italy being a good place for wind farm installations. In the location studied, the first wind farms were built twenty years ago, the towers were about 40 metres in height and the diameter of the blades about 20 metres. The towers had a reticular structure (Figure 2). Towers with a reticular structure have chosen for economic reasons, since they are easy to transport along mountain roads were that are not practicable in the winter. During the last ten years, wind turbines with tubular towers have become more widespread for different reasons. The most important is the safety of workers during maintenance, when the tower is reticular, it is difficult to climb during high winds. In addition, it is not possible to build high reticular structures (the maximum height of a reticular tower is 40 metres). Wind turbines with tubular towers have been built, with higher towers being built to install more powerful engines to produce more electricity (Figures 3 & 4). The engine power is 0.7 MW for reticular towers, while the engine power is 1.5 MW or 3.0 MW for tubular towers. The efficiency of the blades has increased. The blades are put in motion with a wind minimum speed 2.5 m/s to 25 m/s, at this speed the blades stop, since they could break.

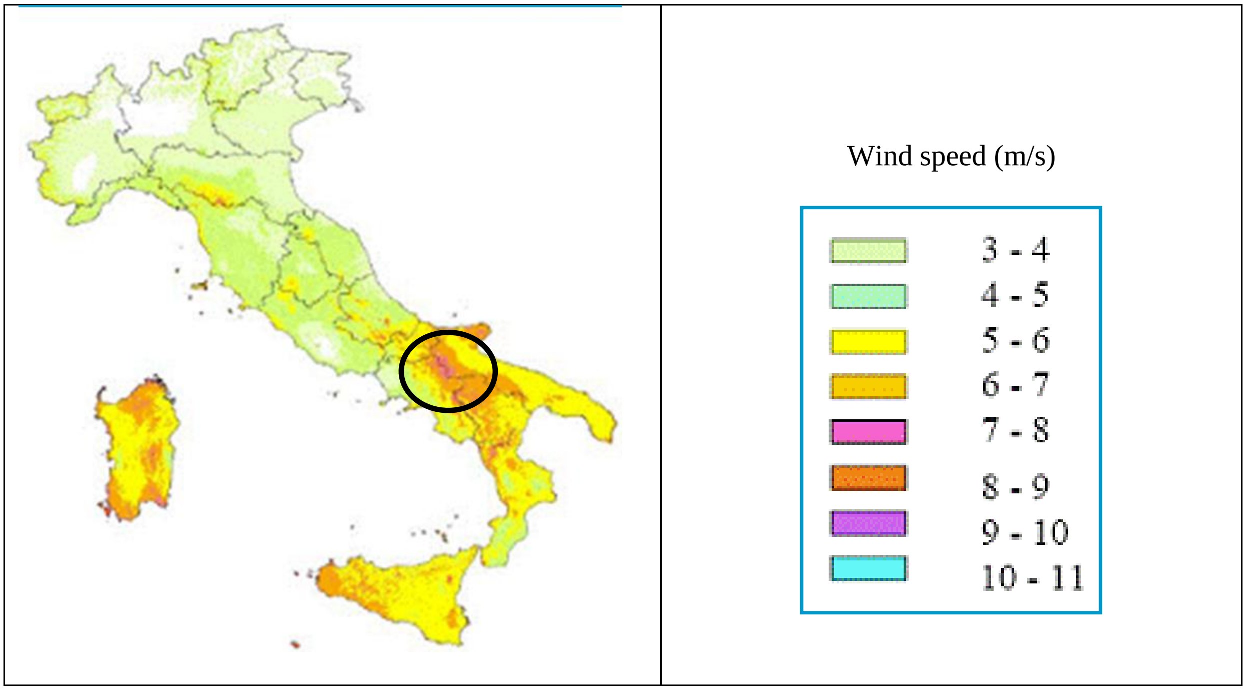

FIGURE 1. Italian map. Wind speed for different sites. The South of Italy is the best location

FIGURE 2. Towers with reticular structures**.**

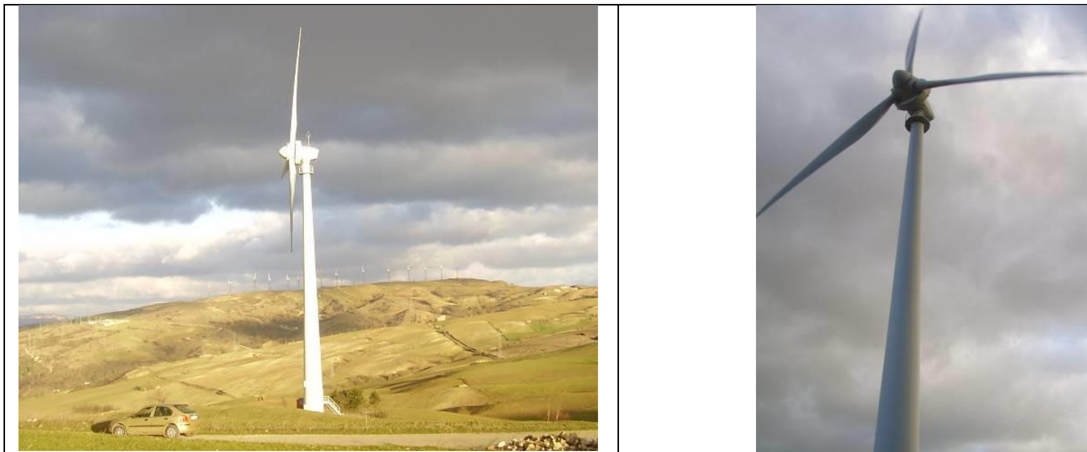

FIGURE 3. Towers with tubular structures.

FIGURE 4. Towers with tubular structures.

ACOUSTIC MEASUREMENTS

The acoustic measurements were carried out with an integrator sound level meter (type Solo 01 dB), at different distances from the wind turbine, the wind speed, the air temperature and the humidity were also measured. The acoustic measurements were carried out selecting points not directly invested by the wind. The wind noise therefore had no significant influence on the acoustic measurements; a windscreen was applied to the microphone. Measurement times were set to have significant values of sound pressure level. The first acoustic measurements refer to reticular towers (Figure 2), with an engine power of 0.70 MW. The measurements distance were 10 m, 20 m and 30 m from the tower. For the distance of 10 m, during the acoustic measurements, the wind speed was 6.0 m/s, while the equivalent linear sound level Leq=88.6 dB, the "A" equivalent sound level LeqA=62.3 dBA. The noise is emitted by the blades rotating and by the interaction of the wind with the reticular tower. Figure 5 shows the frequency and time history of the acoustic measurements for the reticular towers at a distance of 30 m. During the acoustic measurements, the wind speed was 1.3 m/s, the equivalent linear sound level Leq= 69.8 dB, while "A" equivalent sound level LeqA=48.8 dBA. The tubular towers have an engine power of 1.5 MW, with it having been installed five years ago, a height of 50 m, a blade diameter of 60 m. The acoustic measurements refer to Figures 3 and 4. In the last, there is an engine power of 3.0 MW with a height of 80 meters and a blade diameter of 80 meters. During the acoustic measurements at a distance of 10 meters, the wind speed was 5.3 m/s, while the equivalent linear sound level Leq=93.5 dB, and "A" equivalent sound level LeqA=62.1 dBA (Figure 7).

FIGURE 5. Frequency and time history for reticular towers at a distance of 30 m.

FIGURE 6. Frequency and time history for reticular towers at a distance of 30 m.

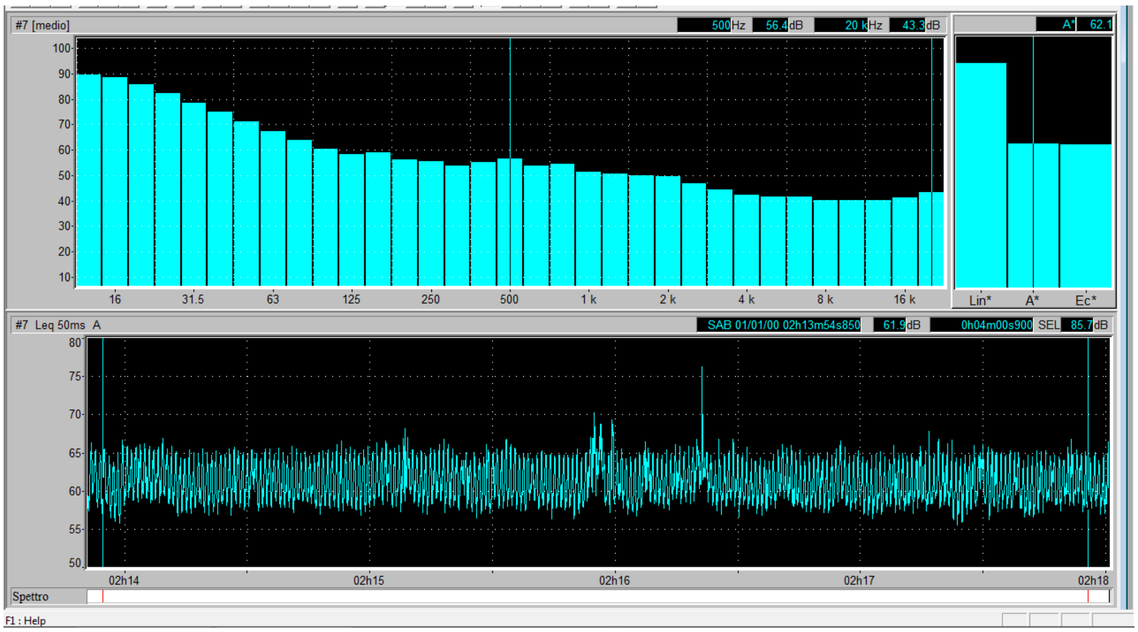

FIGURE 7. Frequency and time history for tubular towers at a distance of 10 m.

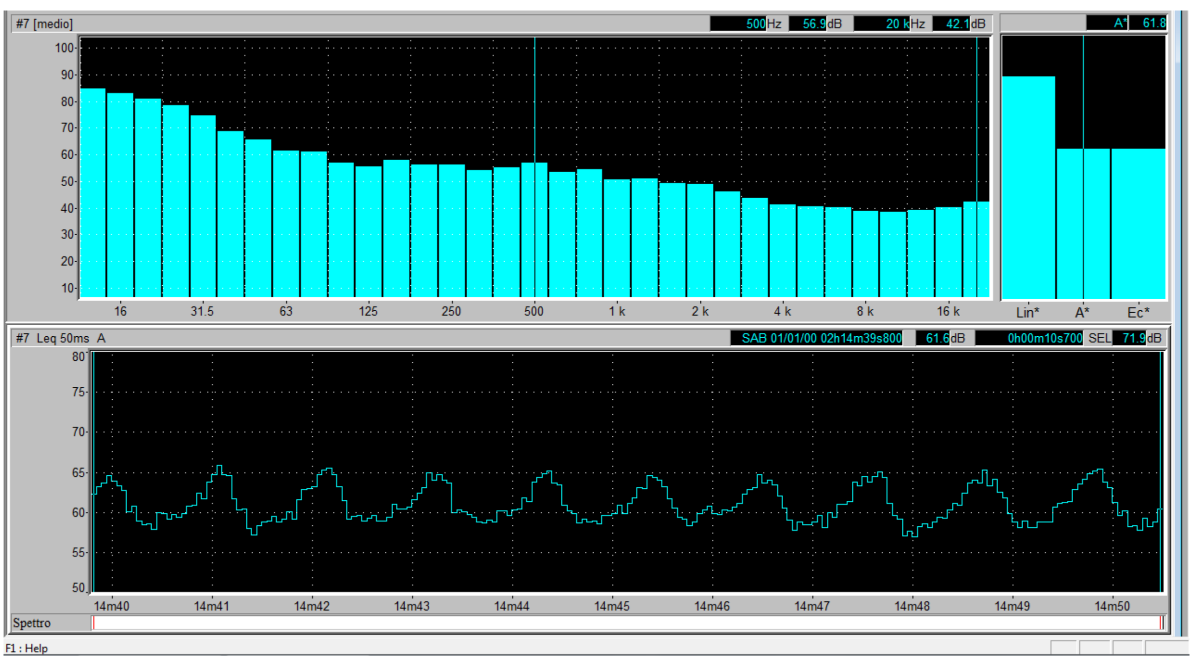

FIGURE 8. Particular of frequency and time history for tubular towers at a distance of 10 m.

Figure 8 shows the frequency and time history of the acoustic measurements for tubular towers, the fundamental frequency is about 1 Hz. Figure 9 shows the time history of the acoustic measurements for tubular towers at a distance of 10 m. It is possible to see the sinusoidal fundamental frequency period at about 1.0 second, with it corresponding to 20 rpm. Figure 10 shows the frequency and time history of the acoustic measurements for tubular towers at a distance of 30 m, with a wind speed of 5.3 m/s, the equivalent linear sound level Leq=88.5 dB and "A" equivalent sound level LeqA=57.4 dBA. In Figure 10 the time history, with the sinusoidal noise component being covered by environmental noise. The "A" equivalent sound level (Leq in dBA) is low. So this level, expressed in dBA, does not create any disturbance to the local population. The problem are for the cylindrical towers due to the rotation of the blades generating tonal components. This can create an annoyance to the population living near the wind farms. The need for higher towers and larger diameters of the blades to increase energy production from renewable sources, present noise impact problems. Figure 11 [3] shows the noise impact due to different sound sources; at the same sound level, the noise of wind turbines creates a greater annoyance. For the reticular towers, the noise impact is not important. The noise is produced by the blades rotating, and the aerodynamic noise of the wind though the reticular tower, with the final noise being broadband and not creating any annoyance. The tubular wind turbines generate tonal components, at low frequencies. This does not decrease with distance and are not facilitated by the windows of the houses. The wind turbines are already installed in areas with few inhabitants, in the outskirts of small towns, where there are no other sound sources and are the only noise source, and are "hearing" as annoying.

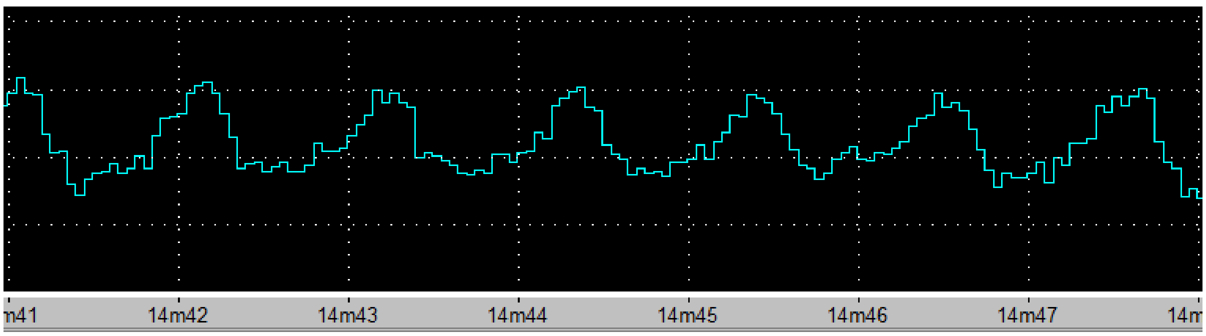

FIGURE 9. Particular of time history for tubular towers at a distance of 10 m.

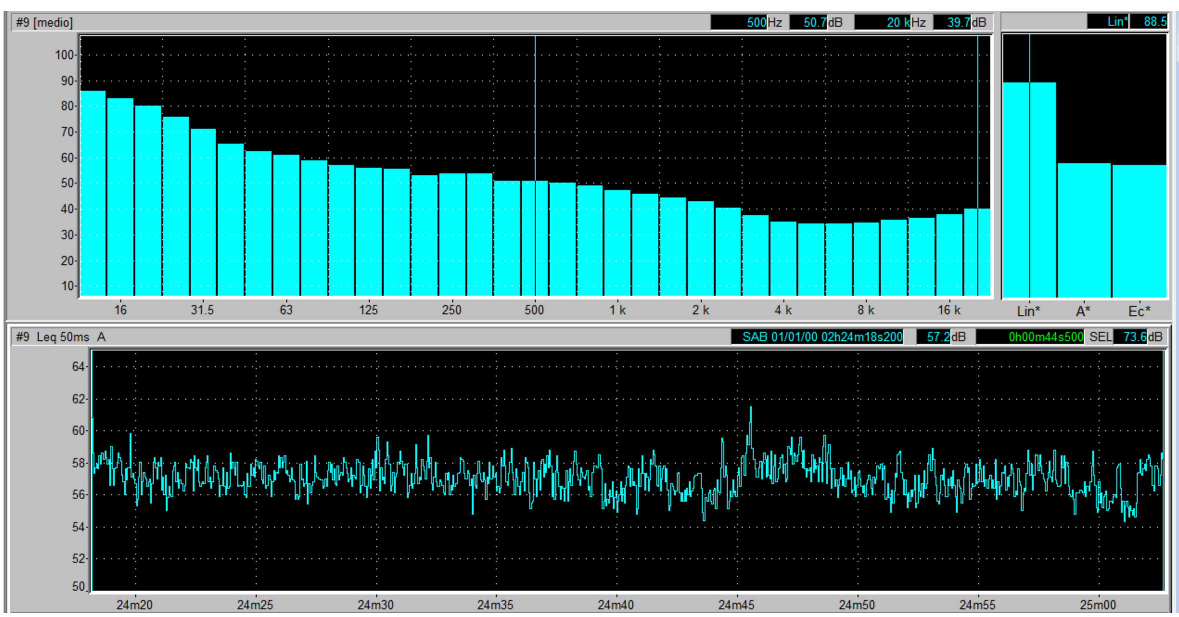

FIGURE 10. Frequency and time history for tubular towers at a distance of 30 m.

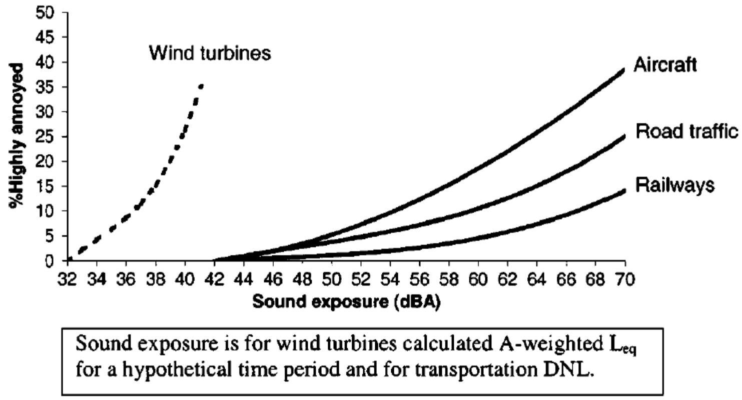

FIGURE 11. Comparison between the dose–response relationship for noise transportation and wind turbine noise.

CONCLUSION

The need to increase the number of wind farms has led to the construction of towers nearer to homes, with the problem of noise being significant. The tonal components at low frequencies do not have high levels of sound pressure, but do generate annoyance. The discomfort increases for the local population, if the wind towers are directly visible. Over the coming years, the increasing demand for renewable energy will lead to conflict between local residents and companies that build wind farms. Understanding of the problem could mitigate this conflict.

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