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Determination and assessment of noise from wind turbines in Germany

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Abstract

In 2014, 28.2 % of the total electrical energy has been generated from renewable energy sources within the European Union. In this context, wind turbines are of great importance. Especially in Germany, the number of these installations has continuously increased in the last years. Therefore, it is particularly important to have clear legal regulations for noise protection by wind turbines. Wind turbines with a height of more than 50 m are subject to licensing pursuant to the German Federal Immission Control Act. Assessment of noise immissions from wind turbines is carried out according to a General Administrative Provision to the Federal Immission Control Act, which is called “Technical Instructions on Noise Abatement - TA Noise”. It describes the methods for the determination and the assessment of noise caused by industrial or commercial installations, including wind turbines. These regulations will be explained in detail. Moreover, the low-frequency noise immissions of wind turbines will be discussed and evaluated.

Keywords: noise, wind turbine, assessment, sound propagation

Determination and assessment of noise from wind turbines in Germany

1 Introduction

Wind turbines are of great importance to meet the demand for electricity with renewable sources of energy. In recent years, the number of wind turbines has continuously increased in Germany. In 2015, there are 25982 wind turbines with an installed wind power capacity of 41652 MW [1].

In Germany, wind turbines with a height of more than 50 m, are subject to licensing pursuant to the German Federal Immission Control Act [2]. Principally, installations subject to licensing shall be established and operated in such a way that this does not involve harmful effects on the environment or other hazards, considerable disadvantages and considerable nuisance to the general public and neighborhood. Moreover, precautions should be taken to prevent harmful effects on the environment. Within the scope of the licensing process, not only environmental aspects are taken into account but also all other legal aspects in connection with the construction of a new wind turbine or the repowering of existing ones. For instance, building regulations as well as nature conservation requirements are also to be considered. One important element of the licensing process deals with the protection against noise. The regulations are laid down in the Sixth General Administrative Provision to the Federal Immission Control Act, which is called “Technical Instructions on Noise Abatement, TA Noise” [3]. It is applied to various kinds of industrial plants as well as commercial operations. This wide range of applicability includes wind turbines. The TA Noise is therefore the most important instrument for the determination and assessment of noise from industrial plants and commercial operations in Germany.

2 Determination of noise immissions

The determination of noise immissions of wind turbines is carried out according to the TA Noise and additional recommendations [4] of the federal states in Germany. The main steps of the noise assessment procedure for wind turbines are shown in figure 1.

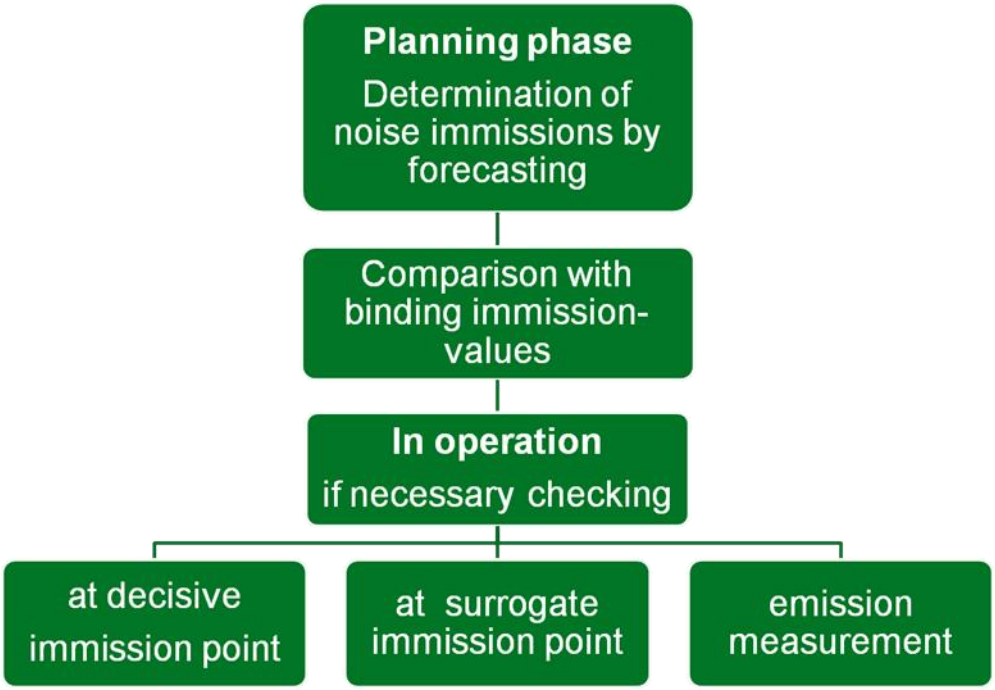

Fig. 1: Noise assessment procedure according to TA Noise

The TA Noise contains criteria to identify and assess the noise immissions of installations subject to licensing, including wind turbines. The noise assessment procedure starts with the determination of noise immissions by forecasting. The calculation method is described in detail in the TA Noise

3 Examination of the sound propagation model

For the determination of the noise exposure caused by wind turbines, the sound propagation alternative method of DIN ISO 9613-2 [5] is used. This method can be applied to various types of noise sources. However, it is questionable whether this the method for calculating the sound propagation is appropriate for modern wind turbines with a height of more than 100 m. For this reason, a research project [6] was conducted which was commissioned by the State Agency for Nature, Environment and Consumer Protection of the German state of North Rhine-Westphalia. In this project, noise measurements have been carried out and compared with calculation results. This study has come to the result that up to a distance of 450 m from the wind turbine the calculation values are above the measured ones. For greater distances, the study shows contradictory results. With increasing distances from the wind turbine, the measurement results are higher than the calculation results. In view of these findings, the German organization for standardization DIN developed an interim method for the calculation of sound propagation at wind turbines [7]. This method takes into account the results of the above-mentioned research project and is based on a plain acoustic model. It describes the wind turbine as an omnidirectional point noise source which is frequency-dependent. The equivalent continuous downwind sound power level L_{fT} is determined by the following equation [7]:

$$L_{fT}\,(\mathrm{DW}) = L_{\mathrm{W}} + D_{\mathrm{C}} - A \qquad (1)$$

where

L_{W} sound power level produced by a wind turbine described as a point source [dB]

D_{C} directivity correction [dB]

A attenuation [dB]

with

$$A = A_{\mathrm{div}} + A_{\mathrm{atm}} + A_{\mathrm{gr}} + A_{\mathrm{bar}} + A_{\mathrm{misc}} \qquad (2)$$

A_{div} attenuation owing to geometrical divergence

A_{atm} attenuation due to atmospheric absorption

A_{gr} ground attenuation

A_{bar} attenuation by a barrier

A_{misc} attenuation caused by other effects

In the equation (2), the attenuation due to the ground effect is set to -3 dB. This value is based on the assumption that modern wind turbines with a height of above 100 m cause only one reflection from the ground. Furthermore, the meteorological correction in the equation for the determination of the long-term average A-weighted sound pressure level L_{AT}(LT) is modified [6]:

$$L_{\mathrm{AT}}(\mathrm{LT}) = L_{\mathrm{AT}}(\mathrm{DW}) - C_{\mathrm{met}} \qquad (3)$$

where

$L_{\mathrm{AT}}(\mathrm{DW})$ average A-weighted sound pressure level for downwind propagation

C_{met} meteorological correction, C_{met} = 0 dB

Currently, the interim method is not applied in practice because some acoustical details as well as legal requirements have not yet been finally clarified. It is envisaged to replace the interims method by a new German guideline VDI 4101 part 2 [8] in the next years.

4 Binding immission values according to TA Noise

An essential part of the TA Noise is binding immission values for points outside buildings. These values depend on the type of land-use and are distinguished between daytime and nighttime. They are given in table 1.

Table 1: Binding immission values according to TA Noise

Types of areas	Day 6 p.m. - 10 a.m.	Night 10 a.m. - 6 p.m.
industrial areas	70 dB(A)	70 dB(A)
commercial zones	65 dB(A)	50 dB(A)
core areas, village areas and mixed-use zones	60 dB(A)	45 dB(A)
general residential areas and small residential states areas	55 dB(A)	40 dB(A)
purely residential areas	50 dB(A)	35 dB(A)
spa areas, for hospitals and nursing homes	45 dB(A)	35 dB(A)

The binding immission values are applied during the day for an assessment period of 16 hours. The full hour with the highest rating level is the basis for nighttime assessment. The reason for this special regulation is that the protection against noise at night is very important because a sufficiently long period of undisturbed sleep is essential for mental and physical rest and therefore healthy. Furthermore, the TA Noise contains special regulations concerning individual short-term noise peaks. These peaks may exceed the values during the day by not more than 30 dB(A), and at night by not more than 20 dB(A).

The type of areas of the binding immission values results from specifications in development plans. They correspond to the building areas, which are defined in a Federal Land Utilization Ordinance [9]. According to this ordinance, for example purely residential areas are only used for living. In contrast to this, village areas may also contain agricultural and forestry holdings. Moreover, the further development of agricultural and forestry holdings is taken into consideration. For the individual types of land-use planning, appropriate area-related binding immission values are defined.

The binding immission values have to be met in order to obtain the license for the operation of a wind turbine. They refer to the forecast respectively measured rating level L_r ascertained at the immission point. In this context, it is generally assumed from the total exposure at the decisive immission point. This is the point in the area of influence of the installation at which binding immission values are most likely to be exceeded. According to TA Noise, the decisive immission points are defined as follows:

- for buildings, 0,5 m outside the middle of the open window of the room which is worst affected by noise
- in undeveloped or built-up areas that contain no buildings with noise sensitive rooms, at the edge of the area where buildings with noise sensitive rooms may be built.

In principle, the binding immission values according to TA Noise may not be exceeded. Exceptions are only being made for the following cases:

- No harmful effects on the environment are to be assumed from the installation when the additional noise exposure from the facility is at least 6 dB(A) below the binding immission values
- It is permanently ensured that the binding immission values are exceeded not more than 1dB(A).

5 Consideration of low-frequency noise

Wind turbines emit low-frequency noise. For the determination and assessment of low-frequency noise, the German standard DIN 45680 “Measurement and assessment of low frequency noise immission” [10] and in the accompanying Supplement 1 is used [11]. The supplement contains reference values, which should not be exceeded.

DIN 45680 contains an auditory threshold. Since some years the question is discussed in the scientific community as well as in the public, whether the protection against low-frequency noise is sufficient. This is especially true for infrasound caused by industrial or commercial installations. A research project on behalf of the German Environment Agency [12] has shown that DIN 45680 as well the international standard ISO 7196 “Acoustics - Frequency-Weighting Characteristic for Infrasound Measurements” have deficits [13]. For these reasons, DIN 45680 is currently under revision [14, 15]. Within this activity, a noise perception threshold is developed. A comparison between this threshold and results of infrasound measurements on several modern wind turbines in Germany [16] shows that the infrasound emission generated by these installations is well below the threshold of human perception.

6 Conclusion

Wind turbines are of great importance to meet the demand for electricity with renewable sources of energy. Especially in Germany, the number of these installations has continuously increased in the last years. Therefore, it is particularly important to have clear legal regulations for noise protection by wind turbines. Wind turbines with a height of more than 50 m are subject to licensing pursuant to the German Federal Immission Control Act. Generally, they should be operated in such a way that this does not cause harmful effects on the population. The determination and assessment of noise from wind turbines is described in detailed legal regulations in Germany. Technical instructions especially contain area-related binding immission values for immission points outside buildings which may not exceeded during the operation of the wind turbine. If these values are exceeded, measures to reduce noise are necessary.

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