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Wind turbines noise's French regulations - Advantages and inconveniences

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Abstract

In France, until today, the noise of wind turbines had to respect the " neighborhood's noise regulations ". This one bases on the respect for an emergence lower than 3 dB at night and 5 dB in the daytime. These rules present the advantage to avoid an excessive annoyance of the neighborhood, but present the inconvenience to make the statutory control measurement extremely delicate. Indeed, when the noise of wind turbines respects the statutory requirement, the measurement of the emergence, which requires to measure the "signal" and the "noise", must be made with a "signal on noise" ratio equal to zero or negative. The wind turbines noise's regulations are now evolving in France, towards that of "establishments classified for the environmental protection". This evolution will circumvent the difficulty of present measurement by defining a maximum allowable limit level at a check point (installations in operation) closer the wind turbines, so that, the signal on noise ratio will increase. This maximum level will have to be defined by the acoustic analysis to respect the regulatory thresholds of emergence with the local resident.

Introduction

The potential development of wind energy in France is considerable :

- The wind resource is significant,
- On the economic plan , attractive fixed fee conditions set by the state are being forwarded.
- In technical terms, maturity has been achieved with efficient and reliable machines.

However, the development of wind energy in France is lagging behind with only 5,000 Mw installed in 2010. At this pace, French wind farms will not exceed 15 000 MW until 2020 instead of 25,000 MW set in the law "Grenelle Environnement", targeting the urgent reduction of emissions of greenhouse gases, but also the desire to diversify energy sources.

One cause of this delay appears to be the social acceptance of wind farms : wind turbines are large structures and their location, most often in rural locations, modifies the visual and auditory landscape which provokes debate, sometimes passionate, and often reactions of rejection.

Noise is one of the main issues with the landscape, in the development of a wind farm. When in operation, the complaints against noise are the main argument.

After discussing the factors related to noise nuisance, we will present the various French regulations on noise in the environment. We'll see how the French legislature regulates noise from wind farms. By comparing these rules with those of other leading countries in wind energy development, we will observe that the French legislation on noise from wind turbines is the most severe. We'll see that these regulations have, however the advantage of avoiding excessive discomfort in the neighbourhood. Finally, in the current regulation of wind farms, we'll talk about the technical difficulty to provide decision on compliance with regulatory limits since because of in this case, the measure of the wind turbine signal and the background noise is made with a signal/noise ratio zero or negative. We'll see what regulatory revisions could propose to resolve this problem.

Is the noise nuisance due to noise itself ?

The annoyance caused by noise is conditioned by many factors other than acoustic, and can be grouped into two families:

- the factors affecting psychical acceptability of the activities which are at the origin of noise, and linking the manageable behaviour of the noisy activity and the relationship with neighbours : a well intended activity, in respect of the rules, benefits all, ... including myself, are some of positive criteria to appreciate (noise of) activity
- the factors which affect the physical acceptability and which can translate through to have an impact on the environment :a muddy road, a bad smell, an undesirable view, they are all rejection criteria, moreover when the installation

and the neighbourhood are closer together, and which contribute to a negative appreciation of the perceived noise,

But, of course, noise annoyance depends on the physical characteristics of the noise itself, duration (and time of day), absolute intensity, and emergence.

One recalls that noise annoyance is greater when the duration of exposure, or the sound level, or the emergence are greater too, and so, all the regulations take these into account.

One recalls also that the differential sensitivity of the ear varies with the perceived sound level as shown in figure 1. That means that ear is more sensitive to the noise variation when the sound level is lower. However this particularity is denied in all the regulations, and we will see below that they all authorise in fact, a greater emergence when the sound level is lower.

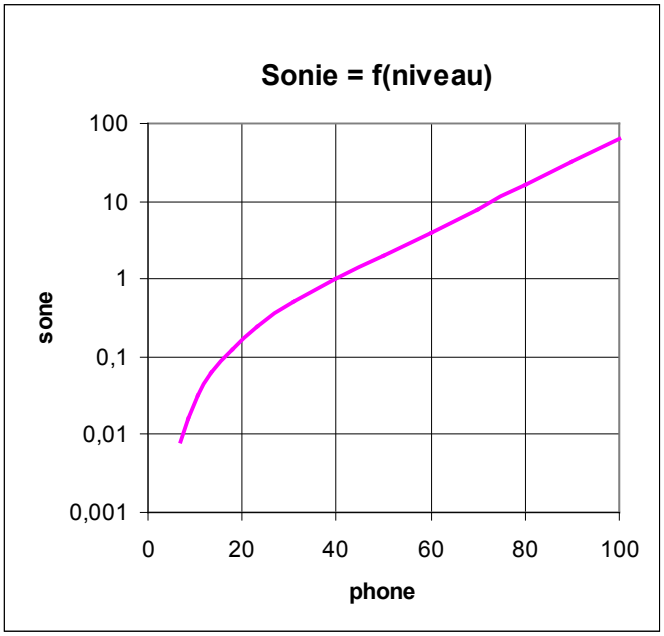


Illustration 1 : Sonie vs sound level

European regulations

All the European regulations distinguish the day and night periods. Some take into account also the evening period. The time limits of these periods depend from one country to another.

Some of them place a value to be respected at the reception point, mostly close to the neighbour, even inside. Most of the European regulations on wind turbine noise rest on the measurement of an absolute sound level close to the neighbour (including wind turbine noise and background noise). More often this value depends of the area (rural, urban, ...) and of the time of the day

Other requirements are expressed in emergence.

The following definitions apply :

- Residual noise, Lr : A-weighted equivalent noise level measured when excluding the specific noise sources under study (here the wind turbines noise WTN)
- Ambient noise, La : A-weighted equivalent noise level due to all the noise sources available, including the specific noise sources under study :

La=Lr “+” L_{WTN}

- Emergence, e : The arithmetic difference between La and Lr : e = La - Lr

We propose to glance over the regulations or recommendations on wind turbine noise in the leading countries. This presentation is not exhaustive.

German regulation

It applies for all types of noise in neighbourhood. It requires maximum global sound level (including the specific noise of the installation on study), values are defined as a function of the area and depends on indoor or outdoor :

Out door :

Classes of land use	day (6-22)	night (22-6)
I. Entirely industrial areas	**70**	**70**
II. Industrials or commercials areas	**65**	**50**
III. Mixed areas	**50**	**45**
IV. Areas of intense human activities	**55 ou 50**	**40**
V. Particularly protected areas (health center, ...)	**45**	**35**

Table 1. Absolute limit values for outdoor environments, dB(A).

Indoor (windows closed) :

Classes of land use	day (6-22)	night (22-6)
For all categories	**35**	**25**

This regulation has the advantage of simplicity and fixe thresholds protectors inside the premises, but relatively tolerant outside.

English Recommendations ETSU-R-97

These recommendations were write to solve the wind turbine problems: measurements with wind, analyses of noise levels depending on wind speeds.

The statistical index L90/10 min of the equivalent continuous sound level, is used for the residual and ambient levels.

The residual levels measured must be correlated to wind speeds measured on site at height reference of 10 meters.

Regulation time

Day time : 7h – 23h,

Night time : 23h – 7h.

Regulatory requirements

These criteria apply to areas representing the outside of each residence. They apply for all wind speeds.

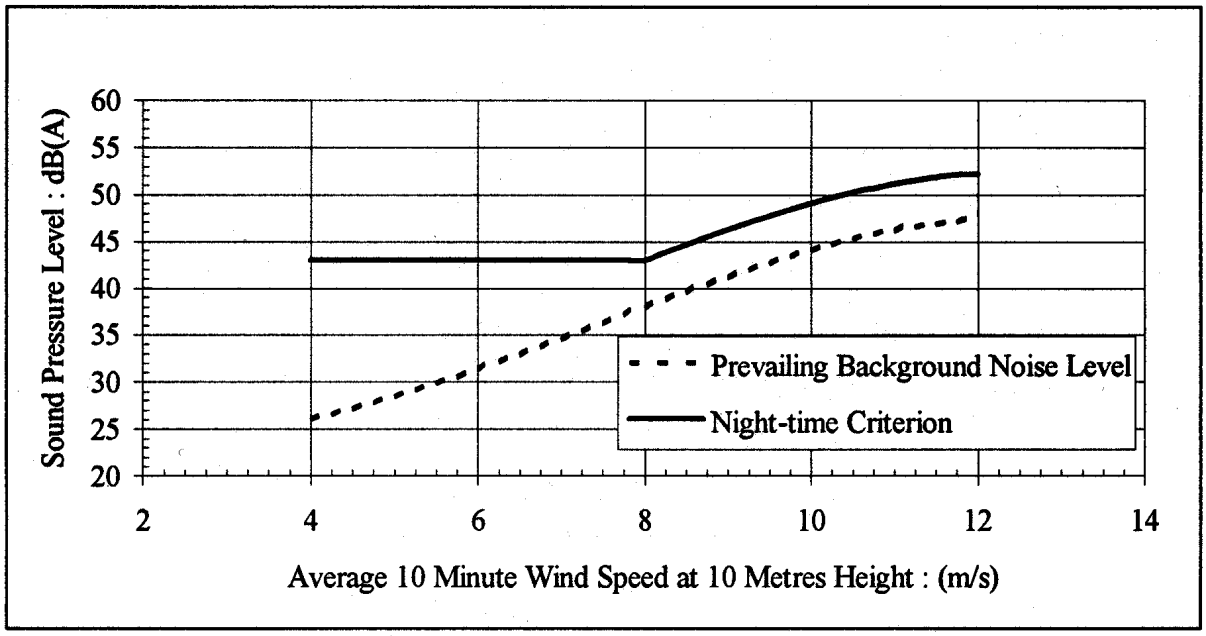
During the day, the value of ambient noise (with wind turbine) must not exceed a limit between 35 and 40 dB(A). The limit is based on the following criteria :

- number of house affected,
- number of machines / installed power,
- level of duration and sound exposure.

During the night, this limit is 43 dB(A).

Beyond these limits, the noise due to wind turbine operation (Lamb) should not exceed more than 5 dB(A) the level of residual noise, whatever the period.

These requirements can be illustrated by two graphs (below).



Example of night-time noise criterion

These requirements allow in fact very high emergence for low noise levels, particularly at night.

Danish Regulation

The noise level of wind turbines in functioning outside the building, should not exceed the following values.

Classes of land use	Day and night à 8 m/s
I. Scattered house	**45**
II. Residential areas	**39**

Table 1. Absolute limit values for outdoor environments, dB(A).

Again, we can see that this regulation allows out side high emergence, at night time, and specially for individual houses

Swedish regulation

The Swedish regulation looks like the Danish one, but limit values out side, with wind turbines working depends on three different day times (day, evening,night) and on thee different areas.

Classes of land use	day	evening	night
I. Industrials or commercials areas	**60**	**55**	**50**
II. Residential areas	**50**	**45**	**40**
III. Recreational areas	**40**	**35**	**30**

Table 1. Absolute limit values for outdoor environments, dB(A).

Italian regulation

This one requires limit values to be respected out door, and emergences to be respected in door

Outdoors ("absolute criterion")

Classes of land use	day (6-22)	night (22-6)
I. Particularly protected areas	**50**	**40**
II. Mainly residential areas	**55**	**45**
III. Mixed areas	**60**	**50**
IV. Areas of intense human activities	**65**	**55**
V. Mainly industrial areas	**70**	**60**
VI. Entirely industrial areas	**70**	**70**

Table 1. Absolute limit values for outdoor environments, dB(A).

Indoors ("differential criterion")

The difference La - Lr =e must not exceed the following limits:

5 dB(A) during the day (06-22)

3 dB(A) during the night (22-06)

These limits do not apply if:

- with open windows, La < 50 dB(A) (day) and La < 40 dB(A) (night)
- with closed windows, La < 35 dB(A) (day) and La < 25 dB(A) (night).

The French regulations of the noise in the environment

This one concerns three fields of application :

- The noise of the infrastructures of transport, ground (highway, railway) and air,

- The noise of the Classified Installations for the Environmental Protection (ICPE). It is mainly about industrial installations, but we also find breeding of animals or installations of storage of dangerous products. Two subcategories exist: the installations subjected to authorization and those who are subjected to simple statement(declaration). In the first case, the applicable statutory text is the order of January 23rd, 1997 and in the second case the order of August 20th, 1985 (formerly applicable to both categories before July 1st, 1997).
- The noises of neighbourhood, governed by the decree 2006-1099 of August 31st, 2006 : all the other sources(springs) of noise are concerned which do not enter the category of the Classified Installations. We find in this family for example, wind farms, the technical equipments of the building (air conditioning) used by the private individuals or the professionals, the equipments of sports and leisure activities, other industrial plants which are not classified such as production plants of drinking water;

Each of these regulations by their criteria, favours more or less the functioning of the activity which it regulates. The noises of transport are the only ones to be limited by a level absolved in front of houses. Two other categories (industrial noises and neighbourhood) are regulated by a criterion of absolute level and emergence. The activities with strong economic stake are more favoured with less severe thresholds. Exception in the rule, the noise of wind turbines is regulated, until now, by the regulations on the noises of neighbourhood, for which we shall see below that the statutory thresholds are the most severe.

Neighbourhood noise : desire to take account of the discomfort

Since 31 August 2006, a new decree on the regulation of the neighbourhood noise (n° 2006-1099) revises the previous (décret 95-408 du 18 avril 1995) and also imposes compliance of the global emergence in dB(A) for outside; the respect of emergences by frequency band for inside, in the case of occupational noise, windows open or closed.

<u>Outside</u>**,** the regulatory limits are :

- There is no breach when the ambient global noise in dB(A) outside is less than 30 dB(A).
- For a noise above 30 dB(A) outside, the emergence of the disturbing noise must be less than :
  - 5 dB(A) during the day (7h - 22h),
  - 3 dB(A) during the night (22h - 7h).

Regarding <u>inside</u> :

- There is no breach when the ambient global noise in dB(A) inside is less than 25 dB(A), windows open or closed.
- For a ambient noise above 25 dB(A) inside, the emergences spectral must be less than:

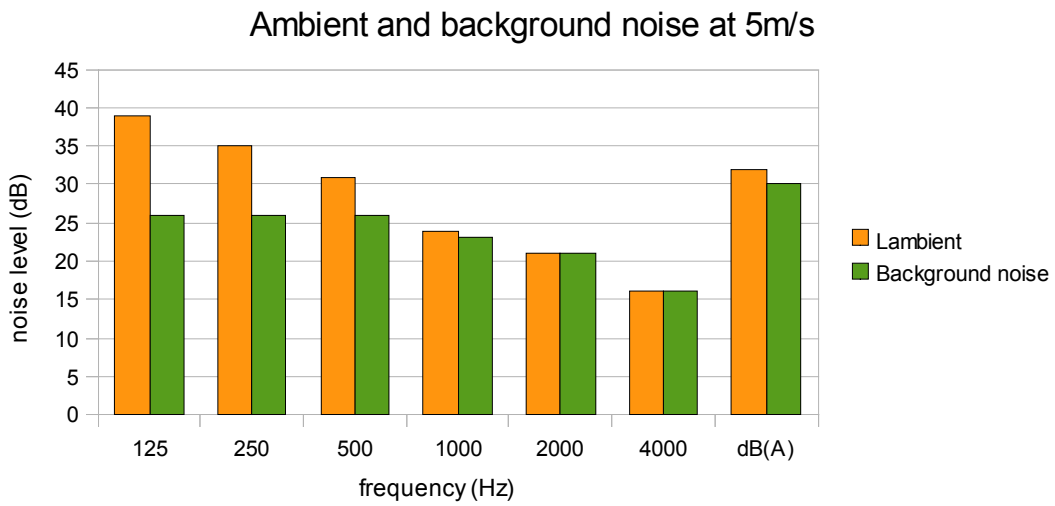
frequency	125 hz	250 hz	500 hz	1000 hz	2000 hz	4000 hz
Emergence (dB)	7	7	5	5	5	5

These regulatory limits are severe because, the night, beyond a low absolute level(30 dB(A)), the regulation authorizes the installation to make just as much noise as background noise .

This value of emergence allows to limit inconvenience to local residents, because the discomfort is well correlated to the emergence, especially since we are more sensitive to an emergence in a background noise less than 40 dB(A). In wind turbine case, the acoustic sensitivity for a wind farm is greatest for low and moderate winds (4 – 6 m/s to 10m from ground). For this conditions, the wind noise in the vegetation is still low, but at the height of the rotor, the wind is sufficient for the acoustic power of the machine is already on the second part of the curve. These conditions correspond to a background noise of between 25 and 30 dB (A), while the noise of machines, depending on the number and distance, is greater than 30 dB (A). Moreover, these ranges of wind are generally more than the half of operating conditions of the wind farm during the night.

Also we can see the spectrum of machine noise is concentrated on the frequency bands 125-500 Hz, while the background noise in rural areas is generally not affected by these frequencies. The graph below shows some spectral emergences important while the global emergence in dB (A) remains below 3 dB (A).

Illustration 2 : Ambient and background noise at neighbourhood



The limitations by frequency band allows also to limit the impact of the acoustic signature of wind turbines more marked on certain frequency bands as that of the background noise

These regulations on neighbourhood noise is harsh but it responds adequately to limit noise of discomfort in the vicinity of the wind turbines. In contrast, the regulatory thresholds to check to the local resident provides measurement condition impossible to realize because, it leads to the characterization of noise measurements equal to or lower compared to the background noise.

Regulation of industrial noise (ICPE)

This regulation (like the neighbourhood noise presented in the preceding paragraph) bases on the concept of emergence.

Order of 23 January 1997 considers that there is non compliance when one of the following conditions is true:

- Maximum permissible levels (L_{limit}) property boundaries of the installation are exceeded. These levels allowable limits at property boundaries have to be determined in the authorization in order to meet the emergence in the emergence areas regulated (among residents). Nevertheless, they are capped and can not exceed 70 dB (A) during the day and 60 dB(A) during the night unless the residual noise level is above this limit for the period.
- The emergence (e) in the area to be emergence-regulated, compared to the level of residual noise (L_r) exceeds a certain value depending on the period and the level of ambient noise as shown in the table :

Ambient noise level existing in the emergence areas regulated (including the noise of the establishment)	**EMERGENCE** eligible for the daytime 7h to 22h except Sundays and holidays	**EMERGENCE** eligible for night time 22h to 7h including Sundays and holidays
Above **35 dB (A)** and less than **45 dB (A)**	6 dB(A)	4 dB(A)
Above **45 dB(A)**	5 dB(A)	3 dB(A)

Table 1 : Regulatory limits for industrial noise (ICPE)

Table: Emergence

Moreover, the regulations allow the study of the tonality. It is detected in a spectrum unweighted third octave when the level difference between the third octave band considered and the four octave bands closest (the two bands immediately below and the two immediately above) meets or exceeds the levels indicated in the table below:

This analysis will be acquired from a minimum of 10 seconds		
50 Hz to 315 Hz	400 Hz to 1250 Hz	1600 Hz to 8000 Hz
10 dB	5 dB	5 dB

In the presence of pure tonal sound, total duration of occurrence can not exceed 30% of the operating time of installation in each period night and day.

Summary table

Country	Absolute criterion	Differential criterion
Germany	**yes for 10 m/s**	**no**
England	**yes for all wind speed**	**yes for all wind speed**
Denmark	**yes for 8 m/s**	**no**
Sweden	**yes for 8 m/s**	**no**
Italy	**yes**	**yes (indoor)**
France until now	**yes**	**yes**
France after july 2012	**yes**	**yes**

Towards a regulatory evolution of wind turbine noise in France

Today, the legal regime of the wind turbines is being changed provided with a ranking of Installation Classified for the Protection of the Environment.

This evolution of wind turbine noise to that of industrial facilities would circumvent the difficulty of present measurement on the regulation of noise from neighbours.

The regulation of industrial noise circumvents this difficulty by defining a maximum allowable limit level at the limit of property line of the industrial facility (installations in operation). This maximum level is defined by the acoustic analysis so that, given the propagation conditions between the property line and local resident, to respect the regulatory thresholds of emergence with the local resident. This has the following advantages:

- have an easy access to the measurement without entering in a property,
- not having to stop the facilities for the control measure,
- getting closer to the facilities, increase the signal on noise ration.

For wind turbine noise, it's possible to consider the same regulatory principle by introducing a check measurement of a maximum allowable ambient level at a distance closer to the wind turbine. Compliance with this value have to ensure compliance with regulatory thresholds emergences among residents, for all operating conditions of the wind farm. We have seen that the turbine noise and background noise is depending of the wind speeds so several values of maximum permissible level must be defined: either for each wind speed, or for some speeds corresponding to different classes of sound levels (for example, 4 – 6 – 8 m/s). Two other additional problems related to wind turbine appears in the application of such guidelines.

- The difficulty of determining a property line to the wind turbine. In France, the operator of a wind farm leased a parcel defined by sweeping of the the wind turbine blades, but he is not owner.
- The distance of wind turbines to houses are important. Under these conditions, the propagation between the sound source and receiver depends on the meteorological conditions (wind, temperature, humidity, …). The definition of maximum permissible level on short distance of the machines will consider this issue.

Conclusion

In France, the current regulations on the noise of wind turbines are the most severe French regulations of the noise in the environment and also the most severe of regulations European. This regulation allows however to limit the embarrassment of the local residents. Indeed, the statutory limitations of emergence are effective from the low levels of background noise. This allows to limit emergences which can be important for low wind speed (low background noise because the noise of the wind in the vegetation is still low and the contribution of wind turbines begin to grow). The limitations by frequency band allows also to limit the impact of the acoustic signature of wind turbines more marked on certain frequency bands as that of the background noise.

These statutory requirements are with difficulty controllable at the local resident's because the wind turbine noise for which we try to check(control) is then equivalent or lower than that of the background noise.

The regulations on the classified plants propose an approach allowing to by-pass this difficulty by defining an acceptable maximal ambient level in limit of property of the industrial installation. This level limit acceptable is defined so that his respect can guarantee at the local resident's, the respect for the emergences. This allows to approach the source of noise so as to improve the signal on noise ratio, also facilitates the access to the measurements and avoids the stop of the installation to be checked.

An evolution of the regulations on the wind turbines noise is thus possible in this direction. This evolution raises however some additional difficulties. The position of control of the maximum level admissible remains to define because the industrial property does not exist in the wind energy. Several acceptable maximum ambient levels of noise will be to define according to the conditions of wind and the meteorological conditions.