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France - Germany: A Comparison of the Acoustic Assessment Procedures

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Summary

The French and the German regulation frameworks for the acoustic assessment of wind farm projects are briefly described. How far the interpretation of the same acoustic situation can differ when the French or the German regulation framework is considered, is shown on the basis of the observation of the same measurement data set. Several aspects of the assessment procedure are discussed: choice of the weather conditions, use of wind screens, assessment of the tonality, measurement and reproduction uncertainties. The consequences of the differing procedures are discussed from the point of view of the dweller, of the wind turbine manufacturer, of the wind farm operator, of the financing institutions and of the regulators. Recommendations for international projects are derived on the basis of the experience gained in France and Germany.

1. Introduction

As a French engineer providing advisory services to German investors, I am often required to explain how and why the assessment of wind farm noise are so much differing from one country to the other [4][12][13].

As an introductory example, please consider the scatterplot of the sound pressure levels which have been measured at a receptor location in the vicinity of a German wind farm (Figure 1).

The scatterplots of the total sound and of the residual sound level hardly differ from each other. The maximum total noise level during the daytime measurement periods remains within 55 dBA, a noise level which compares to the German daytime rating level for small residential areas. On the basis of such a data set, an acoustic consultant in Germany would however resent at giving any opinion about the compliance of the wind farm project. The following sections of this paper will explain why he would rather state that no qualified assessment of the wind farm noise can be made at this location because the signal/noise ratio of the wind farm noise is too low. He would further recommend performing other measurements at a location where the signal/noise ratio of the wind farm noise can be significantly improved.

Similar scatterplots for a wind farm in France would be interpreted differently. An acoustic consultant in France would stress the point that no sound emergence can be noticed. As a consequence, he would say that the wind farm is compliant to the French regulations.

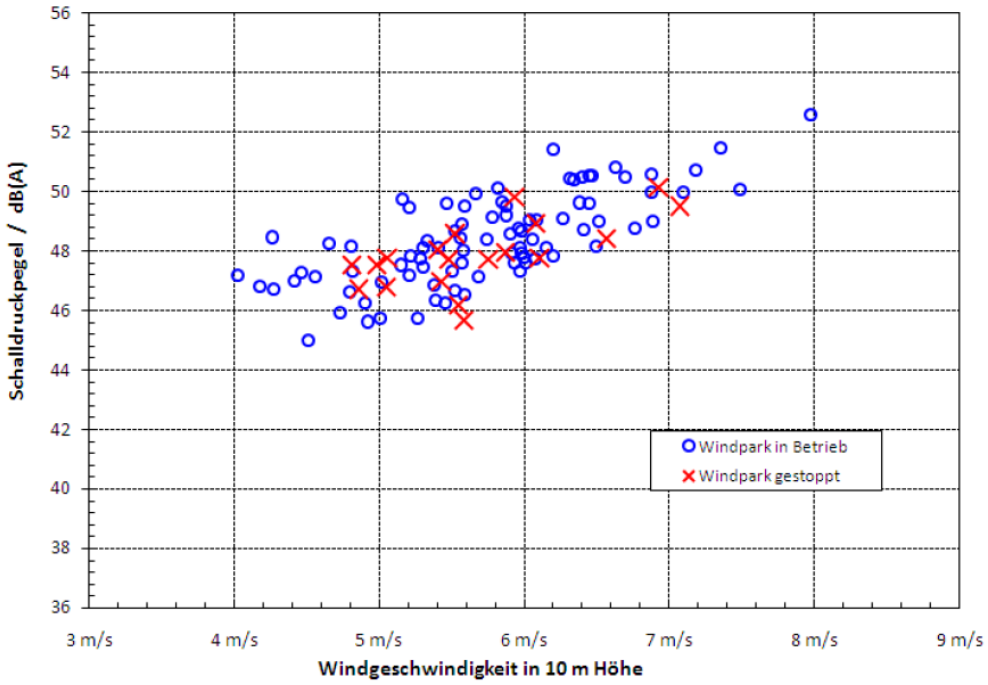

Figure 1: Measured total sound (blue circles) and residual sound (red crosses) levels in $L_{Aeq,1min}$ at the receptor location during daytime (Source: [11])

A wind farm operator is responsible for the compliance of his facility to the local regulations and strives at improving the electricity production. In case of complaints from the dwellers or the need for a noise curtailment plan in order to comply to the regulations, the operator will need a detailed analysis of the acoustic situation at the site in order to assess which corrective measures can be implemented. In order to provide qualified answers to the operator, an acoustic consultant often needs to investigate the acoustic situation far beyond the minimum requirements of the local regulations.

This paper is based on the experience gained while reviewing and assessing numerous wind farm projects mainly in France and Germany. The assessment methods are heavily dependent on the regulatory framework of the country of application. We will hence begin with a brief description of the French and the German regulatory frameworks. For a detailed description of the technical procedures please refer to the relevant national regulations and standards as well as to the international standards. We will then go into more details on selected topics, discuss a few issues and finally compare the advantages and drawbacks of the respective procedures for the different parties involved in a project.

In this paper we will mainly use the international terms defined in ISO 1996-1 but it might be occasionally appropriate to revert to the respective French or German terms.

International: ISO 1996-1	France: NF S 31-110	Germany: TA Lärm §2.4
Total sound	Bruit ambiant	Gesamtbelastung
Specific sound	Bruit particulier	Zusatzbelastung
Residual sound	Bruit résiduel	Vorbelastung
Sound emergence	Émergence	

2. Regulatory Frameworks

2.1 The French Regulatory Framework

The regulations which apply to wind farm projects since 2011 are derived from the general framework of the registered environmental facilities (Installations Classées pour la Protection de l'Environnement (ICPE)) [28][15].

An absolute acoustic threshold at the border of the facility is set to 70 dBA during daytime and 60 dBA during nighttime. The border is defined as a distance of 120 % the total height (hub height + rotor radius) of the wind turbine.

A relative threshold of 5 dBA during daytime and 3 dBA during nighttime is set with reference to the residual sound. The term "sound emergence" is often used, a definition of which can be found not only in the French standards NF S 31-110 and NF S 31-010 [31][29] but also in the ISO 1996-1 international standard as: "increase in the total sound in a given situation that results from the introduction of some specific sound" [22]. In our case the specific sound is the wind farm noise.

Assessing the sound emergence is typically based on the comparison of the sound levels when the wind farm is operating and when it is not operating. The sound emergence is only relevant in France if the total sound level is larger than 35 dBA. The term "sound emergence" is in itself worth a lengthy discussion but this will be addressed later in this paper.

The tonal character of the specific sound (tonalité marquée) must remain within given limits. More details in this issue will be also given below.

The minimum distance to the dwellings is set to 500 m [28].

The main steps of an acoustic acceptance measurement campaign are, in reference to the preliminary French standard PR NF S 31-114 [32]:

a) Prepare the measurement and wait for suitable weather conditions.
b) Measure during a time period typically ranging from a few days to a few weeks
c) During the measurement period, collect weather data at the site and noise level data at a selected set of dwellings
d) Operate the wind farm under test in a sequence of operation / stop phases. The practical duration of the phases typically ranges from one hour to a few hours depending on the operating and the weather conditions
e) Exclude the erroneous data sets from the evaluation
f) Build data classes corresponding to homogeneous conditions e.g.: daytime vs nighttime, standardised wind speed bin, wind direction, hours of the day etc…). A number of data classes is suggested in the preliminary standard but project specific classification methods may be proposed. The classification according to the atmospheric stability [10] is one example.

The acoustic descriptor is $L_{50,10min}$ of the $L_{Aeq,1s}$. The acoustic indicators in each data class are the medians of the residual sound level and of the total sound level. The sound emergence in each class is calculated as the difference between the total sound level and the residual sound level.

The noise limit depends on the residual sound level during the measurement. A detailed assessment of the various acoustic situations will hence typically require several measurement campaigns covering several seasons and/or meteorological conditions.

The residual sound might also evolve as the traffic on the surrounding roads increases from year to year or when additional industrial facilities or wind farms are commissioned. In agreement with the general regulations for the registered environmental facilities, each wind

farm is considered individually, the other surrounding facilities contributing to the residual sound.

2.2 The German Regulatory Framework

The German local development plans define areas and their intended use. For each type of area, maximum immission noise levels are set according to the technical directive on noise (TA Lärm, [34][14]).

Type of area	Daytime: 6 am to 10 pm	Nighttime: 10 pm to 6 am
Industrial areas	70 dBA	70 dBA
Business areas	65 dBA	50 dBA
Cities, villages and mixed-use areas (farming)	60 dBA	45 dBA
Common residential areas	55 dBA	40 dBA
Exclusively residential areas	50 dBA	35 dBA
Health resorts, hospitals and nursing homes	45 dBA	35 dBA

The total sound level to be compared to the maximum allowed immission level is the addition of the maximum contribution of each of the existing and future facilities. The total sound level (Gesamtbelastung) which is relevant here is fairly independent from the weather conditions.

3. Verification of the Emission Characteristics of the Noise Sources

When the characteristics of the wind farm as a source of noise has to be characterised, a sound level measurement using a typical sound level meter setup at the border of the facility is sufficient in France. In Germany, an accurate measurement of the source is necessary. It must be performed according to a German adaptation [35] of the international standard IEC 61400-11.

4. Measuring Equipment

4.1 Acoustic Measuring Equipment

In France, the sound level measuring equipment must fulfil the class I requirements but a standard foam wind screen is usually installed on the microphone. Such wind screens are typically recommended by the manufacturers when the short-term wind speed at the microphone height does not exceed 5 m/s (NF S 31-110 §6.2.2). Under the assumption of a standard logarithmic wind-speed profile, a wind-speed at the microphone height (1,2 m) is sometimes derived from the hub-height wind speed and it is explained to remain under 5 m/s. This method forgets that the short-term wind-speed profile is variable and that the wind speed in the eddies around the microphone location can be much higher than the average wind-speed of the air flow. Experience shows indeed that the turbulent flow around the microphone can induce significant sound level errors [16] and a procedure for the estimation of the bias and the uncertainties due to the wind-induced noise has been proposed [8].

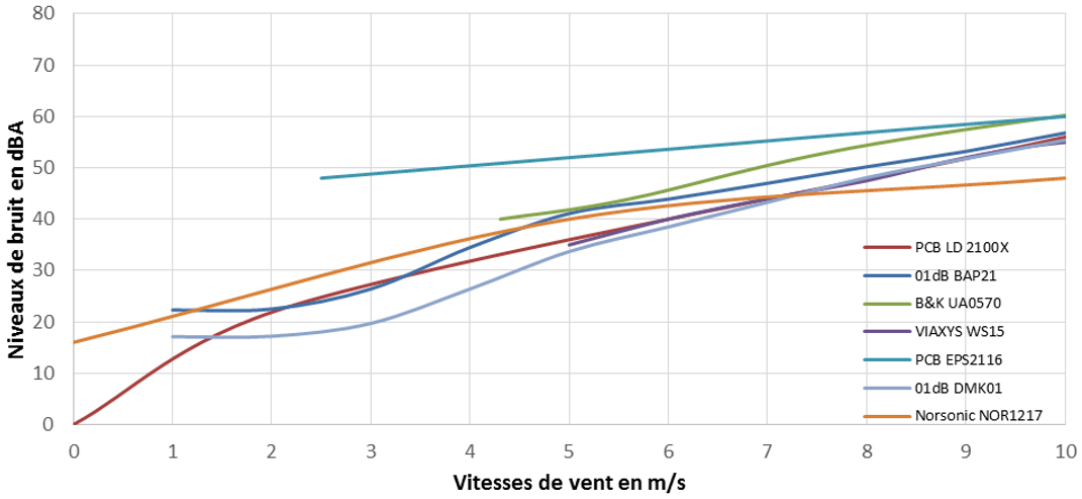

Figure 2: Wind-induced noise on a microphone depending on the type of wind screen (Source: [16])

Under the assumption that the total sound as well as the residual sound will be affected in the same manner, the sound emergence level is considered to be unaffected by the wind-induced noise at the microphone (NF S 31-110 §6.2.3).

In Germany, considering the importance of avoiding any significant bias, of low measurement uncertainties and of the reproducibility of the measurements, the use of a large secondary wind screen is required [35].

A few publications are available where the characteristics of the wind screens and the effects of the wind-induced noise have been investigated [1][2][21][8].

4.2 Meteorological Measurements

The French standards require a detailed measurement of the meteorological conditions with a focus on the acoustic propagation. NF S 31-110 requires i.a. measurements using 10-m masts and the description of the acoustic propagation conditions including cloud cover and solar radiation. Similar requirements are found in the Annex F of NF S 31-010. The wind farm specific standard NF S 31-114 refers additionally to the standardised wind speed which can be derived from the hub-height wind speed. The use of the standardised wind-speed instead of the measured wind-speed at 10 m height has been well accepted by the acoustic consultants and it significantly improves the reproducibility of the assessment procedure. We unfortunately notice that the documentation of the acoustic propagation conditions, although required by the French standards, is seldom fully available in the acoustic assessment reports. Beyond the aspect of acoustic propagation, we consider that the same information can greatly improve the assessment of the residual sound levels [10].

In Germany, the aim of relating the measured sound levels to the operating parameters of the wind turbines is well served by using a similar setup and similar evaluation procedures as required by the IEC 61400-11 standard.

5. Documentation of the Wind Turbine Operation

The particular sound level being the main relevant parameter for the compliance of a wind farm in Germany, the involved parties strive to control and document the operating conditions and the status of the wind turbines as accurately as possible. In critical situations, the operating mode and the rotational speed of the wind turbines have to be logged and made available upon request to the regulators. The involved parties have adapted their working procedures so that this information remains traceable over the past operation periods.

The sound emergence being the main indicator in France, the most important parameter for the wind farm operation is its status: in operation (ON) or stopped (OFF). While preparing an acoustic acceptance measurement, the acoustic consultants usually specify a sequence of ON/OFF operation periods and rely on the wind-farm operator to implement this sequence, and to the wind turbine manufacturer as to the wind turbine specifications.

According to the regulations on registered environmental facilities (ICPE), the legal representative of the project company is ultimately responsible for the compliance of the wind farm to the regulations. In the course of a number of project reviews, we had to figure out in what extent the acoustic assessment could be relied upon and in case not, to sort out which assumption(s) of the acoustic assessment might happen to be misleading. The investigations required addressing the acoustic consultant, the wind farm technical manager and the wind turbine manufacturer. After studying the topography, cross-checking the site-specific wind and weather data, a site visit and critical listening often provided the decisive cues.

6. Tonal Adjustments

Tonal sounds are known to be particularly annoying but modern wind turbines are expected not to emit objectional tonal components. In Germany, the tonal sounds have to be assessed on the basis of the narrow-band analysis according to IEC 61400-11 ed.2 standard in order to later derive a tonal adjustment according to the German standards [35][36][34]. The assessment method is well defined and can be effectively enforced. As a consequence, most wind turbines in Germany are free of objectionable tonal components. Some exceptions are however known but the problems can usually be investigated and solved when necessary.

The general method in France for the assessment of tonal sounds from registered environmental facilities is based on a 1/3rd octave analysis [25][28]. This method is much less sensitive than the narrow-band method according to IEC 61400-11 ed.2. The sensitivity of the method is further reduced by the ministerial order dated 26.08.2011. If tonal sounds are identified on the basis of the 1/3rd octave analysis, they are considered acceptable as long as they do not occur more than 30 % of each of the daytime and nighttime operation periods. We consider this situation very unfortunate because although these tonal sounds are not a necessary evil, they have a high nuisance potential. The dwellers on the countryside can especially feel annoyed, because such tonal sounds do not belong to the “traditional” soundscape. On the other hand, when the tonal sounds remain undetected, a chance is missed to identify and correct occasional malfunctions of the wind turbines.

In some cases, the tonal sounds even prevent newly implemented curtailment plans or other noise reduction measures to reach their objective. The noise-reduced operation modes usually achieve a reduction of the broad-band noise of the wind turbine. In the presence of a tonal sound, the broad-band noise might be reduced but the tonal sound usually remains unaffected. The tonal sound then becomes prominent in the noise spectrum; the objective of reducing the overall particular sound level is not achieved and the wind turbine sound is even more annoying because the masking of the tonal sound by the broad-band noise is less effective than in the former operation mode.

7. Uncertainties

The discussion of the measurement uncertainties is beyond the scope of this paper. We will mention here only a few simple guidelines for the interpretation of the results of a wind farm acceptance measurement campaign. Readers interested at the details of measurement uncertainties will revert to the applicable standards for more information.

The rating of wind farm noise based on sound emergence levels below 3 dBA is prone to a bias and to uncertainties which grow very high as the sound level difference between ambient and

residual sound vanishes. Whereas the uncertainties due to the instrumentation and to the propagation conditions have being investigated in details [20][19][33], the investigations are very scarce when it comes to assessing the reproduction uncertainties of the residual sound levels.

The French standards [32] allow expressing the result of the assessment after deduction of the extended uncertainties from the calculated sound emergence levels. Using this procedure, a wind farm only faces the risk of being non-compliant if the allowed emergence level is exceeded with a high level of confidence, say 95 %. This procedure is in favour of the operator. The dwellers might rather wish an assessment giving them a 95 % confidence that the allowed emergence levels are not exceeded but under the current practice in France, such a requirement would not be realistic.

If a wind farm is found to be compliant and the remaining margin is used for the optimisation of the wind farm, the chances become very few, although they do exist, that the optimised wind farm is still compliant. During a financial transaction between a project developer and an investor, the wind farm developer will aim at increasing the energy output of the wind farm by avoiding any noise curtailment. The acoustic acceptance measurement campaign might turn out to be successful after application of the corrections for uncertainties. The wind farm would be declared compliant because the acoustic assessment has been performed in line with the French standard. The investor would however take over a wind farm with a 95 % confidence level that the acoustic thresholds are not exceeded by more than the extended uncertainty. This means also that he would have only 5 % confidence that the wind farm noise is within the acoustic threshold. This might not be considered to be a problem since the wind farm has already been declared compliant but if a verification measurement becomes necessary, the chances are by far lower than 50 % that the assessment results will be acceptable. The first verification measurement campaign might fail and identifying and waiting for the suitable measurement conditions might last for a long time. If several measurement campaigns have to be performed until acceptable result are available, the accumulated production losses during the stop phases might also become prohibitive. For this reason, we would rather rely on the emergence level results based on the raw emergence calculations, in the hope of having 50 % chances to have correctly assessed the acoustic situation. This means that in case of non-compliance, there would be reasonable 50 % chances of success in case of a new measurement campaign. We consider that this approach balances the risks between the parties.

Considering that the bias and the uncertainties of a method based on sound emergence levels at the receptor location are prone to be high and that the extended uncertainties can be deducted from the sound emergence level, the method does not provide incentive for reducing these uncertainties. In some cases, when the uncertainties grow too high, the French procedure recommends acquiring additional measurement data and / or to refine the classes of homogeneous conditions.

The German regulator is aware of the numerous sources of uncertainty but seeks nevertheless a 90 % confidence level that the particular sound will be lower than the threshold which has been set on the operating permit. To achieve this goal, the acceptance procedure has been tailored to reduce the sensitivity to the measurement and reproduction uncertainties [34][36]. To achieve this goal, the wind turbine noise is preferably measured from a short distance using a large secondary wind screen and the loudest wind turbine operating conditions are considered relevant. The assessments of the noise level at the dwellings rely however on a propagation calculation which itself is prone to uncertainties. The compliance of a wind farm is finally assessed on the basis of a calculated noise level at the receptor location after addition of the extended combined uncertainties which account for the measurement uncertainties, the deviations of wind turbine characteristics from the specifications as well as the meteorological and acoustic propagation uncertainties. Once a wind farm has been declared compliant, the

operator has typically only 10 % risk that a new acceptance measurement would fail at providing confirmation. The 10 % risk means however that exceptions are possible.

Under consideration of the allowed immission noise level which has been set by the regulator, the particular noise of the wind turbine can be slightly increased if all the involved parties succeed at reducing the uncertainties at the various steps of the assessment process. This fosters the development of more accurate working procedures, a better optimisation and a tighter control of the wind turbine.

8. Discussion of Selected Topics

8.1 France: Discussion of the Definition of the Sound Emergence

According to NF S 31-110 the sound emergence refers to the temporal level variation which is caused when the wind farm noise appears or disappears i.e. when the windfarm is put in operation or stopped. The ministerial order of 31.08.2006 about community noise [26] and the French standard NF S 31-010 [29] defined the terms of global and spectral emergence but the assessment is not based on the temporal variation of the noise level but on the difference between the “usual” initial sound level and the noise level during normal operation of the specific sound source. The ministerial order of 05.12.2006 [27] further specified that the assessment within the framework of community noise had to be based on at least 30 minutes of measurements. This assessment procedure has been in use for some time in France and was unfortunately extremely sensitive because, if at any given time the wind farm noise was higher than the background noise for more than 30 minutes, the wind farm would have been declared non-compliant. Due to the fact that the application of this method to the newly commissioned wind farms lead to very unstable decisions, another method had to be proposed. At that time, the method of statistical evaluation of the noise levels after binning according to the wind speed was already under investigation by the French acoustic consultants. Initial attempts were based on a wind speed measured at 10 m height. The statistical evaluation after binning significantly improved the stability of the decision but the reference to a wind speed at 10 m height occasionally led to severe discrepancies depending on the measurement period. Further developments of the method including the use of a standardised wind speed lead to a draft standard [32] which has been referred to by the French regulator [28], at the time when the French administration decided to consider the wind farm projects as registered environmental facilities (ICPE). From this time on, the regulations about community noise were no longer applicable to the wind farm projects. The main principles set out by the preliminary standard PR NF 31-114 [32] are nowadays in application in France but in spite of lengthy discussions and several updates this preliminary standard could not yet be established as a standard.

Through the binning process, several noise level data sets are aggregated as long as they originate from the same binned wind speed but they might as well originate from acoustic situations which, for other reasons, significantly differ from each other.

The sound management plans which are derived from this method are typically static and ensure a deemed-compliance with reference to the acoustic acceptance measurement and evaluation report. It can however not be ruled out that under particular conditions, the curtailment of the wind farm is too severe or other situations where the emergence is indeed temporarily exceeding the permitted levels. Some acoustic consultants and wind farm operators do hope to design an automatic control system which would be able to adjust in real-time the operation modes of the wind turbines on the basis of the real-time assessment of the sound emergence at the dwellers locations [18]. This approach is technically challenging because it relies on signal analysis and processing techniques.

8.2 France: Discussion of the Significance of the Sound Emergence

There is a general agreement that the higher the wind farm noise, the more annoying it is for the dwellers. This formulation is fairly simplistic but it explains why many countries have adopted absolute noise thresholds. On the other hand, a few countries such as France have chosen to consider that the change in noise level is a more relevant criterion. We are personally sceptical because we have not read so far any survey demonstrating the relation between emergence levels and annoyance level. In the course of discussions about the topic of sound emergence we have noticed however what we would consider here misconceptions:

a) “The sound emergence reflects the perception of the wind farm noise by a human.” If the wind farm noise is at the same level as the background noise, the total sound level is 3 dB higher than each of the specific sound and the residual sound. The sound emergence level is hence acceptable according to the French regulations although the particular sound is clearly audible as an independent source of noise and a trained listener could even describe it with a wealth of details.

b) “When the background noise and the particular noise are at the same level, they cannot be distinguished from each other.” A wind farm noise which is at the same level as the background noise is usually not masked by it, by far. As a rule of thumb, a wind farm noise can be masked by the background noise if the wind farm noise is about 8 to 12 dB lower than the background noise [7]. A rule of thumb inherited from the field of speech and audio coding says that the noise of a coding and transmission channel does not disturb the listener if it lies about 10 dB below the speech or audio signal in each frequency band and can be masked by the speech or audio signal.

c) “The nighttime sound emergence level is allowed to grow up to 3 dB in France because such a sound emergence level is hardly perceptible.” It is indeed difficult to identify absolute sound levels on a scale with 3 dB steps, but a level difference of 3 dB can easily be perceived. As an example, the level steps of a portable audio player are typically 2 dB each. This is large enough to be clearly perceptible but not too small so that the user can quickly adjust the level. According to Fastl and Zwicker, the just-noticeable level differences are below 1 dB [3]. Further, a trained ear is capable of perceiving relative level differences of a fraction of 1 dB in individual frequency bands. The level variations might not be perceived for themselves but as a tonal coloration.

8.3 Germany: High Stability of the Assessment Results

If a wind farm is found compliant in Germany, there is only 10% risk that it is not. If a new measurement is performed, the risk of a significantly differing result is low. As a consequence, the administrative decision is stable (a few exceptions do exist however).

The procedure is designed for the worst-case scenario. The sensitivity to the weather conditions is rather low (exceptions do exist however).

The structured set of standards and of the accreditation procedures (FGW TR-1, DIN, VDI, IEC, §26 BImSchG, MEASNET) contributes to the reliability of the procedure and of the personal as well as to a high stability of the assessment results.

The cumulative effects when additional facilities are commissioned are limited because the noise budget for all the wind farm projects and industrial facilities is defined by the noise level guidelines (TA Lärm). Exceptions do exist however, especially when the facilities have been permitted in the past using simpler procedures. Before permitting a new facility, a preliminary update of the planning documentation of the existing facilities might be necessary.

8.4 From the Point of View of the Various Involved Parties

We finally summarize in a tabular form the above discussions.

Involved Party	French Procedure	German Procedure
Wind turbine manufacturer	The French procedure is more flexible as to the operating modes. The lower constraints on tonality leave more flexibility for the choice of the individual components and for the operation procedures of the wind turbine. In case of acceptance problems, it can become difficult to identify which aspects of the project or of the wind turbines have to be improved.	The verification of the wind turbine noise characteristics is more straightforward. The wind turbine specifications and warranties have to be tighter. The introduction of alternative wind turbine versions or other operating modes might be difficult due to the burden of the certification and of the documentation of each modification.
Wind farm technical manager	More operation modes to choose from. The sound management plans are more flexible but also more complicated to implement, to check and to trace.	Fewer operation modes to choose from. Tighter specifications. Easier control and documentation of the operating conditions.
Wind farm operator	More latitude is available as to the sound optimisation strategy. High uncertainty of the acoustic acceptance measurements. The reproducibility risk due to adverse meteorological conditions can be high. The costs of an acoustic acceptance measurement and the associated production losses can be very high. The residual sound levels might increase along the project life, allowing to gradually reduce the noise curtailment measures and, as a consequence, to improve the electricity production.	The sound management plan is usually defined during the development phase of the project. Improvements are only possible in case of a significant upgrade or improvement of the wind turbine. The costs of a verification measurements and the associated production losses are limited.
Financing institution	The assumptions of the pre-construction acoustic survey might be too optimistic, especially as far as the residual sound level is concerned. A significant risk might remain that the assumptions cannot be confirmed by the acoustic acceptance measurements and that a more restrictive sound management plan has to be implemented.	The acoustic risk can be assessed and managed.
Regulator	The operator is responsible for the compliance of the wind farm project to the regulations. The possibilities for the regulator to have direct insight into the project are limited. The acoustic measurements at the receptor location provide the relevant information for compliance testing.	The maximum noise contribution from the wind farm can be set and controlled with a 90 % confidence interval. The regulator has possibilities to directly control several acoustic aspects of the project. The measurement of the source, followed by a propagation calculation, only provides an indirect information about the sound levels at the receptor locations. The administrative decision is very stable.

Dwellers	Thanks to the sound emergence criterion, the increase of the ambient sound level at low wind speeds is moderate. The same sound emergence criterion allows however the wind farm to contribute more noise at high wind speeds because the residual sound level also increases with the wind speed. The overall ambient sound level is subject to increase over time as the number of facilities increases. Tonal sounds are annoying but often remain undetected.	The overall maximum noise contribution from all the surrounding facilities can be controlled by the regulator. The wind turbines are expected to be “state of the art” i.e. free of objectionable tonal sound. Noise curtailment sets in at a given wind speed and the wind farm contribution does not increase beyond the level which has been allowed by the regulator.
Acoustic consultant	The sound emergence criterion is subject to large uncertainties. The standardisation procedure is lengthy. The reproducibility risk due to weather conditions is fairly high. A large variety of requirements and of expectations from the involved parties has to be fulfilled. The expertise of the acoustic consultant plays a key role during the evaluation of the measurement data and the interpretation of the measurement results.	An acoustic measurement of the source can be straightforward. Project specific measurement concepts and alternative measurement locations are sometimes necessary. The measurement and assessment procedures are very detailed and subject to round robins. Low uncertainty measurements are required.

9. Conclusion and Outlook

The comparison of the French and the German procedures has shown that the same acoustic situation can lead to largely differing assessments depending on the regulations of the country of application.

The French standard NF S 31-114 has been under discussion for a number of years now but could not be finalised yet. The notion of sound emergence is intrinsic to many assessment procedures in France but the discussion whether it should be determined on the basis of statistics of binned values, on time sequences or even better in real-time thanks to source-separation signal processing algorithms remains open.

One of the main problems of the French procedure is the reproduction uncertainty depending on varying meteorological conditions. This issue will hopefully be addressed in a future revision of the French standards.

The German procedure has proven to be effective and robust but as the number of wind turbines and the density of the wind farms in some areas increases, an update of the procedures is necessary. Modifications of the acoustic propagation calculation procedure has already been introduced (topic beyond the scope of in this paper) but the technical guideline for the measurement of the source has still to be updated in relation to the IEC 61400-11 ed.3.

Experience shows that reducing the uncertainties goes along with improved and more qualified evaluation methods.

This paper might be of interest for the project team on the measurement of wind turbine noise characteristics in receptor position [23].

We have focussed here on two countries but similar concepts might be applicable to other countries. The IFC EHS guidelines for wind farm [12] are potentially applicable in countries where no specific regulations are available. Their use requires mastering most of the concepts addressed in this paper but special care should be given to the implementation details and to the human, material and financial resources available in the country of application.

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