oduction of a Good Practice Guide to Assess Wind Tur in the United Kingdom Using ETSU-R-97

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vitation of the national Government, a working group was set up by the UK Ins s to develop “Good Practice Guidance” on how to apply the UK wind turbin ent procedure in ETSU-R-97 in the context of planning applications. Followin nce consultation, and two rounds of extensive peer reviews, the guidan d in May 2013.

er will cover the relevant aspects of wind turbine noise assessment considere ood practice in the UK at the application stage, including the baseline noise a ection, the analysis of the data to derive the noise limits for the scheme, logy to adequately predict the propagation of turbine noise.

uded in this paper is a discussion on the elements not included in the guide, su ation of the Government endorsed noise limits, and recommendations for to further understand the effects of wind turbine noise.

duction

K, noise assessments for wind farm developments are undertaken us logy set out in ETSU-R-97 ‘The Assessment & Rating of Noise from Wind d in September 1996. The Government Department of Energy and Climate which has policy responsibility for ETSU-R-97, commissioned a report in how noise impacts are considered in the determination of wind farm p ns, and specifically look at how the ETSU-R-97 methodology was being applie

limits which remain a matter for Government.

er of 2011 and spring of 2012 was spent reviewing the available literature, i
edings from past Wind Turbine Noise Conferences to help the working group
to what was current good practice. The output from many drafting and dis
was an 80 page consultation document. This was sent off for a peer review
he basis of a formal IOA consultation which ran over the summer of 2012. The
ld two workshops in Dublin and London to discuss the issues raised in the cons
t, and to encourage feedback.

ing group gathered together again in the autumn of 2012 to consider the 56
tion responses received from a good cross section of the interested parti
and non members, and began drafting the GPG. Most of the comments r
plementary of the topics covered, and comments were addressed where ag
ing group. The document length needed to be drastically reduced, and where p
ld be as prescriptive as possible. Several respondents were critical of the t
, and felt that the noise limits should have been included.

went to another peer review in March 2013, and following some minor amen
to IOA Council for approval. The approved GPG was published on the IOA we
, and launched at a one day meeting in Bristol on 21st May. First and forem
n IOA document for which the IOA retain editorial control, but of course the do
be recognised within the planning system to give it “currency”. To that end,
the Government to consider endorsing the GPG as “current good practice”. At
submittal, endorsement has been received within England and Wales, and a re
tland and Northern Ireland is expected shortly.

wing sections describe the current good practice established in the GPG.

Introductior

e

pe of the GPG considers all wind turbine developments above 50 kW, reflec
rinciples within ETSU-R-97, and the results of research carried out and exp
ince ETSU-R-97 was published. This does leave smaller developments withou
, for which a number of regional policies appear to be filling the gap, although
iples covered in the GPG would still apply.

entation of the GPG includes text and graphics, with numbered summary boxe
ach section. The GPG notes that it represents good practice as of the
n, and does not exempt further advances from being used. It is anticipate
review of this document will be undertaken, and a new version produce
t changes have occurred. Updates can therefore occur without the need for
e procedures.

equired) Undertake a measurement survey consisting of simultaneous meas
ackground noise levels at representative properties with wind speed and dire
proposed turbine site;
lyse the data to remove rain affected and atypical data, and derive the noise l
scheme;
ate noise predictions & assess compliance with the noise limits for a ca
ine, and provide design advice if compliance with the limits is considered unlike

notes that the main purpose of the procedure is to set out the noise data r
ubsequent analysis needed to allow a decision maker to make an informed dec
ompliance with ETSU-R-97.

gement

ce has shown time and time again that engagement of all of the relevant
makers, developer and local residents) at an early stage of a project and cont
gagement throughout the project is desirable.

nd noise level measurements in particular can be an area of considerable
agreement on the number and position of background noise level measu
should be sought. However, it is also recognised that the decision makers ha
s which need to be prioritised to where they are most needed, and may not
to respond. Engagement should be viewed as an ongoing process.

ckground Data Collection

ing for Background Noise Surveys

-97 considers turbine noise levels from the proposed, consented and existi
)at any property below 35 dB L_{A90} at up to 10 m/s wind speed (10 metre stand
ed) to be acceptable, so 'study areas' for background noise surveys (an
ent) tend to use this as a benchmark. However, when establishing the baselin
there should be no influence from any existing turbines.

ction of monitoring locations is not a straightforward process, and requires a nu
be taken into account, such as the presence of atypical noise sources, acc
oxy sites, and capturing the range of different climates around the wind farm s
cludes that '*the background noise monitoring locations within the study area sh
on the basis of professional judgment, with the objective of collecting sufficient
e background noise levels at each noise-sensitive receptor within the study are
rised*'. Decision makers can help with this process, but as a minimum sh
of the measurement plans to avoid later debate. A well constructed and docu
ethodology is vital to reduce uncertainties in the assessment process.

ng of surveys

current state of the art. Whilst most other surveys would avoid windy situatio
ry to consider measurements in high wind conditions for a wind turbine, and the
hat an enhanced microphone windscreen be used. The GPG notes that s
lds of a diameter of less than 100 mm cannot be relied upon to provide s
of wind noise in most circumstances.

g Noise Measurement Equipment

ement of the equipment is also a critical part of the methodology. ETSU-R-97
ments be made in amenity areas between 3.5 and 20 metres from a dwelling,
current good practice. The measurement position should permit measure
nd noise levels judged to be typical/indicative of the area around the ass
and any other dwellings for which the measurement location will serve as a pro
of noise from local sources should be taken into account when s
ment locations.

also notes that the person selecting background noise monitoring positio
hese locations should record subjective impressions of sources contributing
noise levels, and that residents should be consulted to establish the occurr
noise events during the monitoring period. Photographs showing the posi
g equipment are also required.

Speed & Rain Measurement

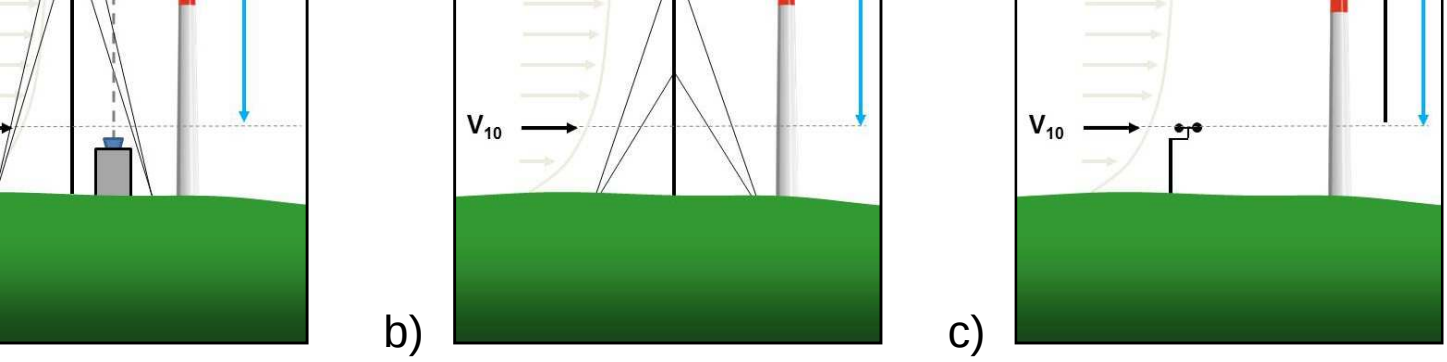
considers that three methods of wind speed measurement may be adopted:

irect measurements at hub height using either:
A met mast carrying one or more anemometer(s) at the proposed turbine hub h
A SODAR or LIDAR system (installed in a suitable location) to determine hu
wind speed directly, or at the two nearest heights to allow hub-height wind s
be derived using an exponential profile.

met mast lower than hub height, but carrying anemometers at two different
ese are then used to calculate the hub height wind speed, using an exponentia
meaningful extrapolation should be undertaken, and this would be achieved
per anemometer (2) being at a height not less than 60% of the hub heigh
oposed turbine and the lower anemometer (1) at least 15 metres below it. With
quirements, the two measurement heights closest to the hub height should be u

met mast carrying anemometer(s) at a height of 10 metres (with wind
rrections to be determined).

a) and b) are preferred. Method c) is only advised if the other methods
in terms of costs. Figure 1 illustrates the different wind speed measurement m
they relate to “standardised” wind speed. The figure shows mast-based and



– schematic representation of the methods used for estimating hub heig during background surveys, which are then standardised (blue arrow) t n case (c), an estimate of the corresponding hub height wind speed is eff for calculating the required corrections (as illustrated).

ing rain gauge should be deployed (or other methods can be used with care) to ta affected by rainfall.

hronisation of Noise, Wind and Rainfall Measurements

notes that measurement intervals for wind speed, noise level and rainfall sh ised to within (at most) one minute over the survey period. Logging devices r time references and the logging protocol may apply a time marker at either the a measurement interval. Such differences must be taken into accou isation of rainfall measurements is less critical.

tions of Surveys

ey duration is determined entirely by the requirement to collect sufficient va adequate range of wind speeds. For pitch-regulated turbines, data should co wind speeds between cut-in and the speed at which maximum sound power . This is an important distinction from the original ETSU-R-97 statement that d up to 12 m/s, as most modern machines reach their maximum sound power c ind speed, and some sites do not exhibit regular wind speeds above 12m/s.

deline, the GPG considered that no fewer than 200 valid data points be reco he amenity hours and night time periods, with no fewer than 5 valid data point nd speed bin. In specific cases where background noise levels are dependent and data is to be 'filtered' into two or more datasets then a minimum of 100 va d 3 valid data points per 1 m/s bin in each data set may be adequate.

a Analysis and Noise Limit Derivation

Filtering

-97 requires that a number of filtering processes are undertaken before the win ground noise relationship can be derived. The first is temporal. ETSU-R- s Amenity Hours (defined as 18:00 – 23:00 hrs Monday – Sunday, 13:00

ation of Wind Speed & Background Noise Plots

-97 states that noise levels should be plotted against wind speed to determ
g background noise levels at a measurement position. The order of regression
near to fourth order) will depend upon the nature of the noise environment. Dir
of prevailing background noise levels may be necessary in specific circums
wind farm is located upwind of a receptor but a significant contributor
nd noise environment is downwind of the receptor in the same wind conditions

rmining the ETSU-R-97 Limit

plete ETSU-R-97 noise limit for each property is obtained from a combinatio
e fixed limit and the derived relative limit (prevailing background curve + 5 d
nity noise limits have been set in ETSU-R-97 on the basis of protecting the am
whilst outside their dwellings in garden areas. The daytime amenity noise li
n two parts: Part 1 is a simple relationship between the prevailing backgroun
h wind speed) with an allowance of +5 dB; Part 2 is a fixed limit during periods
-97 describes three criteria to consider when determining the fixed part of the
of 35 dB to 40 dB L_{A90}, all of which should be considered. They are:

number of noise-affected properties;
potential impact on the power output of the wind farm; and
likely duration and level of exposure.

nale for a choice of this limit, or factors which would assist the determining aut
ect should be set out in the assessment. It is beneficial to the decision maker to
of limits to illustrate the range available and/or the noise limit for the develop
reviously. The GPG does not consider these areas further as the consensus w
ultimately a material planning consideration, and therefore outside the t
.

-97 indicates that for the protection of sleep of occupants within buildings an
level of 43 dB L_{A90} is appropriate when background noise levels are low
nd noise levels are sufficiently high, then the noise limits are set to the pr
nd + 5 dB, in the same manner as that used for the Amenity Hours.

se Predictions

ctions

-97 does not describe a method to predict the immission levels at the
al properties resulting from the operation of the wind farm, but clearly, estimate
se impact at the nearest receptors are required in any planning situation, and th
le and robust. The general study of outdoor noise propagation has received ex
in the past, but there has also been additional research undertaken specificall

ome of this research has demonstrated that the ISO 9613-2 standard in pa widely used in the UK, can be applied to obtain realistic predictions of noise f nd turbines during worst case propagation conditions (i.e. sound speed gradie wind conditions or temperature inversions), but only provided that the app f input parameters and correction factors are made. In particular, the use factor should be avoided, and the full theoretical effects of terrain screening will hieved.

also recognises that the choices which are made in the calculation para for the prediction calculation can have a significant bearing on the outcome lead to unrealistic estimates. In addition, as not all wind turbine sound power le d in the same manner, care needs to be exercised before any calculations d. The choices which are made in the calculation parameters adopted n calculation should be clearly outlined and detailed in any noise assessment be reviewed by any assessor.

notes that whilst some of the source documents for sound power levels tial, numerical values of the source data should be clearly set out in any asse good practice to reference the data sources used, and that predictions sh octave band frequency data whenever available.

rvation in ETSU-R-97 that L_{A90} levels should be determined from calculated L_{A} ction of 2 dB is still considered to be valid. Current good practice is that tona farms are generally best dealt with through a suitable planning condition, since lable information derived using IEC 61400-11 does not apply at typical se s.

, whilst the ISO 9613-2 standard is currently regarded as good practice, a nu eed to be used to ensure a realistic estimate of immission level can be obtain es that:

ation 9 of the standard should be used to calculate ground effects; if no repres ctral data can be obtained, A_{gr} = -3 dB should be used and the air absorpt responding to the 250 Hz octave band;
round factor of G=1 should not be used;
h the exception of propagation over large bodies of water or in urban are ommended to use a ground factor of G=0.5, in combination with emission leve ude a margin of uncertainty;
ceiver height of 4.0 m, and atmospheric conditions of 10°C and 70% humidity used.
ographic screening effects of the terrain (ISO 9613-2, Equation 12) should be reduction of no more than 2 dB, and then only if there is no direct line ween the highest point on the turbine rotor and the receiver location.
rther correction of +3 dB should be added to the calculated overall A-weight

lative issues

-97 states at page 58, *"…absolute noise limits and margins above backgroun the cumulative effect of all wind turbines in the area which contribute to th at the properties in question…*" During scoping of a new wind farm developm tes that consideration should be given to cumulative noise impacts from any oth the locality. If the proposed wind farm produces noise levels within 10 dB wind farm/s at the same receptor location, then a cumulative noise impact asse sary. Equally, in such cases where noise from the proposed wind farm is prec greater than that from the existing wind farm (but compliant with ETSU-R-9 t), then a cumulative noise impact assessment would not be necessary.

esence of an existing wind farm, the GPG considers that suitable backgroun n be derived by one of the following methods:

tching off the existing wind farm during the background noise level surve ociated significant cost implications);
ounting for the contribution of the existing wind farm in the measurement d ctional filtering (only including background data when it is not influenced ting turbines e.g. upwind of the receptor, but mindful of other extraneou rces e.g. motorways) or subtracting a prediction of noise from the existing wi the measured noise levels;
sing an agreed proxy location removed from the area acoustically affected ting wind farm/s; or
sing background noise level data as presented within the Environmental Stat the original wind farm/s (the suitability of the background noise level data sh blished).

sly presented background noise level data is to be used, care should also b ect to any differences in wind speed conditions between the original and pr underlying principle of ETSU-R-97 requires that the background noise levels ation must be correlated with the wind speeds measured on the wind farm Where a systematic difference exists between the wind conditions on the tw rrection will need to be applied, meaning that the derived background noise cu ites will be different.

r a cumulative situation is encountered, the noise limits for an individual wi e determined in such a way that no cumulative excess of the total ETSU-R-9 ld occur.

goes on to consider a number of methods to be used when considering cu which include strategic planning, negotiation, and cumulative noise limits. S is in use in parts of the UK, but the jury is out on how effective this is in re ve issues. Negotiation is rare, and is more likely seen through acquisitions rath

o deal with excessive amplitude modulation was found, but it is hoped that this in the near future.

r of additional aspects or descriptive guidance were considered as part of the ot fit with the need to keep the GPG to the key points, and it was felt that this c h more effectively in Supplementary Guidance Notes. These should be pu he time this paper is presented in Denver and will give additional guidance , data processing, sound power data, wind shear, post-completion measureme wind.

mmendations for Future Research

king group are considering a number of issues where future research is ne ur understanding of wind turbine noise assessment. These could include:

- More evaluation of wind shields to establish suitable designs to limit wind ef the microphone;
- The effects of wind shear variations on background noise measurements;
- An investigation of the proposed planning condition to deal with excess ar modulation for the Denbrook site in the UK (May 2013);
- A UK-based dose response study.

ideration of the Noise Limits

idered by many acousticians in the UK that the increased fixed night time limit ytime one is open to question, and that whilst most sites are constrained by t, some developers are now designing sites to take advantage of the high at night. Few would argue that this is what the original authors of ETSU-R .

PG launch meeting in Bristol in May 2013, a show of hands revealed th s were in favour of the IOA considering the issue of the ETSU-R-97 noise lim a number of the responses received to the GPG consultation. The IOA will n this matter further before deciding what action (if any) to take, although as y a matter for Government, a considered response will be needed.

clusions

has published a Good Practice Guide to supplement the use of ETSU-R-97 in sessing wind turbine noise. It is a significant step forward for the industry, and w ng field. However, it still leaves a number of questions unanswered, particularly t and assess excessive amplitude modulation that will require further resea ent. The GPG will need revisiting when significant advancements in good urred.

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nd Turbine Noise 2009 Conference, Aalborg Denmark, June 2009.
and J. Cooper, Comparison of predicted and measured wind farm noise levels
ns for assessments of new wind farms, Proceedings of ACOUSTICS 2011, 2-4
r 2011, Gold Coast, Australia (The Australian Acoustical Society).