YG-DCO-043-5.3.14G

Yorkshire Green Energy Enablement (GREEN) Project

Volume 5

Document 5.3.14G ES Chapter 14 Appendix 14G - National Grid Technical Report TR(E)564 (2021)

Final Issue A

November 2022

Planning Inspectorate Reference: EN020024

Infrastructure Planning (Applications: Prescribed Forms and Procedure) Regulations 2009 Regulation 5(2)(a)

nationalgrid

DEVELOPMENT OF METHOD FOR ASSESSING THE IMPACT OF NOISE FROM OVERHEAD LINES (NEW BUILD, RECONDUCTORING, DIVERSION AND UPRATING)

This document is for internal use only.

TABLE OF CONTENTS

PURPOSE AND SCOPE

This report documents the need for a clear policy stance on acceptable noise levels from overhead lines and explains how those noise levels, which are presented in PS(T)134[1] were developed.

There are currently no European or UK national noise limits which have to be met. Acceptable noise levels have to be developed by policy makers for different noise generating uses. National Grid Electricity Transmission (NGET) has not had a firm, documented policy stance on acceptable noise levels from overhead lines. Historically, noise criteria have been developed on a project specific basis for Development Consent Order (DCO) applications, but no such criteria existed for internal overhead line (OHL) noise assessments. This has led to a lack of consistency in terms of acceptable noise levels and the standard of noise mitigation required across different overhead line schemes.

[1] Operational audible noise policy for overhead lines (new build, reconductoring, diversion and uprating).

A firm policy stance is required to ensure a clear, consistent approach across schemes, an efficient use of funds for noise mitigation, to provide a clear audit trail regarding our decision-making process and to ensure our decisions are defendable.

PART 1 – WHY NOISE CRITERIA ARE REQUIRED

1 OVERVIEW

Overhead transmission lines can produce audible noise in operation during both dry and wet weather conditions. The noise can be annoying, disturbing and intrusive for people nearby.

As a socially and environmentally responsible business, National Grid is committed to the protection and enhancement of the environment and communities in which we operate. Our aim is to minimise the impact of noise pollution from our overhead lines on noise sensitive receptors (NSR's).

We also have a responsibility to ensure we do not cause a Statutory Noise Nuisance under the Environmental Protection Act 1990. Additionally, where Planning or Development Consent is required for a project, we have to predict and document the impact of noise from the operation of the overhead line on NSR's.

Whilst there are no fixed noise limits laid down by law, government noise policy requires that significant adverse impacts on health and quality of life are avoided and adverse impacts on health and quality of life are mitigated and minimised. The approach to the assessment of noise from our OHL's has been developed taking account of this government policy context.

2 OVERHEAD LINE NOISE

Overhead transmission lines can produce audible noise in operation during both dry and wet weather conditions.

Noise which occurs during dry weather conditions is referred to as 'Dry Noise' and can be described as a crackle. Conductor system noise is caused by corona discharge activity. Most transmission line conductors are designed to operate below the threshold for corona discharge activity, and so usually operate quietly in dry weather conditions. However, small areas of surface contamination on conductors can lead to a local enhancement of electrical stress and cause corona discharge and hence noise to occur.

Noise which occurs during wet weather conditions is referred to as 'Wet Noise' and can be described as a crackle, which is sometimes accompanied by a hum, which usually occurs at 100Hz and may be accompanied by harmonics, typically at 200Hz, 300Hz, or 400 Hz. The highest noise levels generated by an overhead line generally occur during rainfall. Water droplets may accumulate on the surface of the conductor and initiate multiple corona discharges. The number of droplets, and hence the noise level, will depend primarily on the rate of rainfall. Fog may also give rise to increased noise levels, although these levels are less than those during rain. Historical studies determined that hum inception typically occurs at a rainfall rate of approximately 1mm/hr[2]. Noise generated under these circumstances is referred to as 'wet noise'.

3 UK NOISE POLICY

The UK Policy context is very clear that significant adverse impacts on health and quality of life should be avoided and adverse impacts on health and quality of life should be mitigated and minimised.

[2] Studies at Bramley referenced in TR(T)94 'A method for assessing the community response to overhead line noise'.

Noise Policy Statement for England[3] (NPSE)

The NPSE sets out the long-term vision of Government noise policy. The aims of the policy are to:

- Avoid significant adverse impacts on health and quality of life,
- Mitigate and minimise adverse impacts on health and quality of life and,
- Where possible, contribute to the improvement of health and quality of life.

National Planning Policy Framework[4] (NPPF)

The NPPF sets out the Government's planning policies for England. The NPPF states that planning policies and decisions should:

- Avoid noise giving rise to significant adverse impacts on health and quality of life as a result of new development;
- Mitigate and reduce to a minimum, potential adverse impacts on health and quality of life arising from noise from new development; and
- Identify and protect areas of tranquillity which have remained relatively undisturbed by noise and are prized for their recreational and amenity value for this reason.

National Policy Statement EN-1[5] (NPS EN-1)

NPS EN-1 sets out national policy (England and Wales) for energy infrastructure where development consent is sought under the Planning Act 2008. EN-1 states that the Infrastructure Planning Commission should not grant development consent unless it is satisfied that the proposal will:

- Avoid significant adverse impacts on health and quality of life from noise;
- Mitigate and minimize other adverse impacts on health and quality of life from noise; and
- Where possible, contribute to improvements to health and quality of life through effective management and control of noise.

4 GUIDANCE DOCUMENTS

In addition to the UK policy context, other documents offer guidance on the approach to noise assessment and on threshold levels, above which noise can impact on health and quality of life.

The World Health Organisation (WHO) Guidelines[6] set out guideline values for the onset of health effects from noise exposure. They offer little guidance on acceptable noise levels where the noise contains a large proportion of low frequency components typical of overhead line hum in wet weather conditions, simply stating that application of a lower guideline value is recommended.

[3] 'Noise Policy Statement for England', Department for Environment Food and Rural Affairs, March 2010
[4] 'National Planning Policy Framework', Department for Communities and Local Government, March 2012
[5] EN-1 'Overarching National Policy Statement for Energy', Department of Energy and Climate Change, July 2011
[6] 'Guidelines for Community Noise', World Health Organisation, 1999

The Night Noise Guidelines for Europe[7] document observed effect threshold levels for noise at night (based mainly on evidence relating to traffic noise), this being the level of noise above which an effect starts to occur. Such effects include impacts on sleep quality, wellbeing and specific medical conditions.

BS 8233[8] sets out internal noise criteria for bedrooms during the day and night and for living and dining rooms during the day; the standard also sets out external noise criteria for gardens. The noise criteria presented in BS 8233 are based on the guidance contained in the WHO Guidelines and therefore offer little guidance in relation to low frequency noise, other than to state that lower limits might be appropriate.

ProPG: Planning & Noise[9] provides guidance on a recommended approach to the management of noise within the planning system in England. It aims to encourage better acoustic design for new residential development and to protect people from the harmful effects of noise. It sets out internal noise criteria for bedrooms during the day and night and for living and dining rooms during the day.

Under Part III of the Environmental Protection Act 1990[10], noise emitted from a premises, which is prejudicial to health or a nuisance, can be declared a Statutory Nuisance. In such circumstances, a Local Authority can serve an Abatement Notice on the responsible party. Failure to comply with the Notice is a criminal offence and could lead to prosecution and costly mitigation actions.

BS 4142[11] sets out a method for assessing the impact of sound from a proposed new noise source on residential premises. The standard also offers guidance on the application of a decibel penalty where the noise has a distinguishing character, such as if the noise is tonal, impulsive, intermittent or has other distinguishing features.

These guidance documents have been used to aid the formulation of an approach to assessing the impact of noise from OHL's and in the development of noise criteria to uphold the current UK Noise Policy requirements.

5 EVIDENCE FOR HEALTH EFFECTS

The NPSE introduces the concepts of the No Observed Effect Level (NOEL), the Lowest Observed Adverse Effect Level (LOAEL) and the Significant Observed Adverse Effect Level (SOAEL) with regard to noise. The NOEL is defined as the level below which no effect can be detected, below this level there is no detectable effect on health and quality of life. The LOAEL is defined as the level above which adverse effects on health and quality of life can be detected. The SOAEL is defined as the level above which significant adverse effects on health and quality of life occur and is likely to be different for different noise sources and receptors and at different times of day.

The guidance in the NPSE aids the interpretation of evidence relating to health impacts due to noise and what may constitute an adverse and a significant adverse impact.

[7] Night Noise Guidelines for Europe, World Health Organisation, 2009

[8] BS 8233: 2014 'Guidance on sound insulation and noise reduction for buildings', British Standards Institution, February 2014

[9] ProPG: Planning & Noise, Professional Practice Guidance on Planning and Noise, New Residential Development, May 2017

[10] Environmental Protection Act 1990

[11] BS 4142:2014+A1:2019 'Methods for rating and assessing industrial and commercial sound', British Standards Institution, June 2019

Health and Quality of Life

UK Policy requires that significant adverse impacts on health and quality of life are avoided and adverse impacts on health and quality of life are mitigated and minimised.

The WHO defines 'health' as a state of complete physical, mental and social well-being. In the NPSE, 'quality of life' is a subjective measure that refers to peoples emotional, social and physical well-being and 'health' refers to physical and mental well-being. The NPSE recognises that noise exposure can cause annoyance and sleep disturbance, both of which impact on quality of life, it is also agreed by experts that annoyance and sleep disturbance can give rise to adverse health effects.

WHO Guidelines for Community Noise

The WHO Guidelines, published in 1999, are noise levels which correspond to the onset of health effects from noise exposure. The noise levels vary depending on the nature of the NSR, time of day, noise indices used and whether the level applies internally or externally.

The levels are set at the lowest level of noise that affects health (critical health effect) i.e. the LOAEL.

The WHO Guidelines state that low frequency noise is likely to lead to more severe health effects than community noise in general. Consequently, for low frequency noise (such as wet weather hum), the WHO recommends values even lower than the guideline values. The WHO does not however give advice on how much lower they should be set.

The WHO Guidelines recommend 5dB lower daytime noise levels for vulnerable subgroups (Hospitals and pre-schools) when compared to residential properties.

The WHO Guidelines specify an $L_{Aeq,8hour}$ (23:00 to 07:00) outside bedrooms of residential properties of 45dBA as being the Critical Heath Effect Level i.e. the LOAEL. The WHO Guidelines provide Critical Health Effect Levels for many other uses and times of day, including, outdoor living areas, schools, pre-schools, playgrounds, hospitals and industrial/commercial type uses. A list of WHO Guideline levels are presented in Appendix A.

Night Noise Guidelines for Europe (NNGE)

The NNGE were published by the WHO in 2009. They are an extension to, and update of, the WHO Guidelines for Community Noise. The NNGE document reviews the epidemiological and experimental studies into health effects of night time noise exposure, it examines exposure-effects relationships and presents health-based guideline values to prevent harmful effects of night noise in Europe. The values from the NNGE are summarised in Table 1.

The NNGE are based on observed effect threshold levels i.e. the level above which effects start to occur. The majority of research evaluated in the NNGE and on which the guideline values are based relates to traffic noise data.

The NNGE give details of a range of effects on health and quality of life, such as biological effects, effects on sleep quality, well-being and medical effects of exposure to night noise and the level of noise at which those corresponding effects occur.

Table 1: NNGE Effects of different levels of night noise on the population's health[12]

Average night noise level over a year $L_{night,outside}$	Health effects observed in population
Up to 30dB	Up to this level no substantial biological effects are observed. $L_{night,outside}$ of 30dB is equivalent to the NOEL for night noise.
30 to 40dB	A number of effects on sleep are observed. The intensity of effect depends on the nature of the source and number of events. Vulnerable subgroups (e.g. children, chronically ill and elderly) are more susceptible. However, even in the worst cases the effects seem modest. $L_{night,outside}$ of 40dB is equivalent to the LOAEL for night noise.
40 to 55dB	Adverse health effects are observed. Many people have to adapt their lives to cope with the noise. Vulnerable subgroups are more severely affected.
Above 55dB	Increasingly dangerous for public health. Adverse health effects occur frequently. A sizeable proportion of the population is highly annoyed and sleep-disturbed. There is evidence that the risk of cardiovascular disease increases.

BS 8233: Guidance on sound insulation and noise reduction for buildings

BS 8233 outlines internal night time noise criteria in bedrooms of 30dB $L_{Aeq,8\ hour}$. Assuming 15dB attenuation for an open window would result in an external level of 45dB $L_{Aeq,8\ hour}$ which correlates with the WHO Guidelines for community noise on which BS 8233 is based. BS 8233 states that where the noise has strong low-frequency content (such as wet weather hum), lower noise limits might be more appropriate, no guidance is given on how much lower. A list of BS 8233 levels are presented in Appendix A.

ProPG: Planning & Noise

The ProPG states that an external Night time LAeq,8hour of less than 40dB is equivalent to no adverse effect, whilst as the noise increases above 40dB there is an increasing risk of an adverse effect. This correlates with the NNGE. The ProPG recommends internal noise levels based on BS 8233 and states a lower level may be required for low frequency noise but no guidance is given on how much lower.

Dominant industrial/commercial noise is out of scope, but where this type of noise isn't dominant, the guidance can be applied. A list of the ProPG levels are presented in Appendix A.

BS 4142 Methods for Rating and Assessing Industrial and Commercial Sound

BS 4142 compares the existing background L_{A90} in the area to the Rating Noise Level (noise of the sound source plus any correction for the character of the noise). The standard states:

[12] The SOAEL is not defined in Table 1 as the SOAEL is a concept developed for the NPSE to be the level above which significant adverse impacts occur. It is not a concept that is adopted by the WHO.

a) Typically, the greater the difference, the greater the magnitude of the impact.

b) A difference of around +10dB or more is likely to be an indication of a significant adverse impact, depending on the context.

c) A difference of around +5dB is likely to be an indication of an adverse impact, depending on the context.

d) The lower the rating level is relative to the measured background sound level, the less likely it is that the specific sound source will have an adverse impact or significant adverse impact. Where the rating level does not exceed the background sound level, this is an indication of the specific sound source having a low impact, depending on the context.

National Grid Technical Report TR(T)94[13]

TR(T)94 presents a method to assess the potential effects of dry and wet noise from new overhead lines. TR(T)94 does not set specific noise assessment criteria; instead it refers to BS4142:1990 and the subjective response of communities and individuals to changes in noise levels.

PART 2 – SETTING CRITERIA

6 OVERVIEW

The evidence outlined in Part 1, Section 5 and Appendix A of this report has been used in conjunction with the UK policy stance to develop acceptable noise levels for noise from OHL's. The noise criteria developed apply only to new build, reconductoring, diversion and uprating projects as to apply them to existing OHL's would not be practicable. Complaints about noise from existing OHL's are to be dealt with on a case by case basis.

The NPSE states there is a need to integrate consideration of the economic and social benefit of the activity or policy under examination with proper consideration of the adverse environmental effects, including the impact of noise on health and quality of life. When setting noise criteria, the economic and social benefit of electricity transmission and the key role our business plays in the functioning of society has been considered alongside the adverse effects of noise generated by our activities.

The night time period, when people are typically sleeping is the most sensitive period. The criteria have therefore been developed considering the health effects of night time noise. The exception to this is NSR use types that are not used at night, in which case the criteria have been developed considering daytime health impacts. The time of day or night is not a factor in how noisy an OHL is at any particular time. Therefore, if the noise from the OHL meets the criteria presented in PS(T)134 and TGN(E)322, which are based on the more sensitive night time period, then it will meet the criteria during both the day time and night time periods.

In setting the criteria, the evidence in Part 1, Section 5 and Appendix A of this report was analysed. Health effects were categorised in order of magnitude and corresponding noise levels documented for different NSR's. Evidence was considered in relation to the effect of noise being greater on vulnerable subgroups, in addition to evidence suggesting low frequency noise requires lower limits.

[13] Technical Report TR(T)94 'A method for assessing the community response to overhead line noise'. Issue 1 October 1993 (Withdrawn and superseded by PS(T)134, TGN(E)322 and TR(E)564)

7 DISCUSSION

There are two main approaches to the setting of noise criteria, one being criteria relating to absolute noise levels and the other being criteria set relative to the existing background noise levels in the area. Each has benefits and draw backs.

Criteria relating to absolute noise levels set a clear cut off point above/below which a noise isn't/is acceptable. This has the benefit of applying the same criteria to all receptors in a category, thereby ensuring consistency of approach. It makes the noise assessment process more efficient and less time consuming than setting criteria relative to existing background levels. It has the drawback of applying the same approach regardless of existing noise levels in the area and may potentially underestimate the noise impact in areas with low background noise or overestimate the impact in areas with a high background noise level.

Criteria set relative to background take account of the existing noise climate in the area and how likely it is that a noise will cause an adverse impact. This has the benefit of tailoring the noise criteria to each individual receptor. It has the drawback of being time-consuming to undertake the assessment, has risks of lone working, may overestimate the impact in areas with low background noise levels and does not give clear direction to the business on acceptable levels of noise from OHL's.

To improve the efficiency of the noise assessment process and give clarity to the business on acceptable noise levels, applying criteria that relate to absolute noise levels is considered most appropriate. It is however possible that where predicted noise levels from an OHL exceed the absolute levels, the noise from the OHL may be acceptable depending on the existing background noise levels in the area compared to the predicted noise level from the OHL. For example, in a location close to a road with high levels of traffic noise, the noise from the road may mean the noise from the OHL is inaudible. It would be appropriate therefore where the absolute noise criteria are not met, to determine the impact of the predicted noise due to the OHL relative to existing background noise levels. This thought process led to the development of a three-tier assessment approach, whereby if the Tier 1 criteria are not met, a Tier 2 assessment is carried out and where the Tier 2 criteria are not met, a Tier 3 assessment is carried out.

8 CRITERIA FOR RESIDENTIAL PROPERTIES

The greatest amount of evidence into the impact of noise on health and quality of life relates to residential receptors. The criteria for residential properties applies to places where people sleep at night and includes residential schools.

The WHO Guidelines suggest an external night-time L_{Aeq} of 45dB being the onset for health effects and therefore the LOAEL for residential properties. BS 8233 and ProPG: Planning and Noise suggests an internal night-time L_{Aeq} of 30dB being the LOAEL for residential properties, which assuming an open window gives 15dB attenuation would equate to an external L_{Aeq} of 45dB. The NNGE however suggest an external night time L_{Aeq} of 40dB as being the LOAEL for residential properties. Given the wealth of evidence on which the NNGE are based, 40dB is taken as the LOAEL for residential properties and the basis on which the OHL noise criteria have been developed. Given that this is an annual average, the absolute level can be exceeded at some points, under certain conditions, for example in wet weather conditions.

The evidence on which the NNGE 40dB L_{Aeq} figure was derived related mainly to traffic noise data. Traffic noise is considered anonymous and therefore less annoying and less noticeable than noise with distinctive character or regarded as having 'ownership', such as that generated by OHL's. In dry weather OHL's can crackle and in wet weather they can also hum. It was considered appropriate therefore to set the LOAEL at an even lower level. Most guideline documents recommend lower guideline levels for low frequency noise, but do not offer guidance on how much lower. BS 4142 offers clear guidance on penalties to apply where noise is tonal or has distinguishing features.

For tonal noise, BS 4142 recommends applying character corrections ranging from 2dB to 6dB depending on how perceptible the tone is, or is predicted to be, at the NSR. As a worst case, a penalty of 6dB has been applied to the NNGE of 40dB, giving an acceptable wet noise limit of less than 34dB. This is a worst-case approach because the tonal hum may not be clearly perceptible at the receptor and tonal hum may not be present for the full duration that rainfall occurs.

BS 4142 recommends a penalty of 3dB where the noise is neither tonal, nor intermittent, though otherwise readily distinctive against the residual acoustic environment. Dry noise crackle can be considered to fall into this category and so as a worst case, a penalty of 3dB has been applied to the NNGE of 40dB, giving an acceptable dry noise limit of less than 37dB. This is a worst-case approach because dry noise may not be present all the time.

The NNGE document evidence relating to the levels of noise that cause adverse impacts on health and therefore can equate to being above the LOAEL and in some cases above the SOAEL. The NNGE state that adverse effects on health are observed at noise levels between 40 to 55dB and above 55dB adverse effects occur frequently. Between 40 to 50dB the evidence for adverse health effects is considered sufficient, whilst above 50dB the evidence is limited. Consequently, for the purposes of setting criteria for OHL noise, adverse impacts on health and quality of life are considered to occur between 40 to 50dB, as sufficient evidence for this exists, and significant adverse impacts are considered to occur above 50dB, as the weight of evidence is limited for levels above 55dB. This is a cautious approach. Applying the penalties described above leads to adverse impacts for wet noise between 34 and 44dB and for dry noise between 37 and 47dB. Significant adverse impacts due to wet noise occur above 44dB and for dry noise above 47dB.

Where the absolute noise level criteria set out above are not met, it is necessary to understand how the predicted wet and dry noise levels compare to the existing background noise levels with and without noise from rainfall. The higher the existing background noise level, the lesser the impact of the noise from the OHL. Where background noise levels are high enough, the noise from the OHL is unlikely to have an adverse impact. It is therefore important to consider the absolute levels in the context of the existing noise climate.

BS 4142 advises on the likelihood of a noise causing a significant adverse and an adverse impact. The impact of dry and wet noise on residential properties is in line with the guidance in BS 4142 (wet noise accounts for an increase in background noise due to rainfall) , such that a difference in the rating level compared to the background sound level of +10dB or more is likely to be an indication of a significant adverse impact (depending on the context), a difference of +5dB to +9dB is an indication of an adverse impact, a difference of 0 to +4dB is an indication of a minor impact and a difference <0dB is an indication of a low impact. Consequently, for the purposes of setting criteria for OHL noise, a difference of +10dB is a significant adverse impact, a difference of +5 to +9dB is an adverse impact, a difference of 0 to +4dB may be acceptable depending on context and a difference <0dB is no adverse impact.

9 CRITERIA FOR VULNERABLE SUBGROUPS

Evidence suggests that vulnerable subgroups, such as patients in hospitals and children at pre-schools are more susceptible to health effects due to exposure to noise. The NNGE suggests a LOAEL of 40dB but recognises that vulnerable subgroups are more susceptible to noise than the general population. For the purposes of setting criteria for OHL noise, the criteria developed for residential receivers have been lowered by 5dB, resulting in a 29dB criteria for wet noise and a 32dB criteria for dry noise. Given that the NNGE suggest that even in the worst cases, the effects of night noise ranging from 30-40dB seem modest, the 29dB and 32dB criteria should adequately protect vulnerable subgroups and is considered a cautious approach.

The 5dB reduction has also been applied to the adverse impact criteria, resulting in adverse impacts for wet noise from 29 to 39dB and for dry noise from 32 to 42dB. Similarly, the significant adverse impact criteria have also been reduced, resulting in significant adverse impacts for wet noise above 39dB and for dry noise above 42dB.

As for residential properties, if the absolute noise level criteria are not met, it is necessary to understand how the predicted wet and dry noise levels compare to the existing background noise levels with and without noise from rainfall.

BS4142 was developed for residential properties. However, it can be applied to vulnerable subgroups who can also expect suitable conditions for sleep and rest. It also enables a determination of the impact of the OHL noise relative to the existing background noise levels. Where background noise levels are high, the impact of noise from the OHL will be lower. Guidance suggests vulnerable subgroups are more susceptible to noise and therefore the criteria developed for residential receivers have been lowered by 5dB.

Consequently, for the purposes of setting criteria for OHL noise, a difference of +10dB is a significant adverse impact, a difference of +5 to +9dB is also a significant adverse impact, a difference of 0 to +4dB is an adverse impact and a difference <0dB is no adverse impact.

10 CRITERIA FOR SCHOOLS

The WHO Guidelines state that for schools an indoor L_{Aeq} of 35dB is the onset for effects in relation to speech intelligibility. There is some debate as to whether a partially open window offers 10 or 15dB attenuation. If we assume the worst case, that the level of attenuation is only 10dB, this would equate to an external level of 45dB (but could be as high as 50dB if we assume 15dB attenuation). This would equate to the LOAEL and is considered a cautious approach.

Applying the same penalties of 6dB for wet noise and 3dB for dry noise and taking a very conservative approach assuming 10dB attenuation for an open window gives a LOAEL of 39dB for wet noise and 42dB for dry noise. Below these levels the noise is acceptable. The adverse impact criteria, where there may be impacts on speech intelligibility are set between 39 to 49dB for wet noise and 42 to 52dB for dry noise.

The significant adverse impact criteria are set above 49dB for wet noise and above 52dB for dry noise. Above these levels there is likely to be an adverse effect on speech intelligibility, which could impact on education and is also likely to cause annoyance during playtimes.

As for residential properties and vulnerable subgroups, if the absolute noise level criteria are not met, it is necessary to understand how the predicted wet and dry noise levels compare to the existing background noise levels with and without noise from rainfall. BS4142 was developed for the purposes of assessing sound at dwellings or premises used for residential purposes. However, where the absolute noise criteria are exceeded, it can be used to predict how prevalent the noise from the OHL will be compared to existing background noise levels. Where background noise levels are high, the impact of noise from the OHL will be lower than the absolute predicted noise levels suggest.

The criteria are the same as for residential properties, however, as schools operate during daytime periods, the relevant background noise levels against which to assess the impact of OHL noise are daytime noise levels[14], not night time (as is the case for residential properties).

[14] Some schools may operate during the evening. BS4142 defines the daytime periods as 07:00 to 23:00 hours, allowing flexibility to use professional judgement to choose the relevant time of day to determine existing background noise levels.

11 CRITERIA FOR HOTLES

Hotels are considered noise sensitive as they are places where people sleep. They are however less sensitive than residential properties as they are not permanent residences and people would only typically stay for a few nights. Consequently, the long-term health impact data in the WHO Guidelines and NNGE are less applicable than for residential properties. The risk of short-term sleep disturbance and hence annoyance and complaints are more applicable to this use type.

The WHO Guidelines state that for residential properties an $L_{Aeq,\ 8\ hour}$ of 45dB is the onset for health effects. Applying the same penalties of 6dB for wet noise and 3dB for dry noise, gives a LOAEL of 39dB for wet noise and 42dB for dry noise. Below these levels the noise is acceptable. This is a conservative approach given that hotels are not permanent residences.

The WHO guidelines state that for residential properties, there is evidence for cardiovascular disease above an $L_{Aeq,\ 8\ hour}$ of 50dB. This evidence is based on long term exposure and a few nights spent in a hotel would not lead to these effects. These noise levels could however cause awakenings and therefore annoyance and complaints. As such they correlate with adverse impacts. Applying the penalties for wet and dry noise leads to adverse impact criteria of 44dB for wet noise and 47dB for dry noise.

The WHO Guidelines state that for residential properties, health effects occur frequently and a large proportion of the population are annoyed or sleep disturbed above an $L_{Aeq,\ 8\ hour}$ of 55dB. These noise levels are likely to cause awakenings and therefore annoyance and complaints and should be avoided. Applying the penalties for wet and dry noise leads to significant adverse impact criteria of 49dB for wet noise and 52dB for dry noise.

As for residential properties and vulnerable subgroups, if the absolute noise level criteria are not met, it is necessary to understand how the predicted wet and dry noise levels compare to the existing background noise levels with and without noise from rainfall. Where the absolute noise criteria are exceeded, BS4142 can be used to predict how prevalent the noise from the OHL will be compared to existing background noise levels. Where background noise levels are high, the impact of noise from the OHL will be lower than the absolute predicted noise levels suggest.

PART 3 – PRACTICAL APPLICATION OF NOISE CRITERIA

12 OHL VOLTAGE

Noise criteria apply to 275 and 400kV OHL's. Historically 132kV OHL's have been described as practically quiet. Noise modelling in EFC400 using the smallest single conductor (Horse) that could theoretically be strung on L4 and L7 towers confirms this to be the case. In reality, the use of a such a small conductor would not be practical and hence this is a worst-case example assessment. The modelling demonstrates that the noise from this worse case 132kV OHL design would fall into the No Adverse Impact category and therefore noise from 132kV OHL's will always be deemed to be acceptable.

13 TIERED ASSESSMENT APPROACH

To enable an efficient assessment method, a tiered approach to the noise assessment has been developed. The three-tier approach comprises the following steps:

Tier 1: A primary screening step based on 'worst-case' wet noise effects and the pre-determined assessment criteria in Table 1.

Tier 2: A further screening step based on combined wet noise and dry noise effects and, if required, recalculated assessment criteria.

Tier 3: Full assessment following the principles of BS 4142:2014 for both wet and dry noise.

This approach screens out of further assessment, receptors where there would be no adverse impact, ensuring complex noise modelling and background noise measurements are only undertaken where necessary. This reduces the number of properties requiring detailed assessment.

Tier 1

The tiered assessment approach firstly considers wet noise only because this is a worst-case assessment. If the noise criteria are met, no further assessment is necessary, as noise in dry weather conditions will also meet the criteria.

Tier 2

Where the criteria are exceeded, further assessment is necessary because in reality, wet noise will not occur all the time. A more realistic assessment would account for the duration of wet and dry weather and hence account for wet and dry noise in combination. This forms the basis of the Tier 2 assessment, whereby the duration of wet and dry weather is determined to enable the combined wet and dry level noise level to be calculated. The combined wet and dry noise criteria may also need to be recalculated again because wet noise does not occur all the time.

Tier 3

Where the noise levels fail the absolute noise criteria laid down in the Tier 1 and Tier 2 criteria, it is important to consider the predicted noise level relative to the existing background noise. Simply because the absolute criteria are exceeded, does not mean the noise is causing an adverse or significant adverse impact, as the existing background noise level may already exceed the predicted level of noise from the OHL. Consequently, it's essential to understand how the predicted noise level from the OHL compares against the exiting noise climate. The context in which the noise occurs may affect the acceptability of the noise impact and also needs to be considered.

14 DEVELOPMENT CONSENT ORDER

Development Consent Order (DCO) applications require an Environmental Impact Assessment (EIA) to be carried out. The reporting of the noise impact for an EIA differs from the method of reporting for internal noise assessments and local authority planning applications.

DCO projects require the sensitivity of NSR's to be defined, along with the predicted magnitude of the noise impact at each NSR, to give an overall significance of effect. The significance of effect determines whether, in EIA terms, the predicted impact is significant.

Major adverse effects, which correspond to significant adverse impacts are deemed to be significant for the purposes of DCO/EIA noise assessments and should therefore be avoided.

15 EFC400 OUTPUTS

EFC400 is a software tool which can be used to predict noise from OHL's. EFC400 produces an annual average sound pressure level equivalent to an L_{Aeq} for both wet and dry noise and has 12 different noise calculation methods built in. The outputs of each of these 12 methods has been analysed and compared to the outputs of National Grid's DOS based OHL noise prediction tool.

One of the EFC400 inbuilt calculation tools (F9 EPRI in EFC400) is an EPRI method, the theory of which is documented in clear detail in the EPRI Red book. The method is combined in EFC400 with ISO 9613, which takes account of propagation of noise outdoors and also allows the rainfall rate to be adjusted manually. The method predicts the level of OHL noise with an accuracy of +/- 1dB and the predicted noise levels correlate very well (within ~1dB) with the current National Grid method.

The EFC400 software has capabilities beyond those we currently have for modelling noise from OHL's. All input and output parameters are clearly documented and there is less chance of errors being introduced as there is no requirement to transfer data between software packages. The use of this method (F9 EPRI Method in EFC400) is more transparent and defendable than the current National Grid method and is an improved approach to OHL noise assessment.

EFC400 can be used to produce generic data for noise levels at set distances from OHL's. Generic 'look up' data has been produced for each Type Registered OHL configuration. Generic data has been produced for a straight section of OHL, as well as a curved section of OHL. NSR's on the inside of a bend are closer to more than one conductor span and hence noise levels are higher on the inside of a bend and lower on the outside of a bend. The 'Look up' tables give a quick, high level overview of the noise level at set distances from the OHL and can therefore be used to inform noise assessments.

EFC400 can also be used for detailed noise modelling. The specific OHL design can be loaded into the model, along with OS map and terrain data to give detailed, design specific outputs for individual NSR's. Detailed modelling may be used where a NSR is on the edge of a Noise Impact Category or where the nature of the assessment requires detailed analysis of individual NSR, for example, DCO applications.

PART 4 – COMPARISON WITH PREVIOUS APPROACH TO OHL NOISE ASSESSMENT

16 OVERVIEW

Previously, noise criteria only existed for DCO applications and each of these were developed on a project specific basis, taking account of the UK policy context in place at the time when the DCO application was made. Previous DCO criteria, compared to the new criteria are shown in Table 2. In-house noise assessments were undertaken based on operational experience, rather than strictly applied criteria, leading to a lack of clarity and consistency. The new approach to OHL noise assessment will apply to all projects, whether DCO or in-house, leading to a clear and consistent approach.

17 DCO APPLICATIONS

In the context of DCO applications, previously there was no absolute maximum cut off noise level above which the noise was unacceptable. Major adverse effects, which were deemed to occur where the rating noise level exceeded the existing background noise level with or without noise from rain by +5dB or more, were deemed significant. Whilst we would attempt to mitigate the effect of such an impact, there was no policy stance to say this should be avoided. The new policy stance states that significant adverse impacts should be avoided and therefore effectivity sets a maximum limit, which essentially equates to a rating level ≥+10dB. This is a key difference between the previous and new approach.

At the lower ends of the noise criteria, we have previously applied a backstop, whereby background noise levels were set as a minimum of 30dB. The resulting effect of this being that the method potentially underestimated the impact of noise in areas with background noise levels lower than 30dB. In other cases, we assessed against a measured background

level, which could have been considerably lower than 30dB and may have overestimated the impact of noise from the OHL. We also set criteria whereby a Major adverse effect was deemed to occur where the rating level was greater than or equal to 35dB and the difference between the background noise level and the rating level was greater than or equal to +5dB. This therefore took account of the absolute level of noise being important, as well as the difference between the rating level and background noise level. The new approach does not apply those backstops.

The previous assessment method looked at wet noise and dry noise separately. Where wet noise dictated the outcome of the assessment, the duration of wet noise was referenced. As wet noise occurs for a small proportion of time, the impact of wet noise was considered of short duration and therefore of a lesser impact than the assessment outcome suggested. When measured background noise levels were used in the assessment and those background levels were particularly low, dry noise often dictated the outcome of the assessment. Whilst the dry noise absolute levels could have been relatively low, the outcome of the assessment may have suggested a significant adverse effect due to a large difference between the measured background noise level and predicted level of noise from the OHL, which has to assume a level of contamination on the conductors. This may have resulted in an over estimation of the impact. The new approach will more accurately reflect noise levels due to both dry and wet noise combined and is therefore a better reflection of the predicted scenario. In addition, the assessment criteria are directly linked to the current UK policy position. It is therefore considered to be more robust that the previous method.

Table 2: Comparison between previous assessment methods and the newly developed approach[15]

Effect	Previous Criteria (Richborough & Hinkley)[16]	Previous Criteria (North Wales)	New Criteria
Major Adverse	≥+5dB Assessment level	≥35dB Rating level and ≥+5dB Assessment level	≥44dB SPL and ≥+10dB Assessment Level
Moderate Adverse	0 to +5dB Assessment level	<35dB Rating level and ≥+5dB Assessment level	34 to 44dB SPL and +5 to +9dB Assessment Level
Minor Adverse	0 to -5dB Assessment level	0 to -5dB Assessment level	<34dB SPL and 0 to +4dB Assessment Level
Negligible	-5 to -10dB Assessment level	-5 to -10dB Assessment level	<34dB SPL and <0dB Assessment Level
No Effect	<-10dB Assessment Level	<-10dB Assessment Level	<34dB SPL and <0dB Assessment Level

[15] The new Tier 2 criteria are not included in Table 2 as they have to be calculated on an individual basis, however they will not be more than 3dB higher than the Tier 1 sound pressure level (SPL)
[16] Assessed against a 30dB minimum background noise level.

PART 5 - DEFINITIONS AND DOCUMENT HISTORY

18 FORMS AND RECORDS

Not applicable.

19 DEFINITIONS

Not applicable.

20 AMENDMENTS RECORD

Issue	Date	Summary of Changes / Reasons	Author(s)	Approved By (Inc. Job Title)
1	February 2021	New report	Janine Dickinson Senior Environmental Engineer	Jemma Spencer Environmental Engineering Manager

21 IMPLEMENTATION

Audience Awareness

Audience	Purpose Compliance (C) / Awareness (A)	Notification Method Memo / letter / fax / email / team brief / other (specify)
Environmental Engineering	A	Email

PART 6 - GUIDANCE NOTES AND APPENDICES

APPENDIX A – SUMMARY OF EVIDENCE FOR EFFECTS DUE TO NOISE

Noise level (dB)	Indicator	Time period	Night/ day	Health Effect	Source	Where	NOEL/ LOAEL/ SOAEL	Notes*^
30	$L_{Aeq, indoor}$	8 hr	Night	Sleep disturbance	WHO Guidelines	Residential	LOAEL	Values for onset of health effects. Tonal noise requires a lower value. Covers vulnerable people. Sleep disturbance.
30	$L_{Aeq, indoor}$	8 hr & 16 hr	Day & Night	Sleep	WHO Guidelines	Hospitals	LOAEL	Values for onset of health effects. Sleep disturbance day and night.
30	$L_{Aeq, indoor}$	Sleeping time	Day	Sleep	WHO Guidelines	Pre-school bedrooms	LOAEL	Values for onset of health effects.
30	$L_{Aeq, indoor}$	8 hr	Night	Sleep	BS8233	Bedroom	LOAEL	May be relaxed by 5dB and reasonable internal conditions still achieved. Design target for new build.
30	$L_{Aeq, indoor}$	8 hr	Night	Sleep	ProPG: Planning and Noise	Bedroom	LOAEL	Based on BS8233
35	$L_{Aeq, indoor}$	16 hr	Day	Resting	WHO Guidelines	Bedroom/ Living room	LOAEL	Values for onset of health effects. Speech intelligibility & moderate annoyance
35	$L_{Aeq, indoor}$	16 hr	Day	Resting	BS8233	Bedroom/ Living room	LOAEL	May be relaxed by 5dB and reasonable internal conditions still achieved. Design target for new build.
35	$L_{Aeq, indoor}$	16 hr	Day	Resting	ProPG: Planning and Noise	Bedroom/ Living room	LOAEL	Based on BS8233
35	$L_{Aeq, indoor}$	School hours	Day	Speech Intelligibility	WHO Guidelines	Schools	LOAEL	Speech Intelligibility

70	$L_{Aeq,\ indoor\ \&\ outdoor}$	24 hr	Day & Night	Hearing impairment	WHO Guidelines	Anywhere e.g. industrial, commercial, shopping area	SOAEL	Sufficient Evidence. This will protect the public, including most vulnerable subgroups e.g. children, chronically ill and elderly from adverse health effects.
<40	$L_{Aeq,\ outdoor}$	8 hr	Night	Sleep disturbance	ProPG: Planning and Noise	Residential	NOEL	No adverse effect
40	$L_{Aeq,\ outdoors}$	8 hr	Night	Sleep disturbance	Night Noise Guidelines for Europe	Residential	LOAEL	Effects on sleep observed. Vulnerable subgroups more susceptible. However even in worst cases the effects seem modest.
45	$L_{Aeq,\ outdoors}$	8 hr	Night	Sleep disturbance	WHO Guidelines	Residential	LOAEL	Values for onset of health effects. Tonal noise requires a lower value. Covers vulnerable people. Sleep disturbance.
50	$L_{night,\ outside}$	8 hr	Night	Hypertension (high blood pressure)	Night Noise Guidelines for Europe	Residential	SOAEL	Limited Evidence
50	$L_{night,\ outside}$	8 hr	Night	Heart attack	Night Noise Guidelines for Europe	Residential	SOAEL	Limited Evidence
50	$L_{Aeq,\ outdoors}$	16 hr	Day	Moderate annoyance	WHO Guidelines	Outdoor Living area	LOAEL	Values for onset of health effects.
55	$L_{Aeq,\ outdoors}$	16 hr	Day	Serious annoyance	WHO Guidelines	Outdoor Living area	SOAEL	Values for onset of health effects.
55	$L_{Aeq,\ outdoors}$	Playtime	Day	Annoyance	WHO Guidelines	School or playground	LOAEL	Values for onset of health effects.
60	$L_{night,\ outside}$	8 hr	Night	Psychiatric disorders	Night Noise Guidelines for Europe	Residential	SOAEL	Limited Evidence
40-55	$L_{night,\ outside}$	8 hr	Night	Adverse health effects	Night Noise Guidelines for Europe	Residential	LOAEL-SOAEL	Adverse health effects observed. People have to adapt lives to cope.

>55	$L_{night, outside}$	8 hr	Night	Frequent adverse health effects	Night Noise Guidelines for Europe	Residential	SOAEL	Adverse health effects occur frequently. Large proportion of population annoyed or sleep disturbed. Evidence that risk of cardiovascular disease increases.
0	Rating Level		Day/ Night	Low impact	BS4142**	Residential	NOEL-LOAEL	Low impact
+5	Rating Level		Day/ Night	Adverse	BS4142**	Residential	LOAEL-SOAEL	Adverse
+10	Rating Level		Day/ Night	Significant adverse	BS4142**	Residential	SOAEL	Significant adverse

* In all cases the guidance recommends even lower levels for tonal noise

^ Most guidance documents recommend 10 to 15dB attenuation for an open window

** +2dB penalty for tonal noise that's just perceptible, +4dB clearly perceptible and +6dB highly perceptible. +3dB penalty for distinctive noise (not tonal).

National Grid plc
National Grid House,
Warwick Technology Park,
Gallows Hill, Warwick.
CV34 6DA United Kingdom

Registered in England and Wales
No. 4031152