ACOUSTICS AND OVERHEATING- WHERE NEXT?

Colin Cobbing Acoustic Facades Limited and Pinnacle Acoustic Consultants Limited
Dani Fiumicelli Technical Director at Vanguardia

1 PURPOSE

There are a range of factors that affect health and comfort inside dwellings. These include:

- Acoustics
- Natural daylight
- Ventilation
- Thermal comfort (cooling in summer months)
- Indoor air quality
- Safety and security
- Privacy

Good acoustic design does not mean good acoustics. Good acoustic design means holistic design where all the factors affecting health and quality of life and sustainability are optimised as far as possible.

This paper focusses on the interaction between acoustics and overheating.
We discuss the regulatory pressure to tackle the problem of overheating in new development and how the current guidance might change to encourage better design.

2 BACKGROUND

The ProPG, now referenced in the National Planning Practice Guidance, was produced to provide practitioners with guidance on a recommended holistic approach to the management of noise within the planning system in England. It encourages good acoustic design for new residential development and aims to protect people from the harmful effects of noise.

"Good acoustic design is not just compliance with recommended internal and external noise exposure standards. Good acoustic design should provide an integrated solution whereby the optimum acoustic outcome is achieved, without design compromises that will adversely affect living conditions and the quality of life of the inhabitants or other sustainable design objectives and requirements." (ProPG, paragraph 2.21)
i.e. an holistic design process.

ProPG recommends that internal noise guidelines should be achieved as far as possible with windows open and that different design options should be considered. At paragraph 2.21 it states:

"Using fixed unopenable glazing for sound insulation purposes is generally unsatisfactory and should be avoided; occupants generally prefer the ability to have control over the internal environment using openable windows, even if the acoustic conditions would be considered unsatisfactory when open. Solely relying on sound insulation of the building envelope to achieve acceptable acoustic conditions in new residential development, when other methods could reduce the need for this approach, is not regarded as good acoustic design."

Paragraphs 2.34 and 2.36 provide further guidance on ventilation and overheating.
"Where the LPA accepts that there is a justification that the internal target noise levels can only be practically achieved with windows closed, which may be the case in urban areas and at sites adjacent to transportation noise sources, special care must be taken to design the accommodation so that it provides good standards of acoustics, ventilation and thermal comfort without unduly compromising other aspects of the living environment." (Paragraph 2.34)

Paragraph 2.36: *"[where a] scheme is reliant on open windows to mitigate overheating, itis also necessary to consider the potential noise impact during the overheating condition. In this case a more detailed assessment of the potential impact on occupants should be provided in the ADS [Acoustic Design Statement*]".

The overarching aspiration of good acoustic design is that where practicable residents may open windows without any adverse acoustic impact (ProPG para. 2.33); and that use of the building envelope with windows closed, in conjunction with alternative means of ventilation and control of overheating, is only used after reasonably practicable good acoustic design measures have been exhausted. For example, the ProPG [Note 4 to Figure 2] states that

"*designing the site layout and the dwellings so that the internal target levels can be achieved with open windows in as many properties as possible demonstrates good acoustic design. Where it is not possible to meet target internal levels with windows open, internal noise levels can be assessed with windows closed…*".

The AVO Guide provides a practical method to address these requirements noted in the ProPG.

The AVO Guide postdates and references the ProPG and makes is plain that AVOG should be applied after good acoustic design principles have been applied. For example. Paragraph 1.26 states:

"*The starting position when considering mitigation of noise impact on new residential development is to apply good acoustic design, site-wide, as described in the ProPG*."

Essentially the advice of the AVOG applies when despite considering the holistic application of reasonably practicable design measures, it is not possible to fully optimize the design and a balance needs to be struck between acoustics and overheating.

Both the AVOG and the ProPG advocate a systematic, proportionate, risk based, 2-stage, approach.

The ProPG advises that Stage 1 is an initial noise risk assessment of the proposed development site; and Stage 2 sets out a systematic consideration of four key elements for higher noise exposure sites. Where Stage 2 is applicable it leads to recommendations for the decision maker. In simple terms the choice of recommendation is as follows: grant without conditions, grant with conditions, "avoid" or "prevent"

In the case of environmental noise ingress, the AVOG also describes a two-level assessment procedure for the overheating condition. The first level is a site risk assessment based on external noise levels and the assumption that opening windows are the primary means of mitigating overheating. The second level assessment considers the potential for adverse effect on occupants based on internal ambient noise level. The Level 2 assessment is recommended for 'High' risk sites. For 'Low' and 'Medium' risk sites, a Level 2 assessment can optionally be undertaken to give more confidence regarding the suitability of internal noise conditions. This may be particularly appropriate for sites in the 'Medium' risk category.

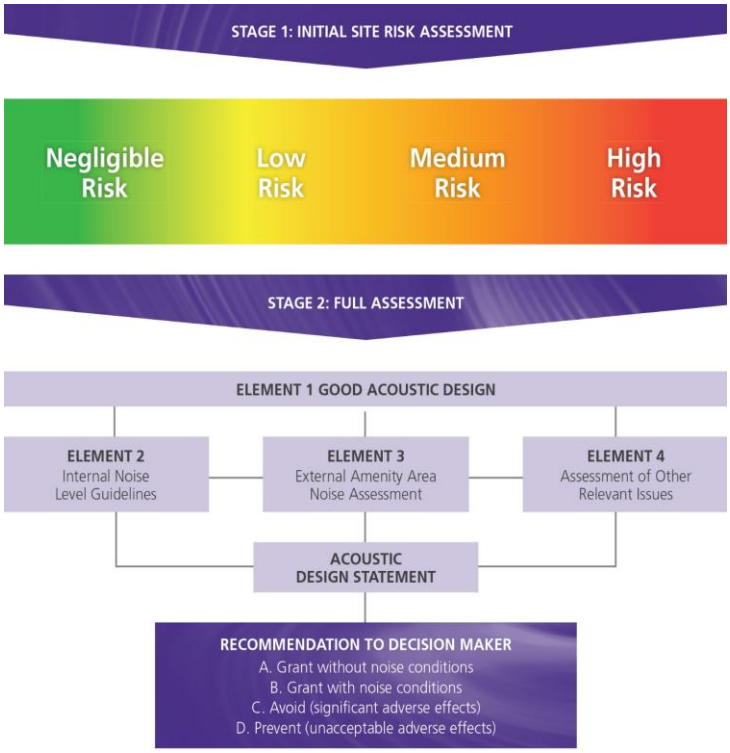
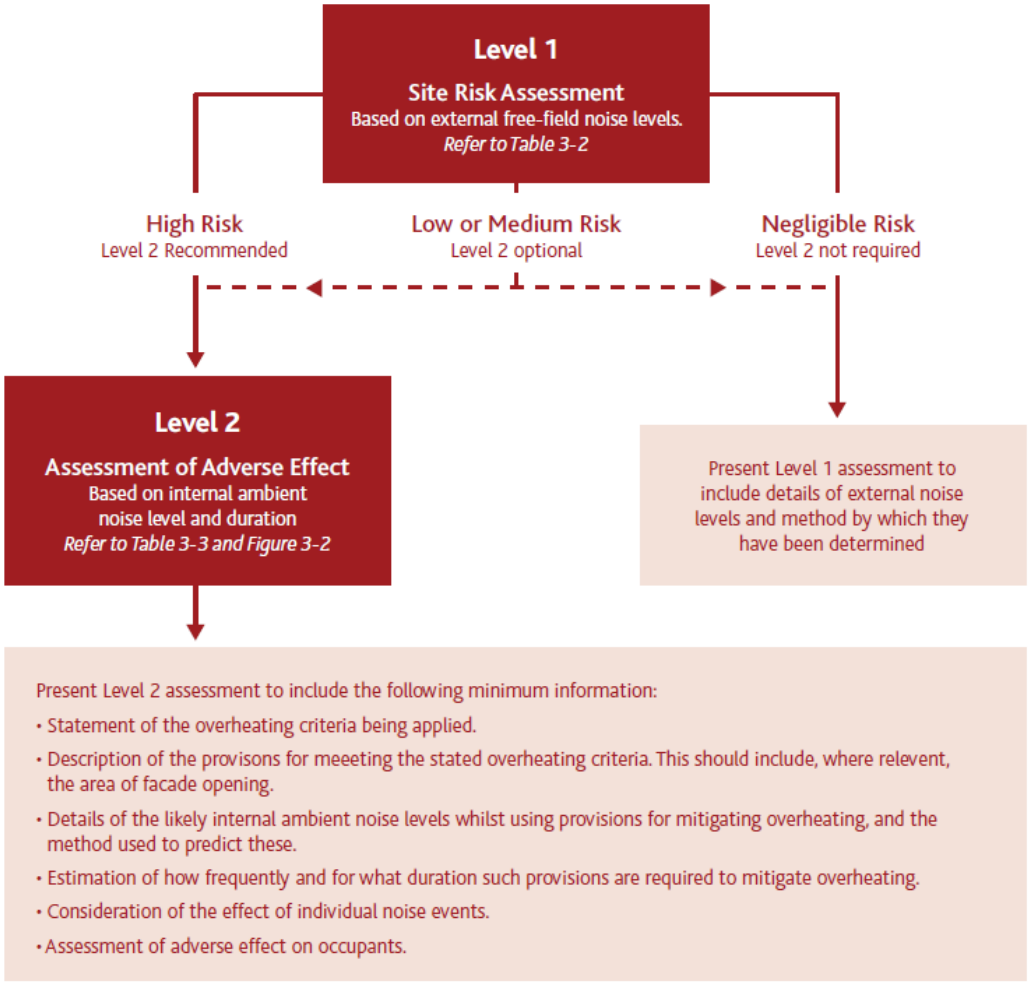


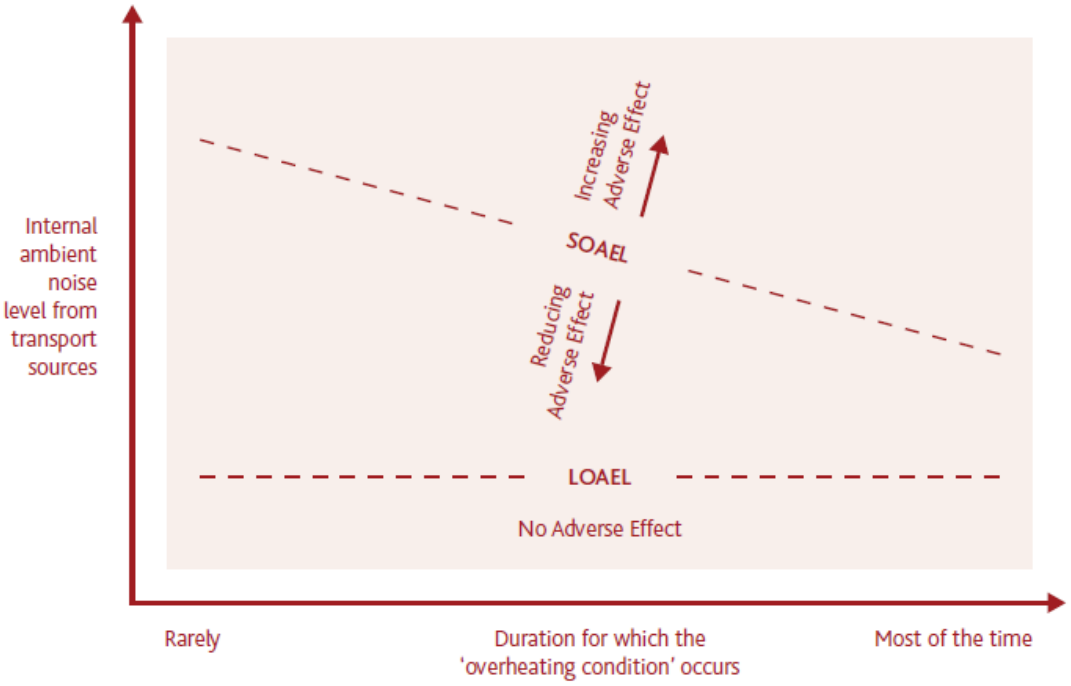
Figure 4 Summary of overall ProPG approach

Figure 3-1 Two-level noise assessment procedure - overheating condition



The Level 2 assessment suggests that assessment of the adverse effect from noise exposure should include an estimate of how frequently and for what duration the overheating condition occurs. The Level 2 assessment provides qualitative guidance to apply a sliding scale for acceptable levels of internal noise based upon the frequency and duration over which the overheating condition occurs (see figure 3-2 reproduced from AVOG).

Figure 3-2 Qualitative guidance on combined effect of internal ambient noise level and duration for the overheating situation



The sponsors of the ProPG i.e. the IOA, ANC and CIEH have recognised that there is potential for inconsistency between the guidance of the ProPG and the advice of the AVOG. They are currently drafting a joint statement recognising this and reinforcing that the ProPG comes before the AVOG in the hierarchy of design. The sponsor organisations intend working together to create a smoother and clear pathway for the documents to dovetail together. This may entail either or both documents being revised.

3 MHCLG CONSULTATION ON THE OVERHEATING APPROVED DOCUMENT

It is likely that the ProPG and AVOG will need to be updated to reflect the outcome of the MCHLG consultation on the Overheating Approved Document [x] (2021).

The MHCLG consultation proposed several passive design solutions to control indoor temperatures during summer months. The passive measures included:

- fixed shading devices;
- glazing design, including limiting glazing ratios, increasing the solar control glazing specifications (g-values);
- building design, for example the **placement of balconies for shading**;
- Shade of adjacent permanent buildings, structures or landscape.

Excess heat should be removed through any of the following:

- opening windows, made more effective by cross-ventilation;
- ventilation louvres in external walls; and
- mechanical ventilation system.

It is hoped that the proposals to minimise heat generation indoors and minimise solar gain during the summer will be adopted.

Amongst other things, the MHCLG consultation suggested that a modified version of TM59 be used to assess and control overheating. It is important to recognise that TM59 considers overheating in isolation and provides pass/ fail criteria for thermal comfort. There is no mechanism to relax the criteria for overheating to allow a balance between overheating and noise.

There is little evidence to suggest that it is appropriate to treat overheating as the overarching priority and that the noise standards should be relaxed during overheating conditions. Our view is that proper consideration should be given to relaxing the noise and overheating criteria so as to achieve an optimum balance, where such a balance is necessary. It should not be one or the other. It is hoped that the proposals to use the strict TM59 pass/ fail criteria will be modified, in accordance with the CIEH recommendations, to allow for more balance between acoustics and overheating in areas of medium and high exposures to noise.

4 OPTIMISATION OF DESIGN FOR INTERNAL ACOUSTICS AND OVERHEATING

In relation to passive design the AVOG provides helpful guidance on the importance of early design considerations to minimise overheating. It advises that:

"In accordance with sustainable design and construction principles, development proposals should, amongst other things, maximise opportunities to orientate buildings and streets to minimise summer and maximise winter solar gains; use trees and other shading; increase green areas in the envelope of a building, including its roof and environs; and maximise natural ventilation. These sustainable design principles mirror good acoustic design as described in the ProPG."

This advice is useful and emphasises the need to consider the application at the earliest possible stage.

Innovative façade designs can also be used to control noise entering dwellings and minimise summer solar gains.

It is well established that balconies can provide effective shading to windows in order to minimise solar gain during the summer months. Balconies can also be used to provide acoustic screening. The AVOG suggest that acoustic balconies can offer improvements in the range of 4-10 dB relative to a standard open window, providing a similar amount of ventilation.

Acoustic Facades Limited are developing a box window system for different sources of noise. In the absence of balconies on the façade, the openings in the outer window are configured according to the orientation of the source. The Sky window is configured for aircraft noise and the City window for roads, railways, industry and other sources located at the surface.

Laboratory tests have shown that the windows can achieve an Rw of up to 46dB. Field tests are needed to establish the additional attenuation expected from directivity losses.

There is a trade-off between the effective area and the amount of air flow across the windows and the level of noise attenuation they provide. The windows can be configured to provide higher effective areas and lower noise attenuation to meet specific project requirements.

The windows also be specifically configured when used in combination with acoustic balconies, to maximise screening to the opening of the outer window. For example, if the source of noise is

located below the height of the parapet, the opening in the outer window can be located at the bottom of the window to maximise screening from the parapet itself. If the source of noise is from an overflying aircraft, the opening in the outer window can be located at the head of the window to maximise screening from the soffit of the balcony located above.

There is no reason why acoustic balconies cannot achieve levels of attenuation at the higher end of the range quoted in the AVOG. As such, when combined with an acoustic balcony the City and Sky windows can potentially be used to achieve good or reasonable internal noise conditions in most of the noise exposure situations encountered in the UK.

This demonstrates that façade solutions can be used to optimise acoustics and overheating. It is recommended therefore that optimisation of acoustics and overheating is always considered first and foremost. Balance should only be considered after optimisation method have been explored and incorporated into the design as far as possible.

City window viewed from the inside

Sky window viewed from the inside

5 FACTORS AFFECTING OCCUPANCY BEHAVIOUR TO OPEN WINDOWS

Both the ProPG and AVOG recommend that noise should be assessed with windows open if there is a risk of overheating and the overheating design strategy relies on windows being open to control indoor temperatures. But it is important to recognise that overheating is just one of a number of reasons why people might choose to open their windows.

The windows open/ closed question was considered by the WHO in the Night Noise Guidelines (NNG). They refer to studies conducted by Passchier-Vermeer et al. in 2002 which carried out detailed noise measurements inside and outside the bedroom and at the same time measured window position with sensors. The results showed that windows were fully closed only during 25% of the nights.

It was stressed that this figure should only apply to facades that have not been fitted with special appliances to reduce noise impact. For example, rooms equipped with air conditioning so that windows can stay closed or could even be sealed.

It is unfortunate that we have little robust information on the occupation of new dwellings and the incidence of when windows are open over a year. In the absence of better data, it is recommended that the information reported in the NNG is used to consider the duration of windows open/ closed over a typical annual period. The noise assessment should not assume that windows are only opened when overheating occurs.

6 ASSESSMENT OF LMAX LEVELS

The ProPG internal noise guidelines work perfectly well, and we do not see any reason to revise them. It is hoped that the ProPG and the AVOG are revised so that the internal noise guidelines are a fully aligned.

It is recommended that the ProPG would benefit if further guidance was provided on the assessment of $L_{AF,max}$ levels.

The ProPG provides recommended guidelines for the maximum internal level of noise from individual external noise events. In noise-sensitive rooms at night (e.g. bedrooms) individual noise events (from all sources) should not normally exceed 45dB $L_{AF,max}$ more than 10 times a night as this represents a threshold below which the effects of individual noise events on sleep can be regarded as negligible.

It also recommends that a more detailed site and scheme specific assessment of the potential impact on occupants should be undertaken where individual noise events are expected to exceed 45dB $L_{AF,max}$ more than 10 times a night.

Sleep disturbance studies conducted by Basner and others (2018) studied noise events free from the influence of other ambient noise according to the following criteria: (1) only events from the same noise source could occur one minute before (e.g., the end of a prior noise event) and 1.5 min after the start of the event and (2) sounds made by the subject such as turning over in bed were allowed before and during the noise event of interest as they could be reactions to the noise. Events defined as 'disturbed' consisted of those in which any other noise event occurred 60 s prior or up to 1.5 min after the start of the first (30 second) noise epoch[1].

A practical solution for the assessment of the $L_{AF,max}$ distribution over a night period could therefore be achieved if the $L_{AF,max}$ levels were established over different time intervals between 1 and 5 minutes. Further analysis and discussion is needed to decide which time period would be best. The $L_{AF,max}$ distributions so obtained could then be used to calculate the number of additional awakenings for a given $L_{AF,max}$ distribution over an 8 hour night period using the exposure response relationships provided by Basner and others. In addition, the number of additional noise

[1] Scoring of sleep stages is usually done on an epoch-by-epoch basis, with a 30-second length used as a standard. More information on objective sleep measurements can be found in the WHO Night Noise Guidelines Chapter 2.

induced EEG awakenings could be calculated using assumptions for windows open and closed over the period of a year. In this way the risk assessment on sleep could assess short-term effects as well as long-term chronic effects. Such an assessment could be linked to occupancy data for how often people open and close windows. The overheating assessment can then factor into this assessment but it should not be the only factor considered.

7 EVIDENCE LED AND HOLISTIC DESIGN

The ProPG encourages LPAs and developers to obtain post occupancy feedback from new residents on acoustic design issues for all new residential development that is permitted in circumstances where there is a potential risk of significant adverse effects arising from noise and that the lessons learned from such surveys should inform future good practice, including local and national plan making and decision-taking activities.

Any surveys should use validated questionnaires and instruments for measuring health and quality of life for a range of factors. A good example is the Building User Survey (BUS) platform.

We would recommend that sensors also be used to monitor indoor temperature and the proportion of time over a year when windows are open. This will provide robust data for future noise and overheating assessments.

8 REFERENCES

1> The ProPG: Planning & Noise- New Residential Development, May 2017. CIEH, IOA and the ANC. **https://www.ioa.org.uk/sites/default/fi les/14720%20ProPG%20Main%20Document.pdf**

2> The Acoustics Ventilation and Overheating Residential Design Guide, 2020. ANC and the IOA. **https://www.association-of-noise-consultants.co.uk/avog**

3> World Health Organisation Night Noise Guidelines for Europe (2009).

4> Basner M, Samuel A, and Iserman, U. (2006) Aircraft noise effects on sleep: application of the results of a large polysomnographic field study, Journal of the Acoustical Society of America, Volume 119, 5 (Part 1), p2772-84 (2006)

5> Basner M and McGuire S. (2018) WHO Environmental Noise Guidelines for the European Region: A Systematic Review on Environmental Noise and Effects on Sleep. Int. J. Environ. Res. Public Health 2018, 15, 519

6> CIBSE (2017) **TM59: Design Methodology for the assessment of overheating risk in homes.**

7> Consultation by the ministry of housing, communities & local government (2021) the future buildings standard **https://www.gov.uk/government/consultations/the-future-buildings-standard.**

8> CIEH response to the MHCLG consultation on the Future Buildings Standard (2021) - **https://www.cieh.org/media/5168/the-future-building-standard.pdf.**