Good Homes Alliance

OVERHEATING IN RETROFIT AND EXISTING HOMES

Tool and guidance to identify and mitigate overheating risks in retrofit and existing homes

September 2022

Rev 1

DISCLAIMER

This GHA Overheating Tool and Guidance is provided as general guidance. The information is intended to support decision-making and facilitate dialogue. Use of the tool and guidance does not guarantee that a home will not overheat, nor does it constitute legal advice or attempt to provide a legal interpretation of the relevant legislation.

ACKNOWLEDGEMENTS

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Project partners and steering group

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- Hayley Chivers, Sarah Wigglesworth Architects
- Paul Ciniglio, National Energy Foundation
- Rajat Gupta, Oxford Brookes University

- Dr Sarah Price, QODA Consulting
- Katharine Ray, Warwick District Council
- Sarah Wigglesworth, Sarah Wigglesworth Architects
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INTRODUCTION

There is growing evidence that UK homes are at risk of overheating, and that this will increase with climate change.

This tool and guidance is intended for use at the early stages of residential retrofit projects or on existing homes, in order to identify key factors contributing to overheating risk and possible mitigation measures. It is applicable to existing homes, retrofits, and conversions of non-domestic buildings to residential accommodation.

It is not meant to provide a detailed assessment, but instead to sit between high-level guidance, often aimed at policy makers, and detailed calculation and modelling tools, often aimed at architects and engineers. It should be used collaboratively to prompt dialogue between clients including housing associations, project teams and local authorities, with disciplines including architecture, building services, acoustics, and environmental health professionals, among others. Ideally, the process should include the residents, as occupancy patterns and behaviours are important factors for effective understanding and mitigation of overheating risk.

By comparison with the New Build version of the GHA Overheating Guidance & Tool, this Retrofit & Existing Homes version is more detailed, albeit still not a detailed design and modelling tool. This is for several reasons related to the nature of projects on existing homes:

- Options for interventions are more constrained, so maximising opportunities often means having to look at more detailed measures than in new buildings
- Projects are often smaller, with more detailed information looked at from earlier stages
- The characteristics and thermal performance of the stock are much more varied than in new homes, so factors which could be assumed and built into the New Build tool have to be assessed specifically for existing homes.

The tool is informed by existing guidance, literature and evidence, and feedback from occupied schemes. It covers early design decisions as well as site-related issues which can impact on overheating risk, such as noise levels, blue/green infrastructure or other site characteristics. It also includes consideration of occupancy patterns and behaviours; where these are not known, they can form part of sensitivity checks on the assessed risk level.

This guidance encourages early-stage decisions, and holistic consideration of overheating risk together with the site context and linked design issues such as ventilation and noise.

This guidance intends to be part of an evolution towards more comprehensive and holistic retrofit approaches as advocated by PAS 2035, by providing guidance for early design stages and linking through to detailed design and in-use stages. It is aimed at generalist stakeholders, including local authorities and housing associations, as well as more technical disciplines including architects, engineers and energy modellers.

Does retrofit increase the risk of overheating?

Best practice retrofit projects address building performance as a whole. It is important to consider the impact of the works on overheating risk not only through energy efficiency measures, but other interventions which may increase or reduce that risk, for example an extension which could create a highly glazed room or increase depth and limit air flow, or works to the façade which introduce better shading and more effective openings.

The review carried out to create this tool and guidance has found evidence that in some cases, energy efficiency measures may increase overheating by increasing the retention of heat inside the dwelling. However, this is usually only a problem if the dwelling is already overheating, due to much more significant factors such as excessive solar gains or insufficient ventilation: in those cases, a highly insulated and airtight envelope may exacerbate overheating, but it was not the original cause of it.

Importantly, retrofit projects also offer significant opportunities to improve conditions through better ventilation and control of solar gains, and reductions in uncontrolled heat gains from inefficient heating and hot water systems.

Why not just install cooling?

Relying on mechanical cooling should only be a last resort to address overheating risk, after passive measures have been explored. This is for a number of reasons:

- Resilience: Homes that rely on mechanical cooling solutions are more vulnerable to power failure or equipment breakdown
- Affordability: Some occupants may not have the means to run and/or maintain cooling systems, or to replace them at their end of life
- Carbon emissions: Mechanical cooling systems contribute to carbon emissions from energy use, and potentially from refrigerant leaks in operation or during installation, maintenance and at end of life
- Negative impact on surroundings: The heat rejected from mechanical cooling plant will increase the air temperature in the immediate surroundings. This could impact neighbouring properties (and is sometimes referred to as pollutant heat); heat rejection plant can also be noisy, which may deter residents of the home or of neighbouring properties from opening windows, further increasing their overheating risk. Finally, the plant may have a detrimental visual impact on the surroundings.

This guidance therefore seeks to remove, or significantly reduce the need for cooling; it should be used regardless of whether cooling may be installed in the future.

HOW TO USE THE TOOL

Overview

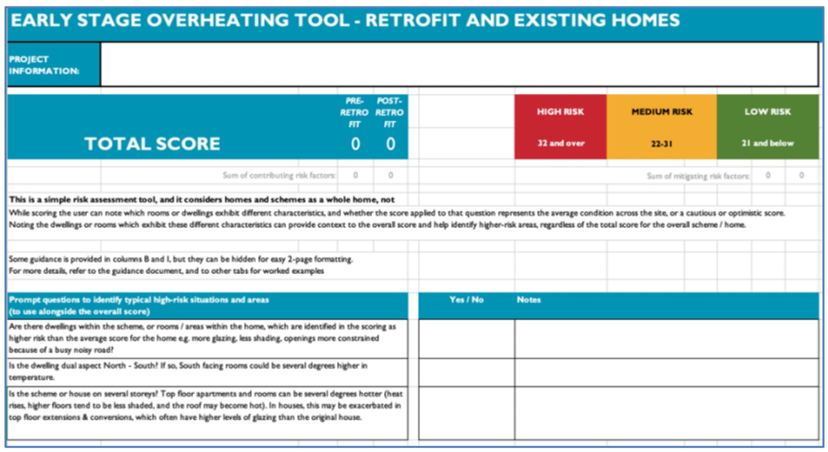
The tool itself is in 2 pages, plus an introduction page for project information and additional notes.

INTRODUCTION PAGE

Project information

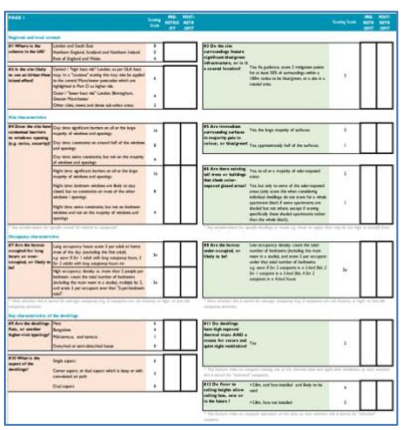
Risk score (the tool can display two scores e.g. pre & post retrofit, or 2 scores under different assumptions)

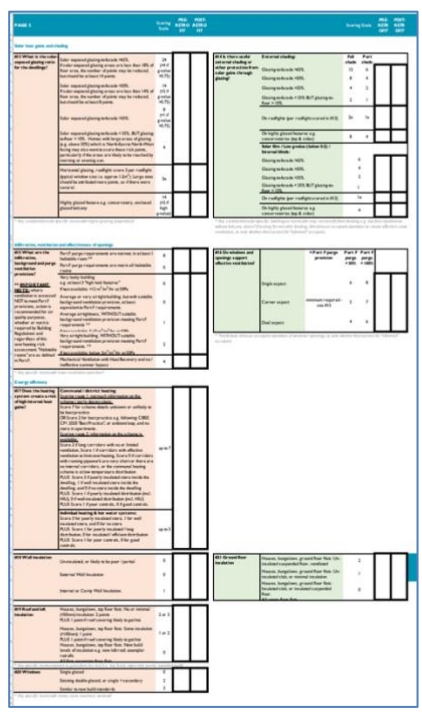
Prompt questions: This is a simple "whole scheme" tool, but these questions may indicate whether some areas or rooms could be more at risk.



Risk scale to gauge the score against

PAGE 1
Site location and context, Occupancy, Essential scheme characteristics





PAGE 2
Solar gains
Infiltration and ventilation
Energy efficiency (fabric and heating systems)

Figure 1: Overview of the overheating risk tool for existing homes and retrofits

The **WORKED EXAMPLES** illustrate the tool used in a range of schemes, from individual homes to larger residential schemes, whether existing homes or retrofit projects.

Page 1 provides the assessed risk score (pre and post-retrofit, if relevant). It also the users of the tool to include notes on the project if they wish, and to go through 3 simple prompt questions to interpret results and provide another angle to the risk assessment, particularly to help spot rooms / dwellings which may be more at risk than the overall home / scheme (see more details in **Variations across schemes**)

Page 2 is about:

- Site characteristics: these are unlikely to change through a project, except possibly in large and extensive projects where the landscaping may lead to changes in blue / green characteristics.
- Occupancy patterns and density: the tool can be used without these questions being scored, but this may be filled if occupancy is known or to carry out sensitivity checks on the results.
- General scheme and dwelling design characteristics, including typology and aspect. These are unlikely to change in most retrofit projects, though they may if there is extensive re-modelling.

Page 3 is about more detailed design characteristics related to solar gains, ventilation and energy efficiency (fabric and heating systems). This is where the majority of opportunities for intervention through retrofit lie.

A downloadable Excel version of the tool and worked examples is available to download for free here: https://kb.goodhomes.org.uk/tool/overheating-retrofit.

Mitigation measures may be needed to reduce the assessed risk, and/or detailed modelling to identify more detailed or complex measures - see **NEXT STEPS**. If the evaluation suggests significant overheating risk without a clear mitigation route, then a more detailed assessment following CIBSE TM59 is recommended.

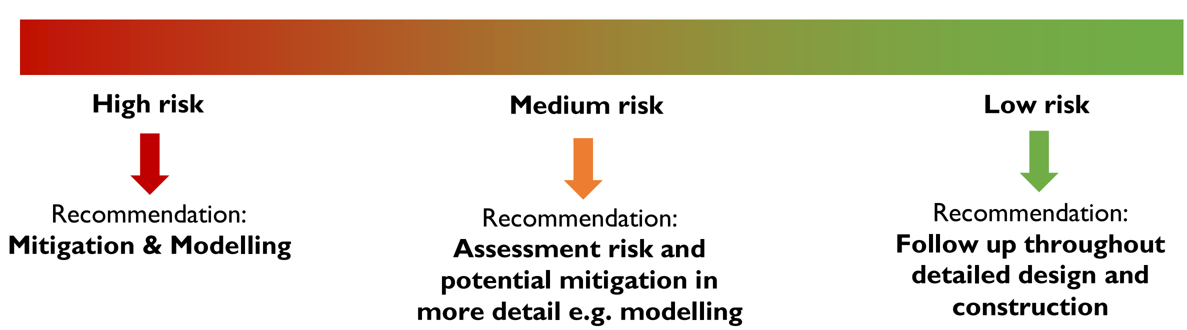


Figure 2: The tool is an initial risk assessment - what to do next depends on the risk category and project context. In all cases, it is useful to carry out some testing of the score under different assumptions e.g. if characteristics are not known for certain, or if they may change in the future (e.g. occupancy patterns), or vary across the building.

Scenario testing

The tool is intended as a "first filter" risk assessment, to guide the main design decisions. Once results are obtained, it is recommended to carry out some **scenario testing** of design options and assumptions, to improve the robustness of results e.g.:

- an **average** score first, for example to represent the majority of dwellings or the user's "best guess" about some of the home's characteristics
- a more **cautious** score e.g. identifying dwellings or rooms with specific characteristics or occupancy patterns, which may put them at a higher or lower risk of overheating.
- A more **optimistic** score if, for example, currently unknown characteristics were confirmed at later stages, or mitigation measures were incorporated.

This guidance provides advice on how to deal with situations where there may be different approaches to scoring, for example if details are not known, or occupancy may vary, or different dwellings have different characteristics across the scheme. Ultimately it is up to the user which approach to adopt, depending on the context of the project and risk assessment.

Variations across schemes

The tool may be used in different ways depending on the context e.g.:

- **Applied to an overall scheme, with questions answered for the majority of the units.** This would be more suitable at the very early stages, especially on projects where works to the existing building are substantial, when key strategic design decisions are being made such as floor layouts (e.g. dual-aspect layouts vs corridors and single-aspect units).
- **Applied to an overall scheme, but used to identify units or house types that may show higher risk characteristics**; this would typically be at a slightly more detailed level of design, when the broad design principles may already be agreed and acceptable, but some flexibility is still available e.g. reducing glazing proportions to the extension or re-modelled envelope, designing for effective openings, or incorporating shading to more exposed areas.
- **Applied to individual dwellings**.

The tool is not meant as an assessment of individual rooms. In practice, there can be significant temperature gradients across a home.

Temperature gradients of a few degrees are often found in North-South dual aspect homes or between a ground and upper floors in a house, and similarly between North and South facing apartments or lower and upper floors within a single building (at equivalent occupant behaviour).

In addition, **existing buildings often have very varied characteristics**, which have evolved over time as successive occupants have adapted the homes to their needs and preferences. One wall may be insulated, another not; on multi-residential dwellings, some occupants may have enclosed a balcony, others not; the lower floors will typically be more shaded by trees and neighbouring buildings.

This means that an overall “medium” score through this relatively simple whole house tool could hide some areas at risk of high temperatures, and others not at all, rather than an average risk across the home. In some cases, this may allow residents to select more comfortable rooms, for example sleeping in North facing bedrooms or avoiding South and West facing ones in the afternoon. However, this is not always possible.

With experience, users of the tool may be able to identify those rooms / homes which are likely to be at a higher or lower risk compared to the rest of the home / scheme. However, it must be remembered that this tool is aimed at being relatively simple to use, to guide design decisions rather than as a detailed design tool.

The tool highlights the questions where the answer may be different in different rooms of a single home, or different dwellings across a larger scheme. In such cases, the user can decide whether to score in a cautious way (based on the rooms / dwellings with the highest risk situation for this question), or optimistic (based on the rooms / dwellings with the lowest risk situation), or average (based on the most common situation across all rooms / dwellings); it is then useful to make a note of the approach taken, as this will add context to the interpretation of the results.

The first page of the tool includes prompt questions on such typical high risk situations:

- **Is the dwelling dual aspect North – South, or does the building have single-aspect South facing dwellings?** If so, South facing rooms or dwellings could be several degrees higher in temperature compared to the North-facing ones (at similar occupant behaviour).
- **Is the scheme or house on several storeys?** Top floor apartments and rooms can be several degrees hotter (heat rises, higher floors tend to be less shaded, and the roof may become hot and contribute to heat gains to the rooms below). In houses, this may be exacerbated in top floor extensions & conversions, which often have higher levels of glazing than the original house.
- **Are there dwellings within the scheme, or rooms / areas within the home, whose characteristics were identified in the scoring as higher risk than the whole home / scheme?** This can take account of orientation and storeys as above but also factors more specific to the home or scheme e.g. more glazing, less shading, openings more constrained because of a busy noisy road.

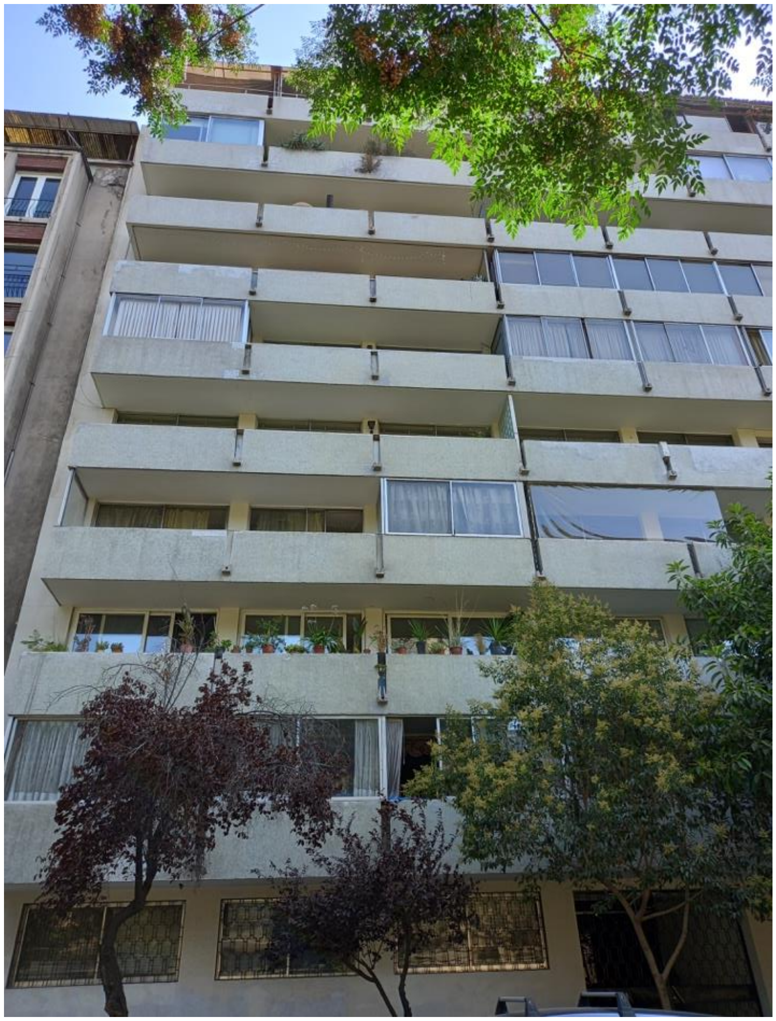


Figure 3: Within a single building, different dwellings may have varied characteristics, due to the original design or subsequent works and adaptations by occupants. The tool user may explore this by using the tool on individual dwellings, or start by scoring the tool for the majority of dwellings before assessing individual dwellings to test the impact of specific characteristics; for example, in this illustrative apartment block, this could involve different scoring for the top floor flats, the ground floor flats, and those which have enclosed their balconies, with or without blinds. Even within individual homes, variations can often be found due to for example different windows (some original, some recent replacements), different shading from trees, different glazing ratios etc.

Taking account of occupants

Occupants vary: they can have different sensitivities to heat and noise, their way to occupy the dwelling evolves, and occupants of a single dwelling change over time.

For dwellings with **occupants likely to be particularly at risk from overheating**, for example in care homes or homes for the elderly, it is recommended to target a “low” risk category. In addition, the scoring should pay particular attention to the points which rely on occupant behaviour: in these types of homes, these points should typically only be scored if there is good confidence that the features will be used e.g. if staff are aware of them and have been instructed how to use them.

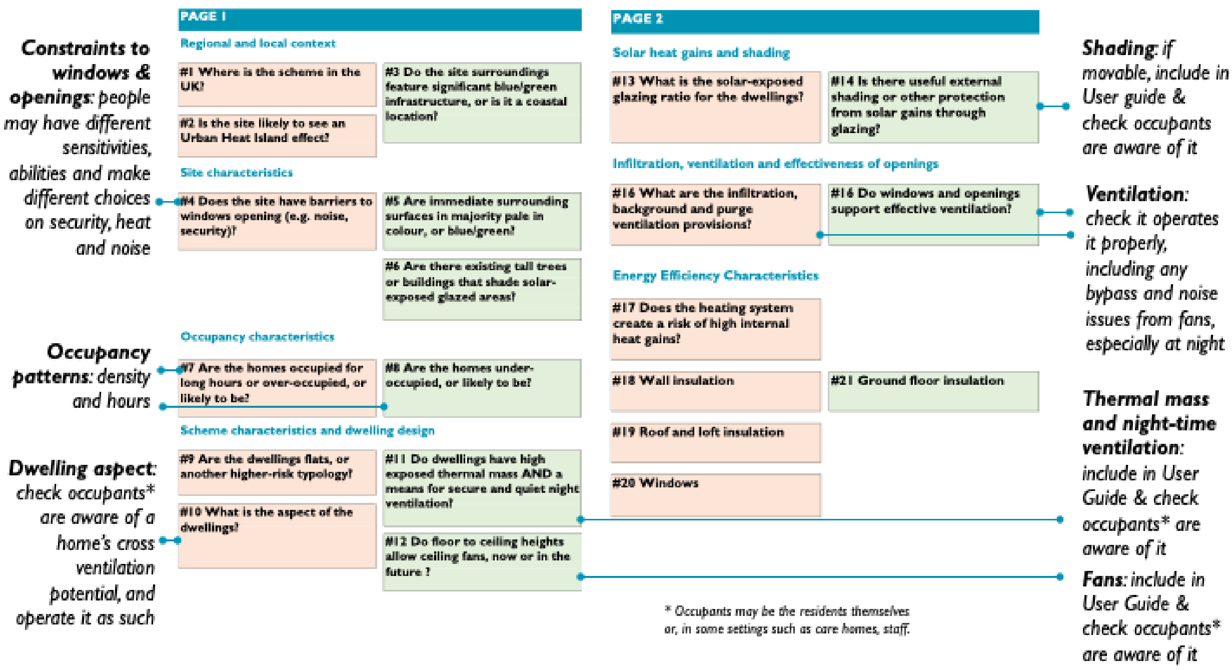


Figure 4: A number of questions in the overheating risk tool can be influenced by occupant sensitivities, choices and behaviours, and this should be taken into account in the scoring. Features that rely on occupant behaviour must be included in the user guide. In homes where occupants may be unlikely to use them (e.g. care homes), mitigation measures should only be accounted for in the score if staff can be relied on to use them.

The **WORKED EXAMPLES** (especially **7 - Existing flat, Paris, Impact of occupant**) include illustrations of how to take account of occupants.

What if your answer is not shown in the tool?

In many questions, for simplicity, the tool only includes responses which have risk or mitigation points attached i.e. if the scheme's characteristics are not shown, it generally means they should simply be given a score of zero.

In some questions, such as **#15** on infiltration and ventilation, the recommended scoring scale has gaps between score bands; this is because, as a relatively high-level tool, an exact scoring would be difficult and may be misleading. In those cases, the tool user may decide to score one way or another, depending on the context and the desired approach e.g. average, optimistic, or cautious.

Inevitably, this tool cannot account for all configurations; some innovative features may be proposed by the team, such as acoustically attenuated natural ventilation openings, which are not included in the tool. In this case, the team should exercise cautious judgement on the closest representative scoring option and test the impact of scoring uncertainty on the risk score; it may also be that in these cases, dynamic modelling is the more appropriate way to explore the solution.

Do however contact the Good Homes Alliance if you think a particularly important characteristic of existing homes or retrofit projects should be added or considered for the assessment of overheating risk, and is not currently included in the tool and guidance.

The **WORKED EXAMPLES** provide illustrations of scoring in a variety of homes and different approaches to the scoring, depending on context for the overheating risk assessment.

PAGE 1

SITE FACTORS

REGIONAL AND LOCAL CONTEXT

#1 - WHERE IS THE SCHEME IN THE UK?

Why?

Geographical location influences external temperature and solar radiation. Schemes in the South are typically more at risk of overheating.

Scoring this question

- 0 points for Northern England, the Borders, Scotland and Northern Ireland
- 8 points for the Thames area, Southeast England and southern England
- 4 points for everywhere else.

Figure 5: Risk zoning from geographical location, based on average external temperature and average solar radiation between May and September (data and zones from SAP 2012 and 10.2).

Note this is based on **current climate data**. Overheating risk is expected to increase with climate change, and current projections indicate that future temperature increases may be more pronounced in the South.

References

The assessment of zones was based on weather data (temperatures and solar radiation) as per zones in SAP 2012 version 9.92, October 2013, unchanged in SAP 10.2, 3rd February 2022.
Climate Change Committee, Progress in adapting to climate change 2021, Report to Parliament, 2021

#2 - IS THE SITE LIKELY TO SEE AN URBAN HEAT ISLAND EFFECT?

Why?

In cities and built-up areas, the preponderance of hard surfaces leads to higher average air temperatures as these surfaces absorb solar heat during the day and release it at night. This is increased by factors including heat rejection from vehicles and air conditioning equipment. This is known as the Urban Heat Island (UHI) effect.

The UHI effect occurs throughout the day but is stronger at night, with night-time temperatures sometimes significantly higher than in surrounding rural locations. Higher night-time temperatures can impact on sleep and the ability to cool building fabric.

Scoring this question

The scoring seeks to take account of temperature differences overall, not just night-time:

- 6 points: the term “central London” is used in the tool for simplicity, but the locations recommended in this category correspond to high heat risk areas identified in the Greater London Authority’s climate risk heat map, i.e. red and orange. See map below for illustration, and references for background data. As a cautious approach, the postcodes in central Manchester which are identified in Building Regulations Approved Document O as higher risk (i.e. M1, M2, M3, M5, M15, M16 and M50) could also be scored in this category, rather than given only 4 risk points.
- 4 points for Greater London i.e. green and blue on the GLA heat risk map, Birmingham and Greater Manchester
- 2 points for other cities, large towns and dense sub-urban areas
- 0 points for rural locations, smaller towns and less dense sub-urban areas.

Note the GLA climate risk map offers a flood risk score, heat risk score, and a combined risk factor. This question should be scored on heat risk alone.

For Greater London postcodes which are not attributed a risk score on the GLA map (i.e. which are grey on the map), the scoring can be based on Approved Document O risk zones – see below.

An element of judgement has to be applied on the suitable categorisation of the site. For example, the user may decide whether to allocate 4 or 6 points to the yellow sites on the GLA heat risk map, depending on site specific context and their preferred approach to scoring (e.g. it would be reasonable to score a yellow location as high risk if the map shows it as surrounded by orange or red ones) . This may be judged on a case-by-case basis, but with caution not to overstate the effects of local greenery against overall trends at the local authority / large neighbourhood level. The more local effects of green infrastructure on temperatures are accounted for in #3 and #5.

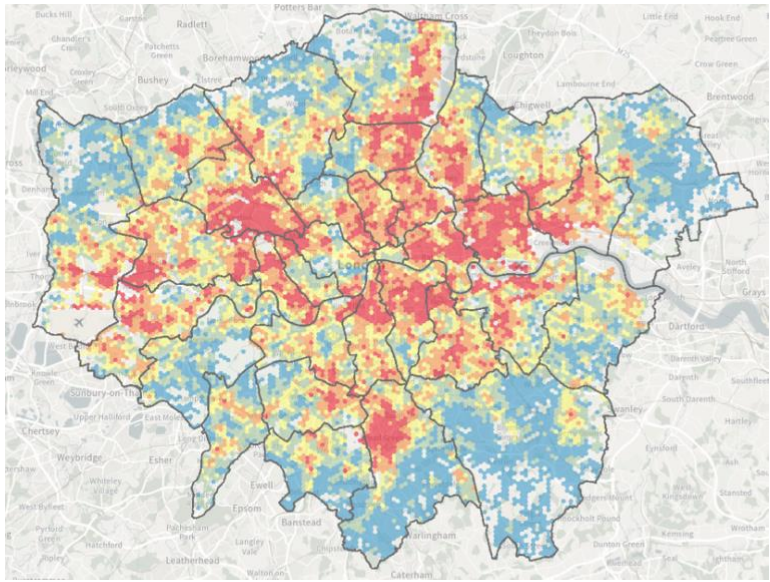


Figure 6: Greater London Authority climate risk (heat) map, available here

How does the scoring for London relate to the "high risk" zones used for Part O?

For London, an alternative to using the GLA heat risk map could be to score according to the high risk postcodes defined in Approved Document O. Very broadly speaking (more or less, at Borough level), there is agreement between the zone considered high-risk in Approved Document O and the higher risk areas in the GLA heat map. However, the GLA map is much more granular, with some areas identified as lower or higher risk which are not the same as in Approved Document O – see illustration in *Figure 7*. If possible therefore, it is recommended to use the GLA map.

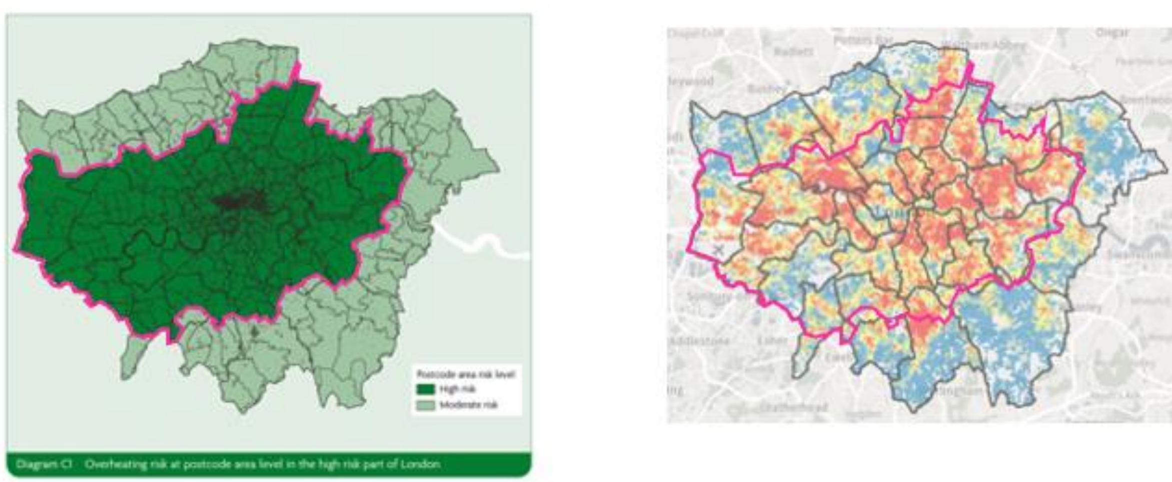


Figure 7: Comparison of Approved Document O "high risk" London zone vs Greater London Authority climate risk (heat) map: while there is high-level agreement, the GLA map is more granular and is recommended to use if possible

Other local authorities may be developing datasets as part of exercises such as heat risk mapping. Do feel free to contact the Good Homes Alliance if you would like a Local Authority reference to be added to this guidance.

Mitigation

Incorporating blue / green areas can help reduce the UHI effect - see #3 and #5.

References

Higher prevalence of overheating in London: Lomas K., Watson S., Allinson D., Fateh A., Beaumont A., Allen J., Foster H., Garrett H., *Dwelling and household characteristics' influence on reported and measured summertime overheating: a glimpse of a mild climate in the 2050's*, Building and Environment, 2021

Met Office, What are urban heat islands? - https://www.metoffice.gov.uk/binaries/content/assets/mohippo/pdf/8/m/mo_pup_insert_health.web.pdf

NHBC, NF44 Understanding overheating - Where to start?, 2012. p9 Urban Heat Island Effect

Zero Carbon Hub, Overheating Evidence Review, 2016, pp 13-14 'Local climate (city level) – Urban Heat Island (UHI)' http://www.zerocarbonhub.org/sites/default/files/resources/reports/ZCH-OverheatingEvidenceReview.pdf

London data: Greater London Authority Climate Risk map https://gisportal.london.gov.uk/portal/apps/webappviewer/index.html?id=73221961118948 40b5e9bae464478167.

Manchester data: http://www.instesre.net/GCCE/ManchesterHeatIsland.pdf

Birmingham data: https://rmets.onlinelibrary.wiley.com/doi/full/10.1002/wea.1998

Building Regulations Approved Document O, December 2021 for June 2022 publication

#3 - DO THE SITE SURROUNDINGS FEATURE SIGNIFICANT BLUE/GREEN INFRASTRUCTURE, OR IS IT A COASTAL LOCATION?

Why?

At the local level, the presence of blue/green infrastructure such as parks, generous landscaped grounds, rivers, or large water features helps reduce external air temperature.

Small blue and green infrastructure elements aggregate and contribute to local effects, so there is a continuum of effects rather than a clear threshold. For the purpose of this tool, the level of blue/green infrastructure considered to have a beneficial effect is at least 50% cover, within a 100m radius from the site (note - this is in line with the approach to this issue in the BRE's Home Quality Mark temperature tool CS210 v0.0, August 2018).

This question can be evaluated from local site information, satellite views (e.g. Google maps), or other mapping resources if available. Examples are included in the references; other local authorities may be developing datasets as part of exercises such as green infrastructure or heat risk mapping. Contact GHA if you would like your Local Authority data to be added to the references.

Local authorities who do not currently have green infrastructure maps may find it useful to develop one, as this can help with a number of objectives beyond addressing overheating risk, such as flood risk mitigation, biodiversity, air quality, and general health and wellbeing.

Figure 8: Examples of local blue / green infrastructure: (left) Local park in Poplar, London; (right) University campus route lined with trees and water features, Birmingham

Sites on the coast are also typically cooler than the wider region, due to the cooling effects of the sea and typically higher / more frequent winds.

Figure 9: Coastal locations are typically exposed to higher or more frequent winds – Illustrations from the Norfolk coast: bended trees, windmill

Scoring this question

Two mitigation points should be allocated if at least 50% of the surroundings within a 100m radius of the buildings are to be blue/green, or for sites in coastal locations.

Areas of green roofs or living walls can be used to contribute to the 50% target here.

Outside of coastal locations, these mitigation points can more easily be awarded in a rural context and for low-density developments, although as this considers the very local context, even in such locations it may not always be met e.g. it wouldn't necessarily be met in developments with large hard-surfaced areas and little planting.

Figure 10: Examples of using satellite view (google) to help score this question: these two sites in East London have similar built typologies with mostly low-rise housing and some isolated high-rise blocks and would score the same for overall urban heat island effect (#2) because of their location in Tower Hamlets and Hackney. However, at the local scale (100m radius) they have very different characteristics in terms of green infrastructure, with the left-hand side site likely to experience higher local temperatures

Mitigation

Options may be limited on many existing homes and retrofit projects, however on larger and more extensive projects, the team should seek to incorporate blue and green infrastructure to increase the proportion in the neighbourhood; more locally this may have added benefits to the scheme itself by offering local shading and cooling effects as well as other biodiversity, health and wellbeing benefits.

References

Evidence and background information: http://www.zerocarbonhub.org/sites/default/files/resources/reports/ZCH-OverheatingEvidenceReview.pdf p14 onwards 'Addressing the Urban Heat Island – Trees and green space'

Blue/green infrastructure mapping of Greater London: https://maps.london.gov.uk/green-infrastructure/ ; in the future this may be linked to quantified data, for example by reference to the Urban Greening Factor used in the London Plan (policy G5)

Blue/green infrastructure mapping of Birmingham: Birmingham Green Living Spaces Plan - https://www.birmingham.gov.uk/greenlivingspaces; see Green & Blue Infrastructure map on Plan 7, p25

Blue/green infrastructure mapping of Liverpool: The Value of Mapping Green Infrastructure, RICS, 2011 https://www.merseyforest.org.uk/files/The_Value_of_Mapping_Green_Infrastructure_pdf.pdf

SITE CHARACTERISTICS

#4 - DOES THE SITE HAVE CONTEXTUAL BARRIERS TO WINDOW OPENING?

Why?

Ventilation is one of the key measures to mitigate overheating risk by dissipating heat from solar and internal gains, and ideally by creating a breeze.

Ventilation is sometimes physically limited by the design of the window or opening – see #15. However, even if occupants can physically open windows or other openings, they are often deterred from doing so by other reasons, the main ones being:

- **Noise levels**: this is known to be a significant barrier to window opening, particularly in urban areas and near transport routes. The risks and possible mitigation measures should be evaluated as part of the retrofit process, with advice from the project team's acoustic consultant (if available) and the local authority's environmental health department on site conditions and how best to balance the needs for ventilation, temperature management and acoustics. See below text, Figure 11 and references for further guidance.
- **Poor air quality/smells**: this should be evaluated as part of the retrofit process, with advice from the project team's air quality consultant (if available) and the local authority's environmental health department. While poor air quality as such may not necessarily change people's behaviour to window opening, smells from surroundings such as busy roads, car park areas, factories, or commercial kitchens, could.
- **Security risks and fear of crime**: as part of the retrofit process, thought should be given to whether occupants would feel safe leaving their windows open, particularly at night when sleeping, or day-time when they are not in that room. Lower floors or other easily accessible areas such as flats along external corridors are likely to be more susceptible. Advice should be sought from the local security officer or police force where there are concerns.
- **Health and safety concerns**: concerns by residents which might restrict how they use openings should be considered e.g. risk of falling from higher floors; strong winds in high-rise buildings making it difficult to open windows safely; fear of small children escaping from openings on ground floors or through patio doors to balconies (especially in non-master bedrooms, which may be used for children).
- **Neighbouring heat rejection plant:** heat rejection plant located near openings may prevent residents from using these openings due to noise issues, or because it would bring hot air in as a result of the heat rejection plant increasing local air temperature.

These considerations are often different during the day and at night, hence the dual approach to scoring for this question.

Figure 11: The busy roads in front of these apartments are likely to make it uncomfortable for occupants to regularly open their windows for long periods of time, due to noise as well as exhaust fume smells.

Scoring this question

Points are awarded on a sliding scale and separately for daytime AND night-time issues:

Daytime:

- **Zero:** no significant external barriers to window opening on any elevation
- **4 points**: a small amount of windows have barriers, but the majority are OK to open
- **8 points**: barriers to a significant proportion of windows and openings (around half). For example this could be the case for a dual-aspect dwelling with one side on a busy road, but the other side quiet.
- **16 points:** significant barriers, likely to mean that most windows would be closed most of the time, or that noise levels could have a significant adverse impact on occupants' health over the long term.

Night-time:

- **Zero:** no significant external barriers to window opening on any elevation
- **4 points**: at least half of the windows, including bedroom windows, are OK to open, but a small number are likely to stay closed. For example this could be the case on a quiet site, where ground floor windows are likely to stay closed for security reasons but the bedrooms are upstairs and windows are OK to open on these floors
- **8 points**: a good proportion of windows and openings are ok to open, but bedroom windows are likely to stay closed
- **16 points:** significant barriers, likely to mean that most windows would be closed most of the time, or that noise levels could have a significant adverse impact on occupants' health over the long term.

Different people have different sensitivities to noise, which means that what is considered disruptive to some, preventing them from opening their windows on a regular or prolonged basis, may be acceptable to others: noise criteria are based on epidemiological data rather than one person's perception. People also have varying sensitivities to heat. Therefore, people may make different choices and trade-offs between heat and noise. When evaluating possible constraints due to noise, an acoustician and/or environmental health officer should ideally be involved to advise on how to score this question, for example in reference to the Acoustics, Ventilation and Overheating (AVO) Residential Design Guide published by the Association of Noise Consultants. The acoustician should advise which Level 1 assessment risk category the scheme falls under, and therefore the appropriate score for day-time and for night-time:

- Windows and openings exposed to "High" risk noise levels should be considered to have significant barriers (e.g. over 62 dB $L_{A,eq\text{-}16hr}$ in the daytime and above 55 dB $L_{A,eq\text{-}16hr}$ at night).
- Windows and openings exposed to "Low" noise levels are likely not to have noise-related barriers (e.g. 52 dB $L_{A,eq\text{-}16hr}$ and below in the daytime and below 48 dB $L_{A,eq\text{-}16hr}$ at night).
- For situations in between, the advice of an acoustic consultant should be sought.

When occupants are known, it can be useful to assess their experience of the current situation, to inform the risk assessment. However, noting the above, caution should be applied as what is acceptable to current occupants may not be for future ones, and solutions should instead strive for best practice and offer a level of resilience.

Note this is slightly different (more flexible) from the scoring approach published in the New Build guidance & tool, which has since been considered a bit too restrictive, especially on the trade-offs that many people may find acceptable between heat and noise.

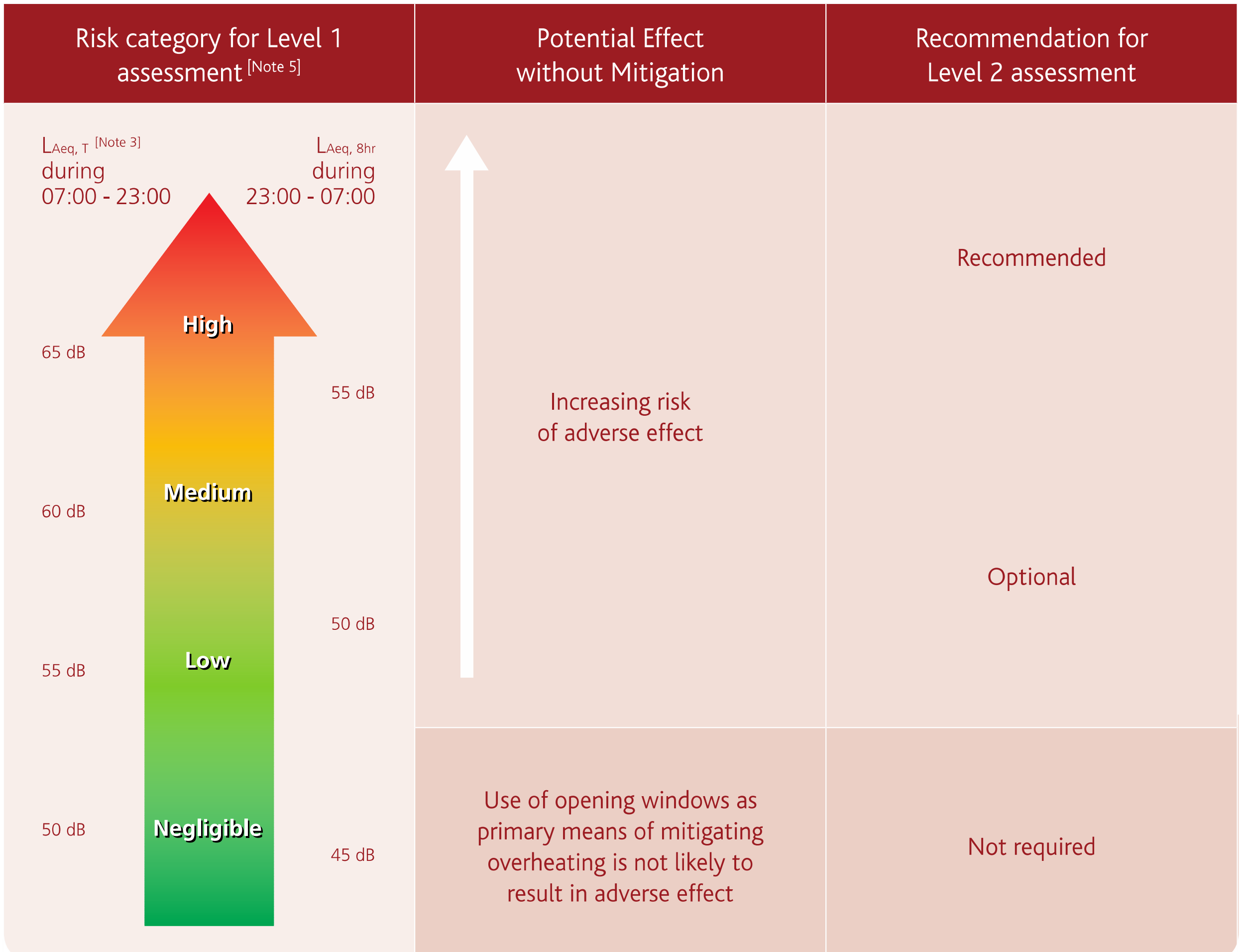


Figure 12: Guidance for Level 1 site risk assessment of noise from transport noise sources relating to overheating condition (Acoustics, Ventilation and Overheating Residential Design Guide, Association of Noise Consultants, January 2020, Table 3-2)

Mitigation

A number of mitigation measures are possible - see references for detail. Some relate to site and building layout decisions at the early design stages e.g. creating buffers to noise through site features and landscaping, locating sensitive uses away from the main sources of noise, and incorporating dual-aspect apartments to allow openings on a quieter side (see also #10). These options are likely to be limited in many existing homes and retrofits, but some could apply in the creation of homes from the conversion of non-domestic buildings, with substantial internal remodelling providing opportunities to consider the layout at the early design stages.

Other measures relate to more detailed design and are likely to be applicable in most existing homes and retrofits e.g. the installation of acoustic louvres or external screens against noise, or of security grilles to allow window opening. However, such measures can affect the facade's aesthetics and therefore also need to be considered early on as part of the retrofit project, especially if it is subject to a planning application, or if the building has heritage value and there may be constraints to interventions on the façade.

Figure 13: Examples of secure window openings. These measures could easily form part of a retrofit project, if not already installed on the existing windows.

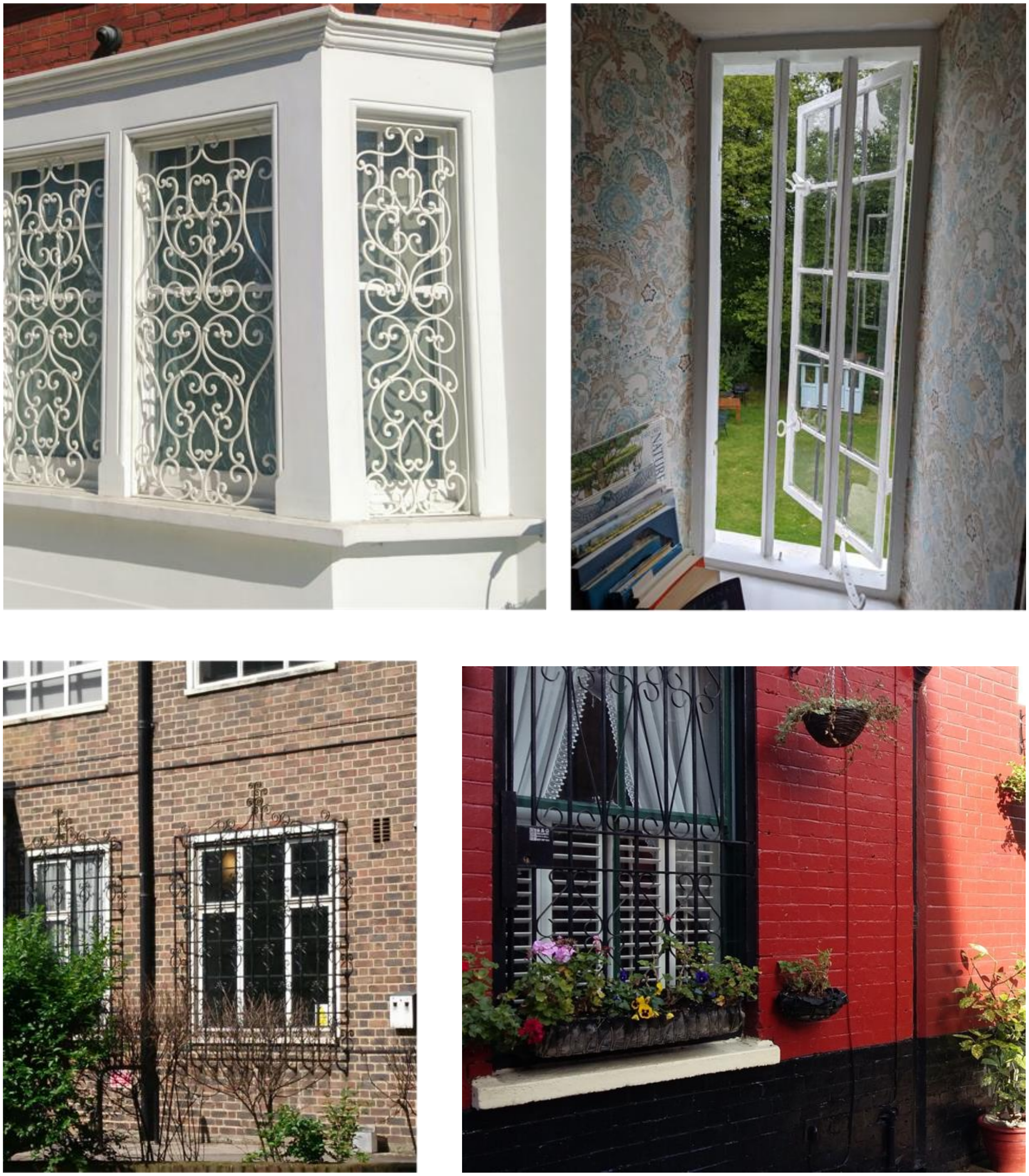


Figure 13 (continued) Examples of secure window openings. These measures could easily form part of a retrofit project, if not already installed on the existing windows.

Figure 14: Example of opening in high-rise building, addressing safety concerns. This could form part of a retrofit project with substantial façade works.

References

Security and noise barriers to openings:

Zero Carbon Hub, Overheating Evidence Review, 2016, http://www.zerocarbonhub.org/sites/default/files/resources/reports/Understanding_Overheating-Where_to_Start_NF44.pdf, p6 'Is the ventilation strategy appropriate?'; p8 site context

2009 study of over 89 participants in London, where over 50% reported they were unable to open windows when needed due to security concerns, and over 30% due to noise: Mavrogianni A., Pathan A., Oikonomou E., Biddulph P., Symonds P., Davies M. (2017) Inhabitant actions and summer overheating risk in London dwellings, Building Research & Information, 45:1-2, 119-142, DOI: 10.1080/09613218.2016.1208431

Noise - site assessments and design guidance:

Association of Noise Consultants (ANC), January 2020: Acoustics, Ventilation and Overheating Guide (AVOG) - Residential Design Guide https://www.association-of-noise-consultants.co.uk/avo-guide/

Institute of Acoustics (IOA), ANC and Chartered Institute of Environmental Health (CIEH): ProPG: Planning & Noise – New Residential Development - https://www.ioa.org.uk/publications/propg

#5 - ARE IMMEDIATE SURROUNDING SURFACES IN MAJORITY PALE IN COLOUR, OR BLUE/GREEN?

Why?

Surfaces of high albedo, for example light coloured ones, are more reflective and lead to lower surface temperatures and lower heat absorption. Similarly, surfaces covered in plants or water absorb less heat and maintain lower surface temperatures. By comparison, surfaces of low albedo, such as dark brick or tarmac, absorb heat and can exhibit much higher temperatures, which then leads to higher temperatures in the immediate surrounding air.

This is particularly important around air inlets (whether openings or mechanical air intakes) as darker, hotter surfaces can significantly increase the temperature of incoming air, potentially turning ventilation from an overheating mitigation measure to an exacerbation.

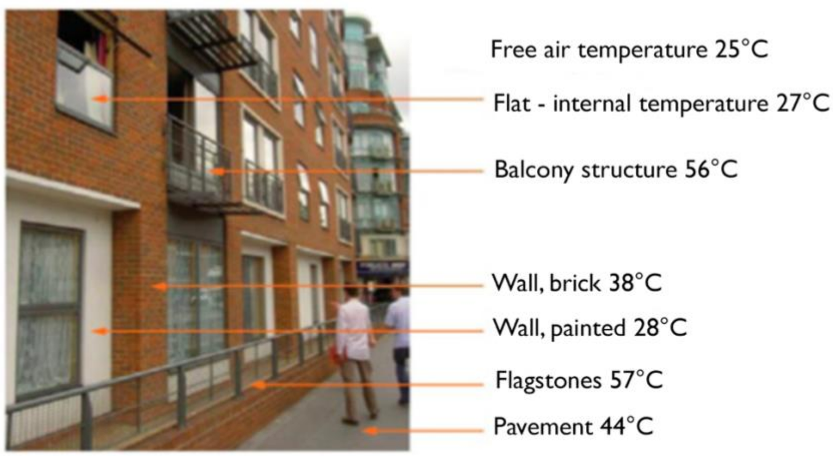


Figure 15: A study carried out by the BRE showed that surface temperatures contributed to overheating risk, with south-facing exposed brick facades and tarmac areas nearby contributing to high temperatures near air inlets

Scoring

Award as a function of whether horizontal and vertical surfaces within 10m of the building(s), and particularly around openings and ventilation inlets, are of a pale colour or blue/green (water or planting):

- 2 mitigation points if the majority are
- 1 point if only around half are e.g. the house may have a planted front or back garden, but not both; or it may have planted back and front gardens, but dark exposed brick walls. Do not award if there are large dark surfaces exposed to the sun, especially around air inlets e.g. an unshaded south-facing brick wall, where windows are located.
- 0 otherwise.

Figure 16: On the left, example of light-coloured (high albedo) facade, likely to be of lower temperatures than surfaces such as brick, as in the example on the right where dark brick south-facing walls could reach high temperatures.

Figure 17: Example of light-coloured (high albedo) facades and external hard surfaces (left) and tarmac (right). Ground surface temperatures are likely to be lower in the left-hand example than the right with a consequent impact on local air temperatures in hot weather, for a given similar location

Figure 18: While individually small, whether front gardens are planted or hard surfaced can altogether have a noticeable cumulative effect on local air temperatures, as well as issues such as sustainable drainage

Figure 19: Retrofitted green walls, London.

Mitigation

Retrofit projects are an opportunity to select surface materials for the façade and immediate surroundings that would not create a risk of hot surfaces, particularly near air inlets, and to introduce planting.

References

http://www.zerocarbonhub.org/sites/default/files/resources/reports/ZCH-OverheatingEvidenceReview.pdf p18 onwards 'Addressing the Urban Heat Island – Albedo' and p22 'Local micro climate – albedo'

University of Kent, Urban Albedo calculator: https://research.kent.ac.uk/urbanalbedo/

Influence of albedo interventions: CIBSE Research Insight 04: *ClimaCare: Climate resilience in care settings*, 2020

#6 – ARE THERE EXISTING TALL TREES OR BUILDINGS THAT WILL SHADE SOLAR EXPOSED GLAZING AREAS?

Why?

Shading from surrounding trees and other buildings can reduce solar gains from glazed areas, and reduce the heat absorbed by the building fabric. The extent will vary depending on the height of trees and buildings, where they are located in relation to the building and sun path, and the type of trees (deciduous or not, shape and density of foliage).

Scoring this question

Mitigation points should be allocated if there are trees or buildings at least the same height (h) as the glazed areas of the dwellings being assessed, and within a radius of h from the exterior walls in either East or West direction, and also South in the case of large buildings. Award points as follows:

- 2 mitigation points if shading from surroundings applies to most solar-exposed areas (applying to the whole scheme being scored)
- 1 mitigation point if shading from surroundings applies to only around half of solar-exposed glazed areas. This should only be scored for individual homes e.g. trees shading the ground floor but not upper floor windows, or a neighbouring building shading one elevation of the home. Do not take the benefits of these points on multi-residential schemes where one dwelling is shaded and others not, unless if scoring specifically for the shaded dwellings.

The scoring may change through the retrofit e.g. a loft extension may mean there is now a new room at higher level, exposed to the sun and unshaded even if the lower floors remain shaded by trees as per pre-retrofit.

Only existing mature and healthy trees being retained should be accounted for, and only if they are tall enough and located close enough to the glazed areas to have a useful shading effect. In most cases, trees located South of the glazed areas should not be awarded points as the sun will typically be too high in summer for them to be effective, unless they really are very close to and much higher than the glazed areas. Note there are good reasons not to plant some tree species too close to building foundations which should be considered.

The impact of buildings may be assessed using a solar shading analysis produced as part of the planning application, if this has been carried out.

An element of judgement has to be applied to scoring this question. In most cases the mitigation points are likely only to be available in small schemes or individual dwellings, as there will usually be too much variation on larger schemes to apply mitigation points for the whole scheme. Even within individual homes, trees may only shade one side of the dwelling, or the ground floor.

Figure 20: The large mature tree on the left provides substantial shading to dwellings immediately behind it, which may even warrant extra mitigation points under question #14. This shading is only available to part of the building: the nearby tree, on the other hand, is still very young, producing hardly any shade: it should not be taken into account, unless possibly to test future scenarios. Scoring for the block should not account for trees, unless if scoring specifically for the shaded dwellings.

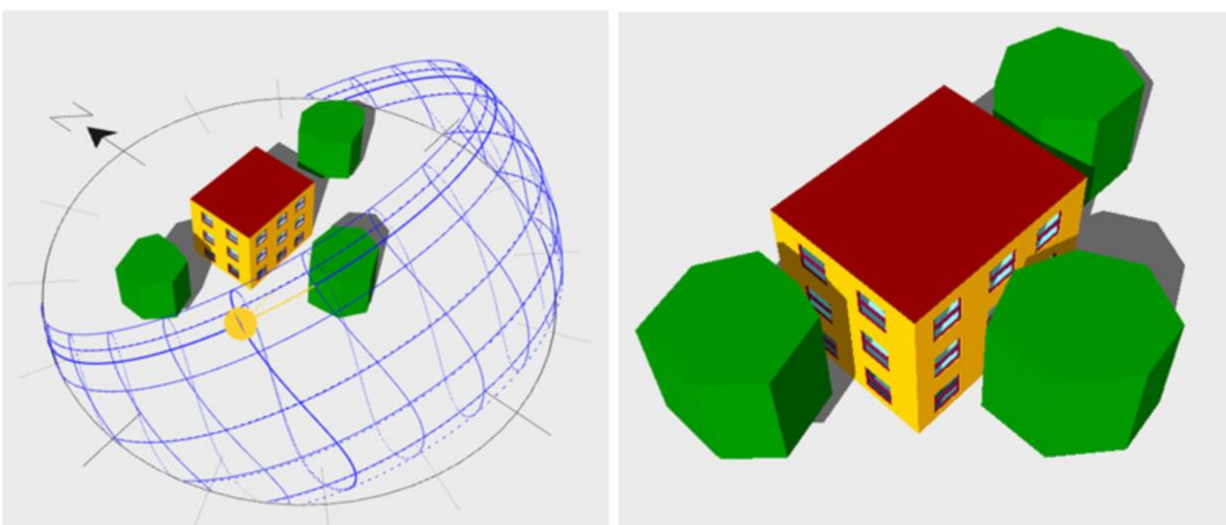


Figure 21: This simple model (left hand image) illustrates a 10m high building surrounded by trees at an approximate 10m distance, and each 10m high. The shading they provide is modest: the snapshot shows the situation at 3pm in May. At this time of year the shadows from the most southerly tree never reach the lower windows as the solar angles are too high. The trees to the east and west do provide shade but only in the early morning and late afternoon. The image on the right shows the increased shading provided when trees are located 5m from the building.

Scoring for substantial shading

In some dense high-rise areas, dwellings at the lower levels may be shaded for a significant proportion of the time by neighbouring buildings. In these cases, the project team may decide to award mitigation points in #14, as if for external shading features. Teams should however also be mindful of any other units on the scheme that may receive little or no shading (e.g. upper floors).

If shading from trees and surroundings is considered really significant and applies to a majority of solar-exposed glazing areas for most of the time, it could also be scored under #14, as external shading. This should however be used cautiously - for example, overheating can occur in mid-season when shading from deciduous trees is only limited.

References

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OCCUPANCY CHARACTERISTICS

The scoring under the tool assumed "normal" occupancy. While this is not strictly defined, high or low occupancy can increase or decrease overheating risk, by affecting heat gains from occupants and their activities, and the likelihood that they will be in the home at periods of high temperature.

Note this is not the only way that occupancy can be taken into account in the tool. Other considerations related to occupant behaviour are highlighted in relevant questions in this guidance e.g. in the operation of window openings, shading devices etc, and summarised in the section on **HOW TO USE THE TOOL - Taking account of occupants.**

The two questions in this section do not have to be scored: the risk assessment can be done without them. However, they can be a useful part of scenario testing, particularly if the homes are likely to be occupied for long hours and/or at high density e.g. care homes, affordable housing. For homes where occupants are known and will not change through retrofit, it is recommended that these questions are included as they are an important part of the context, but the tool user should be mindful that occupants and their occupancy patterns will change in the future, so a degree of resilience has to be incorporated in the design approach.

#7 - ARE THE HOMES OCCUPIED FOR LONG HOURS OR OVER-OCCUPIED, OR LIKELY TO BE?

Why?

High occupancy densities or long occupancy hours contribute to higher internal heat gains from the occupants themselves, and from their activities (e.g. cooking, equipment loads etc).

Long occupancy hours throughout the day also mean that occupants will be home during the hottest hours. To some extent, this is tempered by the fact that, if people are at home, it is also more likely that windows will be operated to purge heat. However, on balance, highly occupied dwellings are often shown to suffer more from overheating. This is particularly prevalent in some housing types such as affordable housing or homes for the elderly.

Scoring this question

The scoring considers two aspects: occupancy hours, and occupancy density.

Occupancy hours:

Scoring is done by reference to adult occupants. How this is defined is not an exact science, but broadly speaking younger children whose patterns follow those of their parents should not be counted, while older teenagers who have more independent occupancy patterns, may operate windows and shading devices etc for themselves, may be counted. This can all be part of the scenario testing, and will depend on whether the tool user wishes to follow a cautious approach.

- Score 3 risk points for every adult at home most of the day (e.g. working from home, stay-at-home parent, resident in a care home etc), over the 1st adult e.g. for two adults at home all day, score 3 points; for 3 adults (or older teenagers) at home all day, score 6 points etc.
- For no-one at home all day on most days, or only one adult, do not score risk points: this is considered part of "normal" occupancy.

Occupancy density

Scoring considers all occupants, and scores for "over-occupancy" if there are more than 2 occupants per bedroom. This only considers the total number of occupants and the total number of bedrooms, regardless of whether they are actually occupied as bedrooms:

- Score 3 risk points per occupant over 2-per-bedroom total. For example, for a 3-bedroom house, the 2-per-bedroom total is 6, and risk points are only attributed from 7 and more occupants.

Single-room homes should in general be treated as one-bedroom dwellings i.e. only counted as "over-occupancy" if there are 3 or more occupants; however, users may wish to take a more cautious approach for very small dwellings, and score for "over-occupancy" if 2 people occupy them.

References

Prevalence of overheating in homes with people away for work: Lomas K., Watson S., Allinson D., Fateh A., Beaumont A., Allen J., Foster H., Garrett H., *Dwelling and household characteristics' influence on reported and measured summertime overheating: a glimpse of a mild climate in the 2050's*, Building and Environment, 2021

#8 - ARE THE HOMES UNDER-OCCUPIED, OR LIKELY TO BE?

Why?

Low occupancy densities lead to lower internal heat gains from the occupant themselves and from their activities (e.g. cooking, equipment loads etc). Occupants are also likely to have more choice of which room to occupy, if temperatures vary across the dwelling (e.g. avoiding top floors, favouring north-facing rooms).

To some extent, this may be tempered by reduced patterns of window opening, but on balance, low occupancy dwellings are less likely to suffer from overheating.

Scoring this question

Scoring considers all occupants, and scores for "under-occupancy" if there is less than 1 occupant per bedroom. This considers the total number of occupants and the total number of bedrooms, regardless of which rooms are actually occupied as bedrooms:

- Score 2 mitigation points per occupant under the total number of bedrooms. For example, for a 3-bedroom house, under-occupancy is counted if there are 2 or fewer occupants: with 2 occupants, score 2 mitigation points; with one occupant, score 4 mitigation points. For a 2-bedroom house with one occupant, score 2 mitigation points even if, in practice, one of the bedrooms is used as an office or spare room.

References

Prevalence of overheating in under-occupied homes: Lomas K., Watson S., Allinson D., Fateh A., Beaumont A., Allen J., Foster H., Garrett H., *Dwelling and household characteristics' influence on reported and measured summertime overheating: a glimpse of a mild climate in the 2050's*, Building and Environment, 2021

KEY CHARACTERISTICS OF THE DWELLINGS

#9 - ARE THE DWELLINGS FLATS, OR ANOTHER HIGHER-RISK TYPOLOGY?

Why?

Flats are typically more prone to overheating. This is due to a number of reasons including their (typically) smaller size, denser occupation, fewer opportunities for cross ventilation, and surrounding dwellings and communal areas reducing heat dissipation or even adding to heat gains. Flats in upper floors of high-rise buildings are even more at risk, as heat rises, and they tend to be more solar exposed.

While these factors are exacerbated in flats, they may be similar in other small and compact typologies. Bungalows are also a higher risk typology, due to their size which is often relatively limited, and their single storey nature with relatively high gains from the roof / attic.

Scoring this question

- 6 risk points for flats (applying to single and two-storey (duplex) dwellings within a larger building).
- 4 risk points for bungalows (i.e. single storey detached dwellings).
- 1 risk point for mid- or end terraces.

As noted in many other questions, schemes in practice may include a mix of typologies. In that case, the approach can vary depending on the context in which the tool is used. For example, the score may represent the majority of dwellings, particularly at the early design stages, before looking at specific typologies or trying to identify the most high-risk dwellings.

References

Prevalence of overheating in flats and other typologies: Lomas K., Watson S., Allinson D., Fateh A., Beaumont A., Allen J., Foster H., Garrett H., *Dwelling and household characteristics' influence on reported and measured summertime overheating: a glimpse of a mild climate in the 2050's*, Building and Environment, 2021

Office of the Deputy Prime Minister (ODPM). Housing Health and Safety Rating System (HHSRS): Operating guidance. London, ODPM, 2006: "Smaller, more compact dwellings, and particularly attic flats, are more prone to overheating than are large dwellings."

Modern English homes at higher risk of overheating , quoting https://www.arcc-network.org.uk/modern-english-homes-at-higher-risk-of-overheating/ Beizaee, A., Lomas, K.J. & Firth, S.K., 2013. National survey of summertime temperatures and overheating risk in English homes. Building and Environment, 65, July 2013: 1–17.

NHBC, NF 46: Overheating in new homes, A review of evidence, 2012
http://www.zerocarbonhub.org/sites/default/files/resources/reports/Overheating_in_New_Homes-A_review_of_the_evidence_NF46.pdf

#10 – WHAT IS THE ASPECT OF THE DWELLINGS?

Why?

Single aspect dwellings are where all rooms, and therefore windows, are on the same facade. Units like this are more likely to overheat as natural ventilation is less effective (lower flow rate) when there is no cross-ventilation (i.e. potential for air to pass through the unit from one facade to another), and this limits the amount of heat that can be purged. In addition, in single aspect dwellings, all solar gains occur at the same time of day, increasing the total peak solar gains.

Note that bay windows or small articulations in the facade do not mitigate for this. Corner units offer some benefit compared to single-aspect ones, but less than dwellings with windows or openings on opposite sides.

Scoring this question

- 6 risk points should be allocated if units are single-aspect i.e. have all windows on the same facade.
- 3 risk points should be allocated if units are corner-aspect i.e. have windows on different facades, but not on opposite sides. This is also recommended if units are dual-aspect but very deep and/or with a convoluted air path, where it is unknown or unlikely that an effective air path will be created by opening windows on both sides. For example, this may be the case in dual aspect houses with a back extension, particularly a deep one. In some cases, users may also use this scoring in dual aspect dwellings where it is not known whether air flow around the building will be effective / sufficient e.g. buildings which are surrounded in close proximity by adjacent buildings or other obstacles which may impede air flow through openings. The **WORKED EXAMPLES - 7 - Existing flat, Paris, Impact of occupant** provides an example of scoring this, first scoring "on plan" in a cautious way, and then scoring knowing the situation in real life.
- 0 risk points for dual aspect dwellings, where it is expected that effective air cross-flows can be created through openings.

This question is scored regardless of the size and effectiveness of openings, which are scored in #16.

Mitigation

On many existing homes and retrofits there will be limited opportunities to improve cross-ventilation, however this is very relevant for more extensive retrofits, and dwellings created from conversion of existing buildings. Layouts should be reviewed at the early design stages to avoid configurations such as long corridors with single aspect units on each side.

In some cases, it may also be that "on paper" the units are dual aspect, but do not operate well as such in practice. This could be due to an internal layout which creates a convoluted and unlikely air flow; or doors assumed by the design team to be left open to create cross-ventilation but actually closed by occupants, for example because they are liable to slam, or because occupants are not aware of the benefits of encouraging cross-ventilation. These are opportunities to identify during site visits and discussions with users, for improvements at often limited intervention cost.

In addition to solar gains and ventilation potential, dual-aspect units often offer other opportunities that will help mitigate overheating risk, such as spreading heat gains throughout the day, and rooms and openings on a quieter facade away from the main elevation on the road (see #4).

Figure 22: Many traditional housing types are dual aspect for example Victorian mansion blocks (top) and Georgian terraces (bottom). However, this has sometimes been altered over the years through partitioning and extensions. A retrofit project is an opportunity to re-establish or improve air paths.

Other design measures that can be used to increase ventilation potential include openings with good free area (see #16). Generous floor-to-ceiling heights and ceiling fans can also help, though to a smaller extent (see #12).

References

Importance of dual-aspect dwellings:

- Zero Carbon Hub, Overheating Evidence Review - Drivers of Change, 2016, http://www.zerocarbonhub.org/sites/default/files/resources/reports/ZCH-OverheatingInHomes-DriversOfChange.pdf p6
- BRE, Guidance Document, Overheating in Dwellings, v3 https://www.bre.co.uk/filelibrary/Briefing%20papers/116885-Overheating-Guidance-v3.pdf p8 & 14
- Zero Carbon Hub, Overheating Evidence Review, 2016, http://www.zerocarbonhub.org/sites/default/files/resources/reports/ZCH-OverheatingEvidenceReview.pdf p73 solutions

Prevalence of single-aspect dwellings in PDR schemes, compared to schemes created through planning permission: Ministry of Housing, Communities and Local Government funded research, Clifford B., Canelas C., Ferm J., Livingstone, N., Lord A. Dunning R., Research into the quality standard of homes delivered through change of use permitted development rights, July 2020

Example of encouragement to dual-aspect dwellings through local planning policy: while typically aimed at new build dwellings, the guidance can also apply to retrofits and conversions:

- The National Model Design Code (Part 2, Guidance Notes) encourages dual aspect dwellings for light, ventilation, and general health and wellbeing.
- Greater London Authority, Housing Supplementary Planning Guidance, Implementation Framework, 2016: https://www.london.gov.uk/sites/default/files/housing_spg_final.pdf

#11 - DO DWELLINGS HAVE HIGH EXPOSED THERMAL MASS AND A MEANS FOR SECURE AND QUIET NIGHT VENTILATION?

Why?

The thermal mass present in medium and heavyweight construction materials can offer an effective means of reducing overheating, particularly during the hottest part of the day and if it is exposed to occupied rooms.

To be effective, thermal mass must be used in combination with night-time ventilation to remove heat that has built up in the dwelling, otherwise heat is gradually released again into the occupied areas, which can be problematic particularly in bedrooms at night. The importance of night purge ventilation should also be explained in the occupants' guide (see **NEXT STEPS**).

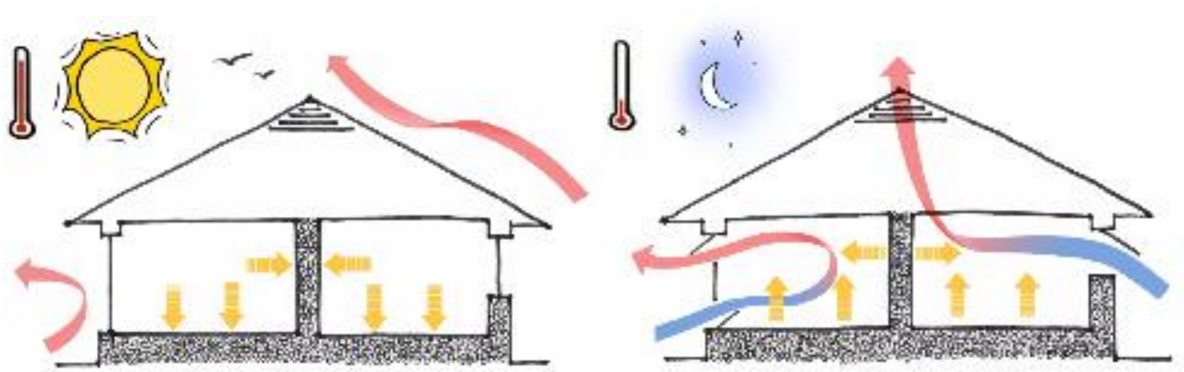

Figure 23: Illustration of thermal mass and night-time ventilation: Heat is absorbed during the day into exposed high thermal mass elements; at night, the heat is released into the rooms and ventilation helps dissipate it to the outside. This relies on night-time ventilation, and cooler night-time air.

Conversely, very lightweight construction types can make homes quicker to respond to temperature fluctuations and therefore increase susceptibility to overheating, although they may also be quicker to cool provided adequate ventilation with cool air.

Scoring this question

Two mitigation points can be allocated where the construction includes high exposed thermal mass (e.g. exposed brick walls; exposed stone or concrete floors; walls or ceilings with wet plaster finish) and there is a realistic strategy for secure and quiet night ventilation. The mass needs to be exposed to be effective at storage, so the score may change through retrofit, for example if the mass is covered by internal wall insulation or plasterboard.

This should apply at least in the bedrooms and main living room. Note this may be affected by the retrofit e.g. if new plaster or internal wall insulation are applied and cover the thermal mass.

This feature **relies on awareness and behaviour of occupants**, and for many occupants thermal mass is not a familiar concept nor an obvious visible feature. If not cooled down at night, the mass will accumulate heat over time, no longer providing benefits or even increasing risk. The feature should therefore be explained in the **User guide**, and this question should be scored with caution e.g.:

- If occupants are known, check they are aware of the feature
- If they are not yet known, check the feature is explained in the **User guide**
- In care homes or those occupied by vulnerable or elderly people, this should only be scored if staff are aware of the feature and have been instructed how to use it, and if they and the residents are comfortable with night-time ventilation (for example, in some cases residents may more-than-average worried about security, and night-time ventilation would affect their sense of security and quality of sleep).

Figure 24: Buildings of traditional construction often have exposed thermal mass, for example with walls made of stone or solid brick, with the mass left exposed or covered by materials such as lime or clay plaster which retain its benefits; the mass may however have been covered by subsequent internal works using plasterboard or other light-weight materials, so this should be checked before scoring the mitigation points in this question.

For some homes it may be helpful to refer to the thermal mass categories within SAP: anything qualifying as high 'Indicative thermal mass' from the table below would qualify - provided it also meets the night ventilation requirement. However, these conventions do not represent the wide variety of construction types in the existing stock. On more traditional construction, exposed solid brick walls or stone walls would qualify as "high" thermal mass, in addition to the types listed in the below table. A suspended timber floor would be considered "low" thermal mass.

. Thermal mass of elements (This is an internal heat capacity of a building element)				Illustrative construction	Indicative Thermal Mass of the whole building
Ground floor	External walls	Party wall*	Internal partitions		
Low	Low	Low	Low	Suspended timber floor, carpeted Timber frame external wall* Timber frame party wall** Partitions: plasterboard on timber frame	Low
Medium	Low	Low	Low	Suspended concrete floor, carpeted Timber frame external wall* Timber frame party wall** Partitions: plasterboard on timber frame	Low
Medium	Medium	Low	Low	Suspended concrete floor, carpeted Masonry cavity wall* – AAC block, filled cavity Timber frame party wall** Partitions: plasterboard on timber frame	Low
Medium	Medium	Medium	Low	Suspended concrete floor, carpeted Masonry cavity wall* – AAC block, filled cavity AAC party wall** Partitions: plasterboard on timber frame.	Medium

. Thermal mass of elements (This is an internal heat capacity of a building element)				Illustrative construction	Indicative Thermal Mass of the whole building
Ground floor	External walls	Party wall*	Internal partitions		
Medium	Medium	Medium	Medium	Suspended concrete floor, carpeted Masonry cavity wall* – AAC block, filled cavity AAC party wall** Partitions: medium block, plasterboard on dabs	Medium
High	Medium	Medium	Medium	Slab on ground, carpeted Masonry cavity wall* – AAC block, filled cavity AAC party wall** Partitions: dense block, plasterboard on dabs	Medium
High	High	Medium	Medium	Slab on ground, carpeted Masonry cavity wall* – dense block, filled cavity AAC party wall** Partitions: medium block, plasterboard on dabs	Medium
High	High	High	Medium	Slab on ground, carpeted Masonry cavity wall* – dense block, filled cavity Dense block party wall** Partitions: medium block, plasterboard on dabs	High
High	High	High	High	Slab on ground, carpeted Masonry cavity wall* – dense block, filled cavity Dense block party wall** Partitions: dense block, dense plaster	High

Figure 25: Indicative thermal mass for different construction types in SAP conventions, version 8.2 - https://www.bregroup.com/sap/standard-assessment-procedure-sap-2012/

References

http://www.zerocarbonhub.org/sites/default/files/resources/reports/ZCH-OverheatingEvidenceReview.pdf P33 'Thermal mass'

Influence of thermal mass: CIBSE Research Insight 04: *ClimaCare: Climate resilience in care settings*, 2020

#12 - DO FLOOR-TO-CEILING HEIGHTS ALLOW CEILING FANS, NOW OR IN THE FUTURE?

Why?

Higher ceilings increase stratification, and also allow for the possibility of installing ceiling fans.

Ceiling fans provide useful air movement, which in turn can improve the comfort experienced by occupants as the breeze generated increases the evaporation of moisture from skin, increasing adiabatic cooling.

Ceiling fans may be a useful option when ventilation to purge heat is otherwise limited - note they cannot replace actual ventilation, as heat does need to be dissipated, but they can help supplement the main ventilation which is provided by openings. For example, if the external environment is noisy and ventilation is provided by acoustic vents to baffle the noise, this will reduce air movement and ceiling fans can help provide a breeze effect which will improve occupant comfort. Ceiling fans usually need a clear 500mm of ceiling height if they are to operate effectively without danger to tall occupants.

Because ceiling fans improve comfort but do not reduce temperature, they can increase the risk of dehydration, as people perceive less the need for drinking. This option should therefore be used with caution in places such as care homes. Public Health England recommend that fans should be at a certain distance from people, and not aimed directly at the body; this is a little vague, but the important point is to ensure that staff are aware of the risk and look after the occupants' hydration needs.

Scoring this question

Award:

- 4 mitigation points if the floor-to-ceiling height within occupied rooms is designed to be 2.8m or more, and ceiling fans are included in the design and will be installed by the developer.
- 2 mitigation points if the floor-to-ceiling height within occupied rooms is designed to be 2.8m or more, so that effective ceiling fans could be installed in the future.

Ceiling fans rely on **awareness and behaviour of occupants**, therefore the feature should be explained in the **User guide,** and the mitigation benefits should only be accounted for if it can be reasonably expected that the fans will be used:

- If occupants are known, check they are aware of the feature
- In care homes or those occupied by vulnerable or elderly people, this should only be scored

if staff are aware of the feature, and instructed on when to use them (together with paying attention to occupants' hydration needs). However, this is a relatively simple feature which residents may quickly become accustomed to use themselves.

Figure 26: Ceiling fan ©Haiku Fans

Desk and standing fans can also be useful to improve occupant comfort, but they are not included here as typically they would be provided by residents rather than the design team. They are likely to have less effect than the combination of high ceilings and ceiling fans, which is considered in this question. If the tool user wishes, they may however be accounted for if present when assessing existing occupied homes (in this case, a maximum of 2 points would be recommended).

Consideration should be given to the noise generated by the fans selected, especially if they are intended for use in bedrooms and if they are portable desk/standing ones as some may otherwise disturb sleep; well-designed and installed ceiling fans can be quiet.

References

Fans & dehydration:

Public Health England, Heatwave plan for England - Supporting vulnerable people before and during a heatwave – advice for care home managers and staff, 2015

PAGE 2

SOLAR HEAT GAINS AND SHADING

#13 - WHAT IS THE SOLAR-EXPOSED GLAZING RATIO FOR THE DWELLINGS?

Why?

Higher proportions of glazing allow greater levels of solar heat gains to enter spaces (the original greenhouse effect). Windows are a vital feature for daylight access, views and ventilation, but excess glazing can have severe consequences in aggravating overheating risk. This question tries to identify schemes where high glazing proportions on **West, South and East** facing elevations (and those in between), as well as exposed **horizontal glazing** (e.g. roof lights), may contribute to overheating.

Highly glazed features such as conservatories can also let in significant solar gains; conservatories can become very hot and also create a risk in adjacent rooms.

Many traditional buildings have reasonable proportions of glazing. However, those with highly glazed features, and those created more recently, whether newly built or by conversion of non-domestic buildings, can have high proportions of glazing.

Scoring this question

This is scored according to the estimated proportion of glazing across the solar-exposed elevations. Elevations facing East, West and South (and everything in between) should be included, even if shaded - the effects of shading features are taken into account in #6 and #14. Illustrations below provide examples of what different glazing proportions might look like in practice. In some cases, large areas of glazing facing North-East to North-West may also be attributed a level of risk.

Glazing to wall vs Glazing to floor

Scoring is mainly done by reference to the glazing-to-wall ratio, as this is the most straightforward to estimate especially at early project stages or when scoring for multiple dwellings, such as block of flats. However, the glazing-to-floor area ratio is ultimately more relevant to the overall increase in temperature in the space, so the scoring scale also relates to floor area.

For example, in dwellings which have two main elevations but only one is solar-exposed (e.g. a North-South dual aspect house), high proportions of glazing on the South facade may be balanced by limited gains on the other, and the glazing area in proportion to floor area may be very reasonable, depending on the depth of the dwelling. Inversely, on dwellings with several solar-exposed facades, such as corner or dual aspect dwellings, reasonable proportions of glazing on the facades may actually result in high gains in relation to the internal space. It can then be useful to consider the proportion of glazing in relation to the floor area, alongside glazing-to-facade proportions. Teams are encouraged to use this additional consideration wherever the information is available.

Which elevations to consider?

Typically, only the main elevations would be looked at: for end terrace or detached and semi-detached homes, this is the front and back. The side elevations would typically have no or limited glazing, and the score should disregard these elevations when calculating the average glazing proportion: the proportion should reflect the front and back elevations. However, glazing features on these side elevations should be counted when considering the glazing in relation to floor area, as it will contribute to total heat gains.






Figure 27: Side elevations in detached and semi-detached homes, or gable walls in end terraces, often have no or very limited glazing, as illustrated in the front, gable and back elevations of these two typologies. Scoring for glazing-to-facade proportions is based on the main elevations, disregarding the side elevations. For example, in the middle illustration, the mid- and end-terrace dwellings have similar proportions of glazing on their main facades, and would be scored the same. However, glazing on these side elevations should be included when checking the glazing-to-floor ratio: this would be the case in the bottom illustration.

Low protection glazing

The risk score should also consider whether the glazing offers particularly low solar protection i.e. g-value of 0.75 or above, in which case additional risk points should be included. This is likely only to apply to original single glazing, very clear and with no additional solar protection.

Windows and other vertical glazing areas e.g. glazed doors, fixed glazing:

- 24 risk points if glazing-to-wall area is > 65% on solar-exposed facades. Add another 4 points if the glazing offers very low solar protection (g-value of 0.75 or above). If solar-exposed glazing areas represent less than 18% of floor area, the number of points may be reduced, but should be at least 14 points.
- 14 risk points if glazing-to-wall area is > 50% on solar-exposed facades. Add another 2 points if the glazing offers very low solar protection (g-value of 0.75 or above). If solar-exposed glazing areas represent less than14% of floor area, the number of points may be reduced, but should be at least 8 points.
- 8 risk points if glazing-to-wall area is > 35% on solar-exposed facades. Add another 1 point if the glazing offers very low solar protection (g-value of 0.75 or above).

- 4 risk points if glazing-to-wall area is < 35% on solar-exposed facades, but solar-exposed glazing areas represent more than 10% of floor area. Homes with large areas of glazing (e.g. above 50%) which is North-East to North-West facing may also want to score these risk points, particularly if the areas are likely to be reached by morning or evening sun.

Other glazing features

In addition to windows and other vertical glazing areas, risk points should be attributed to other glazed features which can create a risk to the dwelling overall, or to specific rooms which may in turn affect adjacent rooms:

- Unshaded horizontal glazing e.g. rooflights: 3 risk points per rooflight, assuming it is broadly of the size of a typical window e.g. rooflight on top of stairs, or one window-sized rooflight in one room: typically, this would mean a rooflight of approximately 1-2m^2. Multiple or large rooflights should be attributed more points, as if there were several rooflights.
- Highly glazed feature e.g. conservatory, large balcony enclosed by glazing, "winter garden": 14 risk points. Add another 2 points if the glazing offers very low solar protection (g-value of 0.75 or above).

What constitutes a "highly glazed feature" is not strictly defined, but it is meant to draw attention to high-risk design decisions. For example, in some cases, a design team may decide to score large bay windows, or bi-fold fully glazed doors which take up an entire wall, as a "highly glazed feature" rather than simply under the points for façade glazing. Ultimately what is important is to be aware whether the scoring approach is "conservative" or "risky", and pay attention to these features to minimise the risk of localised or whole house overheating.

Estimating percentages of glazing

Solar gains will only occur through glazed areas, not the frame. However, this can be difficult to evaluate at the early design stages, so the score can be based on the total area including frame, which then provides a small error on the "safe" side.

Where possible, the score should be evaluated on the proportion of facade **as seen from inside** the occupied areas i.e. from the inside without the slab. Again, this can be difficult to evaluate in a quick assessment at an early stage; as an estimate, the glazing proportion seen from the inside is usually approximately 10% higher than when seen from the outside (in proportion, not in percentage points). For example, if the total facade from the outside is approximately 50% glazed, this is approximately equivalent to a glazing percentage of 55% as seen from the inside (50% PLUS (10% of 50%), or 1.1*50%).

Figure 28: Examples of glazing proportion below 35% of facade area

Figure 29: Example of glazing proportion between 35% and 50% of façade area. These also illustrate situations where it is useful to check the glazing proportion in relation to floor area, not just façade, as reasonable proportions in relation to façade length could still result in high proportions in relation to floor area: corner dwellings, high ceilings, and highly articulated facades with features such as bay windows

Figure 29 (continued): Examples of glazing proportion between 35% and 50% of façade area.

Figure 30: Examples of glazing proportion between 50 and 65% of façade area.

Figure 31: Examples of glazing proportion over 65% of façade area

Figure 32: Proportions vary on each floor. A flat on the first floor may well have quite high proportions of glazing, particularly as floor-to-ceiling heights are relatively high

Figure 33: Example of highly glazed features – (left) enclosed glazed balcony in an apartment block; (right) back extension conservatory (conservatory image courtesy of Mark Williams)

Mitigation

- Reducing glazing areas: In order to maintain good daylight levels with lower proportions of glazing, it is useful to note that glazing areas located below 700mm and in corners do not contribute usefully to daylight levels in a room, but still contribute to winter heat losses and summer overheating risk. Raising sill heights is particularly relevant in bedrooms, where this may help address concerns about the security of openings for children, and where offering views from low-level glazing may be less important
- Incorporating solar protection, ideally as external shading or otherwise as other measures such as solar control glass (lower g-value) or internal blinds - see #14.

References

http://www.zerocarbonhub.org/sites/default/files/resources/reports/ZCH-OverheatingEvidenceReview.pdf p29 ‘Glazing area and orientation’ and p37 ‘Glazing types – existing technologies’

#14 - IS THERE USEFUL EXTERNAL SHADING OR OTHER PROTECTION FROM SOLAR GAINS THROUGH GLAZING?

Why?

External shading devices can significantly reduce the solar gains admitted into a space. This can be in very varied form such as shutters, overhangs, awnings, balconies or the articulation of the facade.

South-facing glazing will benefit most from horizontal shading e.g. louvres, balconies above. East and West facing glazing will benefit most from vertical shading e.g. deep recesses, vertical fins, shading from the sides of surrounding balconies.

The shading devices should be simple to operate and easy to reach. Typically, movable shading devices are preferred as they allow a level of adaptation by occupants; in some cases, the design of devices such as shutters means they can be closed while windows are left open and still allow a level of secure ventilation e.g. at night, or when people are not at home or not in the room. However, movable devices do mean that the benefits of shading provision rely on occupants deploying them, so a simple explanation on their use should be provided to occupants in the user handbook - see **Next Steps**.

Internal shading also mitigates solar heat gains to some extent, but has less effect as heat is already in the space, and it can impede air flow or conflict with window opening. Blinds/curtains with reflective linings will be particularly useful at reducing heat gains; heavy thermal lined curtains are also effective at cutting heat gains, but will affect internal light levels and air flow. Solar control glazing or films also help, but limit useful heat gains in winter and, in some cases, affect light transmittance.

Scoring this question

The scoring takes account of the solar-exposed glazing features as estimated under #13 since the greater the area of glazing the more important solar protection becomes.

External shading

The level of external shading provided needs to be categorised as Full or Partial:

- **Full** implies that all solar-exposed glazing receives half of the sunshine it would without the shading - e.g. shaded for at least half the day, or at least half the area at all times.
- **Partial** implies some shading e.g. some solar-exposed glazed areas receive adequate shading, but not all, or the shading will only have impact during limited periods.

External shading provided on solar-exposed areas where the glazing provision is ...:*	Full shading	Part shading
On glazed areas > 65% glazing-to-facade	12	6
On glazed areas > 50% glazing-to-facade	8	4
On glazed areas > 35% glazing-to-facade	4	2
On glazed areas below 35% glazing-to-facade, BUT above 10% glazing-to-floor-area	2	1
On rooflights (per rooflight scored under #13) **	2x	1x
On conservatories (top & sides)	8	4

* The scoring for shading should follow the category used when scoring for solar-exposed areas: if the scoring under #13 has been reduced to take account of glazing-to-floor area, then the score for shading should match that e.g. if glazing provision is over 65% of façade area but only 14 risk points are scored because glazing areas are less than 18% floor area, then shading provision should be scored for the ">50%" category i.e. 8 (full) or 4 (part) mitigation points.

** Where a home has multiple rooflights with full shading, the mitigation score should ideally be adjusted to reflect a reduction in half of solar gains i.e. on average, 1.5 points per shaded rooflight rather than 2. The Worked Example "Detached house, London, pre- and post- deep retrofit" illustrates this.

Other forms of solar protection

Solar film / Low g-value (below 0.5) / Internal blinds - on ALL solar exposed areas:	
On glazed areas >65% glazing-to-facade	6
On glazed areas >50% glazing-to-facade	4
On glazed areas >35% glazing-to-facade	2
On glazed areas below 35% glazing-to-facade, BUT above 10% glazing-to-floor-area	1
On rooflights (per rooflight scored under #13)	1
On conservatories (top & sides)	4

Movable shading has benefits as it gives occupants control to balance their needs and preferences for views, privacy, light and glare, as well as solar protection. In some systems it also allows windows to remain open for air flow. However, it does rely on **awareness and behaviour of**

occupants. The feature should therefore be explained in the **User guide**, and the mitigation benefits should only be accounted for if it can be reasonably expected that the fans will be used. In dwellings such as care homes or those occupied by elderly people, it would be cautious to only assume the mitigation points if residents or staff are known to be aware of the devices and have been instructed how and when to operate them.

Figure 34: Examples of movable shading devices. They are used differently across the facade, showing user adaptation and individual preferences; these features can reasonably easily be part of a retrofit. On the bottom left image, external shutters were included in the side extension to the original Georgian house, in a Conservation area.

Figure 35: Examples of shading from balconies and façade articulation

References

http://www.zerocarbonhub.org/sites/default/files/resources/reports/ZCH-OverheatingEvidenceReview.pdf p29 'Glazing area and orientation' and p43 'Solar shading – Windows'

http://www.zerocarbonhub.org/sites/default/files/resources/reports/Understanding_Overheating-Where_to_Start_NF44.pdf p23-24 'Solar shading'

CIBSE': TM37: Design for Improved Solar Shading Control https://www.cibse.org/knowledge/knowledge-items/detail?id=a0q20000008I7eIAAC

BRE - solar shading in buildings https://www.brebookshop.com/details.jsp?id=327972

INFILTRATION, VENTILATION AND EFFECTIVENESS OF OPENINGS

#15 WHAT ARE THE INFILTRATION, BACKGROUND AND PURGE VENTILATION PROVISIONS?

Why?

Ventilation is one of the key measures for mitigating overheating risk. Improving ventilation provision (for both background and purge) is a significant opportunity from retrofit, with benefits for air quality regardless of any overheating risk identified.

Infiltration also contributes to air exchange with the outside but, in the summer, due to different temperature and wind conditions this is likely to be much more limited than in winter, with a much smaller effect than through dedicated ventilation and window openings. The airtightness of the dwelling should however be considered, alongside dedicated ventilation provision for background, purge, and heat dissipation.

In many existing homes, the provisions for background or purge ventilation are not sufficient for air quality purposes. While the latest revision to Approved Document F places more emphasis on ventilation, the requirements do not apply in all cases where works are carried out, and there are still issues of compliance and enforcement, even in new build homes.

Heat recovery on mechanical ventilation systems is an important feature of energy efficient homes, significantly reducing heating demand in the winter by recovering heat from the exhaust air to pre-heat the incoming air. However, in the summer, this can increase overheating risk, for example if outside air is relatively mild and background ventilation would have the potential to dissipate internal heat gains, but the incoming air is instead pre-heated through the recovery system. In homes served by mechanical ventilation with heat recovery (MVHR), an effective summer bypass should be provided, to avoid supplying unnecessarily warm air to the home.

As part of the overheating risk assessment, it is therefore useful to assess existing background air exchange through infiltration and dedicated background ventilation, and to remediate it wherever required.

Figure 36: Examples of restricted window openings - left): Only one of six panes was openable, and only to a limited extent - the flats overheated (GHA Preventing overheating report, 2014); right: only the top 2⁄3 part of windows opens, and the opening is restricted to only a very small gap.

Scoring this question

This question considers the effectiveness of openings by *design*; contextual factors which influence the *likelihood of occupants opening them in practice* are scored separately, in #4.

The scoring for this question considers 3 aspects:

- purge provisions
- infiltration and background ventilation provision
- if there is mechanical ventilation with heat recovery, whether an effective bypass is provided on the heat recovery system.

The project team may not be able to provide calculations at the very early stages of design, when little detail is available on the ventilation systems and the size and design of the openings, however the current situation in the existing home and the design options should be discussed and agreed e.g. likely impact of the works on infiltration and air flow, need for providing additional ventilation, broad types of openings, how to provide secure openings, approach to restrictors (if any). By the time of the planning application (if relevant), it is recommended that initial calculations based on the design proposals should be available (whether or not they are required as early assessments of compliance with Approved Document F).

The scoring should take account of **whether the openings and systems are likely to operate properly in practice** e.g. whether high-level openings are easy to reach and operate; whether sash windows slide well or are "sticky" and heavy to open, which may particularly be an issue for less able occupants; whether instructions on ventilation systems are clear and occupants are aware of how to operate them and how to use features such as MHVR bypass, intermittent fans and trickle vents etc. The retrofit project is a good opportunity to improve ease of use and effectiveness, where openings and systems currently do not operate well or are not used as they could / should. In care homes occupants may be in weak physical condition, or have low sensitivity / awareness of need, so it would be cautious to assume that occupants cannot be relied upon to open windows, but the risk points may be avoided if there is confidence that staff can be relied upon for this.

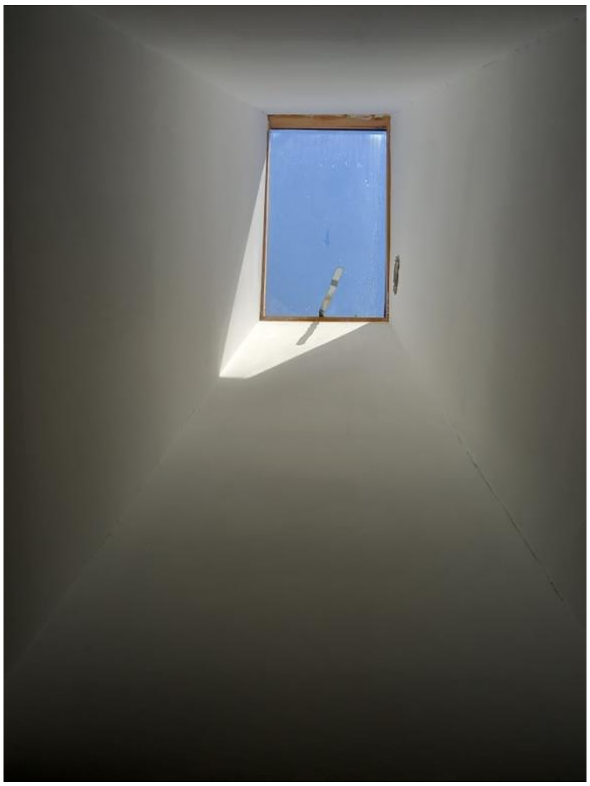

Figure 37: Openings may be available on paper, but in practice difficult to access or operate due to their design, or because the system or feature to operate them is lost or broken e.g. left: a long stick is missing to reach the handle of the high-level opening; right: opening the velux window in this loft conversion involves climbing on the bed and precariously bending over the mezzanine balustrade.

Purge ventilation: Part F and overheating applications

Note that the Approved Document F purge requirements are aimed at situations where high ventilation rates are needed to deal quickly with temporary situations, such as fresh paint or burnt toast. While they may in some cases be used for thermal comfort, this is not what they are intended to address and they may therefore rely on solutions which are not appropriate for longer and more regular use, i.e. to prevent overheating.

It is therefore imperative that proposals for opening sizes and types are discussed with the project team to ensure Approved Document F purge requirements (or

higher) have been considered and can be met alongside other requirements, such as safety and security.

In particular, **restrictors** are often installed on windows for safety or security reasons, and in that case strategies for meeting Approved Document F purge requirements usually assume that restrictors can be overridden for short periods. For the purpose of overheating risk mitigation, overriding restrictors should only be assumed if this can be done while still meeting **best practice recommendations on safety and security** (e.g. those of the Royal Society for the Protection of Accidents and Environmental Health officers, including sill heights). In addition:

- Where restrictors are installed with an override option, they should automatically re-latch once the window is closed
- There should be clear explanations to occupants about the presence of restrictors, how they can be overridden (if applicable), and how they can be re-latched (this should be included in the User guide).

Another example where purge requirements may differ from overheating mitigation strategies is where some rooms may be fitted with mechanical systems to boost ventilation/extract briefly in response to certain activities (e.g. cooking or showering in kitchens and bathrooms). These systems are typically too noisy for occupants to run for long periods (e.g. overnight), and are not sufficient for purging overheating in larger rooms such as bedrooms or living rooms. Proposals for overheating mitigation ventilation to be met purely through mechanical systems (without opening windows) should be treated with much caution - see also Detailed design.

Purge ventilation provisions and effectiveness of openings

This is scored by reference to the minimum requirements for purge ventilation in Building Regulations Approved Document F, whether or not from a strict regulatory perspective they apply to the dwelling / works. As a minimum, the team should satisfy themselves that all habitable rooms meet the minimum purge ventilation requirements of Approved Document F i.e. 4 air changes per hour (ach) can be achieved in all habitable rooms when windows are open:

- Score 8 risk points if there is at least one habitable room where this is not met**
- Score 0 risk points if this is met in all habitable rooms.
- Mitigation points can be awarded for going beyond these provisions – see #16.

** IMPORTANT NOTE: In cases where purge ventilation is assessed NOT to be meet Part F provisions, action is recommended for air quality purposes, whether or not it is required by Building Regulations and regardless of the overheating risk assessment.

Approved Document F (2021 edition, Table 1.4) provides guidance and examples on how that could typically be satisfied:

- Wide openings e.g. hinged or pivot windows with angle over 30 degrees, or opening sash windows, or external doors: total opening provision, per room of at least 1/20th of the floor area
- Narrow openings e.g. hinged or pivot windows with an opening angle of 15-30 degrees:

total opening provision per room of at least 1/10th of the floor area.

Teams would need more detailed calculations and/or expert advice for different types of openings, or smaller openings. ADF states clearly that hinged or pivot windows with an opening angle of less than 15 degrees are not suitable for purge ventilation.

The design of the windows or the application of restrictors can limit the gap created (or 'free area') through which air can flow, and therefore limit the capacity for a dwelling to dissipate heat.

The opening type (top hung, side hung, sash, patio door etc) makes a key difference to how wide a window will open and how well air can flow. Common installations that restrict the air flow include:

- Restrictors installed that cannot be overridden, or which would lead to unsafe openings
- Few small panes openable in larger glazing areas
- Deep reveals limiting the gap obtained when windows open
- Patio doors that don't offer a range of open positions and are therefore unlikely to be left open at night or in unoccupied rooms.

Windows in high rise buildings often have more limited openings due to concerns over high wind speeds or health and safety: well-designed windows can enable good ventilation whilst managing these risks.

Sliding windows or doors, and sash windows can usually achieve large openings in relation to the pane area (up to 50%). Side hung windows can often create wider areas for air flow (potentially the full pane area, if not restricted) than top or bottom hung windows. Some types of folding patio doors allow very large free areas.


Figure 38: Examples of openings providing just under 50% free area: sliding patio door, sash window.

Figure 39: Examples of openings providing up to 90% free area: side-hung patio door; side-hung window

Project teams should also be aware of any heat rejection plant from Air Conditioning units operating nearby as these could significantly increase air temperature in the immediate locality. Openings and air inlets should, as much as possible, be located away from these heat sources, to avoid drawing hot air inside, thereby increasing rather than mitigating the risk of overheating.

See also #4 for examples of openings where security concerns have been addressed.

Infiltration and background ventilation

Scoring is as follows:

- 0 risk points: Very leaky building e.g. at least 3 leaky features, out of: fireplace(s); suspended uninsulated timber floors; cat flap; unsealed letter box through door; no or poor sealing around doors and windows. If an air permeability test was carried out, this could typically be applied to buildings with air permeability >12 $m^3/m^2/hr$ at 50Pa.
- 0 risk points: Average or very airtight building, but with suitable background ventilation provision (natural or mechanical), at least equivalent to Part F requirements. When occupants are known, it is useful to check whether the system operates properly e.g. occupants may not be aware of or may not use features such as MHVR, fans or trickle vents.
- 1 risk point: Average airtightness, WITHOUT suitable background ventilation provision meeting Part F requirements** e.g. no "high leak" feature (fireplace; suspended uninsulated timber floors; cat flap; unsealed letter box through door); general sealing around windows and doors. If an air permeability test was carried out, this could typically be applied to buildings with air permeability of 5-10 $m^3/m^2/hr$ at 50Pa

- 2 risk points: Very airtight building, WITHOUT suitable background ventilation provision meeting Part F requirements**. This would apply to exemplar retrofits, with air permeability equivalent to best practice new build. If an air permeability test was carried out, this could typically be applied to buildings with air permeability below 3m^3/m^2/hr at 50Pa.

The scoring approach is not an "exact" science: Where airtightness levels or the number of "leaky" features do not fall within the indicative bands, it is up to the tool user which way to score, depending on whether they want to take a cautious approach or not, and taking account of other characteristics of the building which may not be accounted for here.

** IMPORTANT NOTE: In cases where background ventilation is assessed NOT to meet Part F provisions, action is recommended for air quality purposes, whether or not it is required by Building Regulations and regardless of the overheating risk assessment.

Info box: summary on Approved Document F requirements for existing homes (2021 edition, in force from June 2022)

The latest revision of AD-F places more emphasis on suitable ventilation provision. While §3.2 seems to provide flexibility not to meet standards, §3.6 emphasises the need to meet minimum standards. One important gap however is in the case of works which do not affect the ventilation provision: there is no overall requirement to bring the ventilation provision to standard in all cases, when works are done to a dwelling.

§3.1 "When building work in an existing dwelling includes work on ventilation, for example:
a. adding a habitable room
b. adding a wet room
c. replacing part of the ventilation system, including extract fans
the work should meet the relevant standards in this approved document."

§ 3.2 When other building work is carried out that will affect the ventilation of the existing dwelling, for example:
a. replacing a window or door
b. doing energy efficiency work
the ventilation of the dwelling should either:
a. meet the standards in the relevant approved document
b. not be less satisfactory than before the work was carried out."

§3.6: "**Building work should not reduce the ventilation provision of the dwelling unless it can be demonstrated that the ventilation provision after the work is carried out meets the minimum standards of requirement F1(1)**."

§3.7 "When carrying out energy efficiency measures to an existing dwelling, an assessment should determine what, if any, additional ventilation provision is needed, based on the estimated impact of the work. The assessment should be carried out by one of the following means.
a. Applying the simplified method in paragraphs 3.8 to 3.13.

b. Seeking expert advice, which may include carrying out an air permeability test that follows the procedures given in Approved Document L, Volume 1: Dwellings."

The simplified method (3.7.a) assumes that the existing dwelling has adequate means of ventilation, through a combination of infiltration and purpose-provided ventilation.

Mechanical air inlets likely to increase risk

The scoring should also consider whether the air brought in by mechanical systems is likely to be hot (hotter than general outside conditions) and itself increase risk. Risk points should be attributed as follows:

- Mechanical air inlet located near heat rejection plant (e.g. from that dwelling or from neighbourhood properties): 4 points if this affects 1 inlet, 8 points if this affects 2 or more inlets
- Mechanical Ventilation with Heat Recovery, if there is no confidence that an effective summer bypass system is in place: 4 points.

There is a wide variety of bypass systems available, which is why their provision in itself is no guarantee that it will be effective. The manufacturer's information should be queried (it is often unclear). Features to watch out for include:

- Whether it is a full bypass, or partial. Some units stating "bypass" or "summer mode" merely reduce the supply air, which is not desirable for fresh air purposes.
- How it is controlled: this is often not explained in the manufacturer's information; it is sometimes on the external temperature, or on extract temperature. Ideally, the bypass should be activated if the extract temperature is higher than a setpoint ***and*** higher than the external temperature. Some units even offer a "cool recovery" function, activated when inside temperatures are lower than external (but above a certain setpoint i.e. not in the heating season).

Mitigation

Ventilation provision is a really important area where works to existing homes can improve overall environmental conditions, including air quality, overheating, and possibly noise (e.g. if systems were previously noisy because of poor installation). Bringing homes to minimum ventilation requirements should be an essential part of the works, whether or not it is strictly required by Building Regulations, and regardless of the assessed overheating risk.

On the other hand, an ill-thought-through retrofit can also create risks by reducing the effective opening area. For example, if adding secondary glazing to existing windows, the resultant effective area may be reduced: how both layers will work together, and the resulting effective area, need to be considered carefully.

Figure 40: Example of secondary glazing added to sash window: (left) before, (right) after: the bespoke secondary glazing was made to match the lines of the original, and the bottom pane slides up, but the overall opening is likely to be less effective compared to the highly effective bottom & top openings possible from original sash windows. Thanks to the slimline profile of the secondary glazing, it was possible to retain the internal shutters.

Figure 41: Examples of much more energy efficient doors pre- (left and middle) and post (right) retrofit: the new ones are less leaky and double glazed (and without the cat flap), but still have high-level openings for night-time ventilation

Additional mitigation points can be awarded for going beyond minimum provision – see #16.

While a more airtight dwelling may contribute to increasing overheating risk, it will not be the reason on its own, and the effect is in any case likely to be quite small. Therefore, it is NOT recommended that poorer airtightness should be sought for the purpose of overheating risk mitigation. The focus should instead be on providing suitable ventilation, protecting against excessive summer solar gains, and other risk mitigation measures.

References

Evidence of poor compliance with ADF requirements: Aecom Limited, research for Ministry of Housing, Communities and Local Government, Ventilation and Indoor Air Quality in New Homes, September 2019.

Only 2 of the 55 naturally-ventilated homes studied met the ADF guidance (2010 revision) with respect both to trickle ventilator provision and intermittent extract fan air flow rates; Only one of the 25 homes with continuous mechanical extract visited met the ADF guidance with respect to both continuous extract fan air flow rates and trickle ventilator provision.

ADF requirements from June 2022: Building Regulations 2010, Approved Document F, 2021 edition

#16 DO WINDOWS AND OPENINGS SUPPORT EFFECTIVE VENTILATION?

Why?

As noted in #15, ventilation is one of the key measures for mitigating overheating risk. While meeting minimum requirements is essential, there are benefits in going beyond. Large and widely openable windows or other openings help create good air flow and a pleasant breeze in hot weather. More generous openings tend to be especially important in warmer parts of the country, where more air exchange may be needed to purge internal heat, and in more sheltered locations, where air flow through openings may be more limited.

Scoring this question

A core assumption here is that all dwellings should have openings in all habitable rooms, whether or not they have mechanical ventilation. Schemes where this is not the case should be treated with extreme caution and are NOT recommended.

The scoring for this question is done by reference to the minimum requirements for purge ventilation in Building Regulations Approved Document F: see details in #15. As for question #15, it is important to consider how easy it is likely to be for occupants to operate the openings and features e.g. ventilation systems with simple instructions, openings which are easy to reach, sash windows which are not too heavy and which slide well etc.

Mitigation points can be awarded if the size and design of openings go beyond the minimum purge requirements of Building Regulations Approved Document F (referred to as Part F here for simplicity), as follows:

	= Part F	**+ 50% compared to Part F**	**+ 100% compared to Part F**
	To be achieved in each habitable room	to be achieved for each habitable room	may be achieved as a total for the dwelling, as long as each habitable room meets the 50% requirements
Single aspect	**minimum required - see scoring in #15**	**6**	**8**
Corner aspect		**5**	**7**
Dual aspect		**4**	**6**

These points are awarded on the basis of the *design* of openings, even if the site is considered to have barriers to window openings (as assessed under #4), because these site characteristics may change in the future, or not affect all occupants in the same way (e.g. some people are more/less sensitive to noise), and because it helps build resilience in the design. In addition, larger or more effective openings may reduce the amount of time windows need to be left open for, thus decreasing the impact of some of these barriers.

In Northern England, Scotland and Northern Ireland, night-time ventilation can be particularly beneficial in purging heat as night-time air is particularly cool. In these locations, if the user is confident that effective night-time ventilation will be practiced by occupants, additional mitigation points may be attributed to take account of this beneficial effect (e.g. 50% more than in the standard scoring). This should be applied cautiously, in a project-specific manner in discussion with the project team and ideally the residents, rather than relied upon by default - for example, this could be part of scenario testing.

References

http://www.zerocarbonhub.org/sites/default/files/resources/reports/Understanding_Overheating-Where_to_Start_NF44.pdf page p18 ‘Restricted ventilation’, p21 ‘Window design’ and p22 ‘Secure ventilation’

http://www.zerocarbonhub.org/sites/default/files/resources/reports/ZCH-OverheatingEvidenceReview.pdf p53 ‘Natural ventilation’

Natural ventilation in non-domestic buildings, CIBSE Applications Manual AM10:2005
http://www.zerocarbonhub.org/sites/default/files/resources/reports/Understanding_Overheating-Where_to_Start_NF44.pdf p28 ‘Case study 3’

ENERGY EFFICIENCY CHARACTERISTICS

This section attributes risks and mitigation points according to the main energy efficiency characteristics of the home (except airtightness, which is considered alongside ventilation under question #15). Energy efficiency characteristics considered here are of two types:

- The efficiency of the heating and water system, which contributes to internal heat gains
- Fabric efficiency.

Generally speaking, improving energy efficiency of the heating system will reduce internal heat gains and therefore it will be beneficial in reducing overheating risk.

The effects of fabric energy efficiency (e.g. insulation and high-performing windows) on overheating can vary:

- When the temperature outside is higher than inside, insulation can be beneficial in limiting heat exchange with the outside
- External insulation can protect roofs and wall surfaces from accumulating heat from solar radiation
- However, in a home which already overheats (for example due to excessive solar gains and/or poor ventilation), then high insulation levels may exacerbate the issue, by reducing heat dissipation.

In many existing homes, fabric efficiency characteristics will vary across rooms and envelope elements: some walls may have been insulated as part of an extension, or windows changed in some rooms over time. Moreover, efficiency characteristics in existing dwellings are often not known with certainty, especially at the early stages without detailed investigations. It is up to the tool user which way to score, depending on whether they want to take an average, cautious or optimistic scoring approach across the building or dwelling. Ideally, this would be part of the scenario testing, to get a sense for how sensitive the risk assessment is to assumptions.

#17 - DOES THE HEATING SYSTEM CREATE A HIGH RISK OF INTERNAL HEAT GAINS?

Why?

Centralised heating systems (e.g. per block or scheme) can contribute to overheating risk through issues including lack of individual controls, and heat gains from distribution pipework and Heat Interface Units (HIUs). This heat is often released 24/7 and, when this happens in internal spaces which are not well ventilated (such as internal corridors), it accumulates and can significantly contribute to overheating of these and neighbouring occupied spaces.

Individual systems, if they are poorly insulated and controlled, can also contribute to overheating risk, particularly if there is a hot water store within the dwelling.

Scoring this question

The scoring should consider both space heating and domestic hot water provision.

Communal / district schemes: Up to 7 risk points:

This applies where dwellings are heated by a system that covers multiple units, thus requiring pipework to distribute hot water for space heating and domestic hot water all year.

Two scoring routes are available, depending on the information available on the communal / district scheme.

Scoring route 1: if little information is available on the scheme:

- Score 7 risk points for unknown or existing schemes i.e. unlikely to be best practice
- Score 2 risk points for best practice schemes e.g. following CIBSE CP1 "Best Practice", or ambient loop, and no hot water store in apartments.

Scoring route 2: if information on the scheme is available:

- Score 2 for long corridors without overheating mitigation, 1 for corridors with effective overheating mitigation (e.g. ventilation), 0 for very short/no internal corridors, or water circulating through corridors and communal areas at low temperature (i.e. ambient loop scheme with heat pump in each apartment so water temperature is only raised in the dwellings)
- PLUS Score 3 for poorly insulated hot water store, 1 for well insulated store, and 0 for no store
- PLUS Score 1 for poorly insulated distribution pipework (incl. HIU), 0 for well insulated (lagged) distribution (incl. HIU)

- PLUS Score 1 for poor controls e.g. temperature and hours when the heating is on is controlled centrally, with little or no possibility for occupants to adjust / switch off, 0 for good controls i.e. occupants can control the timing and level of heating in their dwelling.

Individual heating and hot water systems: Up to 5 risk points:

- Score 3 for poorly insulated hot water store, 1 for well insulated store, and 0 for no store
- PLUS Score 1 for poorly insulated / long distribution, 0 for insulated / efficient distribution
- PLUS Score 1 for poor controls, 0 for good controls.

In the case of instantaneous electric space heating systems, i.e. with no store, no distribution, and straightforward controls, no risk points are allocated to space heating provision but the scoring also needs to consider hot water provision, and how that is stored and distributed.

Electric storage heating systems should typically be scored as having poor controls, unless there is high confidence that the users do / will find them straightforward to use and control e.g. evidence from a site visit or user feedback, or from detailed design information (e.g. pictures of control panels, extracts from the Home User Guide) showing that the systems have been designed to be simple-to-use and intuitive and to provide a good level of control to occupants.

Mitigation

This is an important area where retrofit measures can improve energy efficiency at the same time as reducing overheating risk. A number of mitigation measures are available including:

- Early planning to minimise pipe runs, particularly in enclosed areas such as hallways and corridors
- Ventilating any enclosed areas where heat is likely to accumulate (e.g. with actuated louvres or mechanical extract) to avoid the gradual build-up of heat. This would include corridors and risers with pipework, and areas where the HIU and associated storage (if any) are located. To a very large extent, these measures will also align with energy efficiency considerations i.e. reducing unwanted heat losses through distribution and storage - see references for guidance on good practice.
- Insulation to hot water pipework, HIUs and storage vessels
- Lower flow temperatures, following current best practice or moving towards systems circulating water at even lower temperatures, such as “ambient loops”.
- More efficient control strategies

References

Evidence of risk:

http://www.zerocarbonhub.org/sites/default/files/resources/reports/ZCH-OverheatingEvidenceReview.pdf p51 ‘Central distribution systems’

https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/7604/2185850.pdf
DCLG Investigation into Overheating in Homes Literature Review 2012 (Aecom): "The strongest single message is that overheating is occurring as a result of community/district heating systems in apartment buildings, where unintended heat losses due to a lack of insulation is resulting in problems in some parts of some buildings, especially corridors."

Design guidance:

CIBSE & Association for Decentralised Energy (ADE), CP1, Heat Networks: Code of Practice for the UK, 2020

CIBSE District Heating: Design Guide, 2021

CIBSE Domestic Heating Design Guide, 2021

#18 WALL INSULATION

Why?

The effects of wall insulation vary and can be complex and context dependent. In some cases, wall insulation will be beneficial: for example, if outside air is hotter than inside, insulation will be beneficial by reducing heat exchange with the outside; external insulation and a new cladding on a south-facing wall may prevent it from getting very hot. However, in a home which already overheats (for example due to excessive solar gains and/or poor ventilation), then the indoor temperature may rise above the outdoor one, and in that case high insulation levels may exacerbate the issue, by preventing heat from escaping.

Scoring this question

- Walls which are un-insulated, or only with poor / partial insulation: 0 risk points
- Walls with external wall insulation (EWI): 0 risk points: this is because, from the current state of evidence, the effect of EWI is context-dependent and often beneficial. In some cases EWI may reduce overheating risk, for example if applied to a south-facing brick wall which could otherwise become quite hot in the summer. Tool users may decide to score this differently as part of their scenario testing.
- Internal or cavity wall insulation: 1 risk point. This is because, as for EWI, internal or cavity wall insulation may exacerbate overheating by preventing heat from escaping, but it does not have the potential benefits of protecting the external wall from getting hot.

Note that the application of insulation may also affect scoring in other questions:

- While walls are not identified in the tool as a “high leak” feature, well-applied insulation over a majority of the walls is likely to improve airtightness, and could therefore be part of considerations under #15.
- The application of EWI may also lead to a change in the albedo of surfaces e.g. covering a previously dark brick wall with light coloured render or light timber – this should be scored under #5.
- Internal wall insulation may cover previously exposed thermal mass - this should be scored under #11.

Mitigation

The effect of wall insulation on overheating is likely to be small compared to other measures; indoor-outdoor temperature differences in the summer are smaller than in winter, so the benefits of wall insulation in winter are likely to be much more important than the effect in summer. Wall insulation levels are therefore considered here as part of the overall overheating risk assessment, but other measures should be considered in much higher priority to mitigate overheating risk, rather than limiting wall insulation.

References

Prevalence of overheating with energy efficiency measures: Lomas K., Watson S., Allinson D., Fateh A., Beaumont A., Allen J., Foster H., Garrett H., *Dwelling and household characteristics' influence on reported and measured summertime overheating: a glimpse of a mild climate in the 2050's*, Building and Environment, 2021

Fosas D., Coley D. A., Natarajan S., Herrera M., Fosas de Pando M., Ramallo-Gonzalez A., *Mitigation versus adaptation: Does insulating dwellings increase overheating risk?*, Building and Environment, 2018

#19 ROOF AND LOFT INSULATION?

Why?

Roofs can be an important source of heat gains, as they are typically quite exposed to solar gains and often are of a material which can reach high temperatures. This is particularly a problem for dwellings or rooms located just underneath, if roofs are poorly insulated.

Scoring this question

Risk points should be allocated as follows:

- Houses, bungalows, top floor flats: . up to 3 points in total:
    - 2 risk points if no or minimal insulation (e.g. <50mm), PLUS
    - 1 risk point if roof covering is likely to get hot e.g. lead, dark bitumen.
- Houses, bungalows, top floor flats: up to 2 risk points in total:
    - 1 risk point if some insulation (e.g. >100mm), PLUS
    - 1 risk point if roof covering likely to get hot e.g. lead, dark bitumen
- Houses, bungalows, top floor flats: 0 risk points if new build levels of insulation e.g. new loft roof, exemplar retrofit.
- All flats except top floor flats: 0 risk points

The scoring approach is not an "exact" science: where insulation levels sit between the indicative bands, it is up to the tool user whichever way to score, depending on whether they want to take a "worse case" cautious approach or not. Projects that include converting an attic should give more focus to this question, as this could significantly affect temperatures in the top floor rooms.

Figure 42: Green roof installed as part of a loft extension, replacing the previous sloped concrete roof covering

Figure 43: Wood fibre roof insulation being applied

Mitigation

Retrofit projects are a good opportunity to improve roof insulation, mitigating overheating risk as well as improving energy efficiency in the heating season.

A change in roof covering in the retrofit is also an opportunity to change the albedo of the roof, for example for a light-coloured paint or green roof. This can also contribute to the scoring of #5, particularly on individual dwellings (on larger buildings, the other surrounding surfaces are more expansive and more important, relatively).

References

Prevalence of overheating with roof/loft insulation: Lomas K., Watson S., Allinson D., Fateh A., Beaumont A., Allen J., Foster H., Garrett H., *Dwelling and household characteristics' influence on reported and measured summertime overheating: a glimpse of a mild climate in the 2050's*, Building and Environment, 2021

Fosas D., Coley D. A., Natarajan S., Herrera M., Fosas de Pando M., Ramallo-Gonzalez A., *Mitigation versus adaptation: Does insulating dwellings increase overheating risk?*, Building and Environment, 2018

#20 WINDOWS

Why?

Windows with good thermal performance, i.e. low U-value, help retain useful heat in the winter. In the summer, this can contribute to retaining heat indoors, although this will vary since windows will often be open.

Scoring this question

- Single glazed: 0 risk points (but do consider the g-value, which may be high: this is scored under #13)
- Existing double glazed, or single + secondary: 2 risk points
- Deep retrofit - new-ish equivalent i.e. very good recent 2-glazed with good frame, 3-glazed: 3 risk points.

This question considers the effect of windows through their U-value. Solar control properties (g-value) are considered under the solar gains and protection questions #13 and #14.

In most existing homes, there will be a mix of window types. It is up to the tool user how to score e.g. as an average for the majority of windows for an early indication, or for the worst case to be more cautious.

Note that interventions on windows are also likely to have impacts on the effectiveness of air flow, and this is a much more important consideration. The retrofit offers opportunities (see Mitigation section below) but may also create risks such as affecting the effective opening area – see #15 and #16.

Mitigation

The benefits of high-performance windows which retain useful heat in winter and do not create cold uncomfortable surfaces usually far outweigh the increased risk from heat retention in summer. The replacement of windows is also an opportunity for important improvements e.g. repairing sash windows which do not operate properly, selecting replacement windows which provide a more effective air path, greater / more flexible opening areas or which can be opened securely at night for cooling etc.

The impact of window U-value is therefore considered here as part of the overall overheating risk assessment, but other measures should be considered in much higher priority to mitigate overheating risk, rather than limiting the thermal performance of windows.

References

Prevalence of overheating with double glazed windows: Lomas K., Watson S., Allinson D., Fateh A., Beaumont A., Allen J., Foster H., Garrett H., *Dwelling and household characteristics' influence on reported and measured summertime overheating: a glimpse of a mild climate in the 2050's*, Building and Environment, 2021

Fosas D., Coley D. A., Natarajan S., Herrera M., Fosas de Pando M., Ramallo-Gonzalez A., *Mitigation versus adaptation: Does insulating dwellings increase overheating risk?*, Building and Environment, 2018

#21 GROUND FLOOR INSULATION

Why?

Ground temperature is relatively stable throughout the year, and in the summer can provide a useful source of coolth.

Scoring this question

Mitigation points should be allocated as follows:

- Houses, bungalows, ground floor flats: Un-insulated suspended floor, ventilated: 2 mitigation points
- Houses, bungalows, ground floor flats: Un-insulated slab, or minimal insulation: 1 mitigation point
- Houses, bungalows, ground floor flats: Insulated slab, or insulated suspended floor: 0 mitigation point
- All upper floor flats: 0 mitigation point.

Figure 44: Suspended timber floors can be a significant leak feature, as illustrated by this plastic sheet covering the floor during works, blown from air rising from beneath

Mitigation

The effect of ground floor insulation on overheating is likely to be small compared to other measures; indoor-outdoor temperature differences in the summer are smaller than in winter, so the benefits of insulation in winter are likely to be much more important than the effect in summer. Ground floor insulation levels are therefore considered here as part of the overall overheating risk assessment, but other measures should be considered in much higher priority to mitigate overheating risk, rather than limiting ground floor insulation.

References

Fosas D., Coley D. A., Natarajan S., Herrera M., Fosas de Pando M., Ramallo-Gonzalez A., *Mitigation versus adaptation: Does insulating dwellings increase overheating risk?*, Building and Environment, 2018

NEXT STEPS

Once a scheme has been assessed using this tool and guidance, a number of options are available depending on the level of overheating risk estimated:

- **Low risk:** the team should commit that the key overheating mitigation characteristics of the scheme will be maintained throughout design development to ensure a balance between heat gains and heat dissipation opportunities. Where the project is subject to a planning application, this may be secured by planning condition.

- **Medium risk:** Action is recommended to reduce risk, unless a detailed assessment brings confidence to the team that detailed characteristics and circumstances not accounted for in this tool would, in practice, bring risk to low levels. The scoring may help the team identify opportunities to reduce risk factors and improve mitigation factors, or this may be assessed through more detailed tools (e.g. dynamic thermal modelling against CIBSE TM59).

- **High risk:** a high score means there are likely to be a number of easily identifiable risk factors and/or a lack of mitigation factors, which should enable the project team to determine and incorporate design changes to improve heat balance, before a more detailed assessment (e.g. CIBSE TM59) and detailed design work are carried out. This should save time and resources in detailed modelling and design work for where it adds most value.

In all cases, there will be measures that can be looked into at the detailed design stage - see detailed design guidance.

In general, it is strongly recommended that overheating risk is mitigated **prior to** planning submission and approval, as some schemes may find it difficult to incorporate design changes afterwards (e.g. changing glazing areas or incorporating external shading). This is certainly the case if a "high" level of risk has been identified. Once the project team and local authority are satisfied that the risk of overheating has been mitigated, either through the use of this tool or through an additional assessment, the characteristics of the scheme should be secured through planning condition and checked at completion.

If the team are satisfied that overheating risk can be addressed through design changes that will not affect planning permission, it is recommended to condition the production of a detailed overheating risk assessment with satisfactory results - see guidance below.

Detailed design

There are a number of measures that contribute to or mitigate overheating risk, which are not explored in this tool due to its relative simplicity and its intent to focus on strategic early stage decisions.

These include:

- Mechanical ventilation beyond Part F provision: If mechanical ventilation is provided, this will usually provide background ventilation only, and will be insufficient for the purpose of overheating risk mitigation (by an order of magnitude). In some cases, the team may put forward an increased mechanical ventilation rate. This should be examined with caution to ensure the proposed ventilation rates can indeed be delivered, and that there are no adverse effects, especially noise for the occupants which may deter them from using the system, particularly at night. This type of solution should only be relied upon if subject to a detailed overheating assessment, including the advice from an acoustic specialist.
- Mechanical cooling: as explained in the context for this guidance (**Why not just install cooling?**), it is imperative that overheating risk is reduced as much as possible via passive means before mechanical cooling solutions are considered. If such solutions are installed, they should high efficiency to minimise energy use, not be over-sized, and the location of heat rejection plant should be carefully considered to avoid noise and heat rejection issues for neighbouring areas.
- Detailed thermal mass considerations, for example the effect of insulation which itself may have relatively high thermal mass, such as wood fibre. Such measures on their own may have a small impact, but cumulatively could make a difference, particularly on retrofit projects where other measures are constrained.

If planning consent relies on a detailed overheating risk assessment which takes account of such detailed design measures, this should be conditioned and checked at completion.

Detailed overheating risk assessments

If an overheating risk assessment using more detailed tools and methodologies is carried out, such as dynamic modelling against CIBSE TM59, it is recommended that this is informed by an initial GHA tool assessment, in particular with regards to site characteristics. For example, if it has been established that there are likely barriers to occupants opening windows, this should be reflected in the model set-up. Note this is not possible for all parameters as, although software packages typically take account of weather files, and of Urban Heat Island effects in London, they rarely include more local effects such as green / blue infrastructure or surface characteristics which are considered in this tool.

CIBSE TM59 is currently the most established methodology and it is therefore covered in more detail here. When an assessment against CIBSE TM59 is carried out, the following information should be included in the report:

- Site location and orientation; weather files used should be reasonably local to the site location and be CIBSE 2020 DSY1 files
- Images of the model indicating the sample units selected and the basis for selection
- Images showing the internal layouts for the sample units
- Occupancy levels; profiles should follow the TM59 24/7 levels and not be bespoke
- Information on the construction type with layers of construction (used to determine U-values and g-values) for all external and internal building elements, plus any additional shading features (including any blinds, and demonstrating that the blinds do not clash with opening windows if blinds are used to contribute to a pass). If blinds are assumed these must be installed by the developer and not left for occupants.
- Thermal mass, with an explanation of where the thermal mass is incorporated in the construction, and confirmation that it is exposed (i.e. not covered in plasterboard)
- The ventilation strategy modelled, including details of window opening assumptions and how they relate to the site assessment (including noise levels), free areas calculated, infiltration rates assumed and any mechanical supply/extract flow rates;
- The thermal comfort category assumed based on CIBSE TM52 (2013); this should be Cat. II by default, but Cat. I for vulnerable residents (see section 4.4). Cat. III for existing buildings should not be used for the purposes of this methodology.
- The results of the analysis:
    - reports should be clearly reported based on criteria (a) and (b) in section 4.2
    - corridors should be included where there is communal heating pipework
    - the report may include the results for several iterations explored, to demonstrate the route to compliance
    - if blinds were part of the strategy used to gain a pass, then results without blinds must also be included for information
    - the report should state clearly whether the project passes or fails the assessment and, where a pass is indicated, it should make clear on what design features this depends (e.g. the inclusion of glazing with g-value below x, reduced window sizes, etc). A unit is only shown to comply if all occupied spaces meet relevant overheating criteria.

User guide

It is good practice to produce a user guide that explains to occupants the key features of the scheme; this should be a short and visual document in simple language. It should cover measures they can take to prevent overheating in their home and include as a very minimum information on how to operate all mitigation features which rely on occupant behaviour e.g. external shading, thermal mass. These are highlighted in relevant sections of this guidance, and an overview is provided in ***Figure 4***. Additional measures may be included on a project-specific basis. Typically, this will include (but not be limited to):

- Simple concepts and tips, such as the benefits of cross-ventilation and of utilising the stack effect, if present
- Presence and operation of secure openings that can help ventilation at night or when occupants are not in the room e.g. side panels, window locks
- Presence and operation of movable shading devices
- Presence and operation of thermal mass and nigh-time ventilation
- Presence and operation of ceiling fans, or the ability to install them in the future, and advice on hydration
- Specific advice for vulnerable residents
- How to operation mechanical ventilation systems, including summer bypass if present. The guide should also explain the importance of changing filters and maintaining mechanical ventilation systems: while not an overheating mitigation measure on its own as the ventilation rates will typically be low, low ventilation rates (or systems switched off) due to poorly maintained systems can contribute to high temperatures.

WORKED EXAMPLES

A number of worked examples are available which illustrate the use of the tool in a variety of situations, with notes explaining the scoring. This section summarises the key characteristics of interest in each example. The examples are available as tabs within the downloadable tool spreadsheet.

1 - Victorian end terrace, London, Retrofit and loft extension

- North-South dual aspect small house, retrofit with more highly glazed mansard roof extension; high-level night time openings; known occupant
- Scoring for mix of characteristics across the house (insulation levels, types of windows), and accounting for top floor extensions in a range of questions (e.g. occupancy score, glazing, shading, constraints on window openings etc)
- Compared with in-use feedback

2 - Victorian mid-terrace, London, Existing

- East-West dual aspect family house, back and top floor extensions; known occupants
- Compared with in-use feedback

3 - Georgian semi-detached house, London, Deep retrofit

- Deep retrofit of Georgian semi-detached house; known occupants
- Compared with in-use feedback and temperature monitoring

4 - Victorian end terrace, Midlands, Retrofit

- Retrofit of Victorian cottage
- Impact of energy efficiency and window improvements, and risks of restricted openings through retrofit

5 - Deep retrofit, Detached house, London

- Deep retrofit of detached house, North-South dual aspect; known occupants
- Impact of new rooflights, with and without external shading
- Compared with in-use feedback

6 - Existing end terrace house, retrofit being planned

- Existing 1960s house planning a retrofit; known occupants
- Compared with in-use feedback

7 - Existing flat, Paris, Impact of occupants

- North-South dual aspect deep apartment, community heating, known occupant
- Impact of occupant behaviour: scored "on plan" for average occupant and "as occupied" with occupant actively managing air flow
- Compared with in-use feedback

8 - Existing flat, Paris, Impact of enclosed glazed balcony

- South East-West corner apartment, community heating, known occupant
- Impact of glazed balcony on solar gains as well as air flow
- Compared with in-use feedback

9 - Block of flats, Northern England

- Single aspect (East or West) flats in North of England
- Opportunities for reduction of overheating risk through improvements to ventilation
- An example where detailed modelling can be useful following the initial assessment with the GHA tool
- Compared with in-use feedback pre-retrofit, and TM59 modelling post-retrofit

10 - 1950s block of flats, Great Yarmouth, Deep retrofit

- Deep retrofit of 1950s block of flats
- Compared with in-use feedback