Greenlite Energy Assessors Guide to Avoiding Overheating in Buildings

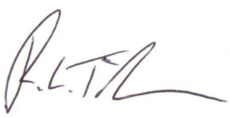
A Concise Guide for Clients, Architects, M&E Engineers & Specifiers to Avoid the Risks of Overheating in New Buildings.

Introduction

Greenlite Energy Assessors have been involved in carrying out overheating analyses of buildings using computational thermo-dynamic modelling for over five years. During that time we have come to understand the common errors made on part of clients, architects, M&E engineers and specifiers, which can often lead to overheating problems.

Though there are documents available which provide definitions for overheating and an explanation as to how these have come about, there are few concise guides which provide design teams with the holistic design information needed to avoid overheating problems in the first instance.

This guide is intended as an 'Overheating Avoidance 101', covering ten top tips we commonly see as the root cause for overheating in modern buildings. By implementing these recommendations, it is hoped that readers of this report will be better equipped with the knowledge required to design buildings free from overheating issues.



Richard Tibenham. Director of Greenlite Energy Assessors.

1. Define and Understand What 'Overheating' Means

The first step to avoiding overheating is to define what the term overheating means, as it can be interpreted in a number of ways.

Agreement on this definition serves all parties involved. Its sets a design performance standard to work towards, and it sets a definition which can be tested and deemed 'overheating' if not satisfied.

Without a definition for overheating in place, it is more difficult to argue that the building is 'overheating', as no agreement has been made defining what this terms means.

The fact that several building occupants find a building uncomfortably hot is not necessarily an indication that a building is overheating, though it is of relevance. When defining a performance standard for overheating, it is important to consider not only what the minimum performance standard is, but also what the user expectations might be. If building users are accustomed to an air conditioned environment, then their expectations will probably be higher than those accustomed to a naturally ventilated environment.

There are several definitions for overheating used within the industry. These are:

CIBSE Guide A:

The definition for overheating contained within CIBSE Guide A can be found in Table 1.8 *'Benchmark summer peak temperatures and overheating criteria'*. The criteria contains a definition for overheating which is commonly referred to in the industry; *'no more than 1% occupied time above a threshold temperature of 28°C, or 26°C in bedrooms'*.

When implementing the CIBSE Guide A overheating definition, two aspects are important to understand;

1. The definition applies to 'occupied time' only. As such, this will probably be a theoretical period. The design team should agree on when the occupied period is. For college buildings for instance, the building may not be occupied during late July and August. For bedrooms, is occupancy during the day necessary to account for or not?

2. The definition is only applicable to areas considered to be 'occupied spaces', which is typically defined as an area which is occupied for a period of more than thirty minutes at any one time. The areas which are applicable to overheating analysis should be defined. Although some areas may not be occupied areas, overheating may still be considered unacceptable. This should be defined within the contract.

The definition has been given in CIBSE Guide A since at least 2006 and is now superseded by several more, arguably more appropriate, overheating definitions. Of all the commonly used definitions for overheating, CIBSE Guide A is one of the more easy to achieve, though may not be so beneficial to building occupants. It should be considered if 1% occupied time above 28°C is acceptable. Many building occupants will be uncomfortable well below this temperature.

CIBSE TM52:

The overheating criteria contained with CIBSE TM52 is far more involved than that contained within Guide A and incurs a greater onus on the design team to achieve a more thermally comfortable building.

The definition includes three criteria which cover 'hours of exceedance' (beyond a calculated threshold), 'daily weighted exceedance' and an 'upper temperature limit'.

Two of the three criteria must be satisfied.

Of the overheating definitions commonly used, CIBSE TM52 provides a more stringent thermal comfort target and as such places a greater onus on the design team to achieve the higher standards.

As with CIBSE Guide A, it is important to confirm which rooms are applicable to the overheating criteria.

HTM03-01:

Healthcare Technical Memorandum 03-01 contains a similar definition to overheating as CIBSE Guide A, though rather than 1% of occupied time, this guide refers to *'50hrs occupied time above 28°C'.*

This definition is specifically applicable to 'clinical areas' only within healthcare buildings.

Similar to the definitions above, it is important to confirm which areas are considered 'clinical areas' and what constitutes 'occupied time'.

In terms of performance, the definition provides similar results to CIBSE Guide A.

Building Bulletin 101:

Building Bulletin 101 (BB101) is a ventilation guide for schools, though it also includes a criteria for overheating. The definition within BB101 is *'no more than 120 occupied hours above 28°C, never exceeding 32°C and no more than an average 5°C temperature differential from inside to outside'.* The code is compulsory for school buildings, though it can be implemented successfully on other building types.

The overheating criteria is quite relaxed by comparison to other codes, and some building occupants may be uncomfortable at these temperatures. For this reason, sometimes school schemes utilise BB101 alongside more stringent codes such as CIBSE TM52.

BREEAM (2014) Hea04; Thermal Comfort:

BREEAM 2014 does not contain a definition for overheating in itself, however it does reference other industry codes.

Under the previous BREEAM 2011 code, the definition used within the thermal comfort credit (then Hea03) was CIBSE Guide A or a 'relevant industry standard'.

CIBSE Guide A became implemented as the common standard, though being not particularly demanding, some building types were found to experience higher than preferable internal temperatures.

Under the BREEAM 2014 code, this has been replaced with more stringent requirements. **Anyone intending to target BREEAM 2014 credit Hea04 should be aware of the implications this has.**

Under BREEAM 2014, for all buildings, Hea 04 is now subject to CIBSE Guide A or a relevant industry standard, and predictive mean vote (PMV) and percentage of people dissatisfied (PPD) metrics against ISO 7730:2005. **For non-mechanically cooled buildings, CIBSE TM52 is also a requirement.**

2. Do not Rely on the Building Regulations to Avoid Overheating

Many in the industry are under the false impression that the Building Regulations Part L2A contains an assessment for overheating.

Part L2A Criterion 3 is not an overheating assessment.

Criterion 3 of Part L2A is an assessment to 'Limit the Effects of Heat Gains in Summer'. The assessment only assesses solar gains occurring across a wall against a benchmark. No accounts of HVAC, floor area, thermal mass or internal gains are taken. The criterion is intended to avoid high solar gains which may be addressed either at construction stage, or later on, with mechanical cooling. The emphasis is on reducing building energy demand and not necessarily addressing the potential for overheating.

The assessment is, in our opinion, a very crude and misleading assessment which gives next to no indication of the likelihood of overheating. This is due to the way in which the assessment is implemented within the SBEM/DSM compliance assessment on a zone-by-zone basis, rather than as an assessment of the building as a whole. The assessment gives a very poor indication that solar gains are 'excessive'. In certain cases the assessment can indicate non-compliance when there is no risk of excessive solar gains, and in other cases the assessment can indicate compliance when excess solar gains are likely.

If building control officers are insufficiently flexible, this can result in poor design decisions being made in order to appease the regulation. For instance, the regulation does not permit for any buildings attempting to achieve 'passive solar heating', which ironically is a planning policy requirement under certain jurisdictions.

It should also be noted that only certain activity types are assessed under the Criterion 3 assessment. Activity types such as 'display areas' and 'circulation spaces' are not assessed.

As such, **do not rely on Part L2A Criterion 3 for an indication of overheating risk.**

'Overheating' remains a design issue, independent of the building regulations. If the risk of overheating is considered of importance, we always advise carrying out a thermal simulation independent of the building regulations compliance assessments. Not only will this provide accurate design data to avoid overheating, it will also add weight to any argument as to why the building should not fully comply with Part L2A Criterion 3.

3. Implement a Cooling Philosophy Early in the Project's Development

Always assume that a building will be at risk from overheating and suitably demonstrate how this can be avoided.

Nearly all buildings will be at some risk of overheating. This can be either easily averted through simple measures such as opening windows, or by using more complex systems like night –time purge ventilation strategies or mechanical cooling.

Some building types are often at much higher risk than others by the virtue of key features common to the building type. Specific examples include doctor's surgeries and care homes. Greenlite Energy Assessors have experience in identifying key features which can often heighten the risk of overheating.

It is worth having an industry specialist assess a design during the early concept stages to help design out features which may increase the risk of overheating. This early stages involvement can save a lot of wasted time and expense at later stages in the projects development.

Features such as rooms with single side ventilation only, fixed glazing with no opportunity for natural ventilation, large areas of unshaded South or West facing glazing and lightweight construction methods should all ring alarm bells with designers.

It should be acknowledged that the responsibility of maintaining thermal comfort should not just be the domain of the mechanical engineer. Particularly where naturally ventilated buildings are concerned, the role of the architectural specification plays an important role in avoiding (or causing) overheating.

One of the common errors we see is the implementation of cooling strategies too late in a project's development. Assigning the responsibility to achieve thermal comfort to the mechanical engineer when the building shell is already built is far too late. This is particularly the case with naturally ventilated buildings, where the window specification and other aspects of the construction fabric play a far greater role in the building's thermal behaviour than that of HVAC systems.

4. Assess the Performance of the Cooling Philosophy as Soon as Possible

Once a definition for overheating has been agreed upon and a cooling philosophy has been defined, it is important to test the cooling philosophy against the agreed overheating definition, using a suitable dynamic thermal modelling exercise.

This assessment will aid in identifying if the cooling philosophy is sufficient to achieve the targeted thermal comfort criteria.

A thermal model which is sufficiently thorough and applied early on in a project's development can help remove problems before they arise and aid in a number of different design issues such as energy efficiency, HVAC system specifications and daylighting design.

5. Understand who Bears Contractual Responsibility for Achieving Thermal Comfort and Co-Ordinate Proceedings Accordingly

Most construction contracts place the contractual responsibility for achieving thermal comfort on the main contractor. This responsibility is often discharged onto the mechanical services engineer.

For certain projects, the employer's agent may have already defined a cooling philosophy for the building and carried out a thermal analysis to demonstrate that it works. This model will then be used to inform the building specification for tendering purposes.

At this stage the main contractor and mechanical services engineer should take heed.

It is very important to acknowledge who is accepting responsibility for thermal comfort within the building. Thermal comfort is effected by factors which go beyond building services, yet it is often the building services contractor whom accepts responsibility. Within naturally ventilated buildings in particular, the specification of HVAC has limited control over the internal environment when compared to the architectural specification. However, the architect rarely bears any responsibility for ensuring thermal comfort.

Factors such as the degree to which windows can be opened can have a very significant effect on thermal comfort. It is therefore of the upmost important that those responsible for ensuring thermal comfort remain well inform on all aspects of the design which relate to this.

When actions are taken outside the control of the mechanical services engineer (or persons responsible for thermal comfort) which are deemed to increase the risk of overheating, it is important that these issues are communicated to the design team and the matter recorded.

Further to the above, it is important to acknowledge that whilst a thermal model may have been constructed at tender stage to indicate that a cooling philosophy will be successful, the employer's agent rarely takes any contractual responsibility to ensuring thermal comfort. As such, it is not recommended to rely on these tender stage models as a guarantee of thermal comfort being achieved. **We always recommend that the mechanical services engineer (or those responsible for thermal comfort) carry out their own thermal model. Carrying on proceedings on the assumption that a tender stage thermal model is adequate, is proceeding at risk.**

6. Acknowledge the Role of Building Layout, Design, Location and Orientation

The architectural design of a building plays a strong role in a building's propensity to overheat. Typically, buildings which contain a high room density have a higher likelihood of overheating than those without, by virtue of the lower levels of natural ventilation likely.

Buildings such as care homes, doctor's surgeries and hotels in particular are higher risk building types, since all these buildings generally involve rooms with single sided ventilation. Single sided ventilation provides poor levels of natural ventilation compared to a room with two sided cross-flow ventilation, therefore windows are generally required to open wider to achieve the necessary levels of ventilation and cooling. Rooms with single sided ventilation only on south or west facing elevations are at heightened risk of overheating, particularly where window opening restrictors are present.

Likewise, location and orientation also play a strong role in a building's propensity to overheat and this should be acknowledged at the earliest design stages. Though it should be obvious, a building located in inner London will have a much greater likelihood of overheating than a building located in Newcastle. As such, the design team should pre-empt the thermal demands placed upon the building by virtue of the location.

Overheating criteria generally make no relaxation for warmer climates, hence projects using the most demanding of weather files – commonly the CIBSE 'London Design Summer Year' weather file, will have to incorporate more stringent efforts to address overheating than a project using the 'Glasgow Design Summer Year' weather file.

The orientation of the building in respect to overheating becomes more critical as the climate becomes warmer. Large areas of unshaded south or west facing glazing on a building in Glasgow will be of far less issue than the same geometry on a building in London. It should not be forgotten though that solar gains do help reduce heating demand in the winter; the key is to size glazing correctly and shade appropriately -hence the context of the site layout and local environment must be given consideration at the earliest design stages.

7. Ventilate Appropriately

Whether it is by mechanical or natural means, regardless of the level of solar shading, any room with a window will generally require some means of ventilation for cooling.

Though it may sound obvious, 'naturally ventilated' rooms with no opening windows struggle to achieve any cooling via natural ventilation. One of the most common problems we see in respect of overheating is either windows to naturally ventilated spaces being unable to open sufficiently, or, being unable to open at all –possibly an afterthought for the purposes of cost savings.

In certain cases, the opening of windows is required to be restricted for various legislative reasons. This can often be applied carte-blanche to all windows, with little consideration to the effect on thermal comfort. **When specifying windows, it is important to consider the implications of window restrictors on thermal comfort. If restrictors can be omitted or relaxed, this is always preferable from a thermal comfort perspective.** Typically, rooms with single sided natural ventilation will require windows to open to around 250mm in order to achieve thermal comfort criteria. This capacity can be reduced by adding mechanical extract to the rear of the room.

In order to reduce or remove the requirement for window restrictors, consider moving pedestrian thorough fairs away from external walls through the use of soft landscaping and such. Check the legislative details that may drive the requirement for window restrictors; if these details are being excessively or needlessly applied, this may result in overheating or needless expenditure on mechanical ventilation and/or cooling.

Where ventilation is assigned for both the purposes of maintaining a fresh air supply and to provide space cooling, the flow rates necessary to achieve space cooling will nearly always be greater than those required for the provision of fresh air alone.

When sizing ventilation systems for the purposes of space cooling, do not assume that minimum ventilation rates for the provision of fresh air alone will be sufficient to deliver thermal comfort standards.

The flow rates necessary to achieve thermal comfort will be dependent upon a wide number of variables, including the heat gains/heat losses within the space, thermal mass within the structure and the requirements of the thermal comfort criteria.

The only reliable method to establish the flow rates necessary is to conduct a thermo-dynamic analysis of the building. Needless to say, the calculation of ventilation flow rates for the purposes of space cooling should be conducted as soon as is viable.

For buildings with employ low thermal mass construction methods, it should be anticipated that ventilation rates for the purposes of space cooling will be higher than those for traditional masonry constructions- potentially in the region of 4-5ach. Likewise, high solar and/or internal gains will incur higher ventilation rates in a mechanically ventilated space.

Finally, <u>always</u> specify heat recovery by-pass dampers on heat recovery units if mechanical ventilation alone is intended for space cooling.

8. Acknowledge the Role of Construction Fabric

Typically, buildings using high thermal mass construction methods result in a lower overheating risk than those using low thermal mass construction methods. The only occasion where this is not the case is in very highly insulated and very air tight buildings, such as those built to the Passivhaus standard, where the benefits of high thermal mass become less pronounced.

For more standard buildings however, high thermal mass construction methods such as traditional masonry methods or concrete frame constructions offer a heat sink, which if suitably conditioned, will stabilise peaks and troughs in the internal temperatures. High mass structures provide ‘thermal momentum’ and also lend themselves to ‘night-time purge’ cooling strategies.

Lightweight construction methods such as timber frame constructions or lightweight steel frame constructions offer very limited thermal mass, hence the likelihood of experiencing overheating is much more likely. As such, attention to the cooling strategy in lightweight buildings is of greater importance.

To be beneficial to thermal comfort, thermal mass must be accessible. Thermal mass needs to have good exposure to the internal air in order to play a significant role in stabilising internal temperatures. Where high thermal mass elements are sheltered from the internal air through low thermal capacity or insulating materials such as ceilings, internal linings, floor coverings and such, the effect of the high thermal mass structure can be lost. A good example of this a concrete frame structure employing ‘dot and dab’ plasterboard linings to all internal walls, metal frame suspended ceilings and thick carpets. In this case, the building will most likely exhibit thermal behaviour more characteristic of a lightweight masonry block construction.

From a thermal comfort perspective, it is more preferable to provide good thermal coupling between the internal surfaces and the high thermal mass structure. Applying plasterwork directly onto high thermal mass walls will achieve this. Leaving intermediate concrete floors exposed will also provide a higher level of accessible thermal mass than where suspended ceilings are installed. The use of suspended ceiling ‘rafts’ can offer a compromise between a fully exposed intermediate floor and a full suspended ceiling. Though carpeted floor coverings are often necessary, these also reduce the thermal capacity of the floor element. Where possible, tiles, polished concrete or alternative high thermal conductivity floor finishes can aid in providing accessible thermal mass.

High thermal mass should however not be used as means to introduce excessive levels of solar gains. Whilst high thermal mass structures are less likely to overheat, once overheating does occur, they will overheat for a longer period. Hence suitable levels of solar gains and ventilation remain required. In practice, low thermal mass buildings will nearly always require some means of mechanical ventilation and/or cooling in order to achieve the thermal comfort standards listed under item one of this guide. High thermal mass constructions can regularly achieve the same criteria with natural ventilation only. This should be given consideration when selecting the favoured construction methods for a scheme.

9. Acknowledge the Role of Solar Gains

Overheating occurs in buildings when the accumulated heat gains to the building exceed the heat losses for a sufficient period.

Heat gains comprise of internal gains; such as occupants, lighting and equipment, external gains; such as conductive gains through the building fabric, infiltration and gains via the ventilation system, and solar gains; incurred through exposure to solar radiation.

The composition of these heat gains varies dependent upon the site location, the activity type of a room, the construction fabric employed and the construction geometry.

For rooms such as gymnasiums and high density IT works spaces, internal gains from occupants and equipment generally dominate the heat gains for the space. However in the majority of other room types, solar gains often play a significant role.

As such, the solar gains to a room should be regulated appropriately to avoid excessive heat gains. This can be done through the suitable sizing of glazing and through suitable shading.

High levels of glazing to a south or west elevation will often either incur high internal temperatures, or the requirement for high levels of ventilation and/or cooling, unless suitable solar shading is implemented.

Vertical glazing to a south elevation is the easiest to shade, due to the high altitude of the sun at noon. Solar shading to west elevations is more difficult, since the sun is at a lower altitude, hence large areas of west facing glazing should be avoided. Vertically orientated bris soleil should be considered for west facing glazing. East facing glazing can cover a larger proportional area than the west since internal and external air temperatures are usually lower in the morning, though there is always a limit to this.

The same is true with 'low-g' solar control glazing. Due to the lower altitude of the sun when in the east or the west, solar radiation hits the pane of glass at an angle closer to perpendicular, resulting in a lower proportion of radiation being reflected than when orientated south. This results in a higher proportion of energy absorbance in west or east facing glazing than for south facing glazing.

As such, reasonable quotas of south facing glazing are no bad thing, since these will also allow for a good degree of winter time passive heat gains, however, **effective shading must be implemented.** This means the appropriate deployment of bris-soleil or solar control glazing. Whilst internal blinds offer some merit, these provide a lower ability to reduce internal temperatures, since they are situated inside the insulation and airtightness envelope.

It should be acknowledged however that solar shading is not a suitable 'replacement' for adequate ventilation. Rooms with windows will nearly always require some means of ventilation for cooling, in addition to solar shading if necessary.

10. Acknowledge the Role of Internal Gains

Internal gains resulting from occupants, lighting and equipment contribute to the risk of overheating.

For most room activity types, solar gains and ventilation rates dictate the thermal environment far more than internal gains, though this is not always the case.

For activity types such as gymnasiums, high density IT work spaces or high occupancy rooms such as theatres and auditoria however, internal gains often form the most significant gains to the room.

When addressing overheating within these room types, it is important to acknowledge what the contributors to overheating risk are - there is little point in addressing solar gains for example if these only contribute a small fraction of the gains to a room.

A thermo-dynamic model will help establish the balance between different types of gains and aid in addressing the correct aspects.

However, as with any model, accurate information is important to generate reliable results, hence, the more accurate the information concerning internal gains –the more accurate the results will be.

Reductions in internal gains through measures such as low wattage lighting, daylight dimming controls to lighting and high efficiency electrical equipment can aid in reducing the ventilation/cooling rates necessary to achieve thermal comfort. Therefore, these two aspects should be considered in relation to one another.