

Avoiding summer overheating

Guidelines for summer comfort in Passivhaus buildings and the PHT Summer overheating tool

May 2021

Contents

Acknowledgements.....	2
SECTION 1 OVERVIEW	
Introduction	4
Overheating mechanisms	5
Localised overheating	6
SECTION 2 DESIGN STRATEGIES	
Design strategies	8
1. Optimising solar gains to avoid overheating.....	8
1.1. Building orientation and glazing.....	8
1.2. Overshadowing from adjoining structures	9
1.3. External shading	10
1.4. Internal shading.....	10
1.5. Glazing g-value.....	10
2. Reduce or minimise internal heat gains	10
2.1. Design of domestic hot water (DHW) systems	10
2.2. Appliances and other building services	12
3. Maximise passive cooling potential	12
3.1. Window ventilation	12
3.2. Overnight ventilation.....	13
3.3. Mechanical ventilation	13
4. Additional strategies	13
5. Summary of design strategies.....	14
SECTION 3 CONSTRAINTS, KEY INDICATORS, AND STRESS TESTS	
Limitations and constraints.....	16
Key indicators	16
Stress tests	19
SECTION 4 OTHER CONSIDERATIONS	
Active cooling	21
Flowchart for assessing overheating risk.....	21
Passivhaus certification.....	21
ANNEX PHT SUMMER OVERHEATING TOOL	
PHT Summer installation instructions	23

Acknowledgements

PHT Author:

John Palmer Passivhaus Trust

The Passivhaus Trust would like to thank the following individuals and organisations for their contribution to this report:

Reviewers:

Alan Clarke

Kym Mead Mead Consulting Ltd

Mark Siddall Lovingly Engineered Architectural Practice (LEAP)

Nick Grant Elemental Solutions Ltd

Sally Godber WARM Ltd

Sarah Price Enhabit Ltd

Will South Etude Ltd



Avoiding summer overheating

SECTION 1

Overview



Introduction

Summer overheating is a potential issue for most new buildings, as well as many existing buildings, and is likely to become even more of a concern as our climate warms. Analysis carried out by MHCLG¹ modelled 8 new-build dwelling typologies² in 5 different locations in the UK. The analysis found that all of the dwellings failed the CIBSE TM59³ overheating criteria.

As a comfort driven approach, the Passivhaus standard includes a summer overheating criterion which requires that internal temperatures do not exceed 25°C for more than 10% of the year. However, as with all models, the process of arriving at this assessment is highly dependent on the assumptions that are made during the modelling process. It is therefore critical that the Passivhaus community adopts a cautious and consistent method of assessing the risk of summer overheating to ensure that Passivhaus buildings remain comfortable both today and in a warming climate. In particular, it should be noted that the climate data in PHPP is historic and therefore we need to properly test our models against either current or future climate conditions.

The risk of a building overheating is often highly dependent on actions taken by the occupants – most commonly to deploy shading or initiate ventilation. Thus, if the modelling assumptions related to these factors are incorrect or overly optimistic, then once in-use a building could exceed the overheating criteria.

Occupancy levels above those predicted and modelled could also have a significant impact on internal heat gains and thus the risk of overheating. It is therefore important that realistic levels of occupancy are modelled to assess the level of overheating risk.

The recommended approach to assessing overheating is to look at the issue in four stages. First, the designer should adopt the best-practice **design strategies** which will help minimise overheating risk. Overlaid on this are the occupant-related **limitations and constraints** which will affect overheating. Then, a series of **key indicators** will tell us whether the design, at this stage, is at low or high risk of overheating and what might be causing this risk. If there remains an unacceptable risk, then the design strategies will need to be revisited to mitigate the risk further. Finally, a series of **stress tests** will demonstrate that the project is robust in a series of challenging circumstances.

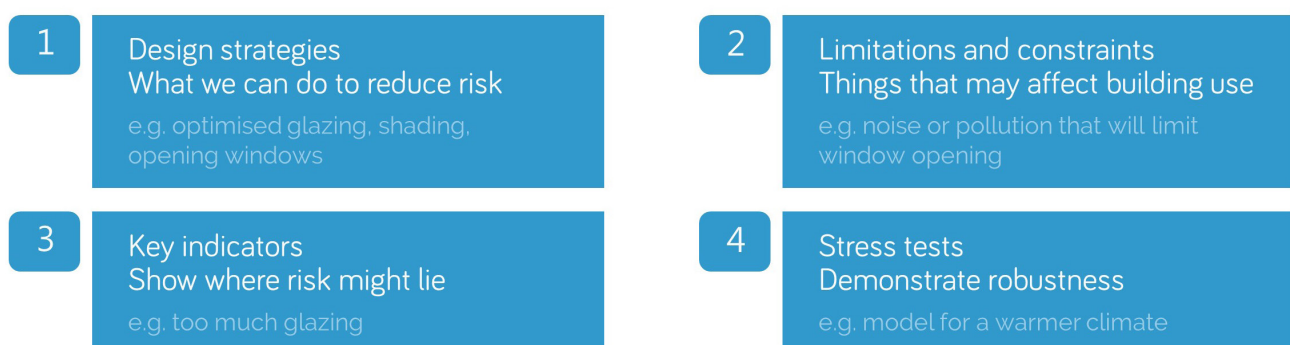


Figure 1 – Key stages in assessing overheating risk.

However, even before these design strategies are considered in detail, it is possible to assess whether a particular project might be at risk of overheating. The Good Homes Alliance overheating risk assessment tool⁴ is an excellent way of screening projects for overheating risk at an early stage.

¹ [Research into overheating in new homes, Phase 1 report](#). MHCLG, Sept 2019

² Five different sizes of apartments, 1 terrace, 1 semi-detached and 1 detached. Fabric specification to meet the minimum Part L requirement.

³ [TM59: Design methodology for the assessment of overheating risk in homes](#). CIBSE, July 2017

⁴ [Overheating in New Homes](#). Good Homes Alliance, July 2019

Overheating mechanisms

In a similar way to the energy balance of a building, there is also an overheating balance. If the amount of heat that is entering the building (gains) exceeds the amount that is being dissipated by either passive or active cooling (losses), then the internal temperature will start to rise and, if not addressed, an overheating situation will arise. However, if losses are matched to the gains, then the building remains in balance.

In most temperate climates, the primary overheating driver is typically solar energy transmitted through glazing. However, internal gains can also be a significant contributor, particularly in multi-residential or non-domestic buildings.

When the way in which a building is used is outside the design parameters, or if certain limitations or constraints have not been considered during the modelling, then a building could overheat despite the baseline modelling suggesting otherwise.

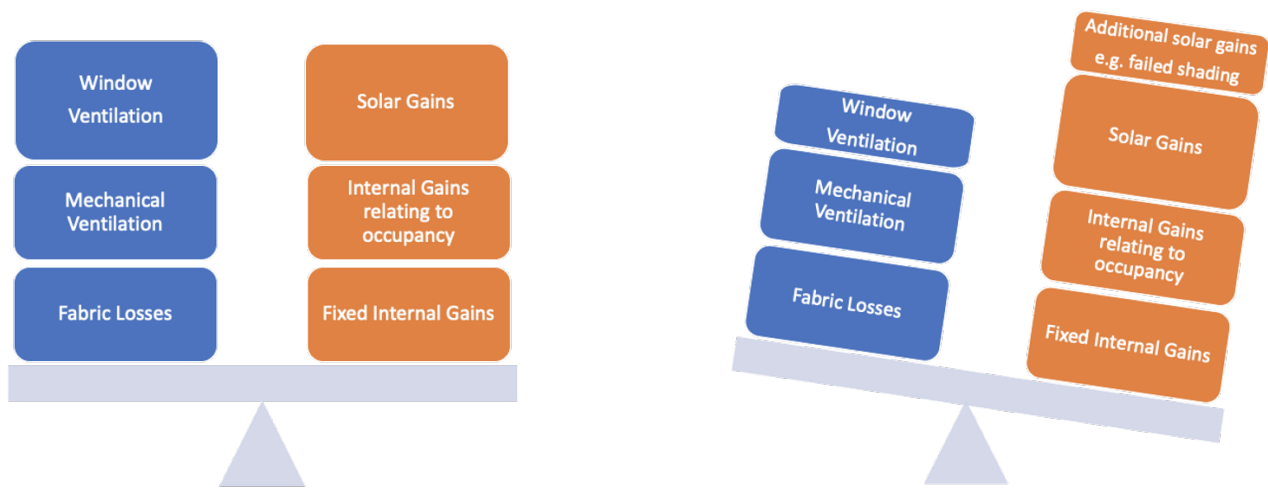


Figure 2 - The overheating balance

Solar gains combined with gains from internal activity must not exceed the heat losses from ventilation and the fabric. If gains are higher than expected and/or ventilation levels are lower, then the building could overheat.

It is therefore essential that the limitations and constraints of a building’s likely usage patterns are properly considered at design stage and reflected in the overheating analysis. If any of these more challenging situations indicates a significant overheating risk, then the design strategies set out in this guidance should be used to reduce the risk to an appropriate level. This can be termed ‘design headroom’ and will ensure that the building is able to remain in balance even in the face of even the most challenging conditions.

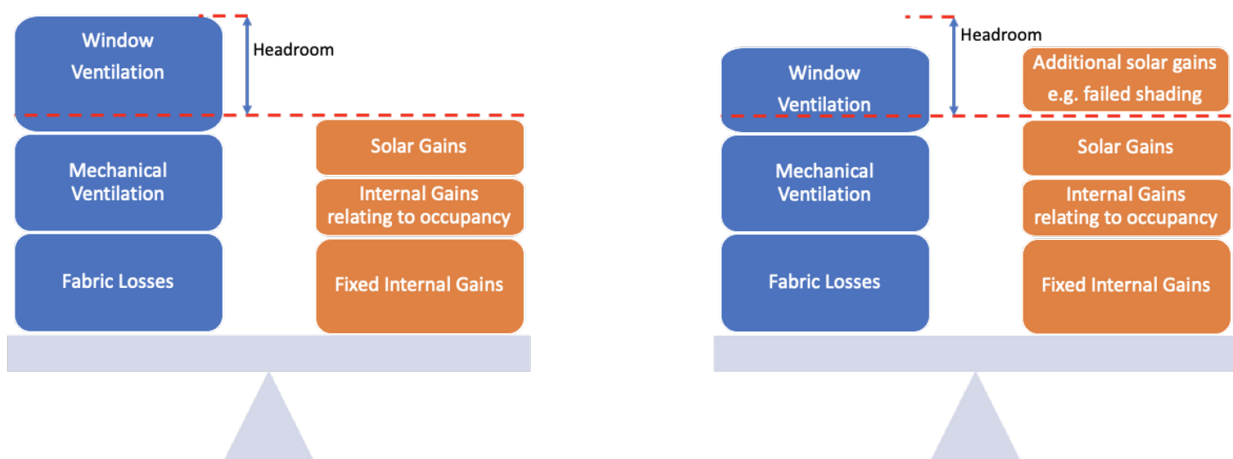


Figure 3 - Ensuring there is design headroom means the building will cope with additional gains, and/or smaller losses.

Localised overheating

The Passivhaus PHPP model considers the overheating risk of the whole building and also averages the risk over the whole floor area and over time. There may therefore be circumstances where the model will indicate an acceptable risk of overheating for the overall building, when specific zones or rooms are actually at a much higher risk. The following indicators should be used to determine whether there may be areas of risk:

- **Is there an area which has a **higher glazing proportion** than the overall façade?**
- **Is there an area where **window opening is restricted** compared to the rest of the building?**
E.g. for noise or security reasons
- **Is there an area which is not subject to the same **shading objects** as the majority of the façade?**
- **Is there an area in which only **single aspect ventilation** is possible?**
- **Is there an area which is adjacent to a particular **internal heat source**?**
E.g. plant room
- **Are any **bedrooms at risk of overheating**?** – typically people are less tolerant of higher temperatures. Specific risk factors could include west facing rooms with no cross ventilation.
- **Is there an area which will have **higher internal gains** for short periods?**
E.g. Bunsen burners in a school classroom

If any of these factors are present, then the specific area or room should be modelled separately using Dynamic Simulation Modelling (DSM) software to assess the level of risk. Care should be taken to ensure the inputs/assumptions that are used in the DSM modelling are realistic and align with the assumptions used for the PHPP model.

When DSM is employed, it should be alongside the CIBSE TM59 methodology for residential buildings and TM52 for non-residential. DSM modelling reports should:

- **Report against criteria for all rooms, including unoccupied zones**
- **Report hours in year (or simulation period) above 25°C for each room so that it can be compared to PH criteria**
- **Report window opening and ventilation system operation assumptions clearly**
- **Use calculated hot water distribution losses from PHPP or secondary calculation**
- **Use calculated window opening areas 'effective area' in calculations.**

Avoiding summer overheating

SECTION 2

Design strategies



Design strategies

This section will look at the primary design strategies which can be used to reduce the risk of overheating. They are:

- | | | | |
|----------|-------------------------|----------|------------------|
| 1 | Optimising solar gains | 3 | Passive cooling |
| 2 | Reducing internal gains | 4 | Other strategies |

In the UK’s climate, for most buildings, the primary overheating mechanisms are solar gain and/or internal gains. The most effective way of reducing overheating risk is therefore to first look at ways of reducing these sources of heat.

1. Optimising solar gains to avoid overheating

1.1. Building orientation and glazing

Overheating needs to be considered right from the start of the design process. This means that the building orientation should be optimised as far as possible to benefit from the opportunity of solar gains in the winter without the risk of too much gain in the summer. The ideal situation is a north-south orientation with daylight-optimised glazing on the north façade and somewhere between 15 and 25% glazing on the south façade. This is optimal as fixed shading or overhangs on the south façade will protect against the high summer sun but will not interfere with the low winter sun when gains are needed. As a rule of thumb, the overhang or fixed shading should subtend an angle of 60° to the lower edge of the glazing.

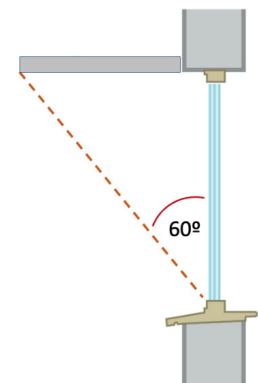


Figure 4 - Optimal sizing of South façade overhang shading

However, it is not always possible to orient a building north-south. Where there is an east-west aspect, additional care should be taken when designing glazing areas and shading to deal with low sun angles which will be typical at the beginning and end of the day in summer. External blinds or shutters are examples of effective options if shading is necessary.

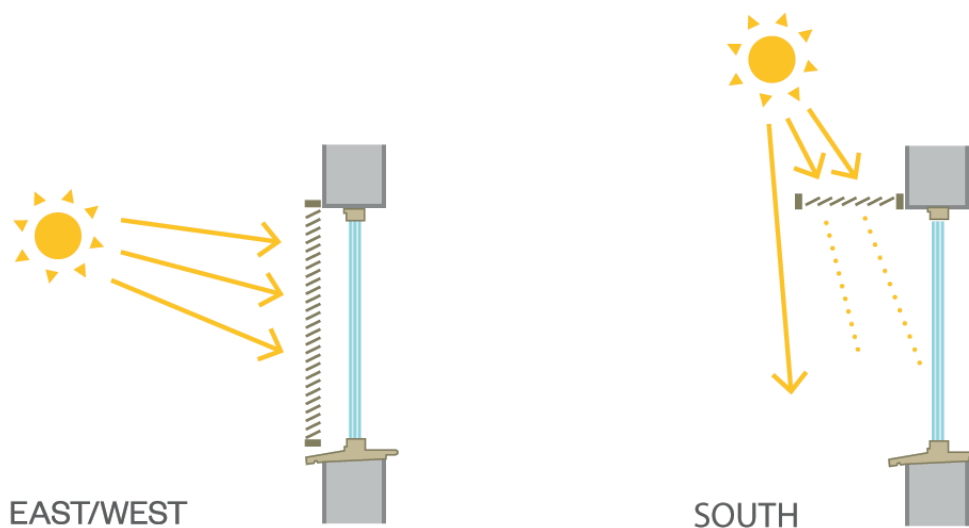


Figure 5 - Shading Strategies (Reproduced courtesy of Levitt Bernstein)

Overall, an indicative proportion of glazing that is typically appropriate for residential buildings is between 15 and 25% as a percentage of the Treated Floor Area.

Glazing size and position should be balanced against achieving good daylighting. Floor to ceiling, vertical glazing does little for daylighting in the bottom third of the window whilst still losing heat and producing gains. Horizontal aspect glazing will therefore provide better daylighting for the same amount of glazing area. It is also easier to maximise openable areas for passive cooling for horizontal windows with a higher cill height.

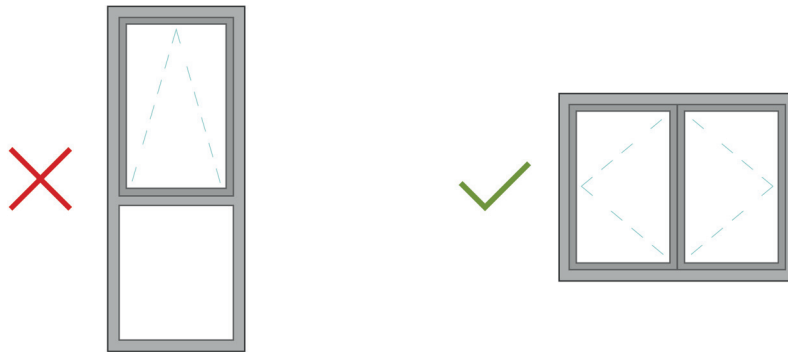


Figure 6 - Glazing aspect and openable areas (Reproduced courtesy of Levitt Bernstein)

1.2. Overshadowing from adjoining structures

It may seem like a clever strategy to utilise nearby buildings or structures to provide shading. However, this can be counter-productive overall as these structures are likely to block much of the low winter sun whilst letting through more of the higher summer sun. As a rule of thumb, buildings should be spaced a minimum of 1 to 1.5m apart for every metre of height or more. Trees can be considered as shading objects, but suffer from the same issue and may well be removed during the building’s lifetime and the worst case condition (i.e. no trees) should therefore always be considered for certification purposes.

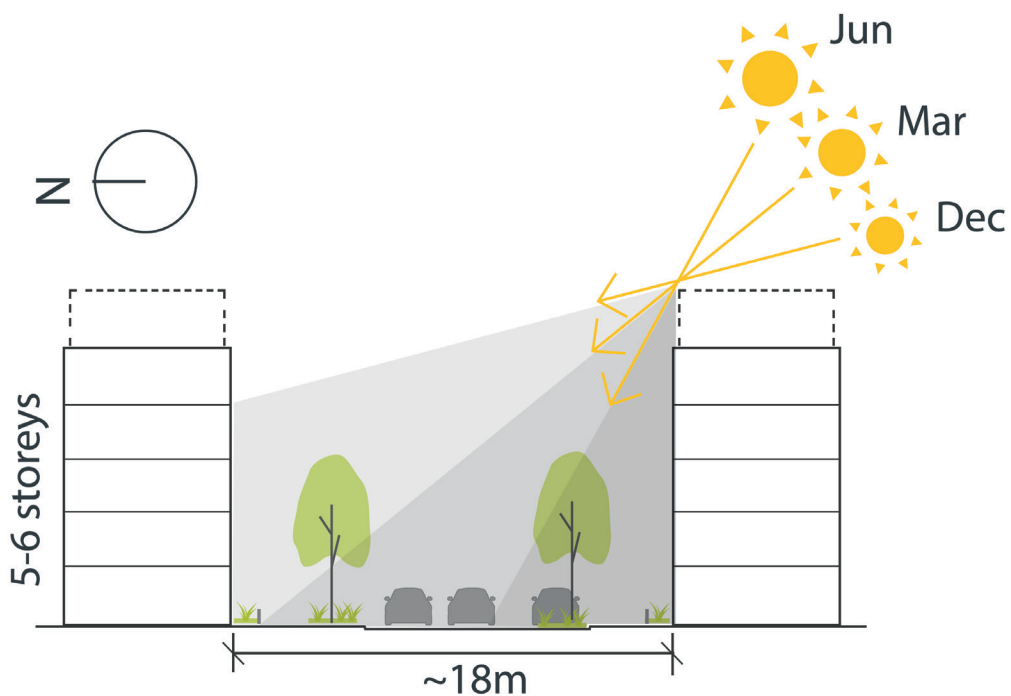


Figure 7 - Overshadowing from nearby buildings (Reproduced courtesy of Levitt Bernstein)

1.3. External shading

External shading systems are highly effective in reducing solar gain. Most preferred are systems which are fixed and require no movement or occupant action to be effective. These types of systems include brise soleil and overhangs.

In situations where fixed shading is not appropriate, deployable shading such as shutters, blinds or awnings are all effective. Wherever possible the most robust solution should be selected. Automatic deployment should be considered where the shading device or window is not easily accessible, but take care as it can be hard to arrange maintenance contracts for such systems.

Where views are an important consideration and fixed shading is not appropriate, semi-transparent blinds can provide a good compromise.

1.4. Internal shading

Where external shading is not feasible, internal shading can be considered. However, this method is far less effective than external shading. External shading can reduce solar gain by between 80 and 100%. In contrast, even the most effective internal shading will only reduce solar gain by a maximum of 40% and in most cases it will be considerably less than this. Most forms of internal shading will also reduce the amount of cross ventilation that is achieved through the window opening. Internal shading is also almost entirely reliant on occupant behaviour and thus there is little effect if the occupants fail to deploy the shading, or perhaps only partially deploy it, for example to preserve views. External shading is therefore always the preferred option.

Internal shades work by reflecting solar radiation back out through the glass and so should be a reflective or bright white coloured blind close to the window for best effect.

1.5. Glazing g-value

A lower glazing g-value will reduce the amount of solar gain. However, this will reduce both winter and summer gains and so the reduction in overheating risk achieved will need to be balanced against the lower winter gains. A lower g-value will also reduce the level of daylighting throughout the year and have an impact on the quality of the views. For individual homes g-values are often the maximum possible, however, using lower g-value glazing in specific locations where there is a particular risk of overheating can be an effective strategy.

The use of specialist solar control glass with g-values lower than 0.3 may seem like an attractive option in some cases. However, not only is this expensive, but it is normally unnecessary unless there are excessive amounts of glazing. It will still result in poor daylighting and is still likely to present a significant overheating risk. In short, do not use very low g-values to try and compensate for too much glazing.

2. Reduce or minimise internal heat gains

2.1. Design of domestic hot water (DHW) systems

One of the primary contributors to overheating is often the domestic hot water system. This is particularly true in multi-residential buildings where there can be long lengths of hot water pipes. In a typical UK dwelling more than half the energy used for hot water can be attributed to wild heat losses within the building. To reduce hot water losses, the following strategies should be employed:

- Minimise pipe-run distances. Length and complexity of pipe runs should be minimised by coordinated and intelligent room layouts. For multi-residential, stacked layouts will minimise both horizontal and vertical distribution lengths. This is best achieved by reviewing the design at stage 2 to ensure the most effective layout and distribution pathways. This is often achieved with vertical distribution (but is dependent

on building geometry) with outlets close to risers. Where hot water or communal heating is circulating year-round reducing flow and return temperatures is very beneficial. Flow temperature temperatures should be minimised – i.e. do not distribute at high temperatures and mix-down at point of use.

- In domestic situations, for non-circulating systems, pipe-diameters can be reduced to small bores (OD~10mm) by use of a radial distribution system whilst still maintaining satisfactory levels of flow and pressure. It is important that these systems are designed appropriately to address pressure drops, the AECB Water Standards and the Passivhaus Designer training provide detailed guidance.
- In particular, the distance between the primary heat source and the hot water storage vessel (if present) should be minimised as these pipes will need to be large. Note that this heat loss mechanism is not currently modelled by PHPP and thus should be carefully designed regardless of the PHPP overheating risk.
- The volume of stored hot water should be optimal (not oversized) and the storage temperature should be as low as is practicable whilst ensuring there is an appropriate periodic (weekly, or even monthly) sanitisation cycle to deal with legionella. A storage temperature of around 50°C is sufficient to provide for hot showers.
- The matching of the heat-source to the hot water storage volume, and the associated hysteresis setting should be optimised to avoid rapid cycling.
- Secondary circulation systems should be avoided (again achieved by efficient layouts). Where they are required, the return pipework should be small bore and the circulation times minimised to accord with the building’s usage patterns.
- For schools and other non-domestic buildings, distribution and storage losses can be much greater than the energy used to heat the hot water that is actually used. If this is the still the case after optimising the design, then point of use electric water heating should be considered as a more efficient alternative.

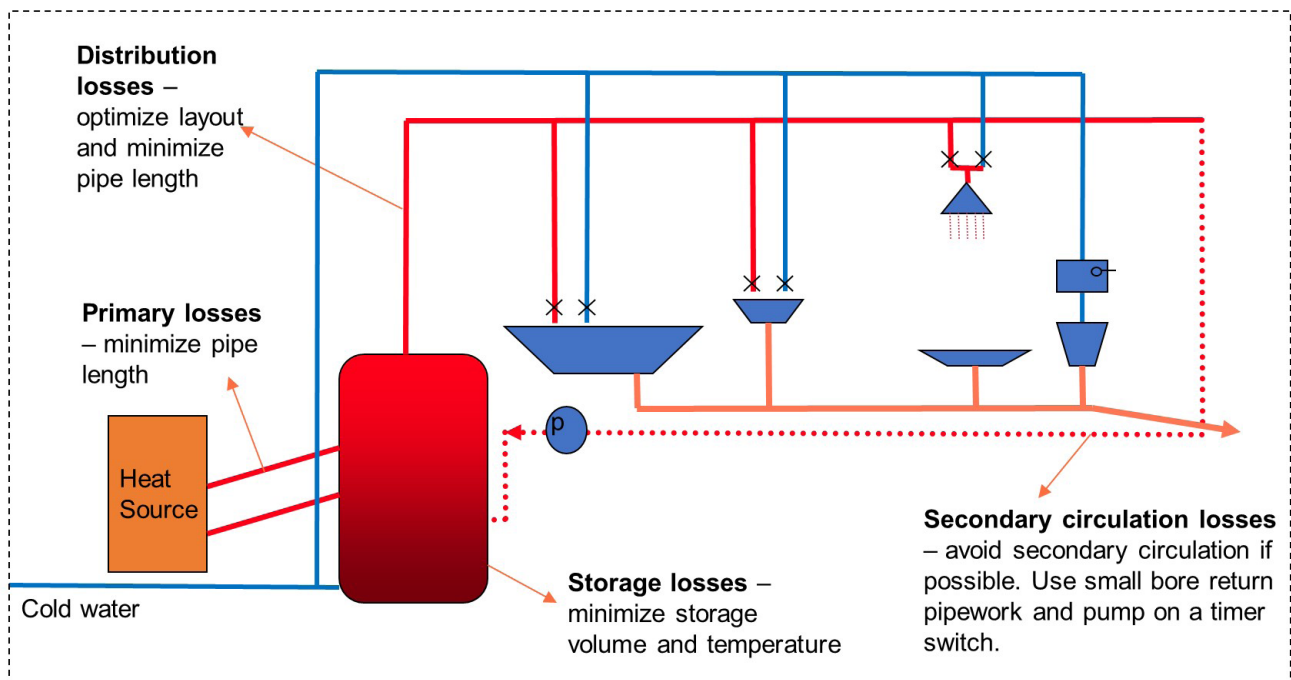


Figure 8 - Opportunities to reduce hot water wild heat gains (Reproduced courtesy of CarbonLite trainers)

2.2. Appliances and other building services

There will also be many other devices within the building that generate heat. These are typically difficult to model and account for as they are often added after the building is complete and may not be part of the building's fixed services. Nevertheless, they can have a significant impact on overheating risk and so need to be carefully considered and modelled in PHPP. Where there is any doubt, the most pessimistic case should be considered.

These devices may include clothes dryers, refrigerators, freezers, dehumidifiers, ovens, computers, printers, etc. Appliances which are always on, even on a low load, often have a disproportionate impact on wild heat gain.

3. Maximise passive cooling potential

Once gains have been minimised, there are several design strategies which can be adopted to maximise the ability of the building to achieve effective passive cooling.

In the UK's climate, we can typically expect to be able use cooler air from outside to help cool the building if overheating has started to occur. Even on a warm summer's day, overnight temperatures will drop to between 15 and 20°C with, up to this point, only very few 'tropical nights' with temperatures above 20°C overnight. Thus, moving cooler outside air through the building, particularly at night, is a primary cooling mechanism. However, it is important not to overestimate how much effective cooling can actually be achieved and, for this reason, conservative values are recommended. It is particularly important that the assumptions relating to occupant behaviour are verified and agreed with the end client or, preferably, occupiers.

3.1. Window ventilation

Moving cooler outside air through the building is primarily achieved by opening windows. Thus, the building's windows are critical factors in achieving sufficient passive cooling. In particular, the following design parameters will need to be considered and optimised:

- **Window size and openable area** Optimal glazing ratios per façade are discussed above and should help avoid excessive amounts of glazing. In addition, the amount of that glazing area which is openable should be maximised.
- **Window design and opening limitations** The effective opening area of a tilted window is far less than if that same window was opened using a side-hung mechanism. Similarly, a top-hung window will not open as far as a side-hung. Furthermore, inward opening windows enable the use of external shutters and insect mesh whilst outward opening windows may be vulnerable to wind. Thus, the way in the window can be opened, combined with its area, determines the actual amount of free-flow openable area that can be achieved. In addition, there may be security or safety-related constraints such as opening restrictors on higher windows – these also need to be taken into account. Insect meshes are useful in allowing the window to be left open overnight, but will restrict airflow to some degree.
- **Cross-ventilation** The amount of air flow that is achieved by cross-ventilation (i.e. air flow from a window on one façade, through the building to a different window on a different façade) is significantly higher than the air flow achieved, even through multiple windows, on a single façade. Thus, cross ventilation should be included in the design wherever possible. For cross ventilation to be effective, the design should also ensure that there is a clear path within the building for the air to flow. Where this is not possible, or where factors such as visual and acoustic privacy will impair the amount of air flow, reduction factors should be applied in the PHPP modelling.

3.2. Overnight ventilation

As set out above, overnight ventilation is likely to be the most effective in achieving cooling as this is when the outside air will be at its coldest. However, night-time ventilation is also when there are the most significant limitations on window ventilation – e.g. noise, security (particularly if unoccupied), drafts, insects and closed internal doors. The windows, and the associated openable areas, that can realistically be used for overnight ventilation should be clearly identified as part of the design and reduction factors applied where cross-ventilation is likely to be compromised.

3.3. Mechanical ventilation

The MVHR systems within a Passivhaus building can help with reducing overheating risk. The summer bypass mode will ensure that when the outside air is cooler than the internal setpoint, and the internal temperature is too high, cooler internal air is brought directly into the building. In situations where window opening is not possible, or likely to be compromised by noise, pollution or security, the MVHR may need to provide all the passive cooling required to address overheating risk.

However, even in boost mode, a typical Passivhaus MVHR system will only achieve around 0.5 ACH. This will provide some level of cooling but is likely to be a lot less than the amount of airflow that can be achieved via opening windows. It should therefore normally be considered a secondary, albeit helpful, mechanism for passive cooling. Without summer bypass the MVHR provides almost no night cooling even when boosted as the cooler incoming air is warmed by the outgoing air as in winter.

If additional cooling is needed, it may be feasible to increase the MVHR sizing to deliver a greater level of airflow for summer conditions only. All the standard Passivhaus noise criteria will still apply and so achieving this increased airflow will need to be balanced against the impact of larger duct diameters and, potentially, a larger and more expensive MVHR unit.

4. Additional strategies

To further reduce the overheating risk, some additional measures can be adopted.

- **Materials** The reflectance of outer cladding material exposed to sunlight will have a significant impact on the rate at which the material absorbs heat and thus how hot that material will become. A dark coloured brick wall can become 20-30° hotter than the surrounding air temperature on a sunny day. This causes updrafts of hot air which can be drawn into ventilation intakes and open windows. Use of light-coloured materials will reduce this effect.
- **Microclimates** Large expanses of unshaded tarmac and pavement will result in a localised rise in temperatures during sunny periods. This will increase the prevalent air temperature which will reduce the amount of passive cooling that can be achieved in nearby buildings. Shading, tree planting and use of light-coloured materials can all mitigate this effect.
- **Passive stack design** Designs can be optimised to capitalise on the stack effect. Designing secure openings on the ground floor which can be left open overnight, coupled with openings on the upper floors, or even the roof (e.g. wind towers), with a clear air-path in between, will facilitate cooler air being drawn into and through the building, even when there is no prevailing wind. However, it should be noted that these mechanisms do rely on cooler outside air and thus will not be effective when overnight temperatures do not drop below 20°C. They should not therefore be considered a substitute for prevention – i.e. optimised glazing and shading.
- **Ceiling fans** Whilst ceiling fans do not achieve any actual cooling, they do result in a perceived temperature drop of 2-3°C and are therefore useful in maintaining comfort levels where there are low levels of overheating. Designers should therefore consider achieving ceiling heights of 2.5m or more which are commensurate with fitting ceiling fans.

5. Summary of design strategies

When deciding which design strategies to employ, it is advisable to focus on those which are both robust and effective. As we may not always be able to rely on cooler outside air, strategies which minimise gains in the first place are preferred, as are strategies which are not reliant on occupant action or automated systems. A summary of these various design strategies together with a subjective assessment of their relative effectiveness and robustness is set out below:

Scenario	Assessment of robustness	Robustness (1-10)	Effectiveness (1-10)
Reduce glazing area	<i>Robust in all situations</i>	10	9
Overhang shading on south facing windows	<i>Robust in all situations</i>	10	9
Reduced g-value	<i>Robust in all situations but reduces winter heat gain</i>	10	7
Reduce Domestic Hot Water gains	<i>Moderately robust – other than usage/ duration which will be subject to occupancy habits</i>	6	6
External blinds	<i>Subject either to automation or action by occupants. Automation could fail and occupants may be disinclined to use due to loss of external views.</i>	3	10
Reduce internal gains from appliances	<i>Subject to both appliance types/numbers and usage by occupants</i>	2	6
Internal shading	<i>Subject either to automation or action by occupants. Automation could fail and occupants may be disinclined to use due to loss of external views.</i>	3	7
Increase MVHR flow rate	<i>Subject to correct control systems and noise limits</i>	6	7
Increase window opening time	<i>Subject to action by occupants and to external factors such as noise or pollution</i>	3	7

Table 1 - Summary of effectiveness and robustness of design strategies

SECTION 3

Constraints, key indicators, and stress tests



Limitations and constraints

In considering how a building will be used, there are several considerations relating to the surrounding environment and occupant behaviour which should be considered and reflected in the modelling and, where necessary, the design amended accordingly. These are summarised below:

Behaviour	Influencing factors	Resultant design actions
Window opening	<ul style="list-style-type: none"> External noise External pollution Security (perceived and actual) Safety (e.g. window restrictors) Insects Accessibility of window opening Occupant presence in the building (inc likely working patterns) 	Reduce the amount of summer ventilation achievable from window opening accordingly
Temporary shading	<ul style="list-style-type: none"> External views Ease of deployment (mechanical/manual) Vulnerability to high winds or vandalism 	Reduce the effectiveness of temporary shading and consider whether alternative options are appropriate
Occupant presence in the building	<ul style="list-style-type: none"> Number of people in the building Frequency of bathing / hot water use Frequency of washing Specific or unusual appliances or systems which will produce additional heat – e.g. indoor growing lamps 	Consider the potential for increased occupancy or high usage patterns and build-in headroom into overheating risk accordingly

Table 2 Summary of limits and constraints

Key indicators

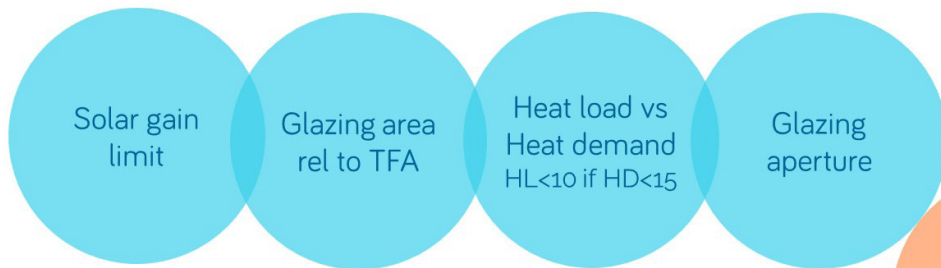
While the PHPP modelling may suggest that the amount of overheating predicted meets the criterion required for certification, if it is subject to occupant inaction, or perhaps a warmer climate, then, as set out above, there will be a significantly increased risk of overheating. In determining which design strategies might be most effective, there are several key indicators within the PHPP model which will give the designer more information about which elements of the design are contributing most to the overheating risk.

These key indicators are summarised below and in [figure 9](#). The best practice values for these key indicators will vary by climate zone and will also, to some extent, be affected by the vernacular architecture of the region. Suggested values for the UK are included in the PHT Summer overheating tool (see Annex) and will be updated periodically as appropriate.

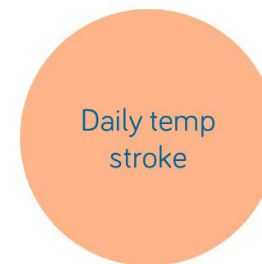
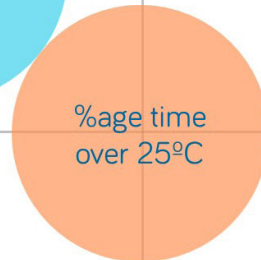
Key indicator	Unit	Implication if too high
Daily temperature stroke	K	A large temperature stroke could indicate an overreliance on overnight cooling to maintain temperature balance. It could also suggest that the PHPP assessment of overheating is inaccurate and that dynamic modelling is required.
Solar gains	kWh/m².a	A high proportion of solar gains could indicate that glazing has been increased to achieve a lower space heating demand and is could therefore result in elevated summer gains
Domestic hot water losses	kWh/m².a	Higher than expected internal gains arising from domestic hot water which could exacerbate overheating.
Total area of window openings (glazing + frame) as a proportion of TFA	%	This is a useful indicator at the early stage of a design where glazing and shading details have yet to be finalised. It indicates that there could be too much glazing area in relation to the floor area
Glazing aperture	m²/m²	This is a more accurate metric once glazing and shading details are known and indicates that there is too much glazing area in relation to the floor area which is not subject to shading or solar gain reduction
Relationship between heating demand and peak heating load	kWh/m².a W/m²	If the heating demand has been met, but the peak load has exceeded the limit of 10 W/m ² , this could indicate that excessive solar gains are being used to reduce the heat demand. A number of experienced practitioners advocate designing to the peak load criteria as this tends to result in better summer comfort.
Ventilation air change rate from windows (Day-time)	ACH	A high air change rate from windows will indicate that the cooling strategy is overly reliant on air flow from opening windows which is subject to both weather conditions and occupancy behaviour and thus may not be realised.
Ventilation air change rate from windows (Night-time)	ACH	A high night-time air change rate could indicate that the cooling strategy is overly reliant on air flow from opening windows at night which is subject to occupancy behaviour and noise/pollution constraints and thus may not be realised.
Thermal mass	Wh/K.m²	Thermally massive buildings (>135) could be at greater risk of overheating. Despite initially slowing down the rate at which the building will warm up, once the overheating balance has tipped, a high thermal mass could perpetuate overheating in warm periods, thus additional 'headroom' should be considered. In these cases, all the key indicators should be considered

Table 3 - Summary of key indicators of overheating

Too much glazing or too little shading



Internal gains too high



Over-reliance on window ventilation

Insufficient cooling for thermal mass

Figure 9 - Key Indicators and what they demonstrate

Stress tests

In determining whether there is sufficient design headroom – i.e. is the building design robust – several stress tests are advised. For each stress test, the PHPP model should be amended just for that factor and the effect on the overheating risk noted. A building whose overheating risk remains acceptable in the face of all the stress tests is highly likely to be robust in all future scenarios. Note that these stress tests should be applied individually, not cumulatively.

The suggested stress tests and associated overheating limits are:

Stress test	Suggested limit for overheating criterion* with stress test applied	What does this test demonstrate?
Reduce window day ventilation rate to 0 <i>(SummerVent sheet, cell L31)</i>	0%	Whether there is a significant reliance on window ventilation to achieve summer comfort
Reduce window night ventilation rate to 0 <i>(SummerVent sheet, cell P59)</i>	<5%	Whether there is a significant reliance on window ventilation to achieve summer comfort
Remove all temporary shading <i>(Temporarily remove all entries in column AH in Shading sheet)</i>	<10%	Whether there is a significant reliance on temporary shading measures which could fail or not be deployed by occupants
Increase occupancy by 100% or fill all bed spaces <i>(Apply 'User Determined' occupancy in cell Q29 on Verification sheet)</i>	<5%	Whether the building is sensitive to increased occupancy in terms of its overheating response
Use Future Climate Data <i>(Use PHPP Summer Overheating tool to apply a 2°C increase and/or heat island effect)</i>	<5%	Whether the building is at risk of overheating in future climates

*percentage time above 25°C

Figure 10 - Stress tests and suggested limits

Avoiding summer overheating

SECTION 4

Other considerations



Active cooling

If, despite the adoption of all the passive design strategies, it is clear from the stress testing that the whole building has a significant overheating risk, then an active cooling system should be designed and sized for the remaining demand. However, in a Passivhaus building this demand is likely to be much lower than a comparable non-Passivhaus, as all the overheating mechanisms will have been minimised and the passive cooling opportunities maximised.

Flowchart for assessing overheating risk

This guidance has set out how limitations and constraints, design strategies, key indicators and stress tests can be used to minimise the risk of overheating. These elements should be employed using the flowchart illustrated in figure 11.

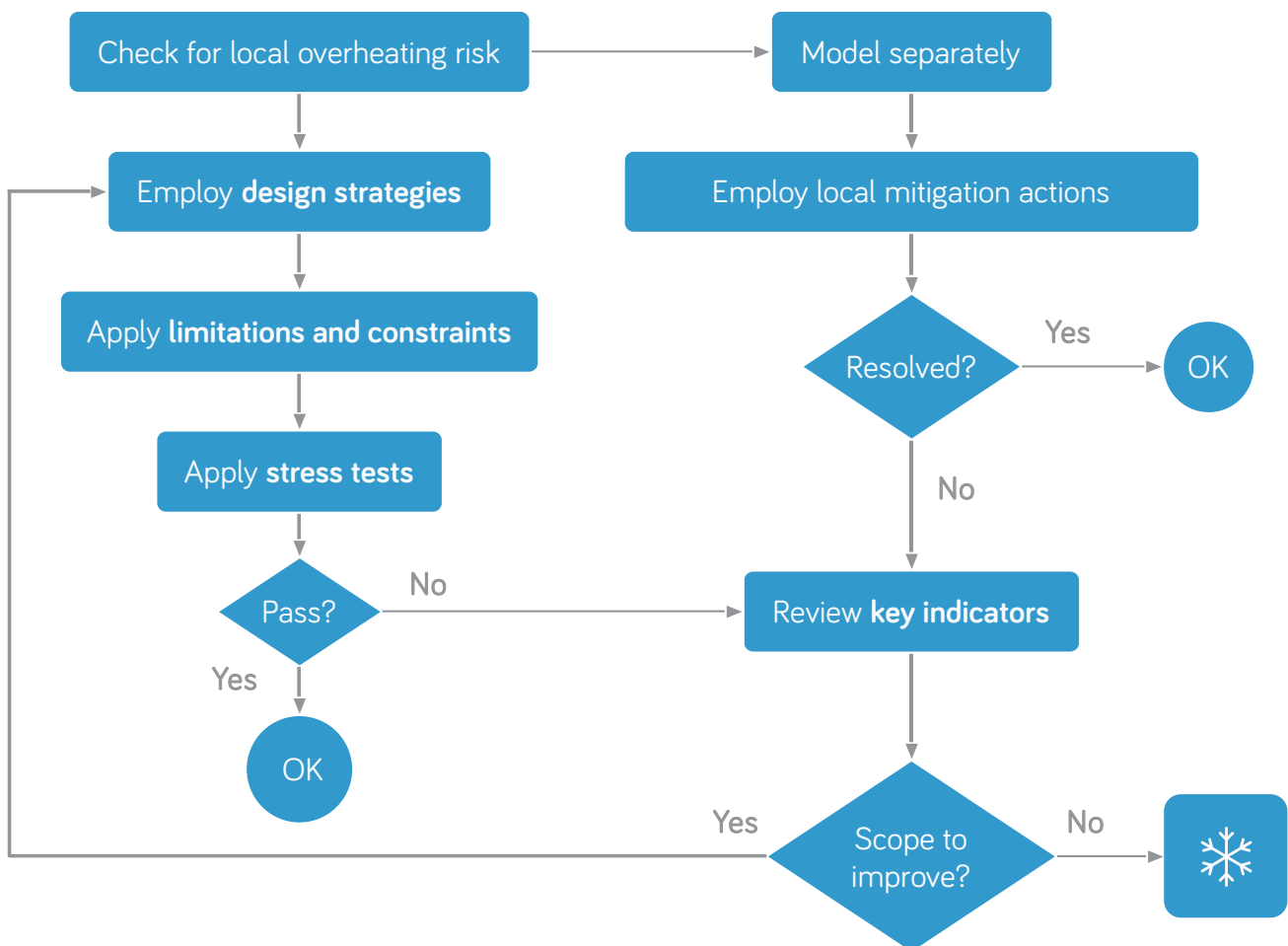


Figure 11 - Decision tree for reducing overheating risk

Passivhaus certification

Where there is any doubt regarding the overheating risk of a Passivhaus project, the guidance set out in this document should be followed and any actions taken to resolve demonstrated to the certifier. In particular, the certifier will satisfy themselves that the stress tests have been undertaken with satisfactory results and that the assumptions relating to occupancy behaviour have been confirmed and agreed with the building occupants.

Avoiding summer overheating

ANNEX

PHT Summer overheating tool



The Passivhaus Trust has developed a plugin tool for PHPP which will assist designers in following the overheating risk assessment process.

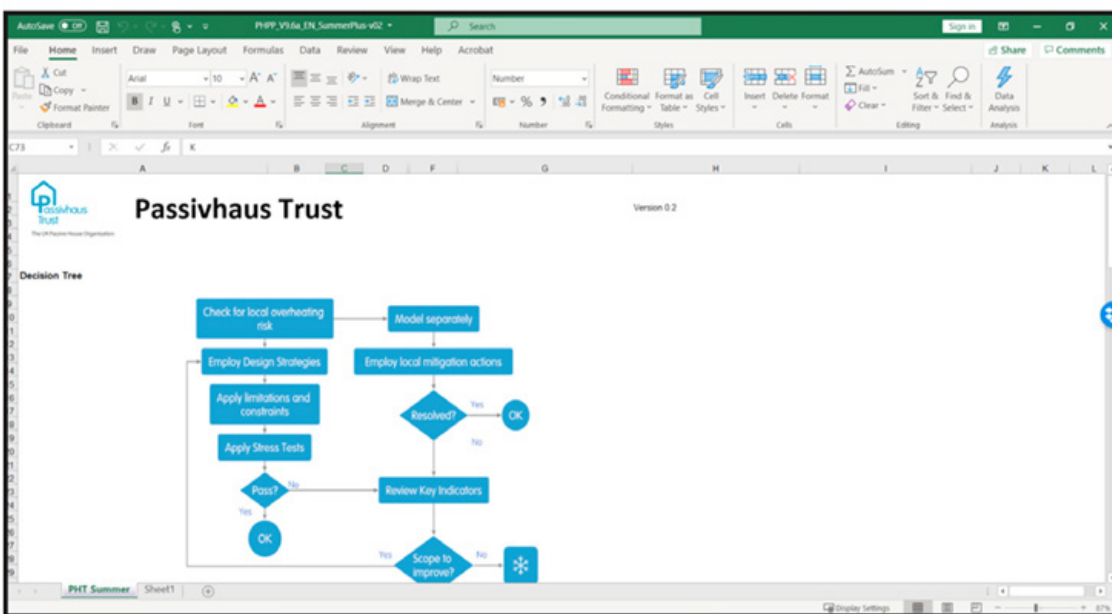
The tool sets out each step and invites the designer to confirm whether the appropriate design actions have been taken. The key indicators are automatically extracted and the stress tests set out for the designer to perform and insert the results.

The latest version of the tool is available for download from:

<https://www.dropbox.com/sh/4bwhkv43mr5bvaw/AAC6koGKBfRNyyf33Vm7xpTPa?dl=0>

PHT Summer installation instructions

Step 1 – Download the overheating tool and open the file

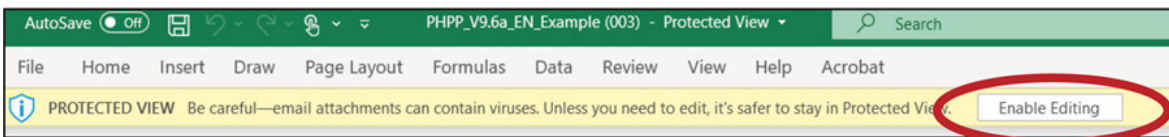


Step 2 – Open your PHPP model

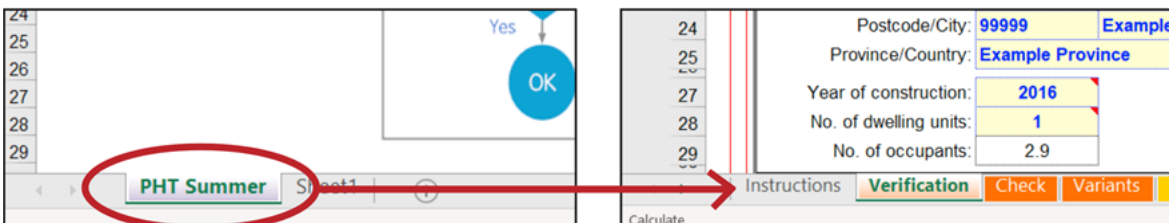
The screenshot shows the 'Passive House Verification' form within the PHPP software. The form is divided into several sections:

- Building:** End-of-terrace Passive House, Street: Example Street 99, Postcode/City: 99999 Example City, Province/Country: Example Province DE-Germany, Building type: Row house, Climate data set: DE-9999-PHPP-Standard, Climate zone: 3: Cool-temperate, Altitude of location: -
- Home owner / Client:** Passivhaus Association of Owners, Street: Example Street 99, Postcode/City: 99999 Example City, Province/Country: Example Province DE-Germany
- Mechanical engineer:** Example Mechanical Services Firm, Street: Example Street 99, Postcode/City: 99999 Example City, Province/Country: Example Province DE-Germany
- Certification:** Passive House Institute, Street: Rheinstr. 44/46, Postcode/City: 64289 Darmstadt, Province/Country: DE-Germany
- Architecture:** Example Architectural Firm, Street: Example Street 99, Postcode/City: 99999 Example City, Province/Country: Example Province DE-Germany
- Energy consultancy:** Example Energy Consultant, Street: Example Street 99, Postcode/City: 99999 Example City, Province/Country: Example Province DE-Germany
- Other fields:** Year of construction: 2018, No. of dwelling units: 1, No. of occupants: 2.9, Interior temperature winter [°C]: 20.0, Interior temp. summer [°C]: 25.0, Internal heat gains (IHG) heating case [W/m²]: 2.4, IHG cooling case [W/m²]: 2.4, Specific capacity [Wh/K per m² TFA]: 204, Mechanical cooling: []
- Calculation electricity / Internal heat gains:** Building type: 1-Residential building
- Internal heat gains:** Utilization pattern: 10-Dwelling, Values: 2-Standard
- Occupancy:** 1-Standard (only for residential buildings)

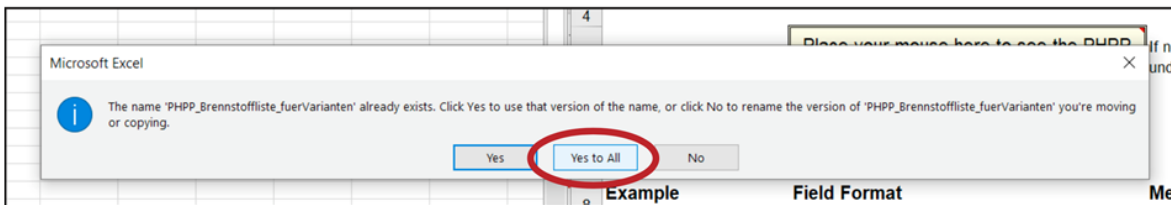
Step 3 – Ensure this file is not in protected view. Press ‘Enable Editing’. Check this for both the overheating tool and the PHPP file.



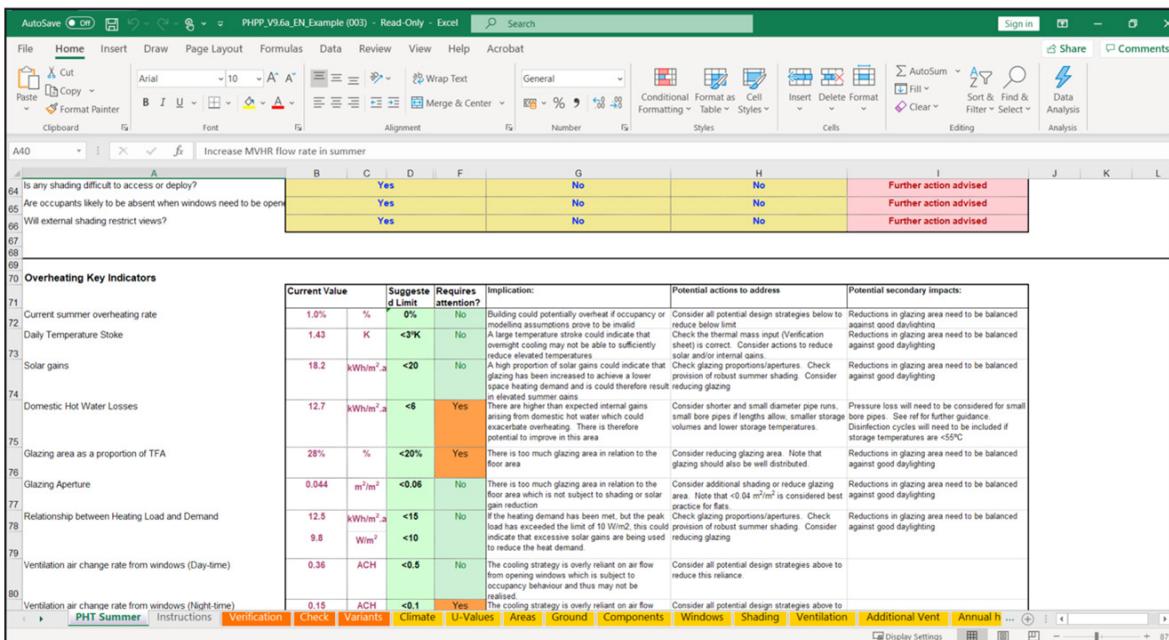
Step 4 - Drag and drop the ‘PHT Summer’ tab from the overheating tool into the PHPP model tabs section. Hold down Alt to ensure a copy of the tab is transferred rather than moved.



Step 5 – You will be asked a question about range names – click on ‘Yes to All’



Step 6 – The tab should then automatically pick up all the relevant data from the PHPP model. You may need to press F9 if your sheet is set up for manual calculations.



The stress tests will need to be undertaken individually by changing the relevant parameters and entering the results into the sheet.