



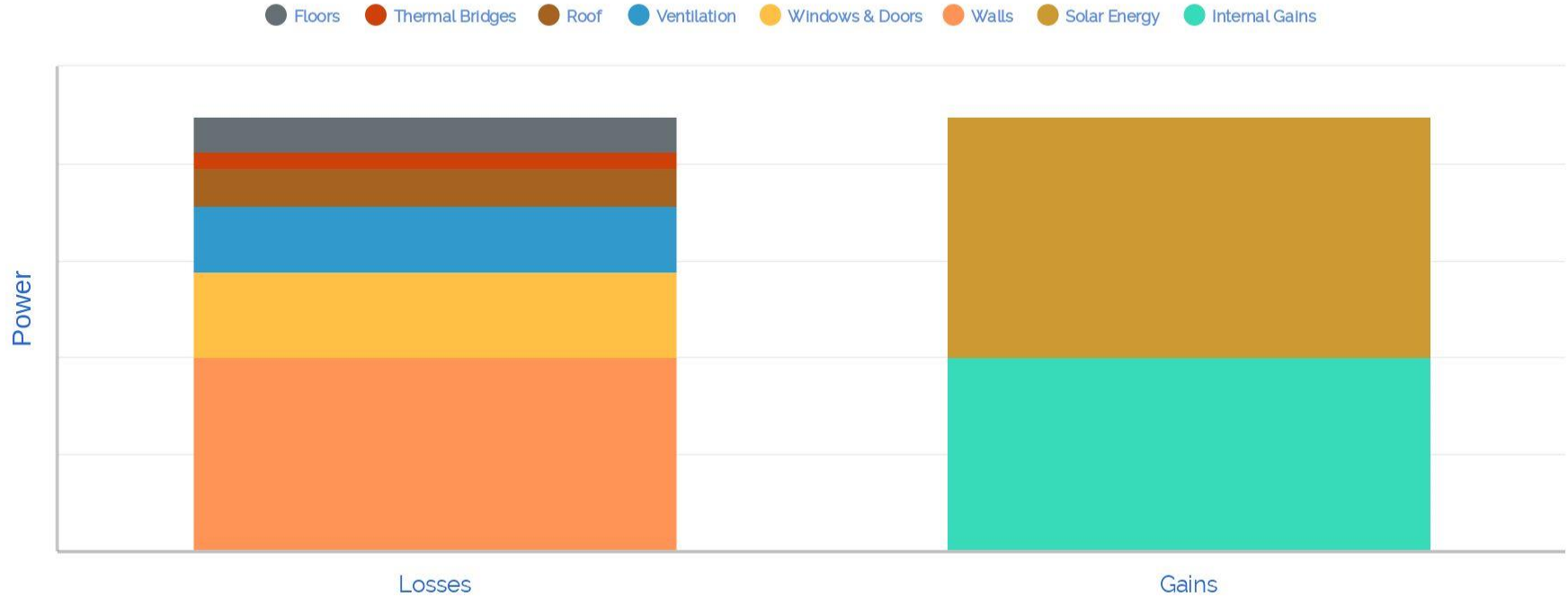
Summer Overheating

John Palmer, Passivhaus Trust

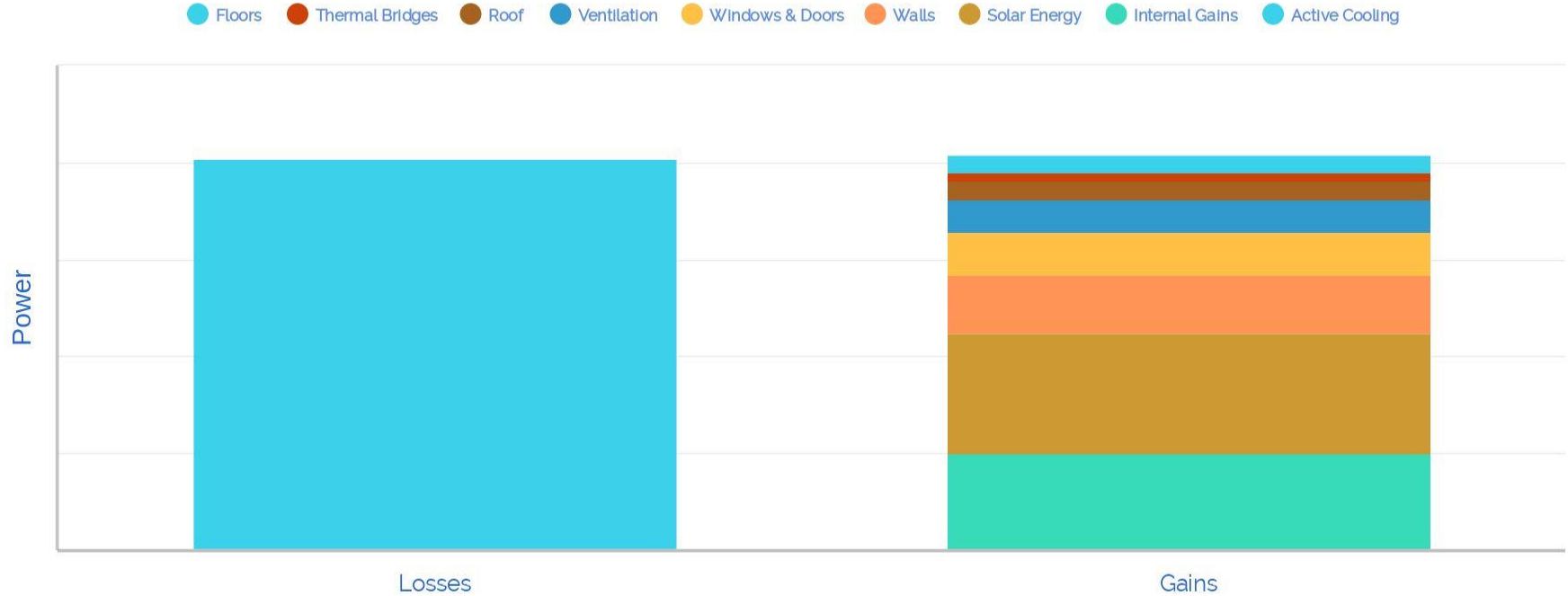
Agenda

- 1 How do buildings overheat?
- 2 Strategies to counter overheating?
- 3 Do Passivhaus buildings overheat?
- 4 Key Indicators
- 5 Stress Tests
- 6 Summer Overheating supplementary tool

How do buildings overheat?



Baby it's hot outside ...



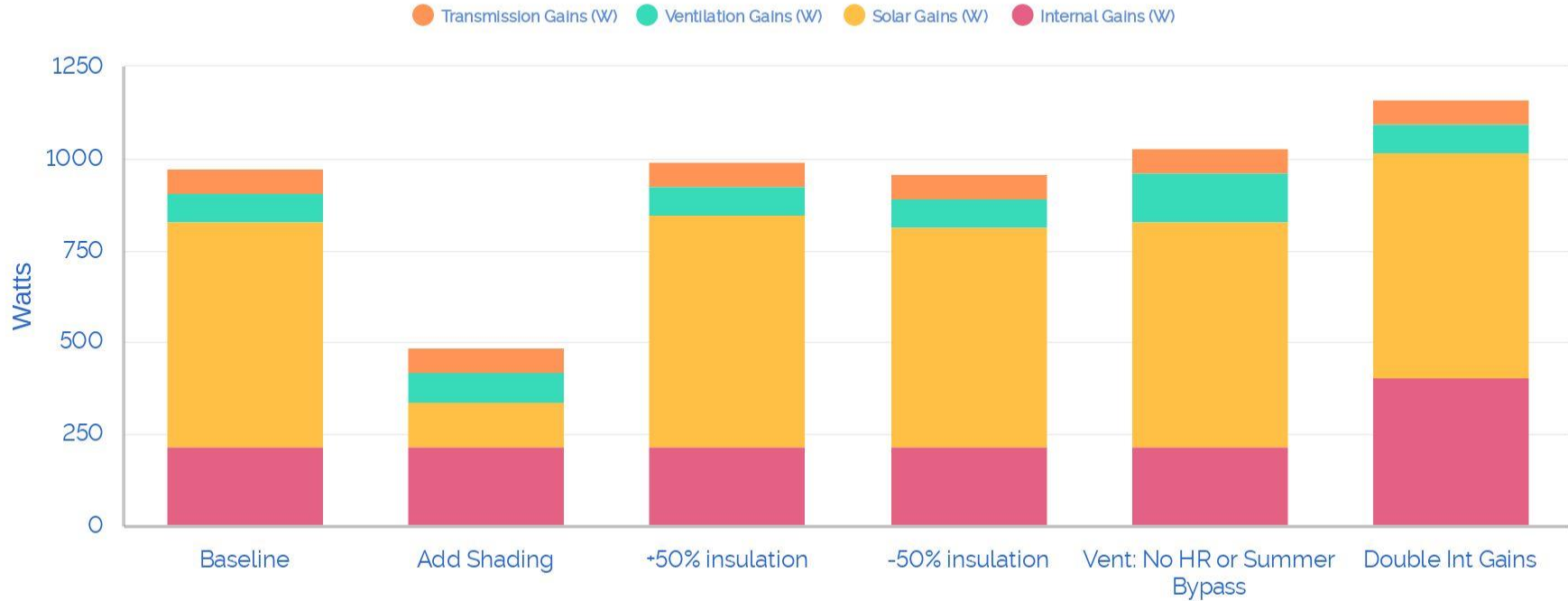
Heating mechanisms

- Solar
- Internal gains from systems
- Internal gains from occupancy

Relative Impact and Sensitivity of heat sources



What about in a warming climate?



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Prevention is better than cure

- Shading
- Reduce internal gains
- Occupancy factors

Removing heat

- Opening windows
- Fabric losses
- Mechanical ventilation
- Active cooling

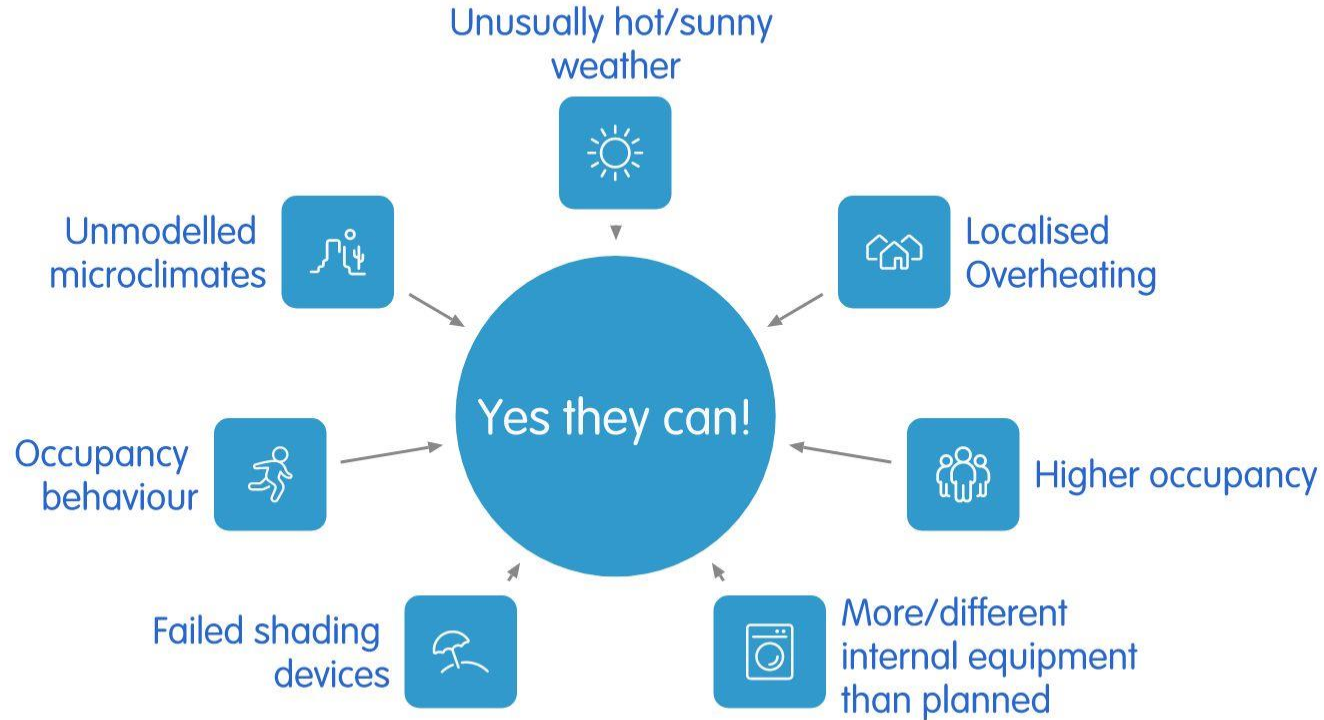
Robustness and Effectiveness of Design Strategies

Scenario	Assessment of Robustness	Robustness (1-10)	Effectiveness (1-10)	Overall Score
Overhang Shading	Robust in all situations	10	9	19
Reduced g-value	Robust in all situations	10	8	18
Reduced glazing area	Robust in all situations	10	7	17
Increase MVHR Flow rate	Subject to correct control systems	8	7	15
External Blinds	Subject either to automation or action by occupants. Automation could fail and occupants may be disinclined to use due to loss of external views.	3	10	13
Reduce Domestic Hot Water Gains	Moderately robust – other than usage/duration which will be subject to occupancy habits	6	6	12
Internal Shading	Subject either to automation or action by occupants. Automation could fail and occupants may be disinclined to use due to loss of external views.	3	7	10
Increase window opening time	Subject to action by occupants and to external factors such as noise or pollution	3	7	10
Reduce Internal gains from appliances	Subject to both appliance types/numbers and usage by occupants	2	6	8

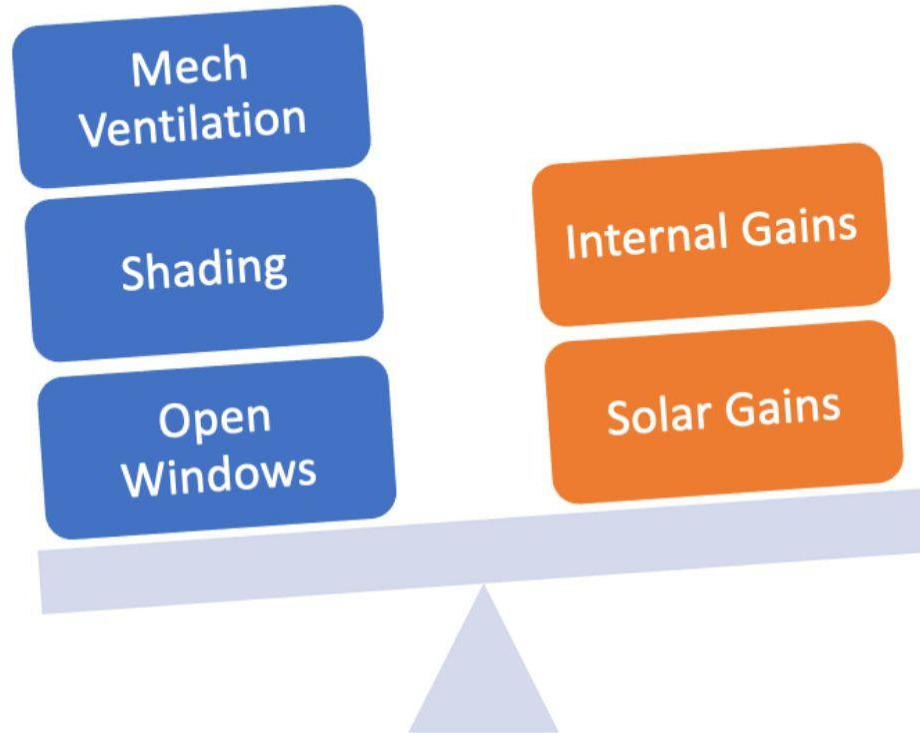
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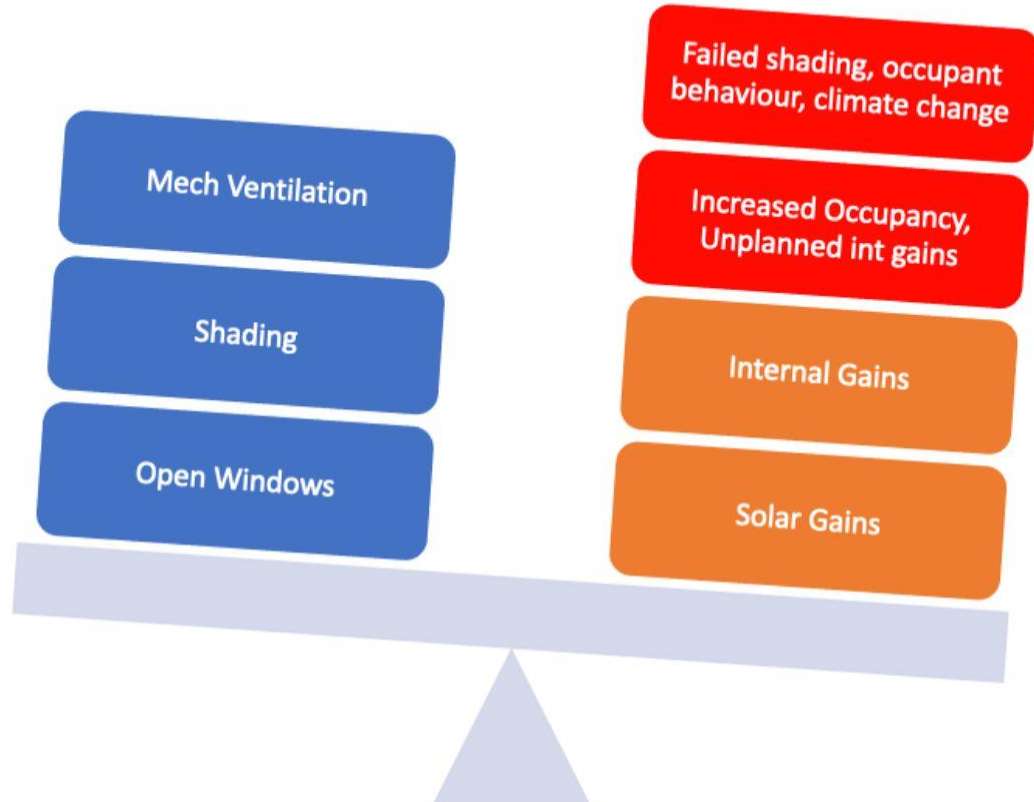
Do Passivhaus Buildings Overheat?



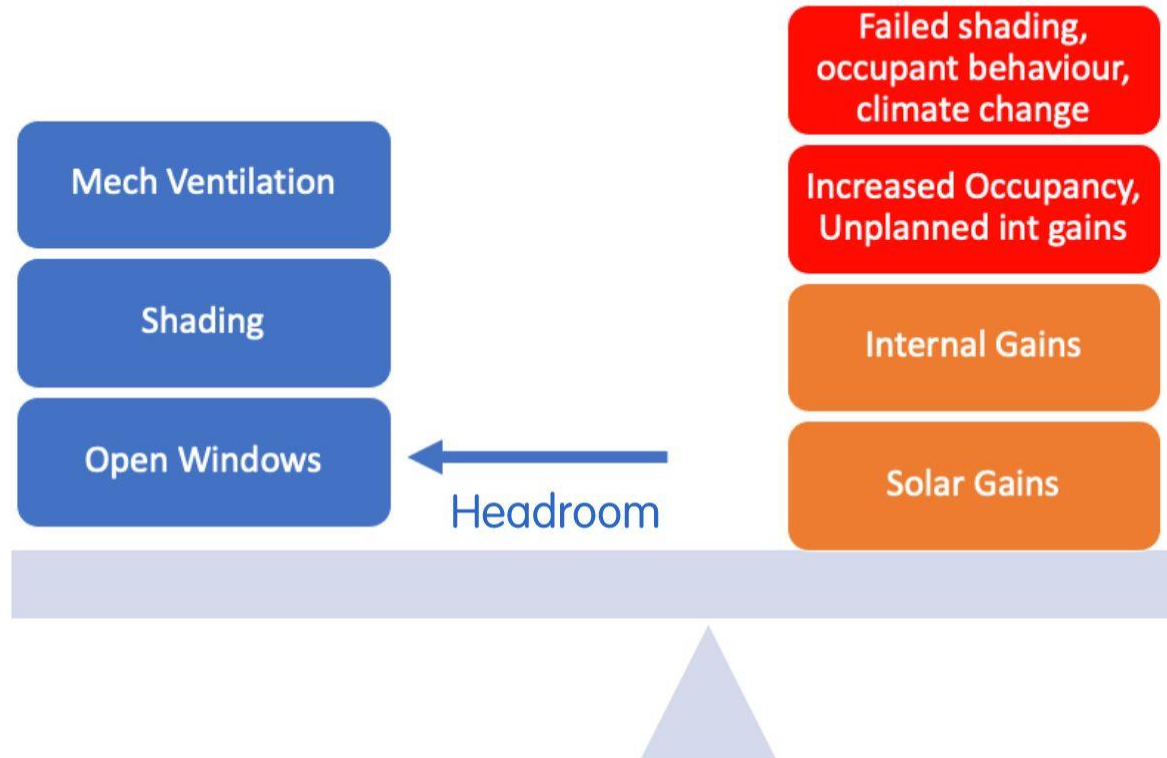
Overheating balance ...



Sprinkle on some unknowns/unplanned



So, we need some headroom ...



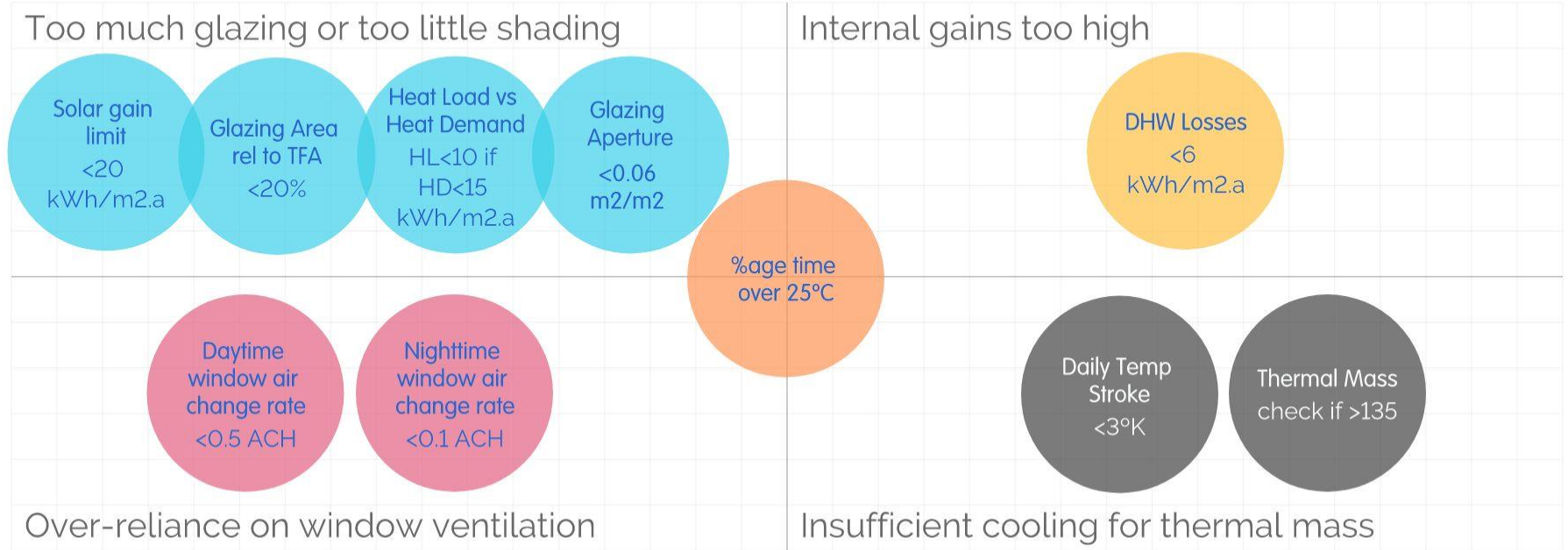
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Key Indicators - how much headroom do we have?

- 1 Percentage time above 25°C
- 2 Solar gain limit
- 3 Glazing area as a proportion of TFA
- 4 Glazing Aperture
- 5 Heating Load vs Heating Demand
- 6 Domestic Hot Water losses
- 7 Daytime air change rate from windows
- 8 Nighttime air change rate from windows
- 9 Daily Temperature Stroke
- 10 Thermal Mass

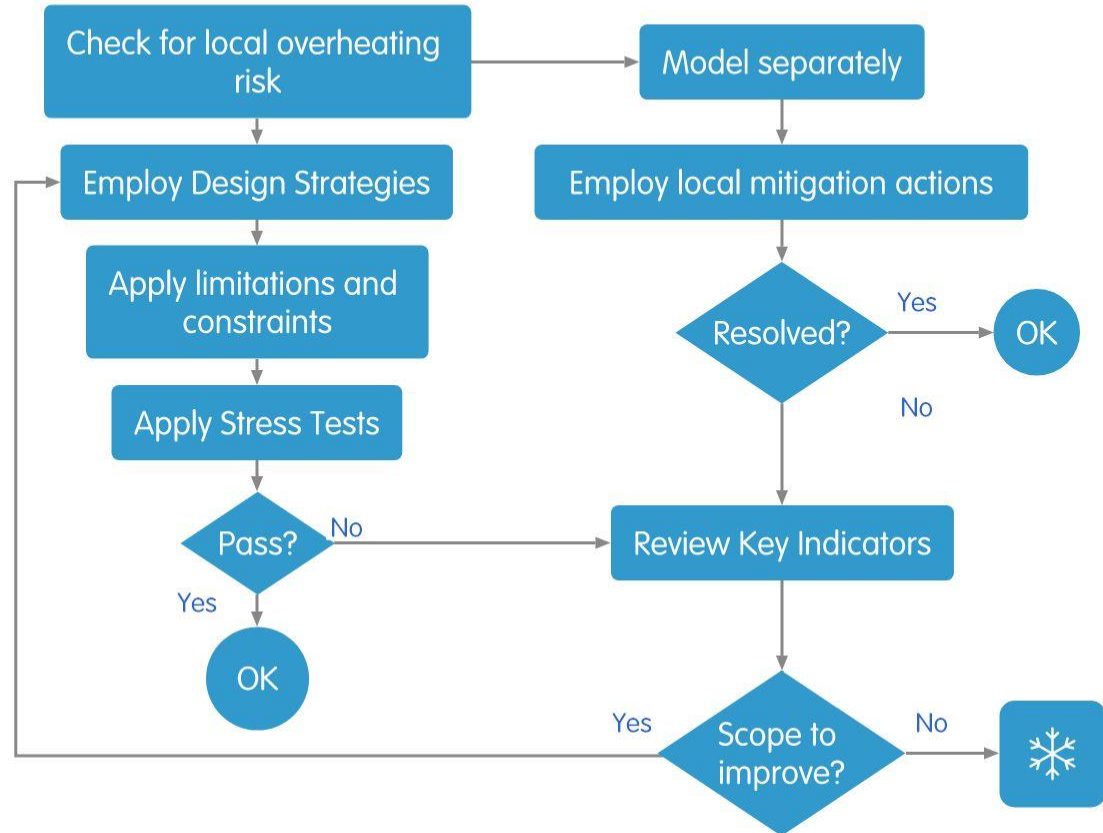
Key Indicators



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How to use the strategies, indicators and stress tests ...



Stress Tests



Reduce window daytime
ventilation rate to zero



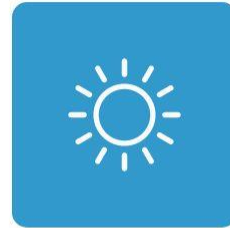
Reduce window nighttime
ventilation rate to zero



Remove all temporary shading



Increase occupancy to 50% or fill
all bed spaces



Use future climate data (1.5°C)
and/or heat island effect

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Summer Plus Sheet

Passivhaus Trust SummerPlus

Design Strategies

	Targeted on over-heating	Notes and Tips
Overhang shading	Reduce solar gain in summer whilst maintaining winter gains	Aim to subvert an angle of 67° from the end of the overhang to the lower edge of the glazing
Reduced glazing volume	Reduce solar gains	Be aware that this is likely to increase space heating demand. Consider down-piston in specific areas where possible
Reduce glazing area	Reduce solar gains	First, meet the balance against reduced gains and reduce the deficit
Increase internal wall area in summer	Increases ventilation rate without opening windows	As a result, losses of increasing the ventilation ducts will need to be minimised. A robust control mechanism for triggering increased flow will also need to be considered
External vertical shading	Reduce solar gain	It adds to occupancy loads, so control mechanisms should be robust and easy to use. Overhang shading should be considered
Reduce domestic hot water losses	Reduce internal gains	Consider shower and toilet diverter pipe runs, small bore pipes if feasible where smaller storage volumes are used
Internal shading	Reduce solar gains	Less effective than external shading and subject to occupancy habits. Look west after summer shading

Risk of Localised Overheating

	Is this area at risk of overheating (to be completed by designer)?	For further action required?	Are any specific shading and/or ventilation measures required (to be completed by designer)?	Status
Is there an area which has a higher glazing proportion than overall?	Yes	Are any specific shading measures needed?	Yes	Further action required
No	No	No	No	No further action
Is there an area where window opening is restricted compared to the rest of the building? e.g. for noise or security reasons	No	No	No	No further action
Is there an area which is not subject to the same shading effects as the majority of the building?	No	No	Yes	No further action
Yes	Are any specific shading measures needed?	Yes	No	No further action
Is there an area which is adjacent to a particular internal heat source (e.g. plant room)	Yes	Are any specific shading measures needed?	Yes	No further action
No	No	No	Yes	No further action
Are there any rooms where rooftop areas are greater than 10% of the roof area?	Yes	Are any specific shading measures needed?	Yes	No further action
No	No	No	Yes	No further action

Limitations and Constraints

Is this address at risk of overheating (to be completed by designer)?	Could it be further limited by additional measures (to be completed by designer)?	Is there any other information available to the designer (to be completed by designer)?	For further action required?
Yes	Yes	No	Further action required
No	Yes	Yes	No further action
No	Yes	Yes	No further action
Yes	Yes	Yes	No further action
Yes	No	Yes	Further action required
Yes	Yes	Yes	No further action
Yes	Yes	Yes	No further action

Overheating Key Indicators

Current Value	Targeted Value	Targeted Unit	Implication	Potential actions to address	Potential secondary impacts
6.2%	5%	%	Yes	Is shading likely to potentially offset if occupancy or internal gains are too high?	Reductions in glazing area need to be balanced against space heating losses
4.19	4	°C	Yes	A large temperature deficit could indicate that a large number of solar gains are being offset by internal gains	Check the thermal mass input of the building to ensure it is sufficient to reduce solar gain internal gains
0.3	0.2	W/m²	Yes	A high number of solar gains could indicate that glazing has been increased to achieve a lower space heating demand and could therefore result in increased summer gains	Check glazing proportions/parameters. Check provision of robust summer shading. Consider reducing glazing
0.3	0.2	W/m²	Yes	There are higher than expected internal gains during the day, which may be due to solar gains and/or internal gains. There is therefore potential to improve the situation	Consider shading and small diameter pipe runs, small bore pipes if feasible where smaller storage volumes and/or lower storage volumes are used
21%	20%	%	Yes	There is too much glazing area in relation to the floor area	Reductions in glazing area need to be balanced against space heating losses
0.048	0.04	W/m²	Yes	There is too much glazing area in relation to the floor area which is not subject to shading or solar gain reduction	Consider additional shading or reduce glazing area. Note that <0.05 of m² is considered best practice for this
15.3	15	W/m²	Yes	If the heating demand has been met, but the peak has been exceeded the limit of 15 W/m², this could indicate that the maximum solar gain are being used to offset the heat demand	Check glazing proportions/parameters. Check provision of robust summer shading. Consider reducing glazing
0.25	0.2	Ach	Yes	The cooling strategy is overly reliant on air flow from opening windows which is subject to the low level of internal and external heat gains	Consider additional design strategies above to reduce this reliance
0.00	0.0	Ach	Yes	The cooling strategy is overly reliant on air flow from opening windows, as high levels are subject to occupancy behaviour and external air conditions	Consider additional design strategies above to reduce this reliance
0.00	0.0	Ach	Yes	Thermal mass is not used to store heat, so the risk of overheating is potentially increased in peak periods. The building's "thermal mass" should be considered. In these cases, all the key indicators should be considered	Ensure thermal mass has been correctly calculated (thermal mass within the thermal envelope and not just in the walls of other buildings within recommended limits)

Stress Testing

Stress Test	Expected Result	What does this test end-on-end do?	Potential actions to address
Reduce window air ventilation rate to 0 (downward trend, not 0.1)	0%	0%	Consider all potential design strategies above to reduce this reliance. Use key indicators to determine what is most impacting overheating
Reduce window air ventilation rate to 0 (downward trend, not 0.1)	0%	0%	Consider all potential design strategies above to reduce this reliance. Use key indicators to determine what is most impacting overheating
Reduce all temporary shading (temporarily remove all windows to provide shading effect)	0%	0%	Consider all potential design strategies above to reduce this reliance. Use key indicators to determine what is most impacting overheating
Use Future Climate Data (use a future climate data set to apply a 1°C increase in peak air temperature)	0%	0%	Consider all potential design strategies above to reduce this reliance. Use key indicators to determine what is most impacting overheating

Design Strategies

Overhang shading

Reduced glazing g-value

Reduce glazing area

Increase MVHR flow rate in summer

External vertical shading

Reduce domestic hot water losses

Internal shading

Impact on overheating	Hints and Tips
Reduces solar gain in summer whilst maintaining winter gains	Aim to subtend an angle of 60° from the end of the overhang to the lower edge of the glazing
Reduces solar gains	Be aware that this is likely to increase space heating demand. Consider lower g-values in specific at-risk areas
Reduces solar gains	Will need to be balanced against reduced gains and reduced daylighting
Increases ventilation rate without opening windows	Acoustic issues of 'oversizing' the ventilation ducts will need to be considered. A robust control mechanism for triggering increased flow will also need to be implemented.
Reduces solar gain	Subject to occupancy habits, so control mechanism should be robust and easy to use. Overhang shading should be prioritised.
Reduces internal gains	Consider shorter and small diameter pipe runs, small bore pipes if lengths allow, smaller storage volumes and lower storage temperatures.
Reduces solar gains	Less effective than external shading and subject to occupancy habits. Last resort after external shading.

Risk of Localised Overheating

	Is this statement true (Yes/No) (to be completed by designer)	Further action required?	Area specific modelling and, if necessary, mitigation action taken? (to be completed by designer)	Status
Is there an area which has a higher glazing proportion than overall?	Yes	Area specific modelling recommended	No	Further action advised
Is there an area where window opening is restricted compared to the rest of the building? e.g. for noise or security reasons	No	None	No	No further action
Is there an area which is not subject to the same shading objects as the majority of the façade?	No	None	Yes	No further action
Is there an area in which only single aspect ventilation is possible?	Yes	Area specific modelling recommended	Yes	No further action
Is there an area which is adjacent to a particular internal heat source (e.g. plant room)	Yes	Area specific modelling recommended	Yes	No further action
Are there any rooms where rooflight areas are greater than 10% of the room area?	No	None	Yes	No further action
Have bedrooms been checked to see if they have openable windows and cross ventilation?	Yes	Area specific modelling recommended	Yes	No further action

Limitations and Constraints

	Is this statement true (Yes/No) (to be completed by designer)	Confirm that these have been addressed in the modelling input (Yes/No) (to be completed by designer)	Evidence of rationale provided to certifier? (Yes/No)	Further action required?
Will external noise limit window opening?	Yes	Yes	No	Further action advised
Will external pollution limit window opening?	No	Yes	Yes	No further action
Will security issues limit window opening?	No	Yes	Yes	No further action
Are there significant restrictions on internal air movement?	Yes	Yes	Yes	No further action
Are windows difficult to access and open?	Yes	No	Yes	Further action advised
Is any shading difficult to access or deploy?	Yes	Yes	Yes	No further action
Are occupants likely to be absent when windows need to be opened?	Yes	Yes	Yes	No further action
Will external shading restrict views?	Yes	Yes	Yes	No further action

Overheating Key Indicators

	Current Value		Suggested Limit	Requires attention?	Implication:	Potential actions to address	Potential secondary impacts:
Current summer overheating rate	6.2%	%	0%	Yes	Building could potentially overheat if occupancy or modelling assumptions prove to be invalid	Consider all potential design strategies below to reduce below limit	Reductions in glazing area need to be balanced against good daylighting
Daily Temperature Stroke	4.19	K	<3°K	Yes	A large temperature stroke could indicate that overnight cooling may not be able to sufficiently reduce elevated temperatures	Check the thermal mass input (Verification sheet) is correct. Consider actions to reduce solar and/or internal gains.	Reductions in glazing area need to be balanced against good daylighting
Solar gains	8.9	kWh/m ² .a	<20	No	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	Check glazing proportions/apertures. Check provision of robust summer shading. Consider reducing glazing	Reductions in glazing area need to be balanced against good daylighting
Domestic Hot Water Losses	6.5	kWh/m ² .a	<6	Yes	There are higher than expected internal gains arising from domestic hot water which could exacerbate overheating. There is therefore potential to improve in this area	Consider shorter and small diameter pipe runs, small bore pipes if lengths allow, smaller storage volumes and lower storage temperatures.	Pressure loss will need to be considered for small bore pipes. See ref for further guidance. Disinfection cycles will need to be included if storage temperatures are <55°C
Glazing area as a proportion of TFA	21%	%	<20%	Yes	There is too much glazing area in relation to the floor area	Consider reducing glazing area. Note that glazing should also be well distributed.	Reductions in glazing area need to be balanced against good daylighting
Glazing Aperture	0.048	m ² /m ²	<0.06	No	There is too much glazing area in relation to the floor area which is not subject to shading or solar gain reduction	Consider additional shading or reduce glazing area. Note that <0.04 m ² /m ² is considered best practice for flats.	Reductions in glazing area need to be balanced against good daylighting
Relationship between Heating Load and Demand	15.3	kWh/m ² .a	<15	No	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.	Check glazing proportions/apertures. Check provision of robust summer shading. Consider reducing glazing	Reductions in glazing area need to be balanced against good daylighting
	9.9	W/m ²	<10				
Ventilation air change rate from windows (Day-time)	0.25	ACH	<0.5	No	The cooling strategy is overly reliant on air flow from opening windows which is subject to occupancy behaviour and thus may not be realised.	Consider all potential design strategies above to reduce this reliance.	
Ventilation air change rate from windows (Night-time)	0.00	ACH	<0.1	No	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.	Consider all potential design strategies above to reduce this reliance.	
Thermal Mass	60	Wh/K.m ²	N/A	N/A	Thermally massive buildings (>135) could be at greater risk of overheating be perpetuated in warm periods, thus additional 'headroom' should be considered. In these cases, all the key indicators should be considered	Ensure thermal mass has been correctly calculated (thermal mass within the thermal envelope) and take action to keep all other indicators within recommended limits.	

Stress Testing

- Reduce window day ventilation rate to 0
(SummerVent sheet, cell L31)
- Reduce window night ventilation rate to 0
(SummerVent sheet, cell P59)
- Remove all temporary shading
(Temporarily remove all entries in column AH in Shading sheet)
- Increase occupancy by 50% or fill all bed spaces
(Apply 'User Determined' occupancy in cell Q29 on Verification sheet)
- Use Future Climate Data
(Use PHPP Summer Overheating tool to apply a 1.5°C increase and/or heat island effect)

Stressed Overheating Limit (to be inserted by designer)	Suggested Limit	Status	What does this test demonstrate?	Potential actions to address
8%	0%	Warning	Whether there is a significant reliance on window ventilation to achieve summer comfort	Consider all potential design strategies above to reduce this reliance. Use key indicators to determine what is most impacting overheating.
4%	<5%	Pass	Whether there is a significant reliance on window ventilation to achieve summer comfort	Consider all potential design strategies above to reduce this reliance. Use key indicators to determine what is most impacting overheating.
12%	<10%	Warning	Whether there is a significant reliance on temporary shading measures which could fail or not be deployed by occupants	Consider switching to fixed shading or otherwise ensure robust deployment mechanisms
4%	<5%	Pass	Whether the building is sensitive to increased occupancy in terms of its overheating response	Consider all potential design strategies above to reduce this reliance. Use key indicators to determine what is most impacting overheating.
9%	<5%	Warning	Whether the building is at risk of overheating in future climates	Consider all potential design strategies above to reduce this reliance. Use key indicators to determine what is most impacting overheating.



Summer overheating

Mech Ventilation

Failed shading,
occupant behaviour,
climate change

Increased Occupancy,
Unplanned int gains

Too much glazing or too little shading

Solar gain
limit
 <20
 $\text{kWh/m}^2\text{a}$

Glazing Area
rel to TFA
 $<20\%$

Heat Load vs
Heat Demand
 $HL < 10$ if
 $HD < 15$
 $\text{kWh/m}^2\text{a}$

Glazing
Aperture
 <0.06
 m^2/m^2

Internal gains too high

DHW Losses
 <5
 $\text{kWh/m}^2\text{a}$

%age time
over 25°C

Daytime
window air
change rate
 <0.5 ACH

Nighttime
window air
change rate
 <0.1 ACH

Daily Temp
Stroke
 $<3^\circ\text{K}$

Thermal Mass
check if >135

Over-reliance



Reduce window daytime
ventilation rate to zero



Reduce window nighttime
ventilation rate to zero



Remove all temporary shading



Increase occupancy to 50% or fill
all bed spaces



Use future climate data (1.5°C)
and/or heat island effect

UKpassivhaus conference 2020

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