World Green Building Week 2017

25 September – 1 October

#OurHeroisZero

Three ways to unlock the potential for Net Zero Buildings

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Supporting World Green Building Week 2017

Buildings are responsible for over a third of the world's greenhouse gas emissions. The World Green Building Council is working hard to change this and make all buildings Net Zero by 2050. World Green Building Week is an annual event that "empowers the green building community to deliver green buildings for everyone, everywhere".

Currently, there are hundreds of inspirational Net Zero buildings around the world. Yet there is a long way to go, and to support World Green Building Week 2017, Eight Associates has collated three of our thought pieces about different ways we can progress towards Net Zero buildings utilising sustainable design.

- **Achieving thermal comfort through sustainability design**
  Overheating is a growing problem in the UK, due to climate change, the urban heat island effect and more highly insulated, highly glazed, air tight buildings.

- **Air tightness – design insight, build tight, ventilate right**
  Poor air tightness can be responsible for up to 40% of heat loss. Considering air permeability at the early design stage is a worthwhile investment.

- **What would improve the quality of energy strategies**
  A planning consent requirement to demonstrate the agreed carbon emission savings at completion would improve the quality of energy strategies.


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Using sustainable design to achieve thermal comfort

Overheating is a growing problem in the UK, due to climate change, the urban heat island effect and more highly insulated, highly glazed, air tight buildings.

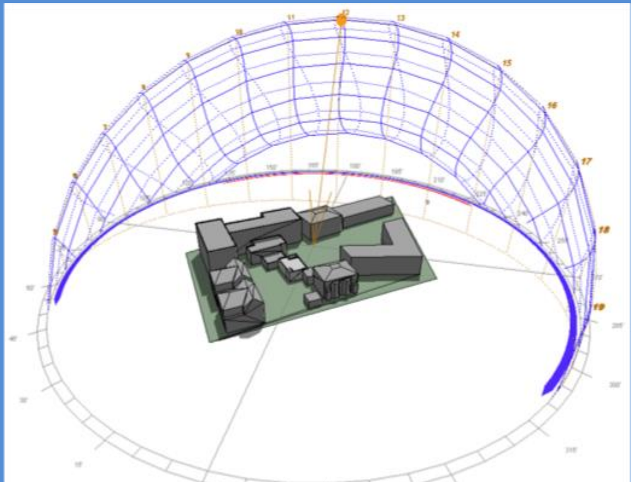
A combination of environmental and personal factors affect thermal comfort: The environmental factors include air temperature, radiant temperature, air velocity, humidity and uniformity of conditions, while the personal factors span clothing, metabolic rate, acclimatisation, state of health, expectation and access to food and drink. The Health and Safety Executive view that 'reasonable comfort' is achieved when at least 80% of its occupants are thermally comfortable. Open plan offices - and also our homes' lounges - are typically between 21-23^{o}C in winter and 22-25^{o}C in summer. Whilst there is no legal maximum workplace temperature, overheating is a serious concern due to health, wellbeing and performance implications.

There are many techniques for estimating likely thermal comfort: Under BS EN ISO 7730 and BS EN ISO 10551 thermal comfort is expressed in terms of Predicted Mean Vote (PMV) and Percentage People Dissatisfied (PPD). The CIBSE Guide approach to overheating for air conditioned buildings is based on not exceeding a single limiting temperature (e.g. 23^{o}C) for 3% occupied (working) hours. CIBSE TM 52 - for naturally ventilated buildings - requires temperatures do not go above a varying 'threshold comfort temperature' for more than 3% of occupied hours, and features two further criteria for the amount of temperature exceedance.

Other overheating standards include SAP – Overheating Assessment, SBEM – Excess Solar Gains and ASHRAE STANDARD 55-2010, among others. Be aware that a 'slight' risk of overheating as identified by SAP analysis may actually result in a high risk when it is properly analysed, as SAP is a very simplified tool that is based on average monthly (not peak) temperatures.

What the primary causes of external heat gains? Sunlight and high external temperatures, and these factors are controlled through the consideration of passive design measures (including optimising orientation and shading devices), construction measures (targeting glazing solar energy transmittance, thermal mass and air leakage) and active design measures (such as heating and cooling capacities, efficiencies and set points, ventilation rates and heat recovery efficiency).

Orientation can enhance a building's thermal comfort passively by taking advantage of solar gains to reduce heat loads or to protect against unwanted solar gains. Orientation also determines the choice of the shading device that is used, such as overhangs, external louvers and internal blinds. Each has pros and cons, including the level of occupant control, glare, and implications for daylight and views.



Using sustainable design to achieve thermal comfort

Thermal mass refers to the ability of building materials to store and emit heat, and careful consideration should be given to integrating thermal mass and ventilation strategies. When the air within a space is warmed due to direct sunlight or heat gains from people and appliances, some building materials absorb heat. As the air cools overnight, this heat is re-emitted into the space. Dense building materials which are exposed to the internal environment can absorb and release heat due to their thermal mass (heat capacity), although this is significantly reduced by for example, levels of internal insulation and service voids.

The **fenestration design and glazing choices** have a massive impact on thermal comfort. In a domestic setting, up to 40% of a home's heating energy can be lost via windows while the required cooling capacity can be increased by up to 50%. Customising the U-value and solar heat gain coefficient (SHGC) for glazing on different elevations at the design stage will optimise predicted thermal comfort.

As a rule of thumb in commercial settings, a façade with greater than 25% (glazing to floor area) should be given increased attention, particularly the glazing solar factor.

While design and construction measures can limit the effects of excessive internal and external heat gains, these cannot be completely eliminated. The most effective way to remove built-up heat is through an **effective ventilation strategy**, to replace existing warm air with fresh air from outside (when the outside air is cooler).

While natural ventilation is highly desirable, it is not always an option due to air and noise pollution. It is common to see residential mechanical ventilation heat recovery (MVHR) units with very low specific fan powers specified to achieve CO_2 targets. However, the lower amount of ventilation provided from smaller power-consuming MVHR units might mean that the dwelling does not meet its required air change rates for air quality and overheating.

Using sustainable design to achieve thermal comfort

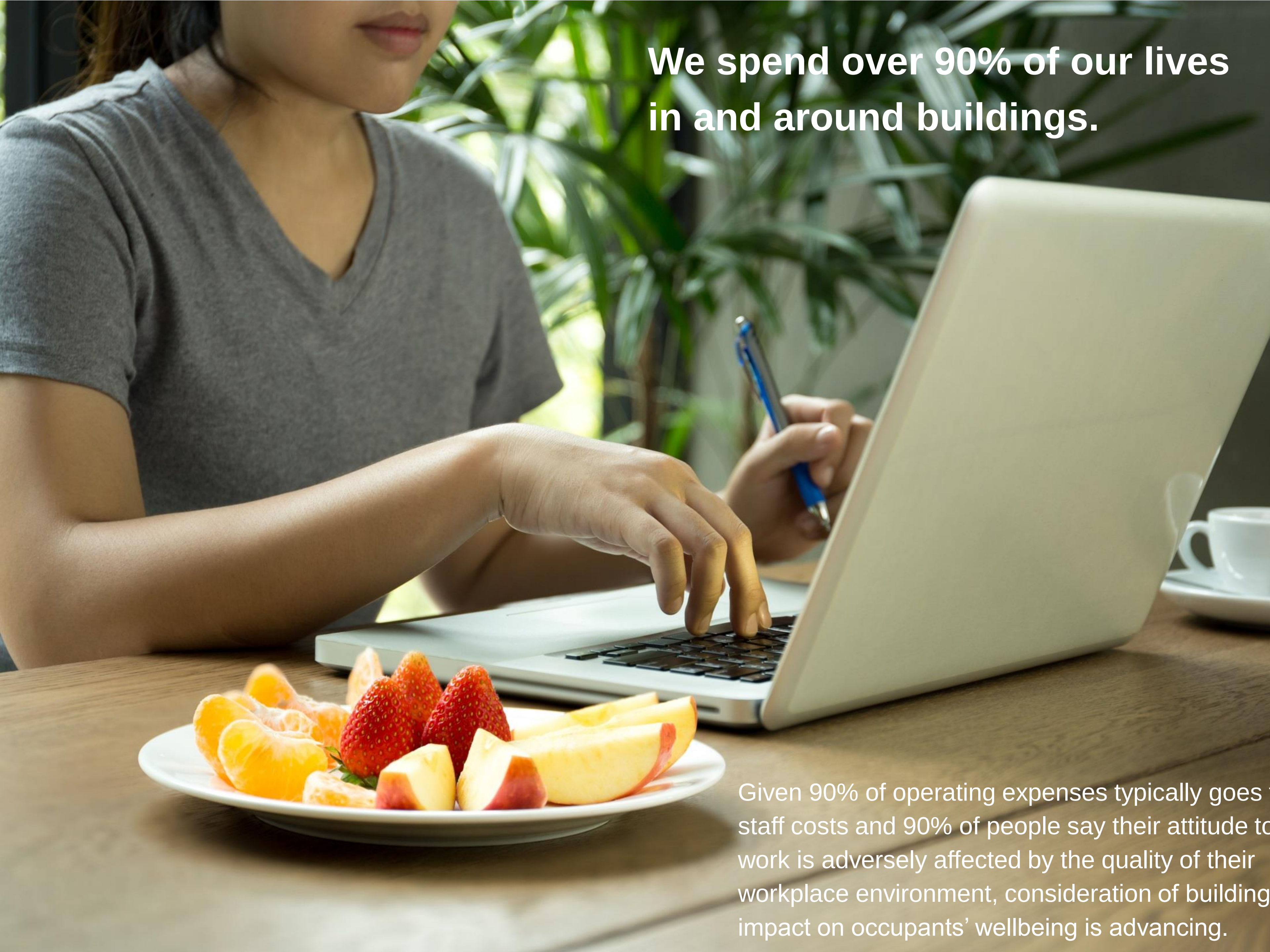
The most effective ventilation strategy will modulate according to the prevailing conditions; higher ventilation rates during periods of high solar and internal gains and the ability to bypass the heat exchanger when it becomes detrimental, and ideally the option to switch to natural ventilation only.

At summer peak air temperatures of 28ºC or more, when ventilation ceases to be of much benefit, air-conditioning may become inevitable. However, a best practice approach would be to fit sensors on opening windows to deter the use of active cooling in conjunction with high volumes of natural air changes.

Comfort levels are influenced by the complex, cumulative effects of site context, external temperature, solar gains, internal gains and building design. These in turn have an impact on a range of health and wellbeing factors, such as daylight views, air quality and noise pollution.

In fact, data suggests that productivity levels drop by 10% - 20%, which equates to a significant revenue loss even in buildings meeting CIBSE Guide A criteria in full.

Achieving thermal comfort through sustainable design involves the careful balancing of interdependent factors, including orientation, thermal mass, glazing, shading and ventilation. The benefits of getting it right are worth it, not just in terms of energy efficiency, but also productivity and wellbeing - which are increasingly becoming the criteria against which to judge a building's quality.



We spend over 90% of our lives in and around buildings.

Given 90% of operating expenses typically goes t staff costs and 90% of people say their attitude to work is adversely affected by the quality of their workplace environment, consideration of building impact on occupants’ wellbeing is advancing.

Design insight, build tight, ventilate right

Poor air tightness can be responsible for up to 40% of heat loss. Considering air permeability at the early design stage is a worthwhile investment.

The air permeability of the building envelope underlies the potential energy efficiency of a building, as poor airtightness can be responsible for up to 40% of heat loss from buildings. The level of air permeability is determined by the standards of design, materials, and workmanship. Well-managed, it enables lower running costs; prevents uncomfortable drafts and minimises condensation risks. If overlooked at the early design stage, it can lead to underperforming buildings that, at worst, fail building compliance – leading to delays and the cost of additional, remedial measures.

Air permeability testing measures the uncontrolled air leakage of a building. This is distinct from the designed controlled ventilation strategy (i.e. mechanical ventilation) which ensures a sufficient movement of air through the building to create comfortable, liveable spaces. Air permeability is measured as the air leakage rate per hour per square metre of envelope area, or the quantity of air in m^3 that leaks into or out of the building per hour measured by pressurising or depressurising the envelope to 50 Pascals (or $m^3/h.m^2$ at 50 Pascals).

Building regulations Part L sets a limiting air permeability of 10 (metres cubed, per hour, per metre squared of external surface envelope area). A well-designed, well-built new build development could realistically achieve $3m^3/hr.m^2$@50PA (if mechanically ventilated) or 5 $m^3/hr.m^2$@50PA (if naturally ventilated). The regulations require that the Building Emission Rate (BER), or Dwelling Emission Rate (DER) does not exceed the Target Emission Rate (TER). SAP calculations are undertaken to determine the energy performance of a dwelling, in which a design air permeability target is set to ensure compliance.

It is worth noting that the air permeability rate for the TER has been set at 7 $m^3/hr.m^2$@50PA therefore design air permeability targets worse than this benchmark will need to offset emissions through other means to ensure compliance.

Design insight, build tight, ventilate right

Infiltration occurs when air leaks through cracks and gaps in the dwelling's fabric. The amount of infiltration is affected by design and quality of construction and by wind speed/direction: Windows and doors lose a lot of heat, so particular attention should be paid to the U-values of openings. Thermal bridging, concerning heat loss through non-repeating linear junctions, should be assessed and minimised too. Minimum U-values should be treated as just that – minimums. If the fabric of the building is well insulated, you will not need renewable technologies or further measures to comply or exceed Part L standards.

All new builds require Air Permeability Testing (APT) on completion and the resulting figure goes into the SAP calculations. It is vital that the envelope is sealed before testing, and a pre-test check should be carried out.

Testing is required on all residential developments, although this may be a sample of units, and non-dwellings. In the case of only a sample of units being tested, the assessed air permeability is the average test result obtained from other dwellings of the same type, increased by 2.0 $m^3/h.m^2$. Where testing is not carried out, an assumed air permeability of 15 $m^3/h.m^2$ must be used in calculations. This default '15' air permeability assessment alone highlights why air tightness testing, done early, is a worthwhile investment.

Design air permeability targets should be considered at the early design stage but this is often overlooked. The key to success is summarised in the below steps:

1. *Accurate early design construction detailing (through design review meetings, to inform the tendering process).*

2. *Design workshops with contractors (on site, covering the correct procedure to create a tight building envelope).*

3. *First and second fix intermediary air tightness testing (to save delays and costs later).*

4. *Consultations with M+E consultants to determine the best ventilation strategy to fit the scheme's design air permeability target.*

5. *Final air tightness testing to confirm as built building compliance.*

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Net zero buildings are highly energy efficient and use clean energy, producing enough renewable energy to meet its own annual energy consumption requirements. In 2015, there were only about 400 net-zero buildings globally.
Net zero is just one way to measure green buildings. BREEAM, LEED, the Well Building Standard, among others, offer different ways to address energy use in buildings.

Evaluating energy strategies

A planning consent requirement to demonstrate the agreed carbon emission savings at completion would improve the quality of energy strategies.

A multitude of factors shape the efficacy of an energy statement – at planning and through the design and construction phase. The bare minimum is that it achieves the Part L Building regulations 2013 baseline, follows the energy hierarchy, is appropriate to its setting and adheres to the local authority's planning policies and management plans.

An effective energy strategy should be 'lean' (minimise energy demand through passive and active measures), 'clean' (select the most energy-efficient heating and cooling infrastructure) and 'green' (show intelligent use of renewable energy and technologies), and clearly identify the operational carbon footprint of the development after each stage of the energy hierarchy, including both regulated emissions and those emissions associated with uses not covered by Building Regulations.

Being 'lean'

The passive design measures, such as optimising orientation, natural ventilation and lighting, thermal mass and solar shading, and active design measures, including high efficacy lighting and efficient mechanical ventilation with heat recovery, underpin a lean energy strategy.

As a starting point when evaluating energy strategies, check the benchmarks used and consistency of assumptions. For example, it is common for the energy strategy and overheating report to not share the same inputs; the overheating modelling may make assumptions that limit the risk of overheating by increasing mechanical ventilation flow rates, while the energy modelling decreases the rates to reduce carbon emissions.

It should be clear how the thermal mass estimation has been arrived at; request a simple table with indicative values for different structure types (high, medium, low) which specifies the ranges being used. Thermal bridging calculations should be clearly presented in a simple table also, with the junction lengths and method used: The common assumption of an average y-value of 0.08 (or even lower) reduces the fabric's thermal bridges by 50% over the default value – and this may not be feasible in practice. The linear lengths should always be measured otherwise the average y-value cannot be accurately ascertained.

The specified airtightness targets should follow best practice, $5m^3/hr.m^2$ for natural ventilation and $3m^3/hr.m^2$ for mechanically ventilated spaces, or there could be air quality issues. Similarly, if mechanical ventilation with heat recovery (MVHR) is specified yet the airtightness design target is greater than 3, the benefit to the development's carbon emission reductions is negated by air leakage through the building fabric.

Evaluating energy strategies

Being 'clean'

Once demand for energy has been minimised, the space heating and cooling energy demands should be accurately assessed and demonstrated. This includes connection to district heating networks or onsite combined heat and power (CHP) engines.

CHPs are often oversized to meet carbon targets on paper, but tend to be only viable on domestic schemes of more than 100 units or commercial schemes with high hot water demand, such as hotels. Ask for a load profile analysis with the hot water demand calculations.

A dynamic overheating risk analysis always should be presented to ensure that the ventilation is adequate to deliver comfort. SAP is a very simplified tool based on average monthly (not peak) temperatures so a slight risk of overheating, as identified by SAP analysis, may actually equate to a high risk.

Details of the proposed active cooling plant should be included, and while the need for air-conditioning is usually designed out, due to future climate change it might be necessary where outside temperature exceed 28 degrees.

Glazing has a large impact on cooling demand, so always review the glazing solar factor and Seasonal Energy Efficiency Ratio (SEER) where the cooling demand for a building is high. These values should be in the report, even though they are not specified in Building Regulations Part L documentation produced by software models.

In non-domestic settings, very high luminous efficacy of lighting is often specified to lower the lighting demand although there is often little evidence to support the values. Where luminous efficacy exceeds 75 lumens per circuit watt, more information should be given as this may not be achievable in practice.

Evaluating energy strategies

Being ‘green’

Given the current carbon intensity of electricity, be wary of developments that appear to show significant carbon reduction improvements when specifying air source heat pumps (ASHP). When specified to provide space heating in domestic settings, ASHPs cannot provide sufficiently high water temperatures for the avoidance of legionella and an additional gas or electric boiler is needed to heat the water to 60oC. Gas fired heat pumps are a good solution to provide the required higher temperatures, although their efficiency levels drop as temperature output increases.

Check that the allocation of photovoltaic systems on the roof is realistic, to identify whether the proposal is possible in practice. Analysis of the shadow effect on the roof is important, and required by the GLA, as even if a small part of the PV panel is shaded the output is vastly reduced.

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It is still not common to find it an explicit condition of planning consent that the carbon emissions reduction stated in the energy strategy are demonstrated at practical completion. Design naturally evolves and without an explicit requirement to demonstrate the agreed carbon emission savings at completion, these design changes will not be made with energy conservation as a priority. This will improve the quality of energy strategies at planning, making consultants responsible for their energy strategy assumptions and inputs, and how feasible they are in practice.

Getting involved in World Green Building Week 2017

#OurHeroisZero

Discover more about net zero and how your home and workplace can become a hero at www.worldgbc.org/worldgreenbuildingweek

Find and attend a World Green Building Week event near you.

Read WorldGBC's report From Thousands to Billions on how we can ensure every building is net zero emissions by 2050.

Join the fight against climate change by championing the need for net zero buildings in your community.