Module 8

# Adapting to Climate

Energy Efficiency for Construction

24 partners 12 countries

*Date of Event*

*Author/ **Institute***

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# Adapting to Climate | Summary

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To equip the learner with the basic knowledge and skills required to understand the principles and importance of healthy comfortable buildings



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# Adapting to Climate | Objectives

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- Identify and explain terminologies with practical relevance to comfort and air quality within energy efficient buildings.
- List and describe the factors affecting occupant comfort in buildings.
- Outline why it is important to adapt construction methods and materials to different climates.
- Identify and explain the impact of indoor and outdoor air contaminants on buildings
- Demonstrate the benefits of using direct passive solar systems in case studies scenarios
- Demonstrate a scenario to achieve a healthy indoor climate

# Adapting to Climate | Contents

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# Sustainability Principles and Level(s) framework

The Level(s) framework contribute to EU and Member State policy objectives in areas such as energy, material use and waste, water and indoor air quality.

Objective 1: Greenhouse gas emissions along a buildings life cycle

Objective 2: Resource efficient and circular material life cycles

Objective 3: Efficient use of water resources

**<u>Objective 4: Healthy and comfortable spaces</u>**

Objective 6: Optimised life cycle cost and value

# Level(s)

**Objective 4: Healthy and comfortable spaces**

The design of buildings that are comfortable, attractive and productive to live and work in and which protects human health.

The indicators to achieve this objective are:

1- Indoor air quality [$CO_2$ level and humidity; list of pollutants]

2- Time out of thermal comfort stage [% of the time out of range of defined maximum and minimum temperatures during the heating and cooling seasons]

Source: thechop.blog

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## Principles: Prioritise comfort for building users

1. Ensure consistent thermal comfort, with awareness of varying occupant needs, to enhance wellbeing.

2. Maintain exemplary lighting for occupant wellbeing, with natural and energy-efficient solutions prioritized.

3. Maintain acoustic comfort.

4. Consider wider comfort indicators to support occupant wellbeing, including olfactory (smell), ergonomic (body positioning) and visual (sight) comfort.

5. Ensure inclusive design of the built environment

# and the Occupants

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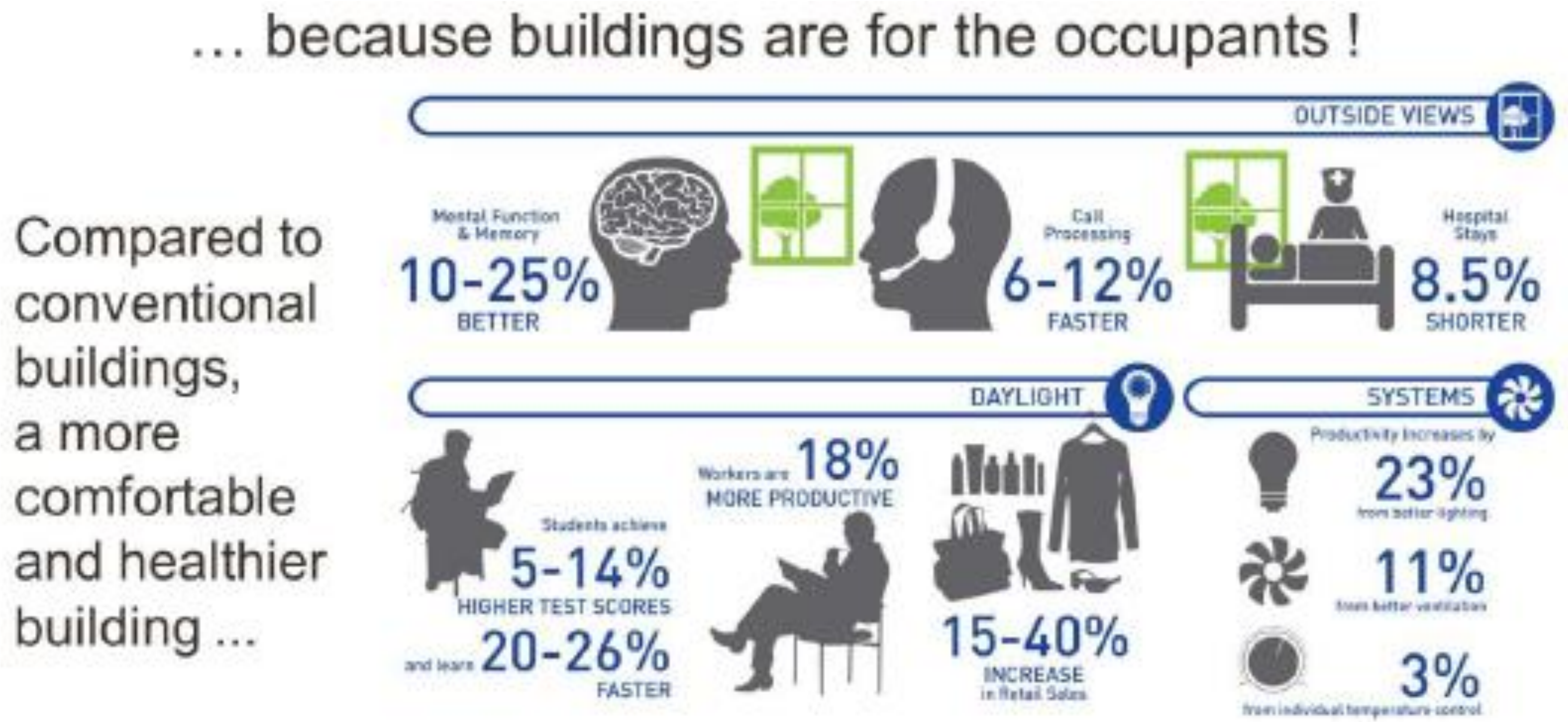


Source: World Green Building Council



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# 1. Comfort





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# Local Thermal Comfort

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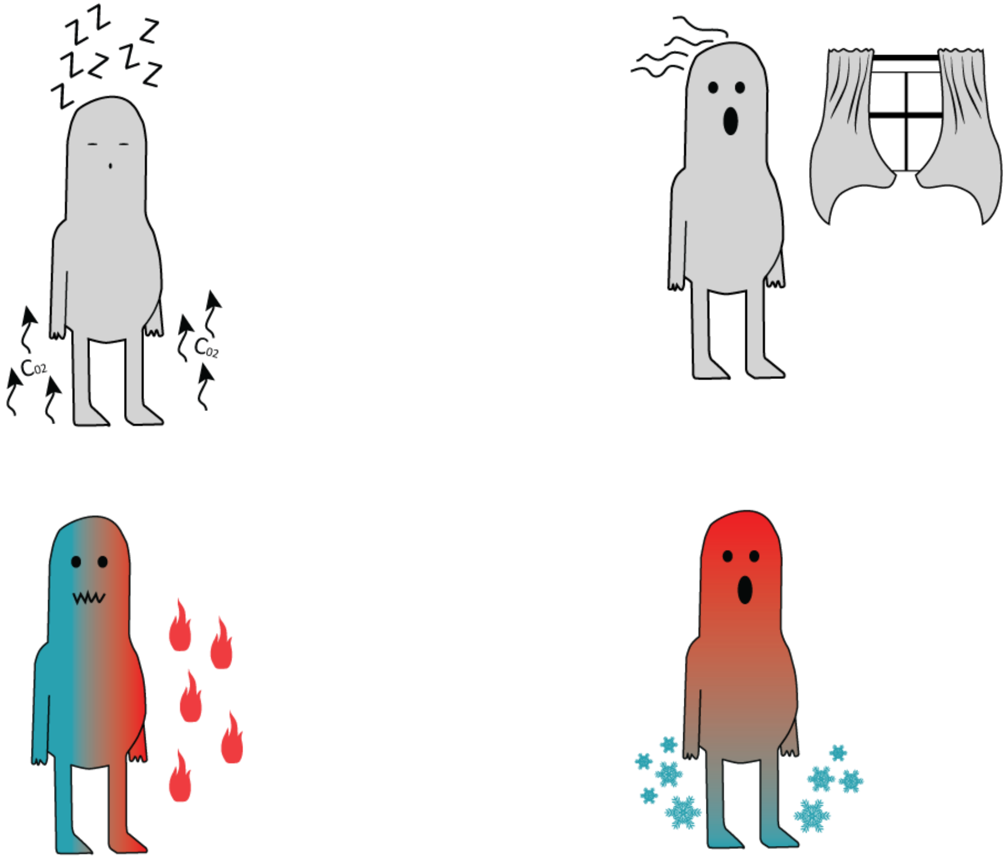
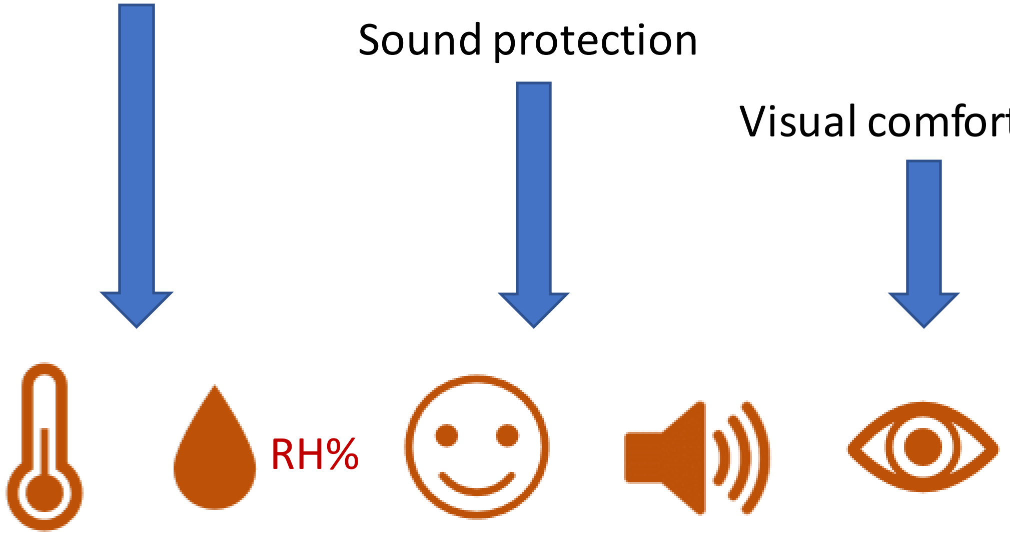



Ensure a healthy and pleasant indoor environment for the occupants.

Thermal comfort

Sound protection

Visual comfort




Sources: Left: Mosart/WWETB Right: BIMzeED

# Keeping Warm

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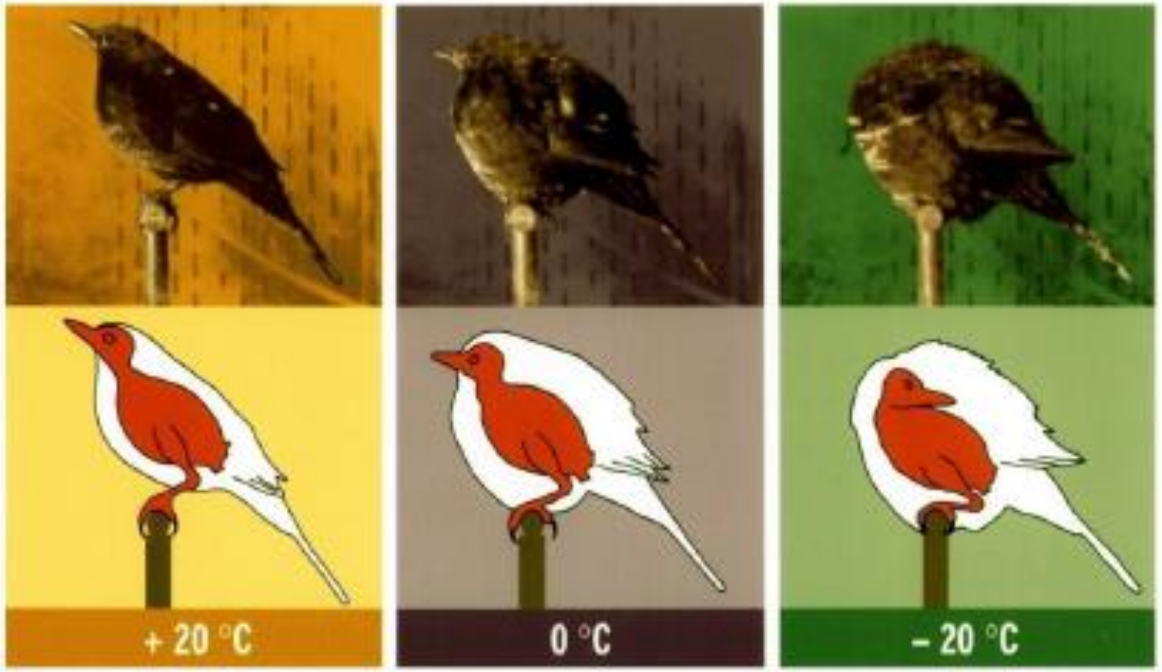


Learning from nature

Preserve the warmth

At low temperatures blackbirds increase their “feather envelope” and withdraws deep into this “Insulation”



Source: CEPH Project

# Rating Thermal Comfort

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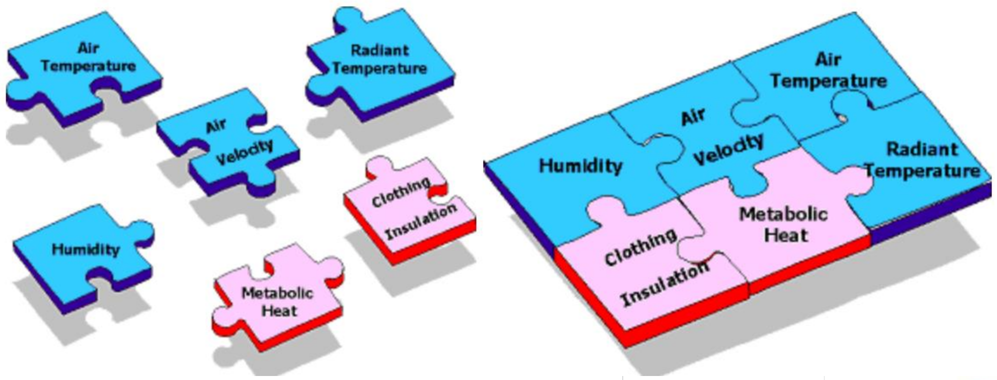
Reduce large temperature differences on different surfaces – **Radiant temperature**

In General, changes in temperature and **humidity** in space and time are perceived as uncomfortable

High **air velocities** are perceived as uncomfortable because of “draught air feeling”

The optimum temperature depends on clothing, activity and metabolism of a person




Source: https://www.hse.gov.uk/temperature/thermal/factors

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# Rating Thermal Comfort

**Air temperature**

This is the temperature of the air surrounding the body. It is usually given in degrees Celsius (°C).


**Radiant temperature**

Thermal radiation is the heat that radiates from a warm object. Radiant heat may be present if there are heat sources in an environment.

Radiant temperature has a greater influence than air temperature on how we lose or gain heat to the environment.


Examples of radiant heat sources include: the sun; fire; electric fires; ovens; cookers; dryers; hot surfaces and machinery, etc.



Source: https://www.hse.gov.uk/temperature/thermal/factors

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# Rating Thermal Comfort

**Air velocity**

This describes the speed of air moving across the employee and may help cool them if the air is cooler than the environment.

Air velocity is an important factor in thermal comfort for example:

- Still or stagnant air in indoor environments that are artificially heated may cause people to feel uncomfortable. It may also lead to a build-up of odour.
- Moving air in warm or humid conditions can increase heat loss through convection without any change in air temperature
- Physical activity also increases air movement, so air velocity may be corrected to account for a person's level of physical activity
- Small air movements in cool or cold environments may be perceived as a draught, as people are particularly sensitive to these movements




Source: https://www.hse.gov.uk/temperature/thermal/factors

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# Rating Thermal Comfort

**Humidity**

- If water is heated and it evaporates to the surrounding environment, the water in the air will provide humidity.
- Relative humidity is the ratio between the actual amount of water vapour in the air and the maximum amount of water vapour that the air can hold at that air temperature.
- Relative humidity between 40% and 70% does not have a major impact on thermal comfort. In none air-conditioned workplaces, relative humidity may be higher than 70%.
- High humidity environments have a lot of vapour in the air, which prevents the evaporation of sweat from the skin. In hot environments, humidity is important because less sweat evaporates when humidity is high (80%+). The evaporation of sweat is the main method of heat reduction.
- When non-breathable vapour-impermeable personal protective equipment (PPE) is worn, the humidity inside the garment increases as the employee sweats, because the sweat cannot evaporate. If an employee is wearing this type of PPE (eg asbestos or chemical protection suits etc) the humidity within the PPE will be high.




Source: https://www.hse.gov.uk/temperature/thermal/factors

# Rating Thermal Comfort

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**Clothing insulation**

- Thermal comfort is very much dependent on the insulating properties of clothing on the wearer.
- Clothing is both a potential cause of thermal discomfort, as well as a control for it, as we adapt to the climate in which we work. You may add layers of clothing if you feel cold, or remove layers of clothing if you feel warm.
- It is important to identify how the clothing contributes to thermal comfort or discomfort.


**Work rate/metabolic heat**

- The more physical work we do, the more heat we produce. The more heat we produce, the more heat needs to be lost, so we don't overheat.
- The impact of metabolic rate on thermal comfort is critical.
- A person's physical characteristics should always be considered, with regards to their thermal comfort, as factors such as their size and weight, age, fitness level and sex can all have an impact on how they feel, even if other factors such as air temperature, humidity and air velocity are all constant.




Source: https://www.hse.gov.uk/temperature/thermal/factors

# Goals of the Building Envelope

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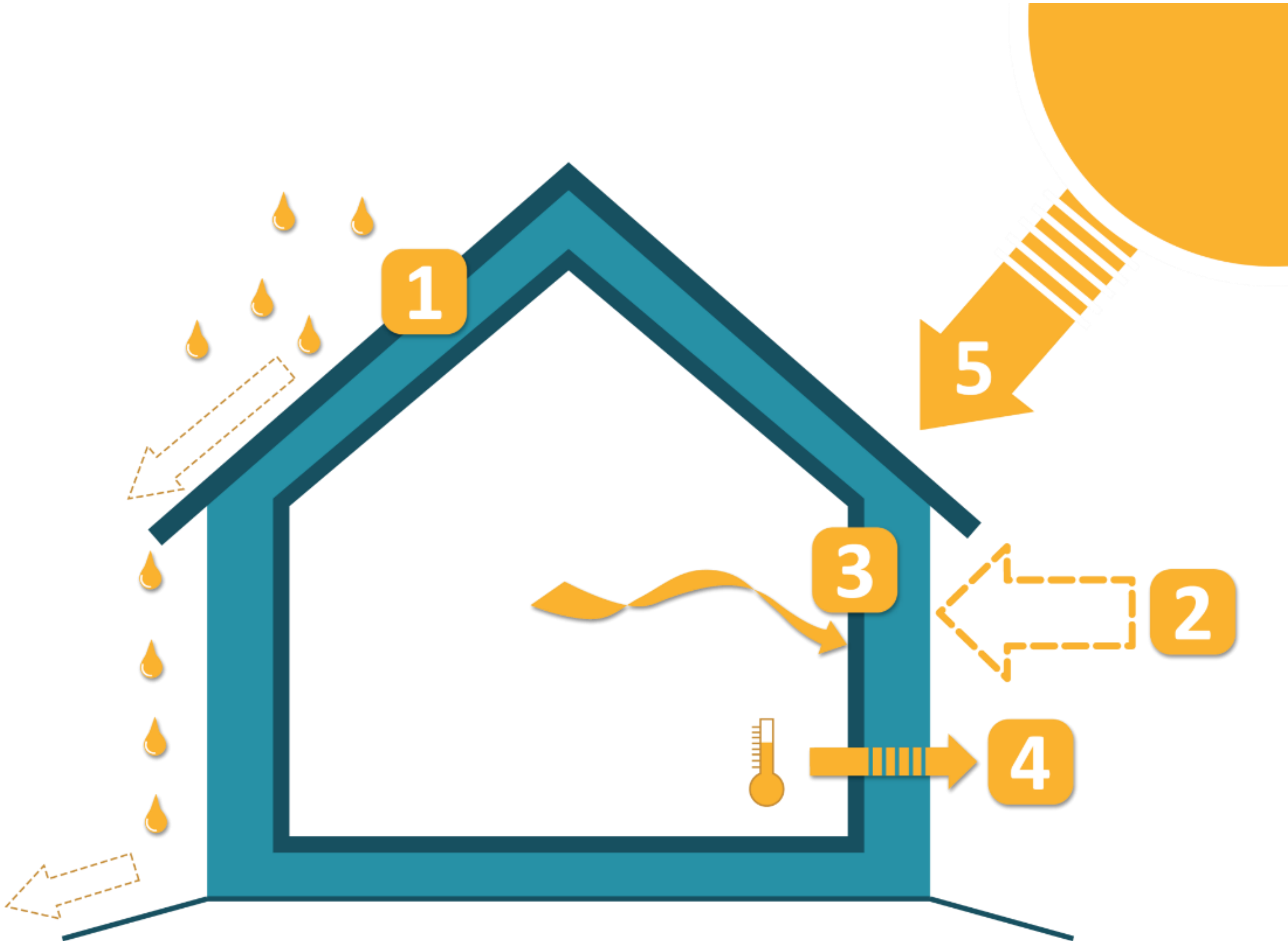
Functions of the thermal envelope:

1. Bulk-water run-off
2. Wind tight protection
3. Insulation & airtightness layer
4. Vapour control layer
5. Prevent overheating



# Effect of Cold Glass - Summary

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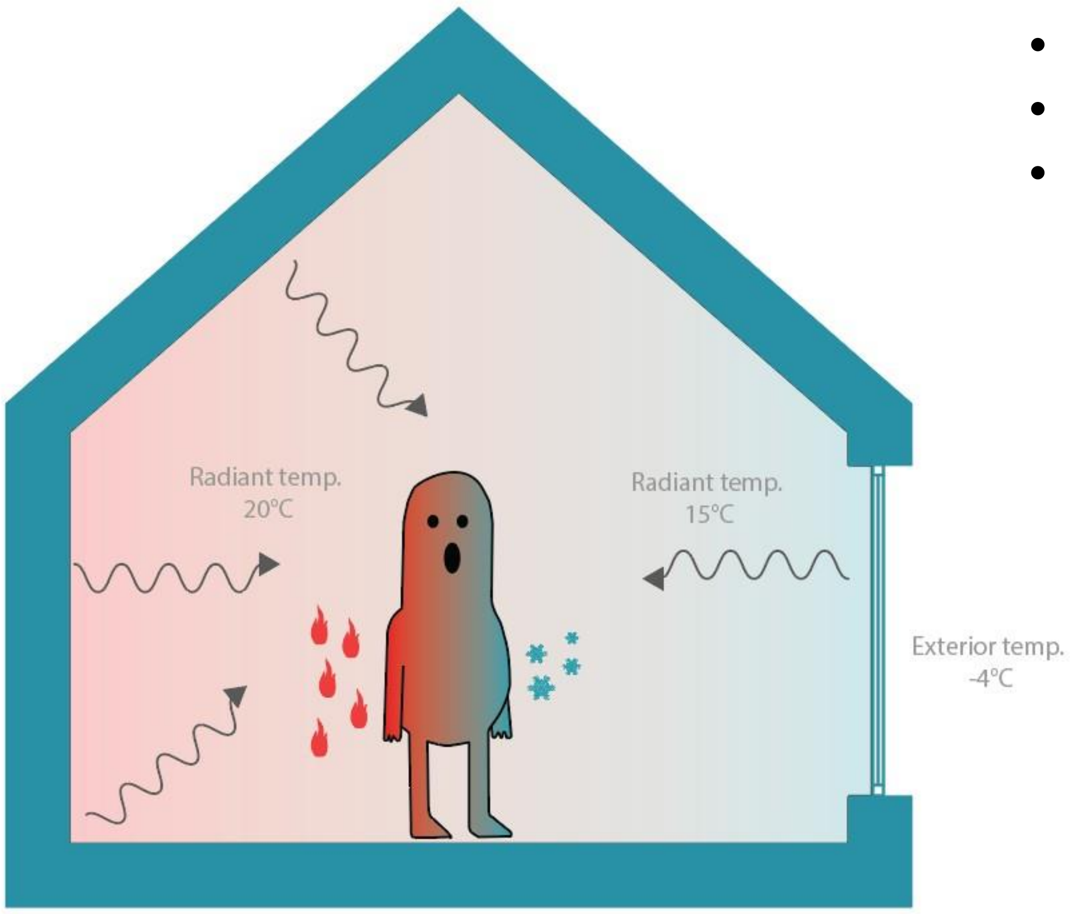


- Good quality double-glazed window:
- $U_w = 1.13\ W/(m^2 \cdot K)$
- Radiant temperature difference: 5 C

- The surface of the glass when it's cold outside is too low.
- A radiator near the window is required to provide comfort
- This is why many windows have radiators under the sill, to combat against draughts.

# Effect of Warm Glass - Summary

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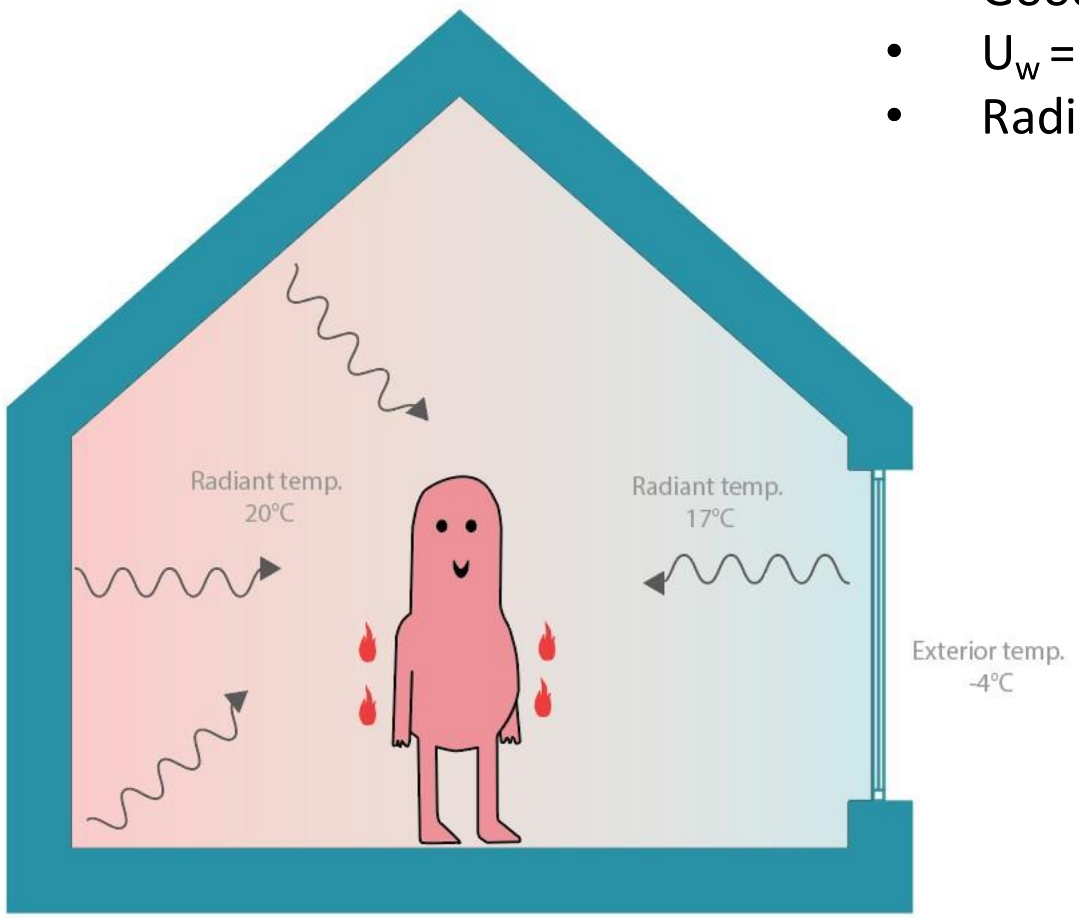


- Good quality triple-glazed window:
- $U_w = 0.70\ W/(m^2 \cdot K)$
- Radiant temperature difference: 3 C

- The surface of the glass is comfortable even when its very cold outside
- A radiator adjacent to the window is not needed for comfort
- With better insulation and improved windows, a heating emitter is no longer needed under windows.
- However, it is sometimes useful to save wall space

# Comfort aspects Typical Buildings vs NZEBs

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Humans feel uncomfortable if objects radiate simultaneously with different temperatures towards our body.

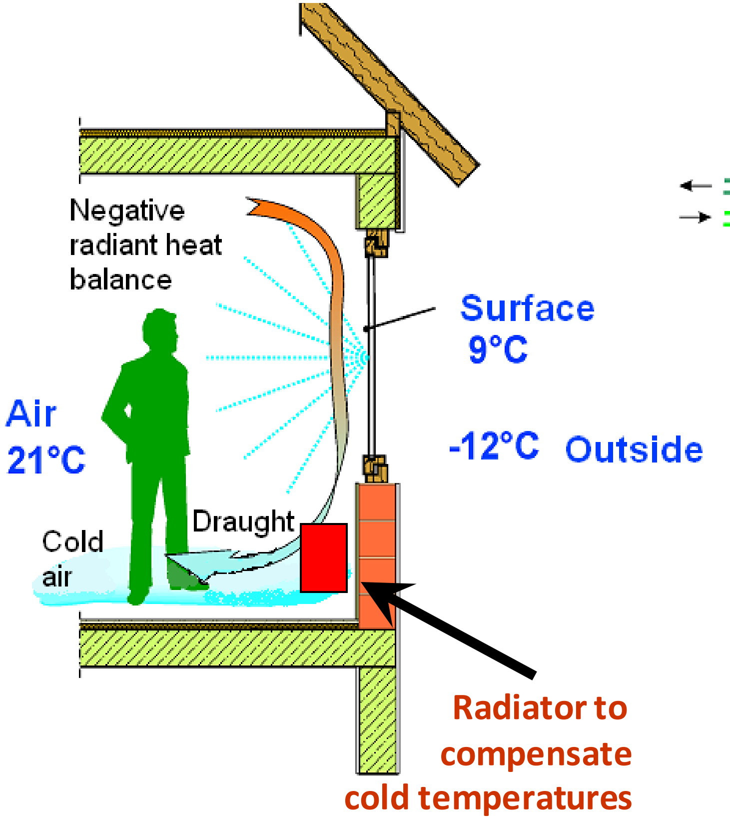
- Comfortable only when the temperature difference is lower than 4K

Window with $U_w$= 0.8 W/(m²K) results with a radiation temperature difference < 3K

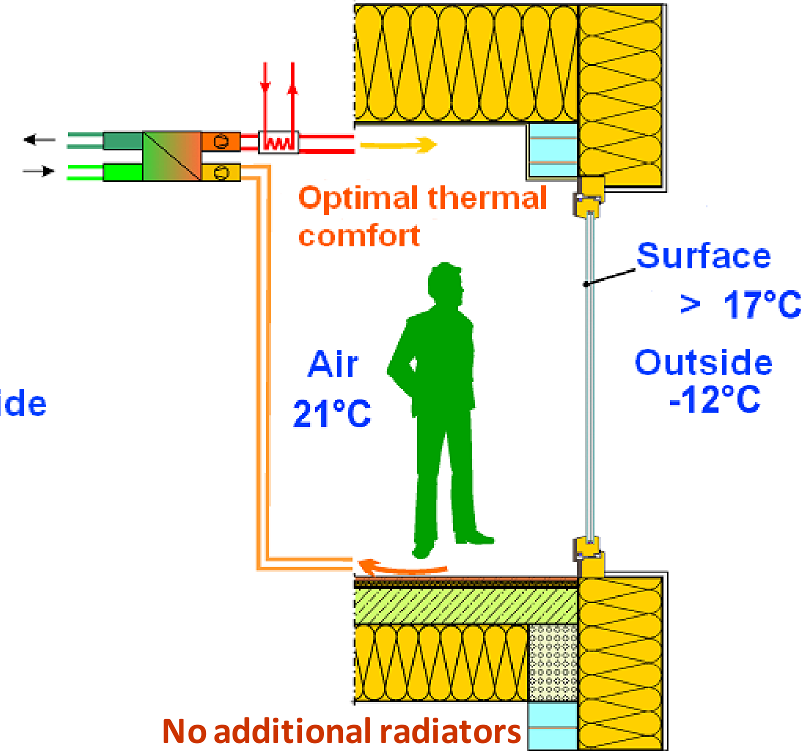
- And a radiator doesn't need to be placed under the window…

K is kelvin.

**Heating load more than 100 W/m²**




**Heating load only 10 W/m²**




Source: Passive House Institute

# Acoustic Comfort

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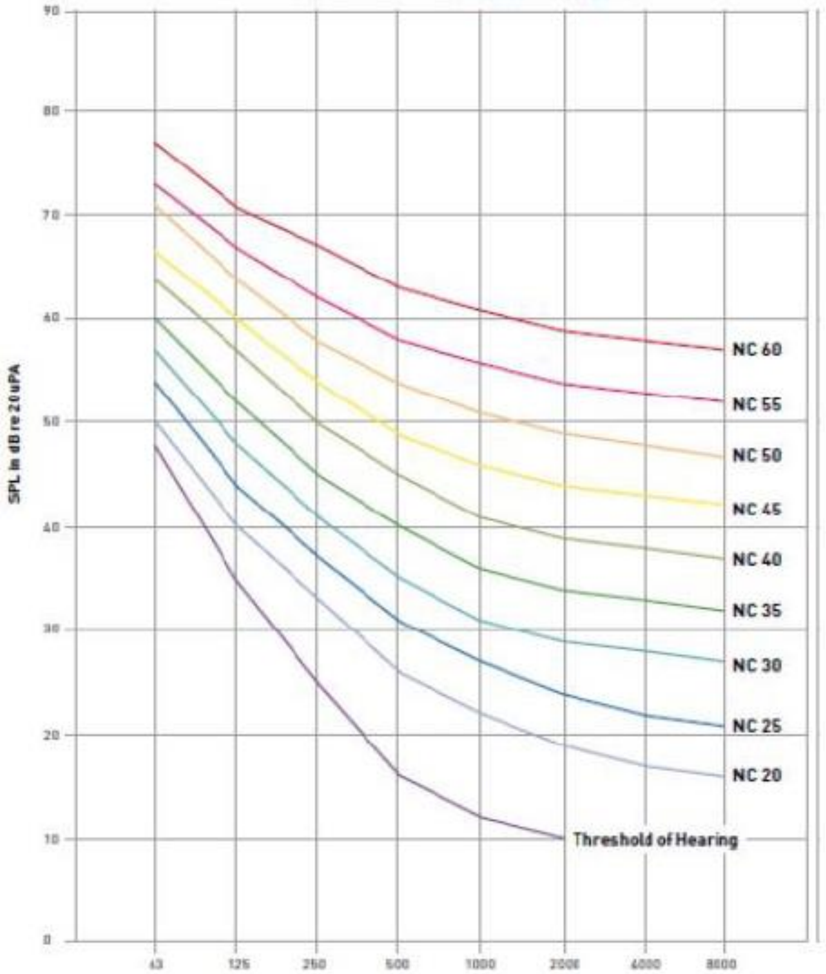
Noise Criteria (NC) Curve




Octave Band Centre Frequency (Hz)

Within well insulated and airtight envelopes, interior noise is more noticeable. Therefore, noise from the building systems, in particular from ventilation system, must be carefully addressed:

- Fan Noise
- HRV vibration to the duct system
- "Crosstalk" noise ( room-to-room transfer)


In order to achieve desired NC level, the following parameters need to be considered:

- Airborne sound isolation performance of the room/space partitioning elements
- M&E installation within and around the room/space of interest
- Interior acoustics.



Source: Rockwool

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# Lighting Comfort

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Light is an integral part of architecture whose internal and external structure, building elements and materials place great demands on light. Some of these demands can be met by daylight, others can only be fulfilled with artificial light.

When artificial lighting is planned, the user's needs must be given thorough consideration, since we should all feel comfortable in our surroundings and enjoy and experience them. Light stimulates us and makes a significant contribution to our health

The amount of lighting in homes, schools, office and other workplaces affects quality and quantity of output and can affect the overall wellbeing of occupants.

Improper illumination levels can result in poor performance and health effects including headaches and eyestrain.

**Lighting – checks levels and render EN12464-1 CIBSE guides for compliance**

# 2. Air Quality

# Effects of Inorganic Pollutants

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| Type of inorganic pollutant | Potential sources in indoor air | Effects on human health |
|---|---|---|
| Nitrogen oxides ($NO_x$) | From outside and inside sources (tobacco smoke and combustion appliances) | An increase of 28µg/m$^3$ was associated with a 20% increased risk of lower respiratory illness in children. Indoor exposure may enhance asthmatic reactions to inhaled allergens. |
| Ozone ($O_3$) | Outdoor $O_3$ resources & air purifiers (electrostatic precipitous, negative ion & ozone generators), computers etc. | Acute exposure to $O_3$ produces decrements in pulmonary function and exercise capacity and induces airways inflammation in both healthy individuals and with pre-existing condition (asthma, chronic obstructive pulmonary disease) |
| Carbon monoxide (CO) | Indoor sources are mainly related to smoke. Carbon monoxide is highly toxic, entering the body by inhalation. | The degree of occurrence characteristic symptoms (headache, fatigue, nausea, rapid breathing, and chest pain) depends on the health and sensitivity of each individual. |
| Carbon dioxide ($CO_2$) | Human metabolism and combustion processes (activities in the kitchen or space heating). | > 1.5% → effects on respiration process, this being hindered.<br>> 3% →headaches and dizziness. |

# Indoor Pollutants

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| Pollutant | Effects |
| --- | --- |
| **Water vapor** | None at moderate levels (30-60% RH). If lower, can be uncomfortable for skin dryness. If too high, can be uncomfortable but also lead to mould/mildew growth. |
| **Carbon Dioxide ($CO_2$)** | Not harmful until concentrations over 5,000 ppm, but as an indicator of air quality it is generally accepted that 1,000 ppm or less should be maintained. (Atmospheric concentration is approximately 400 ppm). |
| **Dust, pollen** | Numerous sources, often an allergen or irritant, can be harmful for repeated or continual exposure to high levels. |
| **Volatile Organic Compounds (VOCs)** | Various natural and artificial chemicals found in paint, adhesives, cleaning products, "new car smell," but also from plants and animals. Some are harmful after long-term exposure, others are harmless. |
| **Carbon Monoxide (CO)** | A product of combustion, this odourless toxic gas causes headaches around 100 ppm for many hours, above 800 ppm cause severe effects within 1 hour, over 1,600 ppm is fatal after 2 hours. |
| **Radon** | A natural but harmful product of the radioactive decay process of uranium, radon must be controlled at ground level with radon barrier and sub-slab exhaust system, if in regions with high levels. |



Source: Fit to NZEB Project

# Sources of Pollutants

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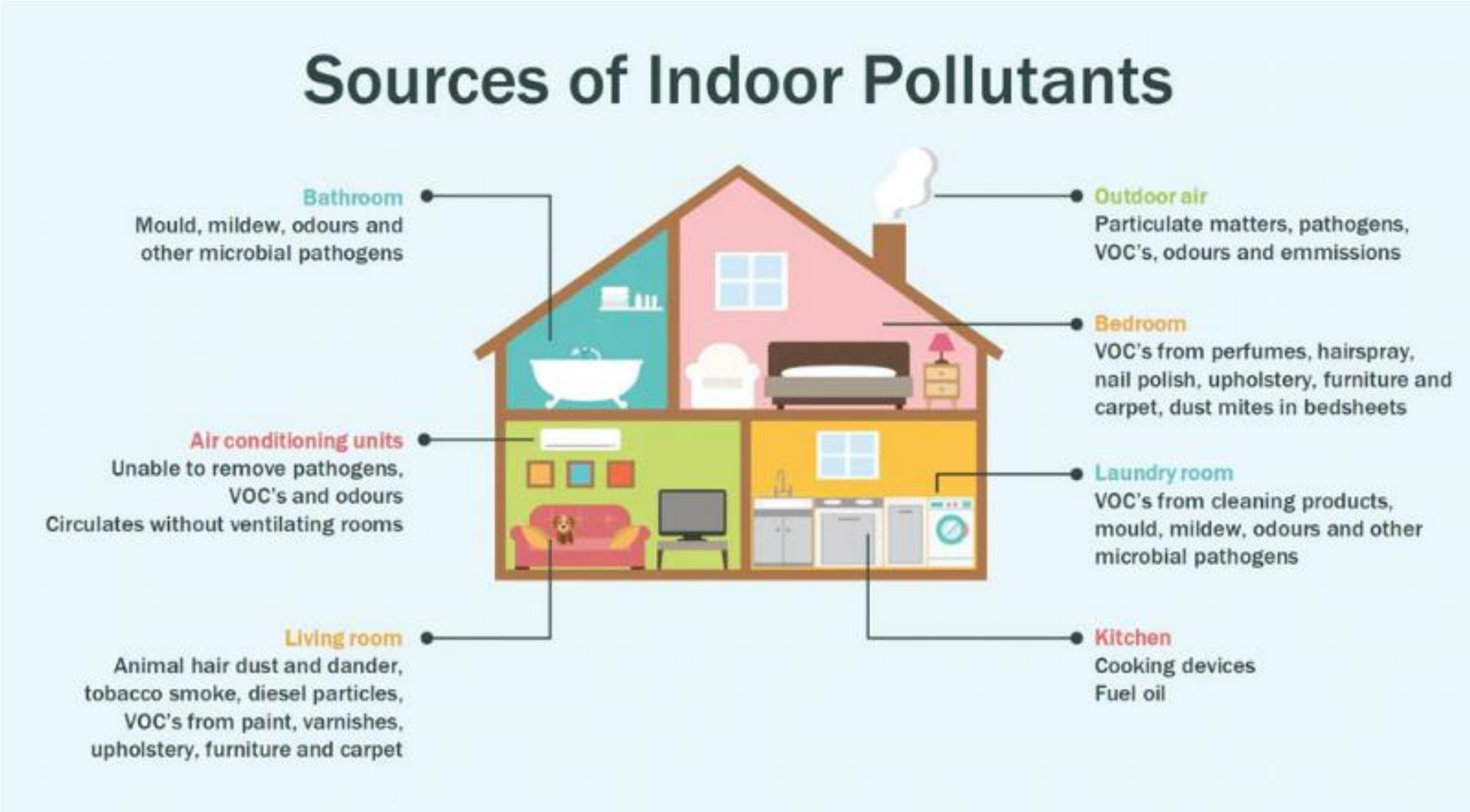



| $CO_2$ [ppm] | Air Quality |
|---|---|
| 2100 | BAD<br>Heavily contaminated indoor air<br>Ventilation required |
| 2000 | |
| 1900 | |
| 1800 | |
| 1700 | |
| 1600 | |
| 1500 | MEDIOCRE<br>Contaminated indoor air<br>Ventilation recommended |
| 1400 | |
| 1300 | |
| 1200 | |
| 1100 | |
| 1000 | FAIR |
| 900 | |
| 800 | GOOD |
| 700 | |
| 600 | EXCELLENT |
| 500 | |
| 400 | |



Image Source: MosArt

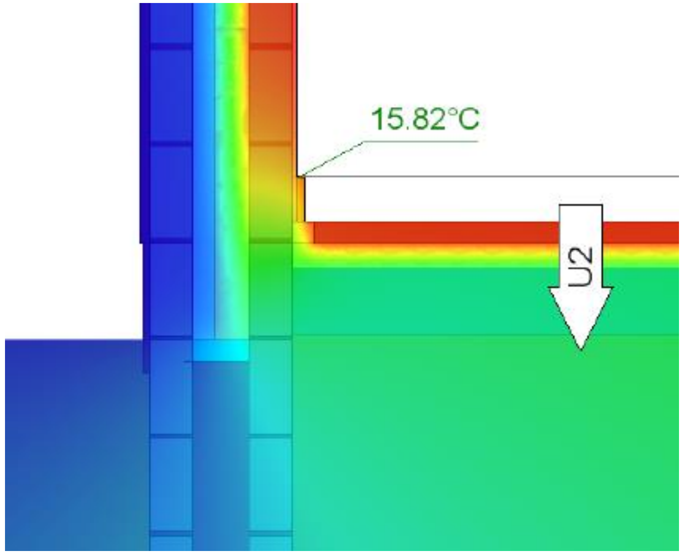
# Thermal Bridging - Temperature and Mould

## Avoid mould growth & increase comfort

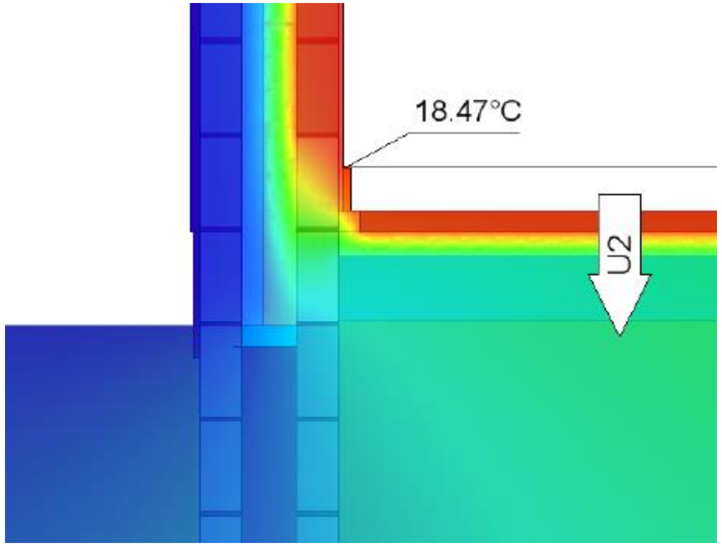
Heat flow is generally **greater at junctions**, and often where the **lowest temperatures occur** on a surface of the wall or ceiling.

**Table 1 Critical temperature factors for avoiding mould growth in buildings**

| Type of building | $f_{CRsi}$ |
|---|---|
| Dwellings; residential buildings; schools | 0.75 |
| Swimming pools (including a dwelling with an indoor pool) | 0.90 |




fRsi = (15.82-0) / (20 – 0)
= 0.791




fRsi = (18.47-0) / (20 – 0)
= 0.923

# Humidity and Mould

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As the internal surface temperature is **dependent on the construction elements**, so too is the risk of mould growth & surface condensation occurring.

A **more insulated the construction** the **higher the internal surface temperatures** and risk of mould growth/condensation occurrence is lower.

The **actual risk** of condensation is dependent on the internal temperatures and external temperatures for a building, as well as the **relative humidity levels** at those temperatures.

It is commonly believed that **relative humidities** of 100% must exist at surfaces in order for condensation and mould growth to occur.

However, mould growth can occur at humidities significantly less than 100%.

Using the psychrometric chart, we can assess what the relative humidity is at the surface given our boundary conditions.

# Psychrometric Chart

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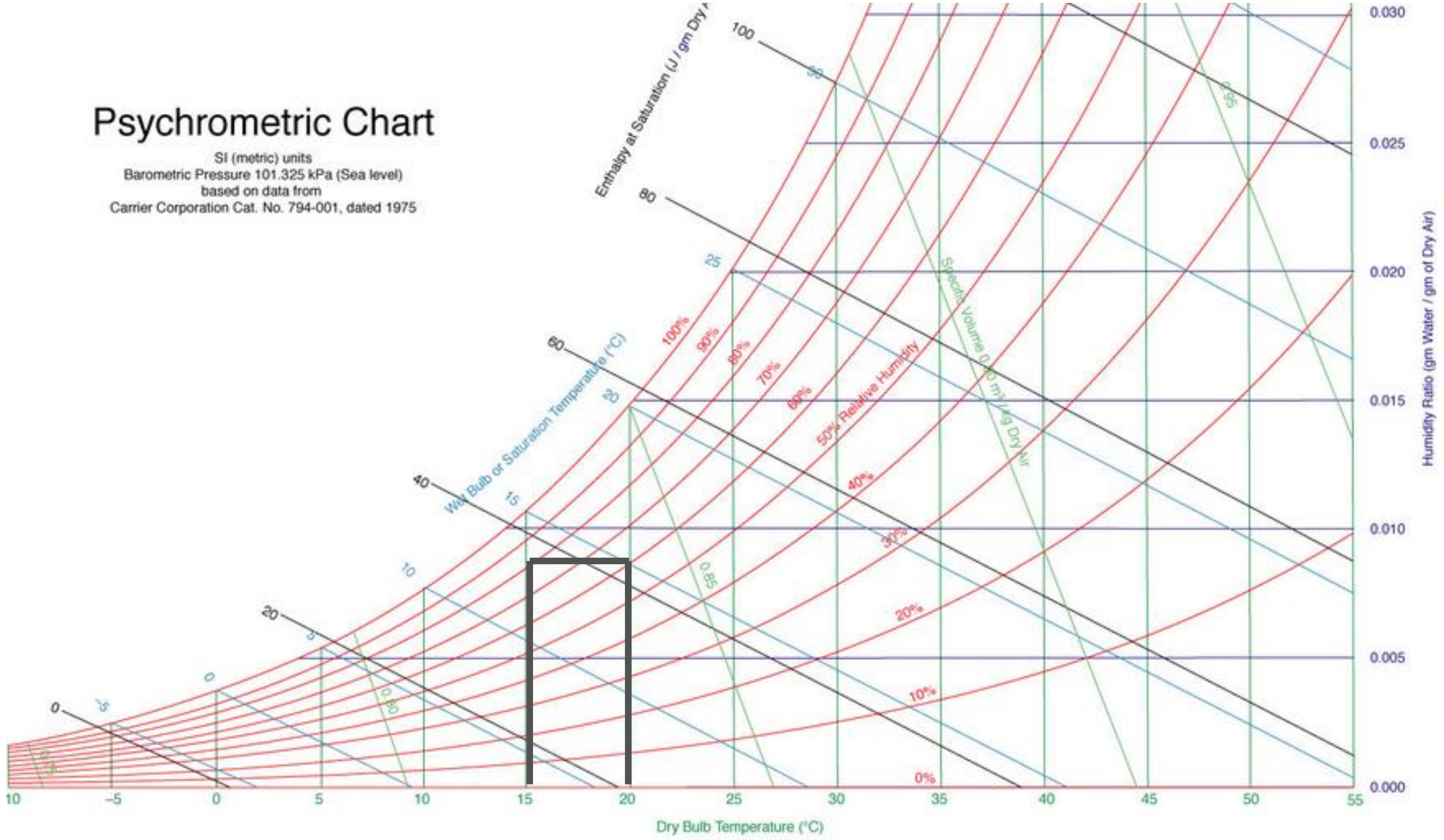

# Temperature and Relative Humidity Comfort Zones

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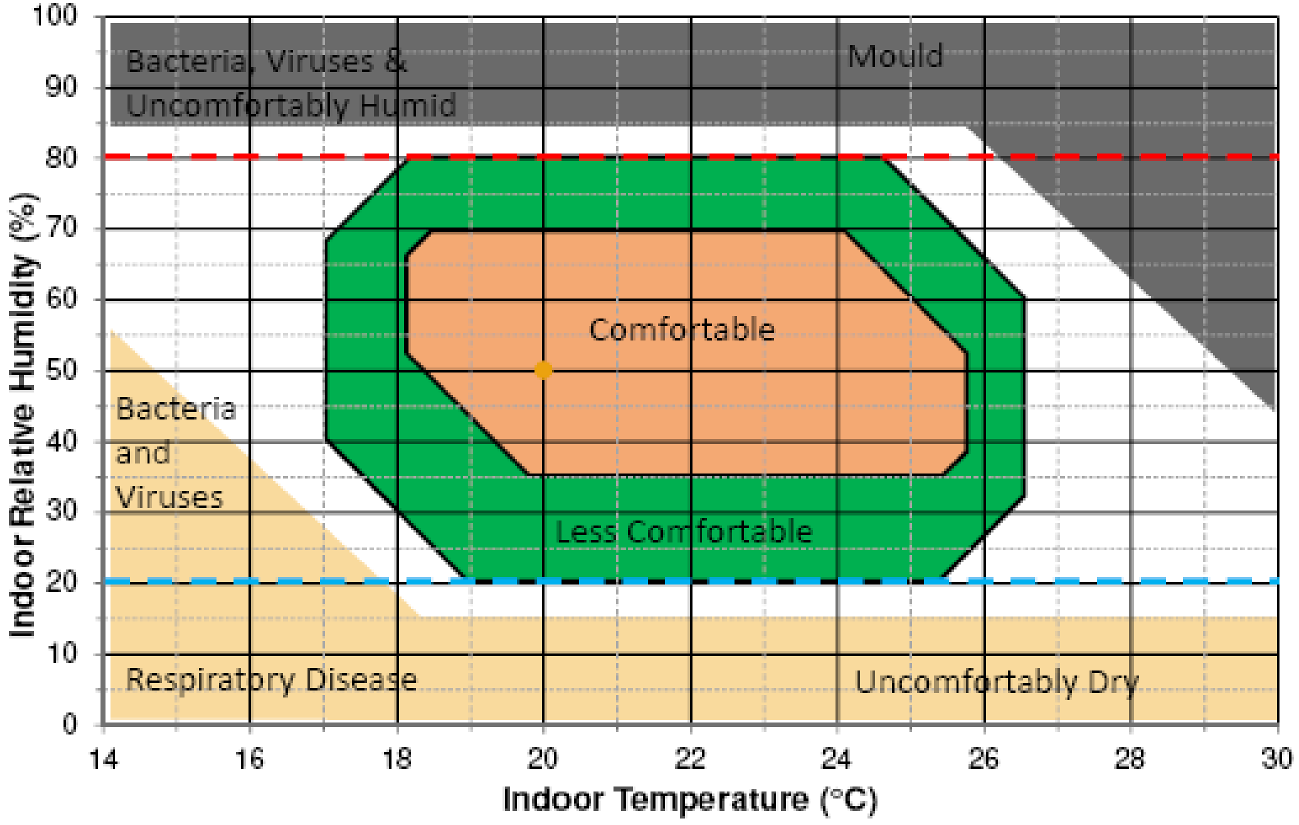


Relative humidity below approximately 30% can cause dryness of the skin and mucous membranes, possibly increasing the risk of infection, as well as dry out wood floors and furniture.

High humidity levels, 70 – 80 % and up, foster mould growth, dust mites, and is generally uncomfortable especially at high temperatures.

**The target range for relative humidity indoors is 35 – 60%**

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## Designing a moisture safe building envelope

### We are concerned with…

1. Warm, moist air coming in contact with cold surfaces. If those surfaces stay cold long enough, mould can grow.
2. Warm, moist air flowing through building assemblies and wetting the materials. This is a problem if the materials we make the building out of are susceptible to decay from prolonged wetting (like wood).
3. Making sure that WHEN the assembly gets wet, there is at least one way for the water to get out.

**Not IF, but WHEN – everything fails at some point, so build it robust enough to handle small failures**



Image Source: MosArt/WWETB

# Thermal Bridging - Mould Very Common at Wall to Wall Junction

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Can cause both health problems for occupants and structural problems



Image Source: Purchased by MosArt/WWETB (iStock 502417080)

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# Thermal Bridging - Mould Very Common at Wall to Roof Junction

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Can cause both health problems for occupants and structural problems



Image Source: Purchased by MosArt/WWETB (iStock 488872199)

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# 3. Health and Safety in Buildings





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**Definitions**

**Safety** is free from risk and danger

**Accidents** is defined as an unexpected and undesirable event resulting in damage or harm

**Hazards** is an unsafe condition or activity, that if left uncontrolled can contribute to an accident

**Risk** is the assessment of “probability of loss” and “potential amount of loss”



Source: Concise Oxford Dictionary

# Chemical Hazards

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Chemicals can exist in the form of:

- Dusts, fumes, fibres (solids)
- Liquids, mists
- Gases, Vapours

| | | |
|---|---|---|
| **Examples of chemical hazards found in construction** | **Asbestos**<br>**Lead**<br>**Silica**<br>**Cadmium**<br>**Carbon monoxide** | **Welding fumes**<br>**Spray paints**<br>**Cutting oil mists**<br>**Xylene vapour**<br>**Solvents** |

# Physical and Biological Hazards

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**Physical hazards** are different types of energy which may be hazardous to workers.

- Noise
- Vibration
- Temperature extremes
- Radiation

**Biological hazards**

Exposure may occur during demolition, renovation/retrofitting works, sewer works, work on air-handling systems or other construction work activities from contact with contaminated or disease-carrying…

- Soil
- Water
- Insects (mosquitoes, ticks)
- Bird or bat droppings
- Animals
- Structures

# Ergonomic Hazards

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**Ergonomic hazards** can cause painful and disabling injuries for example Musculoskeletal Disorders (MSDs).

The following situation may cause these injuries:

1. Heavy, frequent or awkward lifting
2. Repetitive tasks
3. Awkward grips, postures
4. Using excessive force, overexertion
5. Using the wrong tools for the job or using tool incorrectly
6. Using poorly maintained tools
7. Hand-intensive work



Image Source: Pix4free

# Assessment

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Activity

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# Thank You

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EBC CONSTRUCTION SMEs EUROPE

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