



Module 3

Energy and Buildings

Energy Efficiency for Construction



24
partners

12
countries

Date of Event

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To equip the learner with the relevant knowledge required to understand the ways in which heat moves in and out of buildings and the ways that this is measured.





- ✓ Describe the energy profile of buildings in both the residential and non-residential sectors
- ✓ List and describe the modes of heat transfer
- ✓ Identify the principles of how heat transfer occurs in buildings
- ✓ List and describe the factors affecting energy use in buildings
- ✓ List and describe the factors affecting occupant comfort.



Topic 1 – How Energy Works

Topic 2 – Low Energy Techniques

On the following slides you will
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1. How Energy Works



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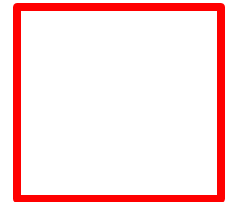
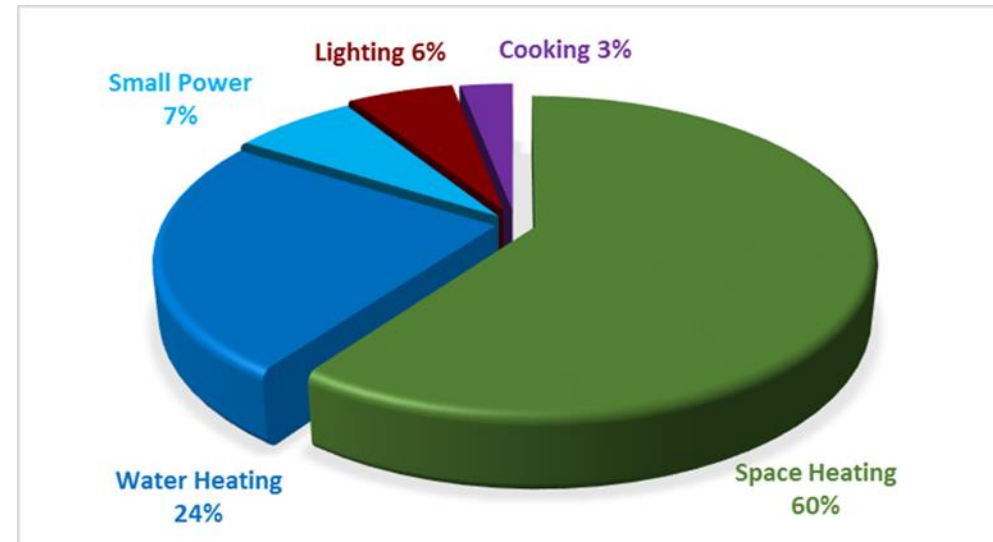
How Energy Works



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Key Building Physics Principles:

- What is interstitial condensation?
- How does heat flow?
- What is a U-value?
- What is a Thermal Bridge?
- What is Air Permeability?
- How and why does mould and condensation form?



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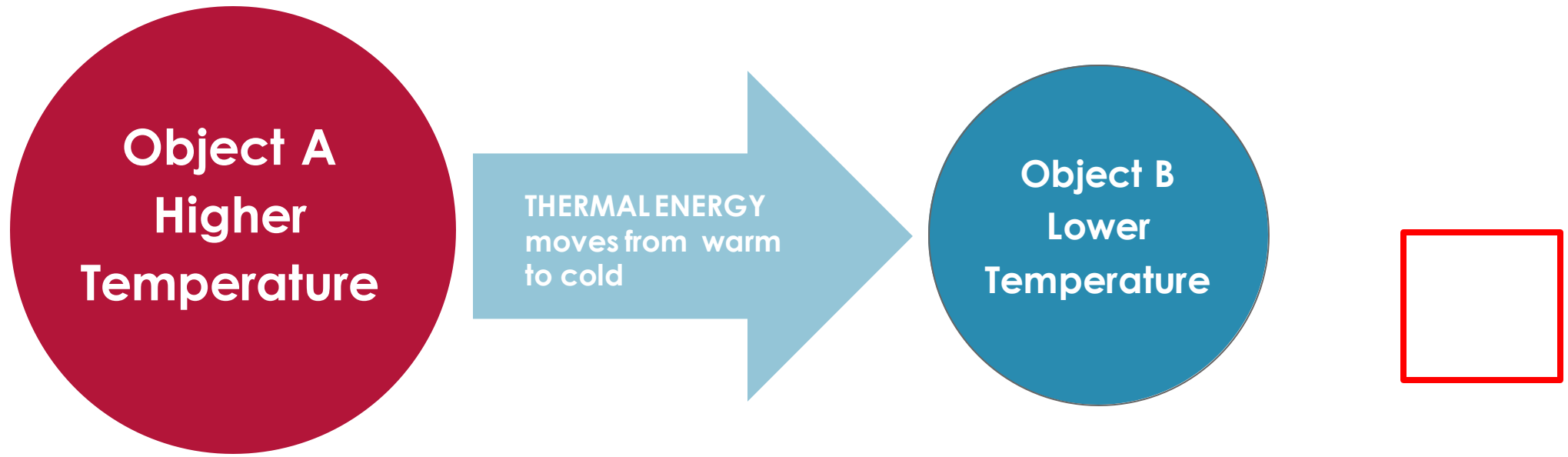
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How does heat flow?



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Thermal Energy always flows from the object or material with a **higher temperature** towards the object or material with a **lower temperature** (the **Second Law of Thermodynamics**).



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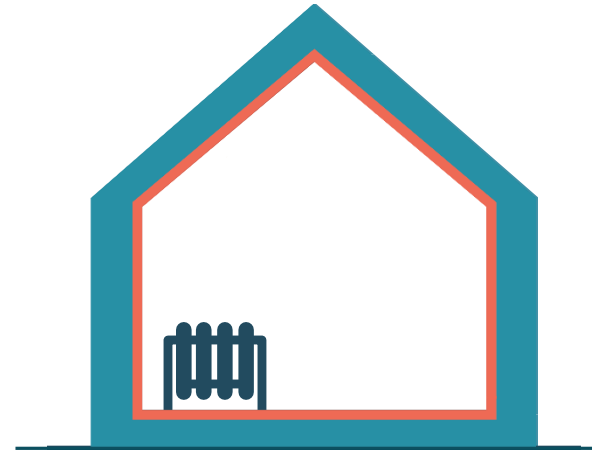


How does heat flow?

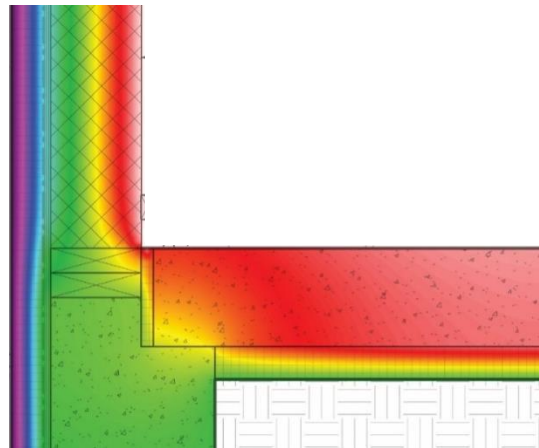


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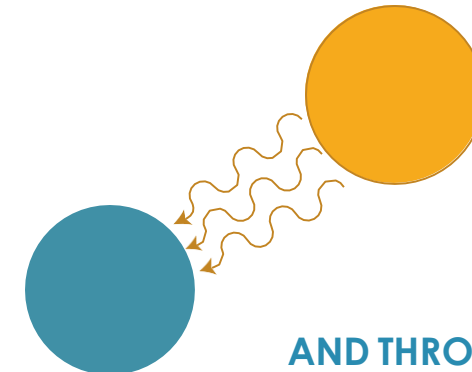
Thermal Energy
Moves in 3
Different Ways...



THROUGH CONVECTION,...



THROUGH CONDUCTION,...



AND THROUGH RADIATION.



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How does heat flow?



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1- High energy performance building.

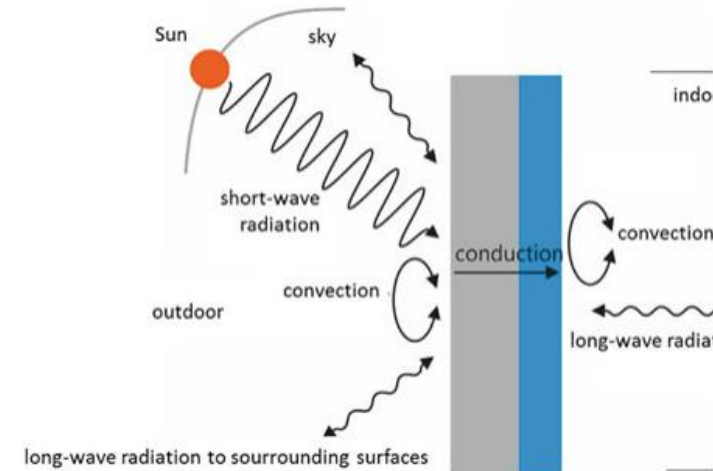
Heat transfer principles

Heat [W] is the energy transfer due a thermodynamic interaction.

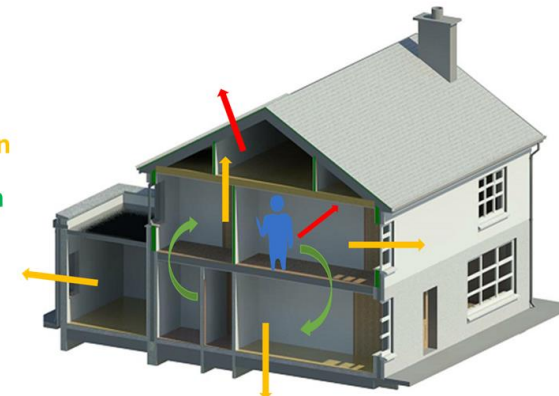
Heat loss is a measure of negative heat transfer through buildings envelope.

This heat transfer can occur in different modes:

- Conduction: It is the transfer of heat that occurs through a material by direct contact between its particles, when there is a temperature difference.
- Convection: Is the transfer of heat from one place to another by mass motion of a fluid such as air or water.
- Radiation: Energy transfer by the emission of electromagnetic waves which carry energy away from the emitting object.



- ✓ Conduction
- ✓ Convection
- ✓ Radiation



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EU and National Drive

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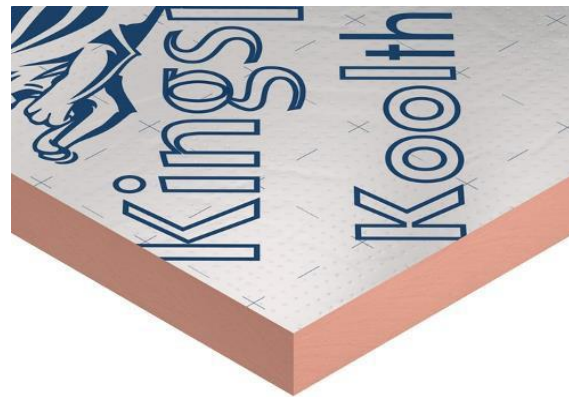
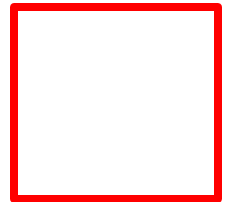


Thermal Conductivity

Thermal Conductivity (Lambda, λ)

Thermal Conductivity is:

- The rate at which heat passes through a specified material
- It is expressed as W/mK
- The lower the conductivity, the better the material is at insulating

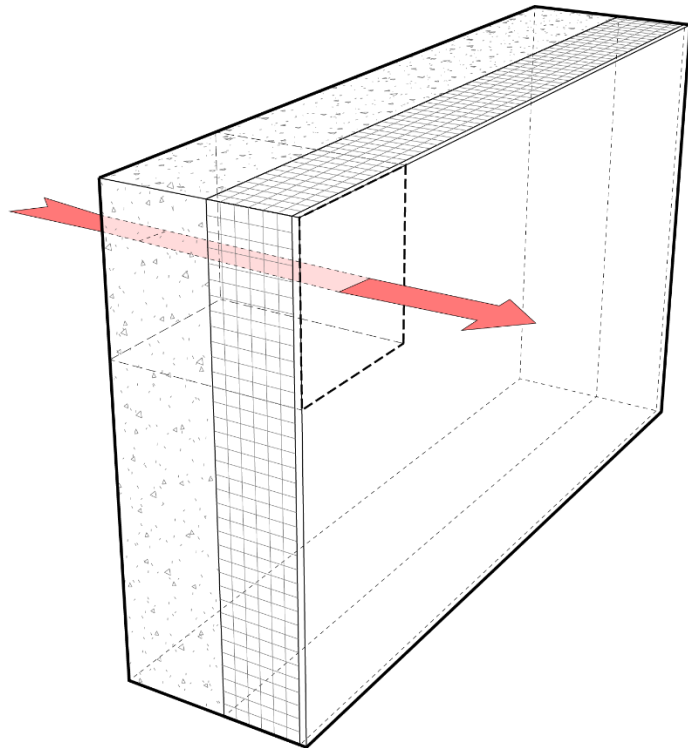


What is a U-Value?



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Thermal Transmittance (U-value)



What is a U-Value?

$$W/(m^2 \cdot K)$$

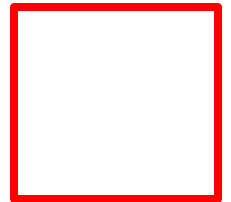
How much heat energy moves

.... **Continuously**

.... through one **square metre** of surface area

.... given a **1 degree** temperature difference
between faces.

Tip! With U-Values,
the lower the
number, the better!



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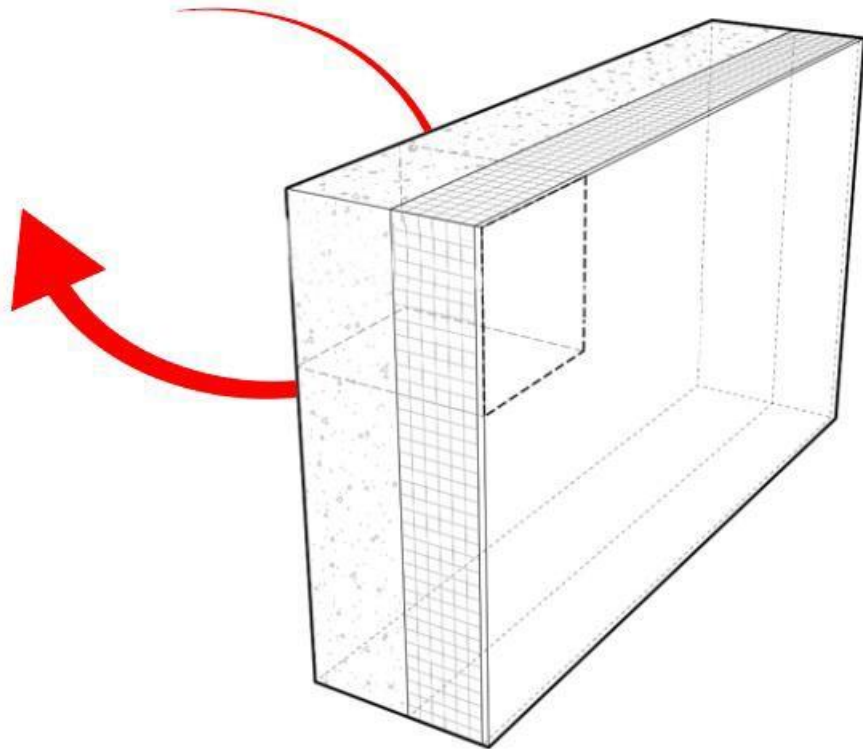


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What is a U-Value?

Thermal Resistance (R-value)



What is an R-Value?

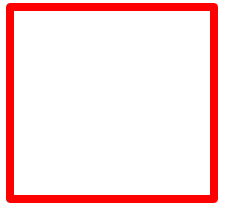
$(\text{m}^2\text{K}/\text{W})$

The ability of a material to **resist** heat transfer. This is known as the **R-value**.

The more a material is able to block the heat transfer, the greater its thermal resistance.

The resistances for each of the materials within an element are calculated and added together to determine the **total resistance** (R_T) of the building element

Tip! With R-Values, the higher the number the better!

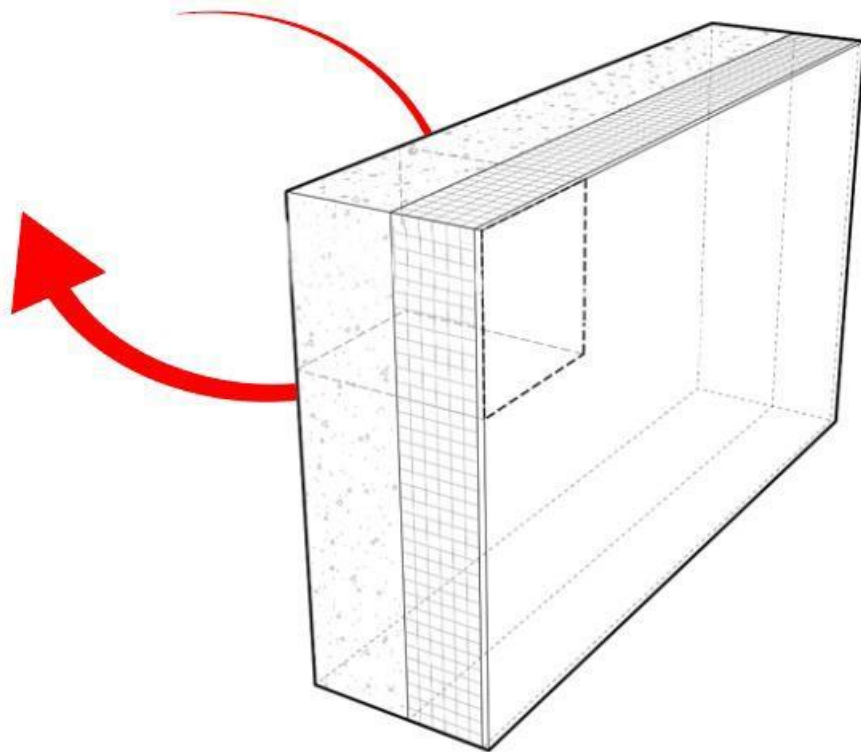


What is a U-Value?



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Thermal Resistance (R-value)



What is an R-Value?

$(\text{m}^2\text{K}/\text{W})$

Tip!

Thickness (m) / Conductivity
(W/mK) = R-Value ($\text{m}^2\text{K}/\text{W}$)

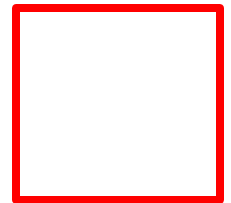
$$\text{R-Value} = d/\lambda$$

The R-value of a material is impacted by two factors;

Material conductivity W/mK

and

Material thickness (m)



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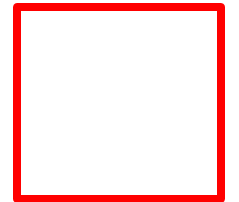
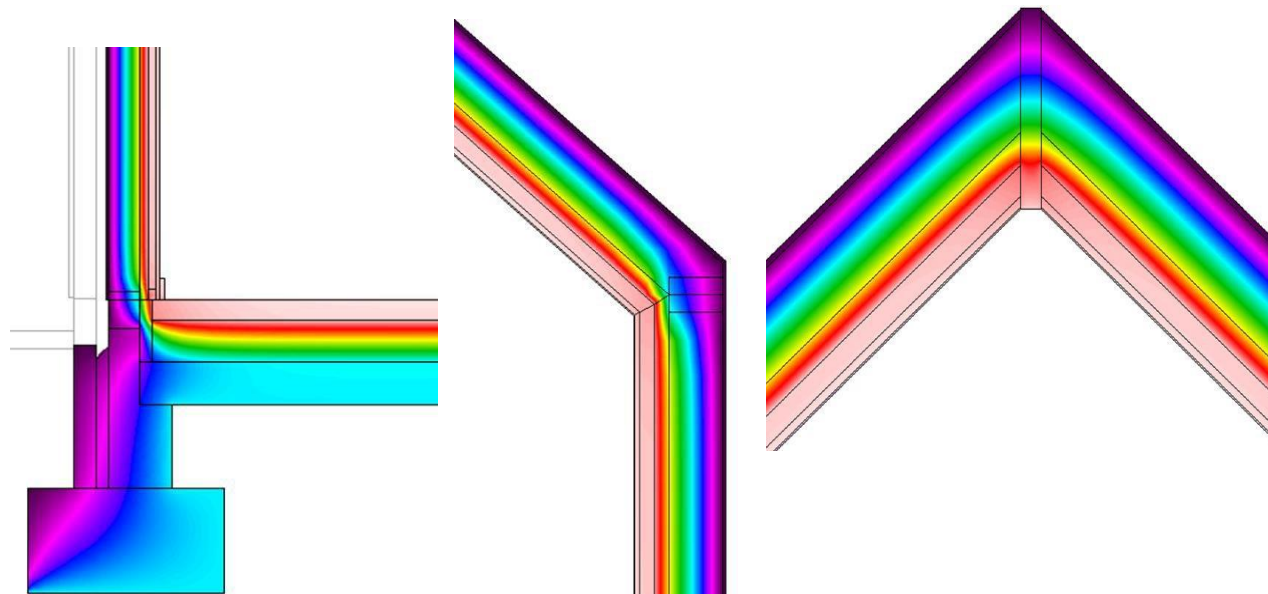


What is a Thermal Bridge?



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A thermal bridge occurs at any location in a building where there is a **break in the continuity of the insulation layer**



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Energy and Buildings

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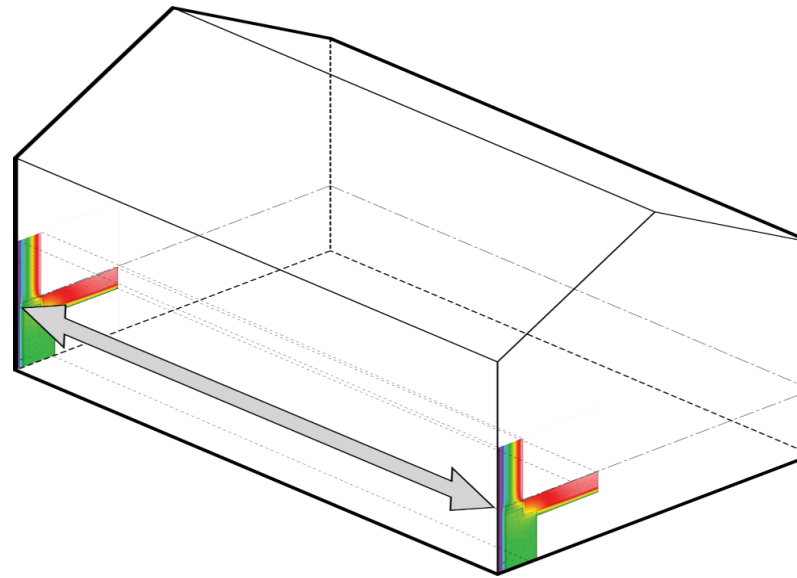
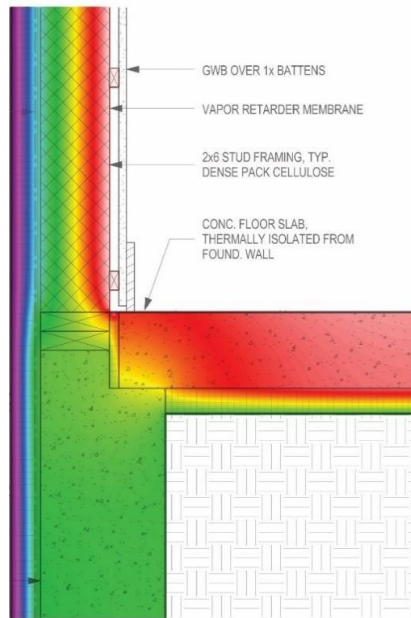


Thermal Bridges

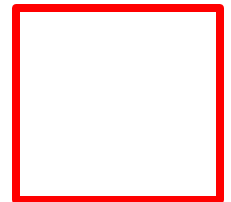


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Linear Thermal Bridges ('Psi Value')



Tip! With Psi-Values,
the lower the number
the better!



What is a Psi-Value?- How much heat energy moves **continuously** through one **linear metre** of junction
given a **1 degree** temperature difference between faces

$$W/(m \cdot K)$$



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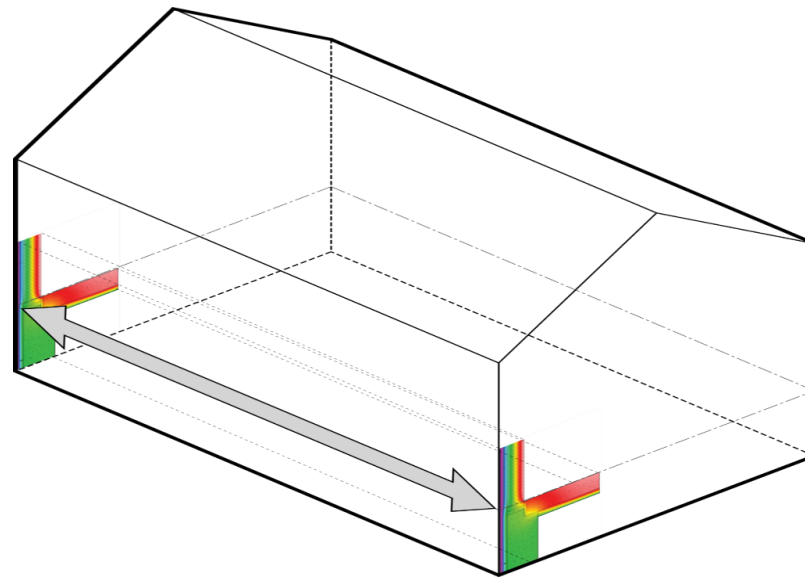
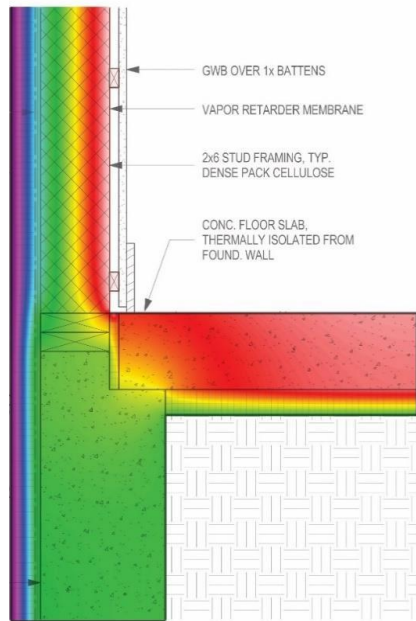


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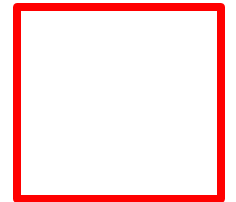
Thermal Bridges

Linear Thermal Bridges ('Psi Value')



The heat loss coefficient of a linear thermal bridge is the loss of energy associated with that thermal bridge (W/K)

$$H_{TB} = L \times \Psi$$



H_{TB} = Transmission heat loss coefficient (W/K)

L = Length of the thermal Bridge over which Ψ applies (m)

Ψ = Linear thermal transmittance (W/mK)



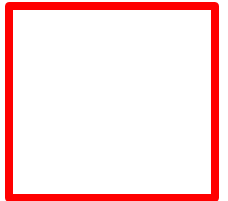
Thermal Bridges



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Impact of Thermal Bridging:

- ❖ High energy losses
- ❖ Surface Condensation
- ❖ Mould
- ❖ Poor Indoor Air Quality (IAQ)
- ❖ Envelope deterioration
- ❖ Interstitial Condensation



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What is Air Permeability?



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What is Air Permeability?

$\text{m}^3/(\text{hour} \cdot \text{m}^2)$ @ 50 Pascal

How many **cubic metres of air**

.... pass through one **square metre** of surface area

.... in one **hour**

.... at a pressure difference of 50 Pascal between the inside
and outside

Tip! With Air-
Permeability, the lower
the number the better!



Negative Pressure Test

Image Source: MosArt



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Air Permeability

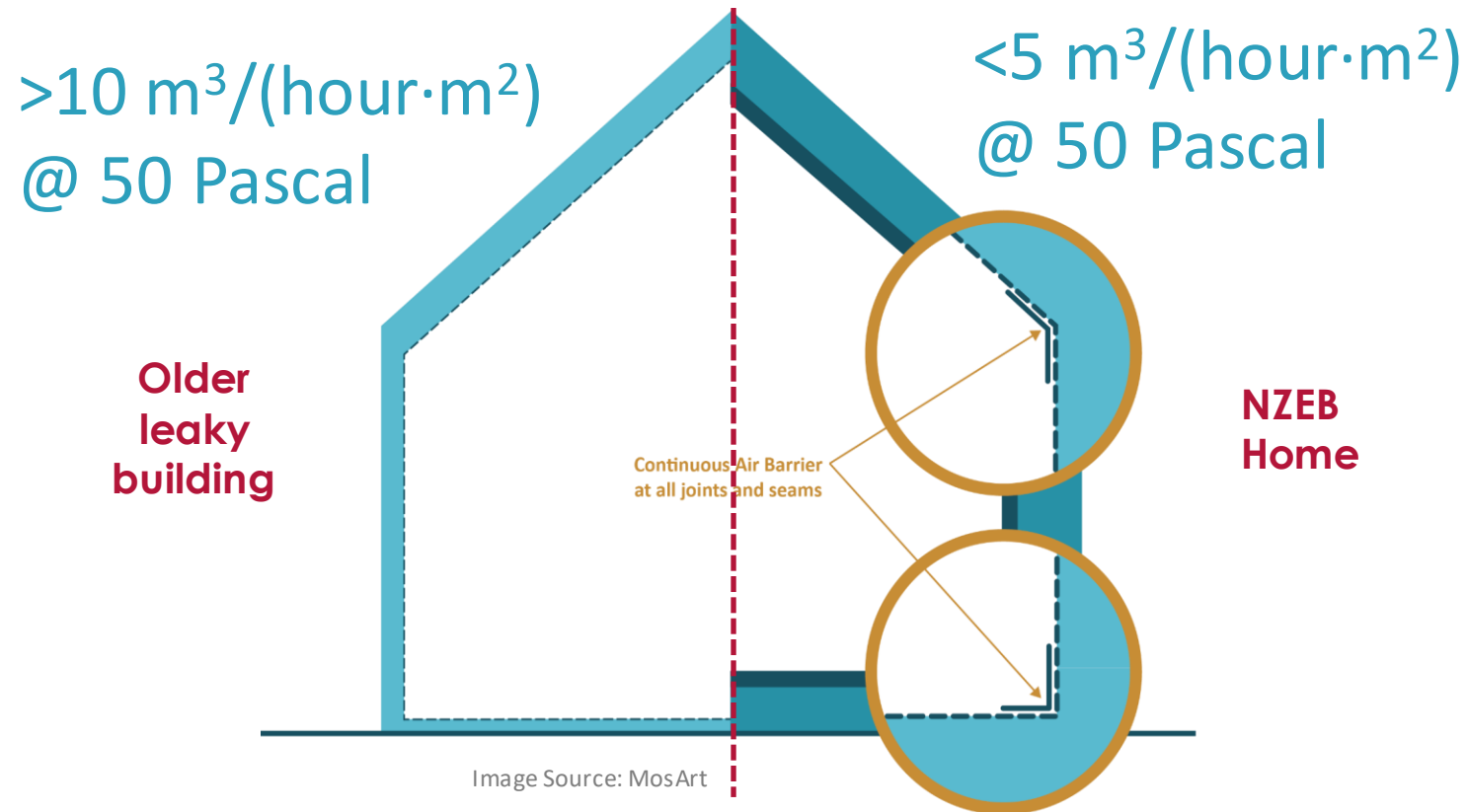


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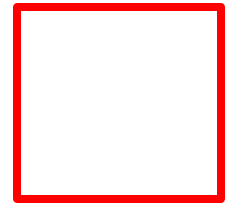
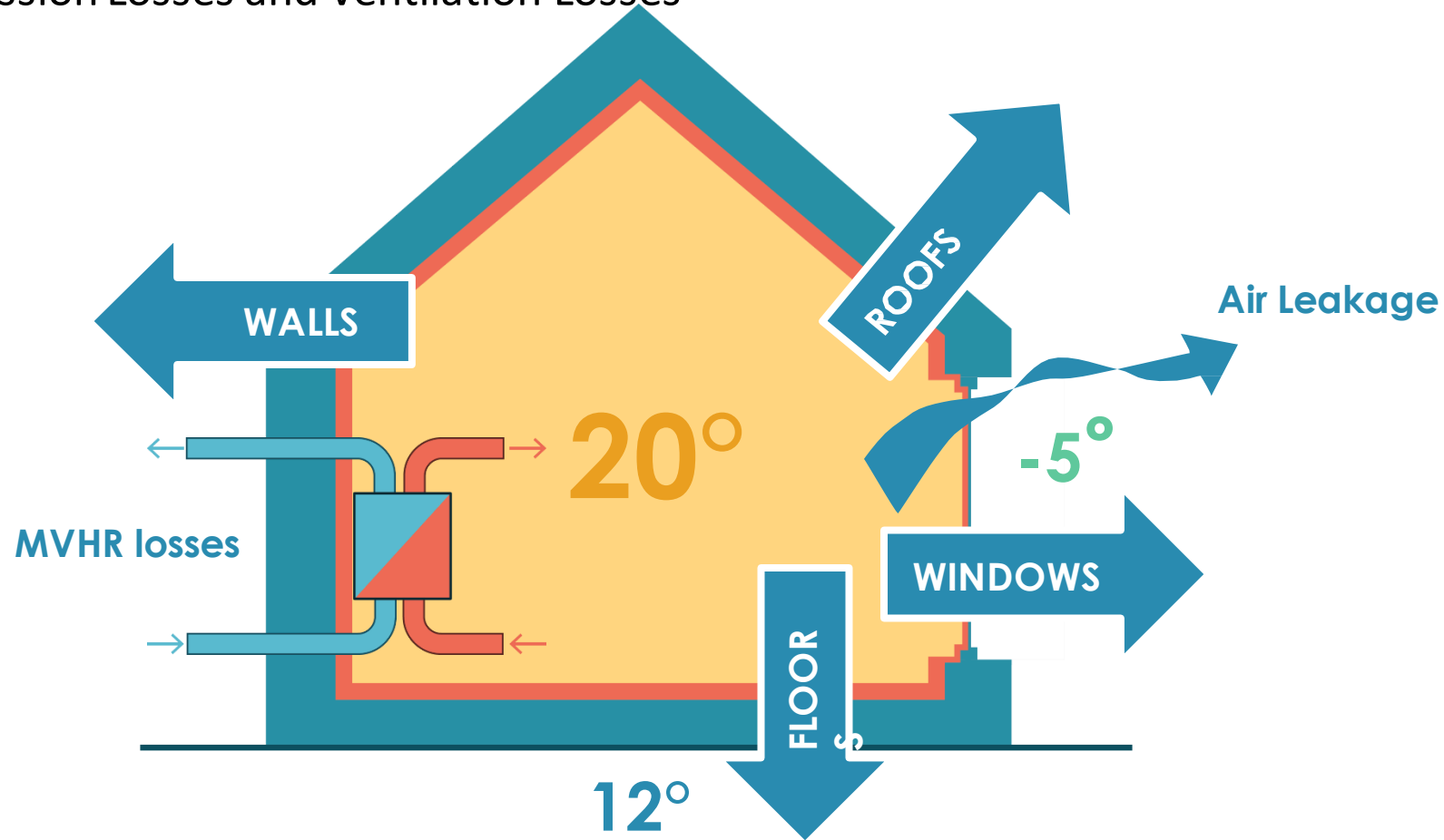


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Transmission and Ventilation Losses

Transmission Losses and Ventilation Losses



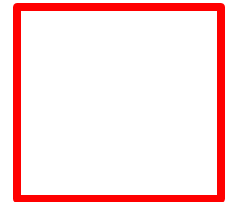
Air Permeability



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Impact of High Air Permeability

- Draughts
- Poor Comfort
- High energy losses
- Envelope deterioration



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Condensation and Mould



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Condensation & Mould

How does condensation form?

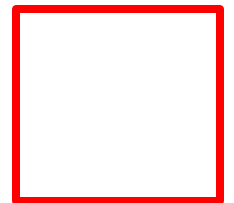
If you cool down air, the ability of that air to hold vapour reduces (the relative humidity increases).

If you cool air down to the 'dew-point', the relative humidity increases to 100%, leading to condensation



How does Mould form?

When warm moist air comes into contact with a surface at a lower temperature, the moisture condenses on to it. After a while, mould will start to grow on the surface.



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Energy and Buildings

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Condensation and Mould



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Condensation & Mould- Critical Temperatures!

Assume indoor temperature of 20°C and a relative humidity of 50%

When will condensation form?

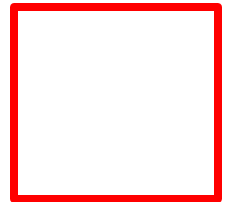
Approximately 9.3°C (= 100% RH)

When will mould form?

Approximately 12.6°C (= 80% RH)

How do you avoid these low temperatures?

Easy – insulate completely and avoid thermal bridges



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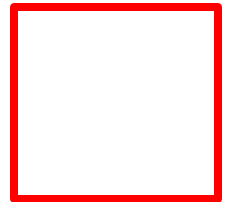
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Psychrometrics

Dry bulb temperature (T_{db}): what you would measure with an everyday thermometer.

Relative humidity (RH or ϕ): how much moisture is in the air compared to the maximum it can hold. It varies with changes in temperature (hence *relative*), even if the actual amount of water vapour does not change (ie, number of molecules). Expressed in %.



Humidity ratio (HR or W): the mass/mass fraction of water vapour mixed with air. Expressed in units of kg moisture / kg dry air.

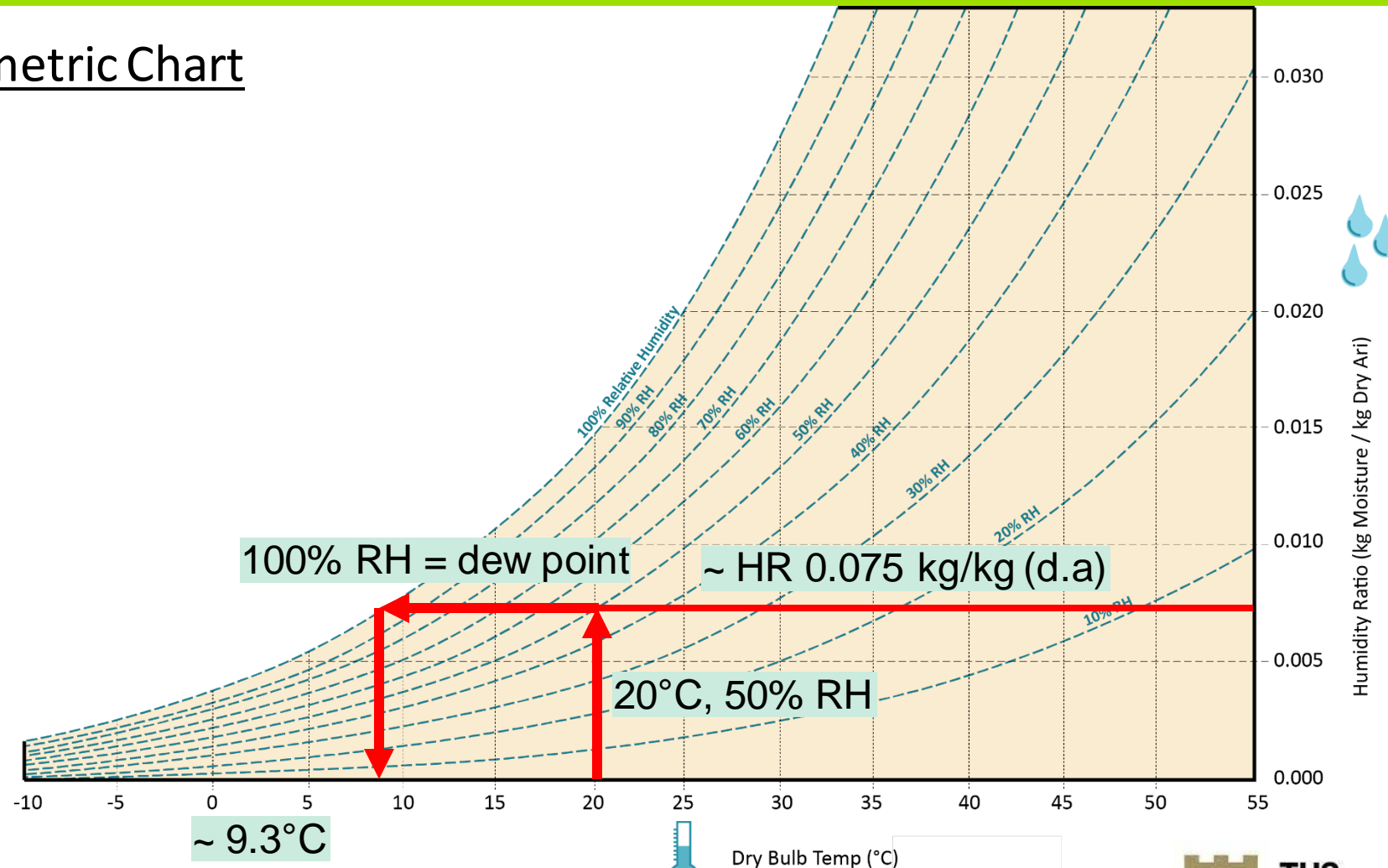


Psychrometrics



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Psychrometric Chart



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Dry Bulb Temp (°C)

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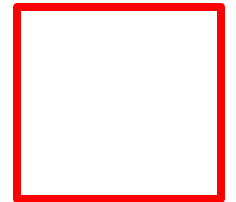
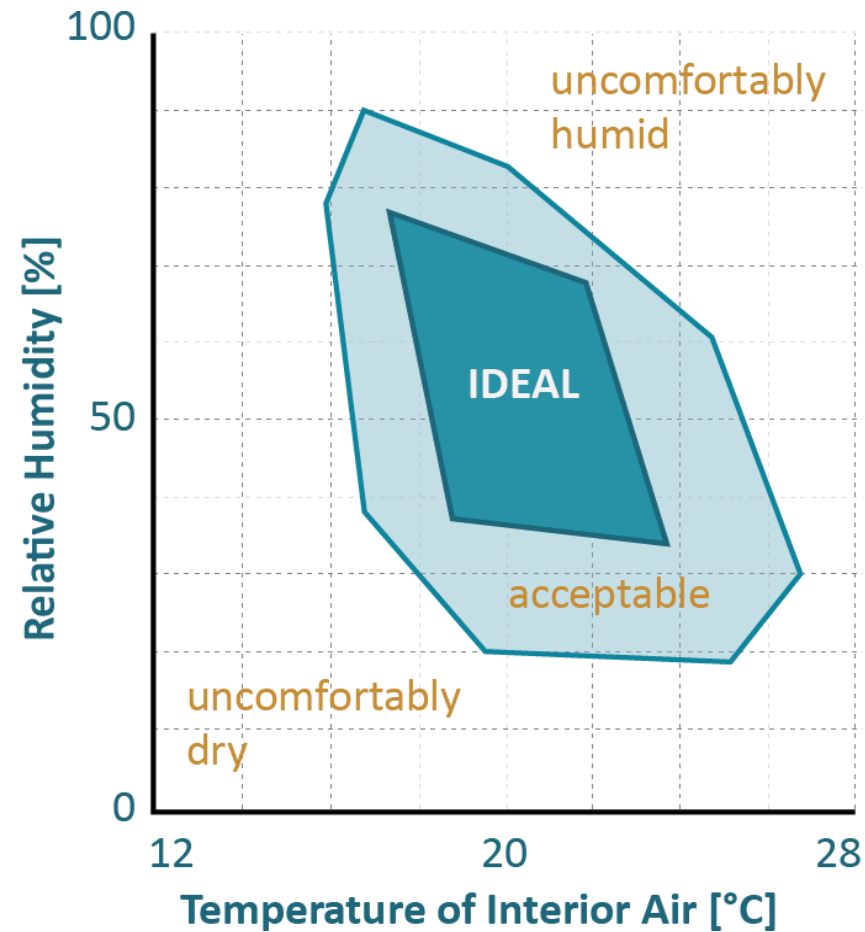


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Psychrometric Chart

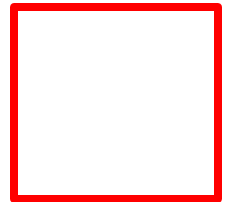
Relationship between
temperature and relative
humidity



What is Interstitial Condensation?

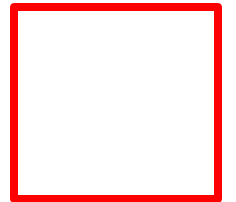
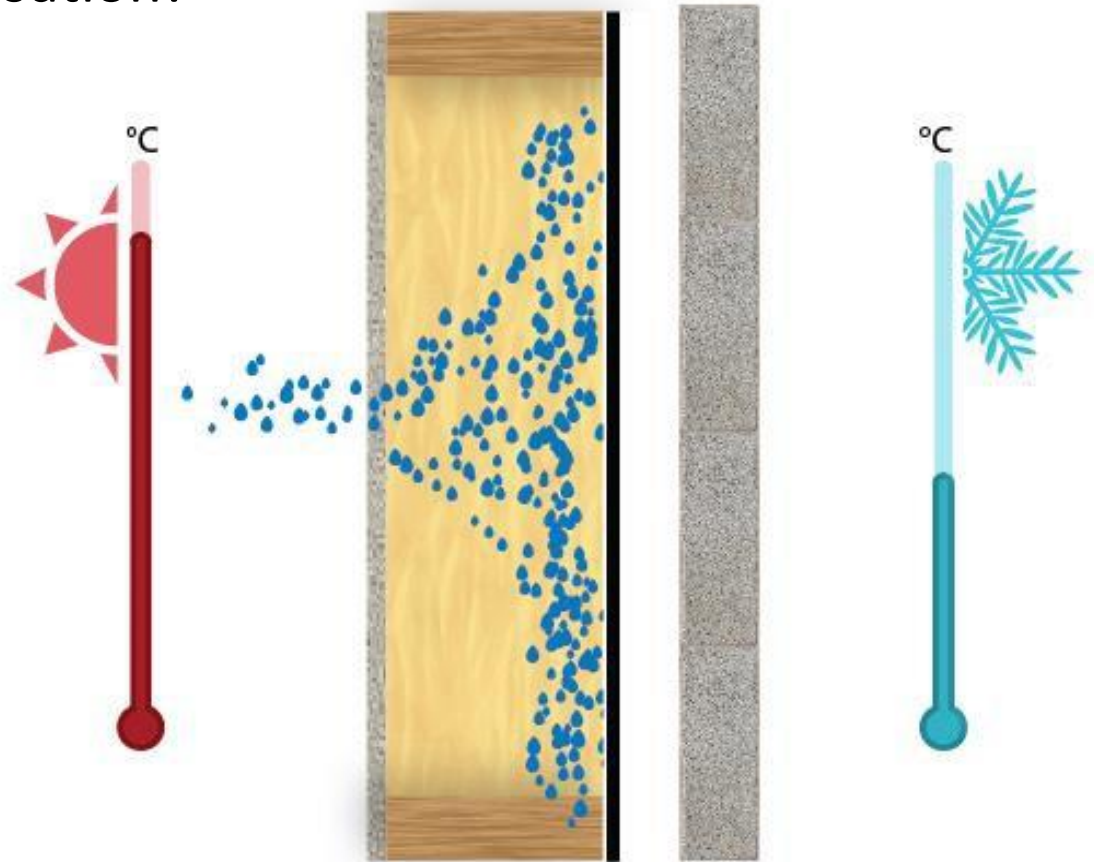
How does Interstitial Condensation Form?

- If your building is **not airtight**, warm humid air will **leak** into the external envelope
- As the air migrates to the outside, the **temperature decreases**
- If the temperature reaches the **dew point**, condensation can form
- If the outside of the envelope is not **vapour open**, condensation can build up in the wall
- This is especially **critical in timber frame** buildings



Interstitial Condensation

Interstitial Condensation!



2. Low Energy Techniques



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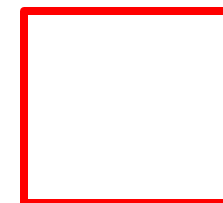
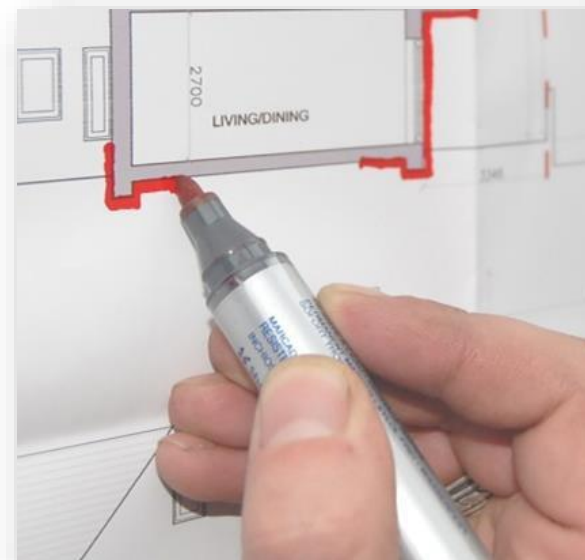
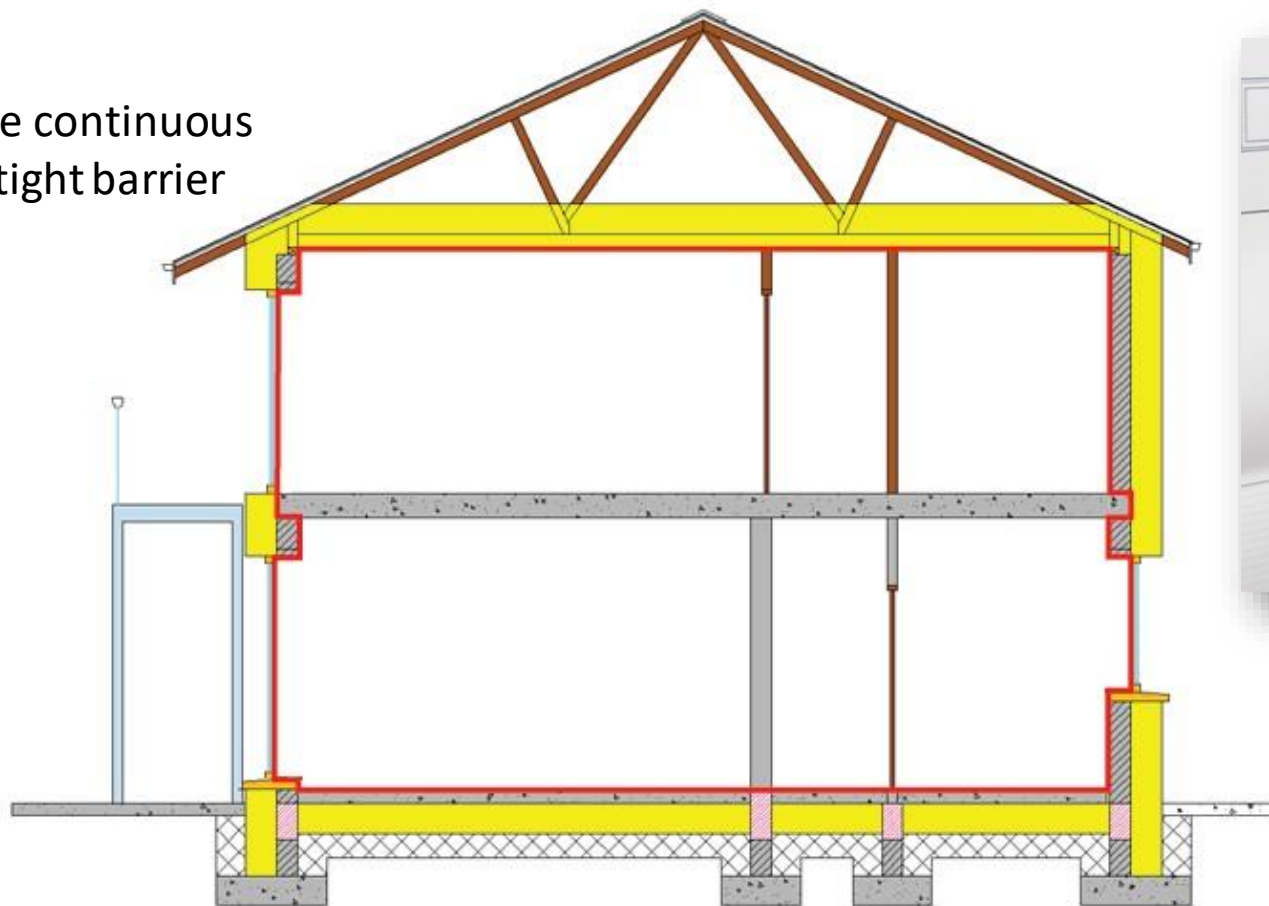


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The 'Red Line' Test

One continuous
airtight barrier



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Protection of Unventilated Warm Roofs



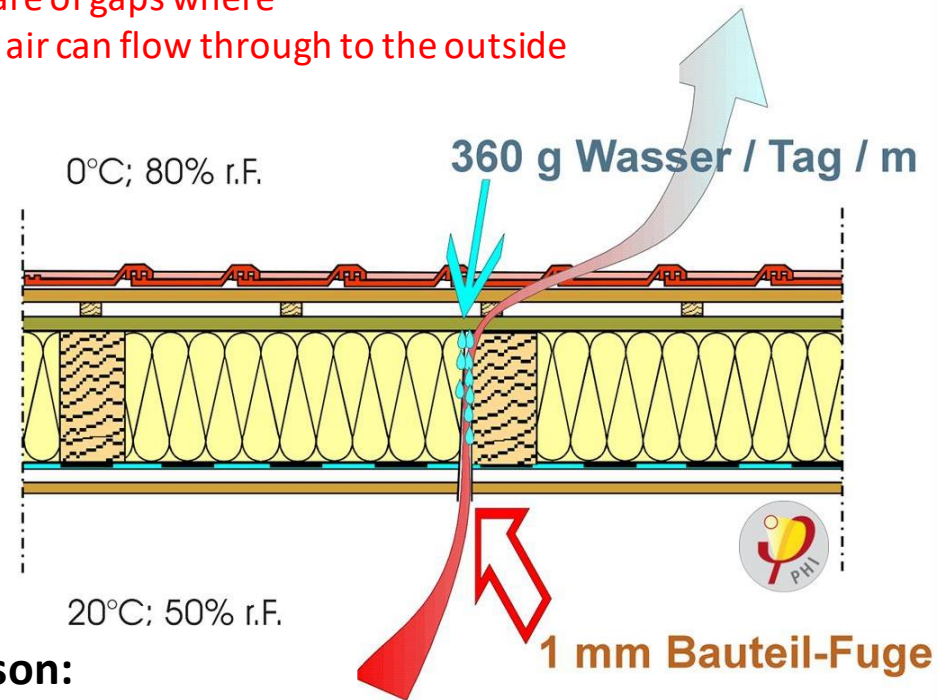
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A gap in the airtight layer that is 1mm wide and 1m long will allow the equivalent of approximately a bottle of beer per day to pass through it

Attention to detail is crucial!

Be aware of gaps where
humid air can flow through to the outside



For comparison:
vapour diffusion only 1 g
water / day / sqm



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Image Source: Left purchased by MosArt (istock -458569487)
Right : Passive House Institute

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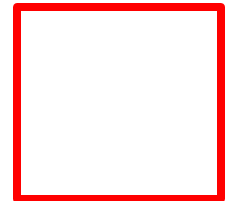
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Airtightness and Vapour Control Membranes



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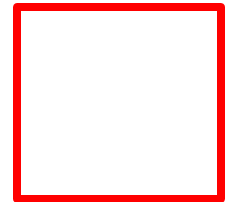


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μ -values and sd-values

- Unit used for measuring the vapour resistivity of a material is a **μ -value** (pronounced mu-value).
- This is a unit that measures a materials **vapour resistivity** relative to the properties of air.
- High μ -value means high resistance to transmission of water vapour, e.g. mineral wool and sheep's wool insulation have a μ -value of 1 while expanded polystyrene has a μ -value of 40.
- When applied to the thickness of material, it indicates its vapour resistance in construction, which is known as an **sd-value** (the thickness which a stagnant air layer would need in order to have the same diffusion resistance as the material in question).

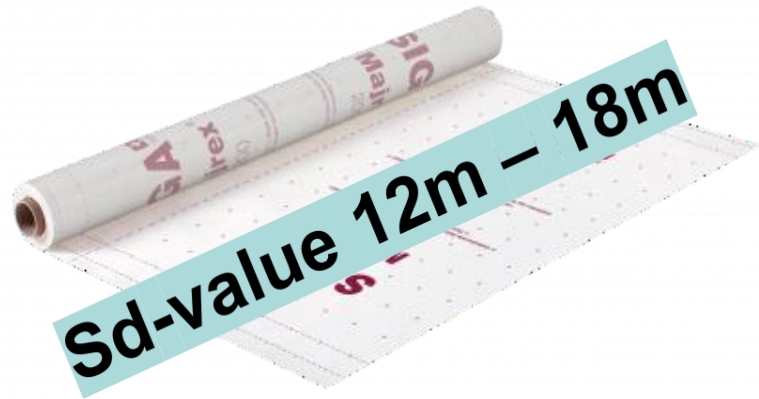


μ -value = vapour resistivity of material

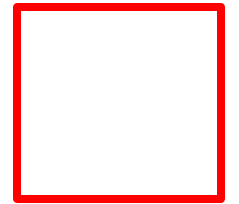
Sd-value = vapour resistivity of building element, accounting for thickness



μ -values and sd-values



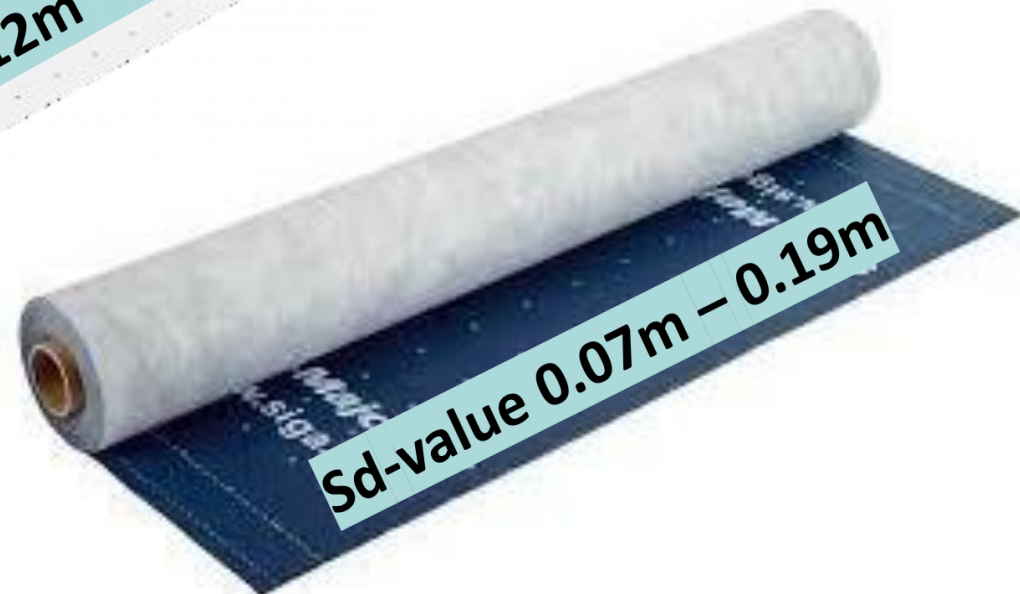
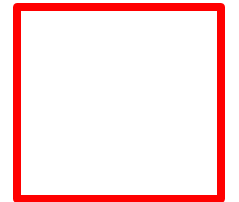
The sd-value of vapour control layers vary from product to product!



sd-values in vapour control membranes vs windtight membranes



We want a high sd-value in airtight layers



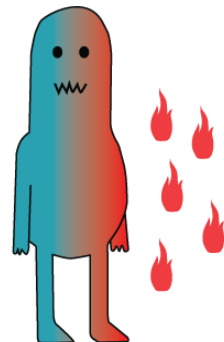
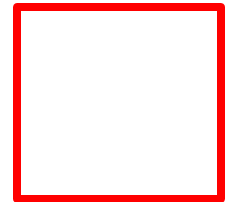
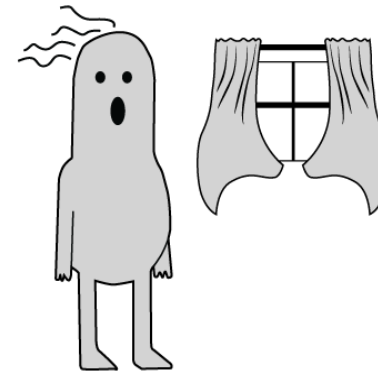
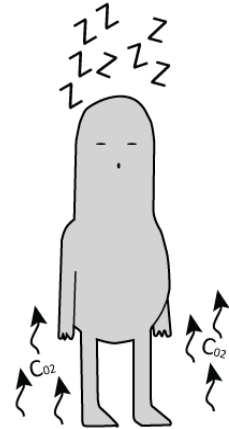
And low sd-values in
windtight/breathable layers



Local Thermal Discomfort



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Assessment



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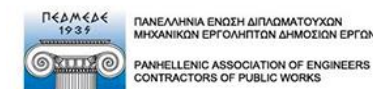


Thank You

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