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Certified Passive House Tradesperson

2.1.1 - Thermal insulation

Speaker:

Published by:
Passive House Institute
Rheinstraße 44/46
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Thermal conductivity λ

Definition: The thermal conductivity λ (lambda) of a material provides information about the quantity of heat that is transferred through 1 m² of a 1 m thick layer of this material when the temperature difference between the two surfaces is 1 degree Kelvin.

How relevant is this in practice?
The thermal conductivity of a material is a **material characteristic**. The effectiveness of insulation can be assessed based on the thermal conductivity. Insulation materials have very low thermal conductivities. The thermal conductivity of a material can be found in the standard DIN 4108-4 or the building authority approval.

Unit for expressing thermal conductivity: W/(mK) (watts/metre and Kelvin)

Example - thermal conductivity of selected building materials:

Aluminium: 160 W/(mK)
Steel: 50 W/(mK)
Reinforced concrete: 2.3 W/(mK)
Sand-lime brick: 1.0 W/(mK)
Wood: 0.13 W/(mK)
EPS: 0.035 W/(mK)

⇨ **Aluminium conducts heat 4000 times better than EPS ("polystyrene")!**

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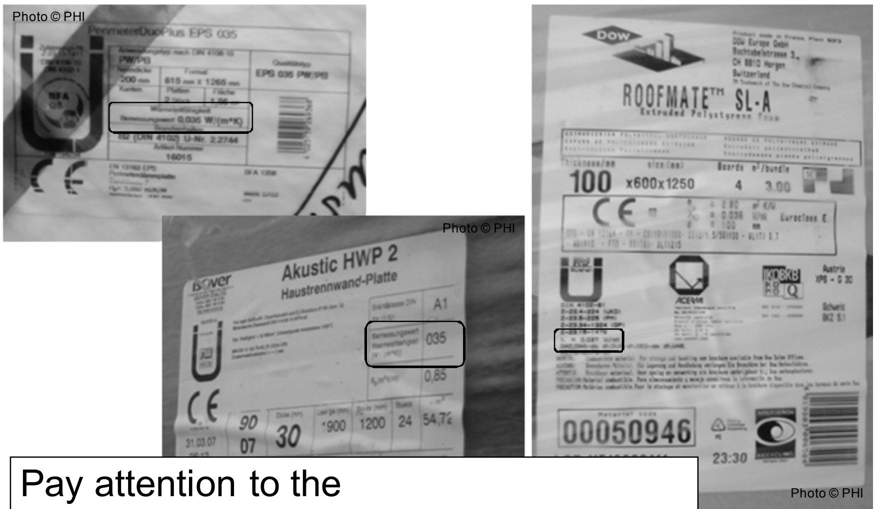
On the construction site…



Pay attention to the
rated value of the thermal conductivity!

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Overall heat transfer coefficient U

Definition: The U-value of a building component describes the quantity of heat that passes through 1 m² of a building component in 1 second when the temperature difference of the air on both sides is 1 degree Kelvin.

How relevant is this in practice?
The U-value describes in detail a **building component** in its **installed state**. Heat transfer through a well-insulated building component is low.

Unit for expressing the U-value: W/(m²K) (watts/square metre and Kelvin)

Example: U-values in practice:
Exterior wall of existing building, without insulation: U-value ca. 1.30 W/(m²K)
Exterior wall of existing building, 2 cm of insulation: U-value ca. 0.80 W/(m²K)
Exterior wall in a Passive House: U-value ≤ 0.15 W/(m²K)

⇨ **The U-value depends greatly on the insulation thickness!**

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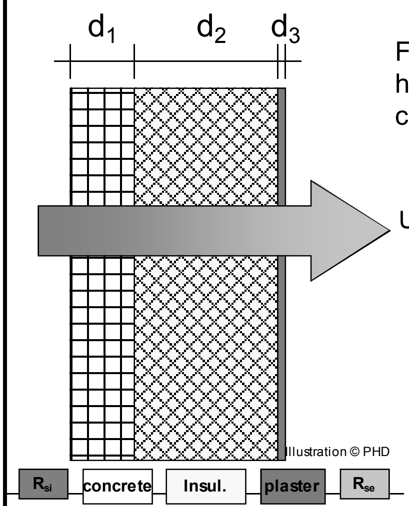
Overall heat transfer coefficient U



Formula for calculating the U-values of homogeneous (= uninterrupted) building components based on DIN EN ISO 6946:

$$U = \frac{1}{R_T} = \frac{1}{R_{si} + d_1/\lambda_1 + d_2/\lambda_2 + d_3/\lambda_3 + R_{se}}$$

R_{si} — concrete — insul. — plaster — R_{se}

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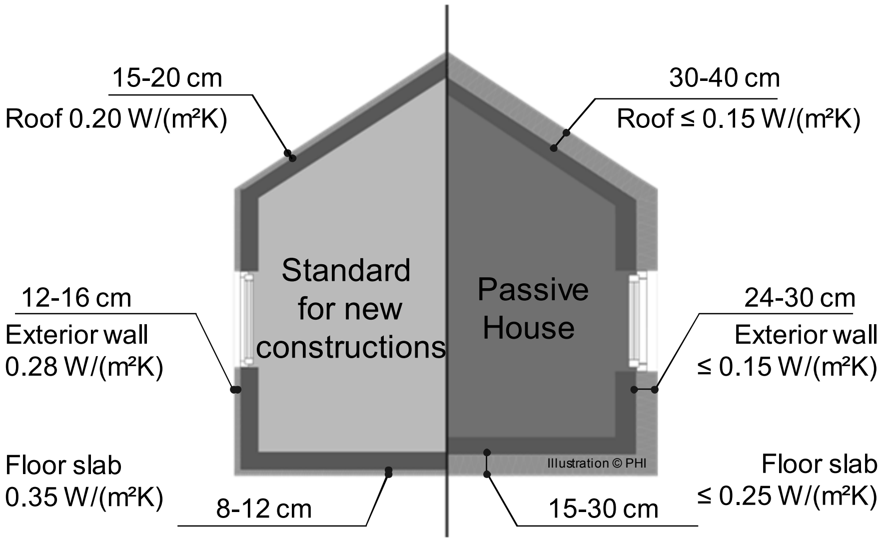
Typical U-values in a Passive House



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Basic principles of building physics

Moisture transport through diffusion

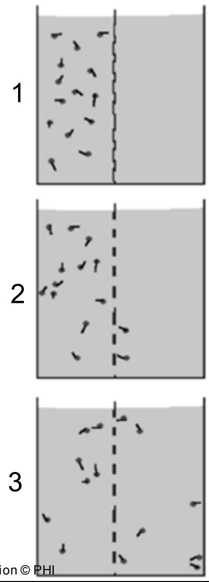
Water vapour diffusion resistance factor μ

Building material	**μ [-]**
Lime-cement plaster	15 - 35
Normal concrete	60 - 100
Polystyrene (PS) particle foam	20 - 100
Fibrous insulation material	1

μ x layer thickness = diffusion-equivalent air layer thickness s_d

Diffusion-permeable: $s_d \leq 0.5$ m
Diffusion-inhibiting: 0.5 m < s_d < 1500 m
Diffusion-impermeable: $s_d \geq 1500$ m

Caution: these must not be confused with the terms “vapour barrier” and “vapour retarder”!



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Overview of insulation materials

Mineral fibre insulation materials

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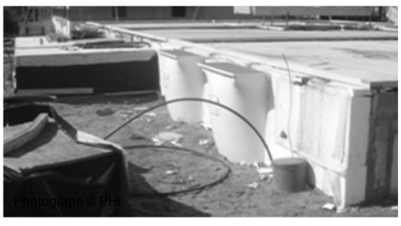
Overview of insulation materials

Expanded polystyrene rigid foam (EPS)

Photograph © PHI



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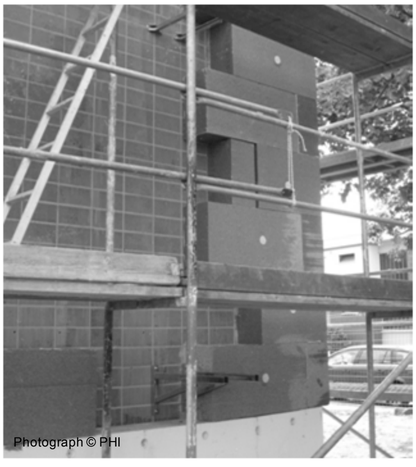

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Certified Passive House Tradesperson

Module 2.2.1 – Ventilation

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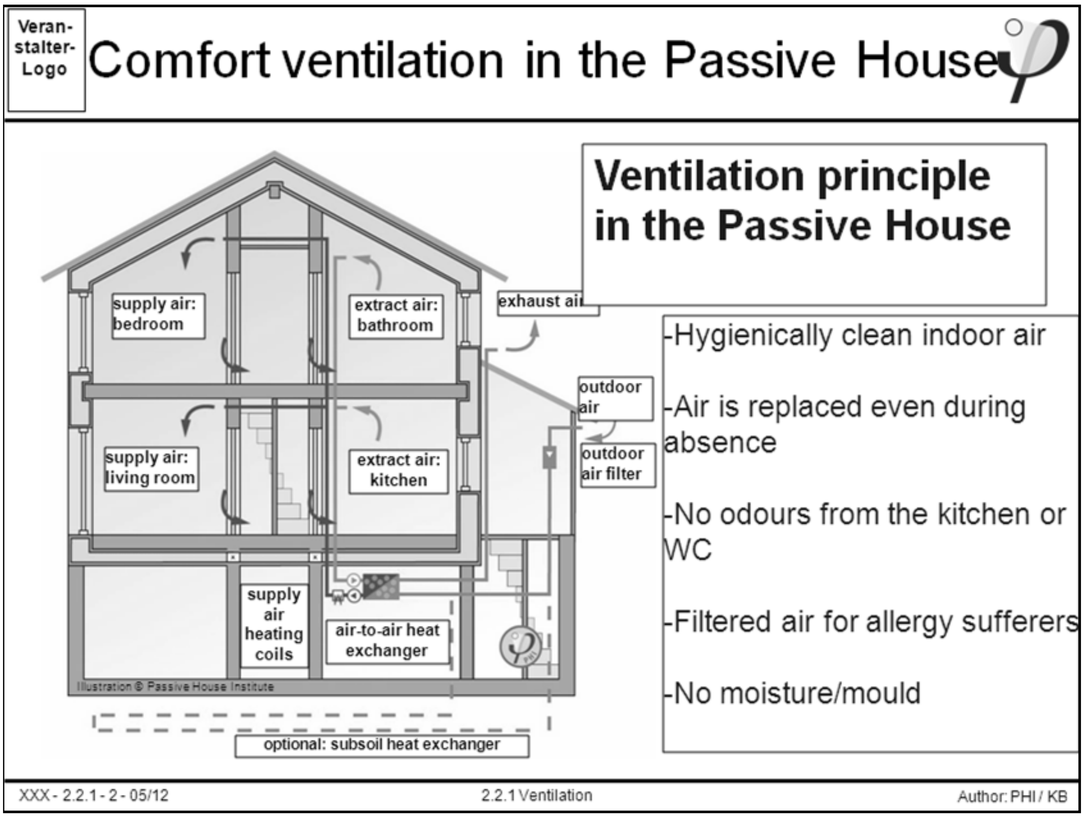
Brief introduction of the speaker



The functional principle of the ventilation system in a Passive House:

Fresh air flows into the living spaces, the living room and bedrooms. These are known as supply air rooms.

The extract air rooms are the kitchen, bathroom and WC. The used air is extracted away from here.

The corridors are known as transferred air zones and are ventilated automatically with the rest of the house.

The heat recovery from extract air is vitally important in a Passive House. The heat contained in the extract air is transferred to the cold fresh air by a (passive) heat exchanger. Depending on the efficiency of this heat exchanger, more than 90% of the heat from extract air can be recovered from the extract air.

The heating demand in the Passive House is so small that it is possible to use the ventilation system for heat distribution simultaneously. Heating coils heat up the fresh air being supplied to the rooms.

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Overview

1. Why is ventilation necessary?
2. Types of ventilation
3. Balanced supply and extract air systems with heat recovery
4. Components of the ventilation system
5. Airtightness
6. Initial operation
7. Summer ventilation

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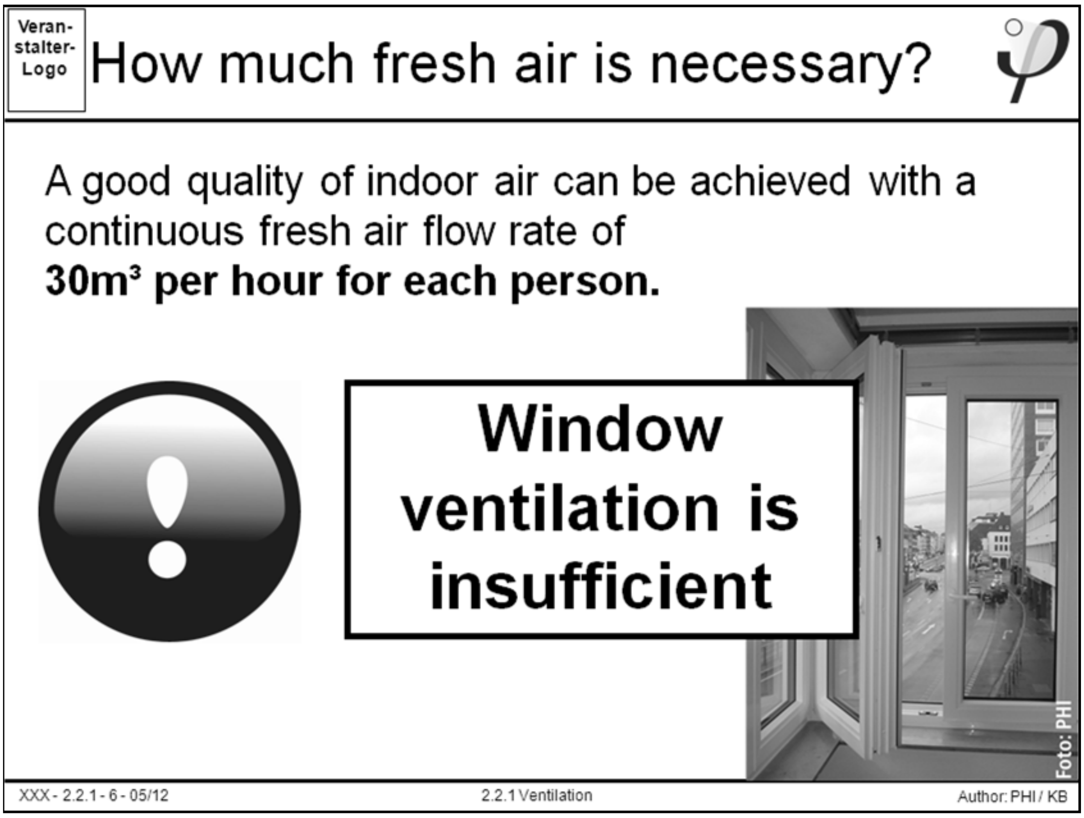
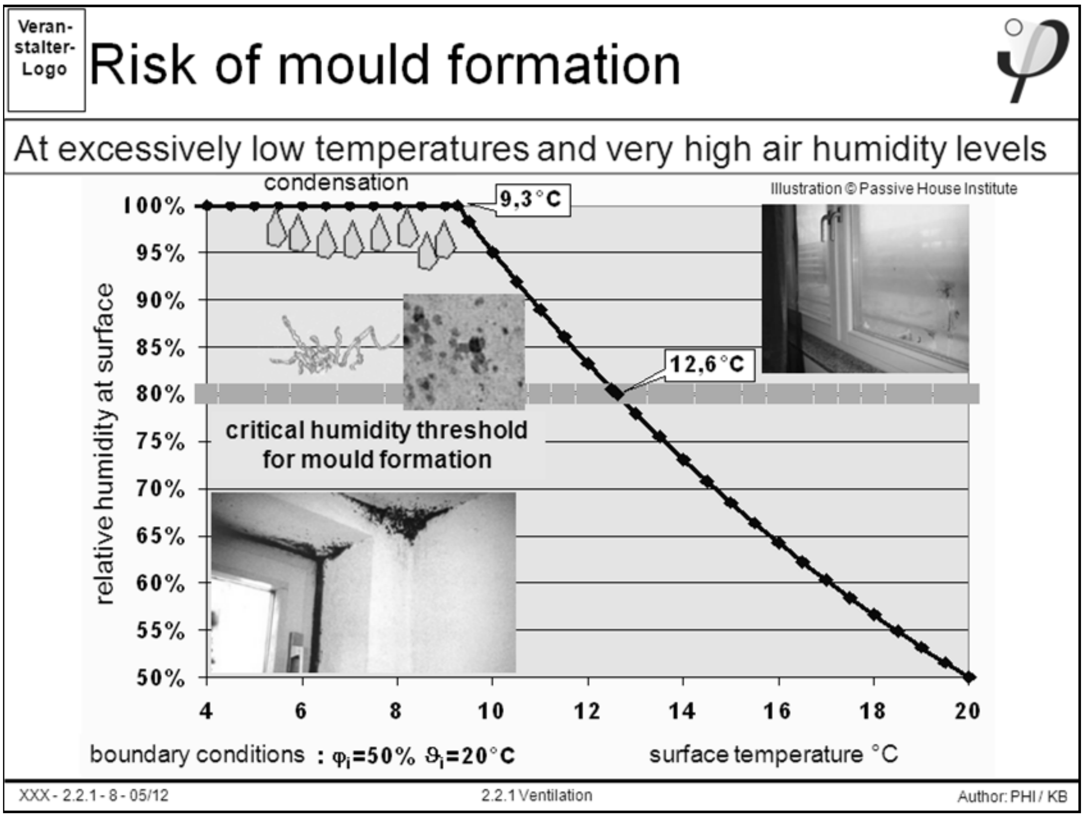


Controlled home ventilation is vital particularly in buildings with an excellent level of airtightness of the building envelope, because in contrast with unrefurbished existing buildings, there are no air flows through leaks in the building envelope.

CO_2 measurements have shown that a good quality of indoor air cannot be maintained by means of ventilation through windows (regular purge ventilation by occupants every 4 hours is practically impossible). An increase up to 2000 ppm was measured especially in bedrooms.

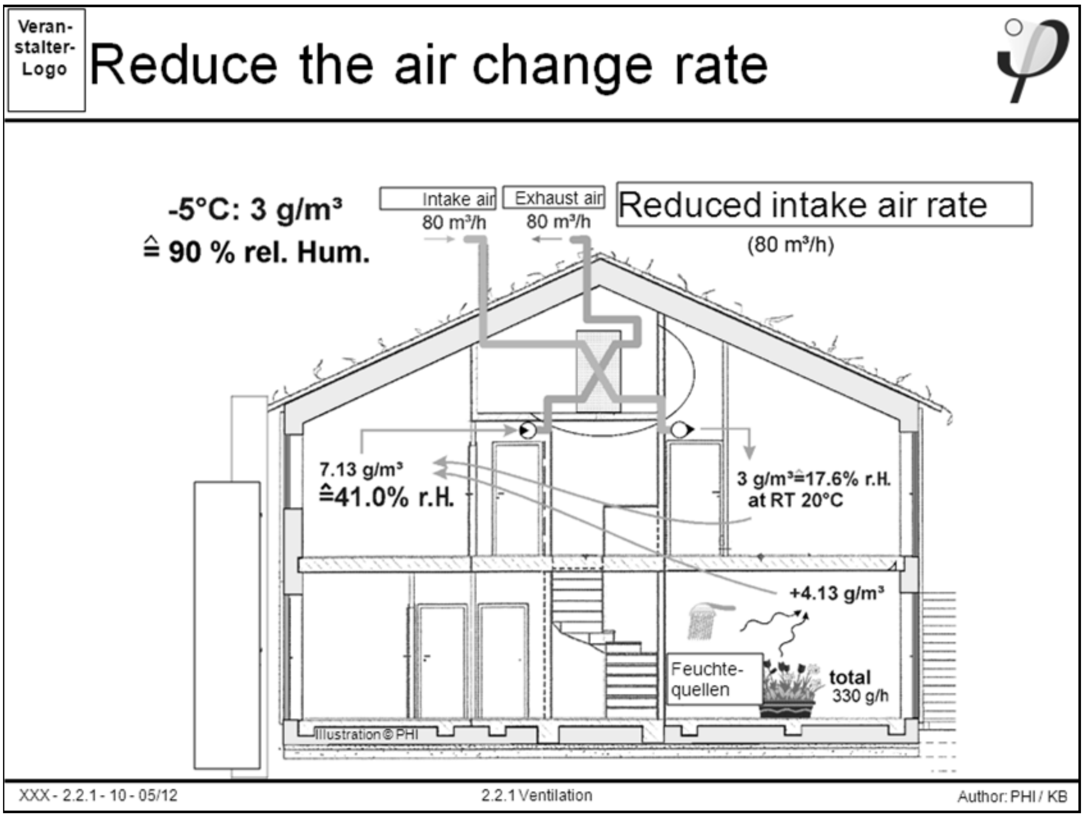


Relative humidity at building component surfaces as a function of the respective temperature of that surface. The diagram applies for average boundary conditions typical for living rooms:

relative air humidity 50 % and air temperature 20 C.

The risk of mould formation depends on the so-called aw-value (that is the equalising air humidity at the building component surface). Growth is somewhat slower at lower temperatures (depending on the type of mould fungus). In general however, one can assume that germination occurs with longer periods of time with aw-values over 80 %. In terms of building physics, the highest possible surface temperatures of exterior building components must therefore be ensured on the one hand, and on the other hand the air humidity must remain limited by means of controlled home ventilation.

Literature: Research Group for Cost-effective Passive Houses 24: Refurbishment of existing buildings with Passive House components. Passive House Institute, Darmstadt 2004



If the fresh air flow rates are reduced to 80 m³/h with the same internal sources of humidity, then the same emission rate now provides 4.13 grams of water per cubic metre of transferred fresh air and the absolute humidity of the indoor air increases to 7.13 g/m³. The relative indoor air humidity is thus 41 %.

If ventilation is not excessive and a reasonable amount of fresh air per person is provided instead, then excessively dry air can be prevented.

It must be pointed out here that with reference to the dimensioning of air flow volumes, no complaints have ever been received regarding poor air quality in Passive Houses, but there have been complaints about excessively dry air.

Note: comfort ventilation provides a healthy and comfortable indoor climate. The air quantities must not be set to such high levels that occupants complain about dry air!