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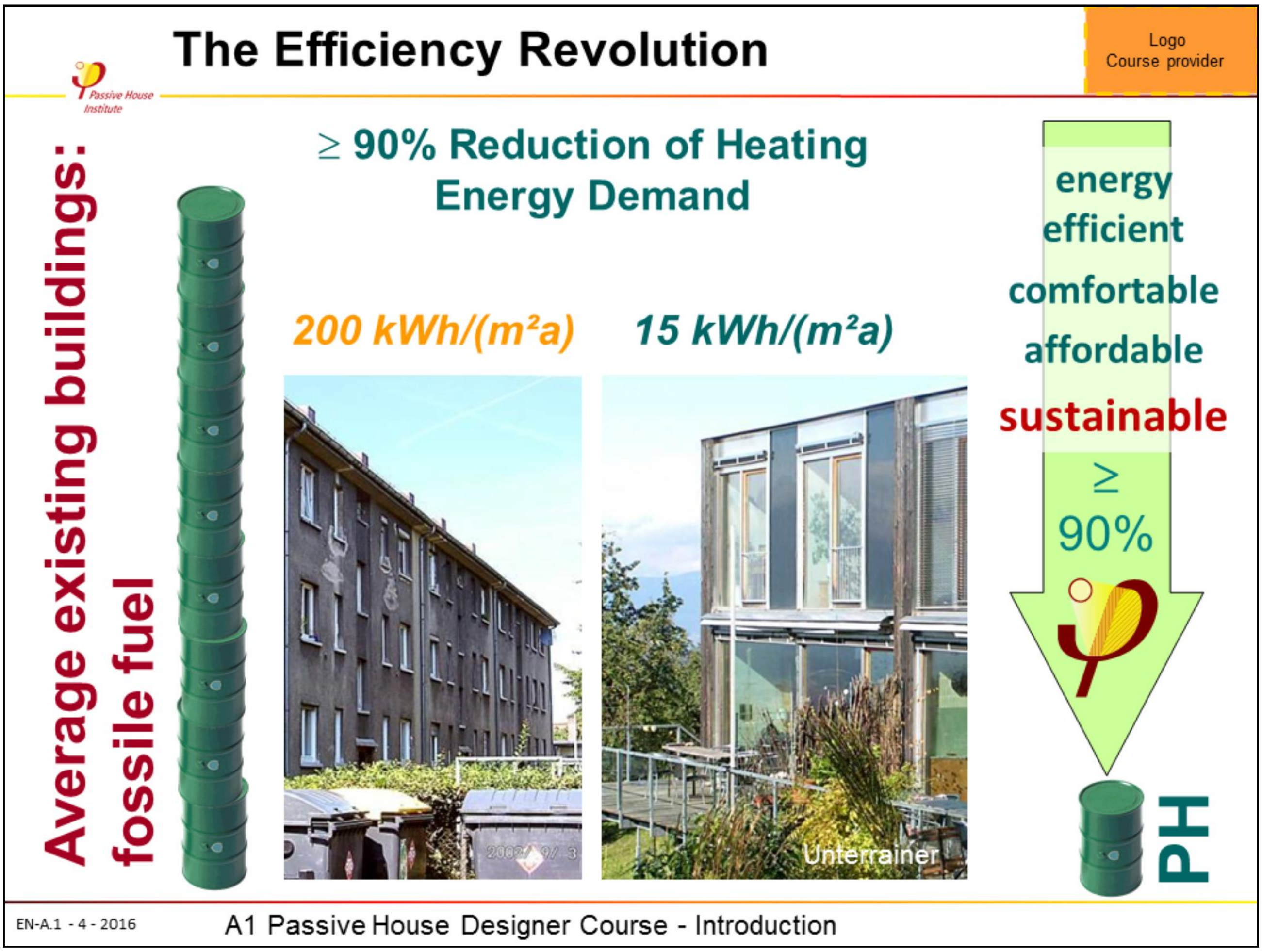
Passive House Institute
DESIGNER
CERTIFIED PASSIVE HOUSE DESIGNER
Welcome to Passive House Designer Course
EN-A.0 - 1 - 2016
A0 Welcome



Passive House is a building standard, which is energy-efficient, comfortable, affordable and environmentally friendly at the same time.

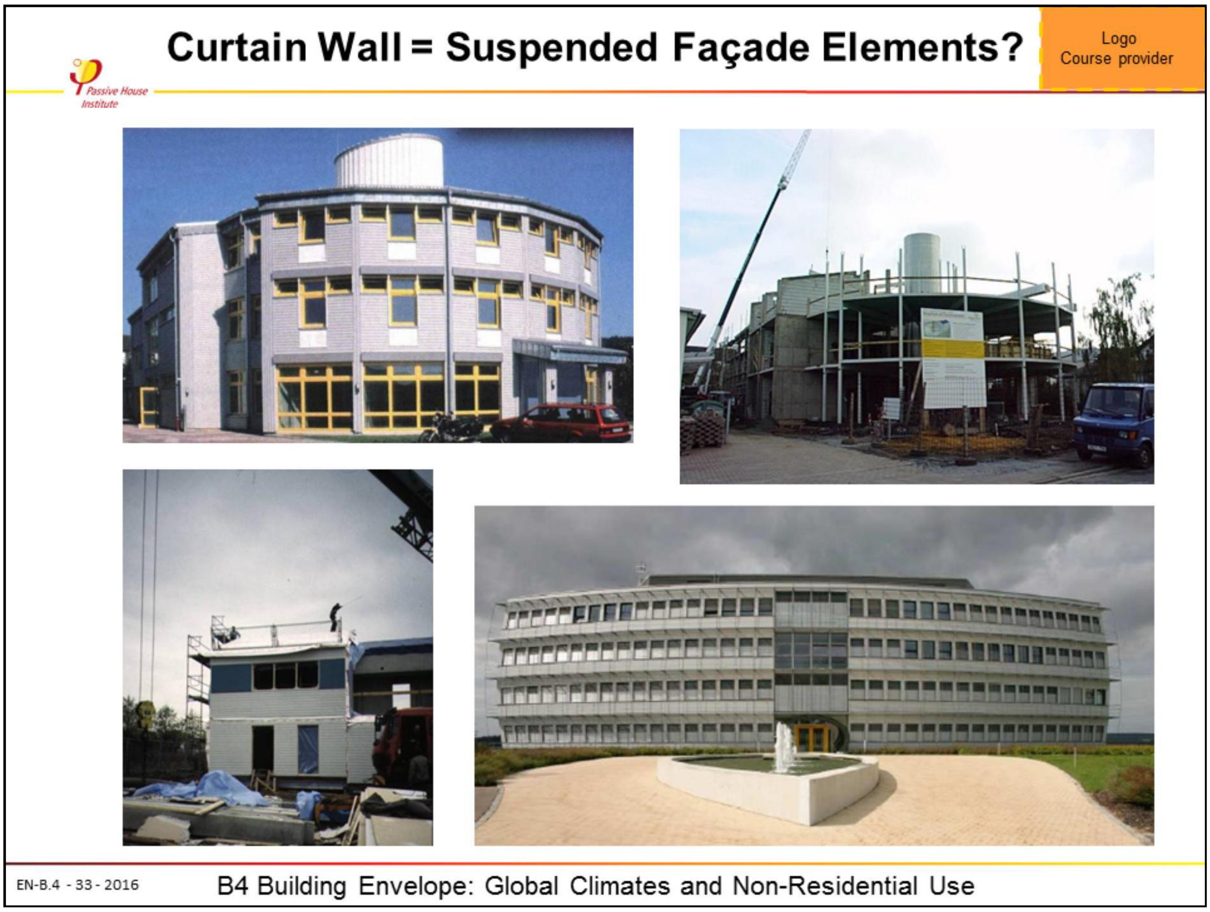
The Passive House is not a brand, it is a building concept which is open to all – and which has proven itself in practice.

The Passive House is the leading standard in energy saving in buildings worldwide: The heating energy saving is typically over 90% compared to the buildings stock and still 75 % in comparison with the requirements of building codes.

Since the heating energy is very low, high energy prices make no difference to residents of Passive Houses.

Passive Houses achieve this enormous energy conservation through the use of special energy-efficient building elements and ventilation techniques.

Notes:



In principle, it is possible to realise Passive Houses with rainscreen facade elements that are not loadbearing in most cases. The supporting structure then usually consists of a reinforced concrete skeleton construction or cross-wall construction. Particular attention must be paid to the details with regard to thermal bridges at the connection to the solid construction, airtight execution and efficient execution of construction work.

Top:	Company offices, Marburg-Cölbe, Germany, © Chr. Stamm
Bottom left:	Terraced housing project, © Rasch & Partner
Bottom right:	Office building, Energon, Ulm, Germany, © Oehler & Archkom

Notes:

Foamglass: Example Project

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Punctiform thermal bridge:
$\chi = 0.02 \ldots 0.04$ W/K

Photo © PHD

EN-B.4 - 51 - 2016 B4 Building Envelope: Global Climates and Non-Residential Use

Sub-construction with thermal separation consisting of foamglass panels. Although these are resistant to pressure, they are not approved as insulation material. The statics/structural stability of this construction must therefore be verified in each case.

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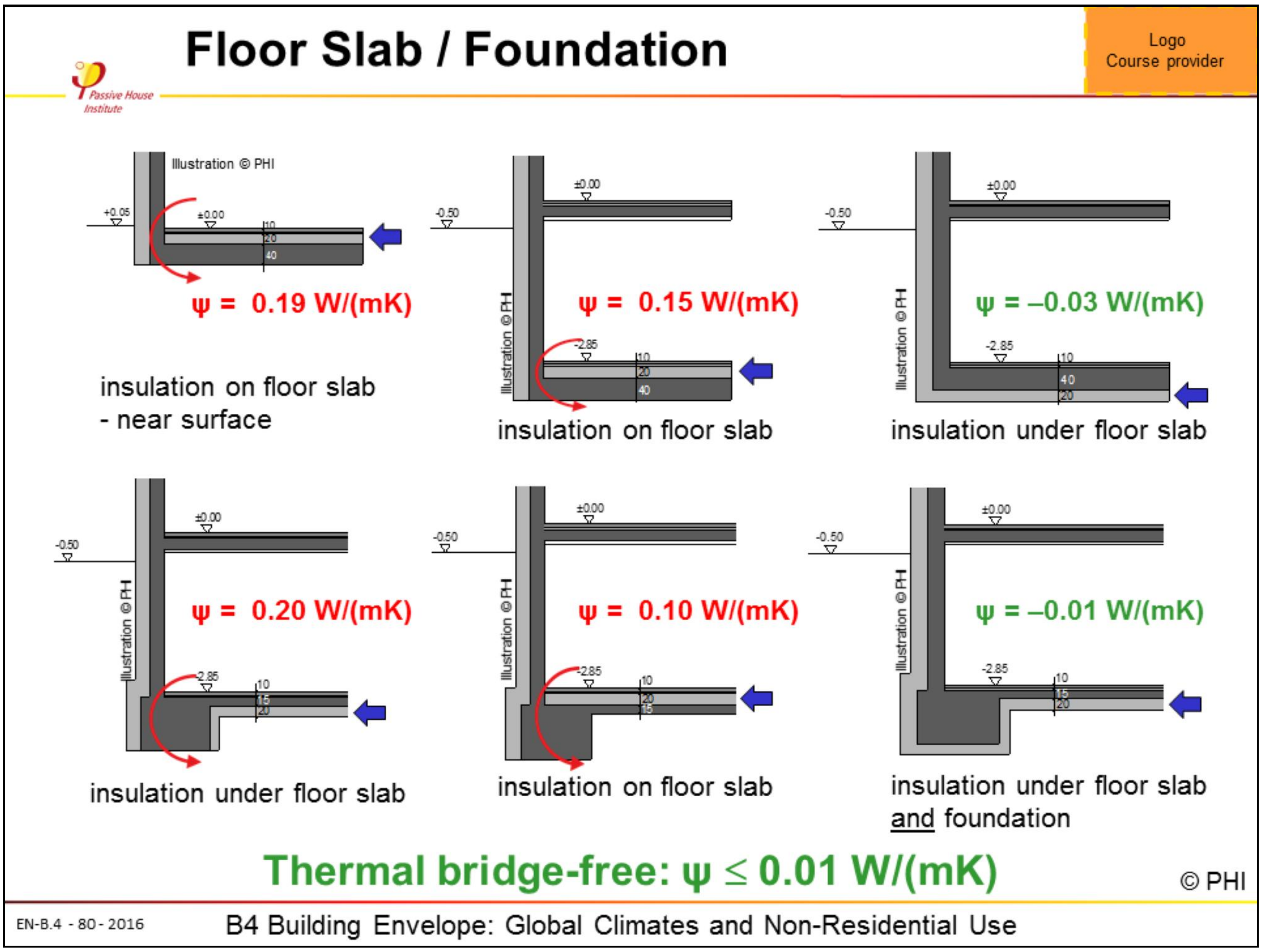
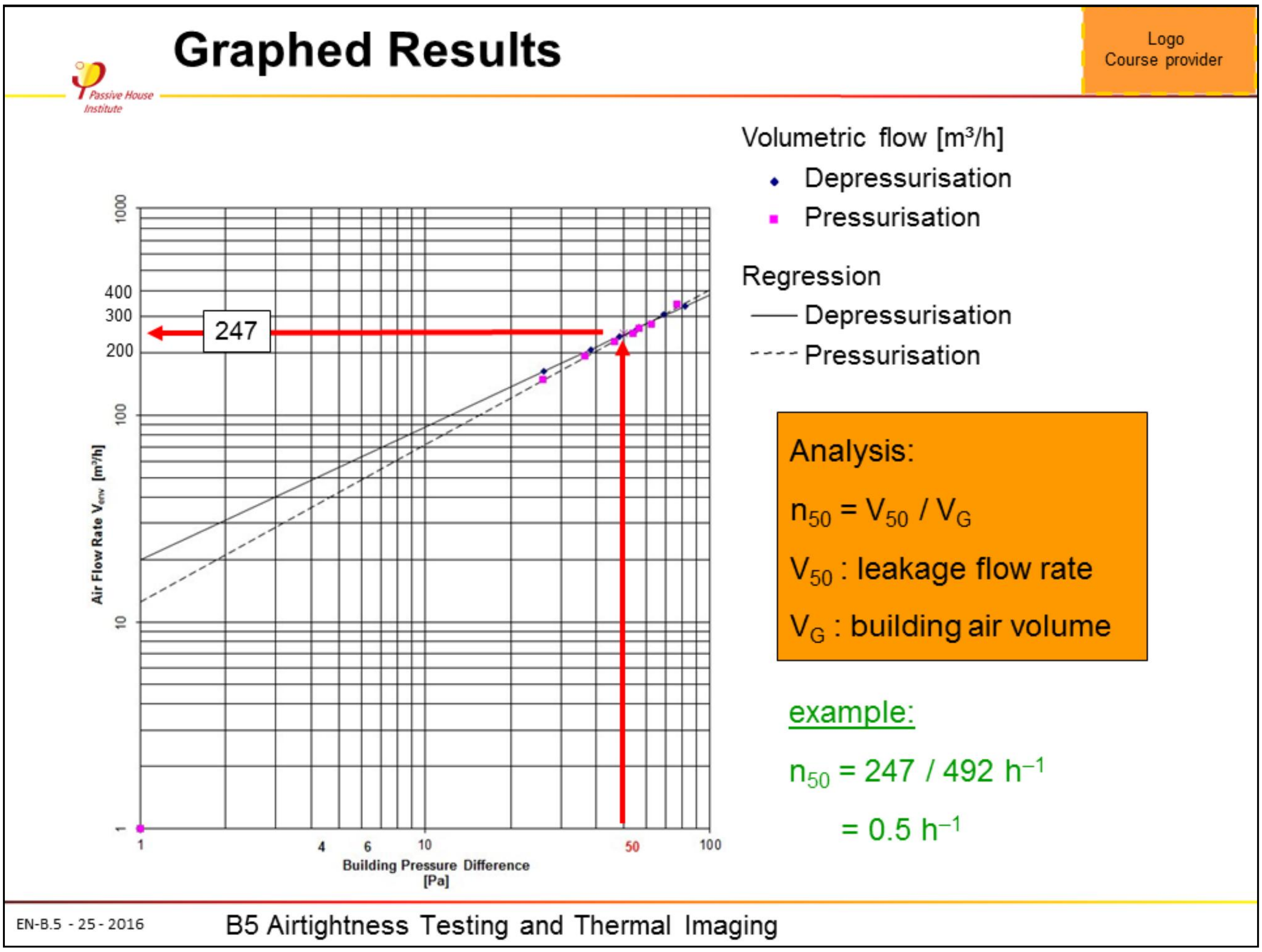


Without insulating blocks, only solutions with insulation on all sides are thermal bridge-free for both load-bearing floor slabs and foundations. Due to the lack of "insulation to the ground", poor detail solutions have a greater effect in case of floor slabs near the surface or for foundations than the same solution implemented deeper in the ground.

Thermal bridges are likely if insulating blocks or insulation under the floor slab are not possible due to structural reasons, which can have a major effect on the heating demand.

Insulation under floor slabs and foundations must be compression-resistant. Several materials with different thermal conductivities can be used depending on the structural requirements, e.g. XPS, foam glass, glass granulate, lightweight porous mortar.

Notes:



The measured values (differential pressure of the building and transferred leakage volume flow) are entered in a double logarithmic diagram (both axes are shown on a logarithmic scale). The entered measured values lie on a straight line. Any deviation of the measurement points from this straight line points to quality issues of the test. The higher the deviations are, the greater the effects of the disrupting influences (wind etc.) and therefore the lower the reliability of the measurement result. On the basis of the measurement points, a best fit straight line is calculated for each set of measurements: the leakage volume flow for 50 Pa is computed using the equation

$V_{50} = C_L \cdot (50\text{ Pa})^n$

with: V_{50} = leakage volume flow at 50 Pa; C_L = leakage coefficient; n = flow exponent.

The values for C_L and n are ascertained using the least squares method.

Characteristic values according to DIN EN 13829

Air change rate n_{50} at 50 Pa

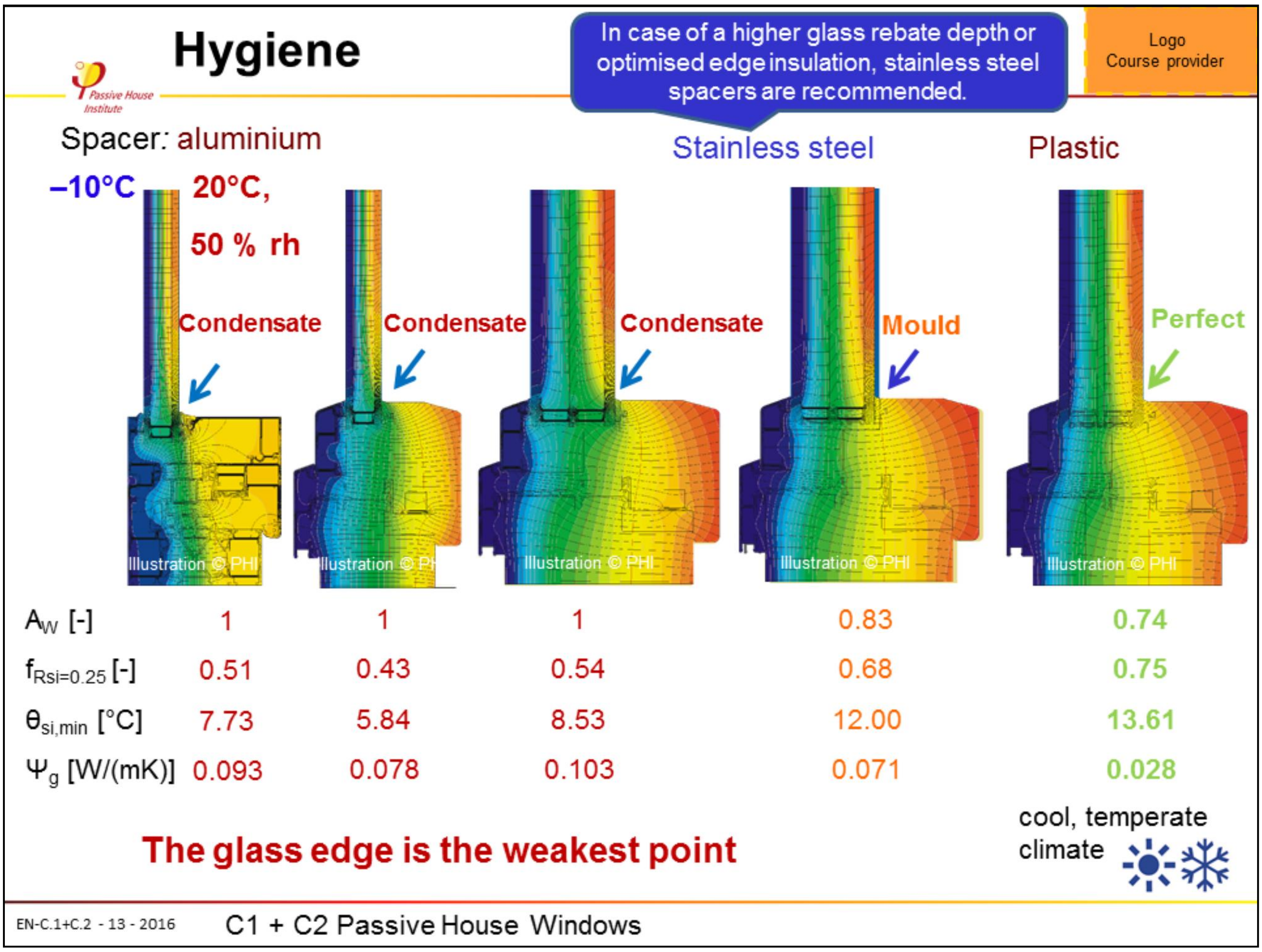
The transferred leakage volume flow V_{50} at a differential pressure of 50 Pa between the inside and outside is based on the heated internal volume V_G. It is used to evaluate the airtightness of a building and represents an important indicator of the airtightness of a building. Since the value is “independent” of the building volume, it can well be used as a value for comparing buildings.

Example: A n_{50}-value of 3 h^{-1} indicates that the air volume is exchanged 3 times per hour at a differential pressure of 50 Pa.

Requirement for a Passive House: $n_{50} \leq 0.6\ h^{-1}$

Restriction for comparison of n_{50}-values:

Comparison will not make sense if the buildings are of a completely different size (single-family house and a multi-storey building or factory building). The q_{50}-value should be used for comparison in this case (reference parameter: envelope area).



With an indoor temperature of 20 °C and a relative indoor air humidity of 50 %, there may be issues relating to mould if the surface temperature falls below 12.6 °C. In the Central European (cool, temperate) climate, a temperature factor of at least 0.7 is necessary at the glazing edge (f_{Rsi}) to ensure an adequate surface temperature $\theta_{si,min}$.

The size of the linear thermal bridge at the glazing edge (Ψ_g-value) depends on the window construction as well as the material(s) used.

The construction of Passive House windows can be optimised by a deeper glazing rebate upstand; however, this often entails larger frame widths, which has a negative effect on the potential solar gains through the windows. Insulation inserts on the outside, which shield the glazing edge from the cold, are advantageous in this case.

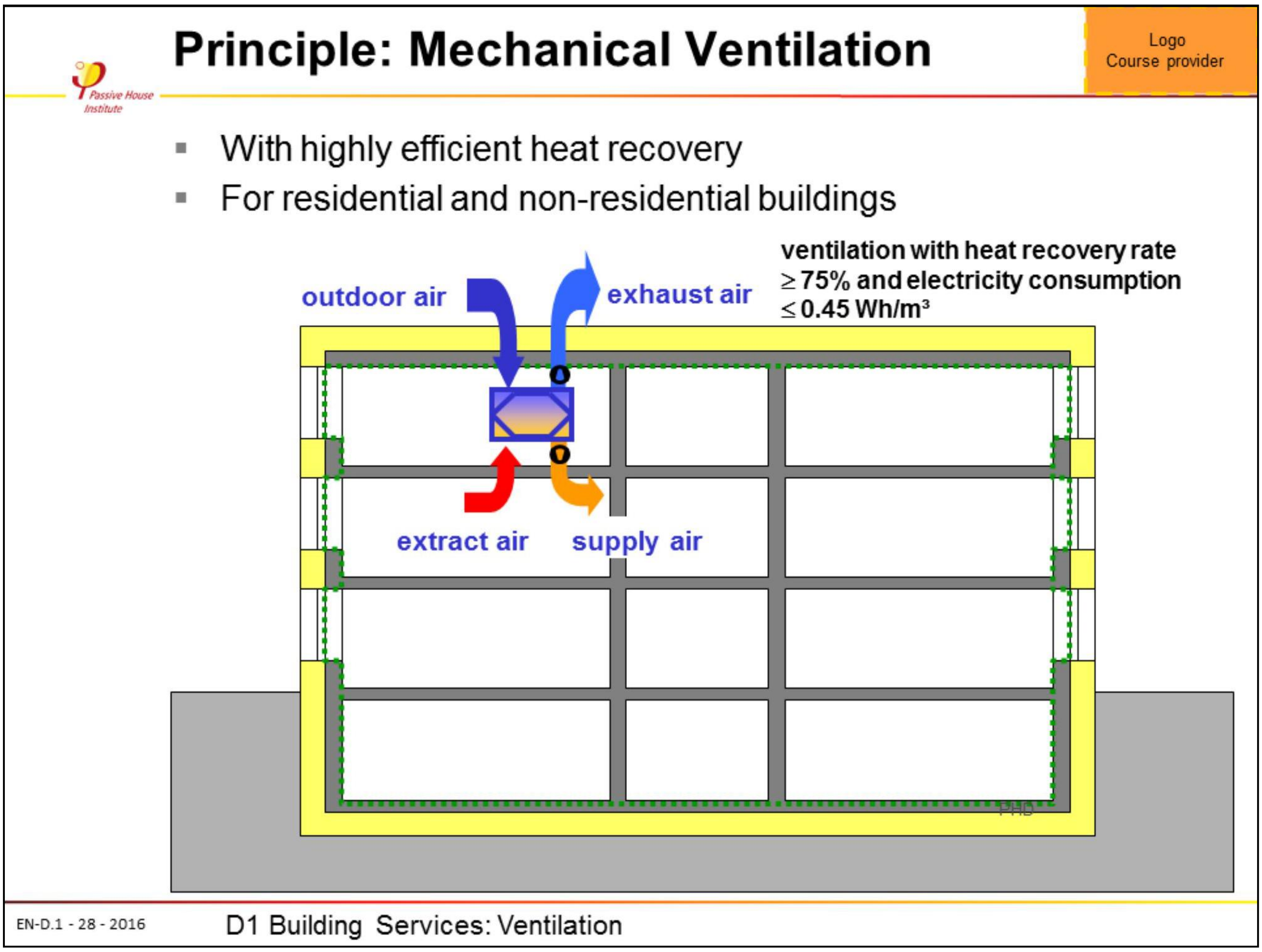
The second option is to choose suitable materials for the warm edge, i.e. the thermally separated glazing edge seal. Many manufacturers of profiles for spacers at the glazing edge have developed products made of materials (stainless steel foil or a combination of stainless steel and plastic) which allow a high level of thermal separation. In contrast to aluminium profiles, heat losses can be greatly reduced with these spacers.

In cool, temperate climates, mould can only be avoided reliably if plastic spacers are used.

Additional information:

The materials for glazing edge seals have been improved considerably since the development of the Passive House window. Stainless steel spacers are at least as durable as aluminium spacers, the use of which can no longer be justified.

Even lower heat losses occur with plastic spacers in which a metal foil is used to seal the gas filling. Today, metal foils are placed on the outside of the plastic body and the spacers are just as durable as the conventional solutions. Same is valid for a new generation of spacers, using a plastic film that is coated by a very thin metal layer to be absolutely gas tight.



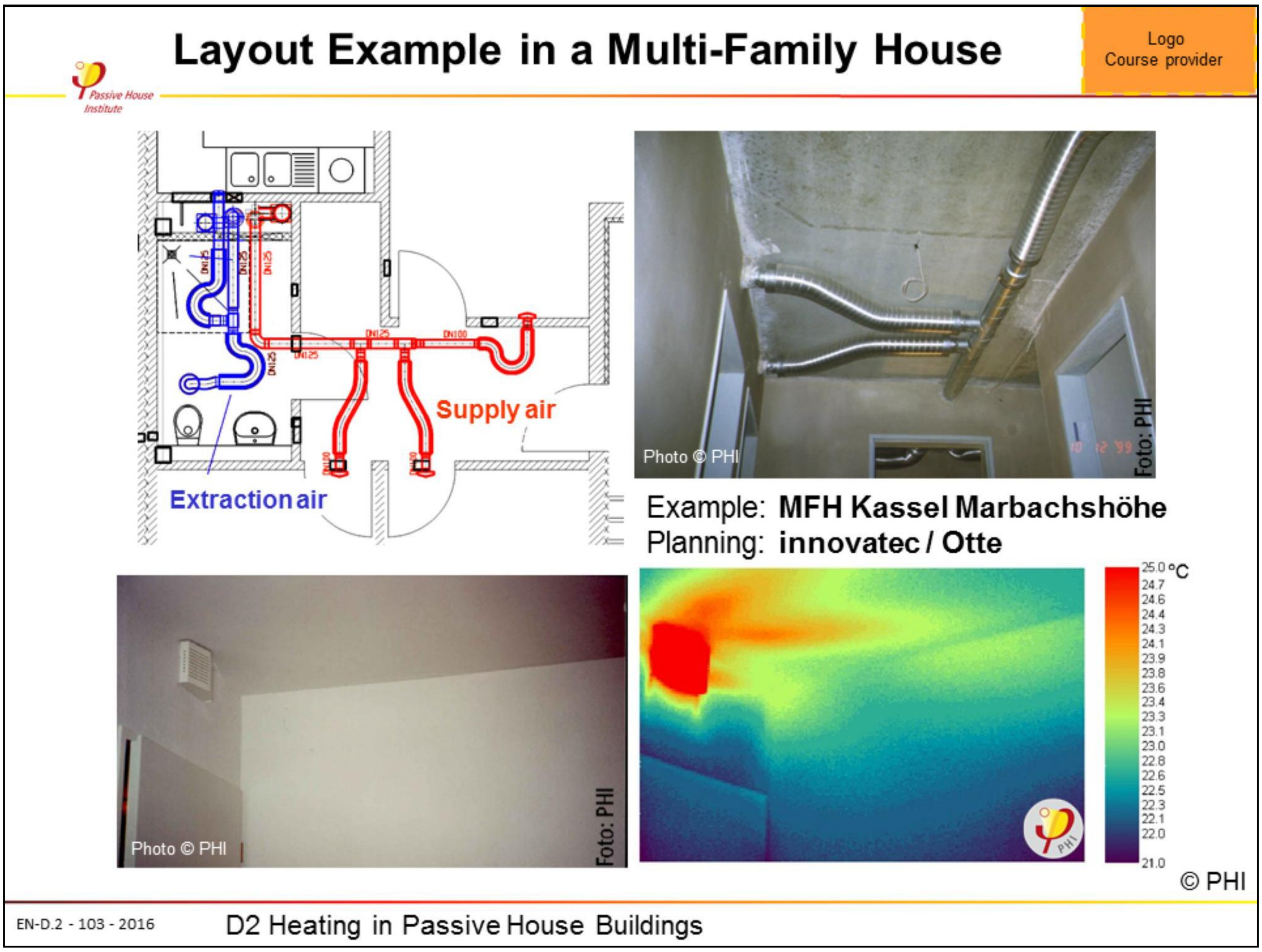
Passive House component ventilation with heat recovery

The demand on fresh air is usually higher in non-residential buildings as compared to residential buildings. The reasons are mainly a higher occupancy rate (e.g. class rooms or offices) or high rates of air contamination (e.g. in laboratories or canteen or restaurant kitchen). A mechanical ventilation system in these cases is not only advantageous but even required. The ventilation concept of Passive Houses considers all rooms within the thermal envelope. Thus, during the heating period, all rooms can be ventilated with heat recovery.

An energy efficient fan transports the used humid air from the extract air rooms (kitchen, bathroom, storage rooms etc.) to the outside. A second fan transports fresh outdoor air into the supply air rooms (e.g. class rooms, offices). These two air streams exchange energy by passing the heat exchanger. Thereby, the warm extract air preheats the cold outdoor air passively.

In order to guaranty both energy efficiency and comfort the heat recovery rate should be ≥ 75%. The specific power consumption of the fans is restricted to 0.45 Wh/m³.

Notes:



The CEPHEUS project Kassel-Marbachshöhe is an example for a design with only supply air heating.

Semi-centralised system with a heat exchanger on the roof. Each flat is equipped with two fans (supply and extract air), one heating coil and the silencers as depicted on the slide.

Note the very short and optimised duct network. This design is ideal.

The thermal image (bottom right) shows the hot supply air entering the room through a jet nozzle, which is mounted above the door [Pfluger 2001].

Notes:

Literature:

Arbeitskreis kostengünstige Passivhäuser, Protokollband Nr. 17: Dimensionierung von Lüftungsanlagen in Passivhäusern. Passivhaus Institut, Darmstadt, 1999 (7. Auflage 2009) [Research Group Cost-efficient Passive Houses, Volume 17: Design of ventilation units for Passive Houses. Passive House Institute, Darmstadt 1999 (7th edition 2009)]. (German only)

Pfluger, R.; Feist, W.: Kostengünstiger Geschoßwohnungsbau in Kassel Marbachshöhe. CEPHEUS-Projektinformation Nr. 11, Fachinformation Passivhaus Institut 2000/1, Passivhaus Institut, Darmstadt, 2000 [Economic apartment blocks at Kassel Marbachshöhe. CEPHEUS Report Nr. 11. Technical information Passive House Institute 2000/1. Passive House Institute, Darmstadt, 2000].

Pfluger, R.; Feist, W.: Kostengünstiger Passivhaus-Geschoßwohnungsbau in Kassel Marbachshöhe. Projektdokumentation, Qualitätssicherung und Wirtschaftlichkeitsbetrachtung. CEPHEUS-Projektinformation Nr. 16, Fachinformation Passivhaus Institut 2001/3. Passivhaus Institut, Darmstadt, 2001 (2. Auflage 2008) [Economic apartment blocks as Passive Houses at Kassel Marbachshöhe. CEPHEUS Report Nr. 16, Technical information Passive House Institute 2001/3. Passive House Institute, Darmstadt, 2001 (2nd edition 2008)].

Climate in Shanghai

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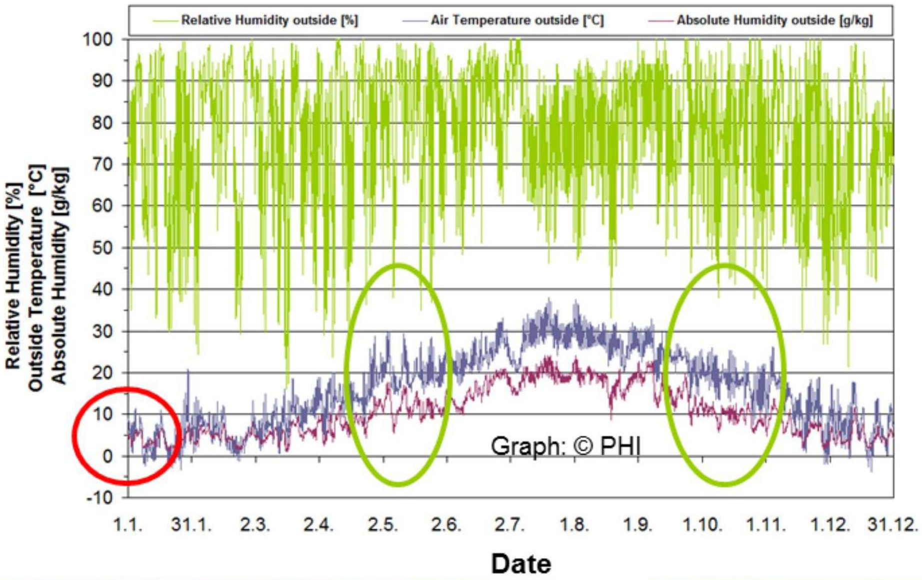
- Moderate winter temperatures (red circle)

  Note: in south of China, people are supposed not to heat
- Very hot & humid summer conditions in July, August, September
- In spring and autumn, 'neutral' outside temperatures



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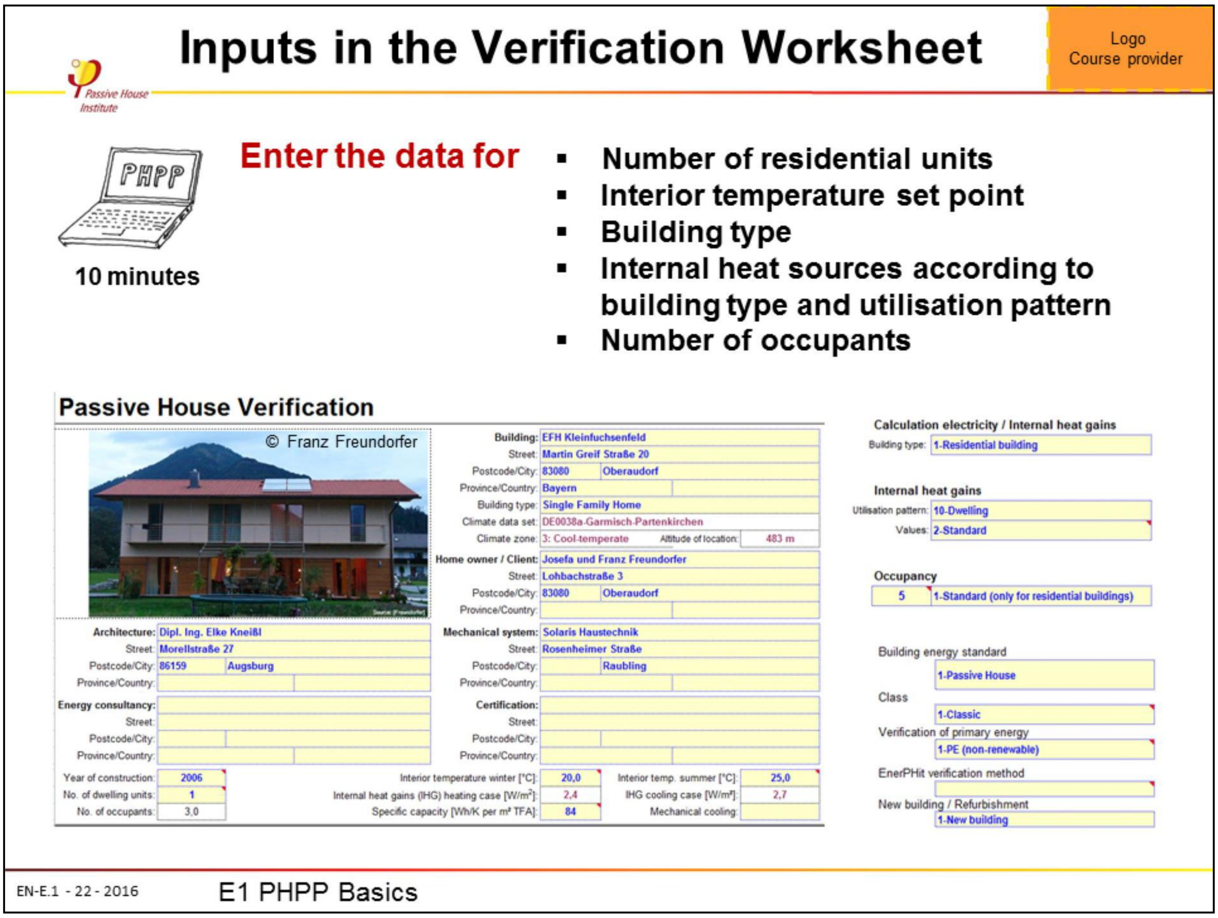
EN-D.3 - 89 - 2016 D3 Cooling in Warm and Hot & Humid Climates

The temperature and humidity are high in summer: dehumidification is definitely needed. The relative humidity line in the top picture can be misleading: the humidity is not high in winter. As previously shown, the relative humidity depends on the temperature of the air. So, when the air is heated during winter from about 5 °C to 20 °C, the relative humidity inside will be OK.

Notes:



Inputs:

- Address data
- Number of occupants:
  Standard in residential buildings is 35 m²/person.
  Individual calculation in non residential buildings.
- Specific capacity:
  lightweight 60 Wh/(m²K)
  mixed 132 Wh/(m²K)
  heavy 204 Wh/(m²K)
- Inside air temperature set point:
  Standard for heating period is 20 °C.
  Standard for cooling period is 25 °C.
- Internal heat gains (IHG) (depending on building type):
  For heating period standard in residential buildings is calculated by PHPP based on the treated floor area per living unit
- for other building uses the default values will be taken into account.
  For cooling period IHG will be calculated by PHPP.

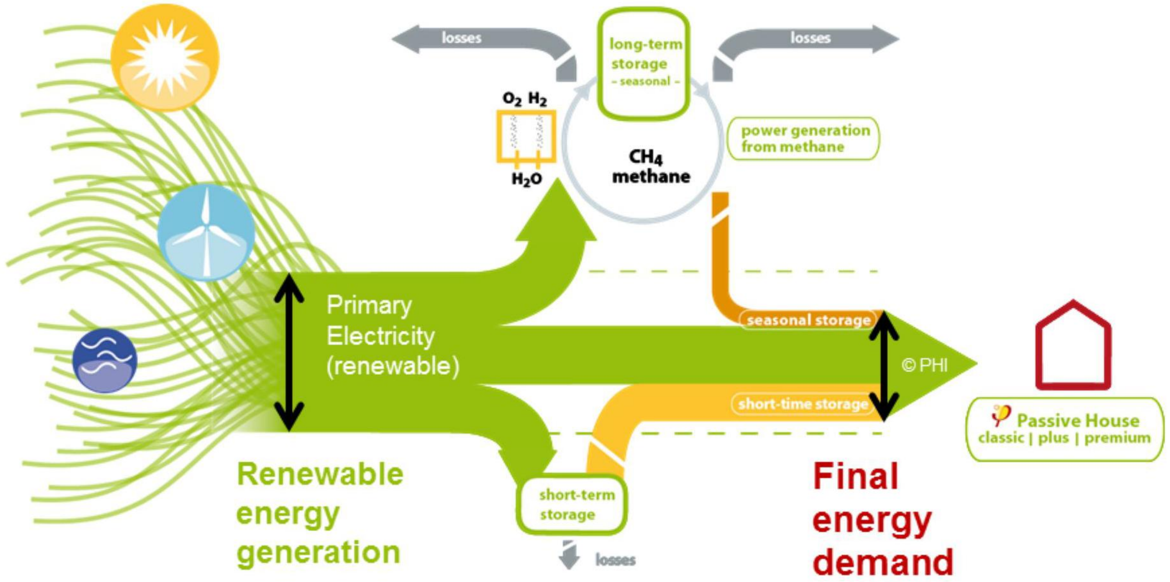
Results/Quality assessment:

- For thresholds see certification criteria

Notes

PER – Storage means Losses

$$\text{PER factor} = \frac{\text{Renewable energy generation}}{\text{Final energy demand}}$$



PER: primary energy renewable

So let's talk about energy storage, that will be necessary to make an all-renewable energy system work. At the beginning we have primary electricity generated from the sun, wind and water energy at our disposal. One part of this energy will be directly used by the house owner when supply and demand happen at the same time. A large part of the excess will be shifted a couple of hours or days in short-term storage facilities, such as batteries. When needed, this energy will then be released again, inducing around 30 % of losses. Some part of the excess, however, will have to be stored for months, to be useful in the winter. There are different theories about what kind of storage are going to be used, we have based most of our calculation on gas because that seems to be the most promising. So basically it is a chemical storage, you transfer electricity into gas and when you need it again you transfer it back from gas into electricity, which causes a massive 70 % of losses in the case of long-term storage. Now you probably better understand the importance of lowering the energy demand of a building in the first place, especially in the winter!

And now we introduce the PER factor. It is basically the ratio between renewable energy supply and final energy demand, so that the storage losses are properly taken into account. So if I need 1 unit of energy and have a PER factor of 1.5, this means I need to provide 1.5 units of primary renewable energy.

Notes

Export to PHPP

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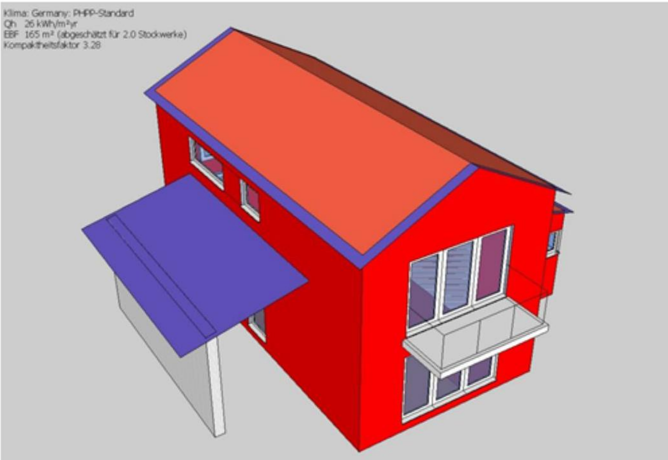
Export Model to .ppp file



EN-E.3 - 84 - 2016 E3 designPH

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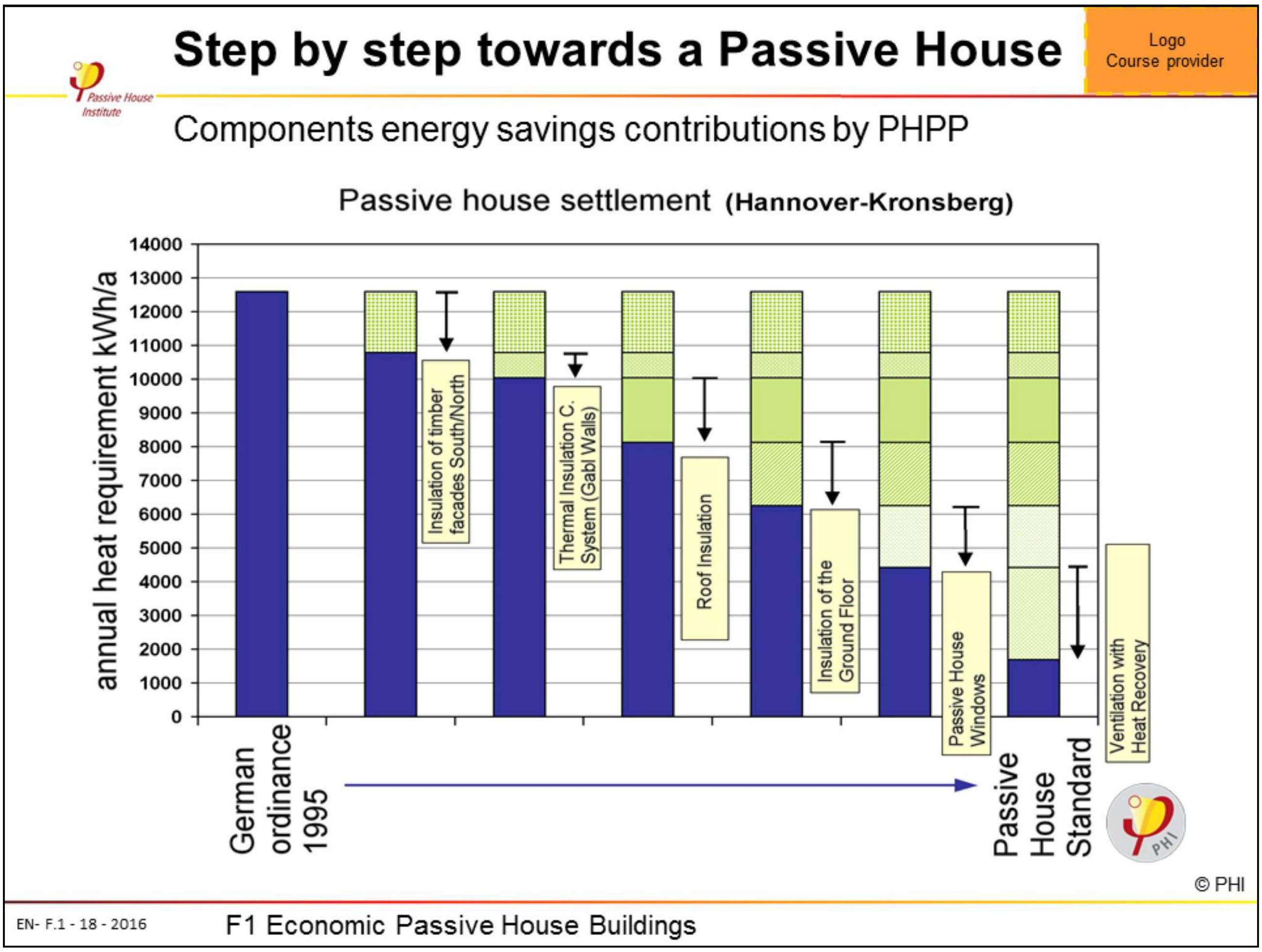


Comparison between U-values and components for the German standard of 1995 and the Passive House standard.

	German standard	Passive House
External walls:	0.50 W/(m²K)	0.12 W/(m²K)
Roof:	0.29 W/(m²K)	0.10 W/(m²K)
Floor:	0.61 W/(m²K)	0.12 W/(m²K)
Windows U_w:	1.90 W/(m²K)	0.83 W/(m²K)
Ventilation:	none	suitable for Passive Houses with 80% heat recovery
Heating:	distribution via radiators (6kW)	supply air, small radiator in the bathroom

Due to better insulation of the opaque building envelope, the heat energy demand decreases by 50 %, which equals 56 kWh/(m²a).

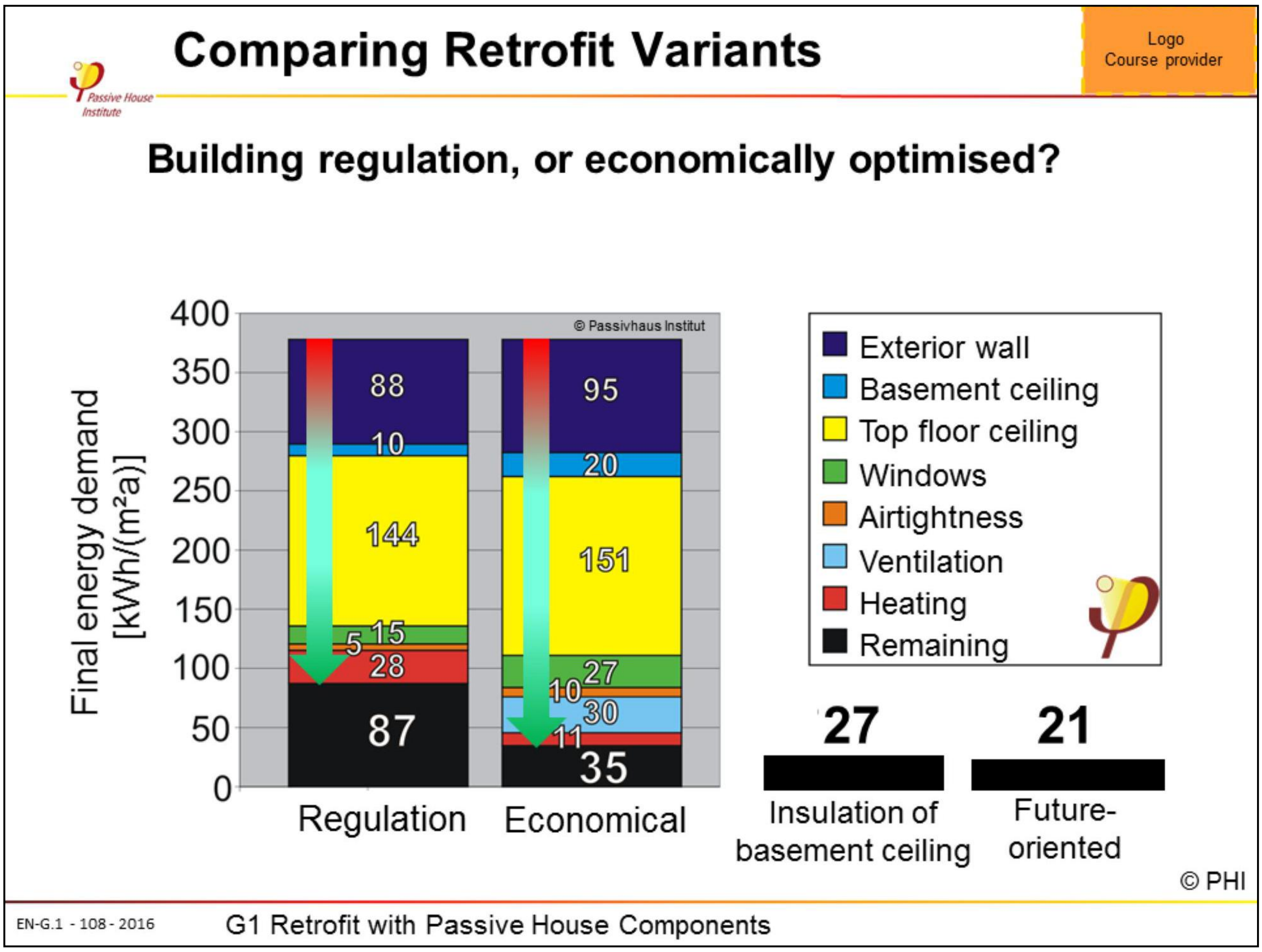
The use of Passive House windows brings about further energy saving of 15 %, to 40 kWh/(m²a). The potential of constructional measures is exhausted at this point.

The next step is to reduce the air heating demand. The use of an efficient ventilation appliance can effectively reduce the heating energy consumption by around 22% – the remaining heat energy demand is now 15 kWh/(m²a) for standard use. This complies with the Passive House standard.

Source:

Feist, W.; Peper, S.; von Oesen, M.: Klimaneutrale Passivhaus-Reihenhaussiedlung Hannover Kronsberg, CEPHEUS Projektinformation Nr. 18. Passivhaus Institut / Stadtwerke Hannover, Hannover/Darmstadt, 2001 [Climate Neutral Passive House Estate in Hanover-Kronsberg, CEPHEUS Final report No. 18. Passive House Institute / Stadtwerke Hannover, Hanover/Darmstadt, 2001].

Notes:



Final energy demand for heating [kWh/(m²a)] for an apartment block built in the 1950s.

The entire height of the bar represents the final energy demand before the refurbishment, which is about 380 kWh/(m²a). The coloured parts show the respective savings due to individual efficiency measures. The black bars represent the remaining final energy demand after completion of refurbishment.

Refurbishment to the minimum requirements of the German regulations for modernisation of individual building components is shown on the left, and refurbishment of all building components to the economic optimal standard (corresponding with the absolute maximum profit over the live cycle of the component) at the right.

Although the difference between both standards of individual measures appears to be small in comparison with the original total demand, the relatively low demand of 35 kWh/(m²a) can be achieved with consistent implementation of an optimal level of energy efficiency for all building components. In contrast, the building refurbished to the prescribed minimum standard has a 2.5 times higher energy demand.

For the economic optimum variant, the apartment block was calculated with an insulation apron without any additional insulation of the basement ceiling (second bar from the left). An even lower final energy demand of 27 kWh/(m²a) for heating results with insulation of the basement ceiling (second bar from right). Another improvement with nearly the same cost-effectiveness results if the level of thermal protection, corresponding to the upper edge of the economically optimum range, is chosen instead of the absolute economical optimum (right bar).

Source

Arbeitskreis kostengünstige Passivhäuser, Protokollband Nr. 39: Schrittweise Sanierung mit Passivhaus-Komponenten. Passivhaus Institut, Darmstadt, 2009 [Research Group Cost-efficient Passive Houses, Volume 39: Step-by-step refurbishment with Passive House components. Passive House Institute, Darmstadt, 2009]. (German only)