iBRoad2EPC

TRAINING MODULE FOR CONSTRUCTION PROFESSIONALS

5 –Manage and oversee the project implementation

This project has received funding from the European Union's HORIZON 2020 research and innovation programme under grant agreement No 101033781

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5 -Manage and oversee the project implementation

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ULO No	Autonomy and Responsibility	Skills	Knowledge
5	**Manage and oversee construction work related to the implementation of construction plans, time schedule and task distribution.**	Explain the responsibilities and processes on the construction site and their influence on step-by-step renovation Ensure continuous interaction between the different construction activities on site	Possible step-by-step renovaiton scenarios The link between different measures in renovation The possible links between the different steps and possible lock-in effects
	Understand requirements for high performance building components used for improvement of the building envelop	Recommend/check/approve the quality and the characteristics of the materials/components to be used	Basic knowledge of thermophysical properties of materials and components used in the building envelope, thermal conductivity, heat transfer, density, moisture permeability, airtightness
	Understand technical specifications of high performance building systems	Recommend/check/approve the components and the equipment to be installed	Basic knowledge of the requirements of the building systems, efficiency, efficacy, SCOP, SEER

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Construction process

Definition

The construction process includes the detailed steps required to complete your construction project. This process can be broken down into five phases – planning/design, pre-construction, procurement, construction, and post-construction.

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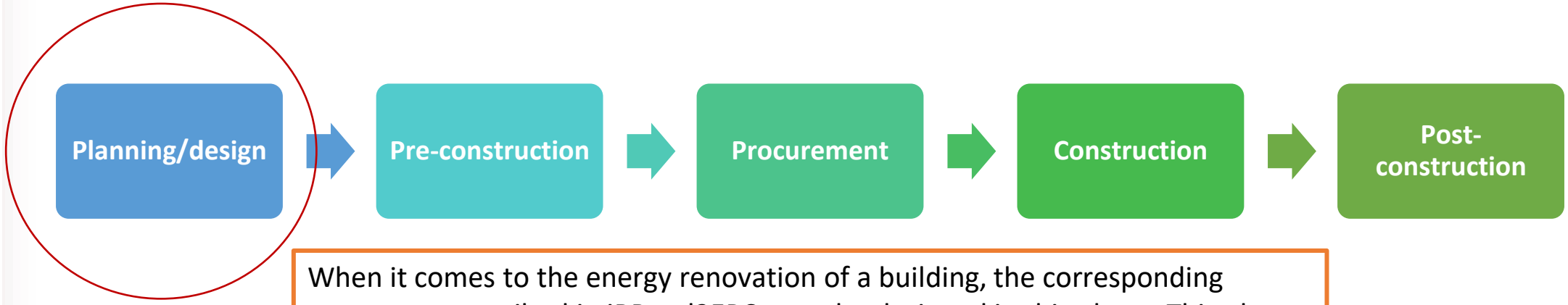
Construction process



When it comes to the energy renovation of a building, the corresponding measures prescribed in iBRoad2EPC must be designed in this phase. This phase is extremely important, because any gap in the project documentation at this stage is a prerequisite for poor implementation of the activities. In addition, the results of this phase form the main documents upon which the conditions for the tendering procedures for implementation are formed.

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Construction process

Project specification

Specifications describe the products, materials, and work required by a construction contract. They do not include cost, quantity, or drawn information, and so need to be read alongside other information such as quantities, schedules, and drawings.
Defining requirements for project execution regarding:

- Materials
- Installation
- Types of building products
- Procedures
- Quality assurance

Specifications should be developed alongside the design, increasing in level of detail as the design progresses. They should not be left until the preparation of production information. By tender, they should describe every aspect of the building in such a way that there is no uncertainty about what the contractor is pricing.

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Construction process

Construction drawings

Construction drawings are the graphical representation of the execution plan for the building. They are fully dimensioned architectural construction drawings and specifications, and any required engineering drawings (including mechanical, electrical, plumbing, air-conditioning, ventilation and heating), and shall include any applicable items and descriptions for proper installation and assembly. Information depicted on the construction drawings shall describe as clearly as possible the necessary architectural, structural and mechanical elements corresponding to approved project specifications, and their respective dimensions, materials and position relative to predefined building markers.

- Plan views
- Section views
- Details
- 3D view

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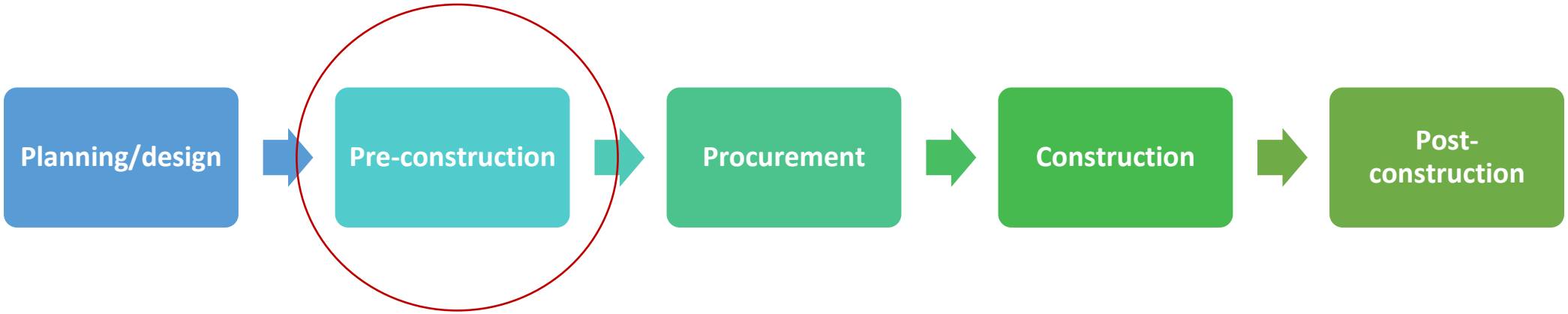
Construction process



This phase is usually associated with the preparation of tender documentation for the implementation of energy efficiency measures. At this stage, it should be decided how to assign the implementation of the renovation, what criteria for the quality of the final product to be set and how to evaluate the offers received.

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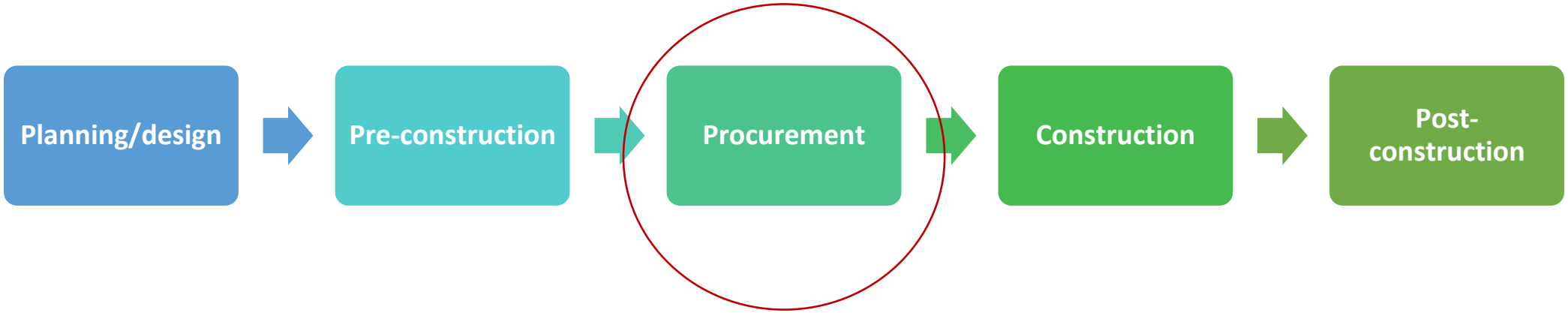
Construction process



This phase begins with the announcement of the tender procedure and ends with the signing of a contract for the implementation of the energy renovation.

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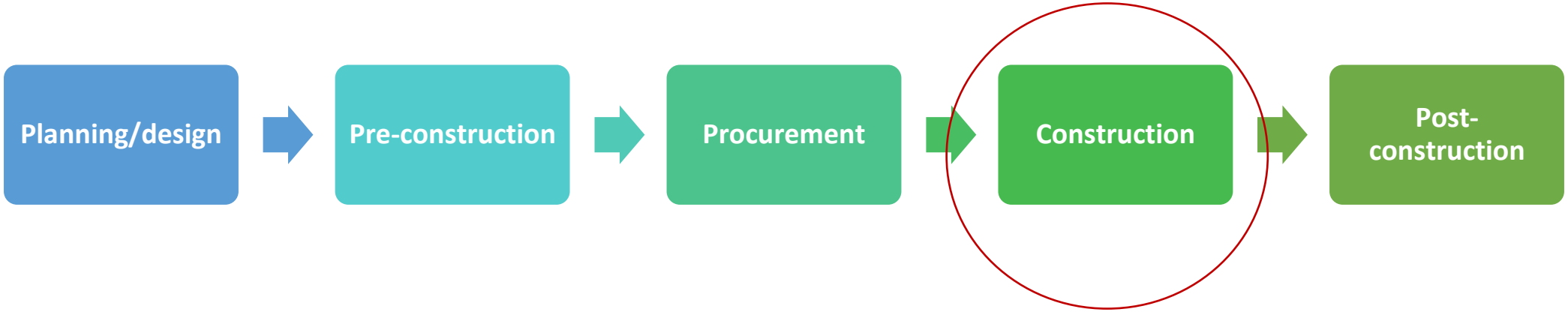
Construction process



This is the phase in which the selected contractor should implement the project and achieve the expected results of the energy audit. It is in this phase that most mistakes are made, which subsequently compromise the quality of final results.

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Construction phase

Definition

Construction phase is the time period of a building project that begins upon completion of the Design Phase and obtaining of authorities‘ approval, or upon award of the first sub-contract related to the construction process; the phase ends when all construction works defined in the project are completed. The finalisation of the construction phase is marked with the **handing-over or commissioning** procedure.

For the construction phase, a **building site manager** is chosen.

The building site manager should always follow the general rules for procuring the building site (*quote respective regulation*) concerning:

- all technical, organisational works, planning and order of the construction works as well as following the **construction time schedule**
- health and safety plan on the building site
- proper execution of construction works in line with respective regulations and **project specifications**

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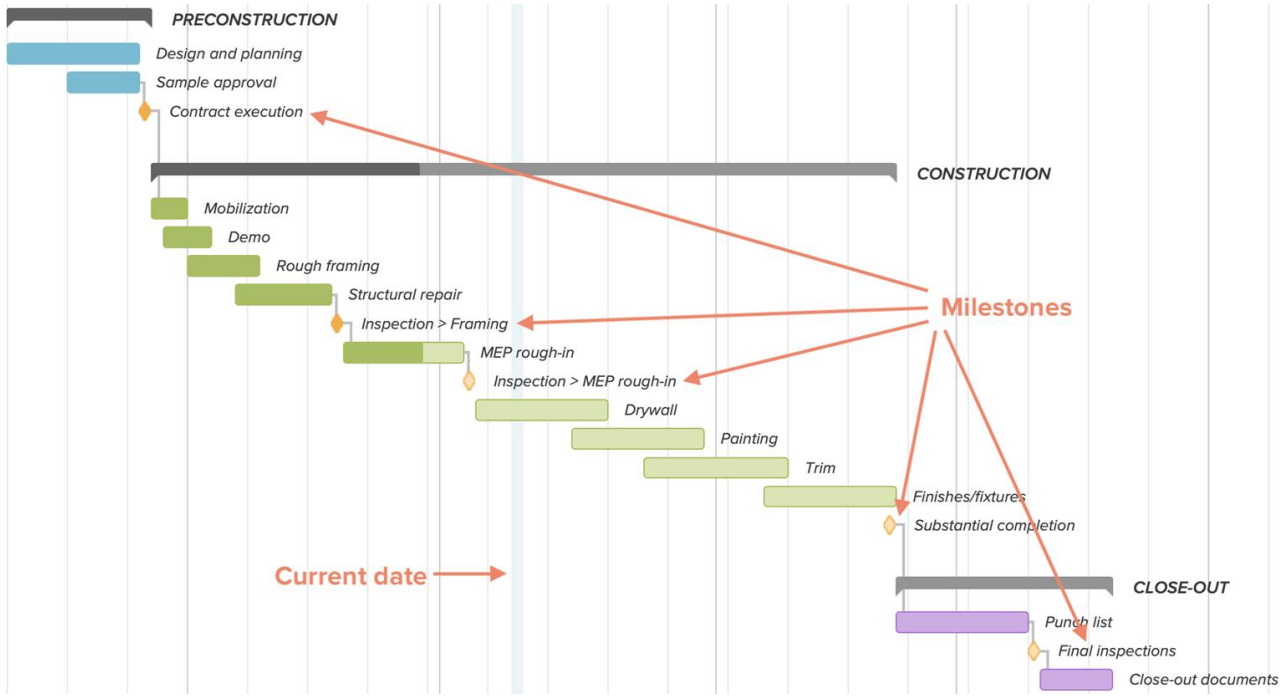
Construction phase

Construction Schedule

A planned schedule of what work will be done and when- a project management timetable including:

- Tasks and their order
- Resources
- Time schedule
- Milestones



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Construction phase

Building site meetings

Control and management of the construction work through active communication. In the presence of project leaders of respective disciplines and their equivalent on the building site, sometimes including the investor. Keeping written records of:

- Updates
- Problems
- Delivery of materials and building elements
- Schedule tracking
- Specifications
- Budget
- Quality assurance

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Construction phase- quality assurance

Materials used: Are they of the right standard, size, shape and material?

Good technical specifications for each material already at the design level

Detailed technical details for the execution of the individual types of work according to the specifically selected materials, components, technologies

Use of material systems of established manufacturers possessing the necessary quality certificates

Modeling results with different materials according to the geographical or operational characteristics of the specific building

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Construction phase- quality assurance

Equipment: Will it work in the environment and is it safe?

In accordance with the functions of the building

Designed in collaboration with other project parts (architecture, heating, ventilation, electricity, energy efficiency, etc.)

Control and management systems

Relevant certificates for quality and energy efficiency

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Construction phase- quality assurance

Agreed ways of measuring quality: What does ‘good’ look like?

Clearly defined quality requirements in the design assignment (energy efficiency class, RES, air tightness, ventilation, etc.)

Reference to certain standards to be followed

Detailed technical specifications of the materials to the construction documentation

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Construction phase- quality assurance

Project management: Timeframes, quality checks, agreed budgets, etc.

Discussion and approval of a detailed time-plan for the implementation of construction activities, taking into account the technological sequence of the building renovation processes

Designate a quality officer and create a quality tracking plan

Planning the supply of materials and equipment according to the technical specifications, the budget and the time-plan for the execution of the work

When performing a step-by-step renovation, it is very important that the activities are planned in such a way that it does not get the so-called "lock-in" effect.

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Construction phase- quality assurance

Certificates and skills: Do your people have the right skills for the job?

Explicit requirement at tender documentation level for contractor experience

Clause in the contract that all workers will undergo specialised training for deep renovation/NZEB (in case they do not already have a certificate certifying their qualification)

Working with a designer trained in near-zero energy buildings

Introductory training for all participants in the process (builders, investor control, construction supervision, management team) at the start of the renovation activities

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Construction phase- quality assurance

Avoid crossing work

- Observe technological procedures
- Connection of constructions
- Correct design details

Avoid damaging the constructions/technological procedures

- Thermal bridges
  - Continuous layer of thermal envelope
- Airtight layer
  - Reduce penetration of airtight layer

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Construction phase- quality assurance

Very often, during detailed inspections of projects that have just been "successfully" completed it is found that the previously set requirements have not been achieved, and this can be due to a number of factors (poor construction, wrong equipment settings, inappropriate user behavior, and even incorrect assumptions). For many of these factors, immediate corrective action can be taken, but only if the causes are identified in time and possibly tied to the final payment of contractors.

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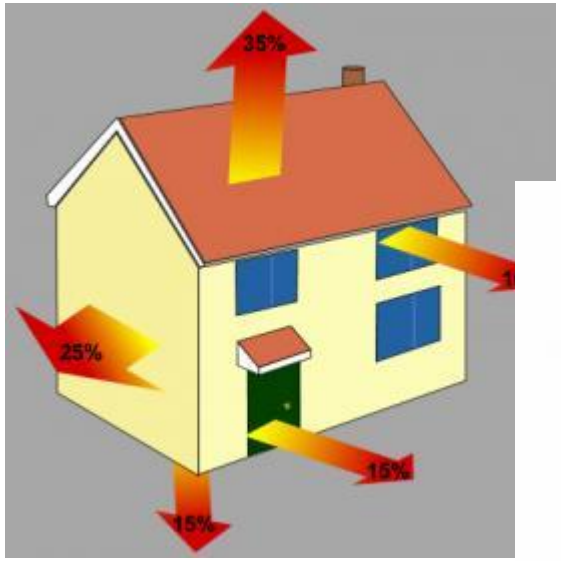
Characteristics of building envelop components for energy renovation

Transmission heat losses

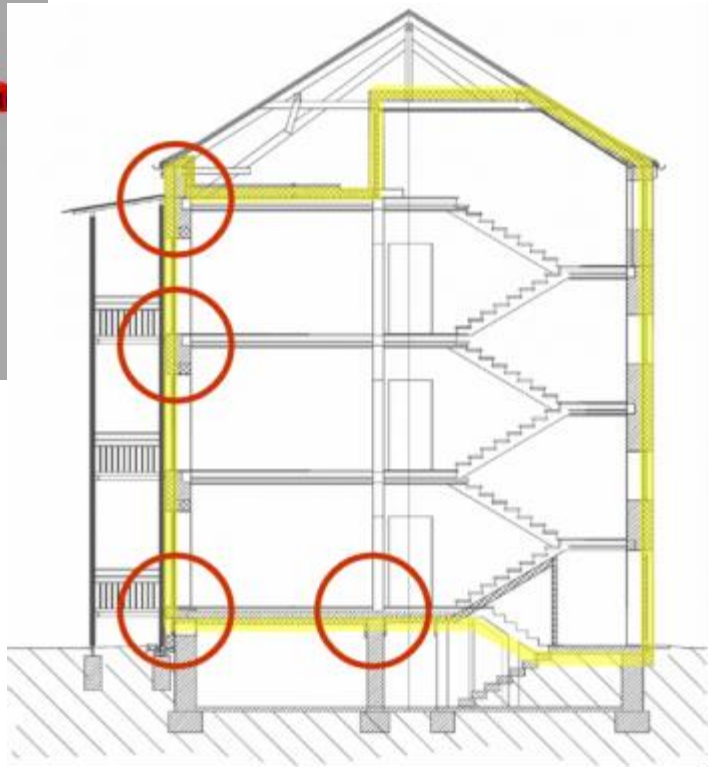
TRANSMISSION HEAT LOSSES

70 % THROUGH SURFACES

30 % THROUGH THERMAL BRIDGES



Heat losses through building edges (junctions), point penetration of building envelope and atypical parts of envelope areas



Source: Passipedia [2]

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Characteristics of building envelop components for energy retrofitting

General concept

- Replacing materials with high thermal conductivity

Materials with high thermal conductivity	λ [W/(mK)]	Replacement with low thermal conductivity	λ [W/(mK)]
reinforced concrete	2,2	expanded polystyrene (EPS)	0,031
structural steel	50	expanded polystyrene (EPS)	0,031
carbon steel	50	high strength stainless steel	15
Compression bar made of carbon/stainless steel	50/16	High strength concrete	0,8

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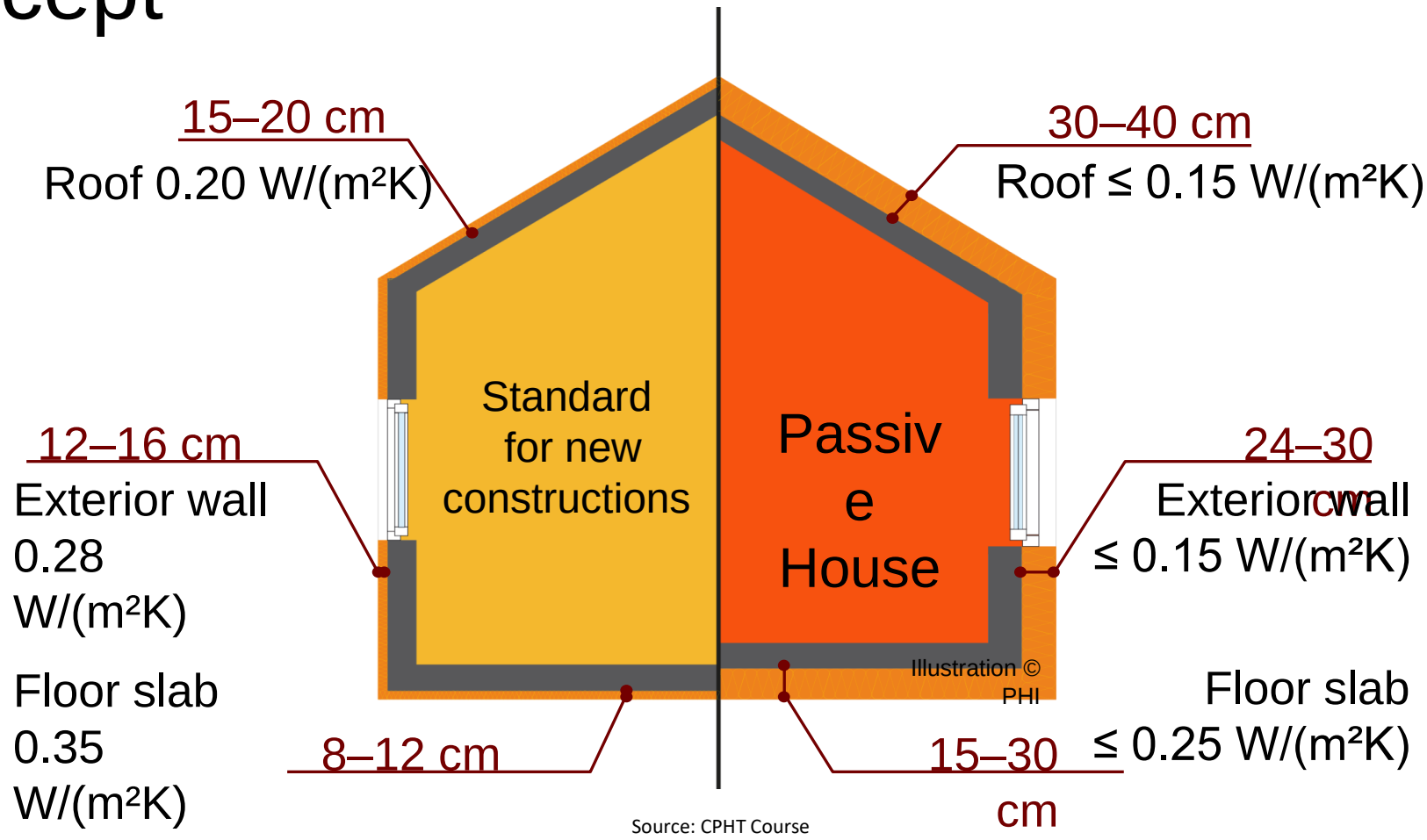
Characteristics of building envelop components for energy retrofitting

General concept

Typical U-values [W/(m²K)] in central Europe



Source: CPHT Course

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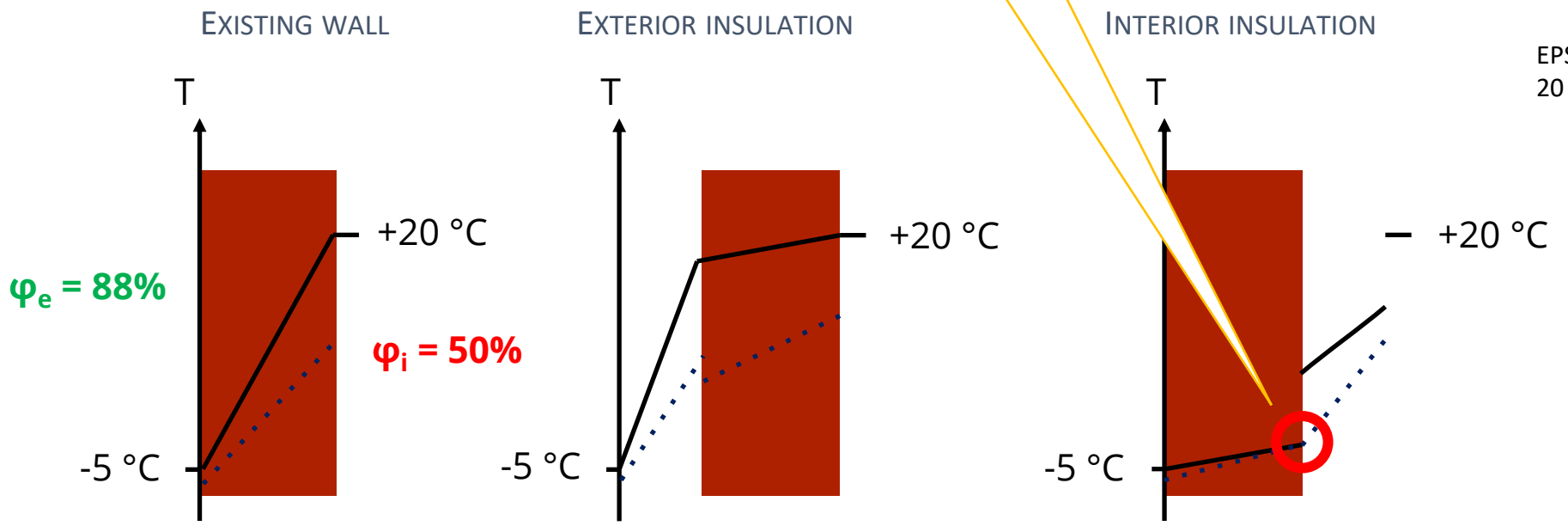
Insulation

Interior vs. Exterior [illegible]on

Temperature profiles



EPS λ = 0.035 W/mK, 15 cm
20 cm clay bricks λ = 0.25 W/mK

Initial state

Long-term experience

Brick wall warmer

 dryer

Brick wall colder

 wet

Source: EU Project SEEDpass & ZEPHIR Passivhaus Italia

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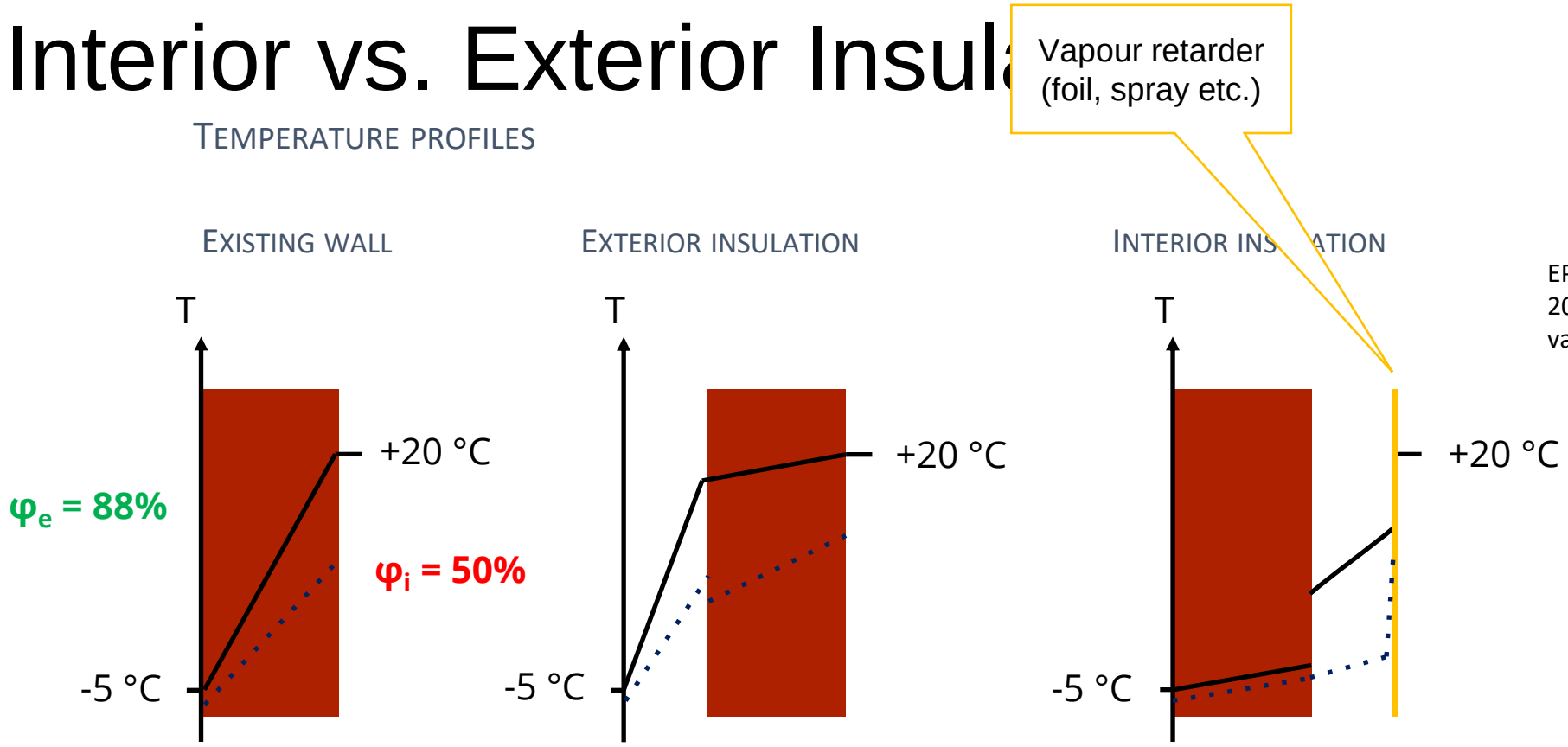
Insulation

Interior vs. Exterior Insula

Temperature profiles



Initial state

Long-term experience

Brick wall warmer

 dryer

Brick wall colder

 dryer, still humid

Source: ZEPHIR Passivhaus Italia

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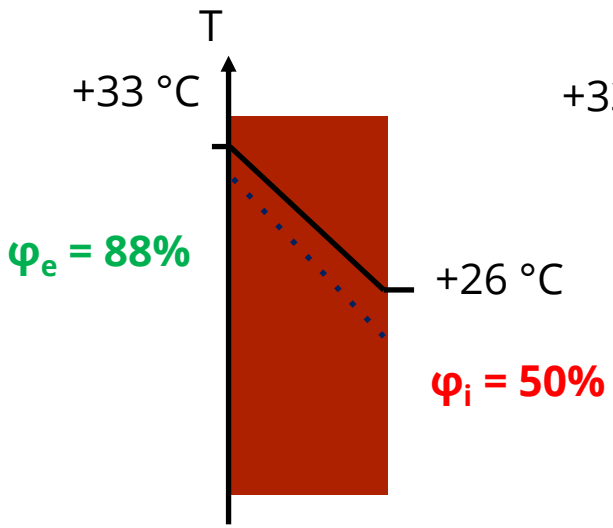
Insulation

Interior vs. Exterior Insulation

TEMPERATURE PROFILES

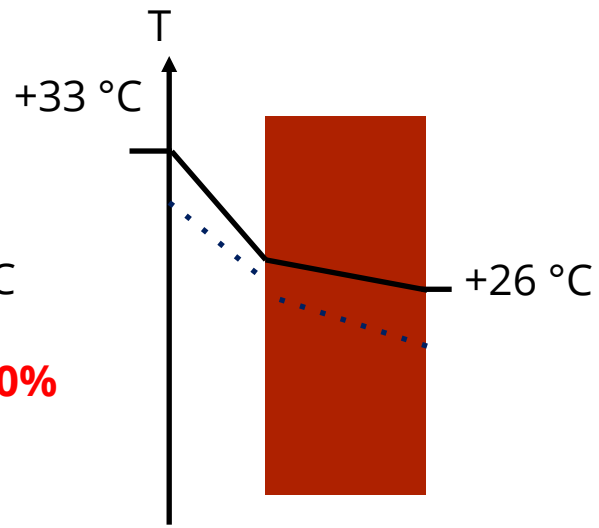
EXISTING WALL



Initial state

Long-term experience

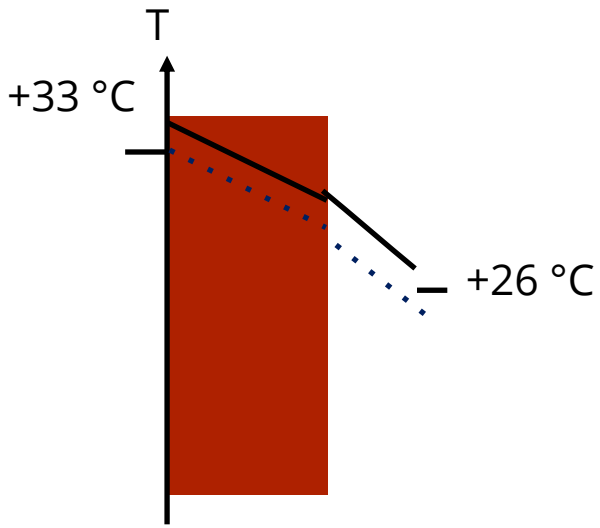
EXTERIOR INSULATION



Brick wall colder

- dryer
- vapour permeable

INTERIOR INSULATION



Brick wall warmer

- more humid
- vapour permeable

EPS λ = 0.035 W/mK, 15 cm
20 cm clay bricks λ = 0.25 W/mK

····· dew point

Source: ZEPHIR Passivhaus Italia

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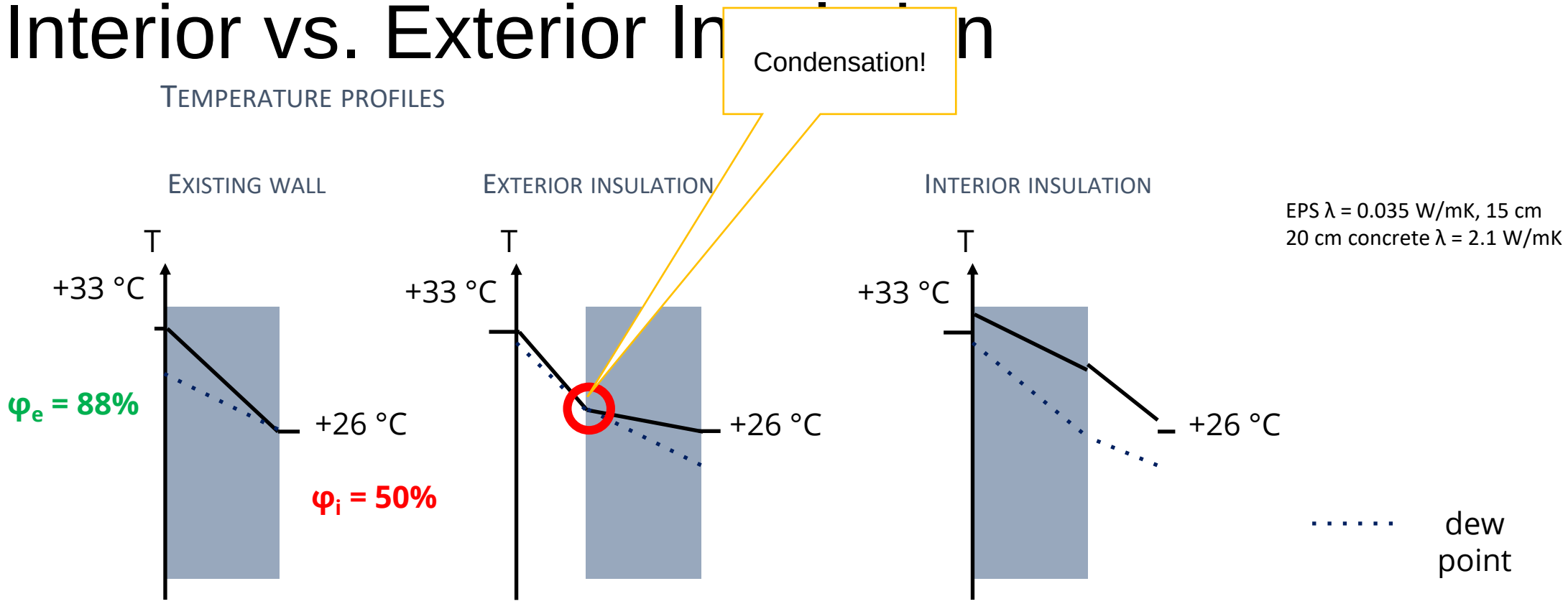
Insulation

Interior vs. Exterior In[illegible]n

TEMPERATURE PROFILES



Initial state

Long-term experience

Concrete wall colder

- **wet**
- vapour tight

Concrete wall warmer

- dryer
- vapour tight

Source: ZEPHIR Passivhaus Italia

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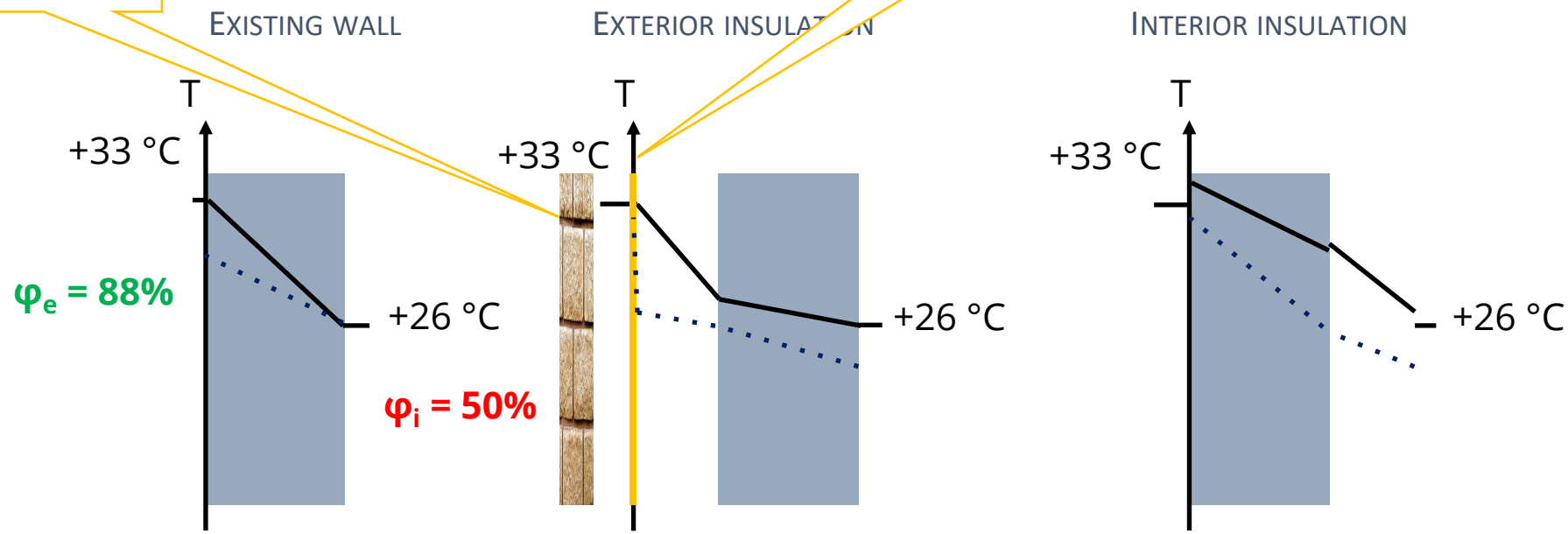
Insulation

Interior vs. Exterior In[illegible]n

(optional) Rain screen

Vapour retarder (foil, spray etc.)

TEMPERATURE PROFILES



EPS λ = 0.035 W/mK, 15 cm
20 cm concrete λ = 2.1 W/mK
vapour retarder, sd = 30 m

dew point

Initial state

Long-term experience

Concrete wall colder

dryer
vapour tight

Concrete wall warmer

dryer
vapour tight

Source: ZEPHIR Passivhaus Italia

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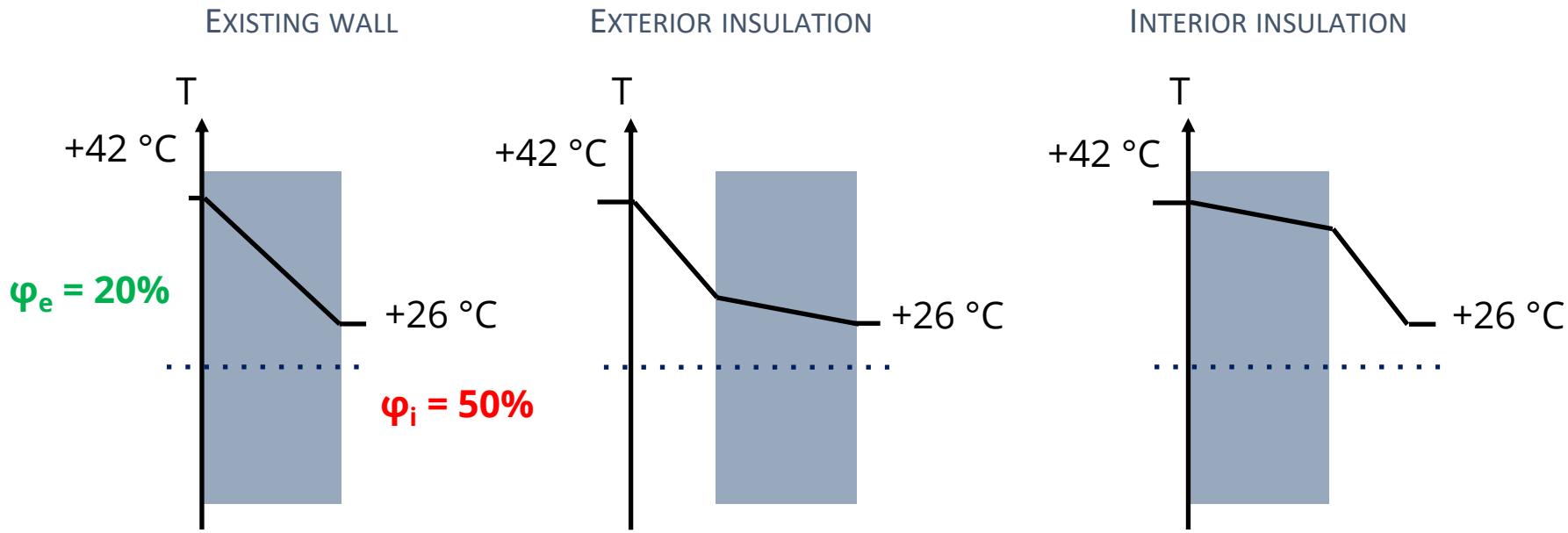
Insulation

Interior vs. Exterior Insulation

TEMPERATURE PROFILES



EPS λ = 0.035 W/mK, 15 cm
20 cm concrete λ = 2.1 W/mK

..... dew point

Initial state

Long-term experience

Concrete wall colder

no issues

Concrete wall warmer

 no issues

Source: ZEPHIR Passivhaus Italia

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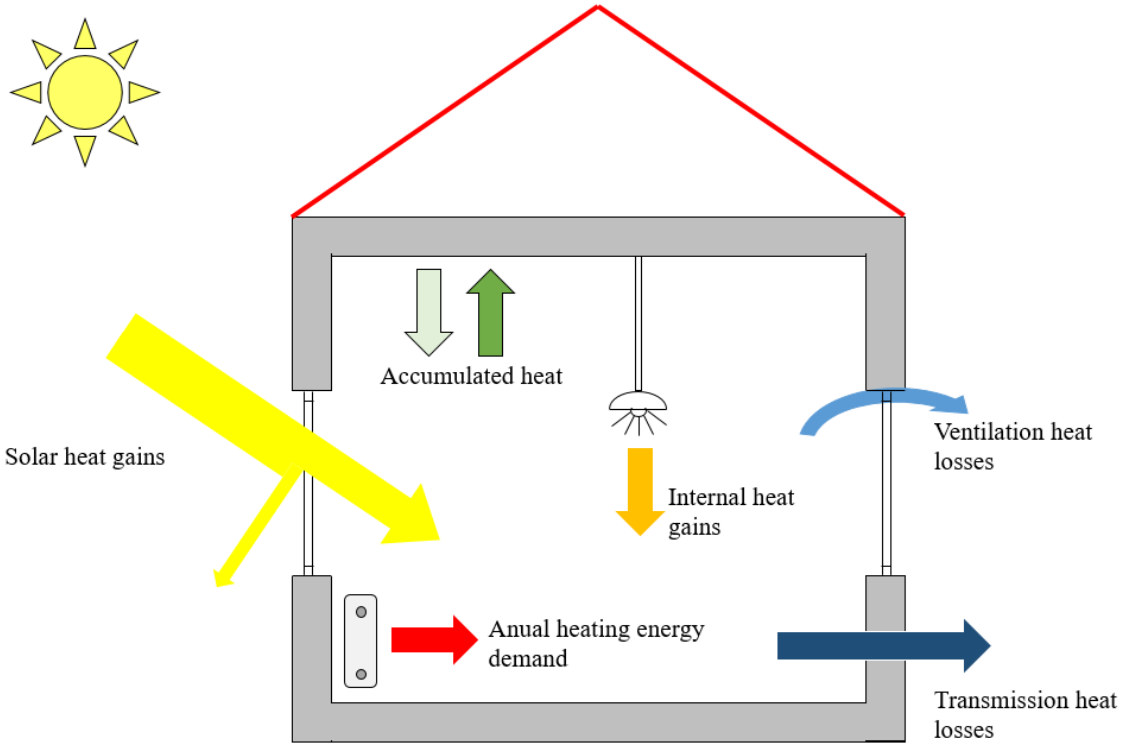
Characteristics of building envelop components for energy renovation

Windows

Energy Balance = Transmission + Ventilation - η * (Solar + IHG)

$$Q_H = Q_T + Q_V - \eta^*(Q_S + Q_I)$$



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Characteristics of building envelop components for energy retrofitting

General function of windows

The heating and cooling demands depend significantly on

- glazing type and size,
- window orientation and
- whether shading is implemented or not.

Windows can reduce the electric lighting by providing natural light.

Effective window design

- a complicated process
- requires thorough investigation of the impact on heating, cooling and lighting.

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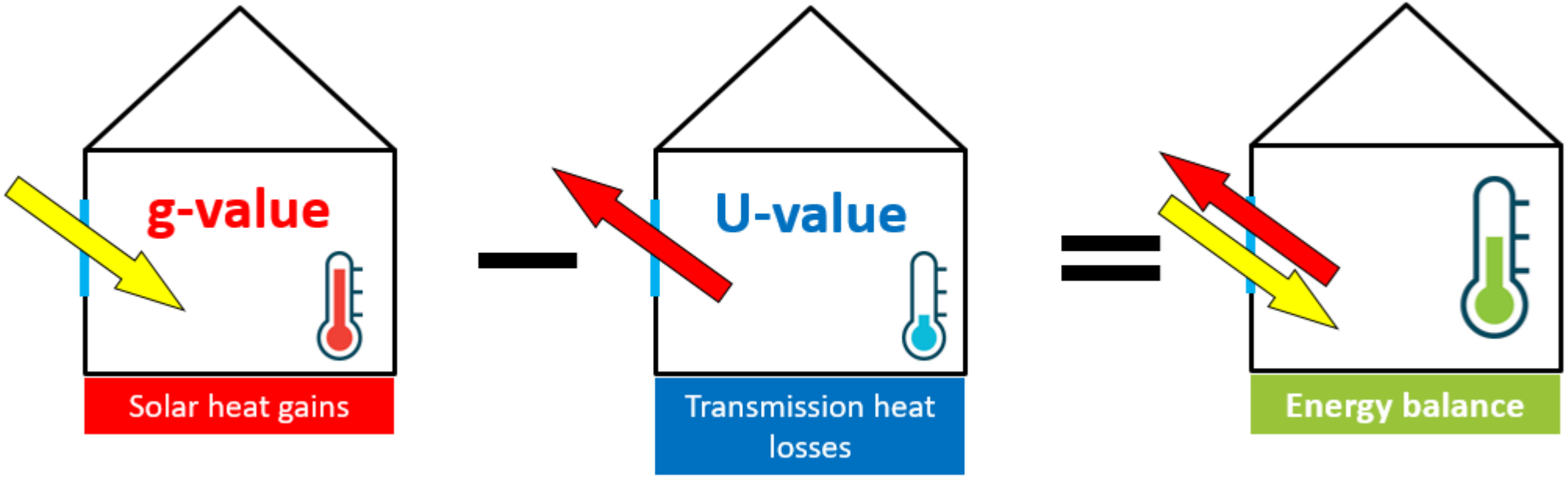
Characteristics of building envelop components for energy renovation

General requirements for windows

Balancing heat losses and heat gains through windows

The U- and g-values are the most dominant factors affecting the annual energy performance.



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Characteristics of building envelop components for energy renovation

General requirements for windows

An optimal energy balance for windows is therefore a **basic requirement** for nZEBs

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Characteristics of building envelop components for energy renovation

General requirements for windows

Thermal transmittance (U_w - value)

0.75

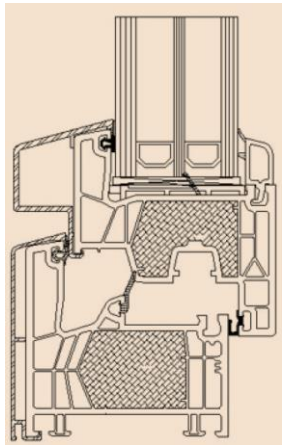
U_w [W/m²K]

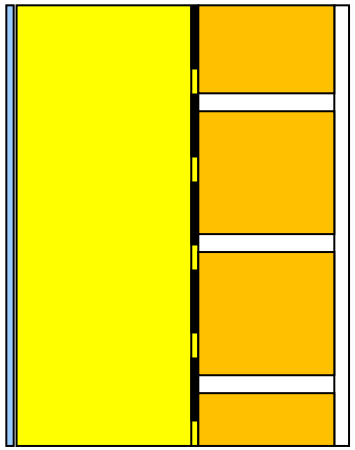
>>>>>

5 ×

0.15

U [W/m²K]





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Characteristics of building envelop components for energy renovation

General requirements for windows

Impact on glazing U-value (Ug)

Glazing type	U-value W/m²K	Solar factor g in %
Double glazing		
12mm air gap no coating on glass	3.0	78
12mm air gap + low e hard coating	1.9	72
12mm air gap + low e soft coating	1.7	58
16mm argon gap + low e hard coating	1.5	72
16mm argon gap + low e soft coating	1.1	58
16mm argon gap + low iron glass + soft coating	1.1	75
Triple glazing		
12mm argon gap + low e hard coating 2 panes	0.9	42
12mm krypton gap + low e soft coating 2 panes	0.6	42
As above (krypton gap) + low iron glass	0.6	62

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Characteristics of building envelop components for energy renovation

General requirements for windows

The interior surface criterion for windows

- Humans feel uncomfortable when objects simultaneously radiate with different temperatures towards our body.
  - Comfortable only at a temperature difference lower than 4K
- Window with U_w=0.8 W/(m²K) results with radiation temperature difference < 3K
  - And a radiator doesn't need to be placed under the window…

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Characteristics of building envelop components for energy renovation

General requirements for windows

Lower U_w

Higher inner surface temperatures

Lower air movement

BETTER COMFORT

U_w-value below 0.85 W/(m²K) for comfort reasons

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Characteristics of building envelop components for energy renovation

General requirements for windows

The installation is vital!

high performance window can only be as good as the installation

- The installation must address several key issues, i.e.:
  - structurally sound,
  - watertight,
  - airtight,
  - vapor smart and
  - increase the installed thermal performance of the window.

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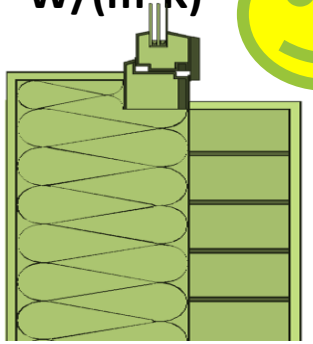
Characteristics of building envelop components for energy renovation

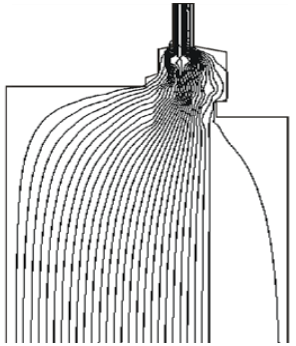
General requirements for windows

Recommended

$\Psi_{install}$ = 0.005 W/(mK)

$U_{w,eff}$ = 0.78 W/(m²K)

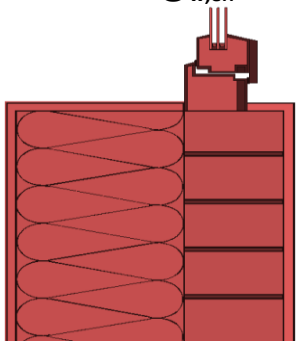


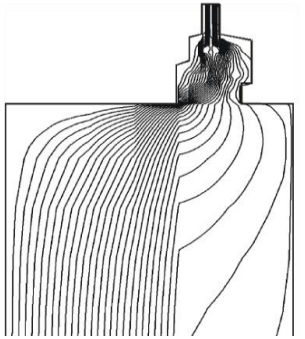


Extremly bad installation

$\Psi_{install}$ = 0.15 W/(mK)

$U_{w,eff}$ = 1.19 W/(m²K)





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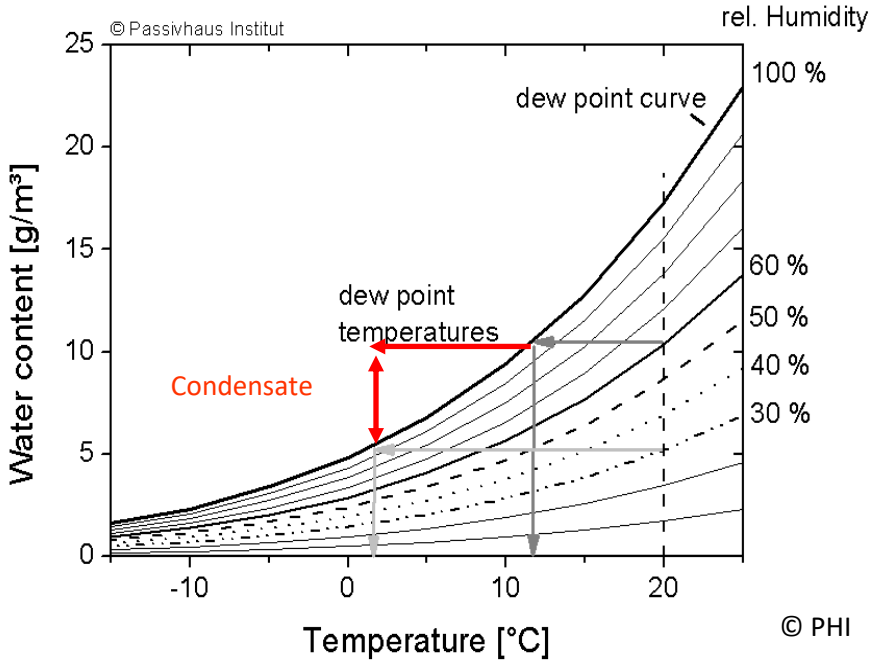
Characteristics of building envelop components for energy renovation

Moisture

Relative humidity ϕ :

Fraction of the water vapour content of the maximum possible water vapour content for a given temperature and pressure.

Dew point (temperature): the temperature at which the air with a certain moisture content is fully saturated and condensate forms (ϕ = 100%).



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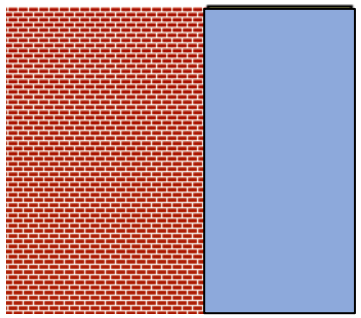
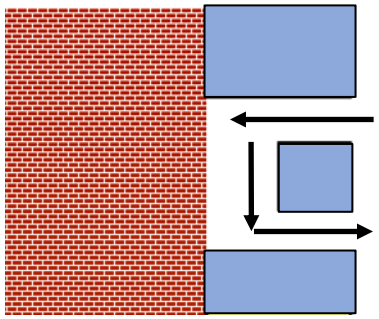
Characteristics of building envelop components for energy renovation

Moisture

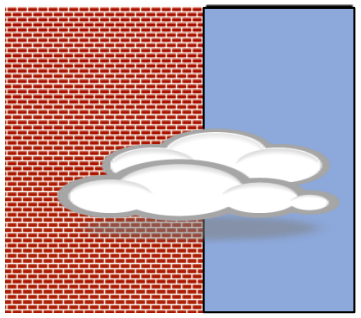
Condensation



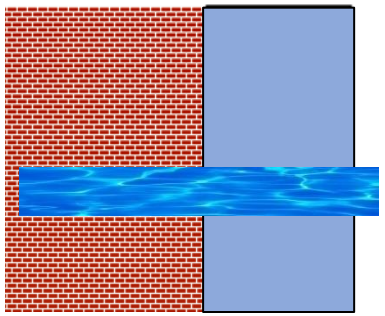
Convection



Vapor diffusion



Liquid water transport



- **Formation of interstitial condensate** on the interior surface (depending on the surface temperature).
- **Humid indoor air flowing behind or through the wall** and interstitial condensate forming behind the insulation layer
- In gaseous form through **vapour diffusion**
- Insertion and **transfer in liquid form**

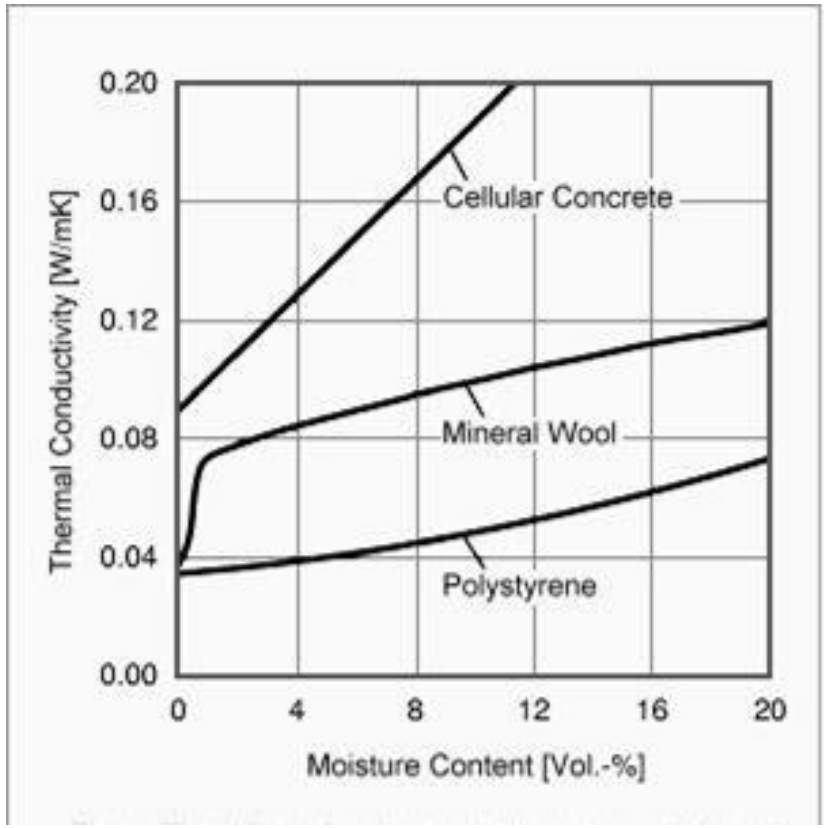
This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 101033781

Characteristics of building envelop components for energy renovation

Dependence of thermal conductivity on humidity content

The heat and moisture transport processes in buildings are usually strongly **coupled**. This is particularly evident in the effect of moisture on the heat insulation of building components.

The effect of moisture on the measured thermal conductivity of building materials



© https://www.wufi-wiki.com/mediawiki/index.php/Details:Physics

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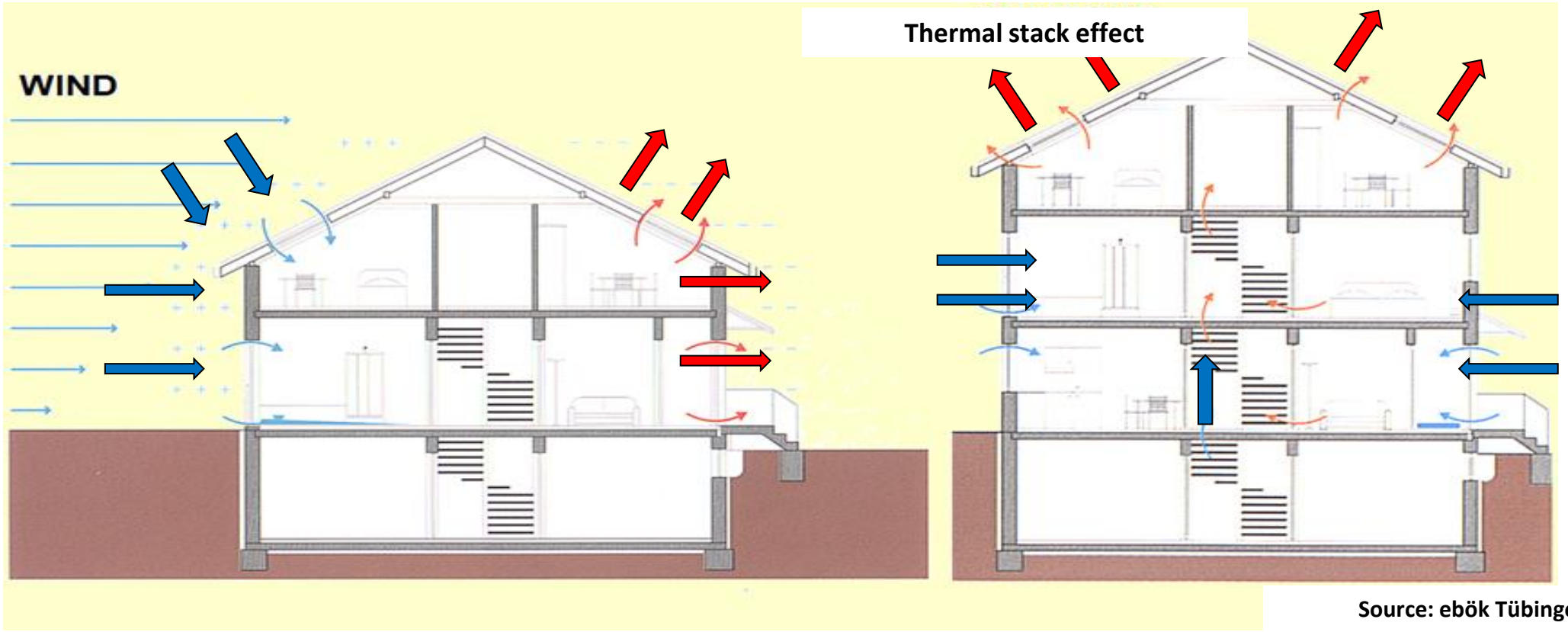
Characteristics of building envelop components for energy renovation

Airtightness - Pressure difference

Infiltration and exfiltration via leakages in the building fabric



Source: ebök Tübingen

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Airtightness

Why build airtight?

- Avoids structural damage (condensate within the fabric build-up)
- Enhances living comfort: no droughts or cold air accumulation (ground floor)
- Avoids pollutants (e.g., Radon) entering the room air
- Air quality: directed air circulation becomes possible, precondition for controllable demand-oriented ventilation
- Energy conservation through reduced ex- and infiltration (ventilation losses)
- Enhances noise protection

BLOWER DOOR
Differential pressure method according to EN 13829 (not ISO 9972!)
Max n_{50} = 0,6/h

Source: CPHD

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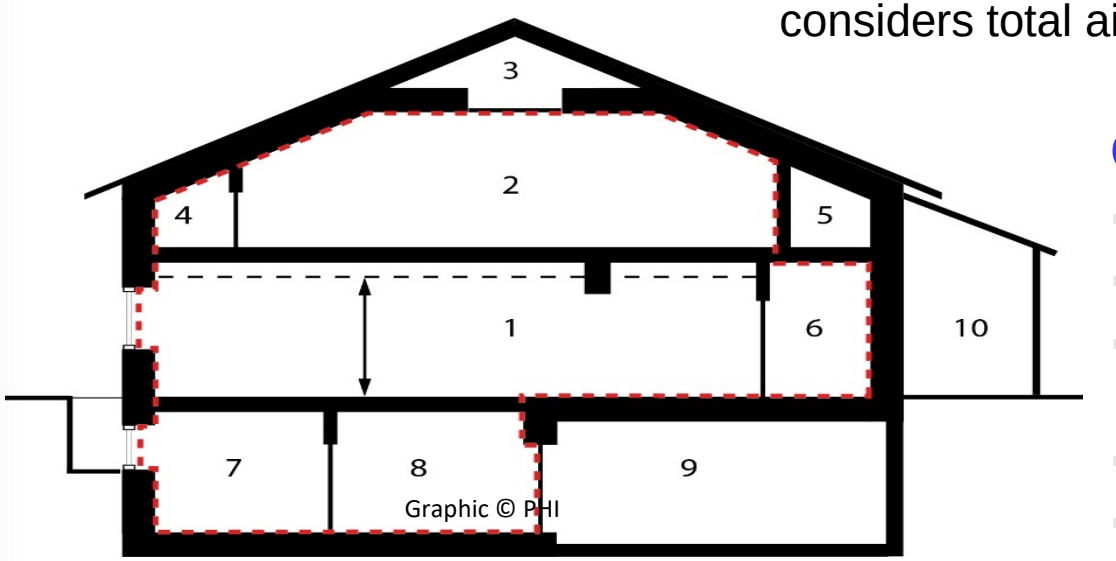
Airtightness

Reference Values



Internal volume (V)

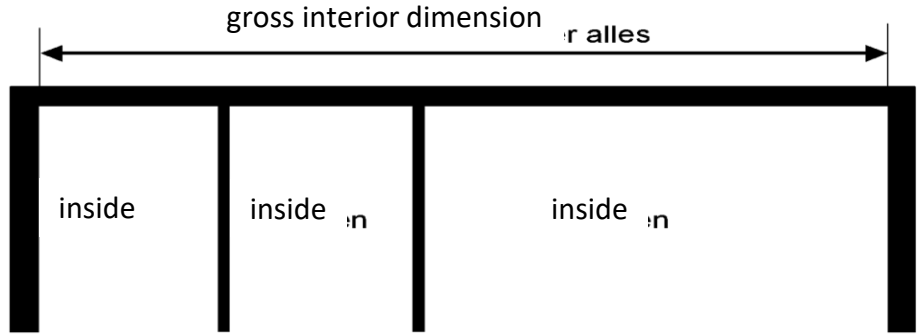
considers total air volume within the thermal envelope

Calculation and documentation

- Per room net floor space * clear height
- CAD data insufficient
- Clear height from finished floor to finished (suspended) ceiling (even if not yet installed)
- Ceiling joists and rafters not deducted
- Furniture is not considered
- Indicate uncertainty, usually 3 to 10 %

Envelope area A

- For large buildings (> 1500 m³).
  Calculation of envelope area according to EN 13829 (“gross interior dimensions”)
- Consider all parts of envelope (ceiling/roof, floor, walls)



Source: CPHD

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Airtightness

Tracing Leakages

At 50 Pa underpressure, inspection of entire building (tracing is easiest at underpressure) leakage search per room

Inspection of typical weak spots:
Doors, windows, corners/joints, outlets, penetrations of airtight layer (pipes, cables) joints between different materials or build-ups

Source: CPHD

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Airtightness

Tracing Leakages

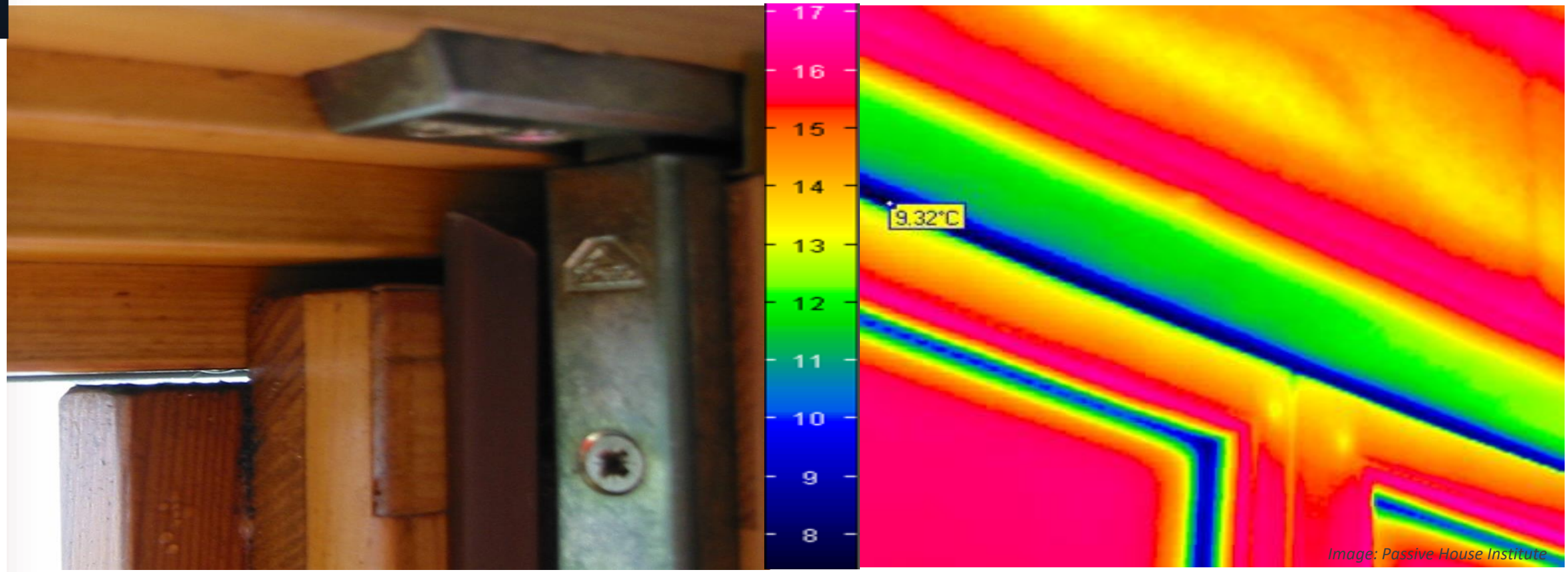

Image: Passive House Institute

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Technical building systems

Definition

Technical equipment for space heating, space cooling, ventilation, domestic hot water, built-in lighting, building automation and control, on-site electricity generation, or a combination thereof, including those systems using energy from renewable sources, of a building or building unit

Detailed information in Module 7 – Heating, cooling, ventilation, and DHW system

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Heating and cooling source efficiency reference values

Adapt to your country

Bulgarian norms (country specific)

- Liqud fuel boilers: η = 86 %;
- Natural gas boilers: η = 92 %
- Coal boilers: η = 65 %
- Biomas boilers: η = 85 %
- Electrical boilers: η = 100 %
- Individual gas heaters: η = 75 %
- Hard fuel stoves: η = 55 %
- Air to air heat pumps: SCOP = 2,6
- Air to water heat pumps: SCOP = 2,2
- Water to water heat pumps: SCOP = 3,5
- Electric heaters: η = 100 %
- District heating: η = 100 %
- Cooling systems: SEER = 2,2

Photo: Baukraft Engineering

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Efficiency of heat pumps

COP (Coefficient of performance): the relation between the power (kW) drawn out of the heat pump (in heating mode), and the power (kW) that is supplied to the compressor

SCOP (Seasonable coefficient of performance): describes the average COP during the heating season, shows how effective the heat pump is in heating mode on annual basis

EER (Energy Efficiency Ratio): A ration of the cooling output relative to input power

SEER (Seasonal Energy Efficiency Ratio): the ratio between the total cooling output during the heating season and the total energy consumption during that time

ESEER (European Seasonal Energy Efficiency Ratio): Based on a formula used in the European region to measure the seasonal efficiency of air conditioners and chillers in cooling mode


Photo: Baukraft Engineering

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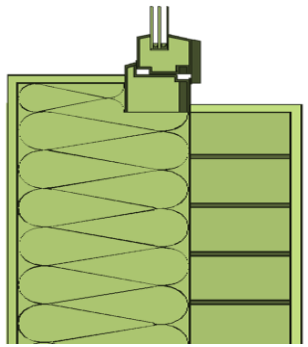
Test Questions

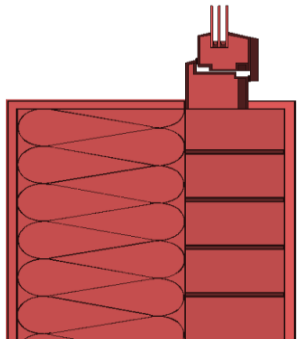
1. **Design specifications are part of which phase of the construction process?**

a) planning/design
b) procurement
c) construction

2. Which window installation detail is correct?

b)





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Test Questions

3. What is SCOP?

a) the relation between the power (kW) drawn out of the heat pump (in heating mode), and the power (kW) that is supplied to the compressor

b) describes the average COP during the heating season, shows how effective the heat pump is in heating mode on annual basis

c) the ratio between the total cooling output during the heating season and the total energy consumption during that time

4. Which is the general requirement for windows?

a) U_w-value below 0.85 W/(m²K) for comfort reasons
b) U_w-value below 0.95 W/(m²K) for comfort reasons
c) U_w-value below 1.20 W/(m²K) for comfort reasons

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Thank you for your time and collaboration

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