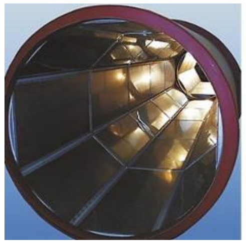
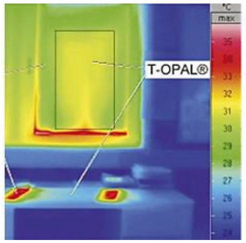
Handling of typical constructions

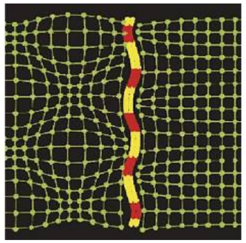
WUFI® Tutorial

Version: July 2025

Auf Wissen bauen



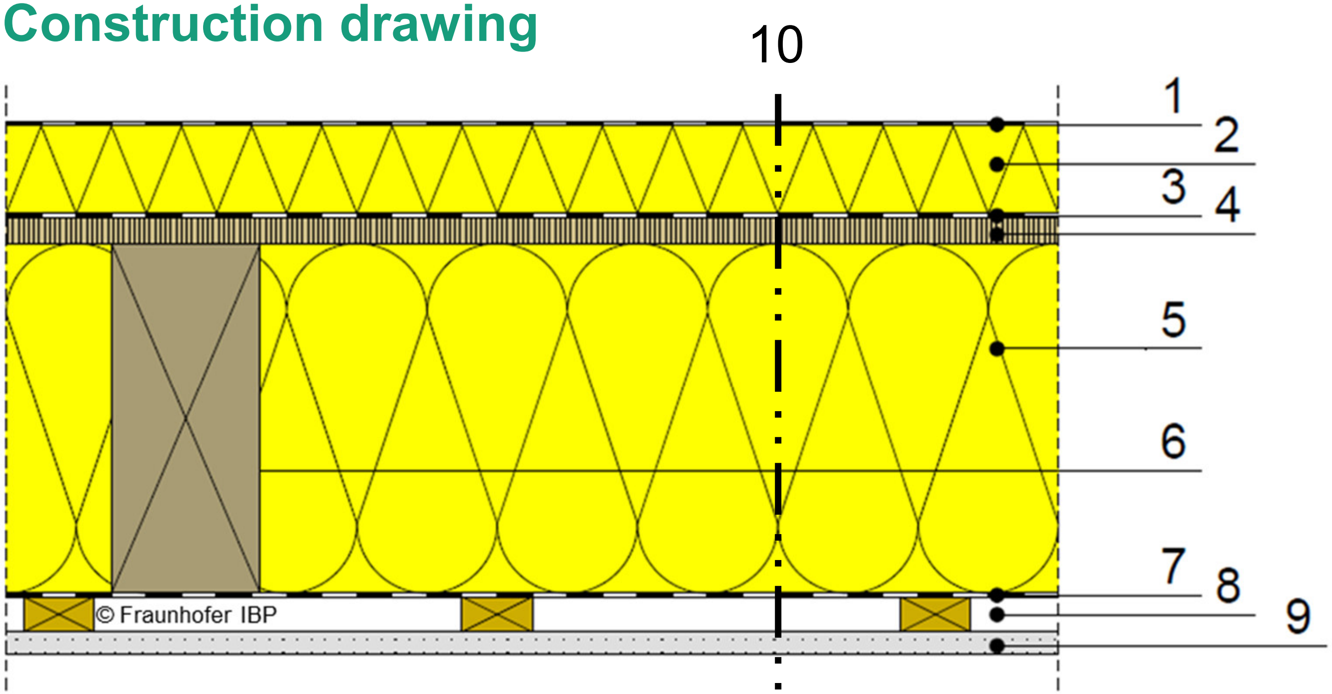



Fraunhofer IBP

Content

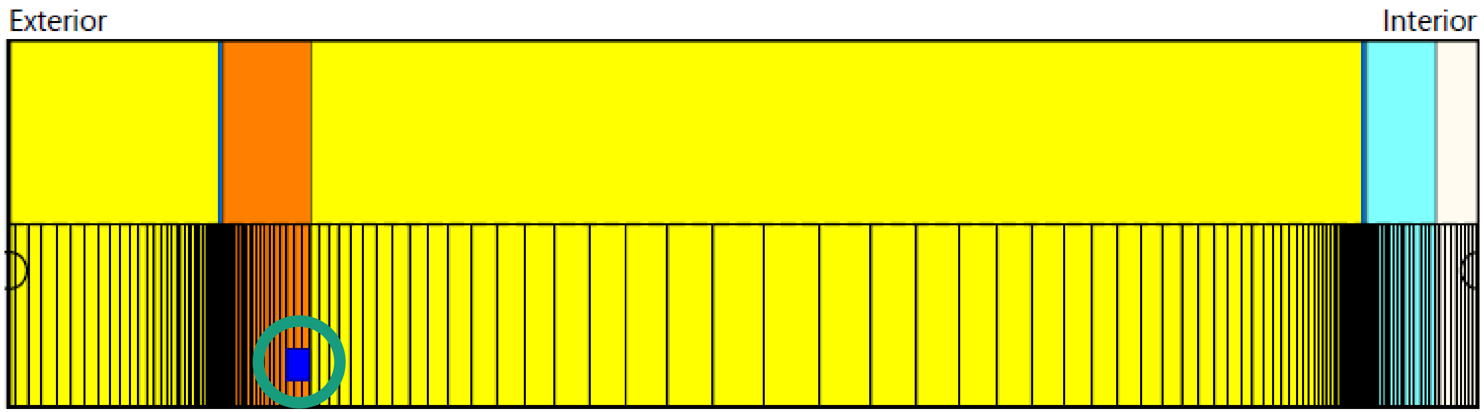
Flat roof

Construction drawing



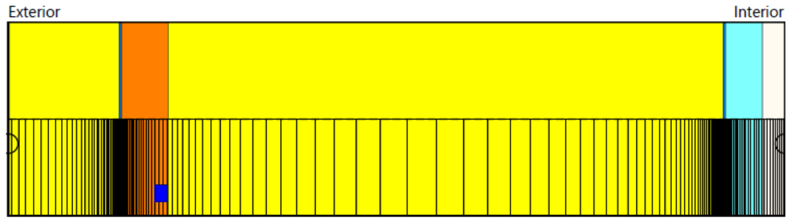
1 Roofing membrane
2 Exterior insulation
3 Vapor retarder
4 Wooden sheathing
5 Insulation
6 Rafter
7 Vapor retarder
8 Installation layer
9 Gypsum board
10 Simulated cross-section

Assembly in WUFI



Flat roof

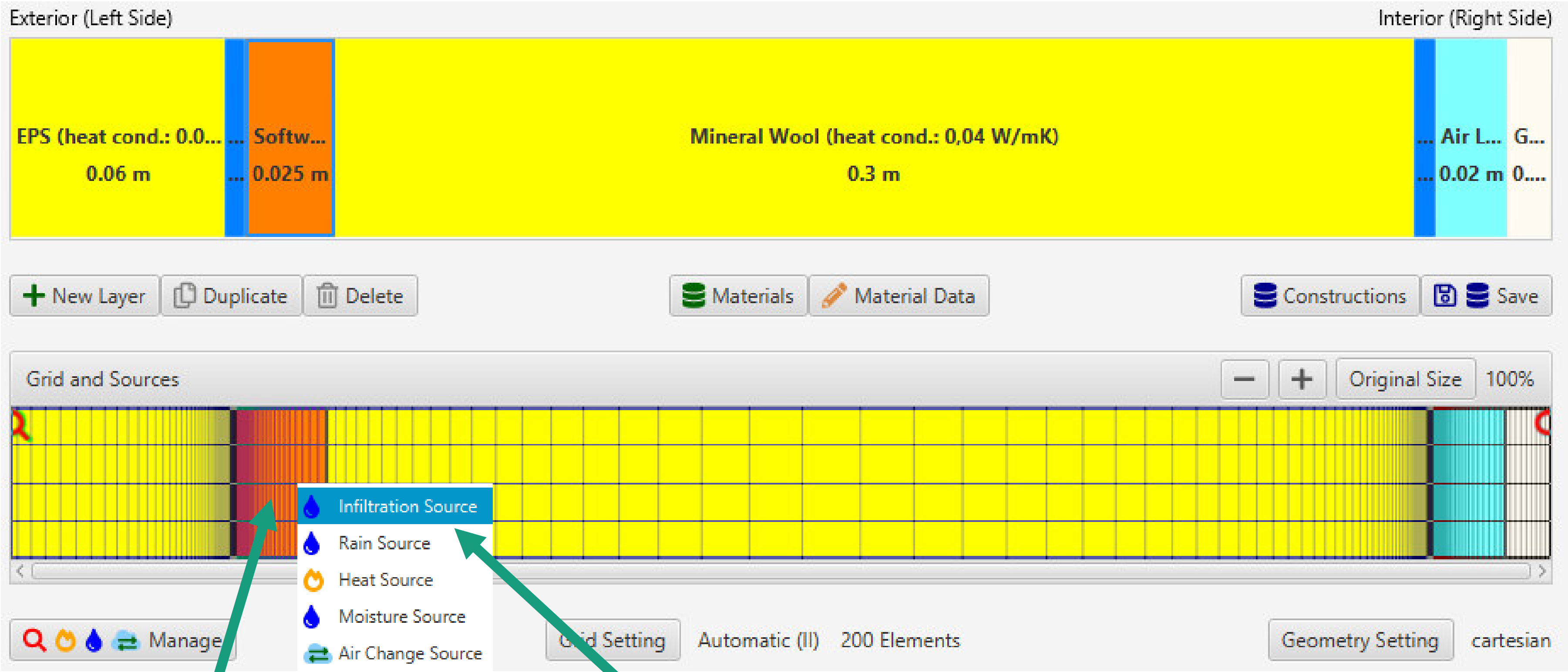
Please note



- Insert an infiltration source at the cold side of the construction (at the position where condensation would occur)
  → depending on the air tightness of the building and the stack height
- Orientation/ Inclination according to planning
- Heat transfer resistance „Roof“ or “DIN 4108-3 – Exterior component”
- Roofing membrane can be considered by using an s_d-value on the outer surface (numerical more favorable)
  → if doing so, use no roofing membrane in the component assembly
  → switch off rainwater absorption
  (remove tick from “Simulation takes rain into account”)
- Short-wave absorptivity depending on colour of roof surface
- Switch on “Radiative overcooling”
- Long-wave emissivity depending on the material of the surface

Flat roof

Input: Moisture Source



2. Select appropriate source

here: Infiltration Source

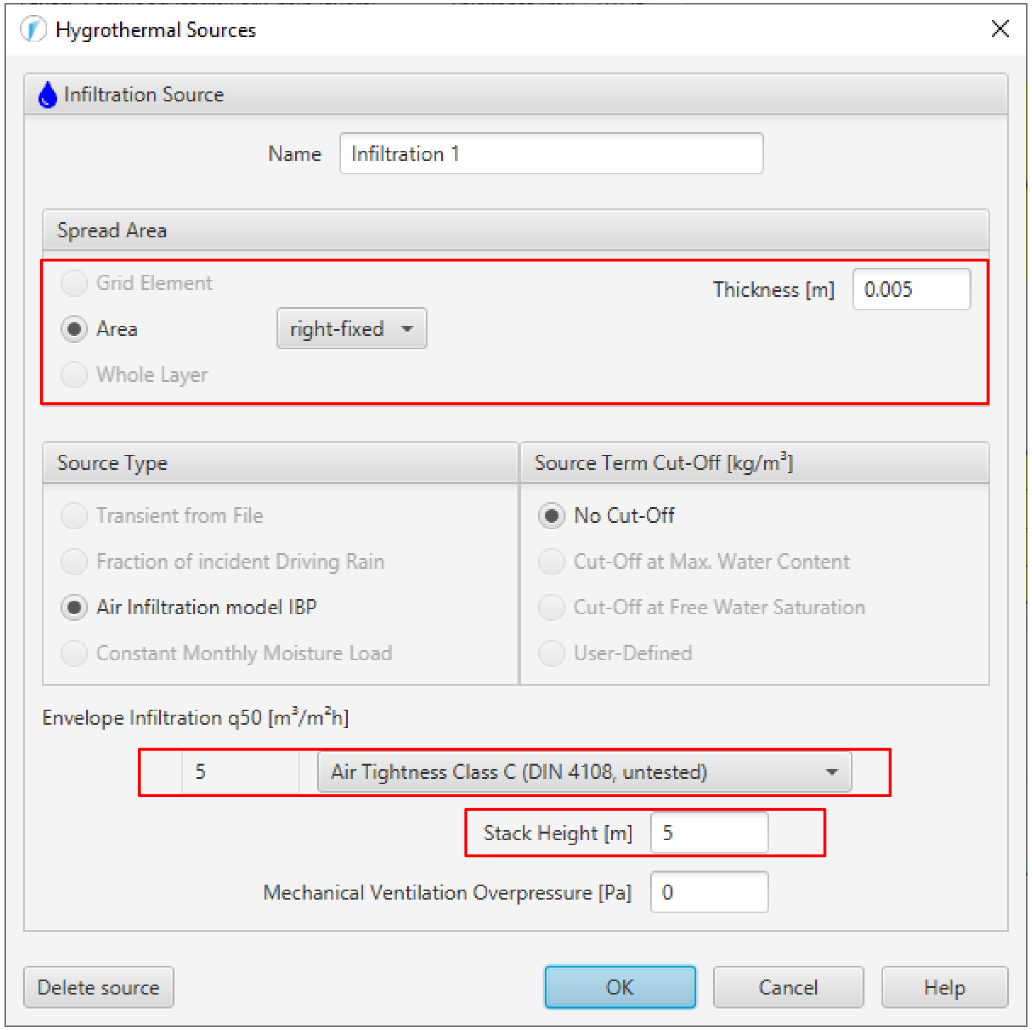
1. Right mouse click
in the layer*

***) Material in which condensation is to be expected due to convection. Infiltration source either in the inner 5 mm of the wooden sheathing or – if there is no sheathing – in the outer 5 mm of the insulation between the rafters.**

Flat roof

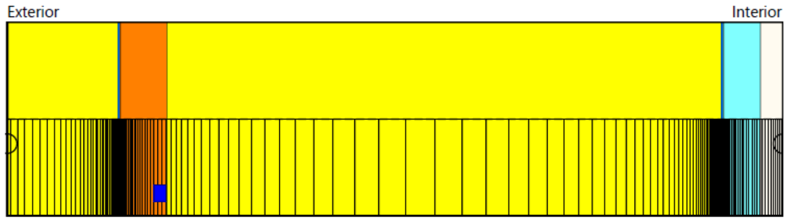
Input: Moisture Source

- Infiltration Source



Flat roof

Result analysis*

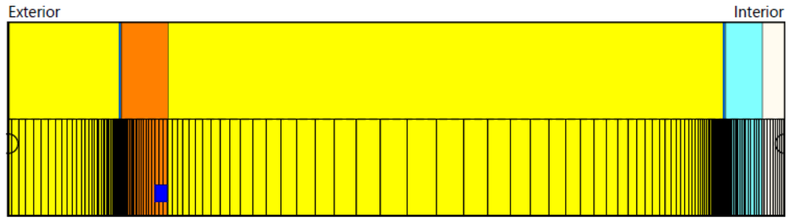


- Check the numerical quality of the result using convergence failures and balances! (→ Guideline for the Result Evaluation)
- Check total water content
  → regular, periodic course?
  → accumulation of moisture in whole construction?
- Check water content in wooden sheathing
- You may check moisture accumulation in the exterior insulation

***) Note: List not necessarily complete. Depending on boundary conditions additional critical positions may occur**
→ Check film

Flat roof

Result analysis*



- In a construction without wood-based or moisture sensitive materials:

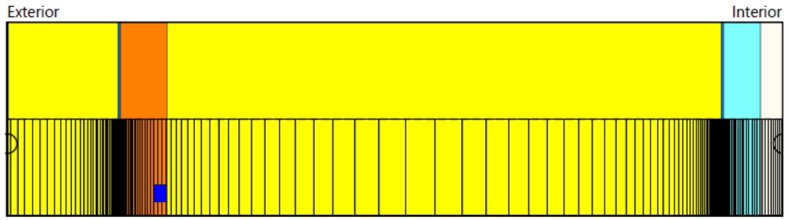
  → Examination of amount of dew water (further information can be found in the Guideline for the Condensation Assessment)

  → Further check influence of moisture content on the thermal conductivity in the material data table „thermal conductivity, moisture-dependent“

***) Note: List not necessarily complete. Depending on boundary conditions additional critical positions may occur → Check film**

Flat roof

Additional information



- Be careful with bright roofing membranes:
The drying potential of the construction is greatly reduced!
- Shading / green roof / gravel roof has to be considered
(more information in the paper Verschattung von Holzflachdächern (only German) and in Guideline for the calculation of extensive green resp. gravel roofs)
- In case of modeling the roofing membrane as s_d-value on the exterior surface, this only models the vapor-retarding property of the membrane, not its rain-tightness → don't forget to switch off rain!
- Considering an insulated roof with rafters, usually the cross section through the insulation is relevant.
- Metal roof: Metal layer is considered as s_d-value at the exterior surface, absorptivity and emissivity according to material
- unsealed seams: effective s_d-value around 25 m – 75 m
- sealed seams: effective s_d-value > 300 m

Content

Flat roof

Pitched roof

Exterior wall with ETICS

Exterior wall with interior insulation

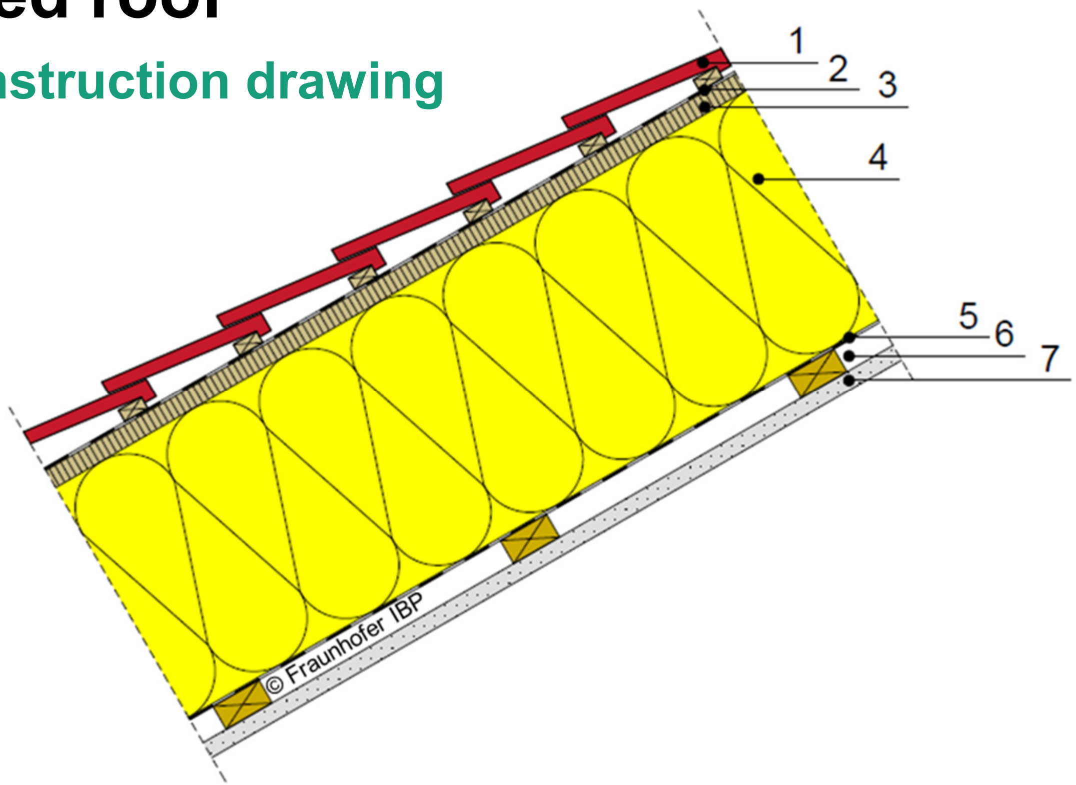
Ventilated timber frame construction

Basement wall without ground water

Interior component

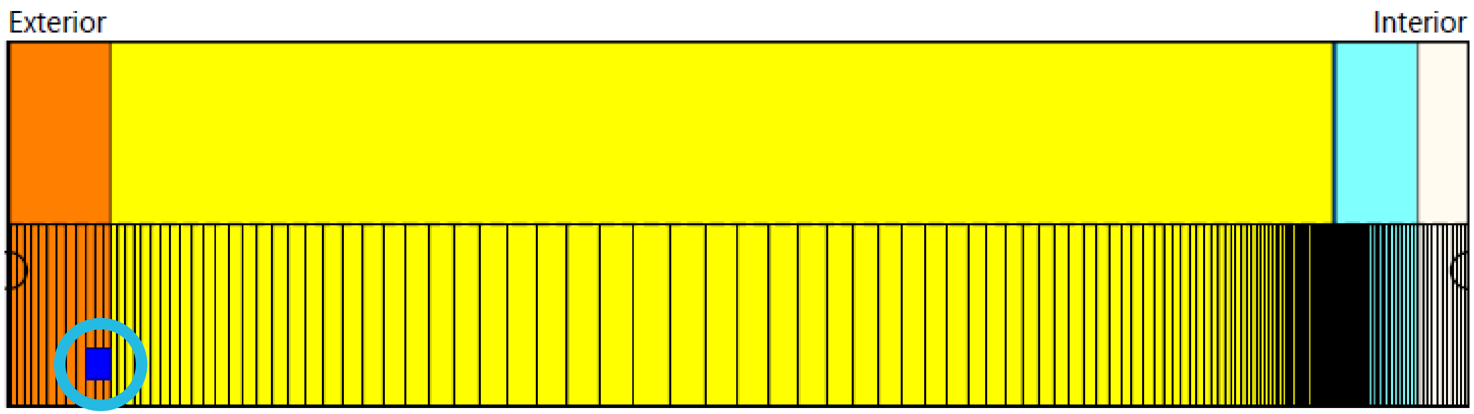
Pitched roof

Construction drawing



1 Roofing tiles and battens
2 Weather-protecting membrane
3 Wooden sheathing
4 Insulation
5 Vapor retarder
6 Installation layer
7 Gypsum board

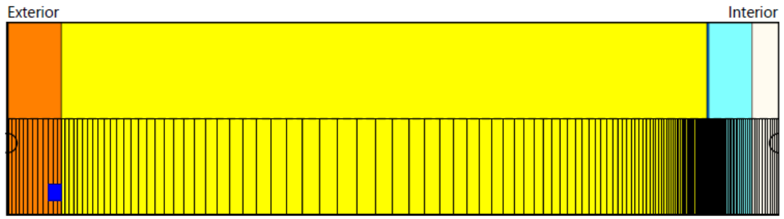
Assembly in WUFI



Fraunhofer IBP

Pitched roof

Please note

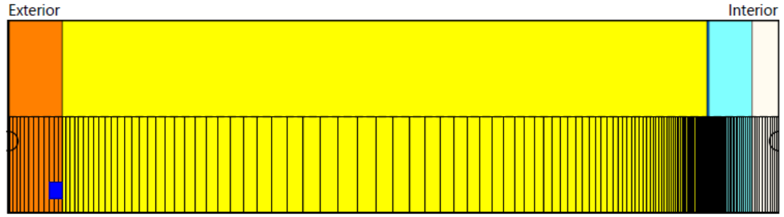


- Insert an infiltration source at the cold side of the construction (at the position where condensation would occur)
  → depending on the air tightness of the building and the stack height
- Relevant orientation: usually North
- Ventilated roofing is omitted for the calculation
  → switch off rainwater absorption (remove tick from "Simulation takes rain into account")
- Underlay membrane can be considered by using an s_d-value on the outer surface (numerical more favourable)
  → if doing so, use no roofing membrane in the component assembly
- For assemblies without a separate underlay membrane:
  → Surface s_d-value of 0.01 m, to consider the reduced relative humidity in the ventilation gap (e.g. due to condensation on the roofing covering).
  → otherwise, it can lead to very high moisture contents in timber boards or similar materials which can absorb liquid water

Fraunhofer IBP

Pitched roof

Please note

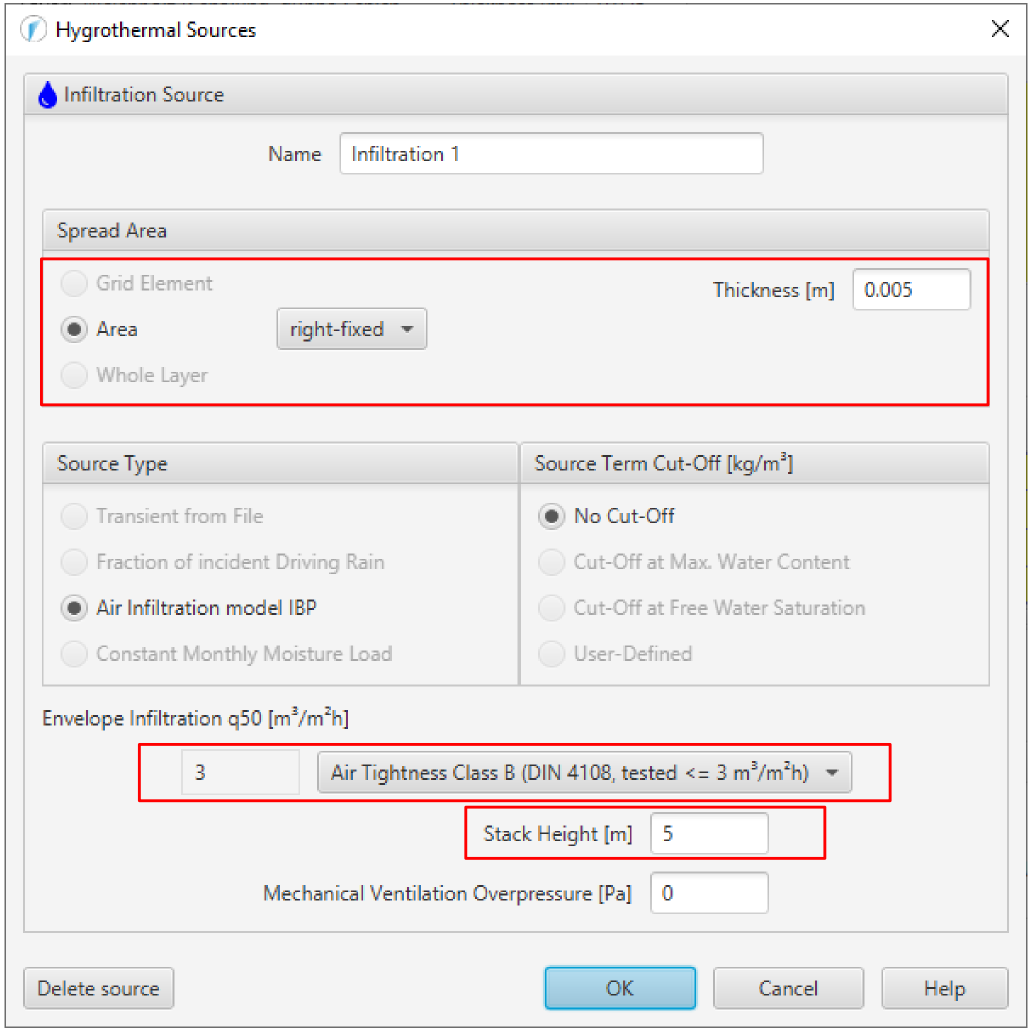


- Heat transfer coefficient (exterior):
  → select "Pitched roof": weak, normal or strong ventilated
  → the long-wave radiation parts are set to 0 W/m²K
  (for more information: Hygrothermal Simulation of ventilated pitched roofs)
- Short-wave absorptivity depending on colour of the roofing tiles
- Switch on "Radiative overcooling"
- Long-wave emissivity depending on the material of the roofing tiles
- Set the reduction factor to the absorption coefficient:
  „Pitched roof, ventilated, middle position"
  (further information: Hygrothermal Simulation of ventilated pitched roofs)

Pitched roof

Moisture source setup

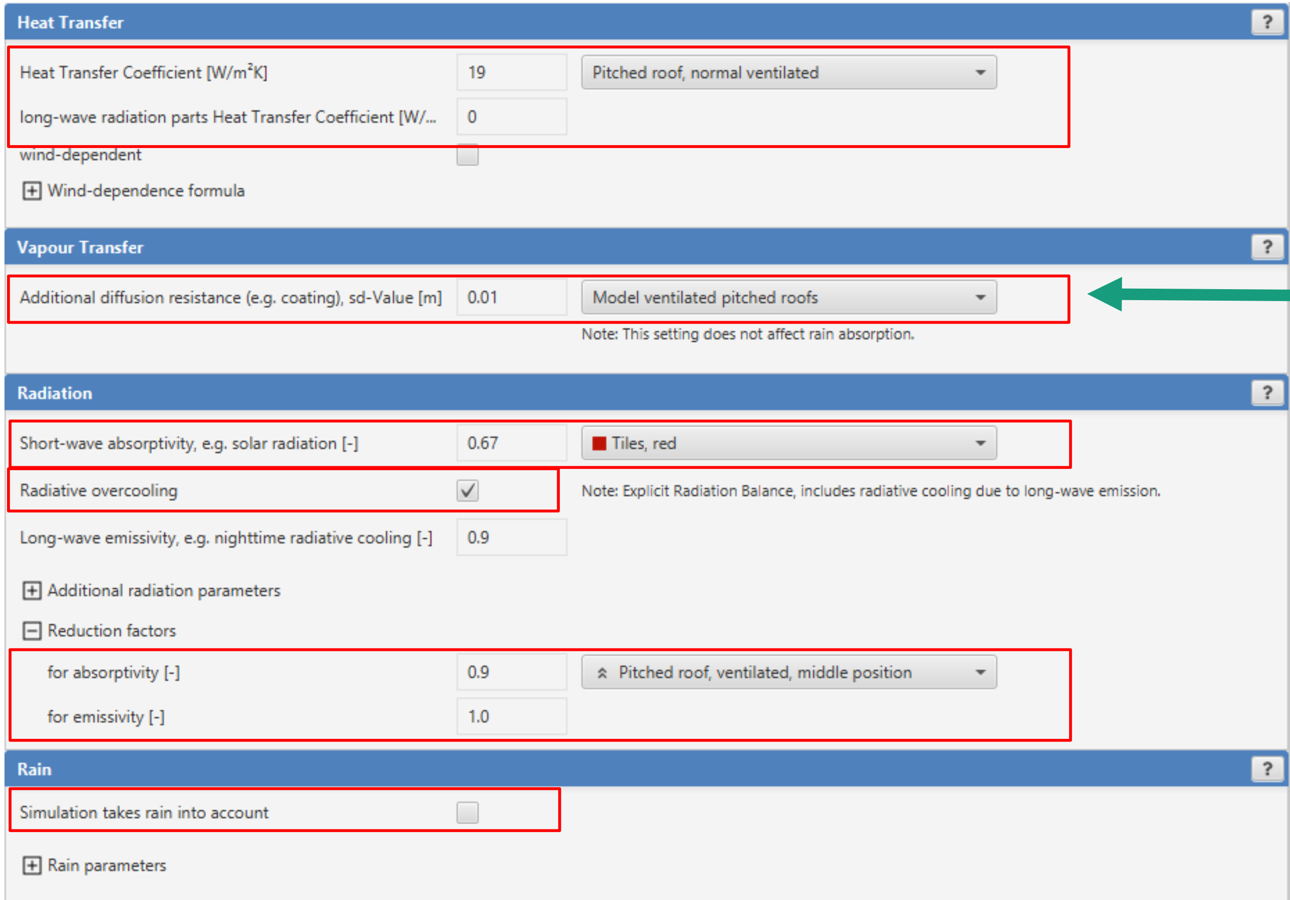
- Infiltration Source



For procedure:
see „flat roof“

Pitched roof

Input: Surface transfer parameter

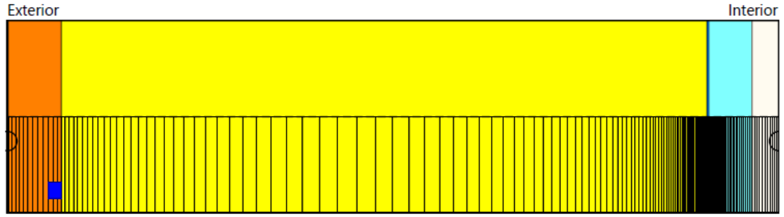


For assemblies without underlay membrane

<u>Otherwise:</u>
Enter the s_d-value of the underlay membrane

Pitched roof

Result analysis*



- Check the numerical quality of the result using convergence failures and balances! (→ Guideline for the Result Evaluation)
- Check total water content
  → regular, periodic course?
  → accumulation of moisture in whole construction?
- Check water content in wooden sheathing
- In a construction without wood-based or moisture sensitive materials:
  → Examination of amount of dew water (further information can be found in the Guideline for the Condensation Assessment)
  → Further check influence of moisture content on the thermal conductivity in the material data table „thermal conductivity, moisture-dependent“

***) Note: List not necessarily complete. Depending on boundary conditions additional critical positions may occur**
→ Check film

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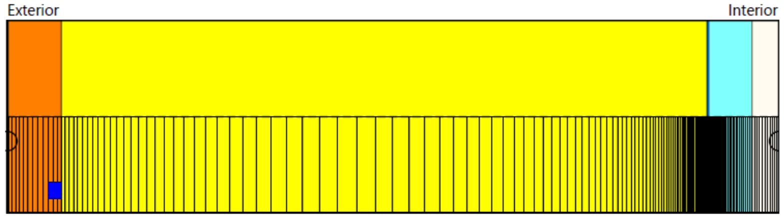
Pitched roof

Additional information



- Heat transfer coefficient according to the latest research results by Kölsch (Hygrothermal Simulation of ventilated pitched roofs)
- In case of modeling the underlay membrane as s_d-value on the exterior surface, this only models the vapor-retarding property of the membrane, not its rain-tightness → don't forget to switch off rain!
- Metal roof: Metal layer is considered as s_d-value at the exterior surface, absorptivity and emissivity according to material
  - unsealed seams: effective s_d-value around 25 m – 75 m
  - sealed seams: effective s_d-value > 300 m

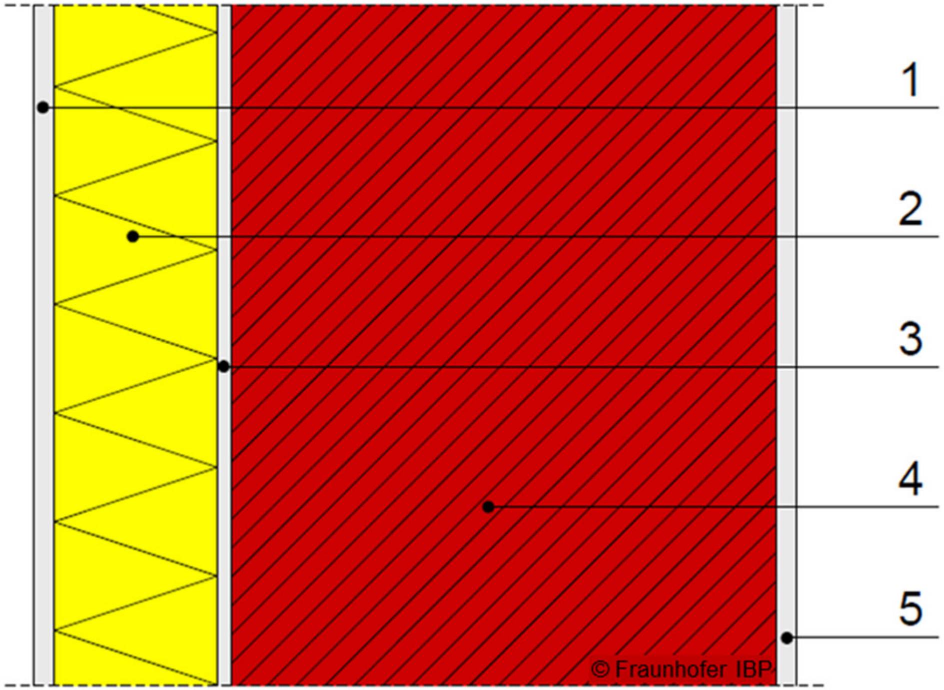
Content

- Flat roof
- Pitched roof
- Exterior wall with ETICS
- Exterior wall with interior insulation
- Ventilated timber frame construction
- Basement wall without ground water
- Interior component

Fraunhofer IBP

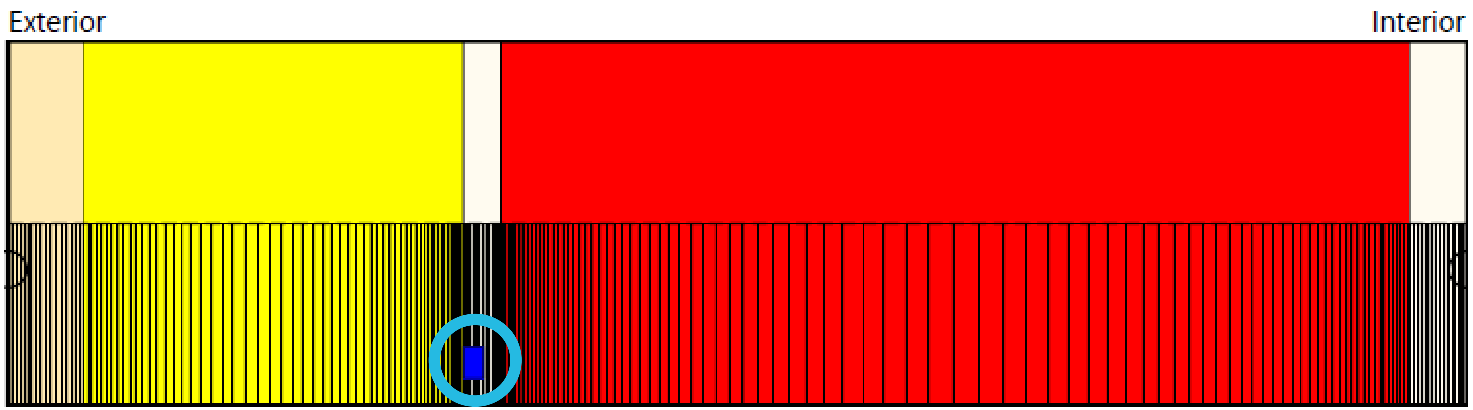
Exterior wall with ETICS

Construction drawing



1 Exterior plaster
2 Insulation
3 Plaster
4 Masonry / concrete
5 Interior plaster

Assembly in WUFI



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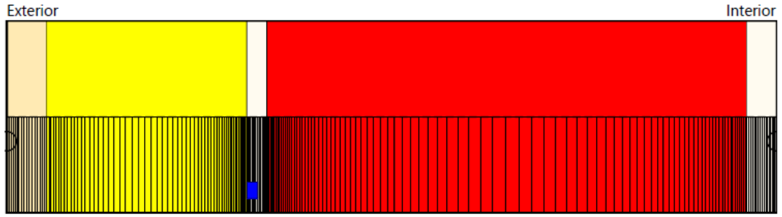
Exterior wall with ETICS

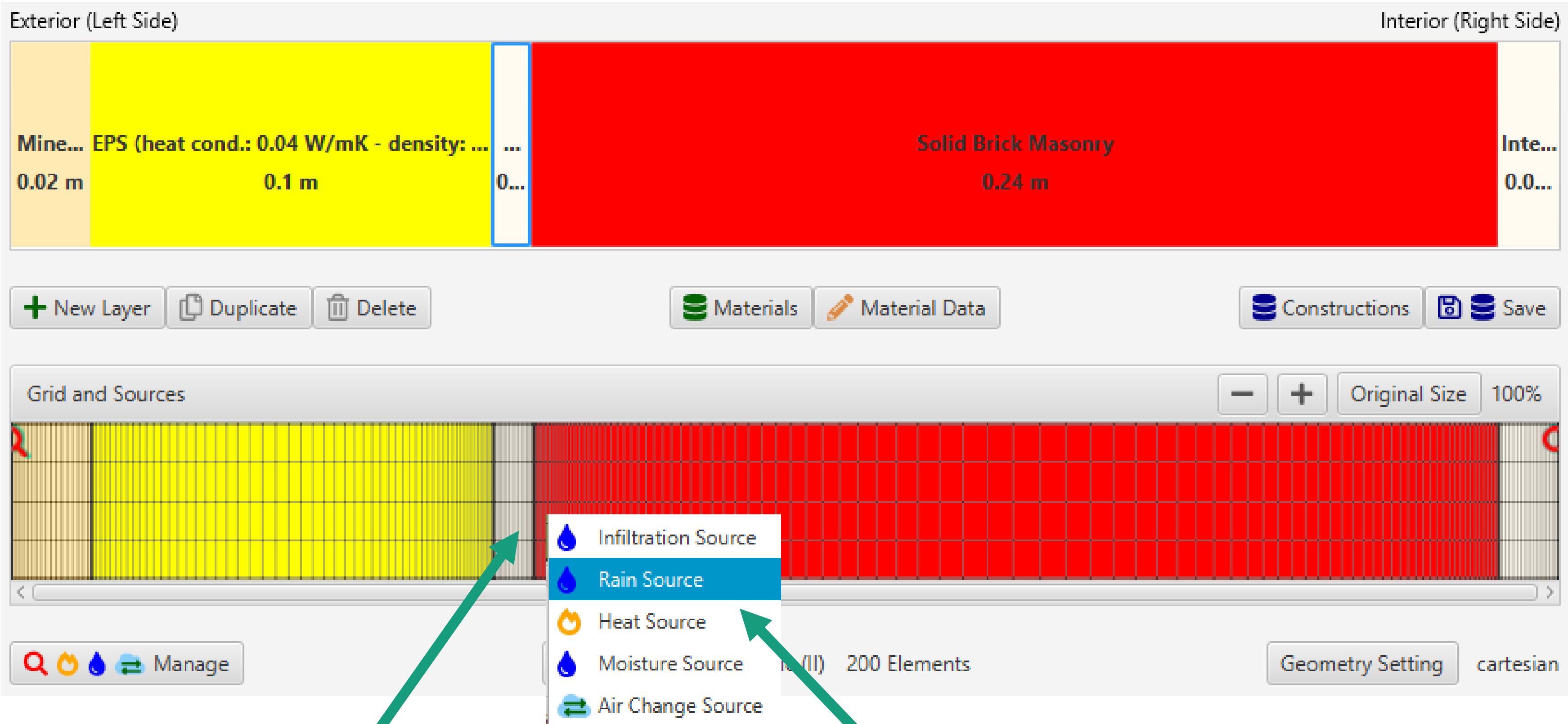
Please note



- Moisture source behind ETICS: 1 % of driving rain
- Relevant orientations: Prevailing direction of driving rain and North
- Short wave absorptivity depending on colour of exterior plaster
- Long wave emissivity for plaster (if not known: 0.9)
- If the short-term hygrothermal behaviour of the outer surface is to be evaluated, switch on “Radiative overcooling”
- Rain parameters: Depending on inclination of component (vertical wall: 0.7)

Exterior wall with ETICS

Input: Moisture source



1. Right mouse click in the layer*

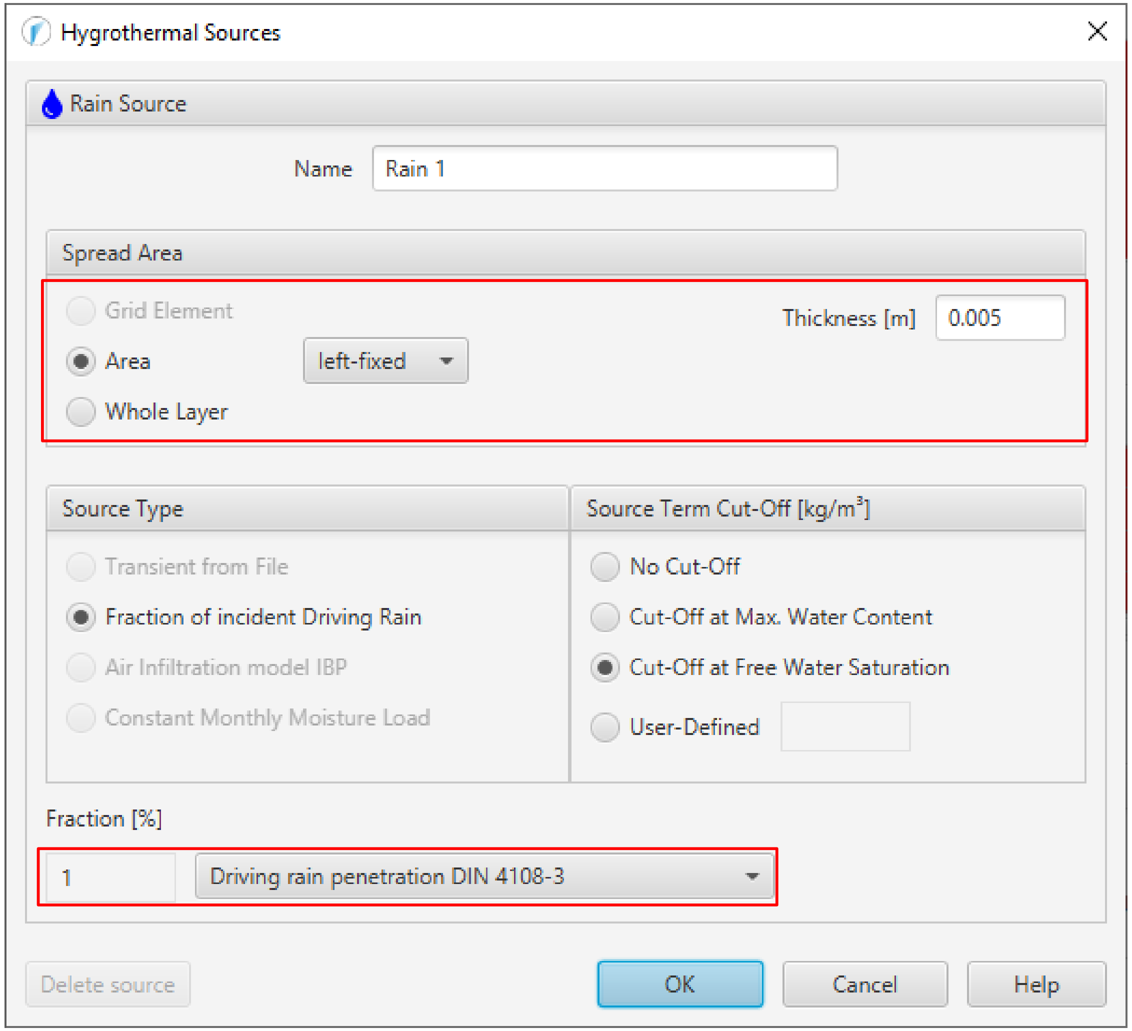
2. Select appropriate source *here: Rain Source*

***) Driving Rain source is inserted in the outer 5 mm of the layer behind the insulation.**

Exterior wall with ETICS

Input: Moisture source

- Rain Source



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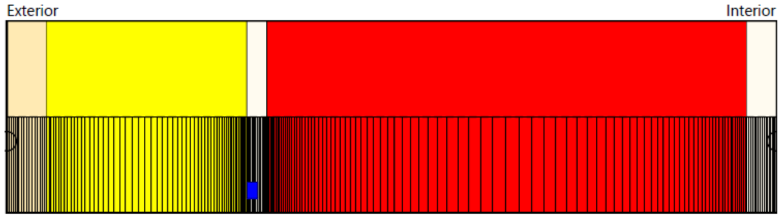
Exterior wall with ETICS

Result analysis*

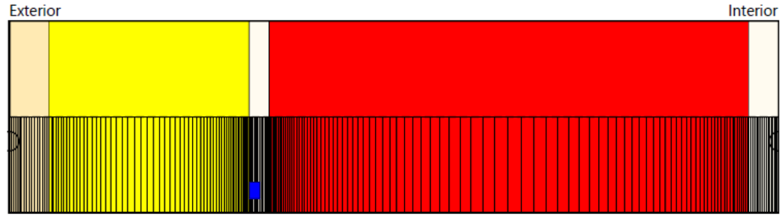


- Check the numerical quality of the result using convergence failures and balances! (→ Guideline for the Result Evaluation)
- Check total water content
  → regular, periodic course?
  → accumulation of moisture in whole construction?
- Check water content in the insulation
  → Reduction of thermal conductivity?
- Relative humidity at the interface between exterior plaster and insulation during winter → risk of frost damage?
- At warm and humid sites check relative humidity between insulation and wall (dew water and failure of adhesive may occur)

***) Note: List not necessarily complete. Depending on boundary conditions additional critical positions may occur → Check film**

Exterior wall with ETICS

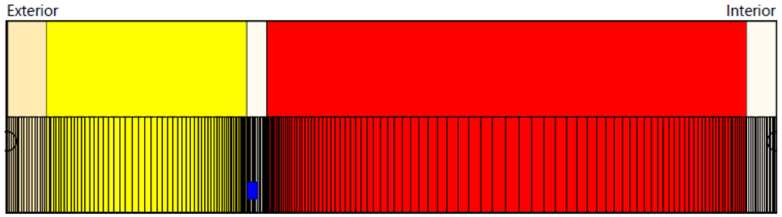
Additional information



- Determining the main direction of driving rain by using the climate analysis (usually West in Middle Europe)
- The moisture source of 1% of the driving rain behind the ETICS is regulated in the ASHRAE Standard 160 as well as in the EN 15026:2023 and represents critical positions e.g. in the area of window frames

Exterior wall with ETICS

Additional information

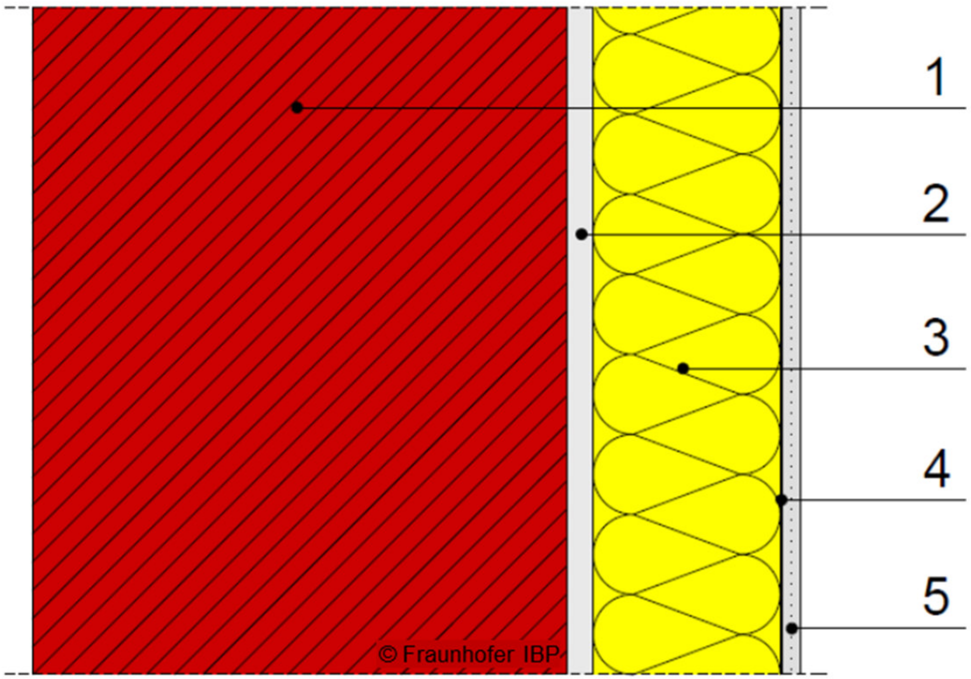


- Information on the calculation and evaluation of ETICS with wood fibre insulation can be found in the following guideline: Guideline for the calculation and evaluation of an ETICS with wood fibre insulation

Content

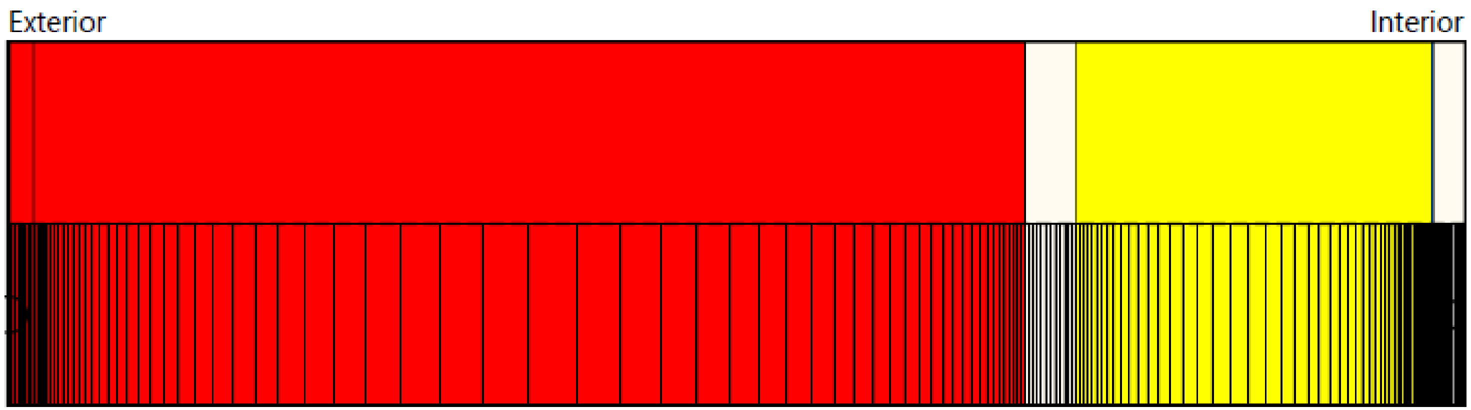
Exterior wall with interior insulation

Construction drawing



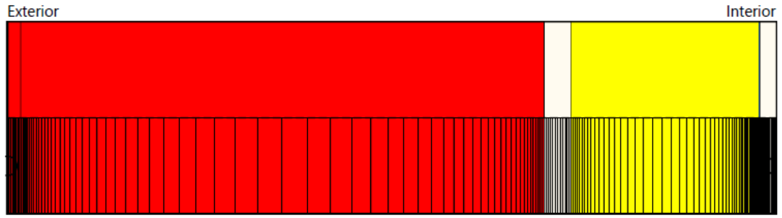
1 Facing brickwork
2 Interior plaster or adhesive
3 Interior insulation
4 Vapor retarder
5 Gypsum board

Assembly in WUFI



Exterior wall with interior insulation

Please note



- Relevant orientations: Prevailing direction of driving rain and North
- Short-wave absorptivity depending on colour of exterior surface
- Long-wave emissivity for exterior surface (if not known: 0.9)
- Using “Radiative overcooling” usually not necessary
- Rain parameters: depending on inclination of component (vertical wall: 0.7)
- If needed: Water-repellent treatment of the exterior surface to reduce rainwater absorption

Exterior wall with interior insulation

Water-repellent treatment of façades

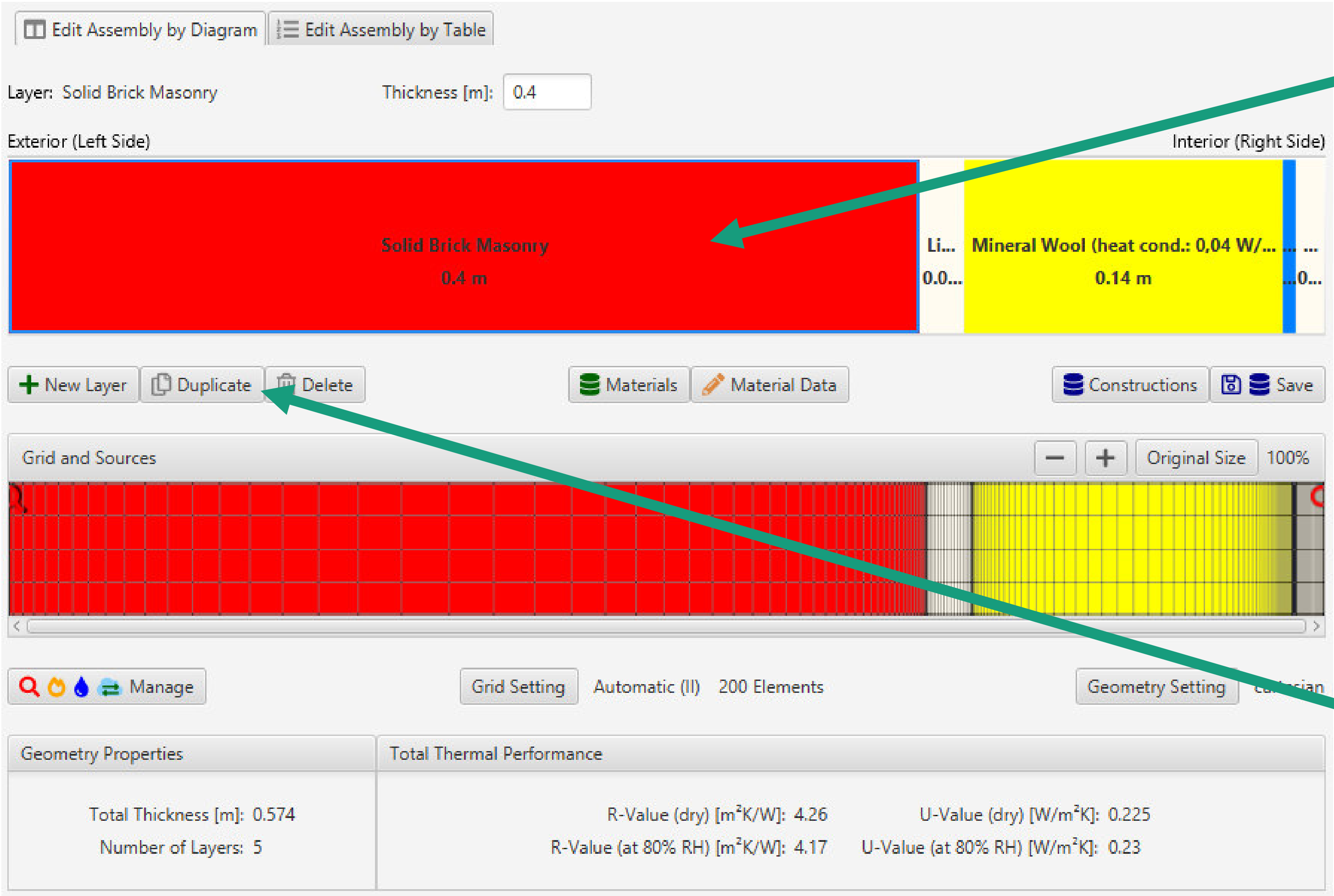
Modification of the A-value without influencing other material properties (e.g. s_d-value)

Step by step:

1) Split the exterior layer into a surface layer (0.5 – 1.0 cm depending on penetration depth of treatment) and the remaining layer. To do this, duplicate the original layer and then adjust the two thicknesses as needed.
2) Edit the material properties of the new exterior layer:
   - “Unlock” the material
   - Switch “Liquid Transport Coefficients” for suction and redistribution to “generate”
   - Adjust “Water absorption coefficient”
     Be careful with the units: $[kg/m^2\sqrt{s}]$ is the A-value in $[kg/m^2\sqrt{h}]$ divided by 60 !!!

Exterior wall with interior insulation

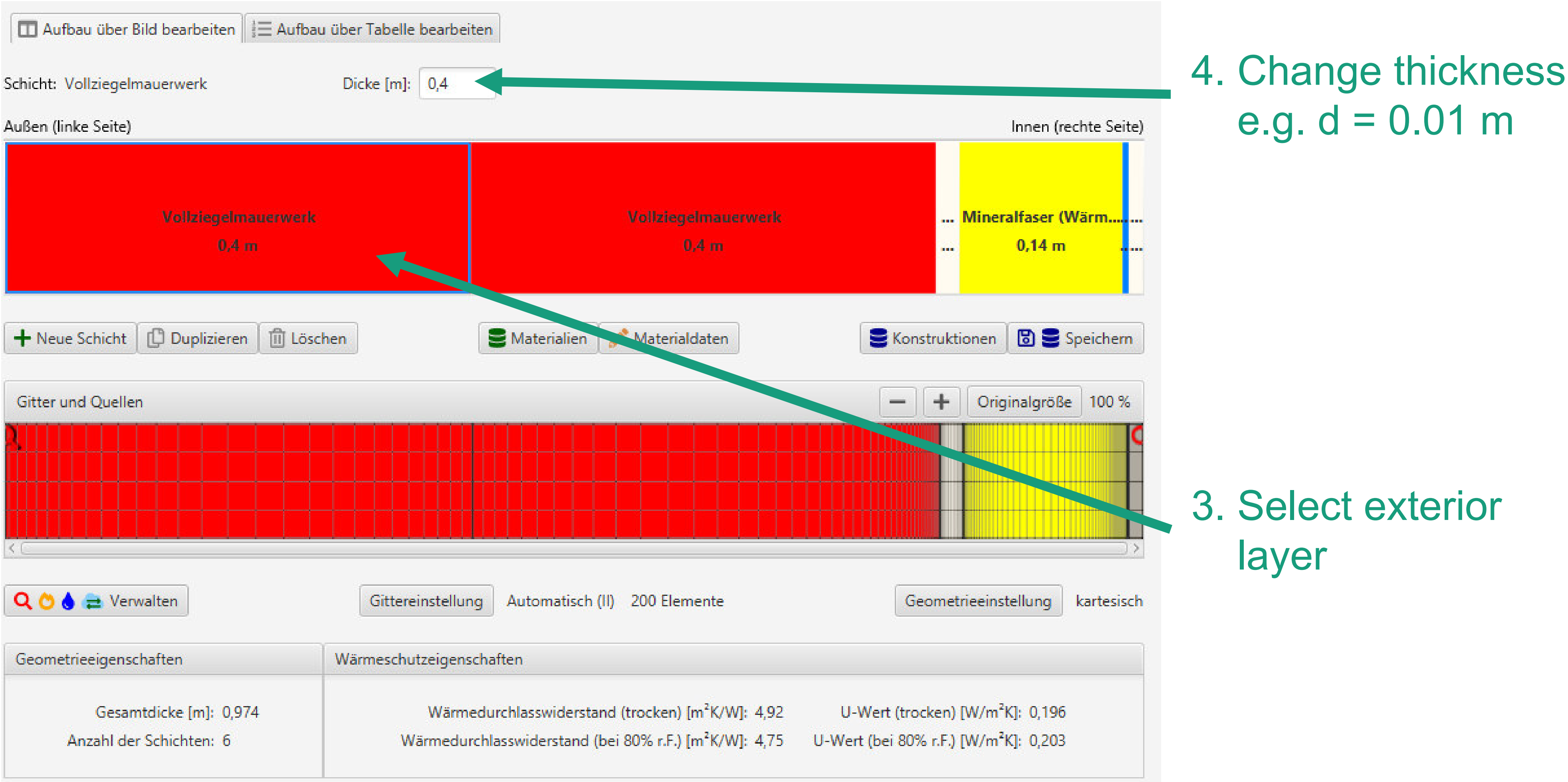
Water-repellent treatment of façades



1. Select exterior layer
2. Duplicate layer

Exterior wall with interior insulation

Water-repellent treatment of façades



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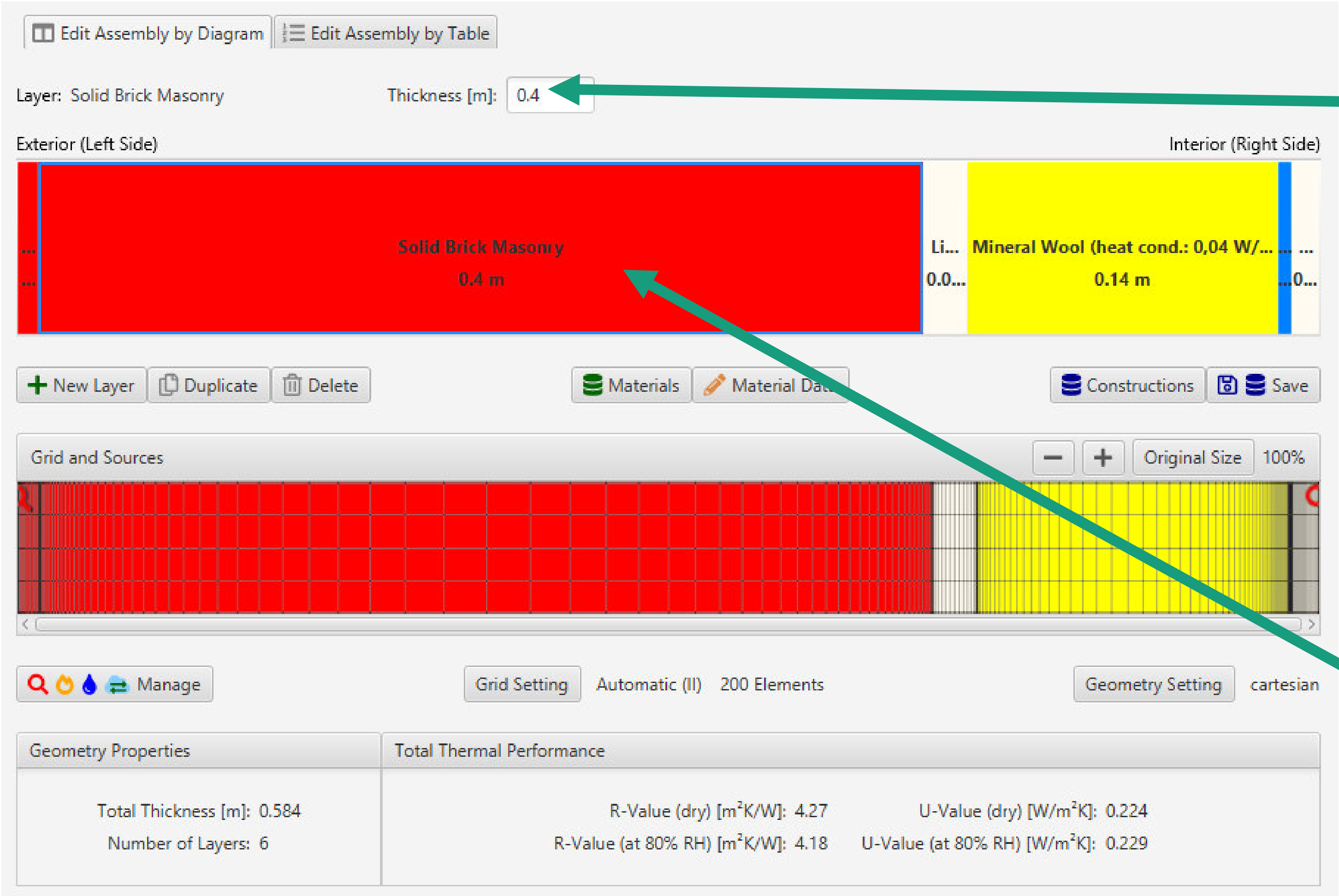
Exterior wall with interior insulation

Water-repellent treatment of façades



6. Change thickness e.g. d = 0.39 m

5. Select interior layer

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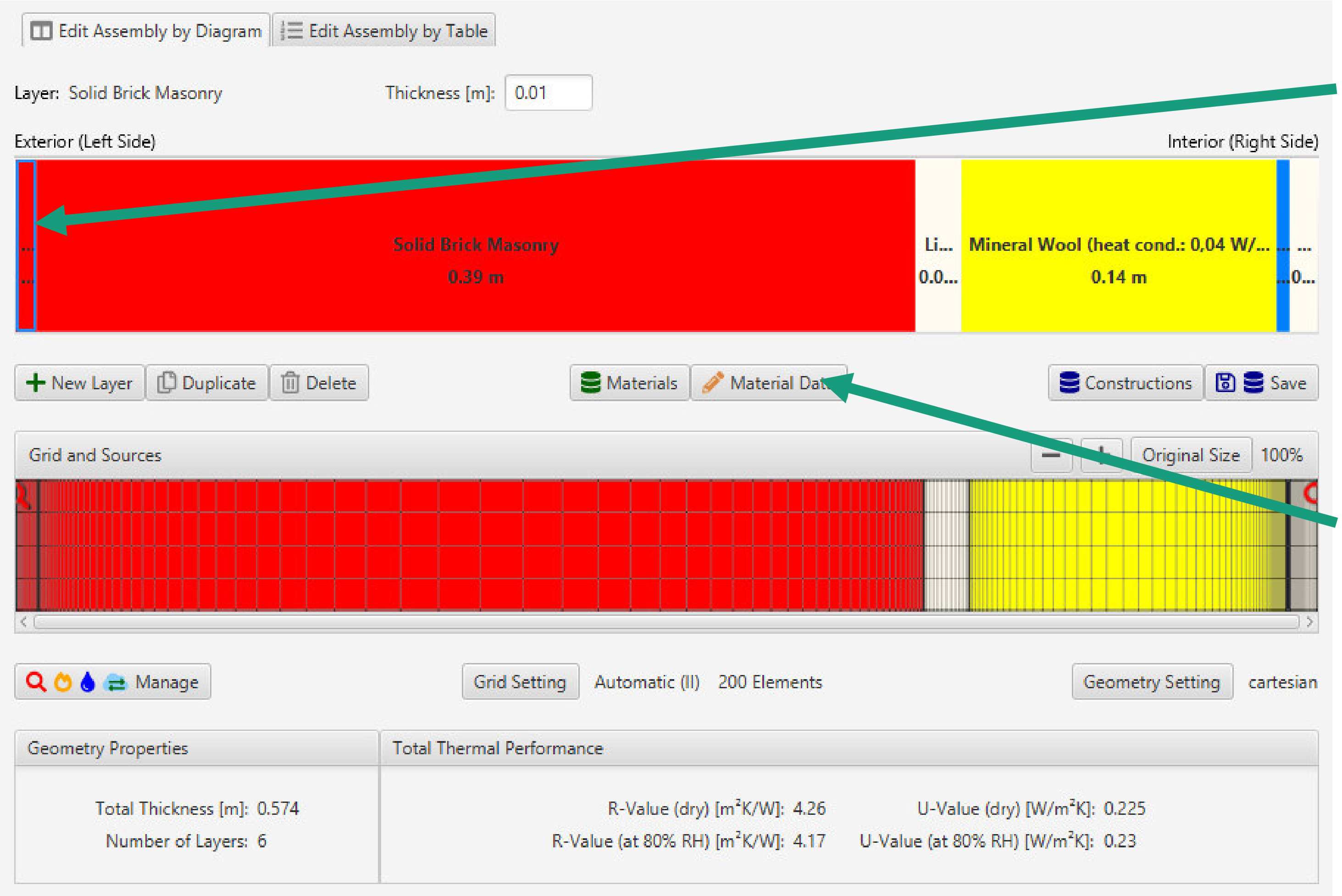
Exterior wall with interior insulation

Water-repellent treatment of façades



7. Double click on layer

7. Or click „Material data"

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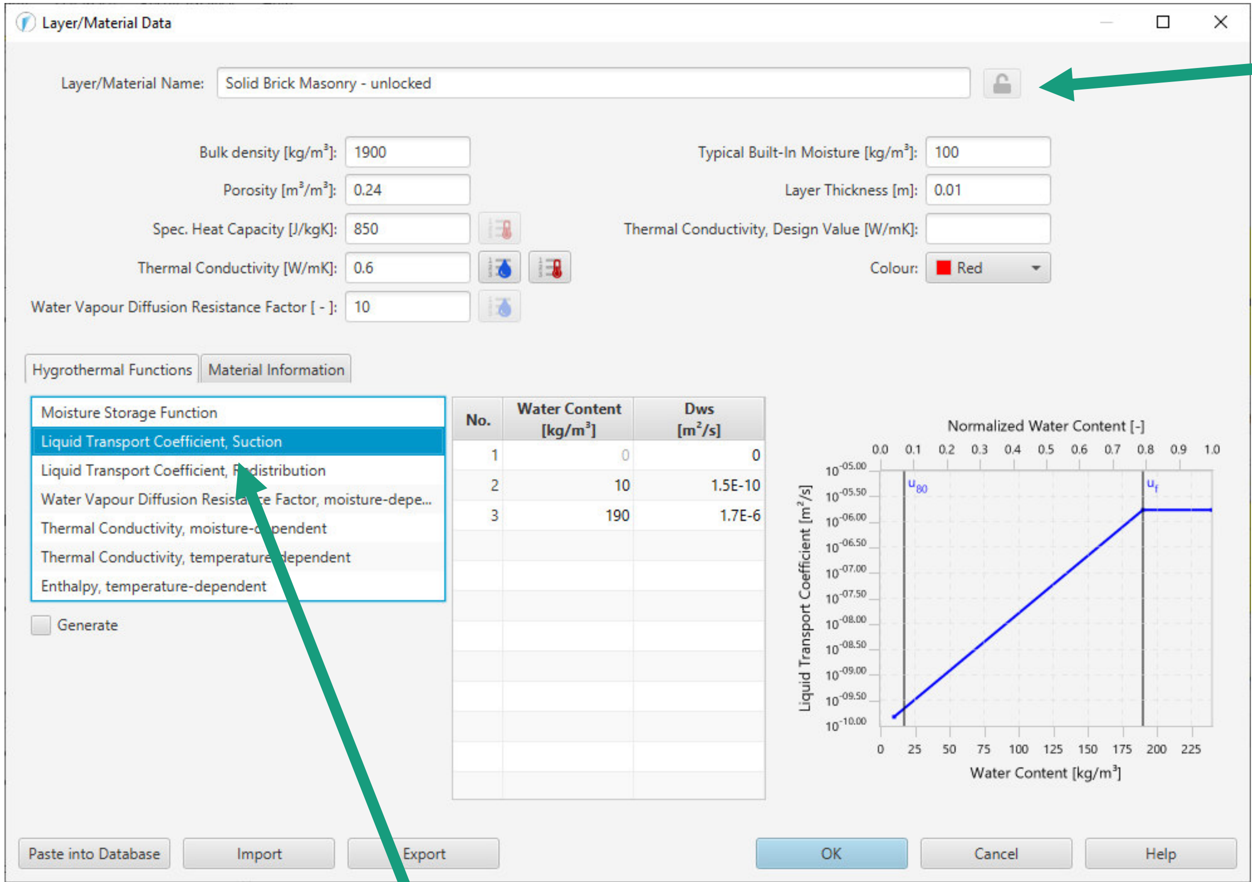
Exterior wall with interior insulation

Water-repellent treatment of façades



8. Unlock material

9. Select „Liquid Transport Coefficient, Suction“

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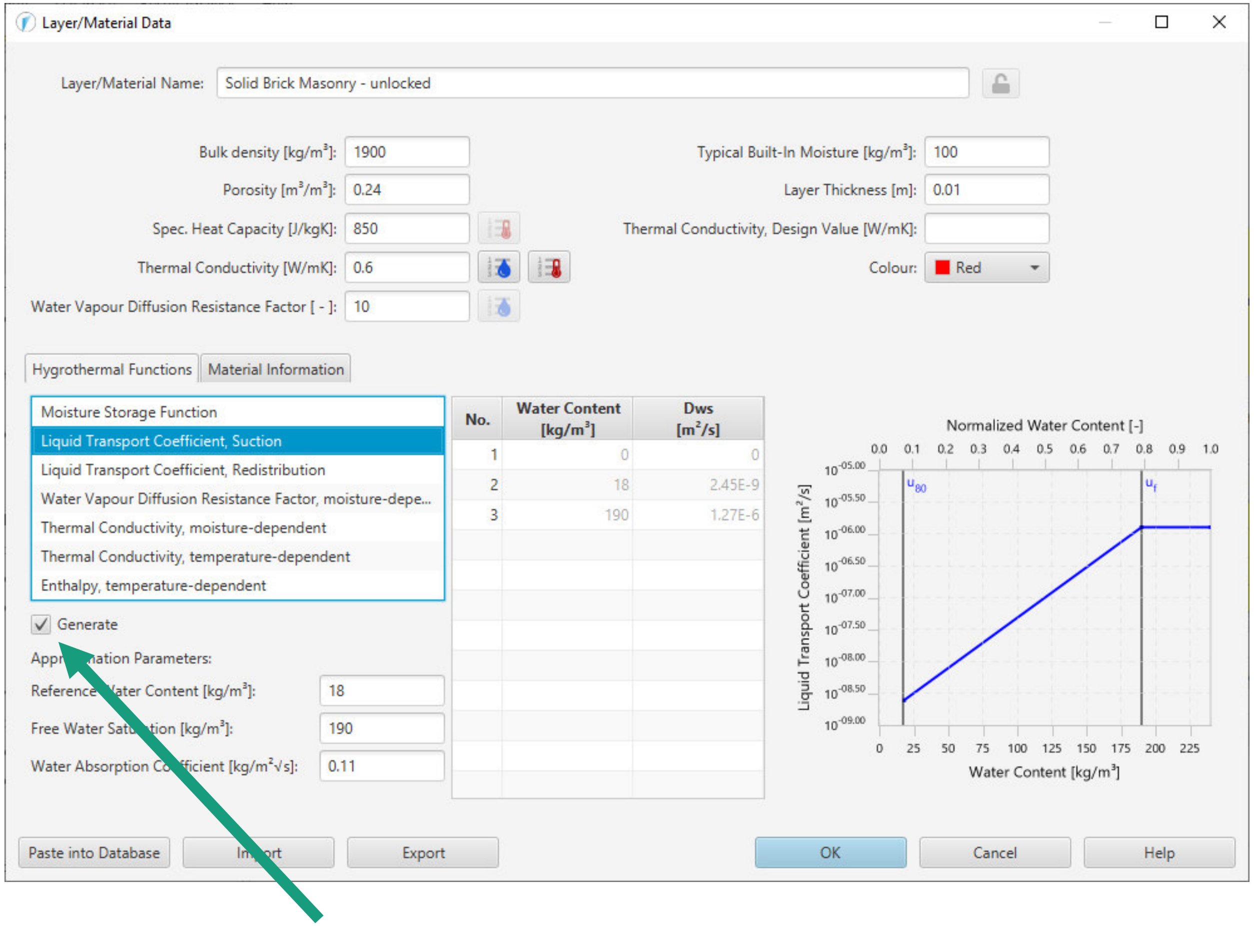
Exterior wall with interior insulation

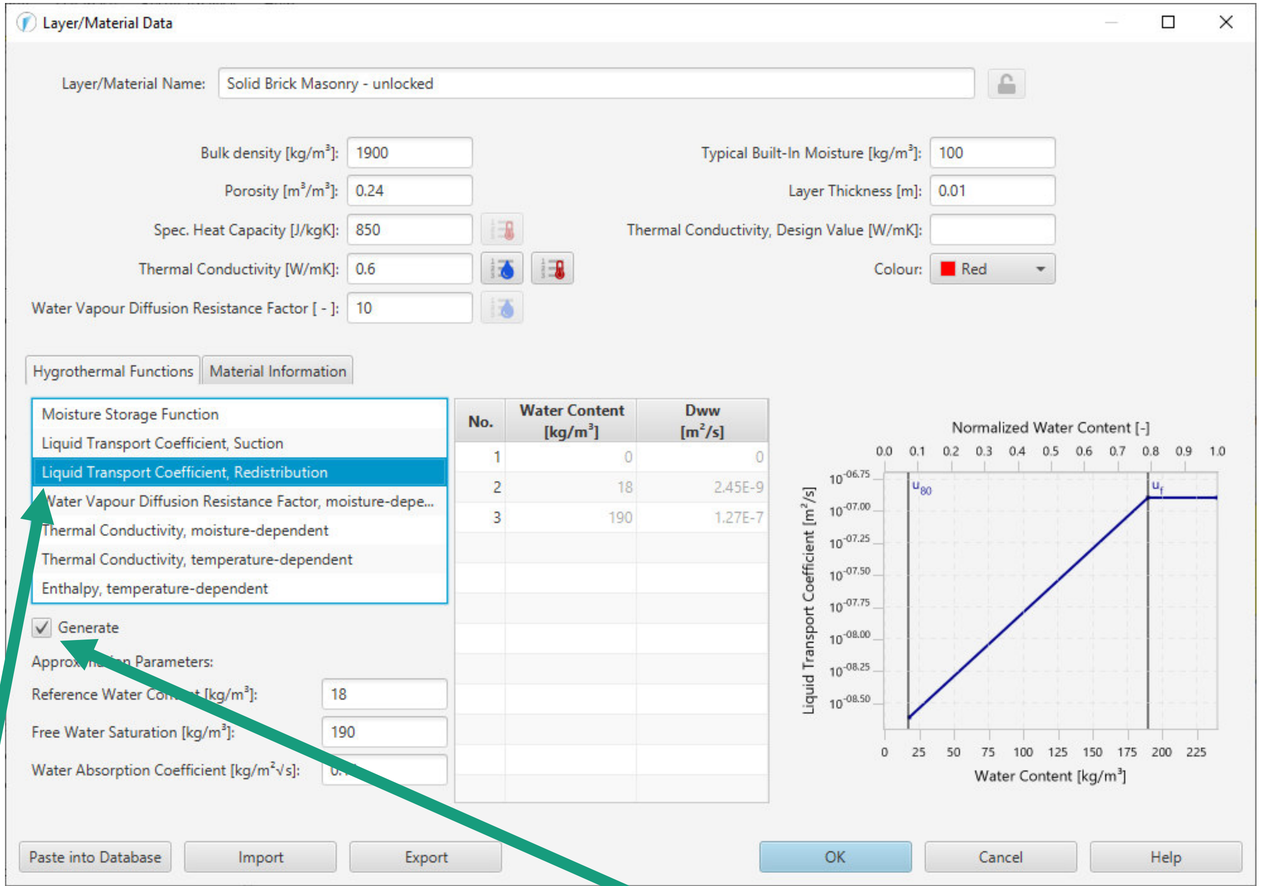
Water-repellent treatment of façades



10. Select „Generate“

Exterior wall with interior insulation

Water-repellent treatment of façades

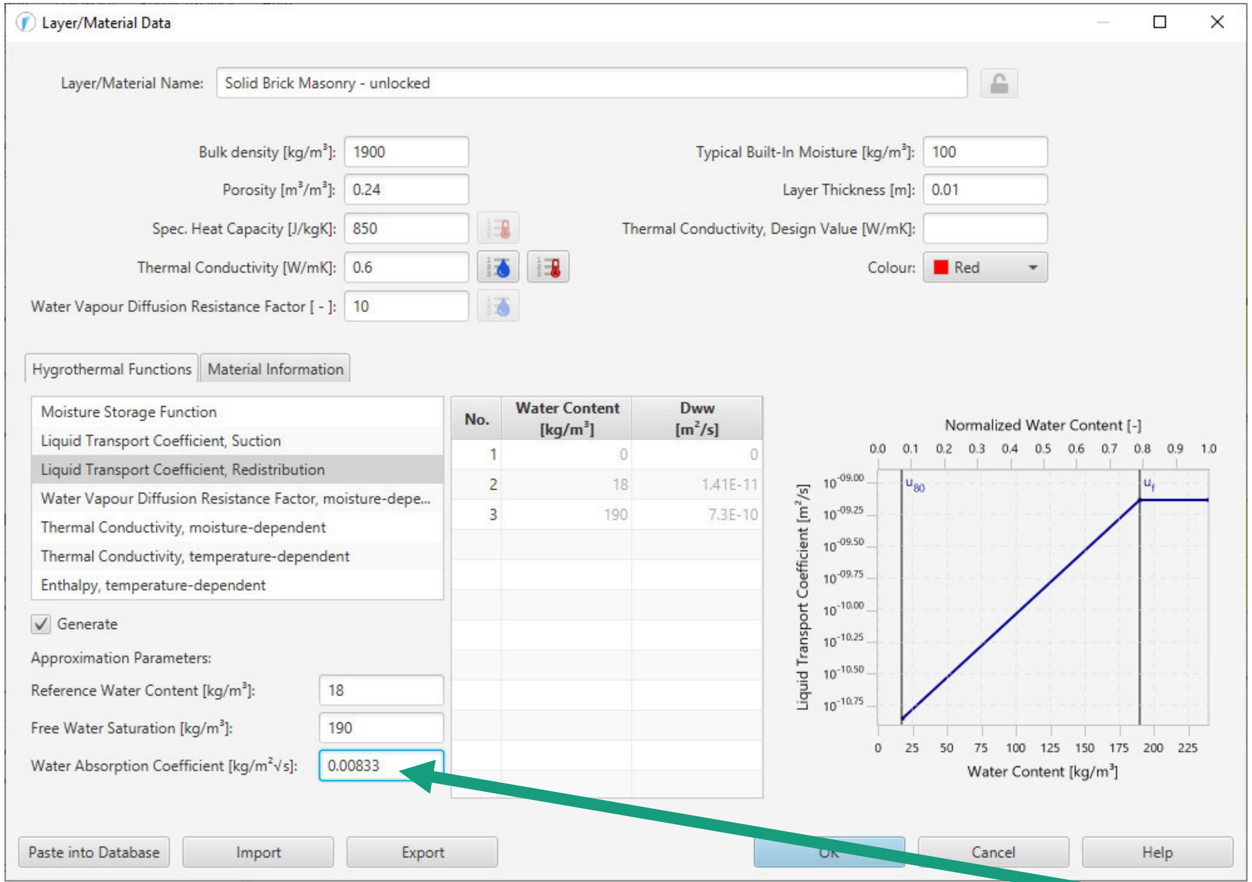


11. Select „Liquid Transport Coefficient, Redistribution“

12. Select „Generate“

Exterior wall with interior insulation

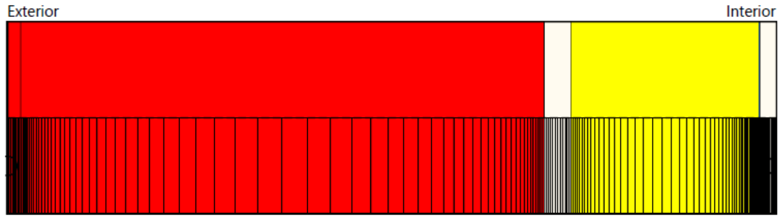
Water-repellent treatment of façades



13. Enter A-value
here:
0.5 kg/m²√h / 60
= 0.00833 kg/m²√s

Exterior wall with interior insulation

Result analysis*

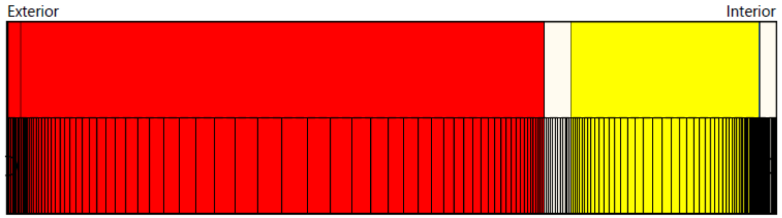


- Check the numerical quality of the result using convergence failures and balances! (→ Guideline for the Result Evaluation)
- Check total water content
  → regular, periodic course?
  → accumulation of moisture in whole construction?
- Relative humidity at the interface between interior plaster and interior insulation < 95 % RH
  → risk of frost damage?
  → or: frost-resistance of materials necessary
  (Insulation system plaster, wall materials)

***) Note: List not necessarily complete. Depending on boundary conditions additional critical positions may occur**
→ Check film

Exterior wall with interior insulation

Additional information



- An interior insulation reduces the drying potential of a construction due to a lower over-all temperature and a higher diffusion-resistance to the interior side.
- The moisture content at the interface interior plaster / interior insulation usually can be reduced by an enhancement of the protection against driving rain (e.g. by water-repellent treatment, new exterior plaster, paint coat) .
- Water-repellent treatment according to WTA:
  - A-value < 0.1 kg/m²√h
  - 50 % increase of the s_d-value
- Investigations of an exposed masonry need the knowledge of effective material properties, combining the properties of bricks and mortar.
- A gypsum plaster at the interior surface usually has to be removed before applying an interior insulation.
- Smart vapor retarders are favourable since the drying potential to the inside mainly remains unaffected.

Content

Flat roof

Pitched roof

Exterior wall with ETICS

Exterior wall with interior insulation

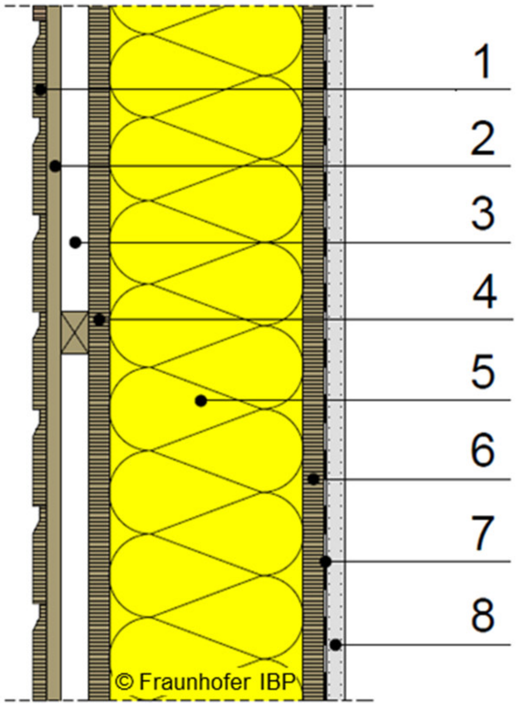
Ventilated timber frame construction

Basement wall without ground water

Interior component

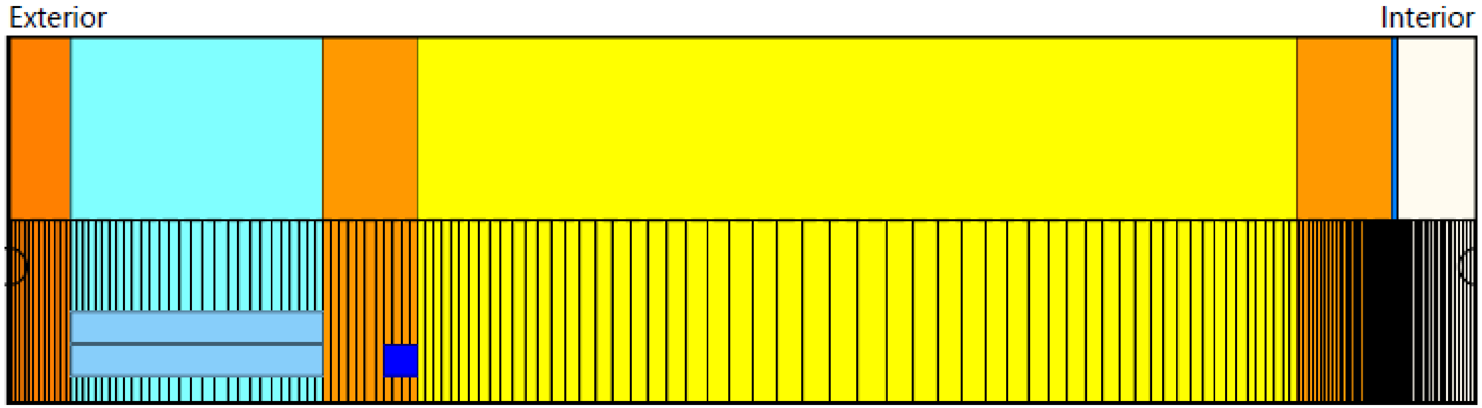
Ventilated timber frame construction

Construction drawing



1 Planking
2 Battens
3 Counter battens
4 External cladding
5 Insulation
6 Internal Cladding
7 Vapour retarder
8 Gypsum board

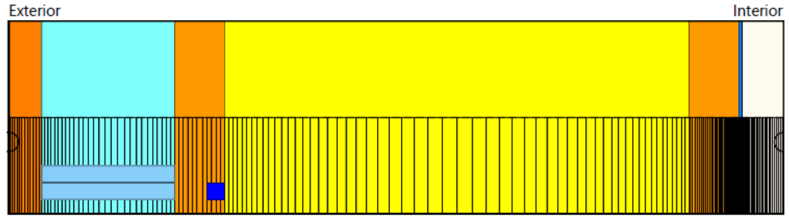
Assembly in WUFI



Fraunhofer IBP

Ventilated timber frame construction

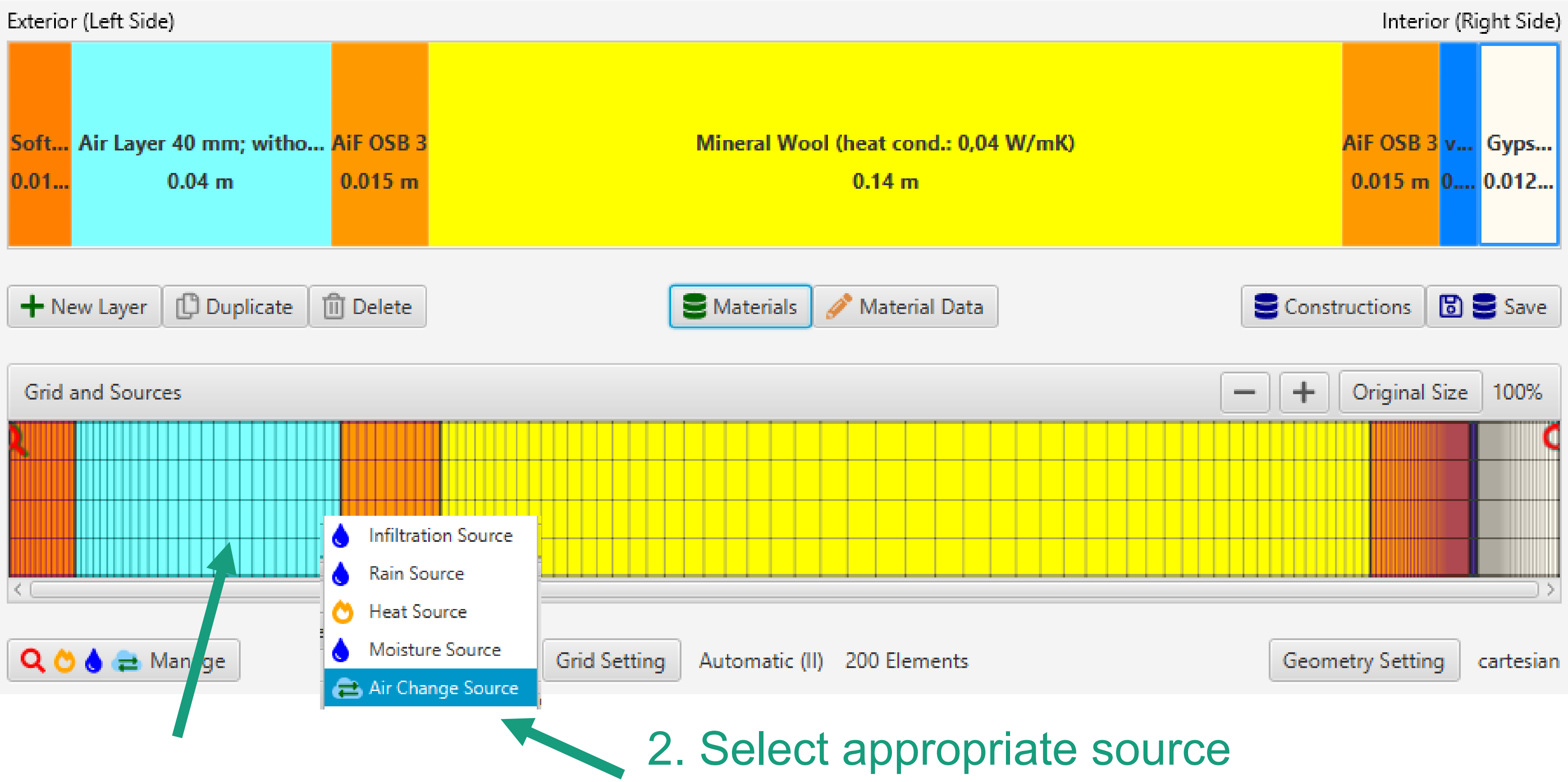
Please note



- Insert an air change source in the air layer
  → The exchange rate is dependent on construction, surface colour and ventilation openings
- Insert an air infiltration source at the cold side of the construction (at the position where condensation would occur)
  → depending on the air tightness of the building and the stack height
- Relevant orientation: North
- Short wave absorptivity depending on colour of surface
- Long wave emissivity depending on material of surface
- If the short-term hygrothermal behaviour of the outer surface is to be evaluated, switch on “Radiative overcooling”
- Rain parameters: Depending on inclination of component (vertical wall: 0.7)

Ventilated timber frame construction

Input: Air change source



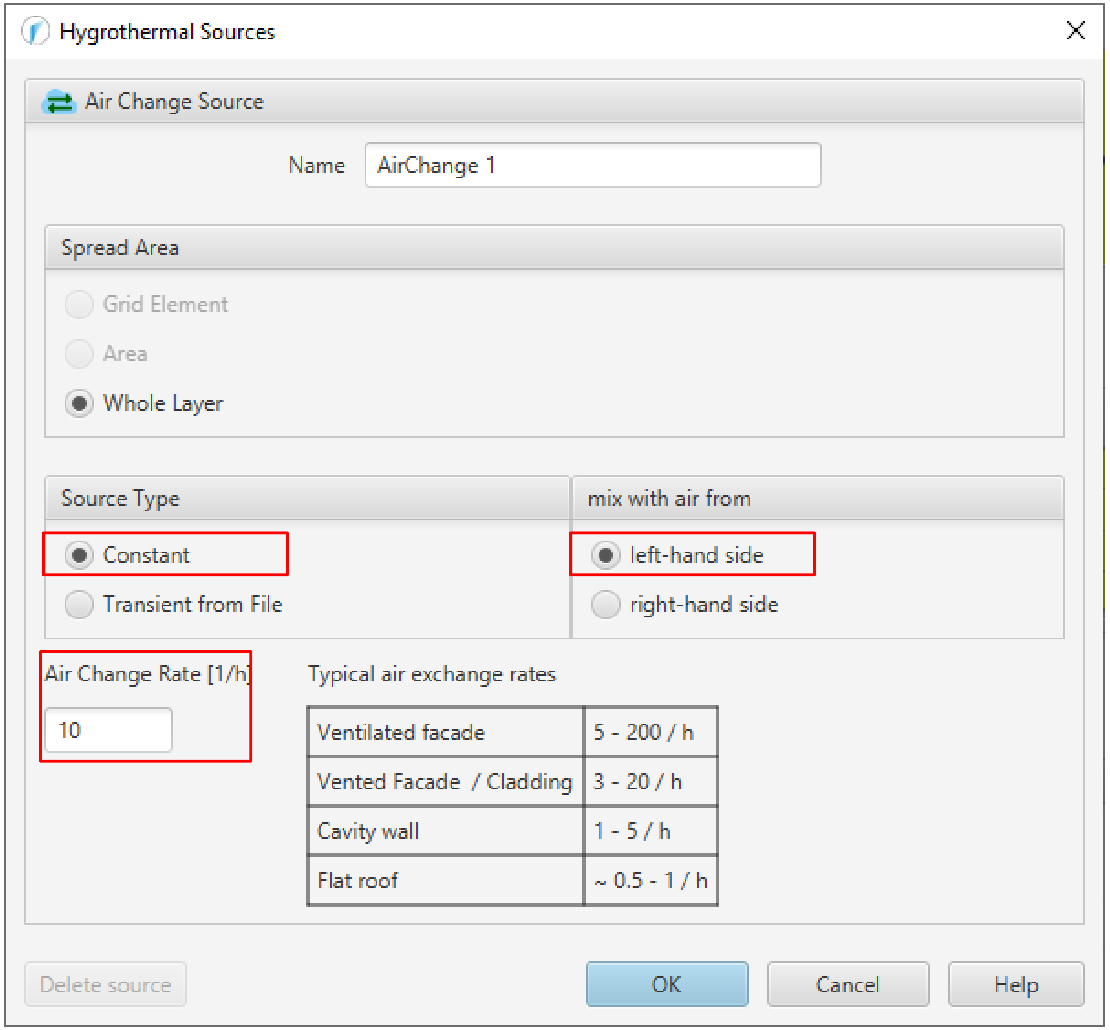
2. Select appropriate source

here: Air Change Source

1. Right mouse click
in the air layer

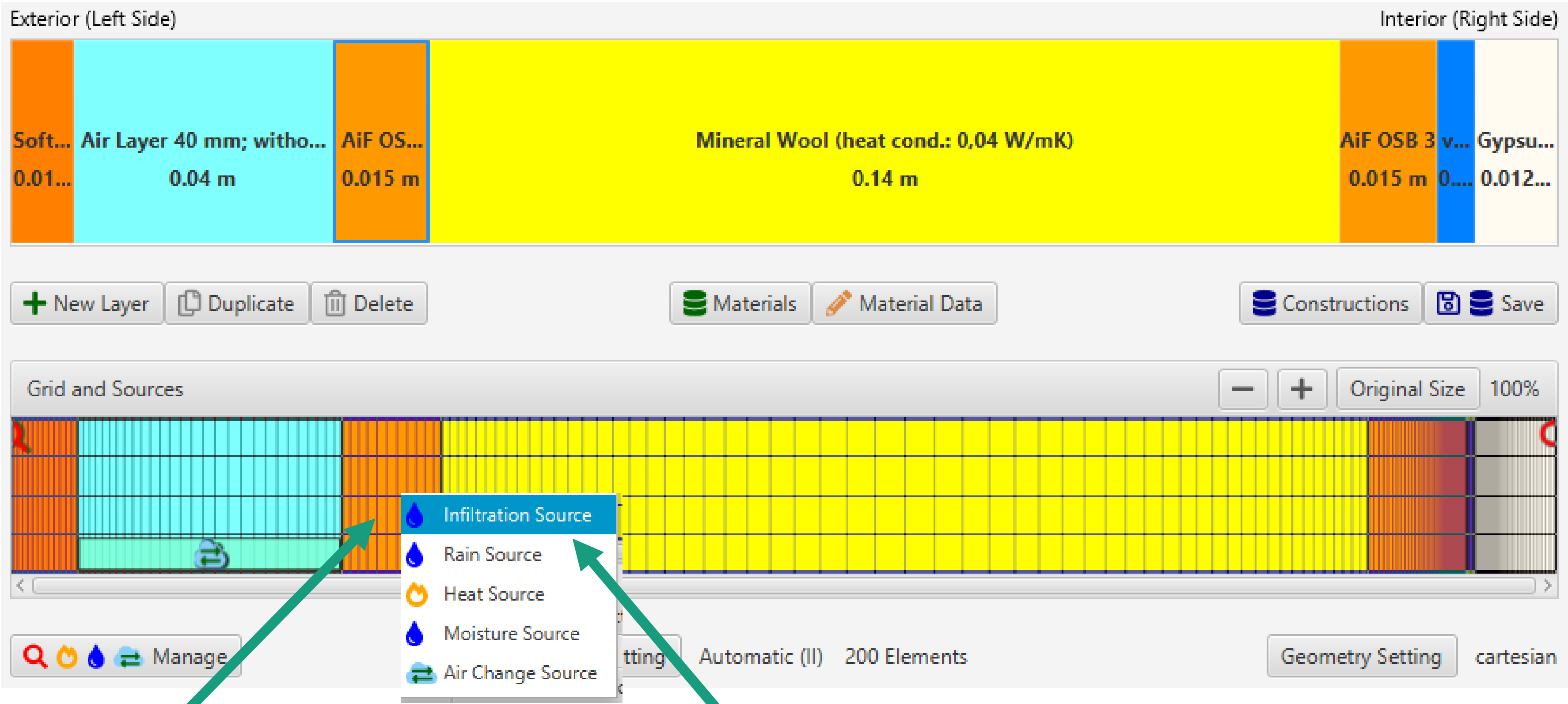
Ventilated timber frame construction

Input: Air change source



Ventilated timber frame construction

Input: Moisture source

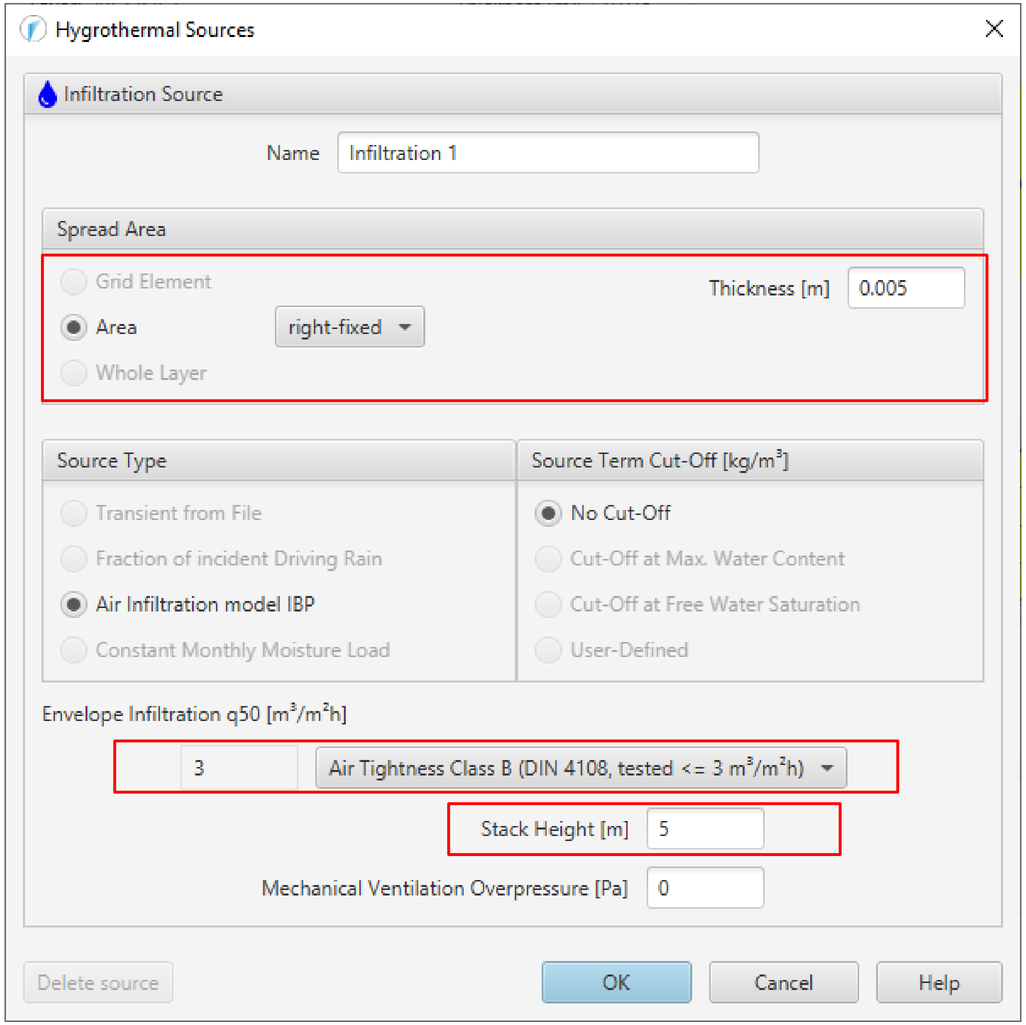


1. Right mouse click
   in the external cladding

2. Select appropriate source
   here: Infiltration Source

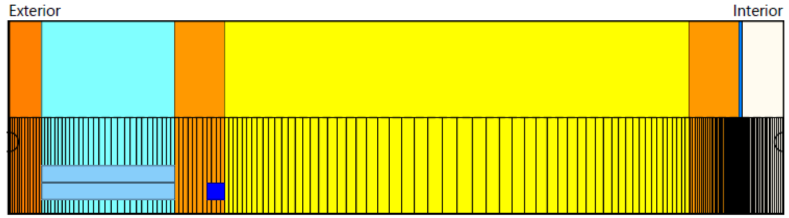
Ventilated timber frame construction

Input: Moisture source



Ventilated timber frame construction

Result analysis*

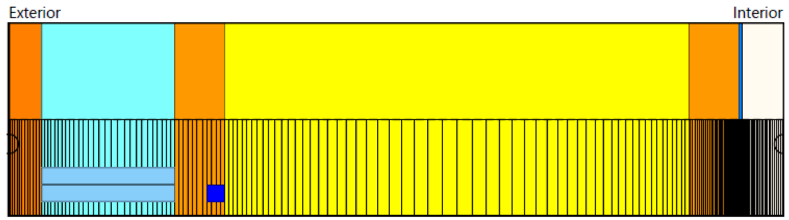


- Check the numerical quality of the result using convergence failures and balances! (→ Guideline for the Result Evaluation)
- Check total water content
  → regular, periodic course?
  → accumulation of moisture in whole construction?
- Check water content in the external cladding
- If necessary, check moisture content of the insulation

***) Note: List not necessarily complete. Depending on boundary conditions additional critical positions may occur**
→ Check film

Ventilated timber frame construction

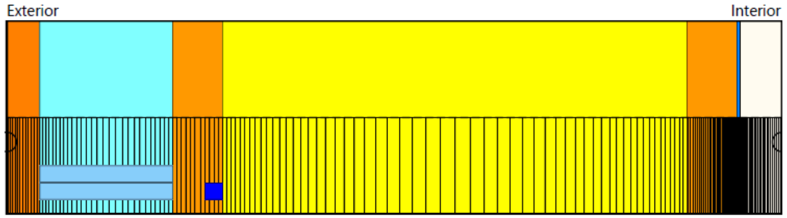
Additional information



- As the occurring air exchange rates are often not known, it may be useful to vary the air exchange rate to see its influence on the hygrothermal behavior of the construction.
  (Information on this can be found in the WTA Guideline 6-2-2014 chapter 5.1)

Ventilated timber frame construction

Additional information



- Examples for air change rates for ventilated facades

Guide values for air changes	Flow rate [(m³/h)/m²]	Gap [mm]	ACH [1/h]
Wood Siding	≈ 1,83	≈ 5	20
Vinyl Siding	≈ 9,14	≈ 5	200
Facing brick	≈ 2,74	≈ 25	10
Stucco (vented)	≈ 1,83	≈ 10	10
Sheathing flanking flow*	≈ 0,91	≈ 5	10

*The flank flow refers to the leaks in the area on the outer panel.

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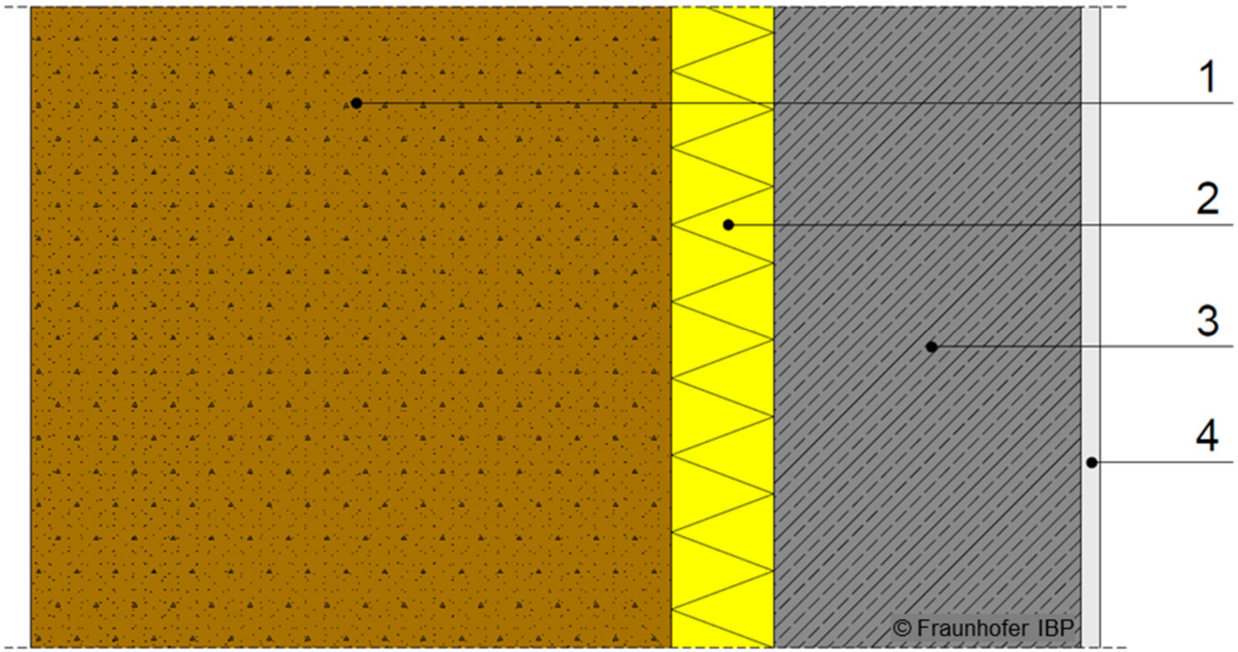
Basement wall without ground water

Interior component

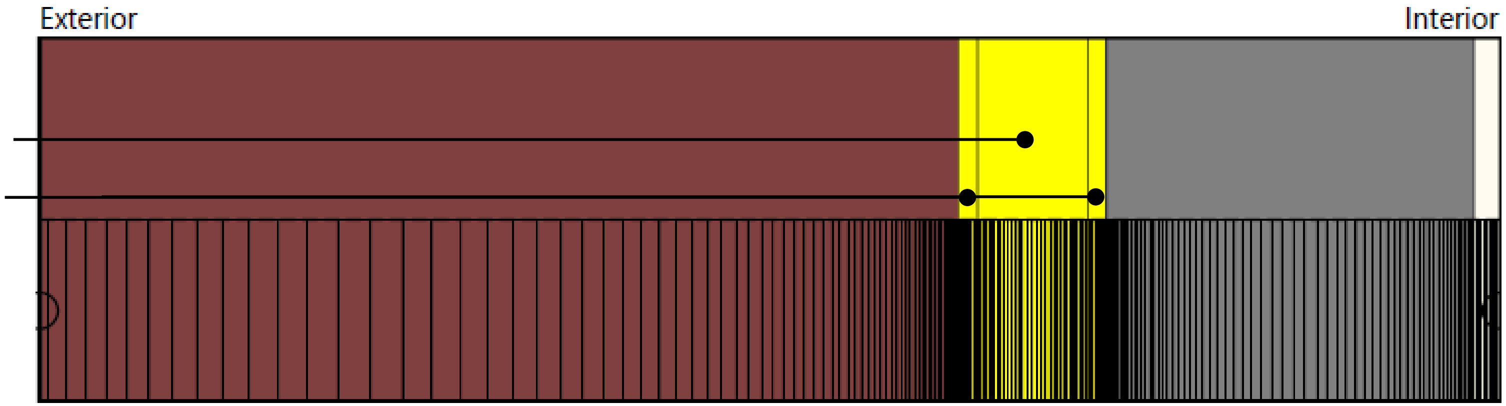
Basement wall (without ground water)

Construction drawing

1 Soil
2 Perimeter insulation
3 Concrete wall
4 Interior plaster



Assembly in WUFI



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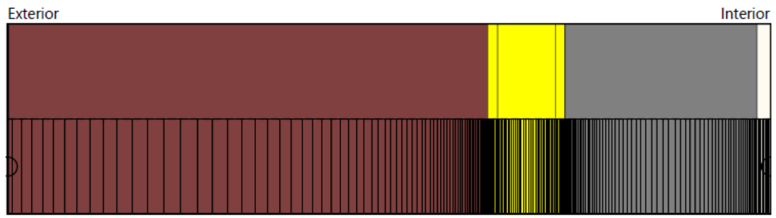
Basement wall (without ground water)

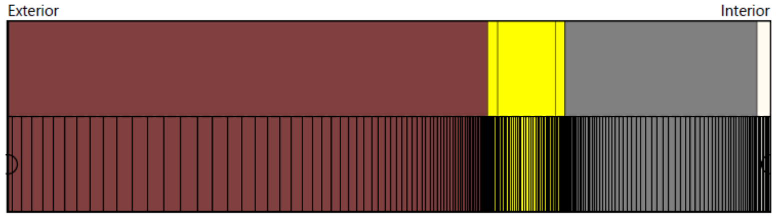
Please note



- Insert the soil layer as a separate material layer in the simulation in order to take into account the interaction between the construction and the soil.
  → Generic material data „Soil 'Christian' DIN“ with a thickness of about 0.5 m
- The XPS perimeter insulation consists of the core and the outer surface skin, each 1 cm thick (is defined as a system in the material database).
- Heat transfer coefficient (exterior): „Basement“
- No radiation absorptivity / emissivity
- No rainwater absorption
- Set interior climate depending on utilization

Basement wall (without ground water)

Please note



Temperature at the exterior surface (soil temperature)

- The WTA Guideline E-6-2 (12/2024) recommends applying a sinusoidal annual curve depending on the outdoor climate and the depth below ground level. Up to a depth of 2 m, the values to be used for the hygrothermal references years are given in a table.
- DIN 4108-3 from 2024 specifies a siplified approach with a minimum value of 1 °C at the beginning of February and a maximum value of 17 °C at the beginning of August.
- Alternatively, the values for the soil temperatures can also be taken from the literature (e.g. values from the diagram on the next slide) and applied as a sine curve. (This procedure is described in the following as an example)

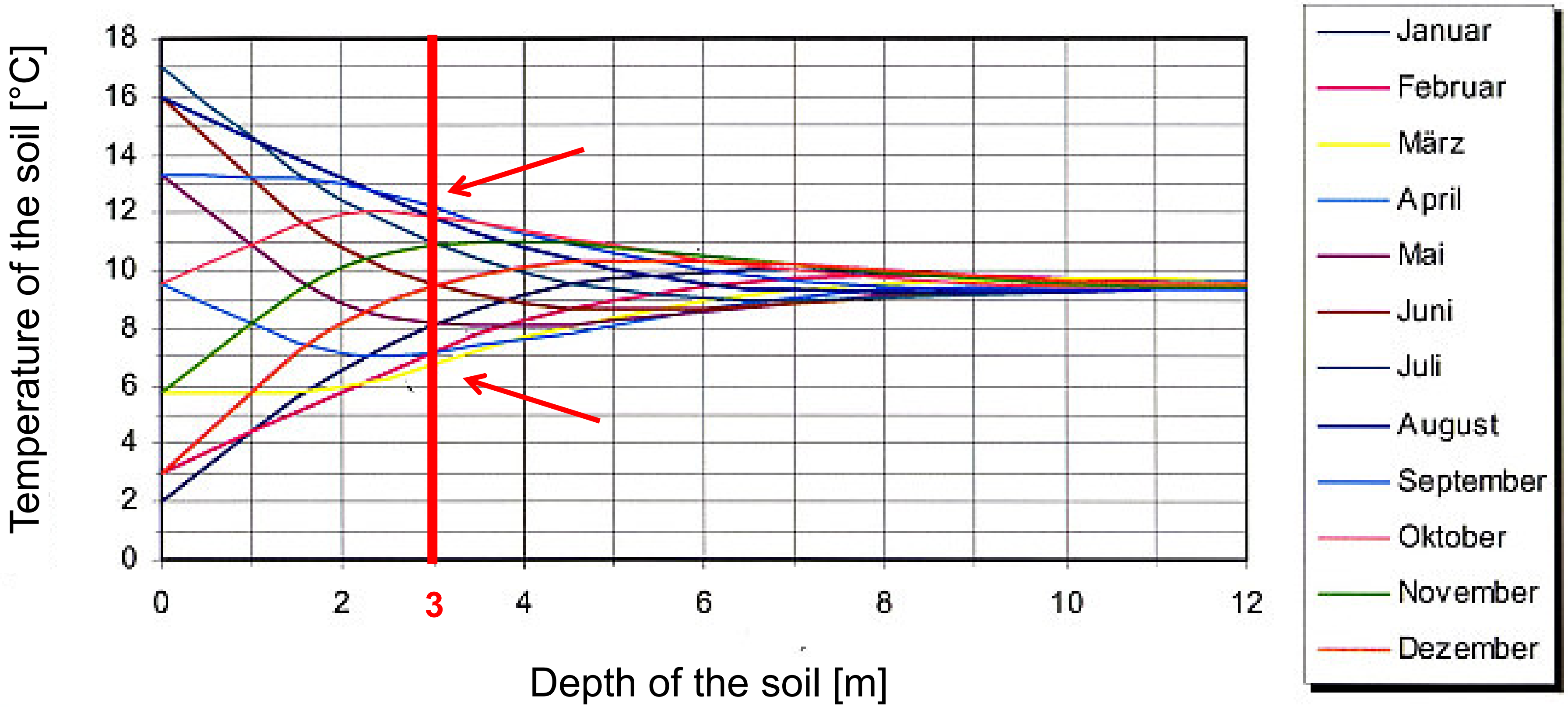
Relative humidity at the exterior surface

- All approaches should be combined with a relative humidity of 100 %.

Basement wall (without ground water)

Input: Soil temperature

Average soil temperature for each month depending on the depth of the soil

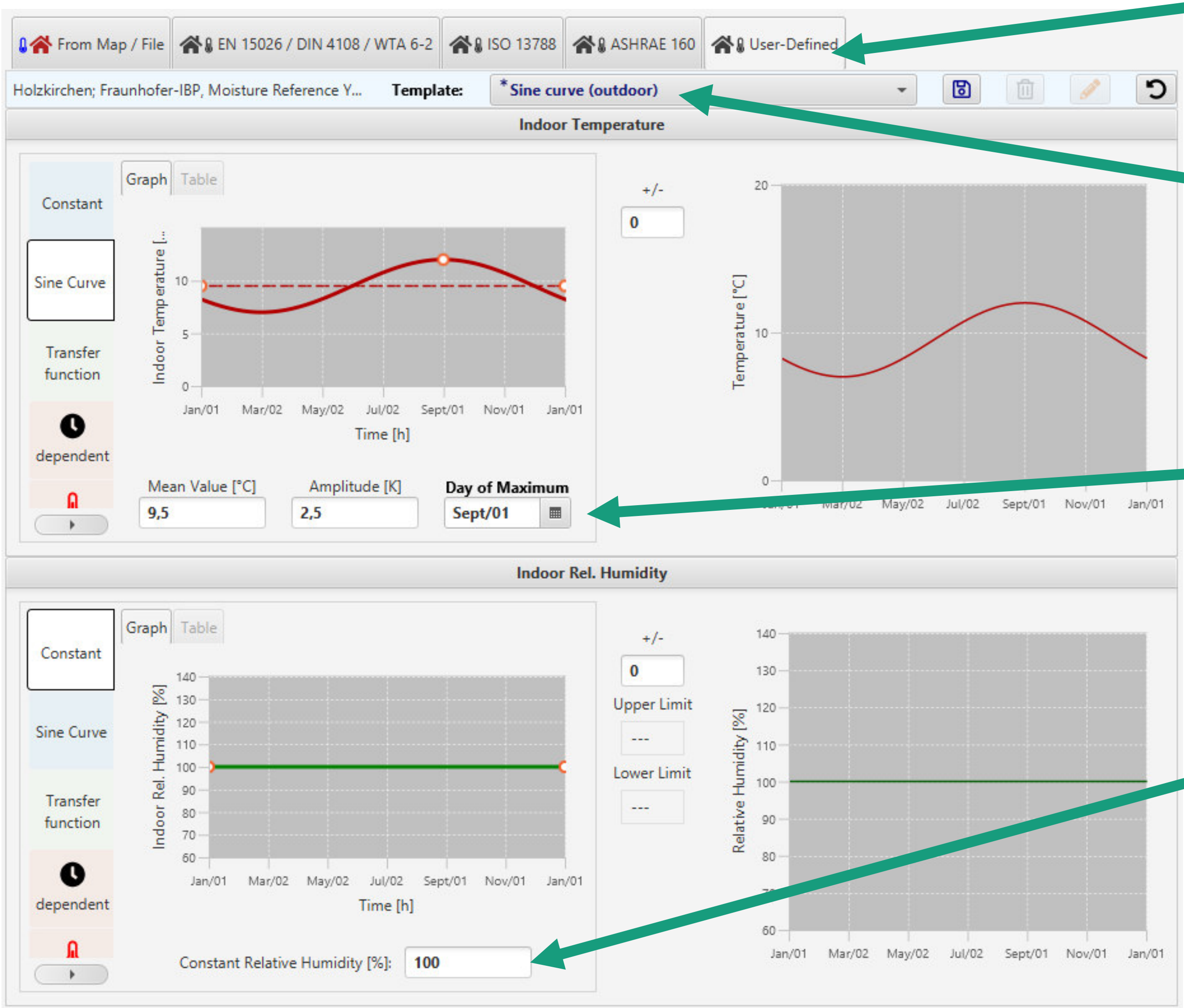


Example for a depth of 3 m:
Minimum of about 7 °C in March and
Maximum of about 12 °C in September

Ref: Heidreich, U.: Nutzung oberflächennaher Geothermie zum Heizen und Kühlen eines Bürogebäudes. Symposium Energetische Sanierung von Schul- und Verwaltungsgebäuden, FH Münster 2006.

Basement wall (without ground water)

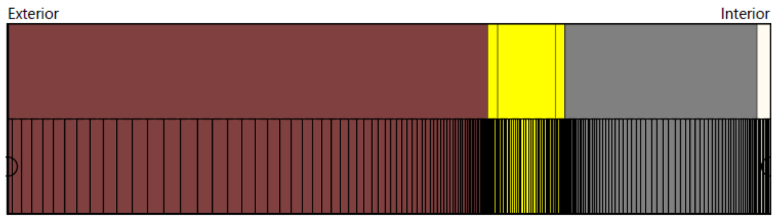
Input: Soil temperature



1. Select User-Defined
2. Select sine curve (outdoor)
3. Enter Mean value, Amplitude and Day of Maximum for the temperature
4. Relative humidity constant 100 %

Basement wall (without ground water)

Result analysis*

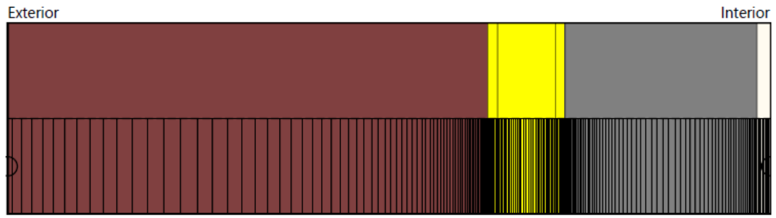


- Check the numerical quality of the result using convergence failures and balances! (→ Guideline for the Result Evaluation)
- Check total water content
  → regular, periodic course?
  → accumulation of moisture in whole construction?
- Check water content of insulation
- Check water content in masonry / concrete

***) Note: List not necessarily complete. Depending on boundary conditions additional critical positions may occur → Check film**

Basement wall (without ground water)

Additional information



- Set the initial water content in the soil to 99 % relative humidity in order to reach a steady state in the soil more quickly and thus reduce the computing time.
- If a capillary-breaking layer such as a dimpled membrane is used in front of the perimeter insulation, this can be modelled in the simulation using a foil. The thickness of the foil must not be changed; the s_d-value must be selected according to the used product.

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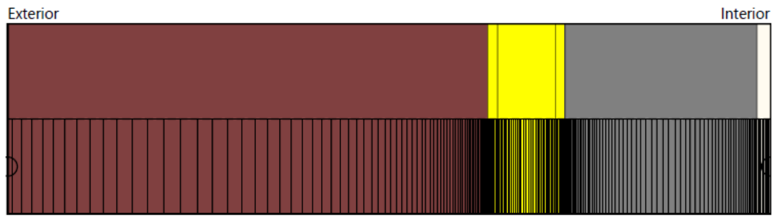
Basement wall (without ground water)

Additional information



<u>Consideration of water in the soil:</u>

- Material data containing moisture storage function and moisture transport coefficients (e.g. „Soil ‘Christian’ FSP“) must be used. Further soil materials can be found in the “North American Database in the “Soil” section.
- The soil has to be saturated during the calculation period (check water content after calculation).
- Create a climate file, which contains rain for each time step (with CreateClimateFile.xls).
- The rain parameters must be set to 1.
- Pressurized water can not be taken into account!

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Interior component (partition wall)

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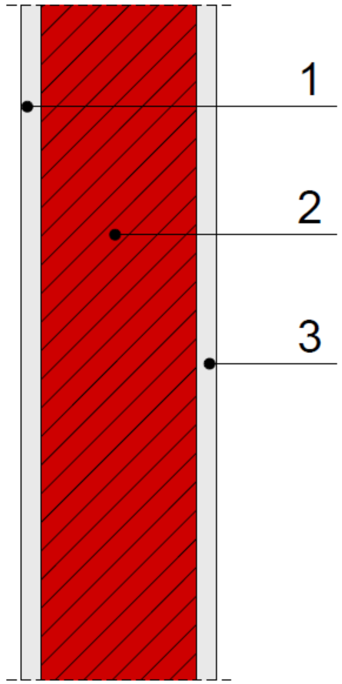
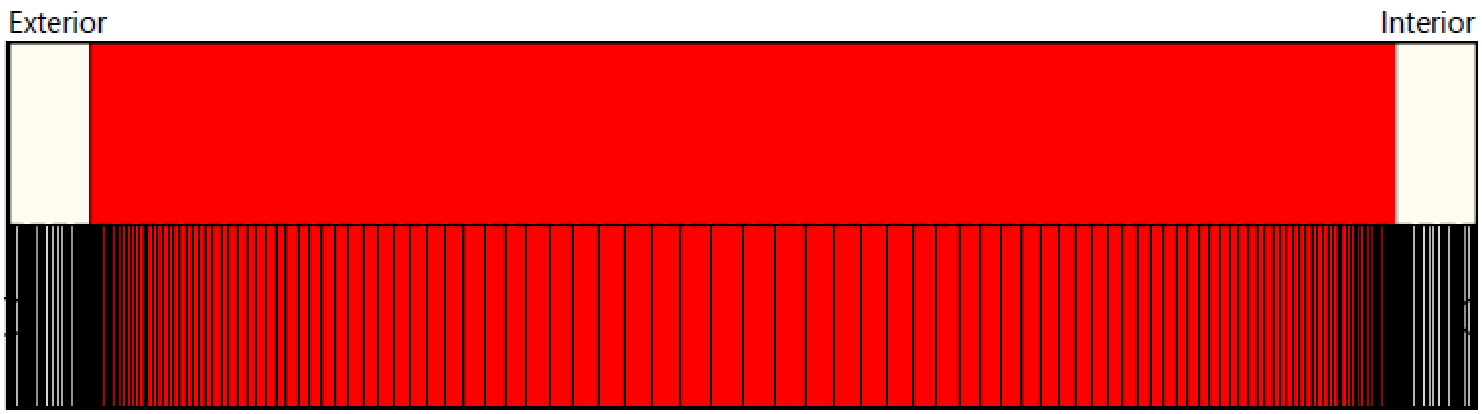


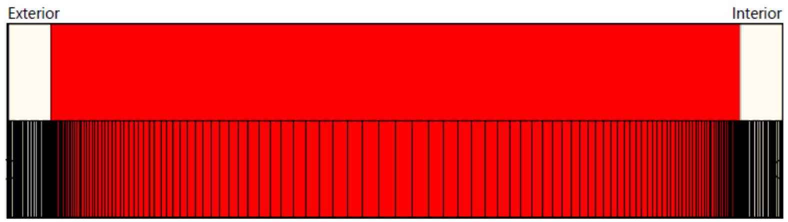
1 Interior plaster
2 Masonry
3 Interior plaster

Assembly in WUFI



Interior component (partition wall)

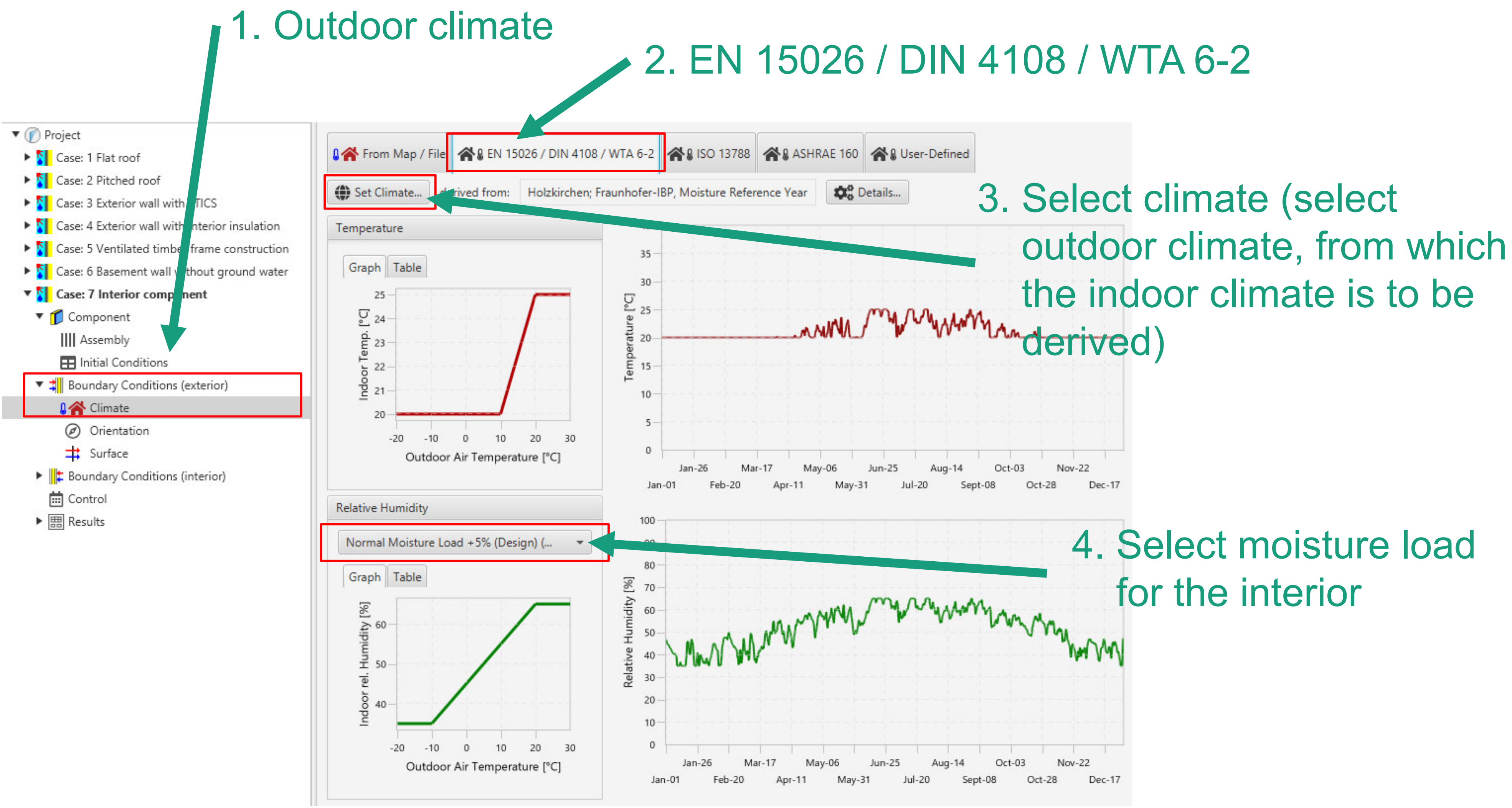
Please note



- Heat transfer coefficient „exterior“: 8 W/m²K (Partition wall)
- Heat transfer coefficient „interior“: 8 W/m²K (Partition wall)
- Indoor climate on both the outside and inside
    - Indoor climate according to DIN 4108 / EN 15026 / WTA 6-2 derived from the outdoor climate (outdoor climate must be selected)
    - Sine curves user-defined (e.g. for cellar rooms)
    - Constant indoor climate (e.g. for air conditioning)

Interior component (partition wall)

Input: Outdoor climate – according to EN 15026 / DIN 4108 / WTA 6-2



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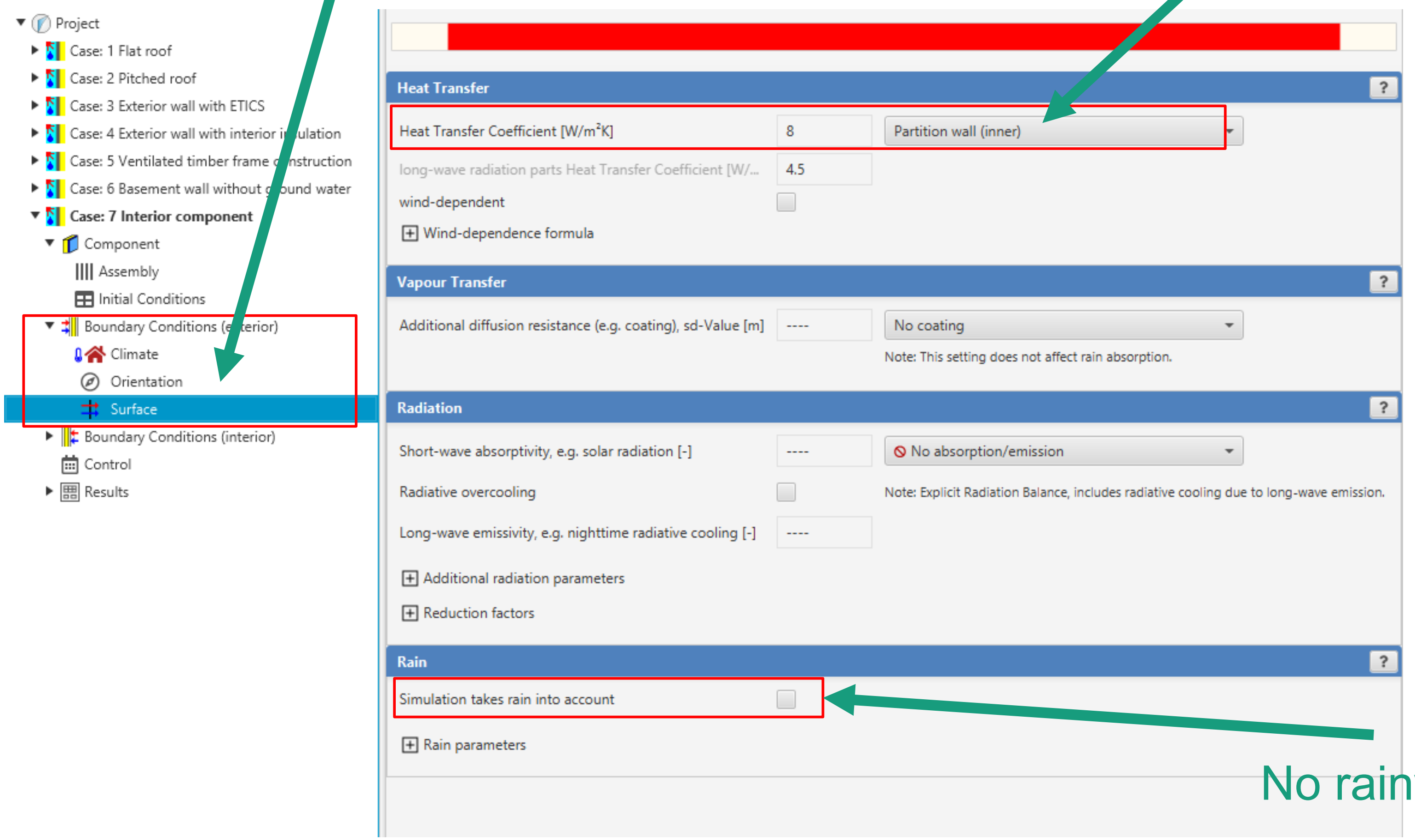
Interior component (partition wall)

Input: Outdoor climate – according to EN 15026 / DIN 4108 / WTA 6-2

Surface (exterior)

Heat Transfer Coefficient: Partition wall



No rainwater absorption

Interior component (partition wall)

Input: Outdoor climate – sine curve

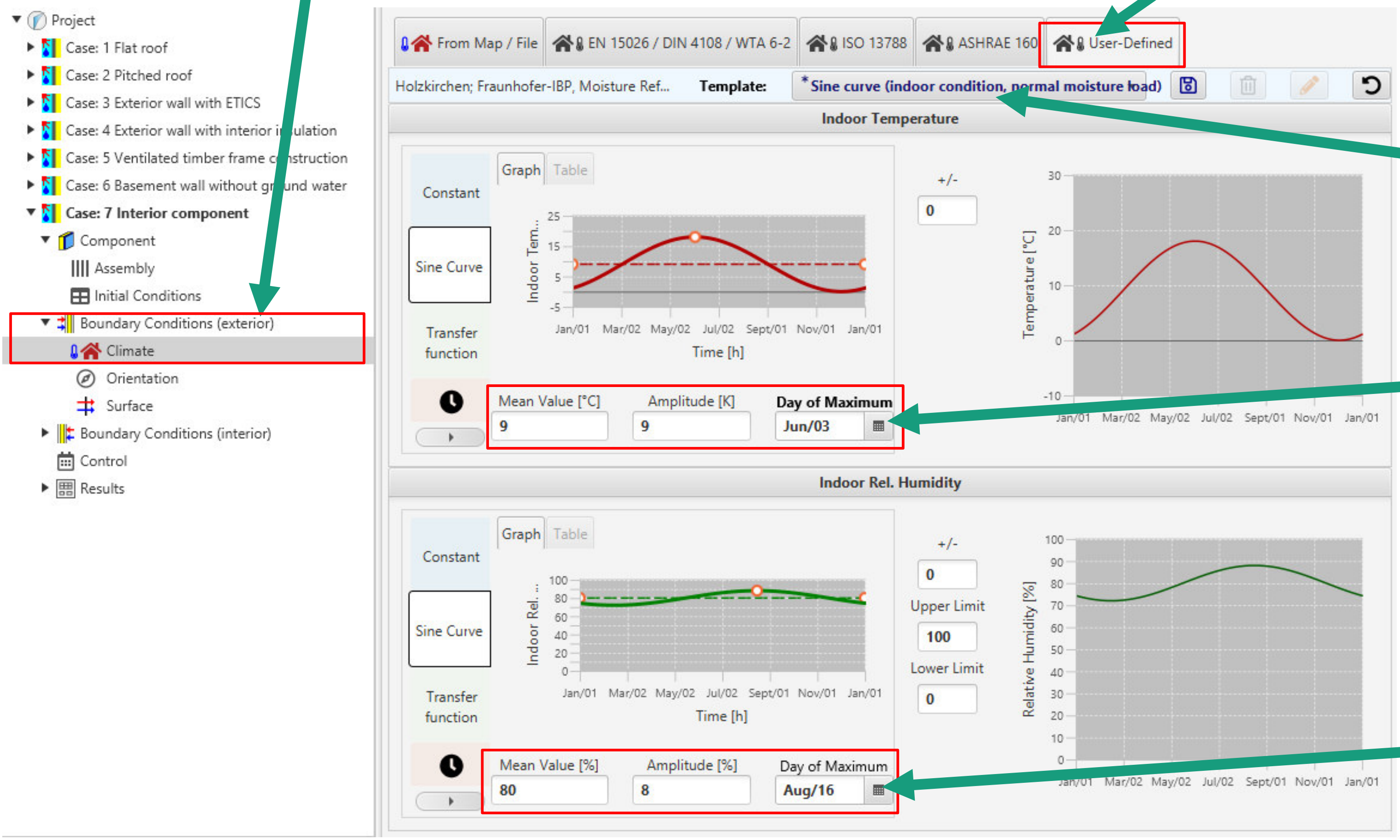
1. Outdoor climate

2. User-Defined

3. Select sine curve

4. Define sine curve for temperature

5. Define sine curve for relative humidity



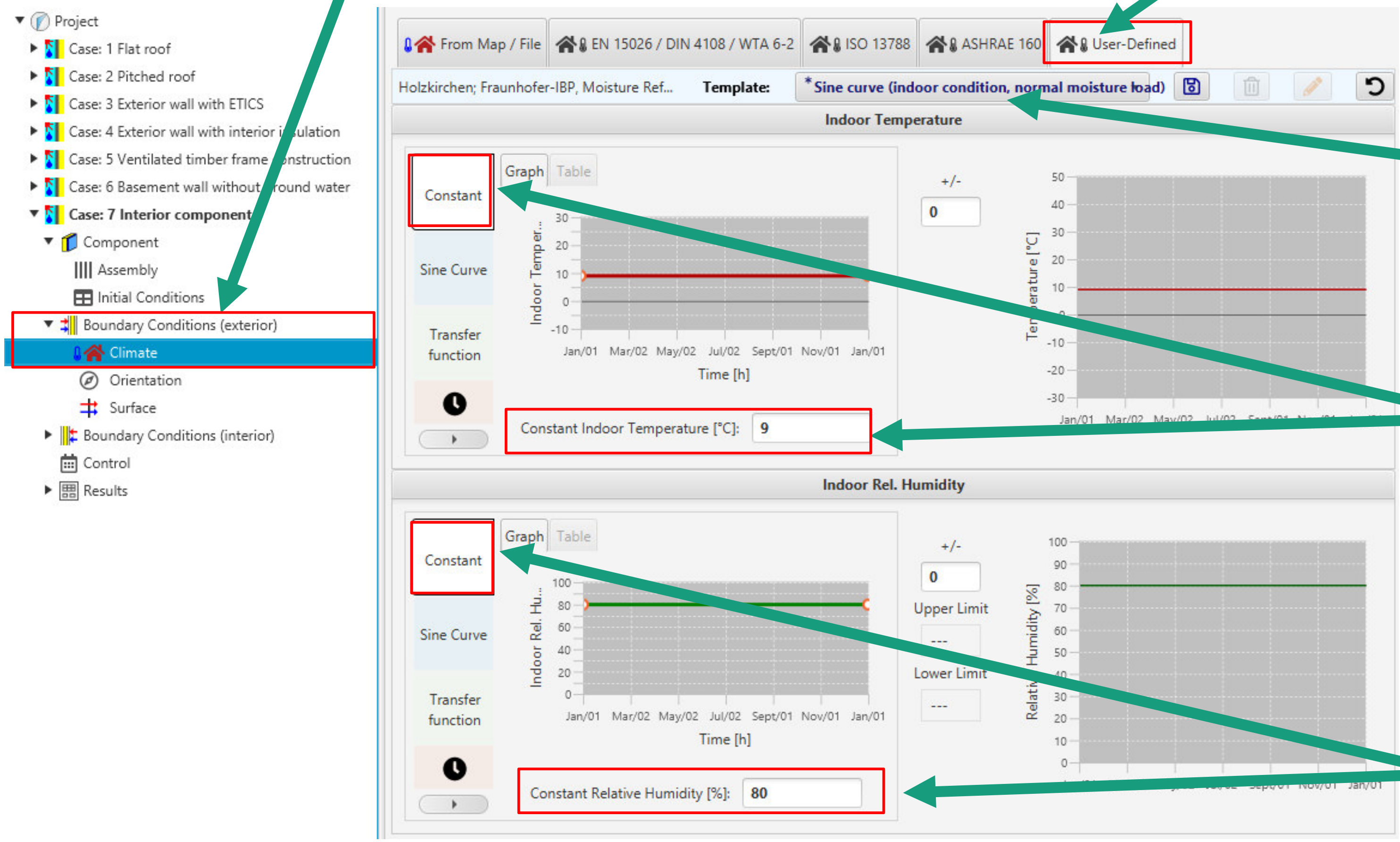
Fraunhofer IBP

Interior component (partition wall)

Input: Outdoor climate – constant climate

1. Outdoor climate

2. User-Defined



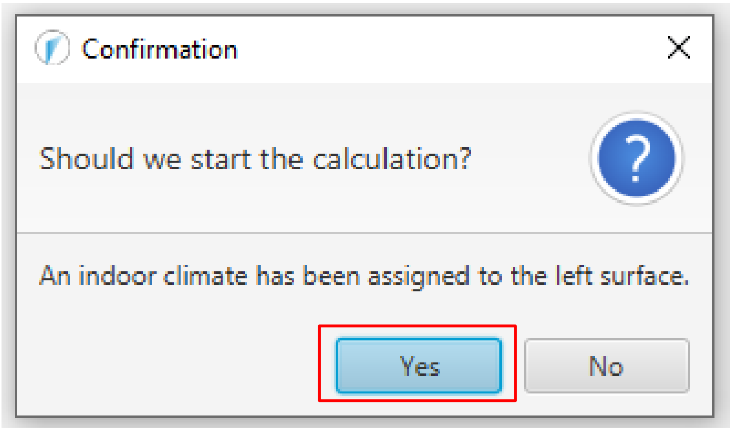
3. Select sine curve

4. Select „Constant“ and specify temperature

5. Select „Constant“ and specify rel. humidity

Interior component (partition wall)

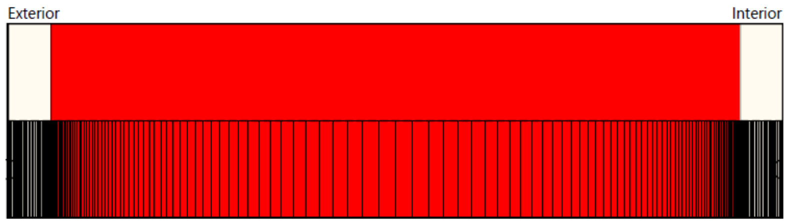
Warning at calculation start



- This warning appears at the start of the calculation and can be ignored for the calculation of an interior component

Interior component (partition wall)

Result analysis*



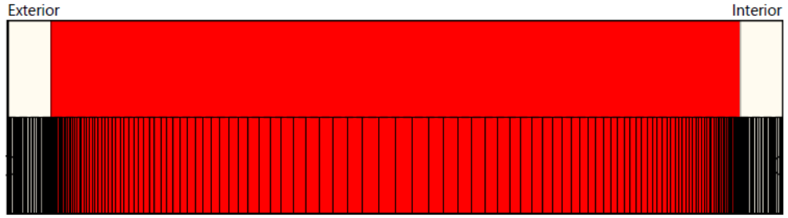
Evaluation depends on the type of construction / situation

- Check the numerical quality of the result using convergence failures and balances! (→ Guideline for the Result Evaluation)
- Check total water content
  → regular, periodic course?
  → accumulation of moisture in whole construction?
- Check the water content in individual materials, especially if they are sensitive to moisture

***) Note: List not necessarily complete. Depending on boundary conditions additional critical positions may occur**
→ Check film

Interior component (partition wall)

Additional information



- Critical positions can occur in particular, if the neighbouring rooms have significantly different temperatures.

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Handling of typical constructions

Auf Wissen bauen