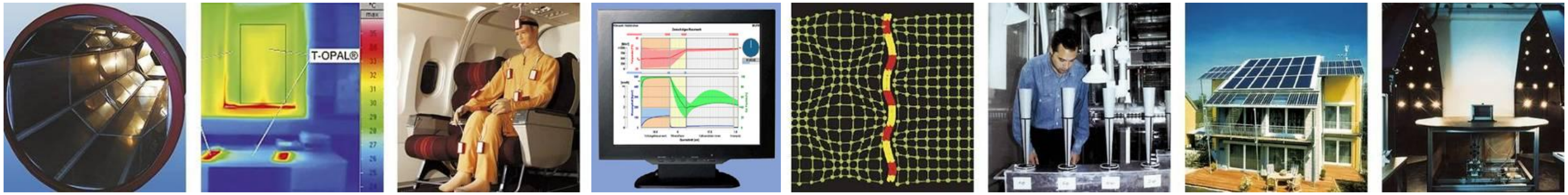


WUFI®

Guideline for Using the Air Infiltration Source in WUFI®

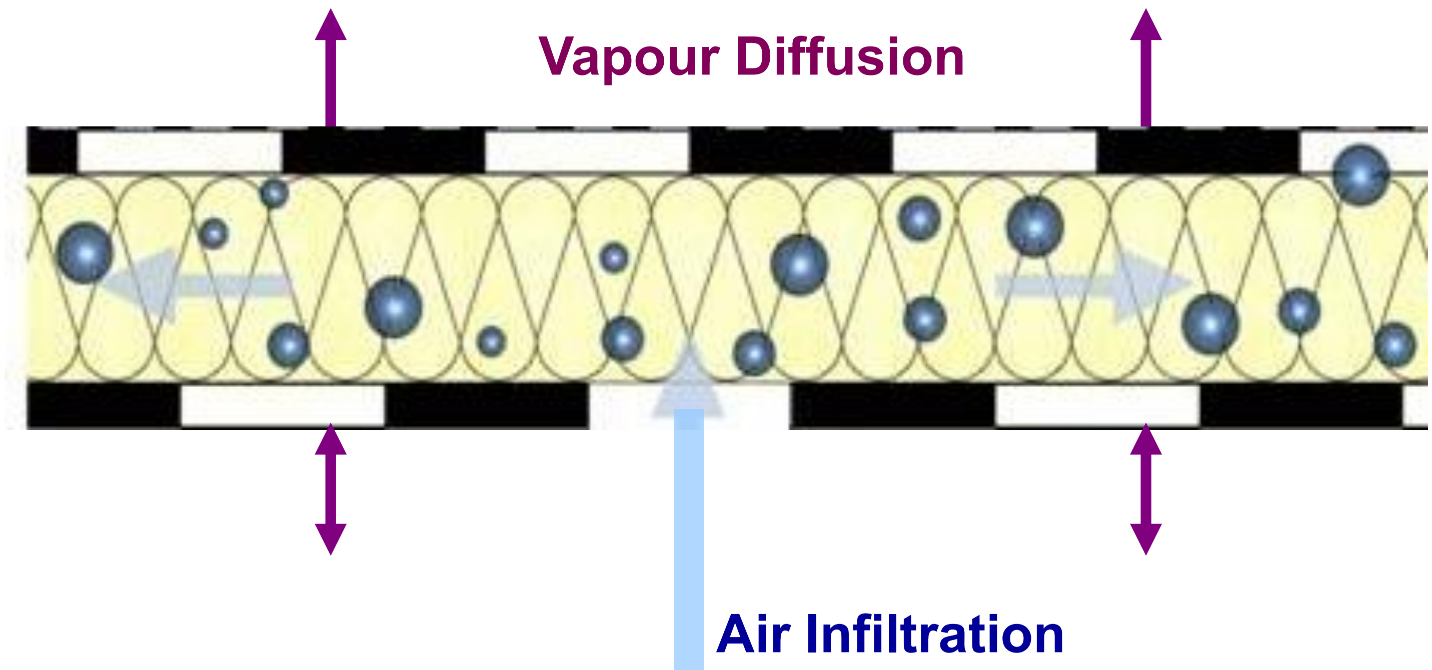
Date: July 2026

Fraunhofer
IBP

Content

Damage caused by Air Infiltration

Moisture entry by air infiltration due to small, unavoidable leakages.

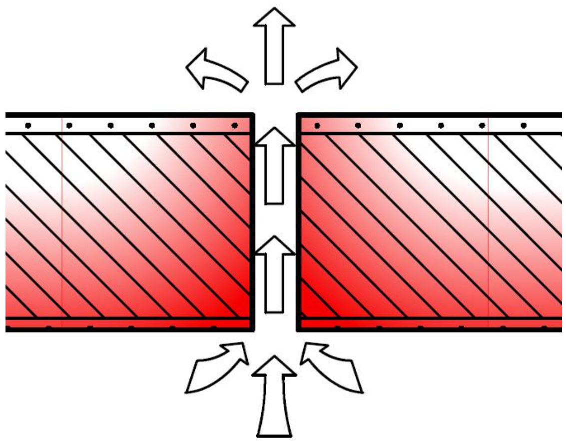


Problem: Moisture entry by air infiltration > Drying by vapor diffusion

Damage caused by Air Infiltration

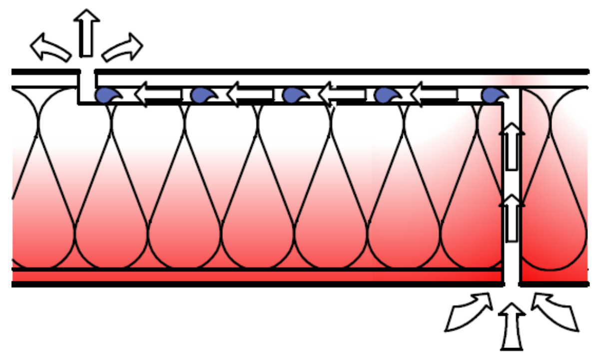
What kind of leakages are responsible for moisture damage?

“Energy“ leak



Warming of the flow path in case of strong air flux
→ no or only little condensation

“Moisture“ leak



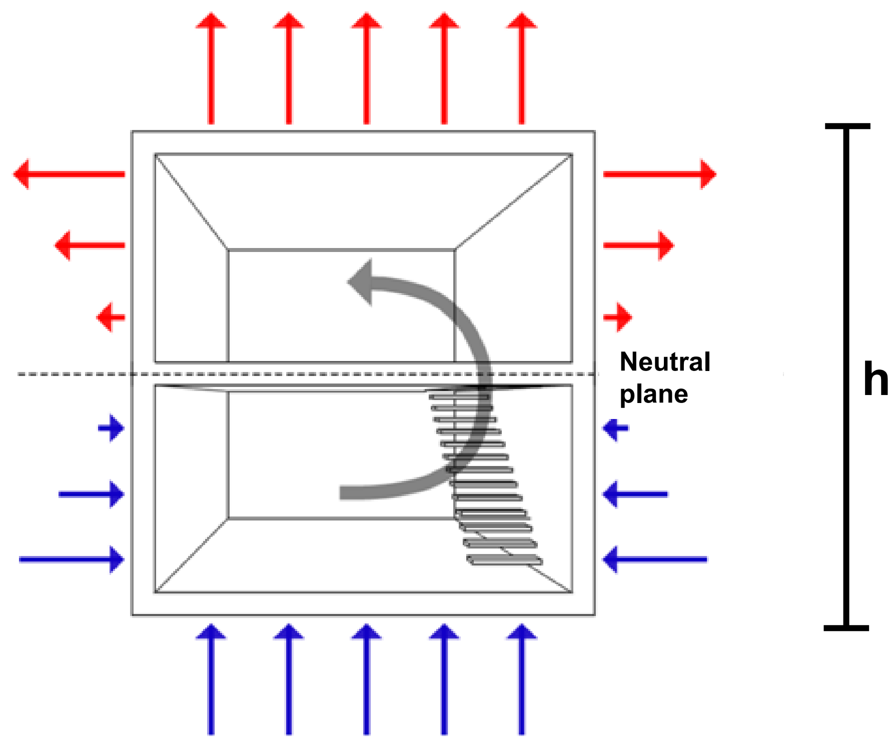
Cooling of the air in case of slow and tortuous air flux
→ potential of serious condensation

Dew water due to vapor convection only for “moisture” leakages, if $P_i > P_e$ and $\theta_{source\ position}$ < dew-point temperature of the indoor air.

Damage caused by Air Infiltration

Overpressure depends on:

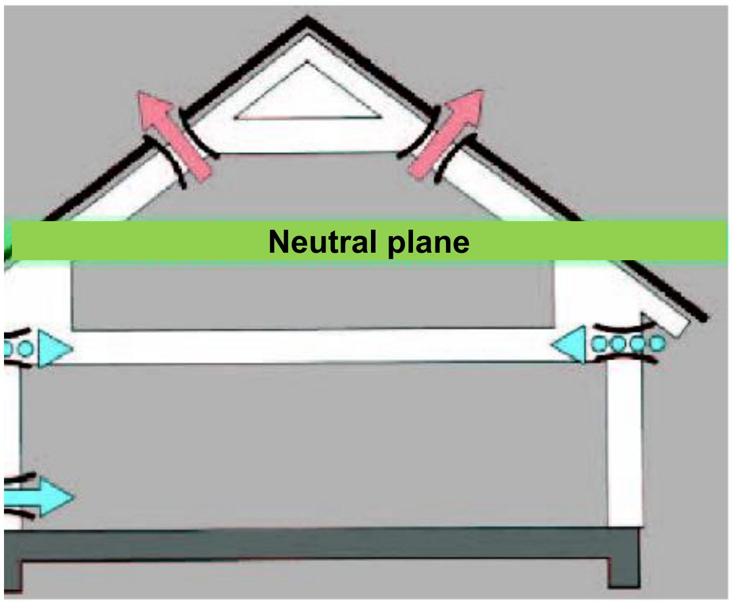
- temperature difference between indoors and outdoors
- height of connected indoor air volume

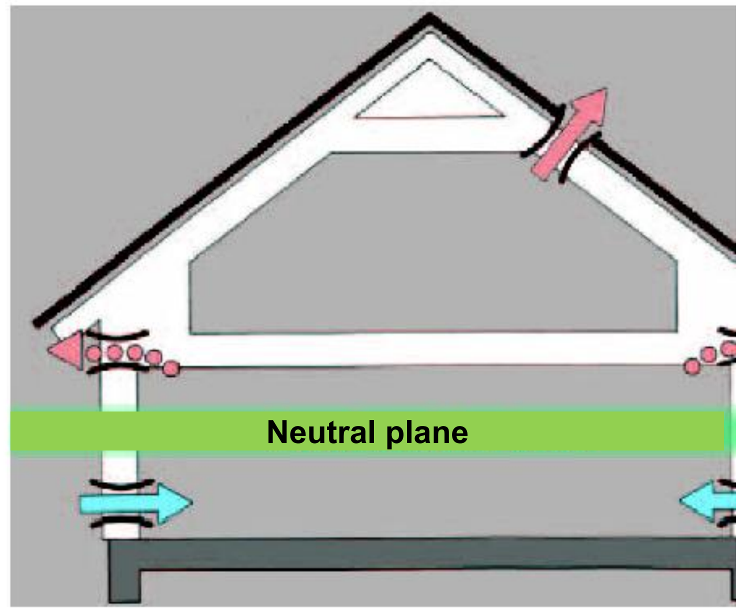


Overpressure due to buoyancy (stack effect) permanently present in winter

Damage caused by Air Infiltration

- Air flow in the overpressure range from inside to outside (moisture entry)
- Air flow in the vacuum range from outside to inside (drying)





→ No moisture problems due to convection in the bottom part of the building

Standards: EN 15026 and DIN 68800-2

EN 15026 [5] - principle

Provides the basis for considering infiltration in hygrothermal simulations by including convective moisture transport in the assessment.

Recommendation from EN 15026:

> *"For moisture control analysis by hygrothermal simulation, convective moisture supply should also be taken into account as a matter of principle if there are no justified reasons to rule it out."*

DIN 68800-2 [1] - requirement in Germany

The German wood protection standard (current 2022 version) specifies the application for Germany.

For wooden lightweight constructions, **air infiltration has to be considered as a standard case** for moisture design.

Thus, DIN 68800-2 turns the general EN 15026 principle into a concrete requirement for the relevant German application.

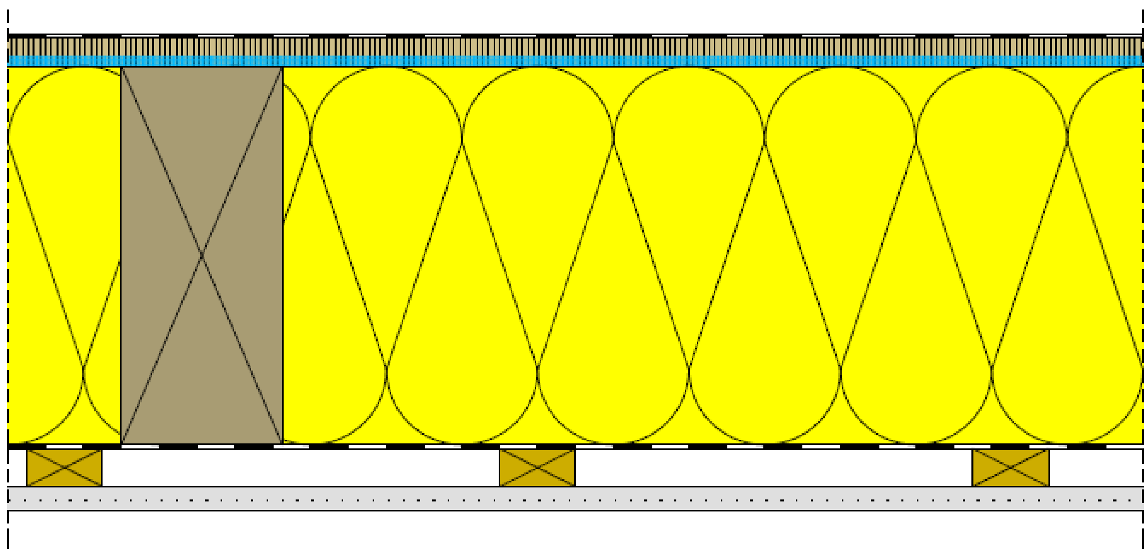
Practical consequence for this guideline

> **Use the WUFI® air infiltration source** for wooden lightweight components unless the exclusion of convective moisture supply is technically justified and documented.

Proceeding

All necessary input data for the simulation of a lightweight flat roof are described below with special focus on the air infiltration source.

Also, the evaluation of the construction will be explained.



Input – Component

Component – Assembly

Roofing membrane

The roofing membrane is not included in the calculation as a component layer but is considered as an s_d-value in the surface transfer parameters.

This leads to identical results but may speed up the calculation considerably compared to considering the roofing membrane in the component assembly.

Underlying roof assembly

The underlying layers are to be entered according to the assembly in the cavity axis.

Note: For the evaluation of the moisture conditions, mostly the cavity section is considered. This is where the most critical conditions normally occur due to the highest insulation level combined with the lowest vapour diffusion resistance: This leads to the highest vapor pressure gradients, while in the rafter section the vapor diffusion resistance is higher and the thermal conductivity lower.

Component – Assembly

Infiltration source

According to DIN 68800-2 [1], the amount of moisture that convectively enters the construction as a function of the airtightness always needs to be assessed for wooden structures and is considered in the simulation using the IBP infiltration model.

The moisture source must be placed at the position in the component assembly where the condensation water will form in practice – usually this is below the second airtight layer on the cold side of the component.

For roofs we recommend the following settings:

- with wooden sheathing: moisture source in the interior 5 mm of the wooden sheathing
- without wooden sheathing: moisture source in the exterior 5 mm of the insulation layer

Input – Infiltration Source

Component – Assembly

Infiltration source

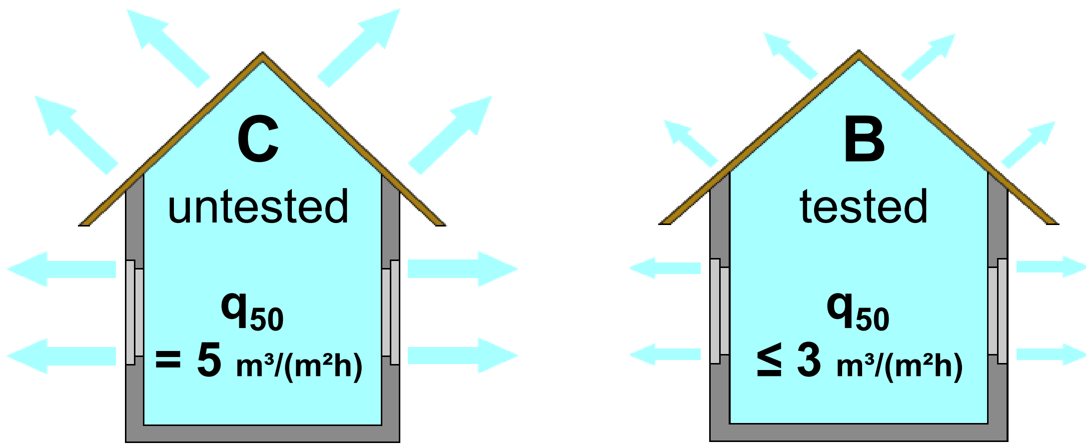
The amount of moisture entering in winter is automatically determined in the program depending on the overpressure due to the building's thermal buoyancy (temperature difference between outside and inside as well as specified air space height), the indoor air humidity and the specified airtightness of the building envelope [2].

The indvidual parameters are described in detail on the following slides.

Input – Infiltration Source

Air Infiltration Model IBP:

Envelope Infiltration q_{50} [m³/(m²h)]

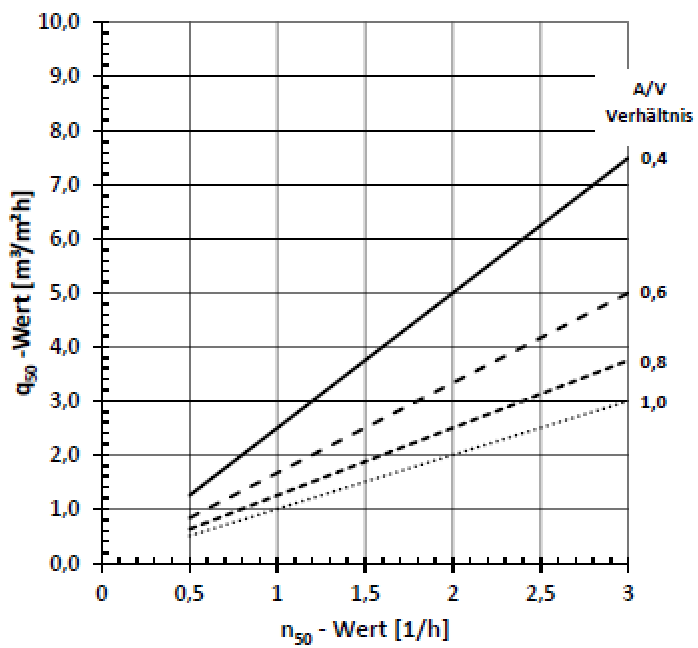


According to DIN 4108-3 [3], airtightness class C is to be used for untested buildings. With a measured q_{50}-value ≤ 3 m³/(m²h), airtightness class B can be applied.

Air Infiltration Model IBP:

Envelope Infiltration q_{50} [m³/m²h]

The air infiltration model requires the building envelope air permeability, q_{50} [m³/m²h]. If only the air change rate at 50 Pa (n_{50} [1/h]) is available, the corresponding q_{50}-value can be determined from the building's A/V ratio (envelope area-to-volume ratio) using the figure below:



formula: $q_{50} = n_{50} / (A/V)$

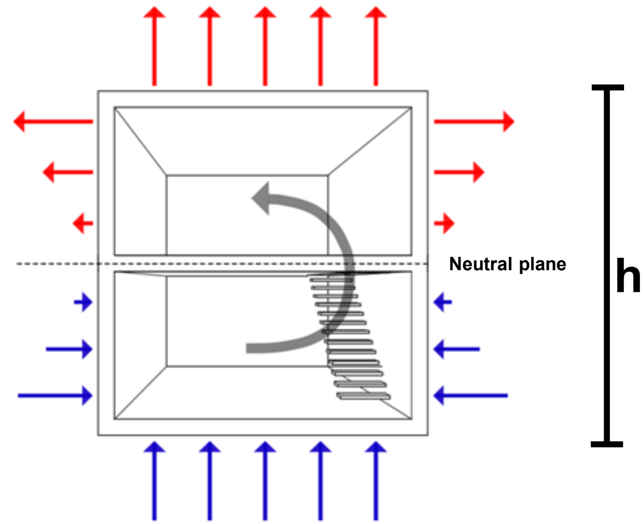
Source:
Holzbau Deutschland-Institut e.V.: Flachdächer in Holzbauweise. holzbau handbuch, Reihe 3, Teil 2, Folge 1. 2. Auflage, Januar 2019. Berlin.

Input – Infiltration Source

Air Infiltration Model IBP:

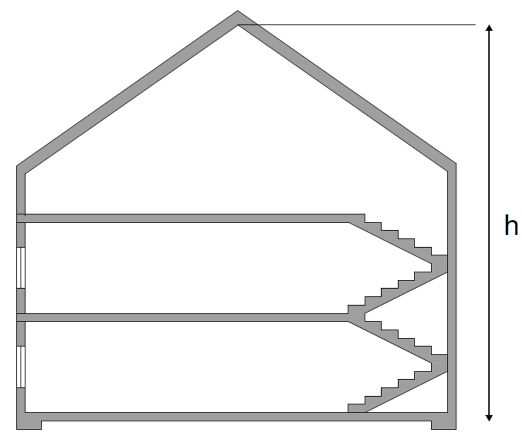
Stack Height [m]:

Corresponds to the height of the connected and heated indoor air space.



Example:
Single-family houses with open stairwell

→ here the total building height (h) should be applied (possibly including a heated cellar)



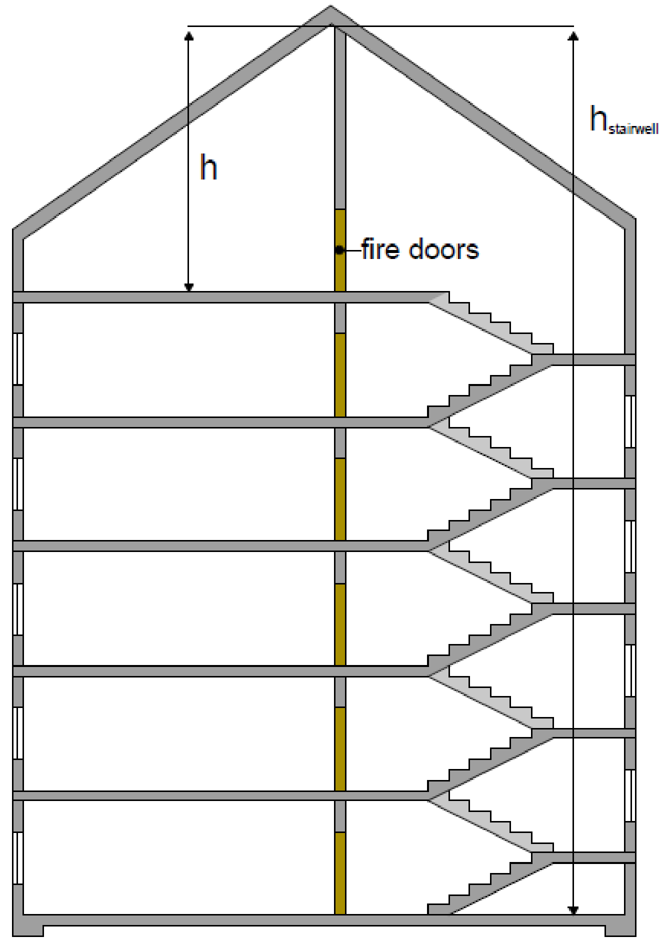
Input – Infiltration Source

Air Infiltration Model IBP:

Example:
apartment buildings with “separate“ stairwell

→ In case of pressure-sealed fire doors a meaningful reduction of the stack height is justified. For example, for the roof only the height of the upper floor (h) can be used (or two-story heights to be more on the safe side)

In the stairwell, the height of the contiguous air space would be significantly larger ($h_{stairwell}$), but in most cases the stairwell is unheated with a lower pressure difference between inside and outside. Furthermore, the moisture load in the stairwell is usually lower (this should be taken into account by suitable climate conditions).



Air Infiltration Model IBP:

Mechanical Ventilation Overpressure [Pa]:

Here, it is possible to take into account overpressures or negative pressures generated by existing air-conditioning systems.

The declared value is constantly set to the pressure difference between inside and outside.

Input – Infiltration Source

Air Infiltration Model IBP:

Summary:

Modelling of vapor convection due to leakages for the evaluation of the moisture protection with the help of hygrothermal simulations.

The moisture entry due to vapour convection is determined for every time step situation-specific depending on:

- the transient boundary conditions (interior and exterior climate)
- the temperature at the expected position of the condensation formation
- the airtightness of the building envelope
- the stack height

Input – Initial Conditions

Component – Initial Conditions

Initial Temperature and Moisture in Component:

A constant initial relative humidity of 80 % and an initial temperature of 20 °C should be used as a default setting.

If increased built-in moisture contents are known, these can be specified separately for the corresponding layer.

Input – Outdoor Climate

Boundary Conditions (exterior) – Climate

Outdoor Climate:

A climate appropriate for the location of the building should be used.

For Germany:

The hygrothermal reference years (HRY), which were created for 11 locations in Germany as part of a research project [4], are useful here. These locations are representative for the respective climate region. For more information, please refer to the
WUFI® Help (F1) → Topic: Hygrothermal Reference Years

The Holzkirchen location, with 20% reduced radiation, is considered critically representative of German locations up to altitudes of 700 m. This can be set in the simulation by reducing the absorption coefficient from a to a*0.8. This climate was also used for the exemption of deemed-to-satisfy constructions in DIN 4108-3 [3].

Input – Orientation / Inclination

Boundary Conditions (exterior) – Orientation

Orientation

The relevant orientation is usually North with the lowest radiation gains. Alternatively, for specific projects, the most unfavourable real orientation can be used. However, the orientation is only of minor importance for pitched roofs with an inclination close to zero degrees.

Inclination

The inclination of the roof must be specified according to the planned roof inclination.

Input – Surface Transfer Coefficients (exterior)

Boundary Conditions (exterior) – Surface

Heat Transfer

The heat transfer coefficient at the exterior surface is assumed to be 19 W/m²K for flat roofs according to experience values of IBP from numerous field and object investigations.

The 25 W/m²K proposed in some standards corresponds to an average wind speed of higher than 6 m/s, which is well above the average value for Germany with about 3.5 m/s and thus too far on the safe side. (If the short-term behaviour of the surface temperatures is also to be evaluated, the setting "wind-dependent" may be used).

Vapor Transfer (additional diffusion resistance)

The roofing membrane is not considered as a component layer but is specified as an additional diffusion resistance (s_d-value) in the surface transfer parameters.

Note: This value has no influence on rain absorption!

Input – Surface Transfer Coefficients (exterior)

Boundary Conditions (exterior) – Surface

Radiation: Short-Wave Absorptivity

The short-wave radiation absorptivity should be selected depending on the colour of the roofing membrane.

Radiation: Long-Wave Emissivity

For roofing membranes, the long-wave radiation emissivity is usually 0.9.

To consider the (night-time) overcooling, the explicit radiation balance must always be used for roofs due to its large field of view to the sky.

Rain

As the roofing membrane is assumed to be rain-tight, but is not included in the component in WUFI®, rainwater absorption is switched off.

Input – Indoor Climate

Boundary Conditions (interior) – Climate / Surface

Indoor Climate:

By default, we recommend using the indoor climate with medium moisture load + 5% for design purposes (according to DIN 4108-3 [3] and EN 15026 [5]).

Alternatively, depending on the use of the building, the indoor climate with low moisture load (according to EN 15026 [5]) or with medium or high moisture load (according to DIN 4108-3 [3] and EN 15026 [5]) can be applied. For example, constant or measured conditions can also be applied.

Heat Transfer:

The heat transfer coefficient at the interior surface is assumed to be 8 W/m^2K according to DIN 4108-3 [3].

Input – Control

Control

Period of Calculation:

It is recommended to start the calculation on October 1st, because the component usually moistens up further in the following winter months before drying out possibly starts in spring. This start date is therefore usually an extra stressing of the component.

The calculation time depends on the time the construction needs to reach steady-state conditions. Usually, a calculation time of 5 years is sufficient. It can be assumed that calculation times will tend to be shorter for diffusion-open components and longer for diffusion-tight components.

Evaluation - General

General:

Check the numerical quality of the result using convergence failures and balances!
→ Guideline for the Result Evaluation

No long-term moisture accumulation in the construction!

Evaluation of the total water content:

→ Usually only qualitative assessment of the moisture balance

→ Decreases: Component dries

→ No change over annual cycle:
dynamic equilibrium is reached

→ Long-term increase:
permanent moisture accumulation in the construction

Evaluation - General

General:

Evaluation of the water content in individual material layers:

→ Qualitative assessment of the moisture balance

→ Quantitative assessment of the moisture values

→ Initial increase: can be caused by a redistribution of the initial moisture in the construction

→ Long-term increase: moisture accumulation in the material layer

→ Moisture-sensitive materials (for example wood and wood-based materials…) must not exceed the respective limit values.

Evaluation - General

General:

Identification of critical positions within the construction:

→ Possible with WUFI® Animation1D (movie)

→ Extreme values in the relative humidity and in the water content often represent critical positions (for example at layer boundaries…)

Evaluation - Wood Decay

Wood decay – Evaluation according to DIN 68800-2 [1]

Critical moisture conditions regarding damage to the wood can occur if the moisture content limits of 20 % by mass for wood and 18 % by mass for wood-based materials specified in DIN 68800-2 [1] are exceeded over a long period.

However, this limit value includes high safety margins and, in contrast to the WTA guideline, no specifications are made for the evaluation range. In the case of thin wooden sheathing, the entire section of the sheathing shall be evaluated, otherwise the most critical 1 cm thick section should be used in accordance with the WTA evaluation.

If the wood moisture remains below the limit values (see above), no further evaluation is necessary.

Evaluation - Wood Decay

Wood decay – Evaluation according to WTA Guideline 6-8 [6]

If the limit value for wood of 20 % by mass according to DIN 68800 [1] is exceeded, also an evaluation according to the WTA 6-8 [6] can be carried out. Here, the evaluation of wood structures is carried out based on temperature-dependent limit values for the relative pore air humidity in a 1 cm thick layer at the relevant position of the wood. This allows a more accurate and realistic evaluation.

This evaluation is not permissible for wood-based materials, as other limit values for rotting processes may apply here.

Evaluation - Wood Decay

Wood decay – Evaluation according to WTA Guideline 6-8 [6]

Limit curve for wood decay depending on temperature (x-axis) and relative humidity (y-axis) according to WTA 6-8 [6].
Below the red limit line, wood decay is not possible in solid wood.

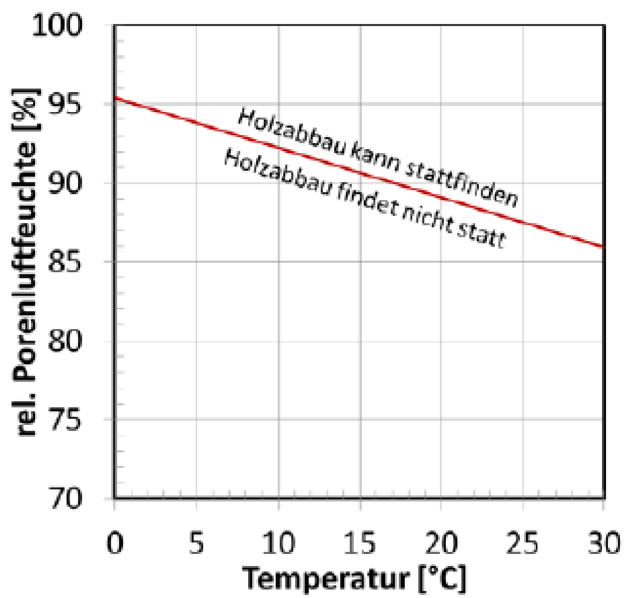


Abbildung 1: Grenzkurve der rel. Porenluftfeuchte bezogen auf die Temperatur einer 10 mm dicken Holzschicht, die im Tagesmittel nicht überschritten werden darf.

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Literature

[1] DIN 68800-2: Holzschutz - Teil 2: Vorbeugende bauliche Maßnahmen im Hochbau. Beuth Verlag, February 2022.

[2] Zirkelbach, D.; Künzel, H.M.; Schafaczek, B. und Borsch-Laaks, R.: Dampfkonvektion wird berechenbar – Instationäres Modell zur Berücksichtigung von konvektivem Feuchteeintrag bei der Simulation von Leichtbaukonstruktionen. Proceedings 30. AIVC Conference, Berlin 2009.

[3] DIN 4108-3: Wärmeschutz und Energie-Einsparung in Gebäuden - Teil 3: Klimabedingter Feuchteschutz - Anforderungen, Berechnungsverfahren und Hinweise für Planung und Ausführung. Beuth Verlag, March 2024.

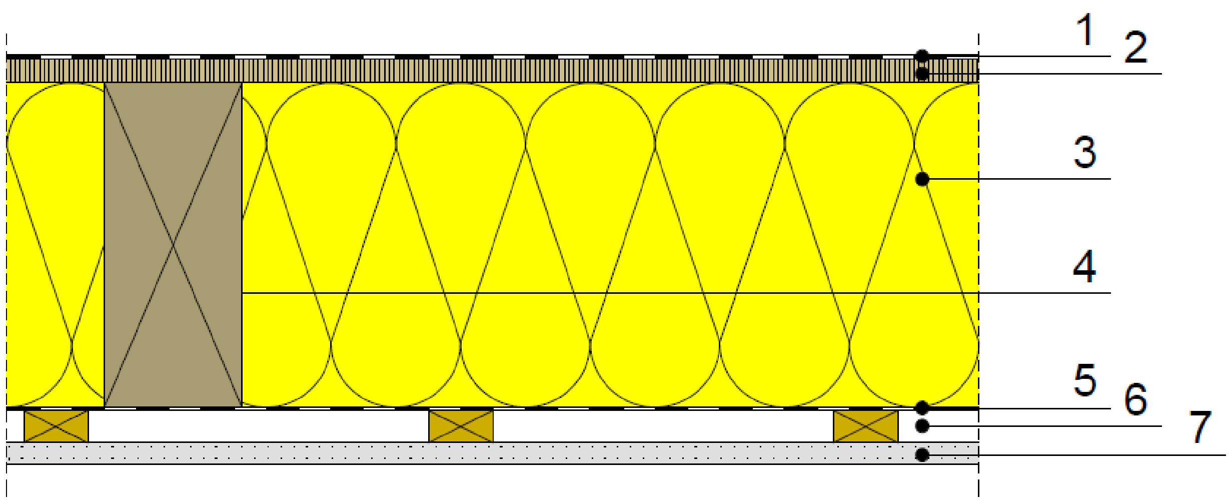
[4] Research Report: Energieoptimiertes Bauen: Klima- und Oberflächenübergangsbedingungen für die hygrothermische Bauteilsimulation. IBP-Bericht HTB-021/2016. Carried out on behalf of Project Management Jülich (PTJ UMW). July 2016.

[5] EN 15026: Hygrothermal performance of building components and building elements - Assessment of moisture transfer by numerical simulation. Beuth Verlag, December 2023.

[6] WTA Guideline 6-8: Feuchtetechnische Bewertung von Holzbauteilen - Vereinfachte Nachweise und Simulation. August 2016.

Example: Wooden Flat Roof Construction

Hygrothermal assessment of a wooden flat roof construction.



1 Roofing Membrane
2 Wooden Sheathing
3 Insulation
4 Rafter
5 Vapor Retarder
6 Installation Level
7 Gypsum Board

Example: Wooden Flat Roof Construction

Assembly (from outside to inside):

• Vapour retarder (s_d = 300m)		
• AiF OSB 3	0.022	m
• Mineral Wool (thermal cond.: 0.04 W/mK)	0.24	m
• PA-Membrane	0.001	m
• Air Layer (25 mm)	0.025	m
• Gypsum Board	0.0125	m

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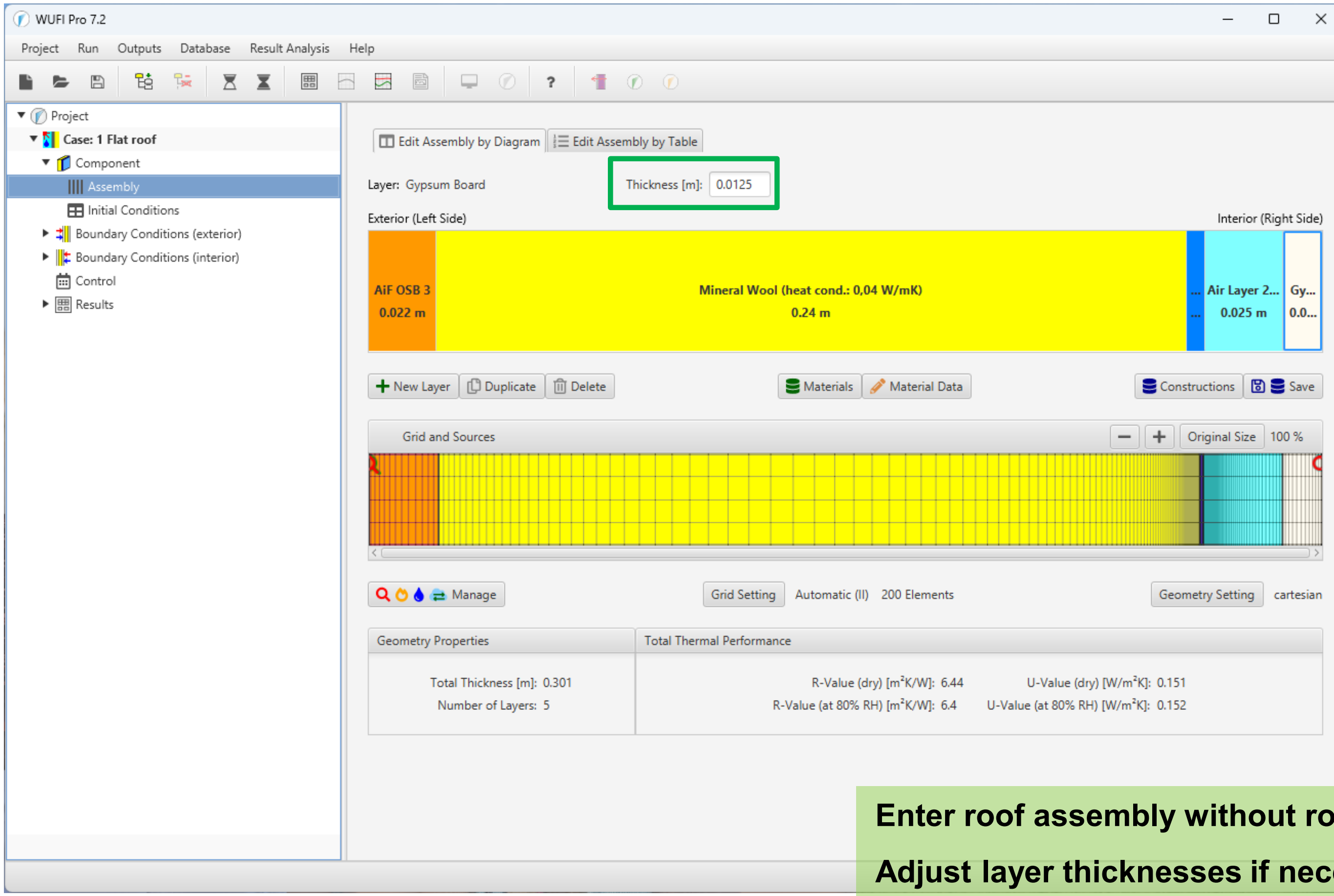
Example: Wooden Flat Roof Construction

Boundary Conditions:

- Flat roof (3° to the north)
- Dark roofing membrane:
  short-wave radiation absorptivity: 0.8
  long-wave radiation emissivity: 0.9
- Outdoor climate: Holzkirchen
- Indoor Climate: Medium Moisture Load + 5 %
  according to DIN 4108-3
- Envelope infiltration: q_{50} = 3 m³/(m²h)
- Stack height: 5 m

Example: Input – Component Assembly

Input: Component – Assembly



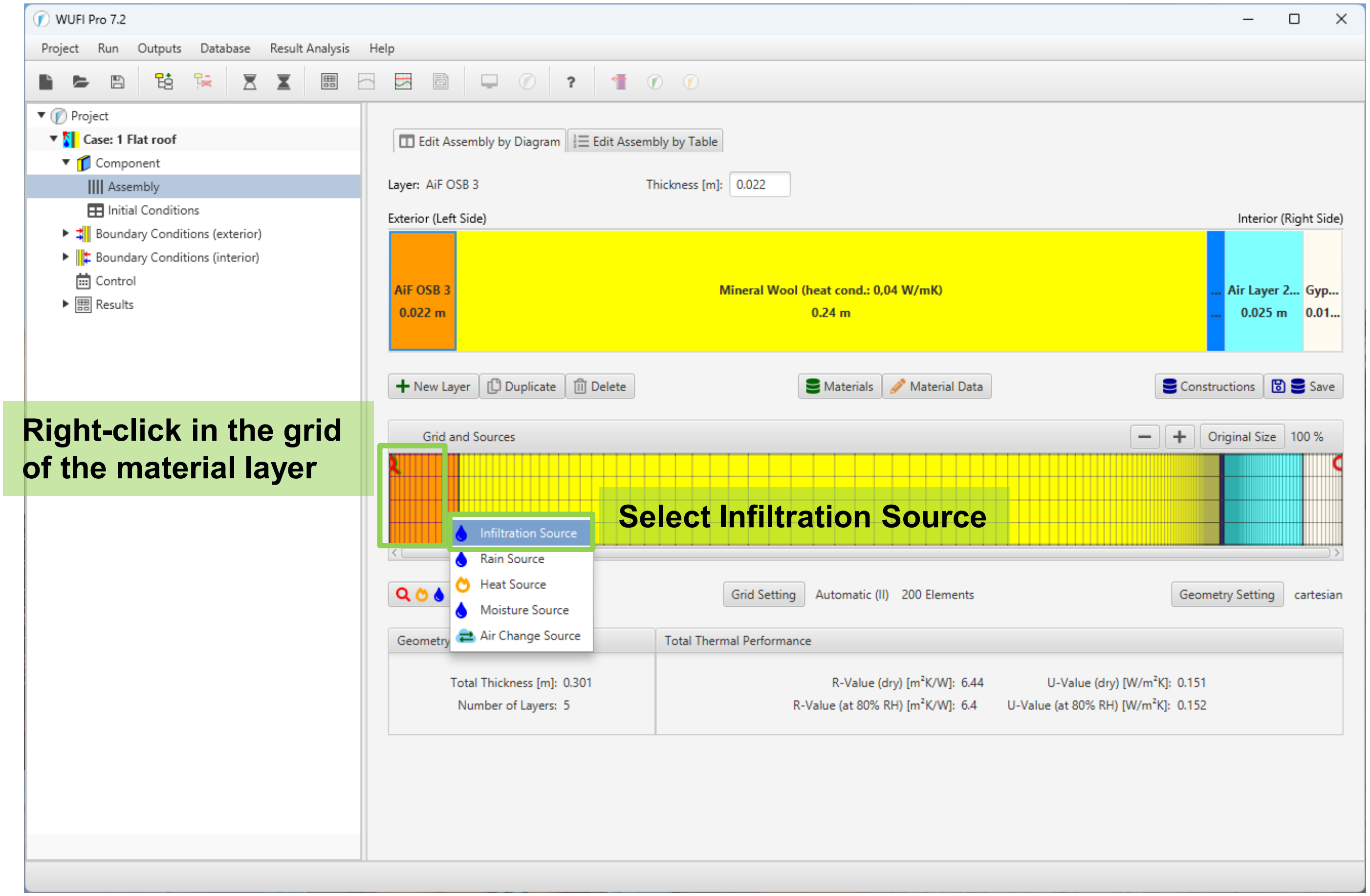
Enter roof assembly without roofing felt

Adjust layer thicknesses if necessary

Example: Input – Infiltration Source

__Input:__ Component – Assembly

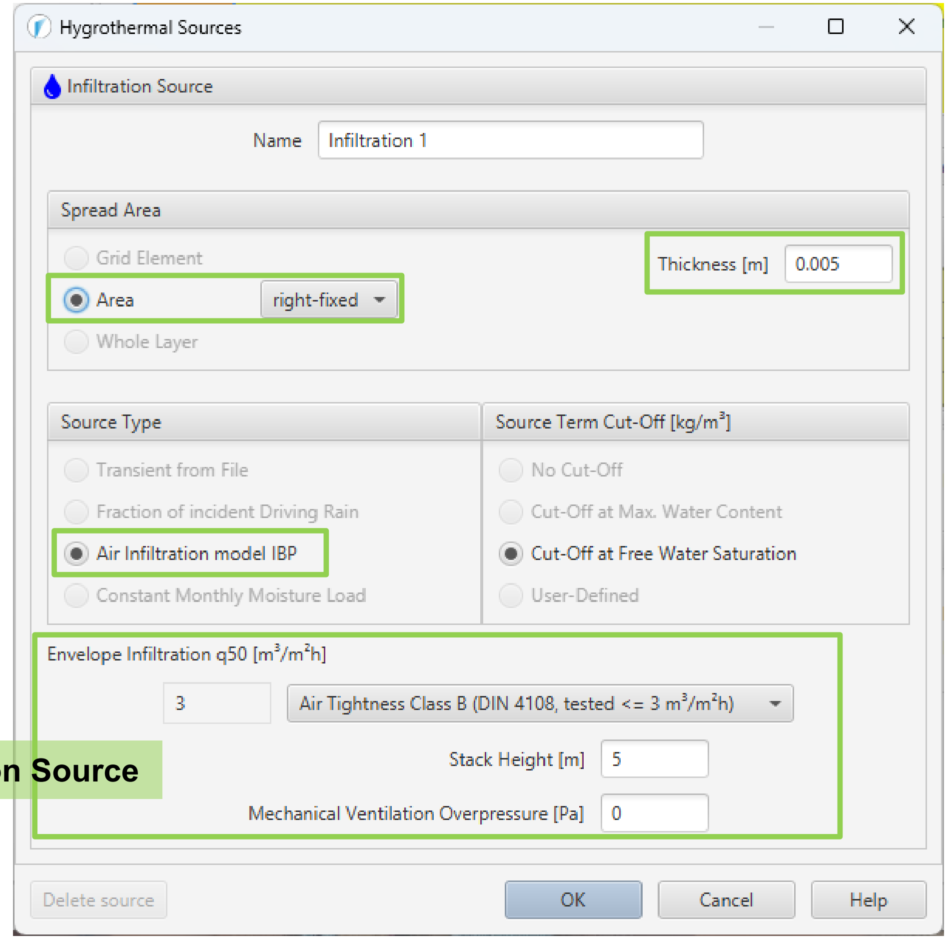
Infiltration source according to DIN 68800 in the OSB



Example: Input – Infiltration Source

<u>Input:</u> Component – Assembly

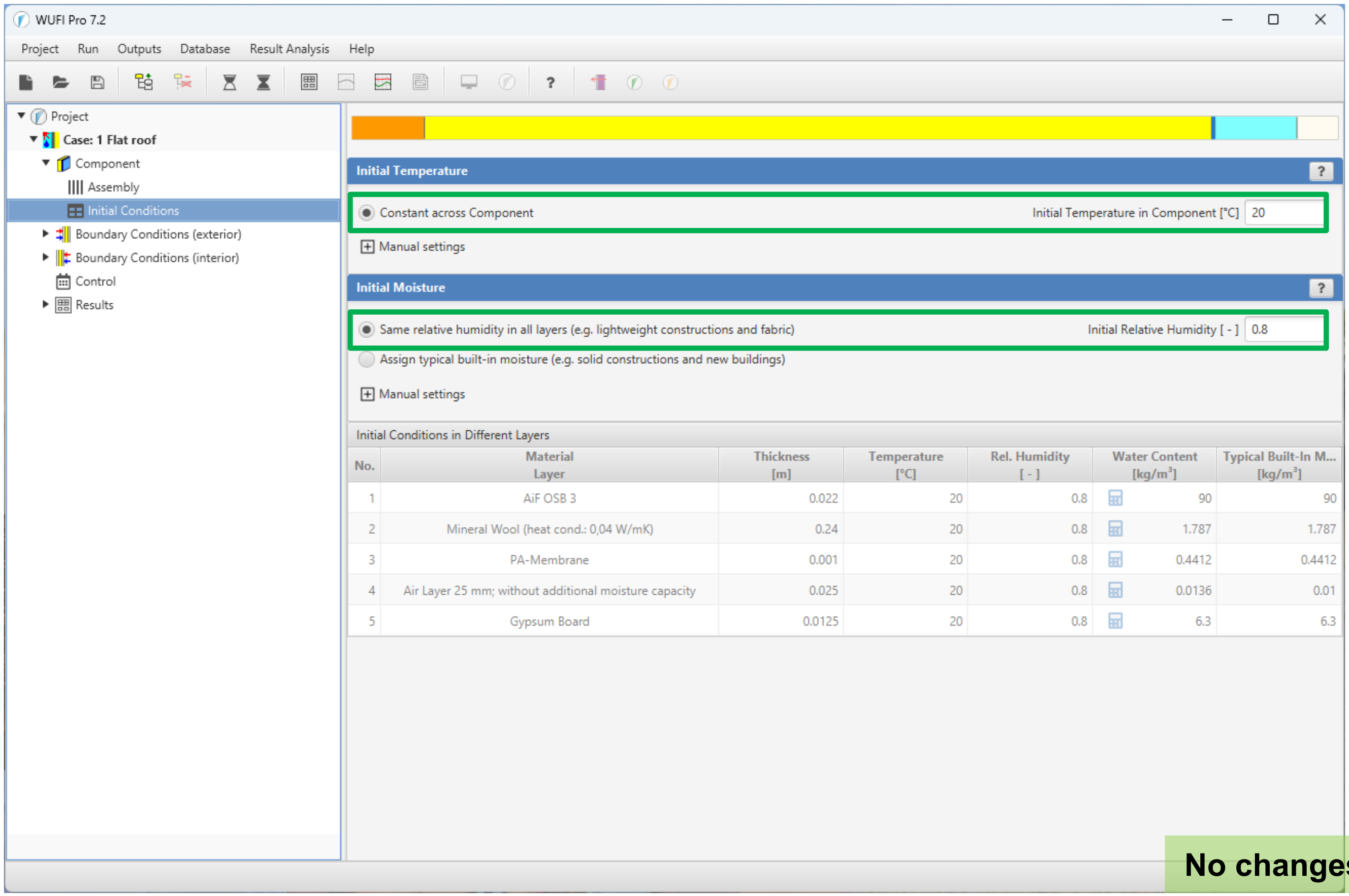
Moisture source in the interior 5 mm of the OSB.



Adjust Infiltration Source

Example: Input – Initial Conditions

Input: Component – Initial Conditions

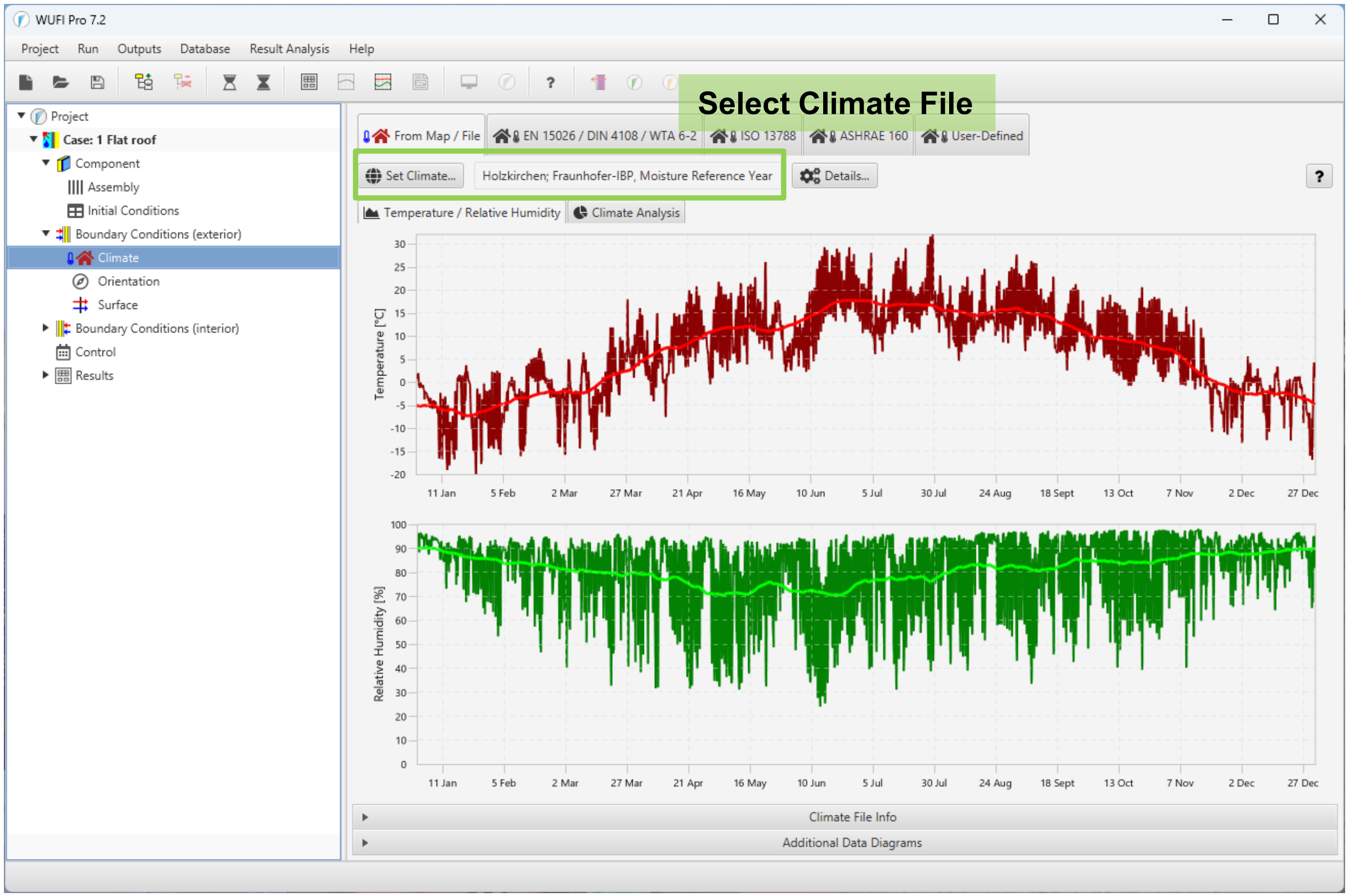


No.	Material Layer	Thickness [m]	Temperature [°C]	Rel. Humidity [-]	Water Content [kg/m³]	Typical Built-In M... [kg/m³]
1	AiF OSB 3	0.022	20	0.8	90	90
2	Mineral Wool (heat cond.: 0,04 W/mK)	0.24	20	0.8	1.787	1.787
3	PA-Membrane	0.001	20	0.8	0.4412	0.4412
4	Air Layer 25 mm; without additional moisture capacity	0.025	20	0.8	0.0136	0.01
5	Gypsum Board	0.0125	20	0.8	6.3	6.3

No changes required

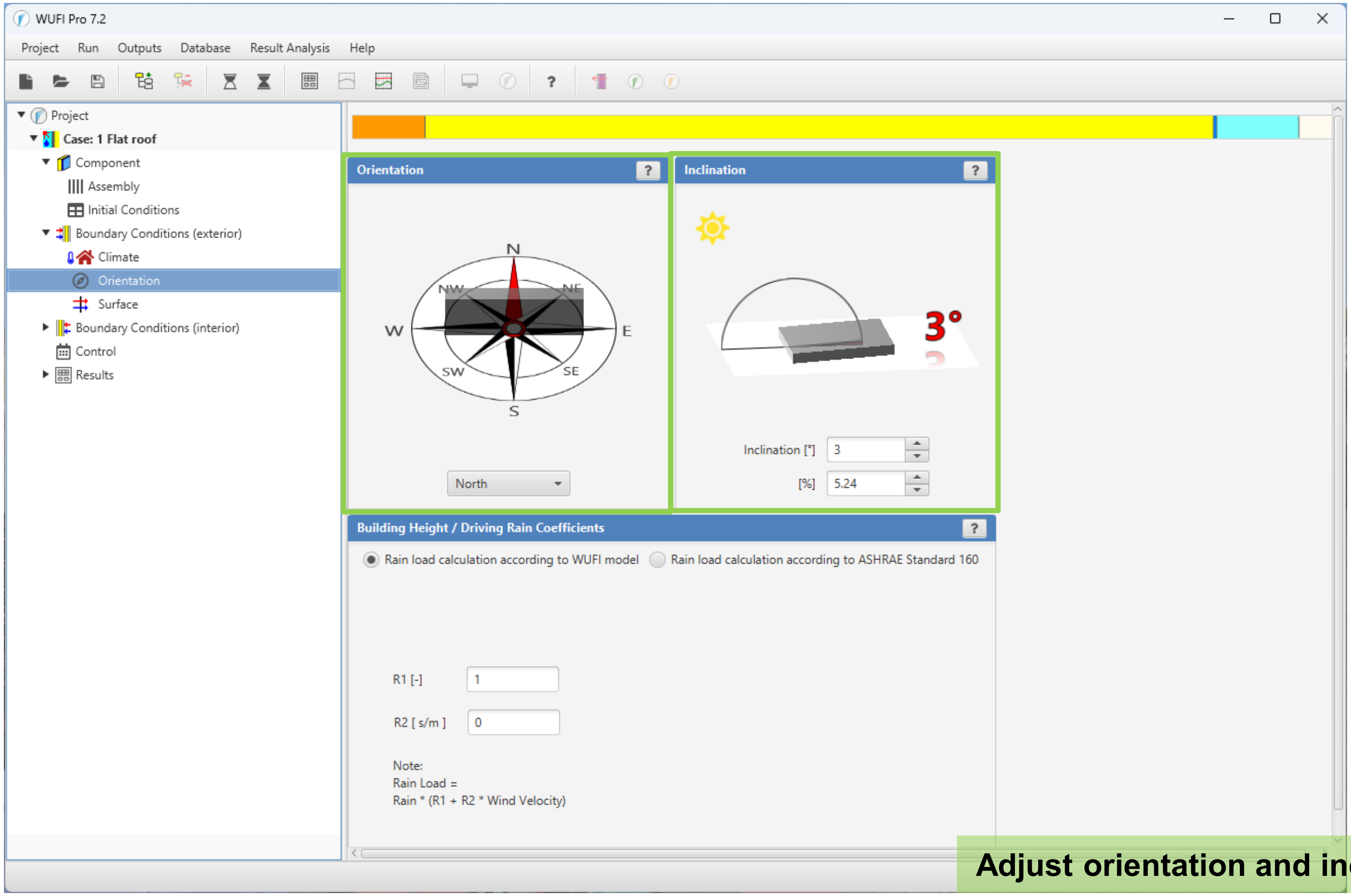
Example: Input – Outdoor Climate

<u>Input:</u> Boundary Conditions (exterior) – Climate



Example: Input – Orientation / Inclination

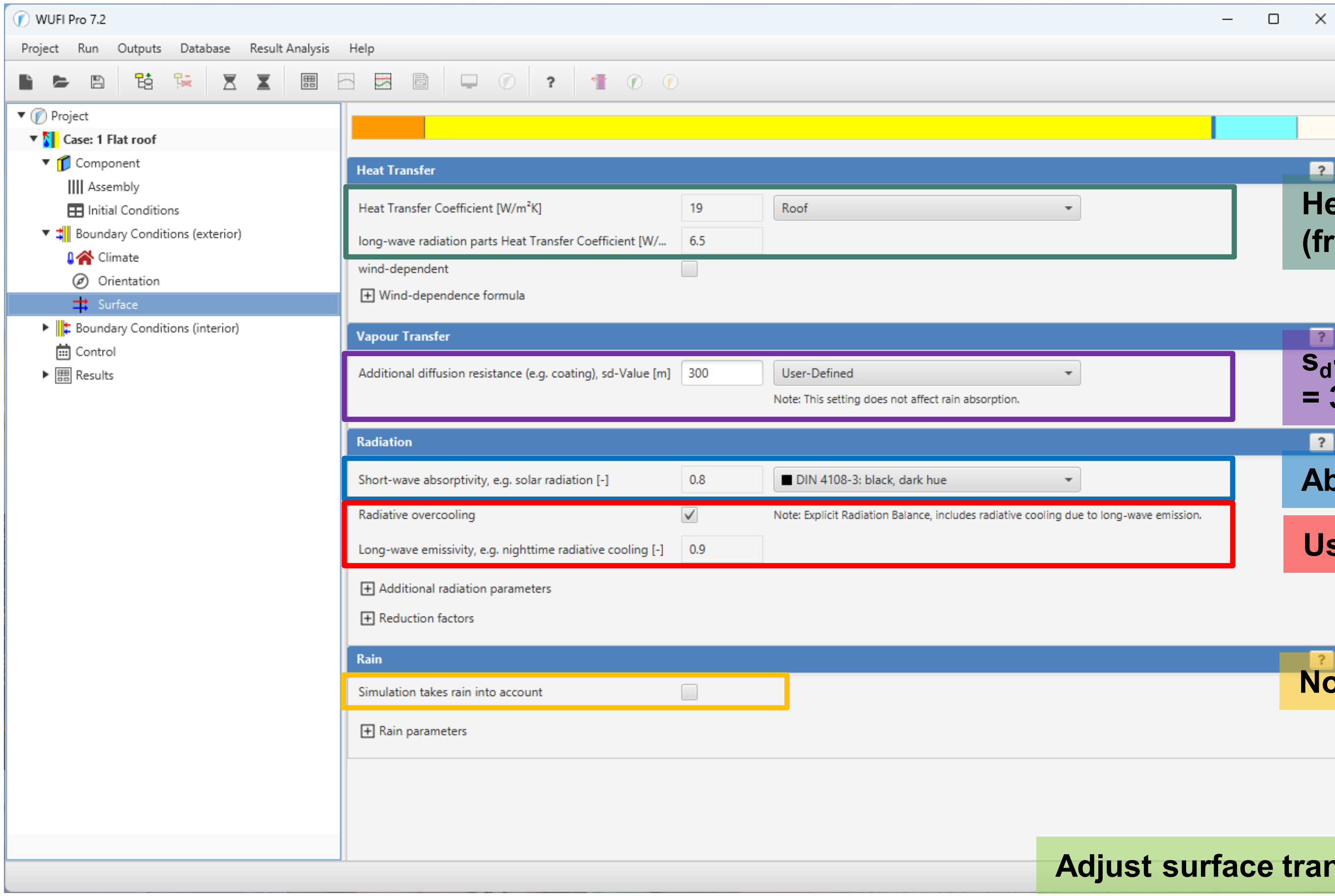
<u>Input:</u> Boundary Conditions (exterior) – Orientation



Adjust orientation and inclination

Example: Input – Surface Transfer Coefficients (exterior)

Input: Boundary Conditions (exterior) – Surface



Heat Transfer Coefficient (from list: roof)

s_d-value of the roofing felt = 300 m

Absorptivity (black, dark hue)

Use radiative overcooling

No rainwater absorption

Adjust surface transfer coefficients

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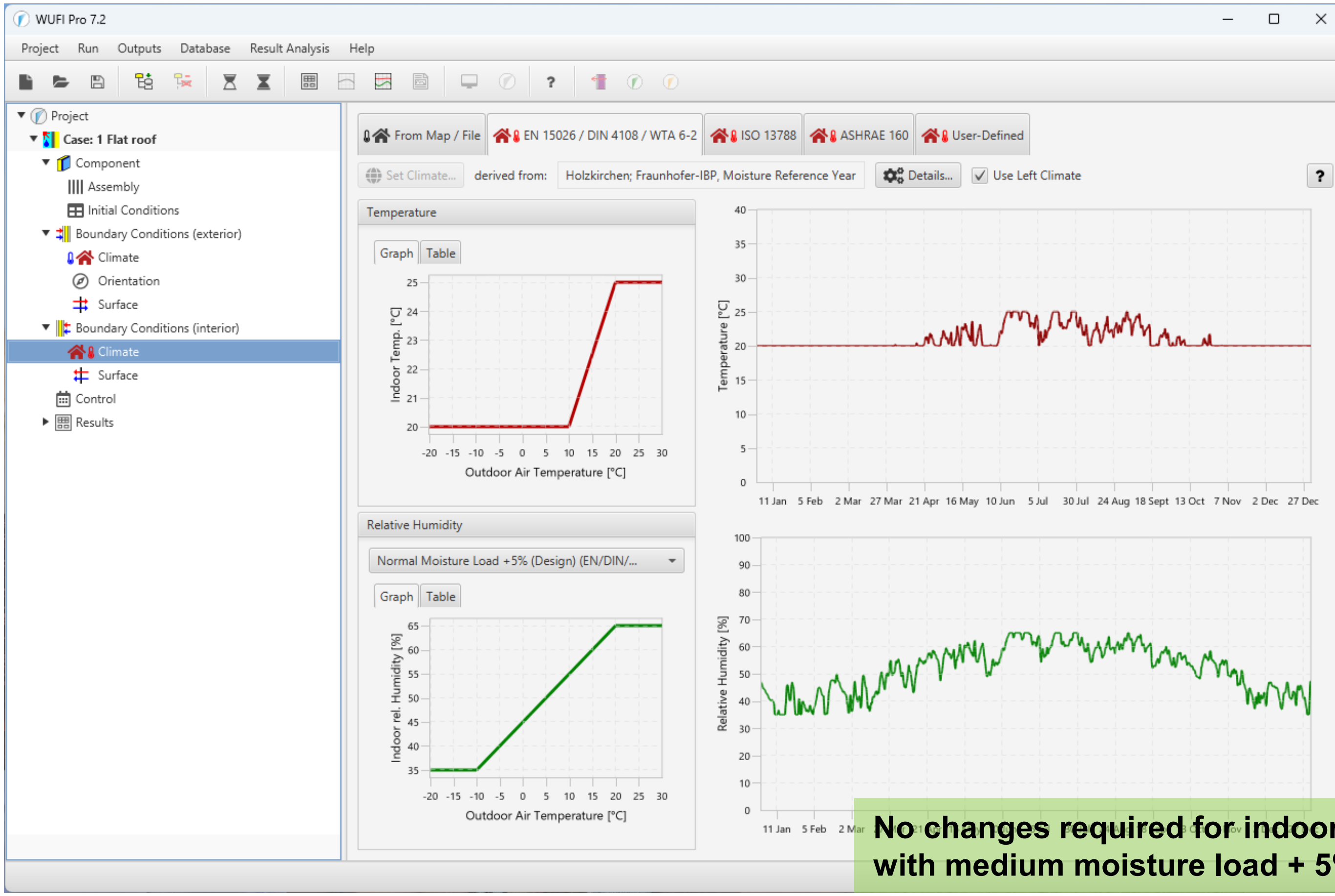
Example: Input – Indoor Climate

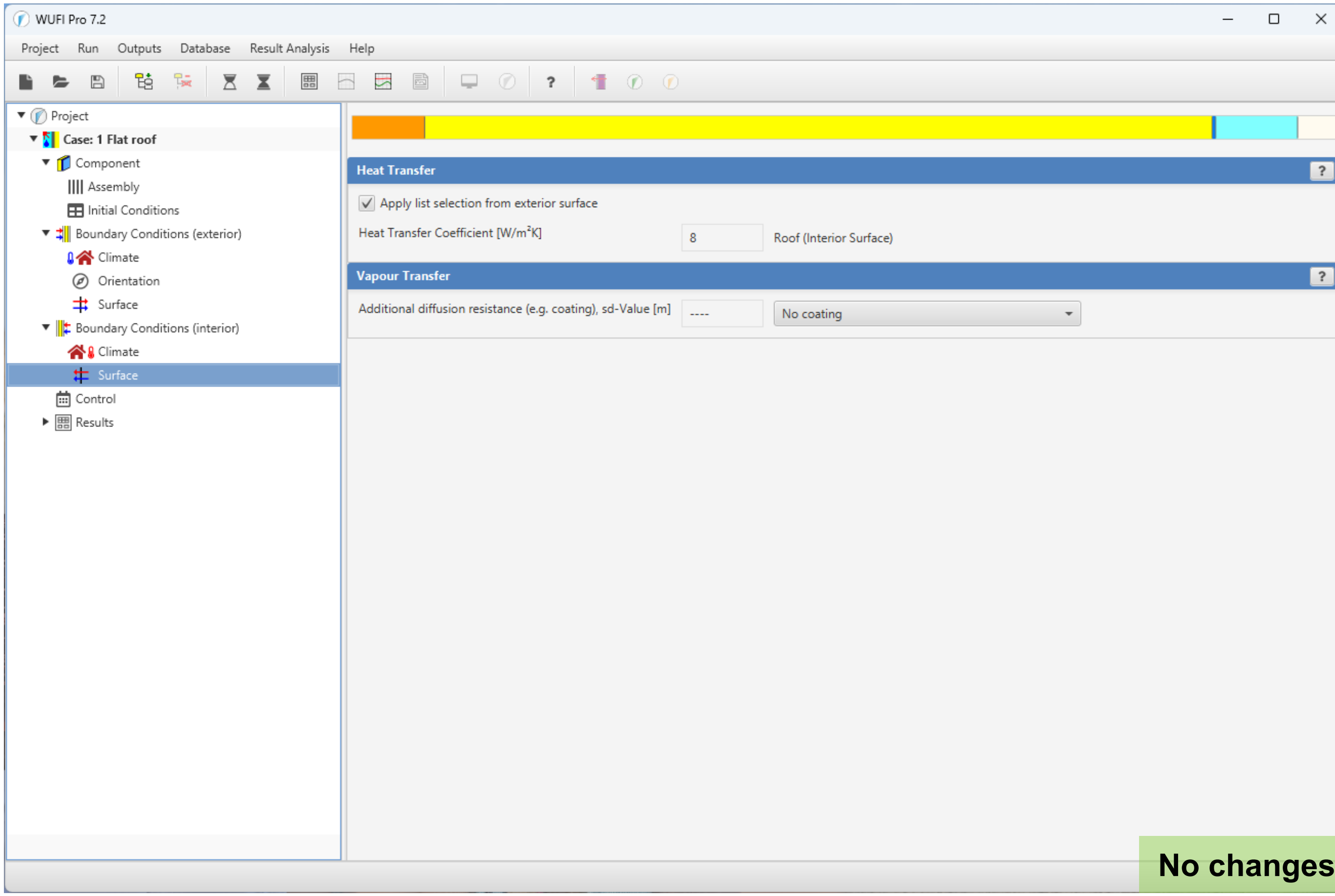
Input: Boundary Conditions (interior) – Climate



No changes required for indoor climate with medium moisture load + 5%

Example: Input - Surface Transfer Coefficients (interior)

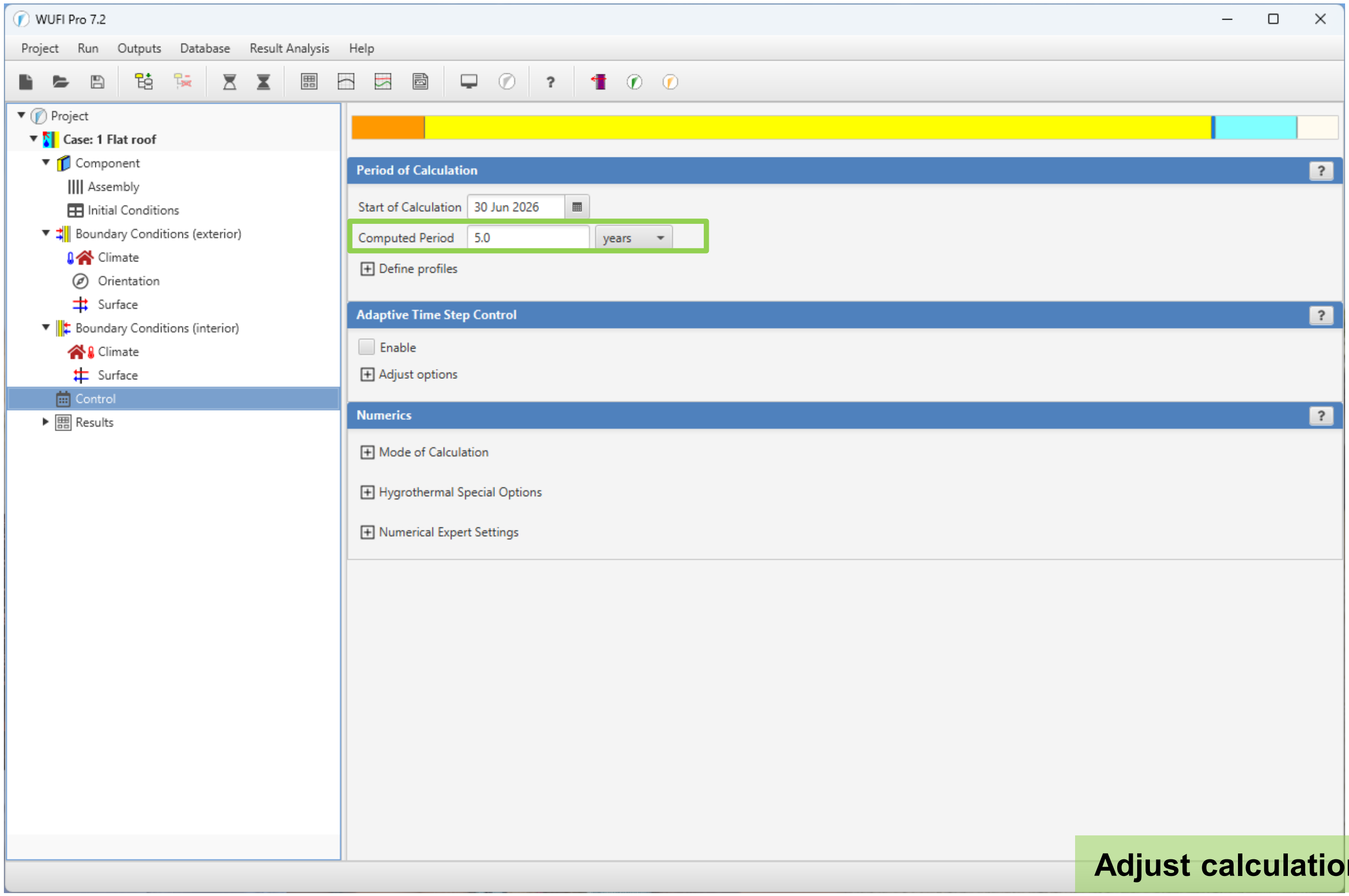
__Input:__ Boundary Conditions (interior) – Surface



No changes required

Example: Input – Period of Calculation and Numerics

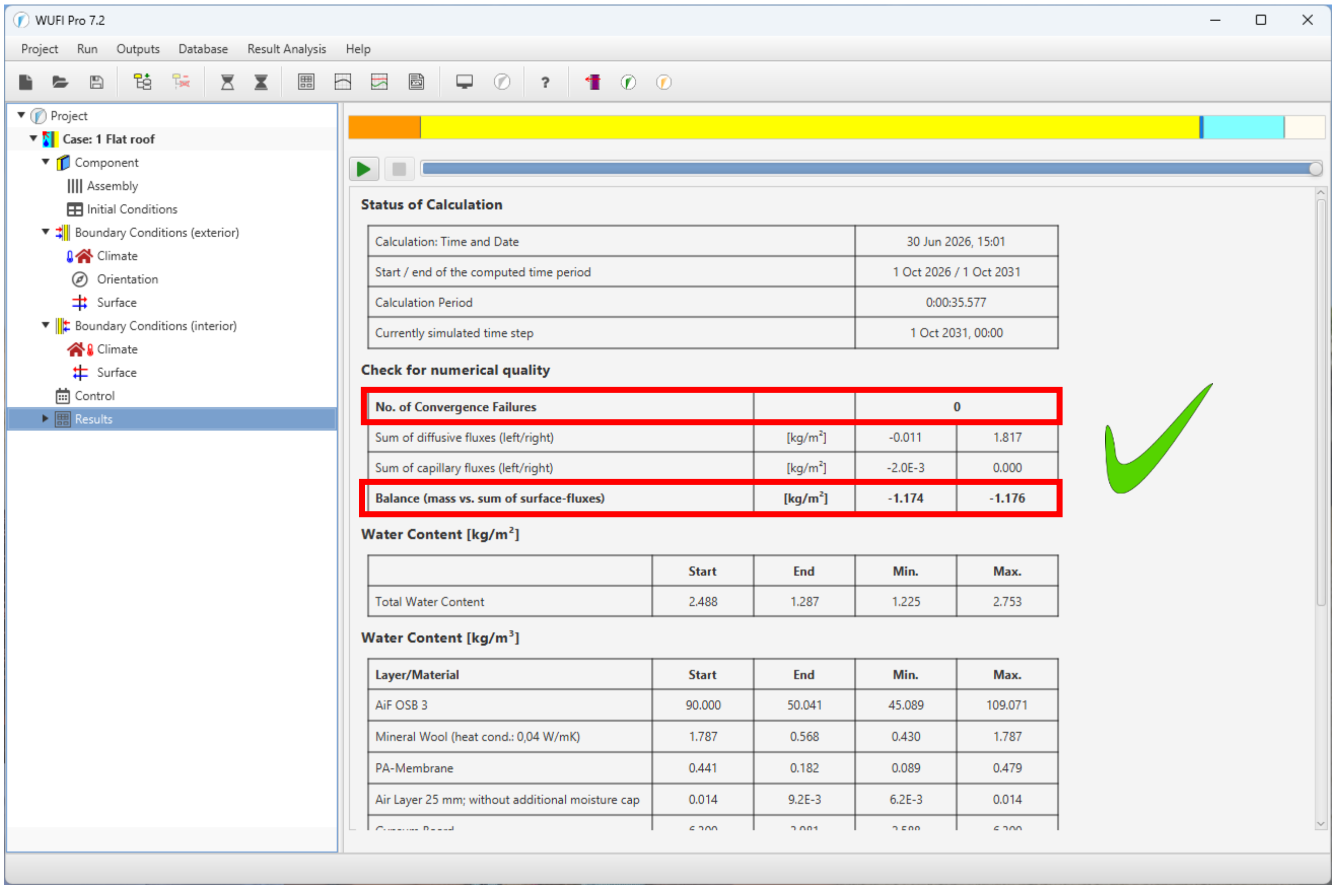
Input: Control



Adjust calculation period

Example: Evaluation – Check for numerical quality

Results:



Status of Calculation

Calculation: Time and Date	30 Jun 2026, 15:01
Start / end of the computed time period	1 Oct 2026 / 1 Oct 2031
Calculation Period	0:00:35.577
Currently simulated time step	1 Oct 2031, 00:00

Check for numerical quality

No. of Convergence Failures		**0**	
Sum of diffusive fluxes (left/right)	[kg/m²]	-0.011	1.817
Sum of capillary fluxes (left/right)	[kg/m²]	-2.0E-3	0.000
Balance (mass vs. sum of surface-fluxes)	**[kg/m²]**	**-1.174**	**-1.176**

Water Content [kg/m²]

	Start	End	Min.	Max.
Total Water Content	2.488	1.287	1.225	2.753

Water Content [kg/m³]

Layer/Material	Start	End	Min.	Max.
AiF OSB 3	90.000	50.041	45.089	109.071
Mineral Wool (heat cond.: 0,04 W/mK)	1.787	0.568	0.430	1.787
PA-Membrane	0.441	0.182	0.089	0.479
Air Layer 25 mm; without additional moisture cap	0.014	9.2E-3	6.2E-3	0.014

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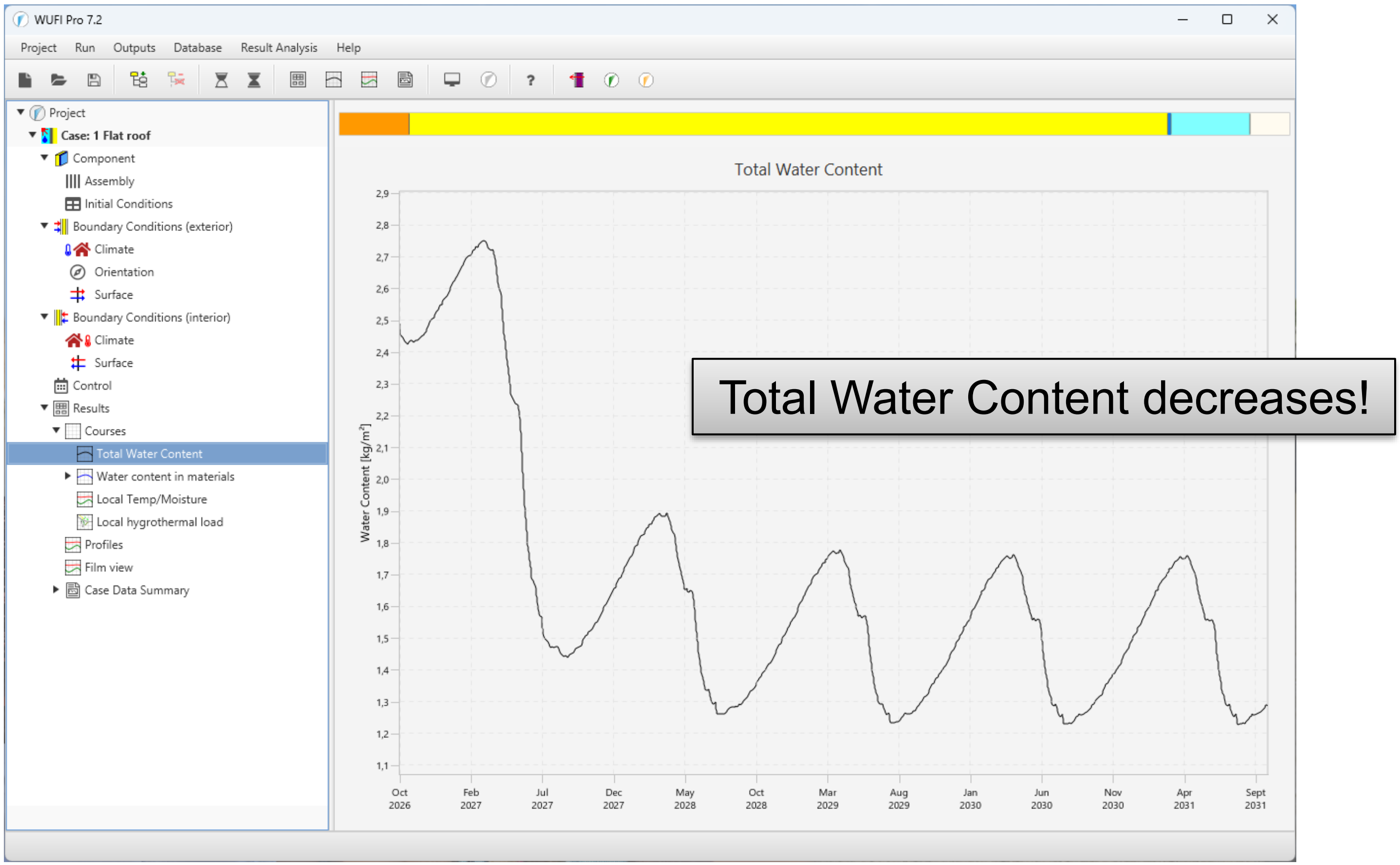
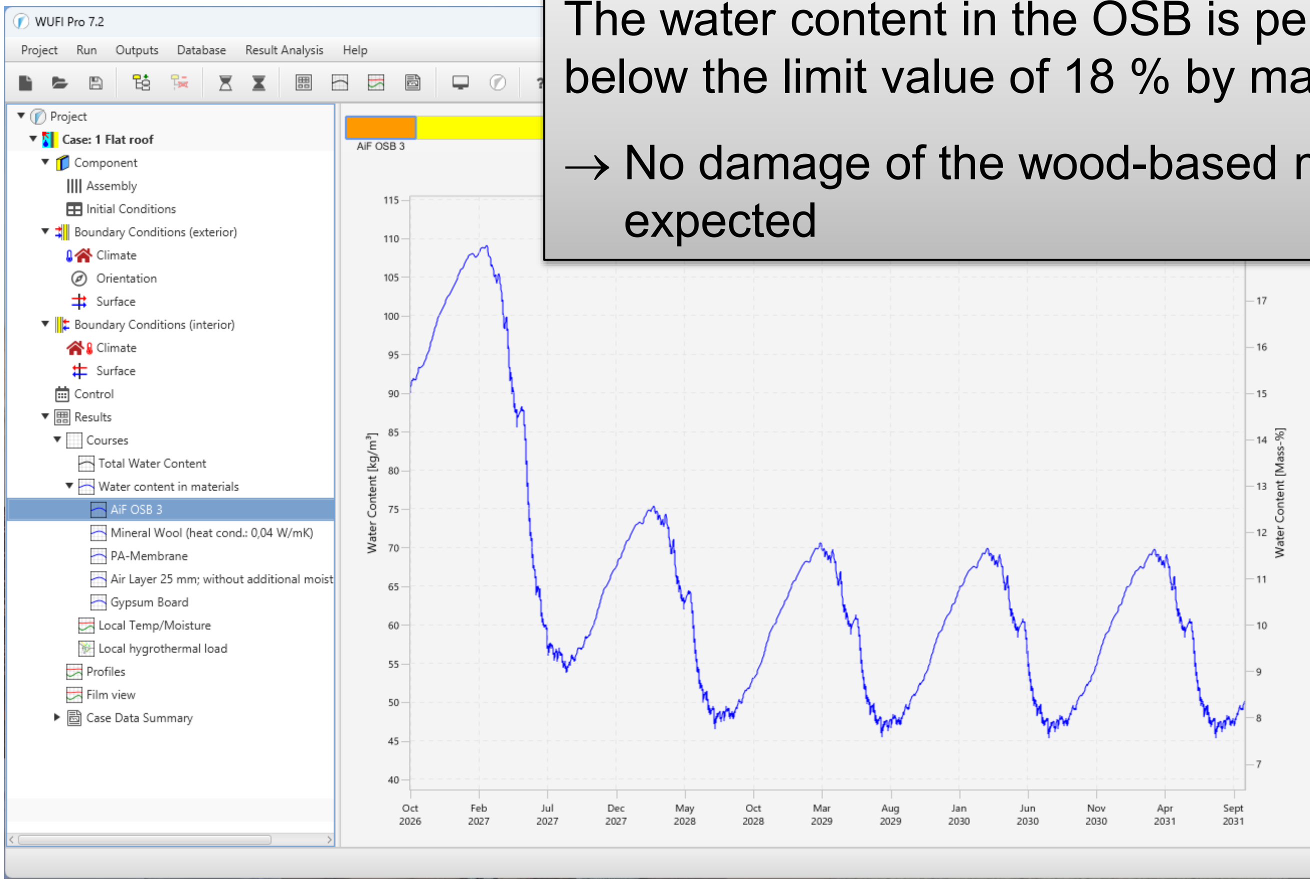
Example: Evaluation – Total Water Content

Evaluation:
Total Water Content



Example: Evaluation – Wooden Sheathing

Evaluation:
Water Content in the OSB



The water content in the OSB is permanently below the limit value of 18 % by mass.

→ No damage of the wood-based material is expected

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