WUFI®

Guideline for Assessing the Risk of Mould Growth with WUFI®

Date: March 2026

Fraunhofer
IBP

Content

Basics: Mould Growth in and on Components

Mould growth in occupied dwellings has the following effects on the occupants, among others:

- Aesthetic concerns

- Hygienic concerns

- Potential health hazards due to the production and dissemination of harmful substances

Basics: Factors Influencing Mould Growth

Influencing Factor	Reality	Consideration
Moisture	Most important influence	Can be influenced or determined by the planner through construction and material selection respectively through consideration of real usage. (These factors are also considered in WUFI® Bio)
Temperature	Strong influence	
Time	Strong influence	
Substrate	Nutrients from substrate and contaminated surfaces	
pH-value	Is influenced by the fungi themselves – difficult to predict	Mostly difficult to predict – should in doubt be considered favourable. (These factors cannot be considered in WUFI® Bio)
Light	Growth also possible without light	
Oxygen	Normally available	
Presence of spores	Normally available everywhere	
Surface roughness	Lighter contamination	
Biological interactions	unavoidable	

Fraunhofer
IBP

# Basics: Factors Influencing Mould Growth

Growth requirements for mould:

Reduction to the essential influencing factors temperature and humidity, their combined exposure time as well as the substrate quality.
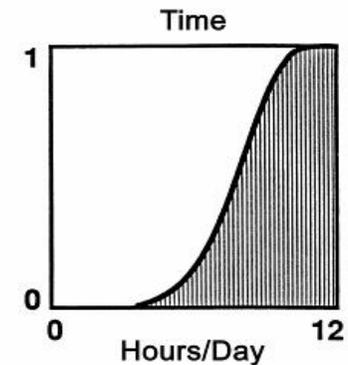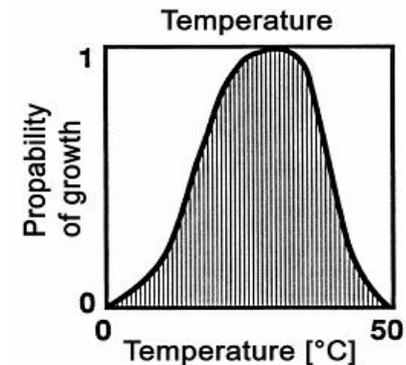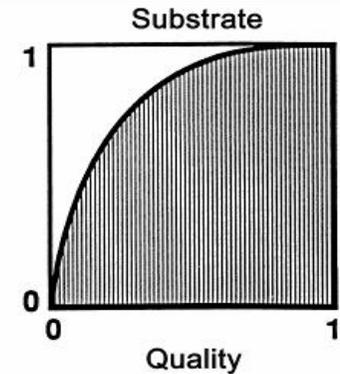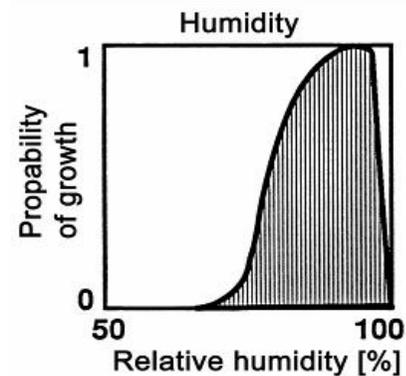
Germination and growth conditions of single mould species:

- Mould spores are exposed to different combinations of temperature and relative humidity, and the times needed for germination are plotted in a temperature-humidity diagram. The curves of equal germination time are called isopleths.

- Isopleth systems for germination time and growth rate of Aspergillus restrictus (Smith*):
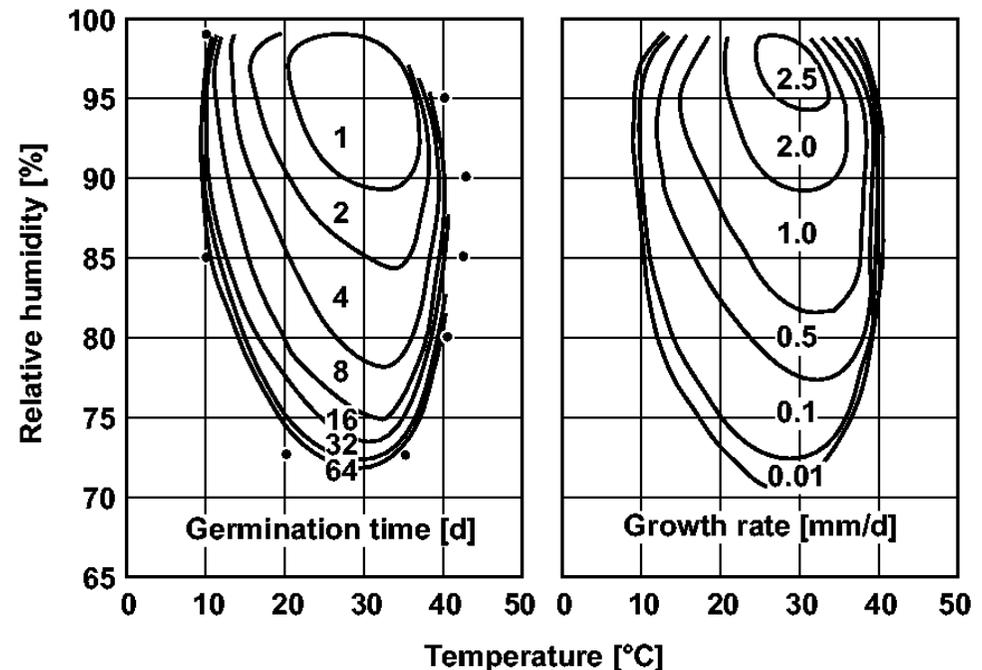

Smith, S. L.; Hill, S. T.: Influence of temperature and water activity
on germination and growth of *Aspergillus restrictus* and *Aspergillus versicolor*.
Transactions of the British Mycological Society Vol. 79 (1982), H. 3, S. 558 - 560.

WUFI® Bio: Evaluation of Isopleths

Combination of the lowest growth conditions to LIM-Curves:

- The lowest germination isopleth (left figure – blue curve) separates the diagram into the region where ambient conditions allow the spore to germinate and the region where germination is not possible.

- For all practically relevant mould species, the lowest germination isopleths are combined into one diagram (right figure) and then the lower envelope of this set of curves is defined as generic Lowest Isopleth for Mould growth (LIM, right figure – red curve)

Substrate:
Optimal
culture medium

WUFI® Bio: Evaluation of Isopleths
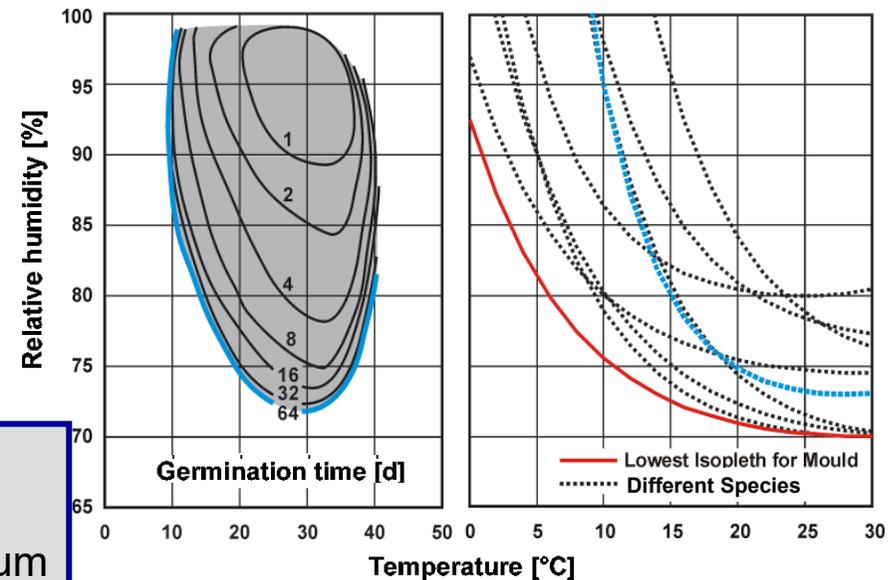
Adaption of the LIM-curves from optimum substrate to building materials:

- Experimental determination of the isopleth systems by cultivating the mould on a culture medium (biological full medium).

- In buildings generally only substrates with a lower nutrient supply are available → consideration of the nutrient quality by the use of two substrate classes for building materials:

II less bio-utilizable substrates (mineral building materials)

I bio-utilizable substrates (wall paper, wood, strongly contaminated surfaces)

0 optimum substrate (biological full medium)
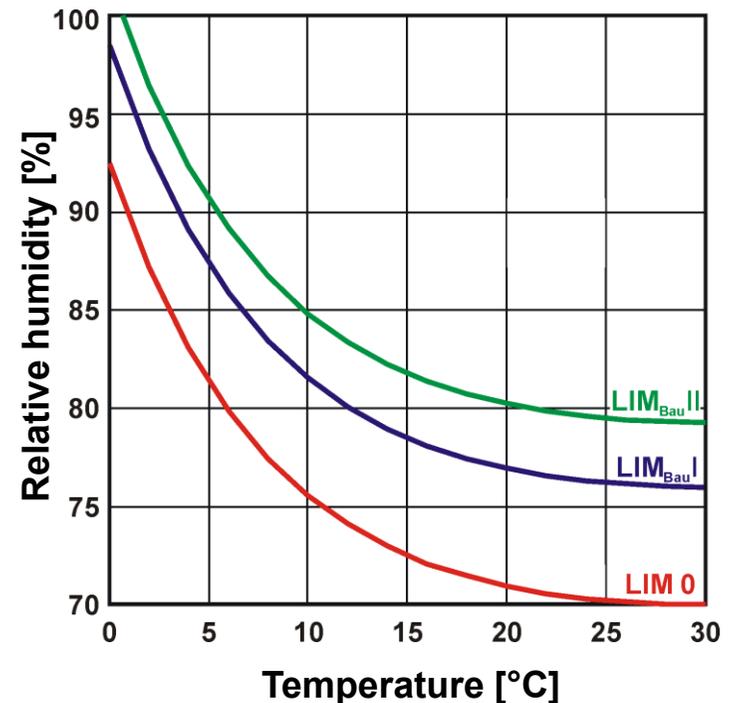
Calculation of a generic model spore:

- A mould spore has a certain osmotic potential which enables it to take up water from its environment → mathematically this potential can be described by a moisture storage function.

- The spore wall has a moisture-dependent diffusion resistance, which delays the moisture exchange with the environment.

- With changing ambient temperature and humidity the water content in the spore also changes → by reaching a certain critical water content, the spore germinates.
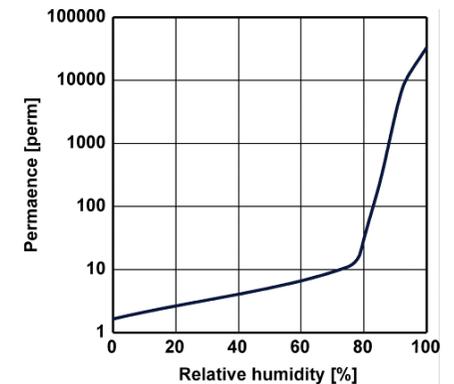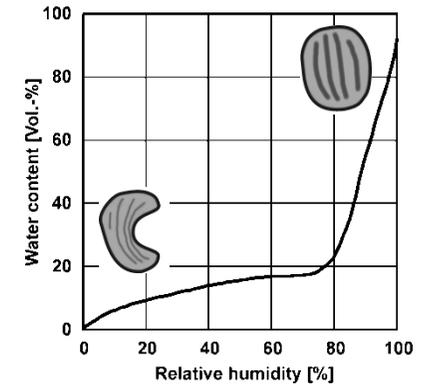
model spore
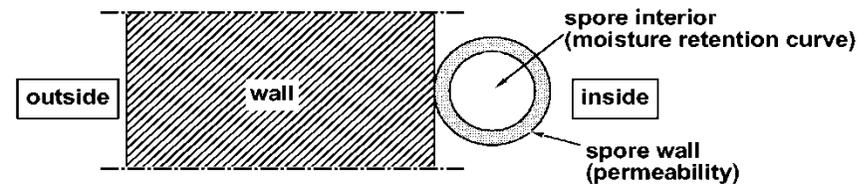
1. Comparison of the calculated conditions with the LIM curves shows whether temperature and humidity combinations occur, in which long-term germination of the spore would be expected.

2. If so, evaluation of the position with WUFI® Bio and calculation of the temperature-dependent water content in the model spore.

3. If the limit water content is exceeded in the spore, the spore germinates and mycelium growth starts.

4. The expected growth is then given according to the growth isopleths and summed up.

5. The traffic light helps assess the risk.

Download-Link WUFI Bio: WUFI® Add-ons | WUFI (en)

Fraunhofer
IBP

WUFI® Bio: Notes and Limitations

- The biohygrothermal model is an assessment of the risk of mould growth, it is not necessarily a realistic simulation of the growth processes in all points.

- Usually, the predicted spore germination times may be shorter, or the growth rates may be higher than they are under real conditions (safe side)!

- It is assumed that mycelium growth stops when the moisture content in the spore falls below a critical water content, and instantly resumes when the critical water content is exceeded again.

- The biohygrothermal model is only applicable for interior surfaces. In the case of differing boundary conditions (for example in the construction or on exterior surfaces) it must be considered in individual cases, whether the model can be used. Maybe other effects can impede the growth: heating through solar radiation, disinfection through UV radiation or washing-off through rain. However, comparative evaluations can also be carried out at these positions. We recommend to use the model only on the warm side in the construction.

WUFI® Bio: Application

Input data:

- Specification of the occupant exposition class. This indicates the extent to which the user gets into contact with the evaluated position of the component (respectively with the mould or spore).

- Three classes are available:
  - Indoor surface or position in contact to indoor air
    (e.g. interior wall surface, installation layer, etc.)
  - Surface inside construction without direct contact to indoor air
    (e.g. unused roof space, outside ventilated cavity of a wall, etc.)
  - No impact on occupants expected
    (e.g. perimeter insulation, cavities in multi-layered, rendered masonry, etc.)

WUFI® Bio: Application
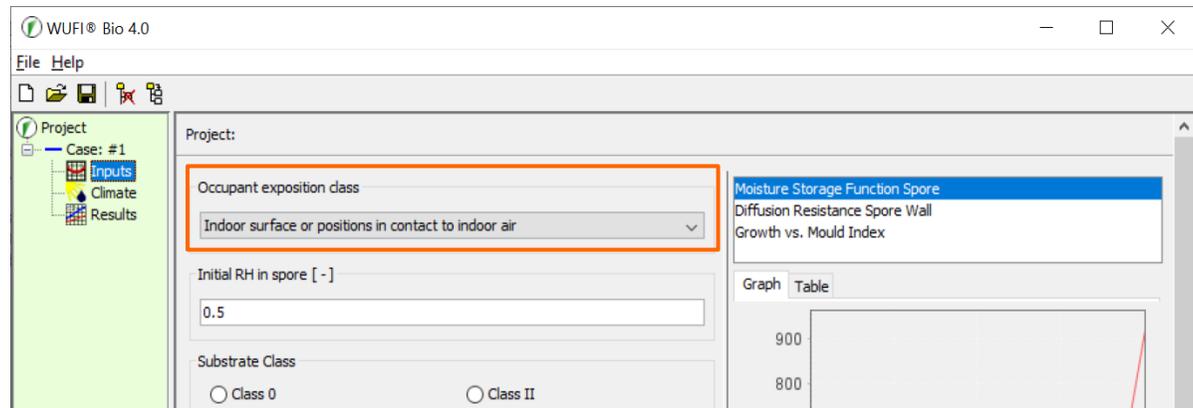
Input data:

- Specification of the initial humidity in the simulated spore. This only affects the early stages of the simulation. After a while, the water content in the spore will be dominated by the ambient conditions. (recommendation: 0.5)

- Selection of the substrate class:
  - Class 0
  - Class I
  - Class II
  - Class K
    (growth properties of species critical to health)

WUFI® Bio: Application
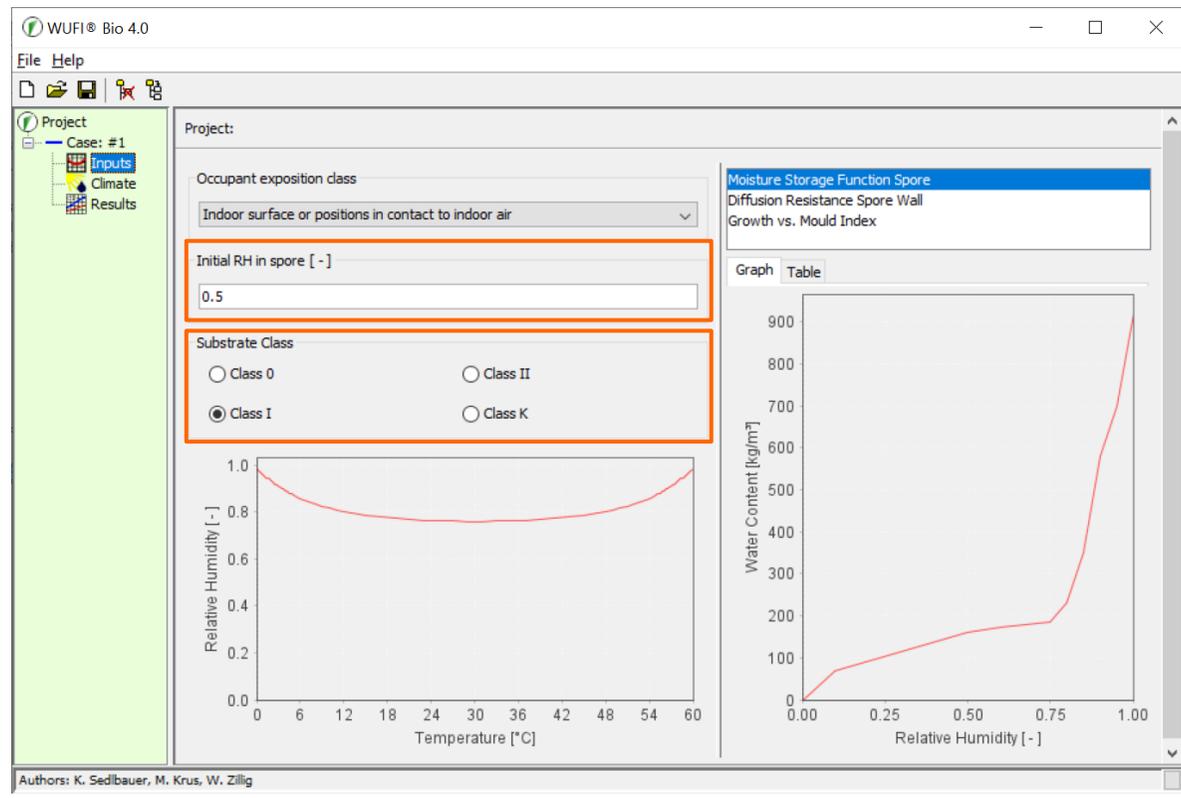
Input data:

- Specify the climatic conditions to which the model spore is exposed.

- If you have started WUFI® Bio directly out of WUFI® or Animation1D, the climate conditions will automatically be transferred to WUFI® Bio and displayed in this dialog.
Note: If WUFI® Bio is started directly out of WUFI®, only the climate conditions of the interior surface are shown. To evaluate a different position, WUFI® Bio must be started from Animation1D. Here you can select any grid element.

- Otherwise, climate data can be imported manually (e.g. measurement data).

WUFI® Bio: Application
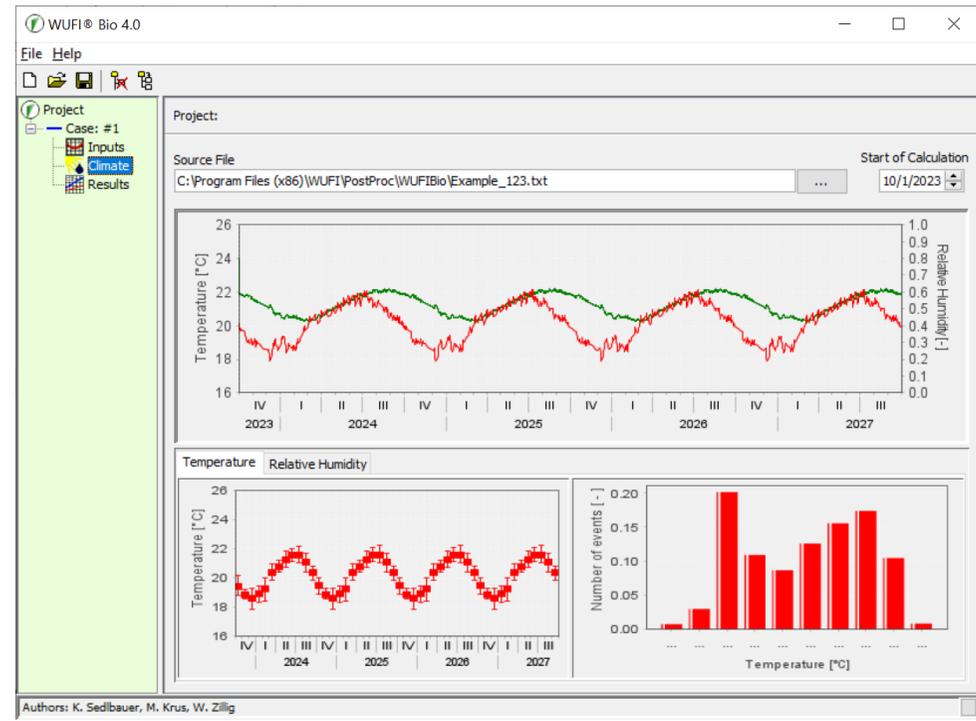
Evaluation of the results:

- Top diagram: calculated water content in the spore (blue) and the critical water content (red).

- Bottom diagram: mycelium growth (in mm) to be expected after germination.

- Growth rate:
  Describes by how many millimeters the edge of the infested area moves outward over time; the total growth is then the radius of a mould blotch (in a petri bowl).

- Alternatively:
  Result of the evaluation can be expressed in terms of the "mould index".
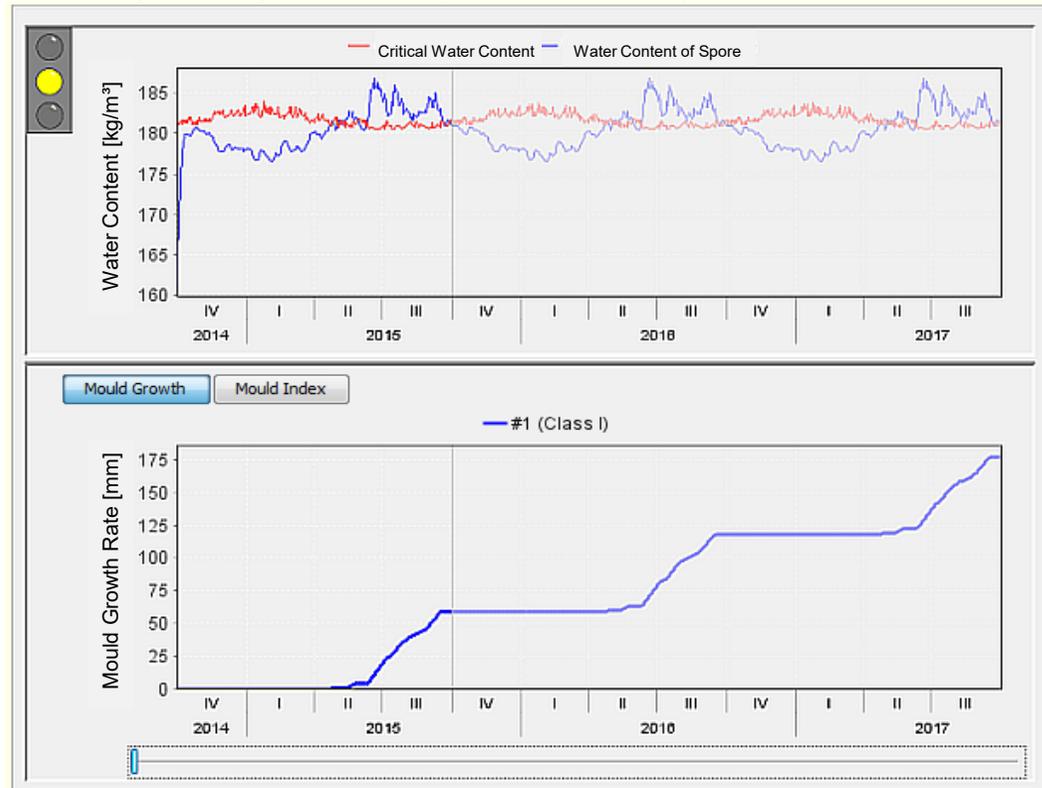
Evaluation of the results: Mould Growth Rate [mm]

- The starting point of the evaluation can be adjusted within the calculation period using the slider (1). Each evaluation period covers one year (green area).

- The growth predicted for the following period (green and orange area) represents a forecast starting from the selected evaluation point.

- When slider (1) is moved, both the start date of the growth analysis and the maximum expected growth at the end of the evaluation period (2) change.
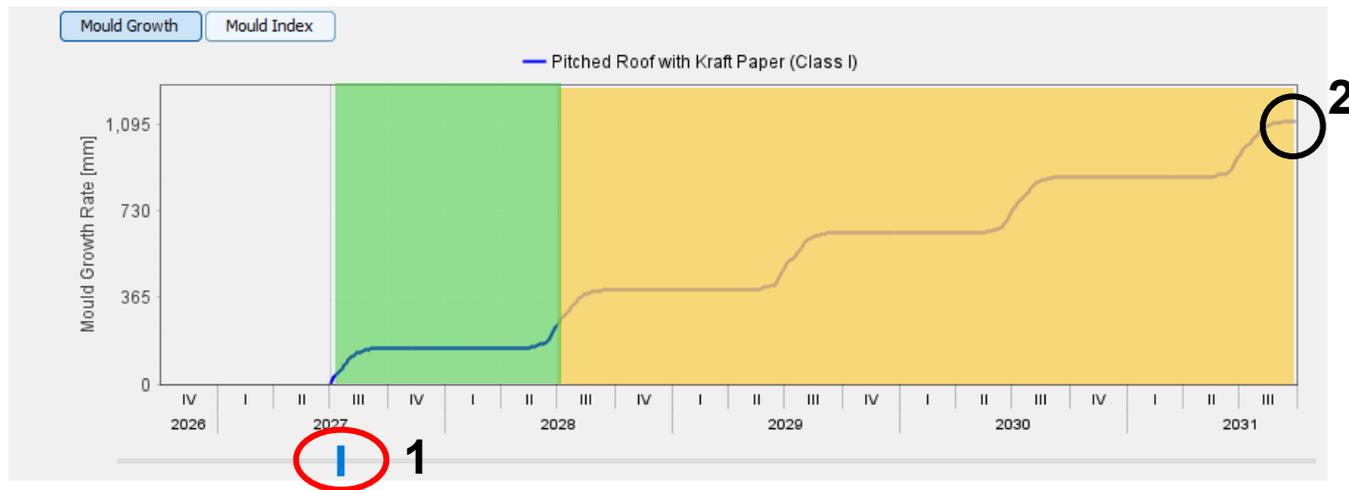
Evaluation of the results: Mould Index

- The Viitanen model uses a six-level "Mould Index" describing the intensity and spread of the growth.

- Since the "Mould Index" can be interpreted more easily, WUFI® Bio's mould growth can automatically be translated into the "Mould Index".

Index	Description
0	no growth
1	some growth visible under microscope
2	moderate growth visible under microscope, coverage more than 10%
3	some growth detected visually; thin hyphae found under microscope
4	visual coverage more than 10%
5	coverage more than 50%
6	tight coverage, 100%

Fraunhofer
IBP

WUFI® Bio: Application

Evaluation of the results: Mould Index

- The one-year evaluation period can be shifted within the calculation period using the slider (1) (green area). The value at the end of this one-year period (2) is used for the assessment.

- Each point in the following period (orange area) represents the predicted end state of the preceding one-year evaluation period.

- When slider (1) is moved, both the start date of the evaluation and the corresponding mould index value at the end of the one-year period (2) change.

WUFI® Bio: Application
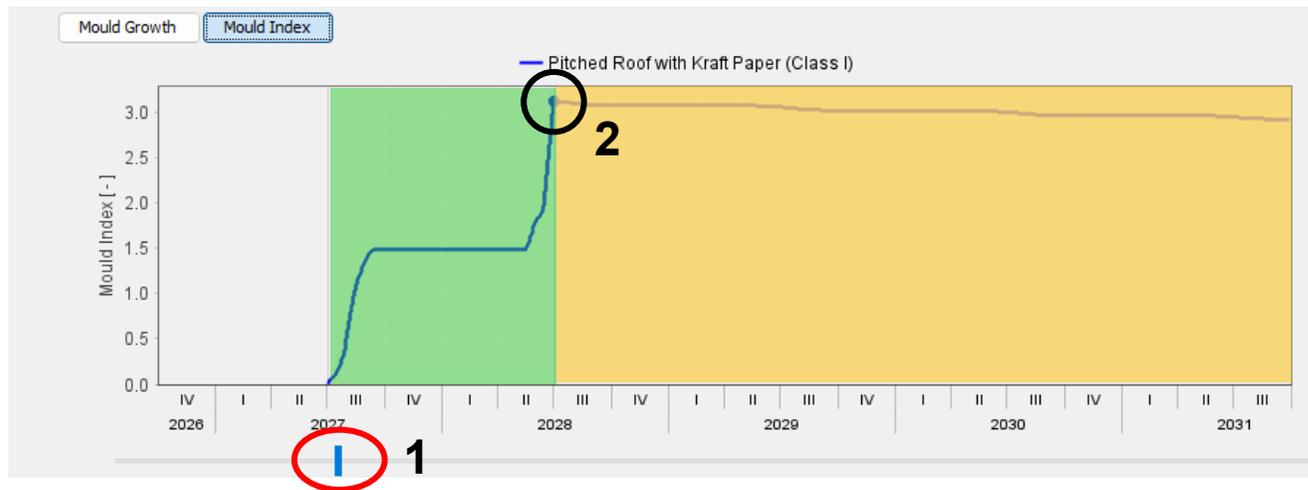
Evaluation of the results:

- The signal light presents a general assessment of the mould growth risk.

		Occupant exposition class		
		Indoor surface or position in contact to indoor air	Surfaces inside constructions without direct contact to indoor air	No impact on occupants expected
🟢	Mould Growth (g_m)	*(< 129 mm/year)*	*(< 176 mm/year)*	*(< 239 mm/year)*
	Mould-Index *(MI)*	**< 1**	**< 2**	**< 3**
	Assessment	Usually acceptable.		
🟡	Mould Growth (g_m)	*(129 ≤ g_m < 176 mm/year)*	*(176 ≤ g_m < 239 mm/year)*	*(≥ 239 mm/year)*
	Mould-Index *(MI)*	**1 ≤ MI < 2**	**2 ≤ MI < 3**	**≥ 3**
	Assessment	Additional criteria or investigations are needed for assessing acceptability.		
🔴	Mould Growth (g_m)	(≥ 176 mm/year)	(≥ 239 mm/year)	
	Mould-Index *(MI)*	**≥ 2**	**≥ 3**	
	Assessment	Usually not acceptable.		
		Calculation period is less than 1 year. No assessment possible.		

Fraunhofer
IBP

Using the example of a pitched roof with metal sheet and two different interior vapour retarders, the procedure for assessing mould risk is explained.
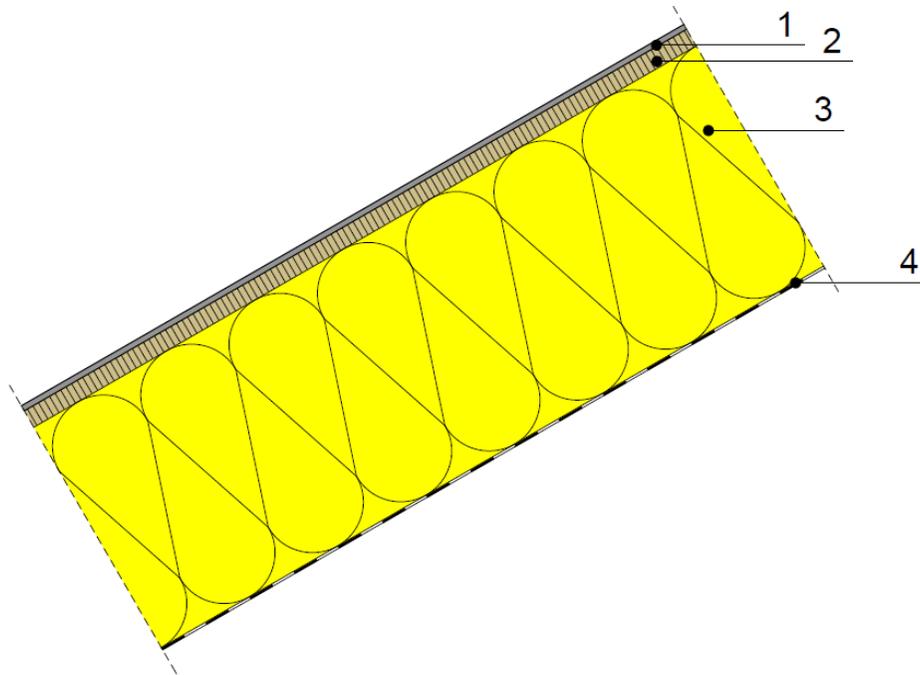
1 Metal roofing (zinc)
2 Wooden sheathing
3 Insulation
4 Vapour retarder

Note: It is assumed that the wooden sheathing has an increased initial moisture content!

Examples: Component Assembly

Assembly (from outside to inside):

- Zinc roofing (s_d = 50 m)

- Wooden sheathing (Softwood) 0.02 m

- Mineral Wool (heat cond.: 0.04 W/mK) 0.14 m

- Case 1: Kraft Paper (s_d = 3 m)
  Case 2: PA-Membrane (moisture-variable)

Boundary Conditions:

- Pitched roof (50° to the North)

- Zinc surface (a = 0.6; ε = 0.4)

- Outdoor Climate: Holzkirchen

- Indoor Climate: EN 15026 with medium moisture load +5%

- Air tightness of the der building envelope: q_{50} = 3 m³/m³h

- Stack height: 5 m

- Initial moisture in the wooden sheathing: 25 % by mass

Fraunhofer
IBP

Example: Evaluation Matrix

Evaluation Matrix:

The following matrix shows the evaluation criteria relevant to this design.

	Criteria
1) Numerics	No or only small differences in balances (especially in the case of convergence failures)?
	Consistent, periodic course of total water content?
2) Evaluation parameters	Total water content reach dynamic equilibrium or decreases?
	Risk of wood decay in the wooden sheathing? (limit values according to DIN 68800 or WTA 6-8)
	Risk of mould growth behind the membrane / paper?

Fraunhofer
IBP

Case 1: Component

Input: Component - Assembly

Input the roof assembly without metal sheet

if necessary: adapt thickness of the layers

Case 1: Infiltration Source

Input: Component – Assembly

Infiltration source according to EN 15026 in the wooden sheathing

Case 1: Infiltration Source

Input: Component - Assembly

Moisture source
in the interior 5 mm
of the wooden sheathing.

Case 1: Initial Conditions

Input: Component – Initial Conditions

Initial water content in the wooden sheathing: 25 % by mass

Case 1: Outdoor Climate

Input: Boundary Conditions (exterior) – Climate
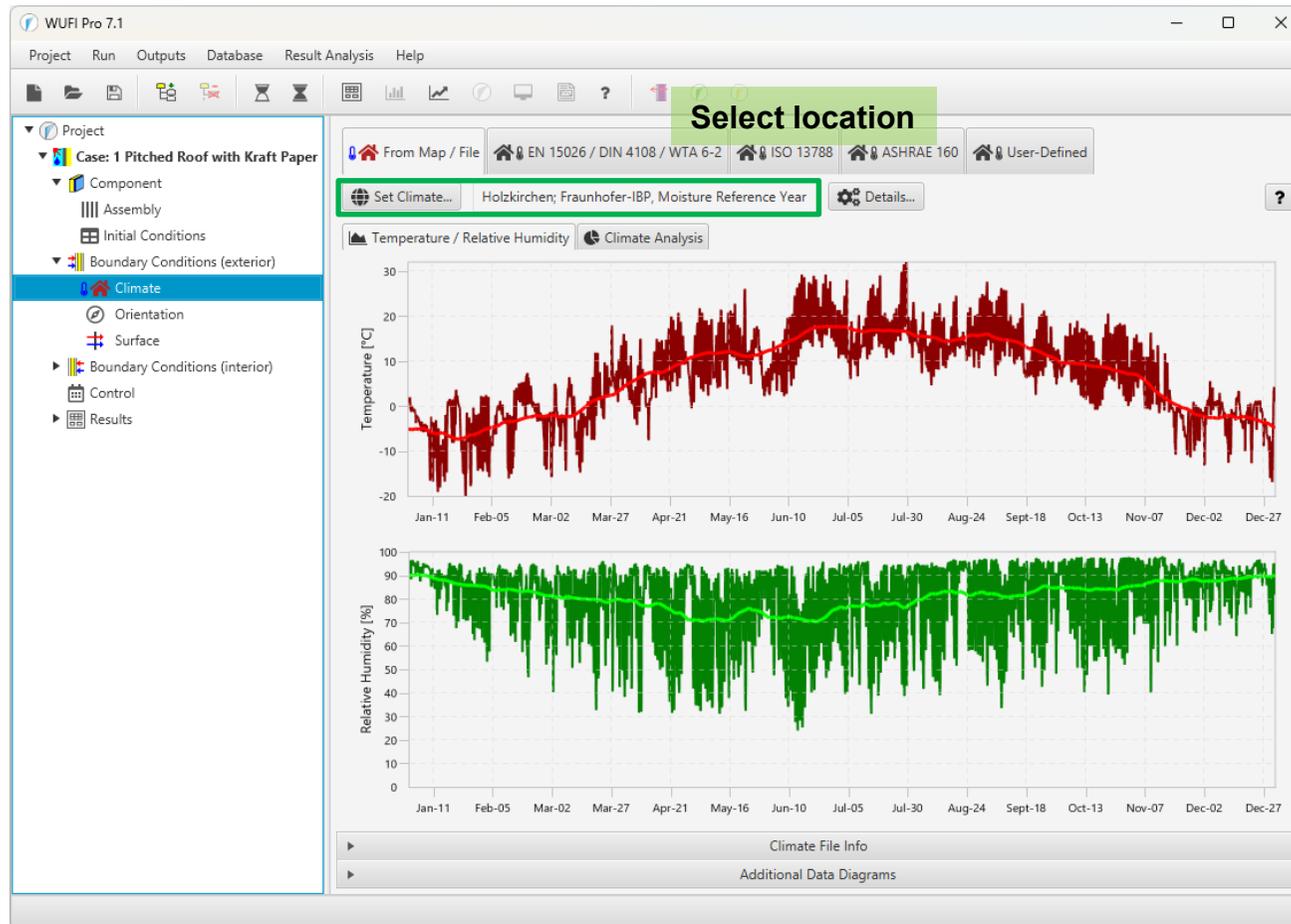
Case 1: Orientation / Inclination

Input: Boundary Conditions (exterior) – Orientation

Adapt orientation and inclination

Case 1: Surface Transfer Coefficients (exterior)

Input: Boundary Conditions (exterior) – Surface

Heat transfer coefficient (from list: Roof)

s_d-value metal roofing (from list: s_d = 50 m)

Absorptivity = 0.6

Consider radiation overcooling; Emissivity = 0.4

No rainwater absorption

Adapt surface transfer coefficients!

Case 1: Indoor Climate

Input: Boundary Conditions (interior) – Climate

No changes required for indoor climate with medium moisture load + 5 %
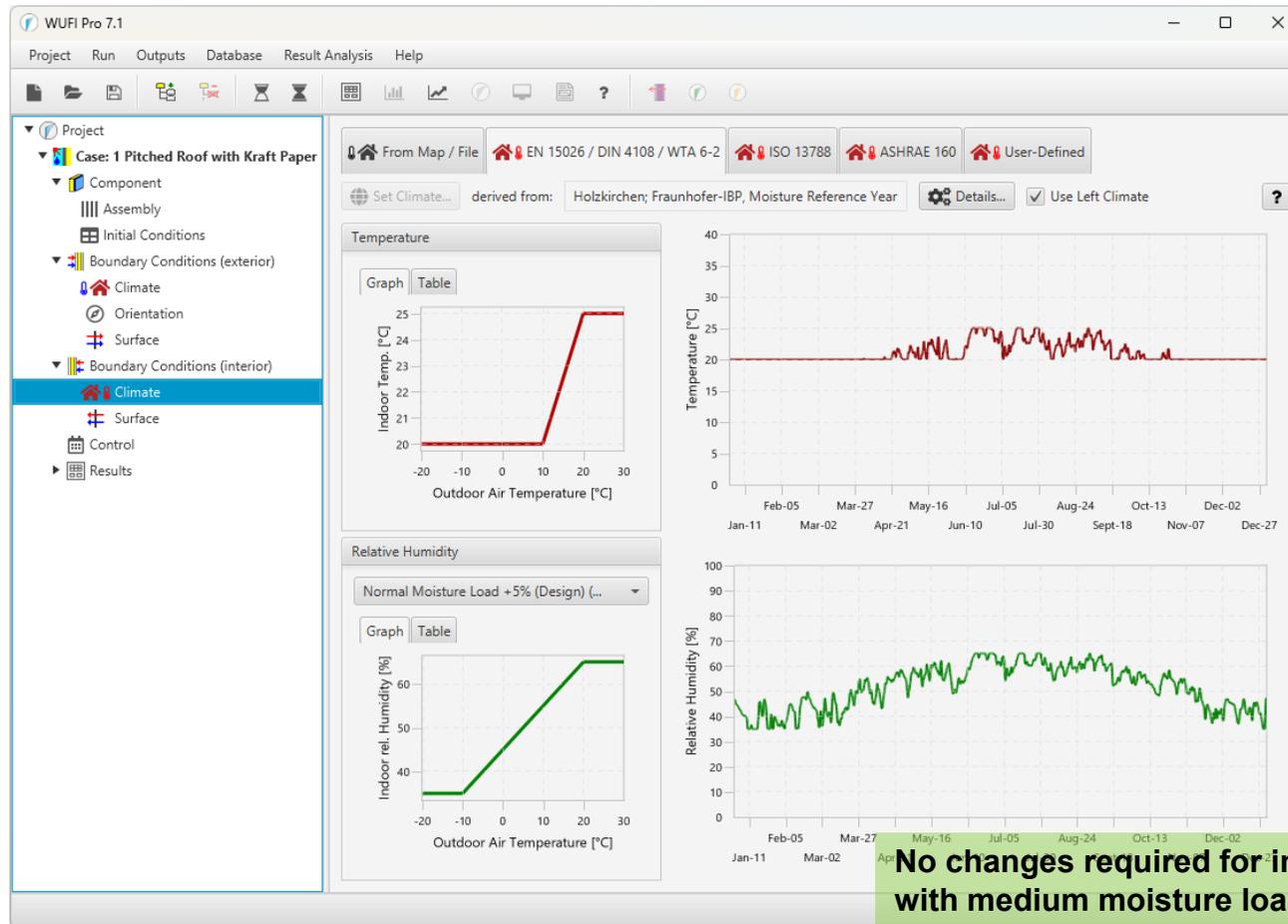
Case 1: Surface Transfer Coefficients (interior)

Input: Boundary Conditions (interior) – Surface

Case 1: Calculation Period

Input: Control

Adapt calculation period if necessary

Case 1: Evaluation – Check for numerical quality

Evaluation:

Hardly convergence failures and small differences in balances!
The last one indicates that the convergence is rather difficult.

Evaluation:

Total water content

Case 1: Evaluation – Wooden Sheathing
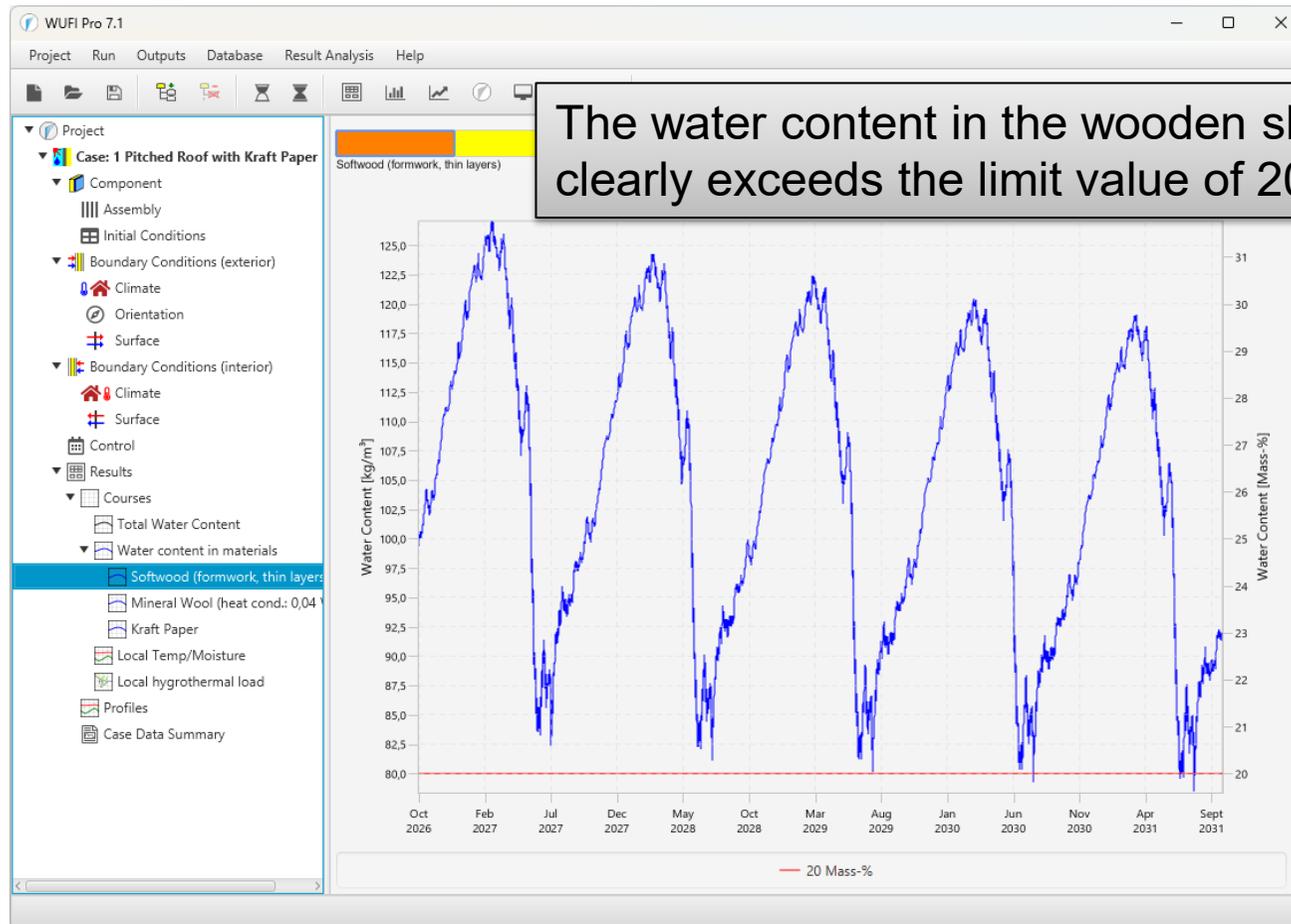
Evaluation:

Water content in the wooden sheathing

The water content in the wooden sheathing clearly exceeds the limit value of 20 % by mass!

Evaluation:

Mould growth risk behind the vapour retarder

- Open WUFI® Animation

- Zoom in the boundary layer
  mineral wool / vapour retarder
  (while pressing the left mouse
  button: pull a box from the
  upper left to the lower right)

- Press the WUFI® Bio-Button
  in the taskbar and
  select the outermost
  element of the kraft paper.

Pitched Roof with Kraft Paper

Evaluation:

Mould growth risk behind the vapour retarder

Evaluation:

Mould growth risk behind the vapour retarder

Check the climatic boundary conditions!

Case 1: Evaluation – mould growth behind vapour retarder

Evaluation:
Mould growth risk behind the vapour retarder
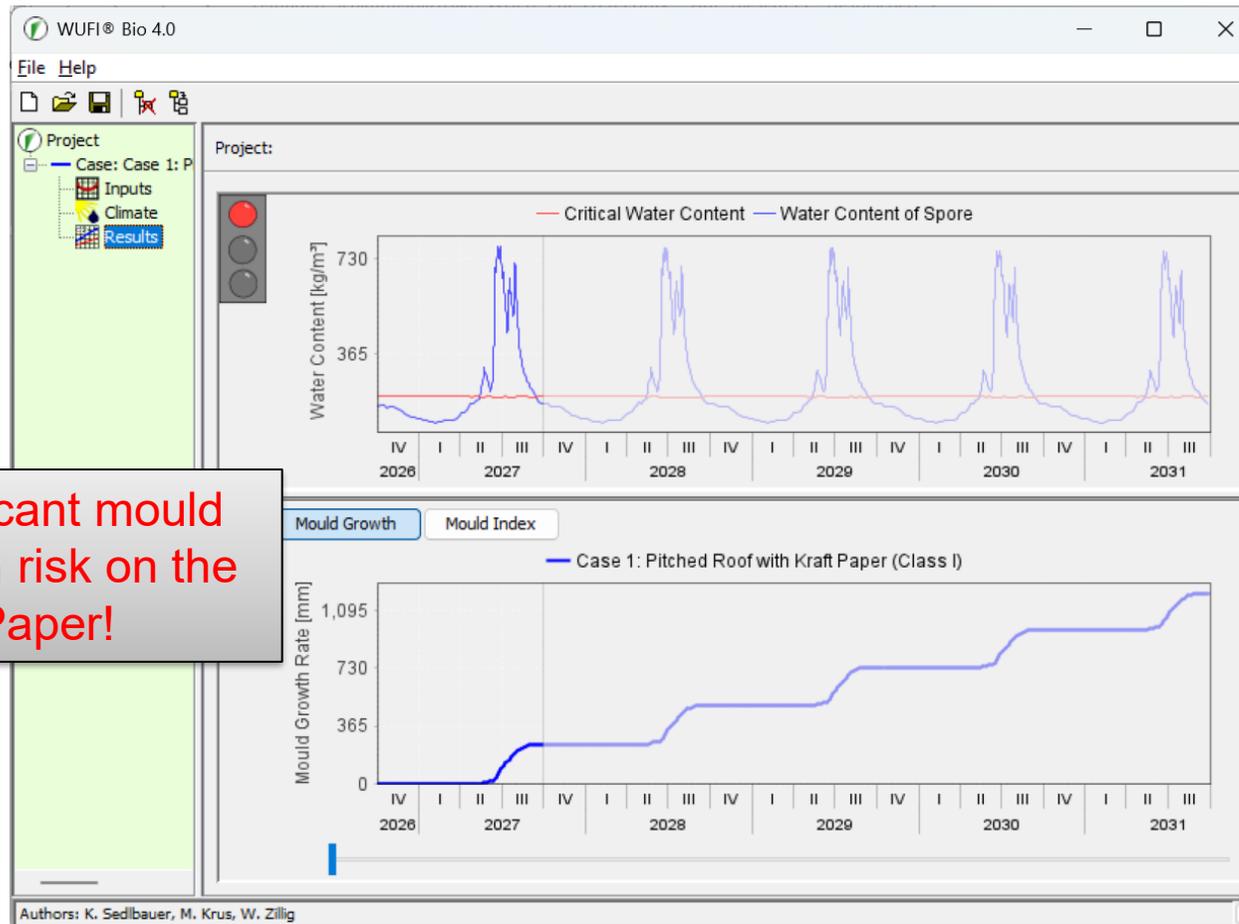
Case 1: Evaluation Matrix

Evaluation Matrix:

	Criteria	Kraft Paper
1) Numerics	No or only small differences in balances (especially in the case of convergence failures)?	✔
	Consistent, periodic course of total water content?	✔
2) Evaluation parameters	Total water content reach dynamic equilibrium or decreases?	✔
	Risk of wood decay in the wooden sheathing? (limit values according to DIN 68800 or WTA 6-8)	✖
	Risk of mould growth behind the membrane / paper?	✖

Case 2: Replacement of the Vapour Retarder

Input: Component - Assembly

Case 2: PA-Membrane

Evaluation:

Hardly convergence failures; differences in balances OK!

Case 2: Evaluation – Total Water Content

Evaluation:
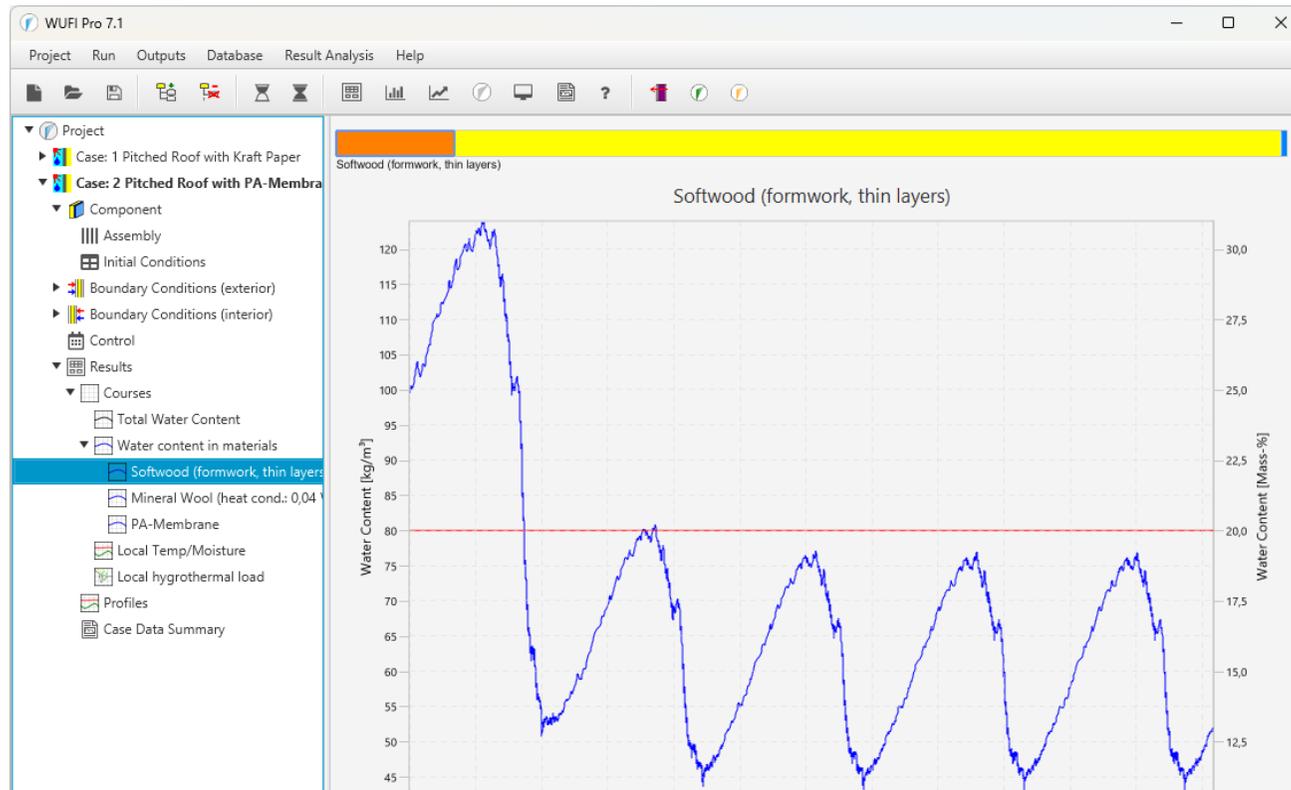
Total water content
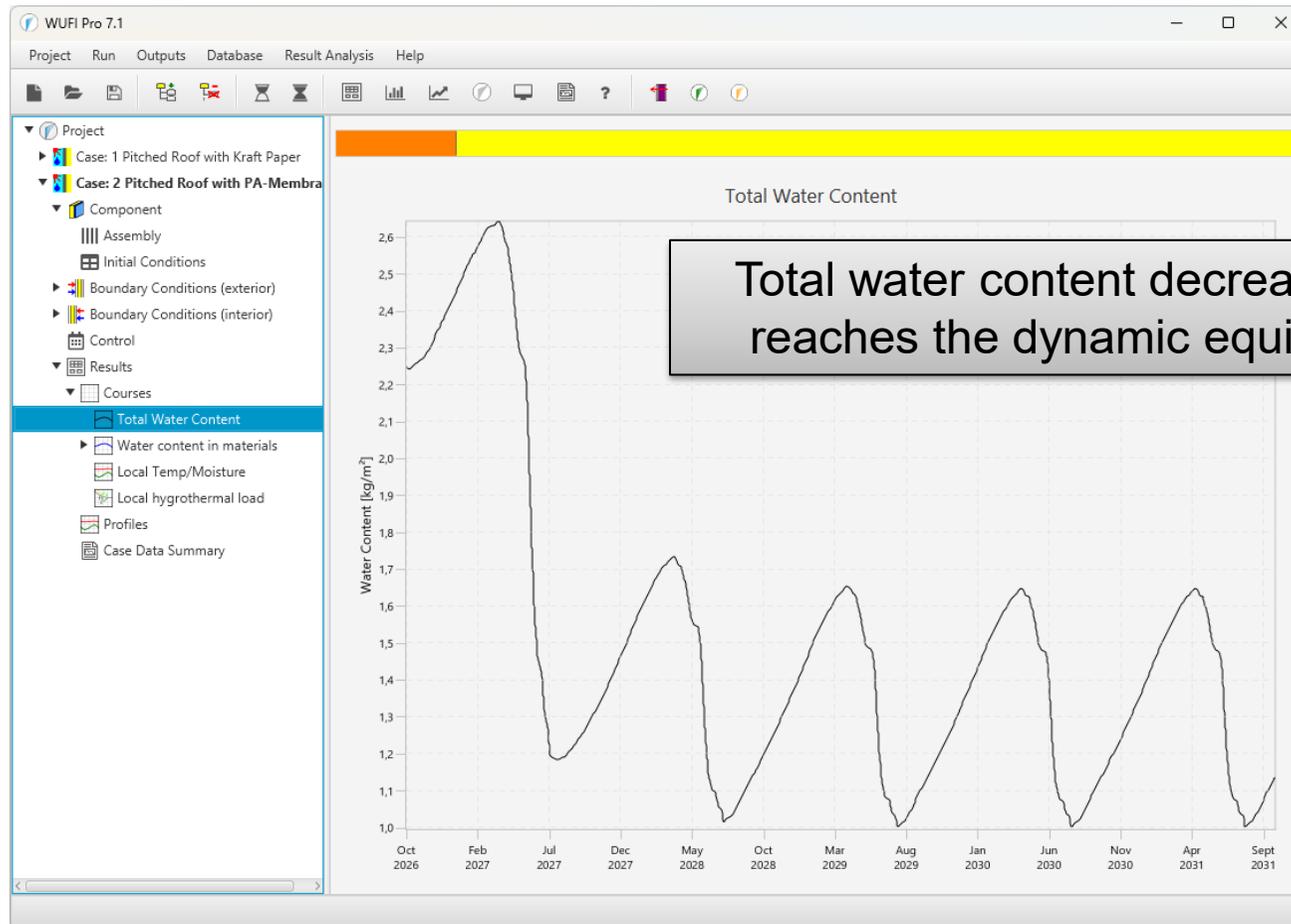
Case 2: Evaluation – Wooden Sheathing

Evaluation:

Water content in the wooden sheathing

After the redistribution of the initial moisture in the first year, the water content in the wooden sheathing remains below the limit value of 20 % by mass!

Case 2: Evaluation – mould growth behind vapour retarder

Evaluation:
Mould growth risk behind the vapour retarder

Select Occupant Exposition Class:

Indoor surface or position in contact to indoor air

Select Substrate Class:

The PA-Membrane is to be classified as a non-biologically usable plastic membrane to Substrate Class II.

Case 2: Evaluation – mould growth behind vapour retarder

Evaluation:

Mould growth risk behind the vapour retarder

Check the climatic boundary conditions!

Evaluation:

Mould growth risk behind the vapour retarder

No mould risk on the PA-Membrane!

Case 2: Evaluation Matrix

Evaluation Matrix:

	Criteria	PA-Membrane
1) Numerics	No or only small differences in balances (especially in the case of convergence failures)?	✔
	Consistent, periodic course of total water content?	✔
2) Evaluation parameters	Total water content reach dynamic equilibrium or decreases?	✔
	Risk of wood decay in the wooden sheathing? (limit values according to DIN 68800 or WTA 6-8)	✔
	Risk of mould growth behind the membrane / paper?	✔

Fraunhofer
IBP