

**WUFI®**

## **Example Cases WUFI® Pro: Green Roofs (generic)**

**Version: July 2021**

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### „Generic Substrate“

This substrate should be used if no measured material properties for the green roof are available. The application is limited due to the experimental basis and the effective radiation parameters for locations in Central Europe (or comparable climates).

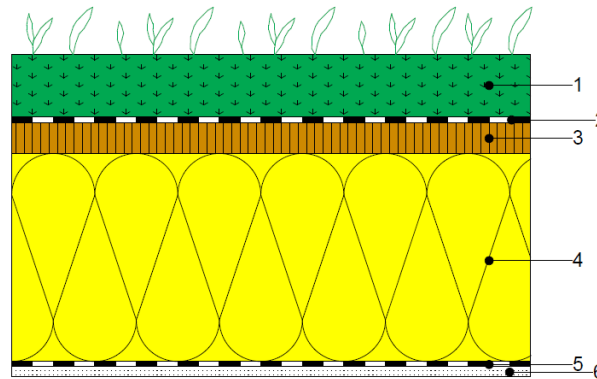
More information about the different models  
and there development can be found in the  
[Guideline for the Calculation of extensive Green Roofs \(generic\)](#)

# Extensive Green Roof on Lightweight Construction

On the basis of two example cases, the procedure for the evaluation of green roofs on lightweight constructions is described below. The necessary material data, the moisture sources and the boundary conditions as well as the procedure for the evaluation of the construction are explained.

## Example A:

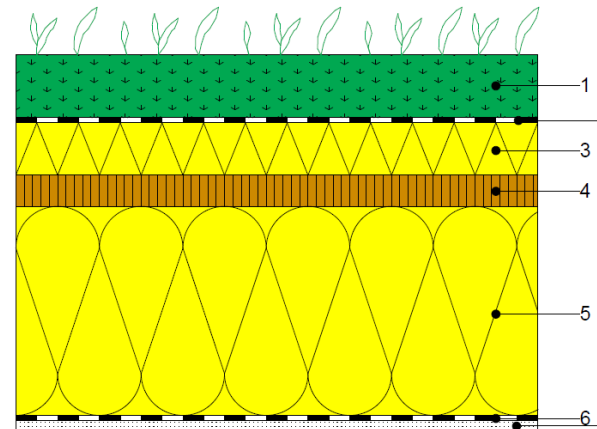
Extensive green roof on  
lightweight construction  
without additional insulation



- 1 Substrate incl. Planting
- 2 Roofing Membrane ( $s_d = 300 \text{ m}$ )
- 3 Wooden Sheathing
- 4 Mineral Wool Insulation
- 5 Moisture-variable Vapour Retarder
- 6 Gypsum Board

## Example B:

Extensive green roof on  
lightweight construction  
with additional insulation



- 1 Substrate incl. Planting
- 2 Roofing Membrane ( $s_d = 300 \text{ m}$ )
- 3 EPS-Insulation
- 4 Wooden Sheathing
- 5 Mineral Wool Insulation
- 6 Moisture-variable Vapour Retarder
- 7 Gypsum Board

## Example A: Assembly

---

Assembly (from outside to inside):

- Generic Substrate 0.06 m
- Roofing Membrane ( $s_d = 300\text{m}$ ) 0.001 m
- Wooden Sheathing (Softwood) 0.025 m
- Mineral Wool (heat cond.: 0.04 W/mK) 0.24 m
- Moisture-variable Vapour Retarder (Vario KM Duplex) 0.001 m
- Gypsum Board 0.0125 m

## Example A: Boundary Conditions

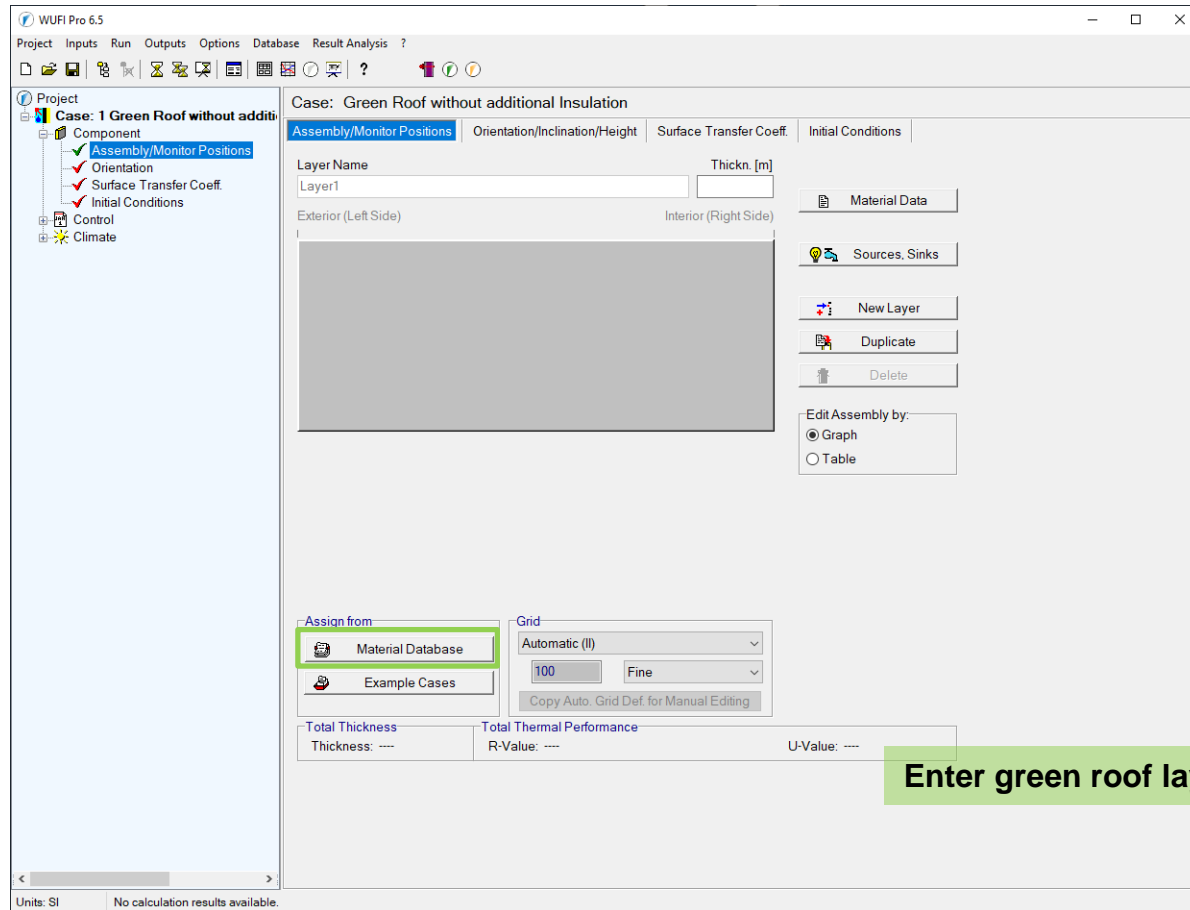
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### Boundary Conditions:

- Flat roof (3° to the North)
- Short-Wave Radiation Absorptivity / Long-Wave Radiation Emissivity: according to the Generic Green Roof Model
- Outdoor Climate: Holzkirchen
- Indoor Climate: Medium Moisture Load + 5 %  
according to DIN 4108-3
- Air Tightness of the Envelope:  $q_{50} = 3 \text{ m}^3/\text{m}^2\text{h}$
- Stack Height: 5 m

# Example A: Component Assembly

Input: Component – Assembly / Monitor Positions



# Example A: Component Assembly

Input: Component – Assembly / Monitor Positions

The screenshot shows the WUFI materials database interface. On the left, a tree view lists various material sources, with 'Green and Gravel Roofs' highlighted under the 'Fraunhofer-IBP' category. The main table displays a list of materials with their properties. The 'generic substrate' material is selected and highlighted in blue. Below the table, the 'Material Information' tab is active, showing details for the 'generic substrate' (thickness ≤ 15 cm). A note explains that the material properties were developed within a research project funded by the German Federal Ministry of Transport, Building and Urban development. A green callout box points to the 'Assign' button at the bottom right of the interface.

Material Name	Bulk density [kg/m³]	Porosity [m³/m³]	Heat Cap. [J/kgK]	Therm. Co... [W/mK]	Vap.Res. [-]
generic gravel	1400	0.3	1000	0.7	1
generic substrate	1500	0.5	1500	0.9	1
Optigreen Economy Roof 1 (protection mat) 3-3	83	0.95	840	0.035	1
Optigreen Economy Roof 1 (sedum planting) 1-3	1500	0.5	1000	0.2	5
Optigreen Economy Roof 1 (substrate type M incl. FKD) 2-3	900	0.65	1000	0.4	3.3
Optigreen Economy Roof 2 (protection mat) 3-3	83	0.95	840	0.035	1
Optigreen Economy Roof 2 (sedum planting) 1-3	1500	0.5	1000	0.2	5
Optigreen Economy Roof 2 (substrate type M) 2-3	900	0.65	1000	0.4	2.2

**Material Information** | Hydrothermal Functions

substrate (thickness ≤ 15 cm)

NOTE: Input of a moisture source ("fraction of driving rain") in the lowest 2 cm of the layer which deposits 40 % of the rain with clipping to free water saturation.

The material properties were developed within the research project "Zuverlässige Beurteilung der hygrothermischen und energetischen Auswirkungen von Gründächern" (SF-10.08.18.8 / II 3-F20-10-1-100), funded by the research program "Zukunft Bau" of the Bundesinstitut für Bau-, Stadt- und Raumforschung (German Federal Ministry of Transport, Building and Urban development).

Added to DB: 24.07.2013  
Last update: ---

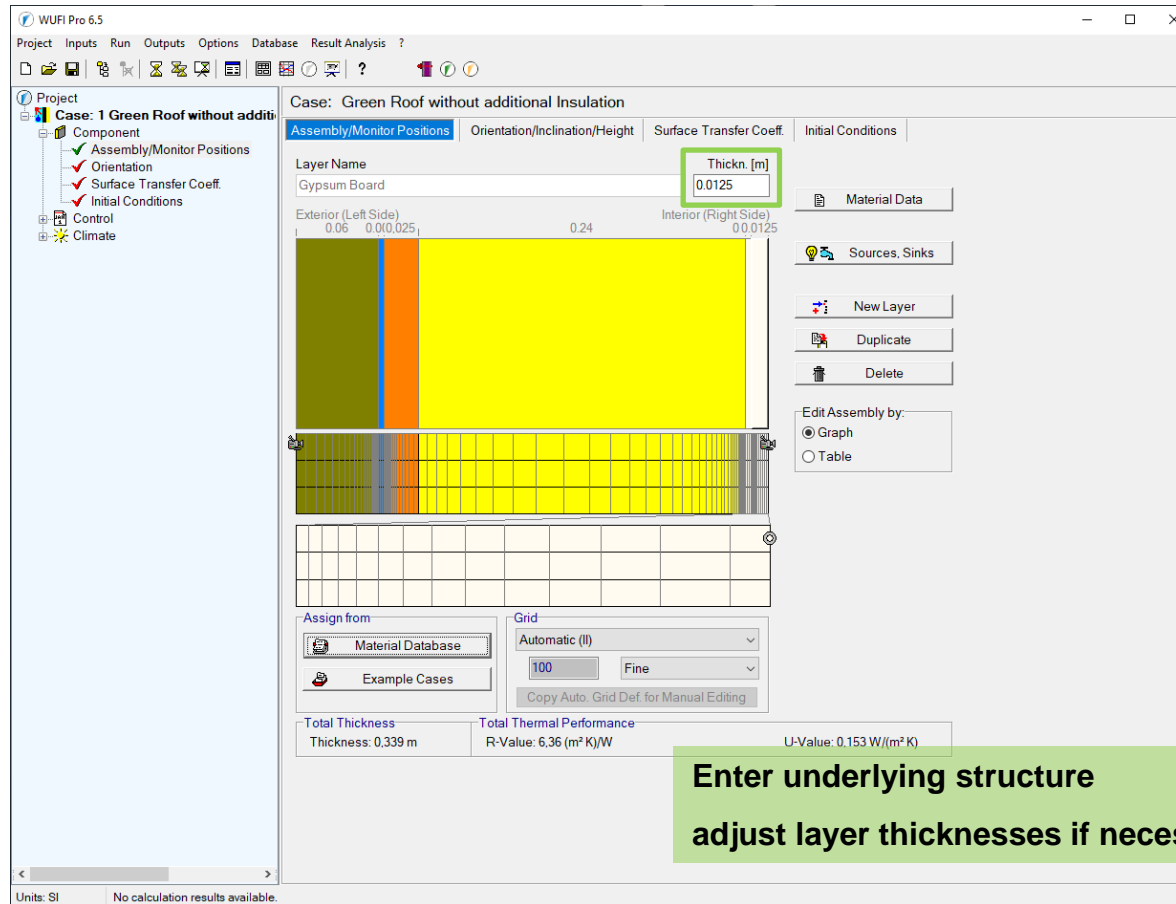
Thickness [m]: 0.06 | Assign | Cancel | Help

**Enter green roof layer**



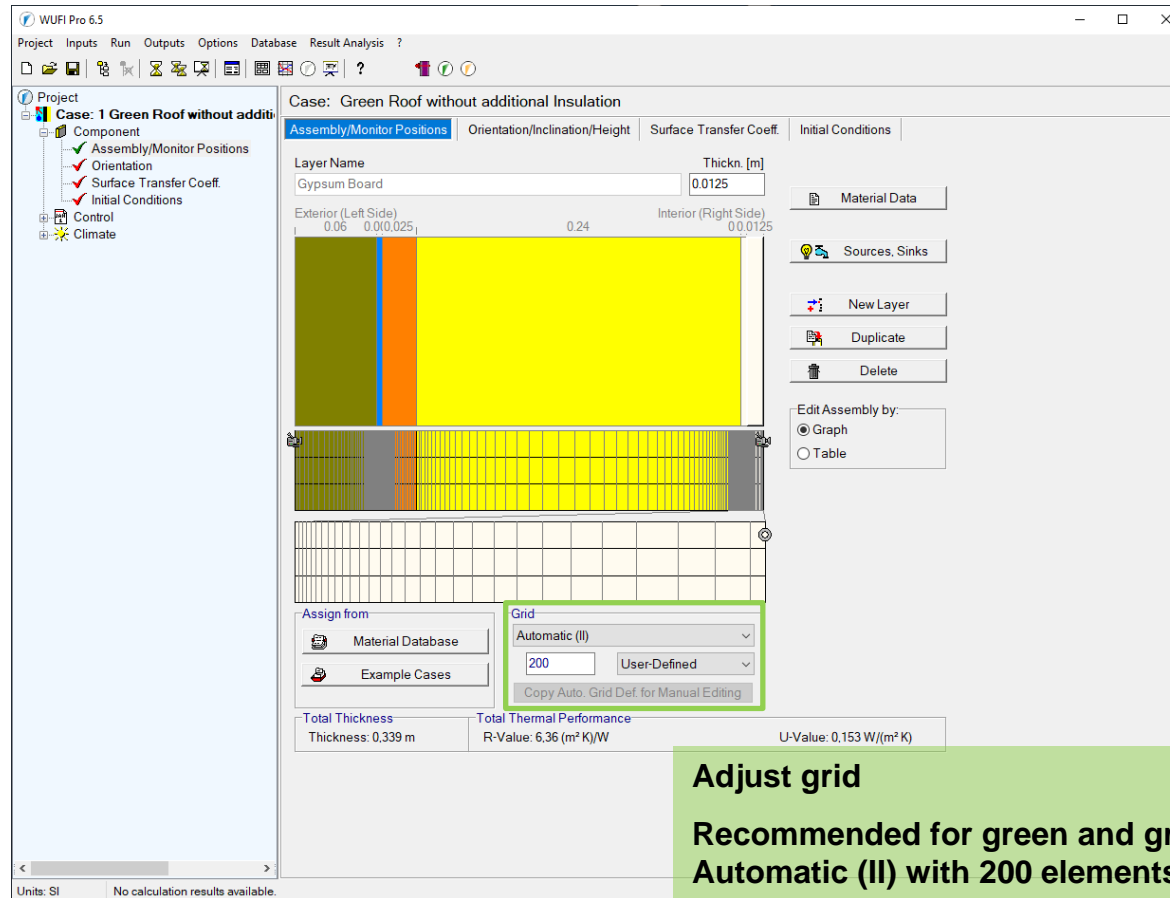
# Example A: Component Assembly

Input: Component – Assembly / Monitor Positions



# Example A: Grid

Input: Component – Assembly / Monitor Positions



Adjust grid

Recommended for green and gravel roofs:  
Automatic (II) with 200 elements (user-defined)

# Example A: Moisture Source in the Substrate Layer

Input: Component – Assembly / Monitor Positions

Enter moisture source in the layer „Generic Substrate“.

The screenshot displays the WUFI Pro 6.5 software interface. The main window shows the 'Assembly/Monitor Positions' tab for a component named 'generic substrate'. The layer thickness is set to 0.06 m. The 'Sources, Sinks' button is highlighted with a green box. The 'Hygrothermal Sources' dialog box is open, showing the 'generic substrate' layer selected. The 'New Moisture Source' button is highlighted with a green box. The dialog box also includes buttons for 'New Heat Source', 'New Air Change Source', 'Edit', and 'Delete'. The 'OK', 'Abort', and 'Help' buttons are at the bottom of the dialog box.

**Select component layer**

**Sources, Sinks**

**New Moisture Source**

Hygrothermal Sources

Layer/Material Name: generic substrate

Hygrothermal Sources

Nr.	Type	Name
-----	------	------

New Heat Source ...

New Moisture Source ...

New Air Change Source ...

Edit ...

Delete

OK Abort Help

## Example A: Moisture Source in the Substrate Layer

Input: Component – Assembly / Monitor Positions

Moisture source in the  
lowest 2 cm of the layer  
„Generic Substrate“.

The screenshot shows the 'Moisture Source' dialog box with the following settings and annotations:

- Name:** moisture source in the substrate
- Spread Area:** ☒ Several Elements
- Start Depth in Layer [m]:** 0.04
- End Depth in Layer [m]:** 0.06
- Source Type:** ☒ Fraction of Rain Load
- Source Term Cut-Off [kg/m³]:** ☒ Cut-Off at Free Water Saturation
- Fraction [%]:** 40
- User-Defined:** User-Defined

Annotations in green boxes:

- Lowest 2 cm in the substrate** (pointing to the depth fields)
- Enter fraction of the driving rain** (pointing to the fraction field)

Buttons at the bottom: OK, Cancel, Help.

# Example A: Infiltration Source

Input: Component – Assembly / Monitor Positions

Infiltration source according to DIN 68800 in the wooden sheathing.

The screenshot displays the WUFI Pro 6.5 software interface. The main window shows the 'Assembly/Monitor Positions' tab for a case named 'Green Roof without additional Insulation'. The assembly is visualized as a cross-section with layers: a green layer (top), a yellow layer (middle), and an orange layer (bottom). A green box highlights the yellow layer, with the text 'Select component layer' overlaid. The yellow layer is labeled 'Softwood' with a thickness of 0.025 m. The assembly is divided into three sections: 'Exterior (Left Side)' with a thickness of 0.06 m, 'Interior (Right Side)' with a thickness of 0.00125 m, and a central section with a thickness of 0.24 m. The total thickness is 0.339 m, and the total thermal performance is R-Value: 6.36 (m² K)/W and U-Value: 0.153 W/(m² K). The 'Hygrothermal Sources' dialog box is open, showing the 'Layer/Material Name' as 'Softwood'. The dialog box has a table for 'Hygrothermal Sources' with columns 'Nr.', 'Type', and 'Name'. The 'New Moisture Source ...' button is highlighted with a green box, and the text 'New Moisture Source' is overlaid. The 'OK' button is also highlighted with a green box.

**Sources, Sinks**

**Select component layer**

**New Moisture Source**

**OK**

## Example A: Infiltration Source

Input: Component – Assembly / Monitor Positions

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

The screenshot shows the 'Moisture Source' dialog box with the following settings and annotations:

- Name:** infiltration source
- Spread Area:** ☒ Several Elements
- Start Depth in Layer [m]:** 0.02
- End Depth in Layer [m]:** 0.025
- Source Type:** ☒ Air Infiltration model IBP
- Source Term Cut-Off [kg/m³]:** ☒ Cut-Off at Free Water Saturation
- Envelope Infiltration q50 [m³/(m² h)]:** 3
- Air Tightness Class B (DIN 4108, tested <= 3 m³/m²h):** (dropdown menu)
- Stack Height [m]:** 5
- Mechanical Ventilation Overpressure [Pa]:** 0

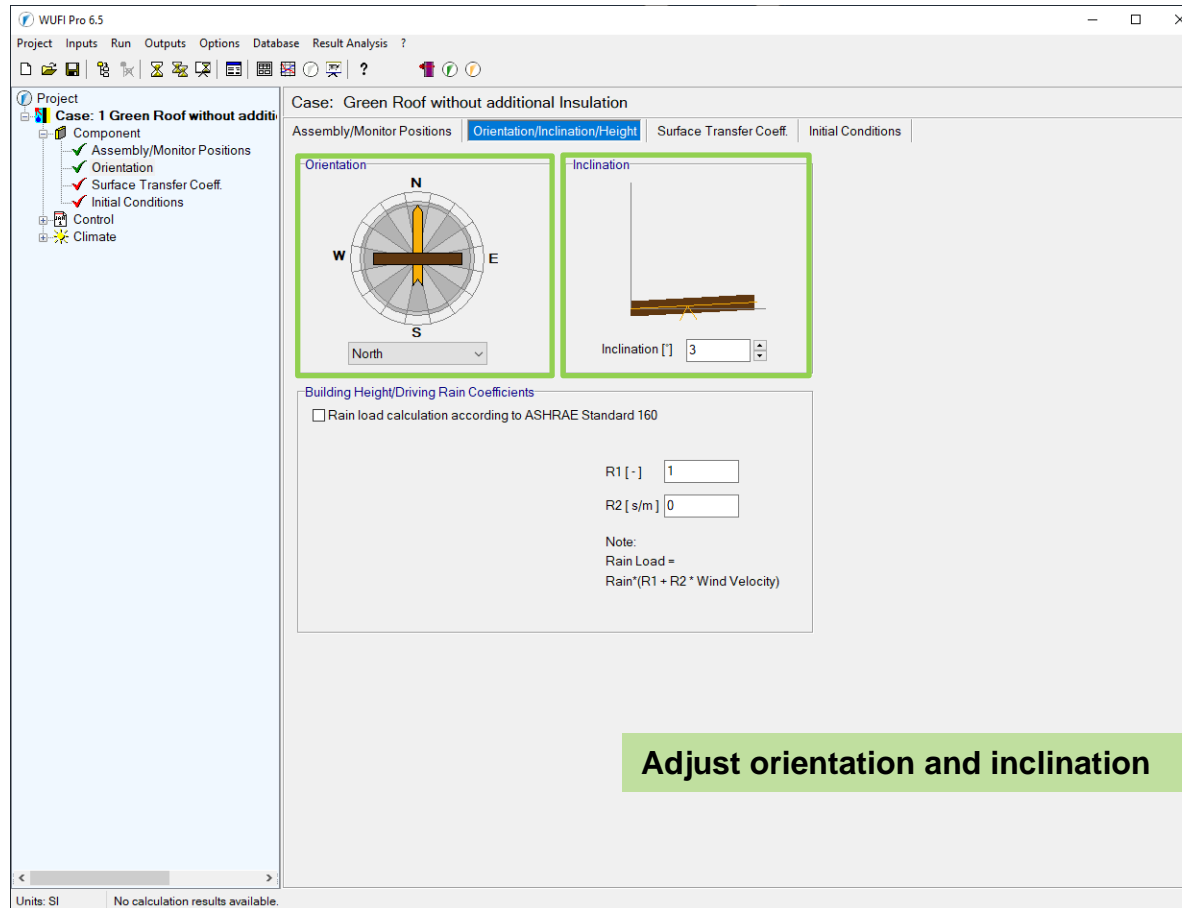
Annotations in green boxes and text:

- Interior 5 mm of the sheathing** (points to the depth fields)
- Adjust infiltration source** (points to the infiltration model and envelope infiltration fields)

Buttons at the bottom: OK, Cancel, Help.

# Example A: Orientation / Inclination

Input: Component – Orientation



# Example A: Surface Transfer Coefficients

Input: Component – Surface Transfer Coeff.

WUFI Pro 6.5

Project Inputs Run Outputs Options Database Result Analysis ?

Project: Case: 1 Green Roof without additional Insulation

Component

- Assembly/Monitor Positions
- Orientation
- Surface Transfer Coeff.
- Initial Conditions
- Control
- Climate

Case: Green Roof without additional Insulation

Assembly/Monitor Positions Orientation/Inclination/Height **Surface Transfer Coeff** Initial Conditions

Exterior Surface (Left Side)

Heat Transfer Coefficient [W/(m² K)] 19 Roof

includes long-wave radiation parts [W/(m² K)] 6.5

wind-dependent ☐

sd-Value [m] No coating

Note: This setting does not affect rain absorption

Short-Wave Radiation Absorptivity [-] 0.3 Green roof, generic model

Long-Wave Radiation Emissivity [-]

Reduction factors caused by shading:

for absorptivity [-] No shading

for emissivity [-]

Explicit Radiation Balance ☐ Note: This option takes radiative cooling due to long-wave emission into account. Sensitive cases may require sufficiently accurate counter-radiation data in the weather file.

Ground Short-Wave Reflectivity [-] 0.2 Standard value

Adhering Fraction of Rain [-] 1.0 Depending on inclination of component

Interior Surface (Right Side)

Heat Transfer Coefficient [W/(m² K)] 8 (Roof)

sd-Value [m] No coating

Units: SI No calculation results available.

Heat Transfer Coefficient for Roof = 19 W/m²K

Radiation Absorptivity and Emissivity: Green roof, generic model

No use of the Explicit Radiation Balance

Adhering Fraction of Rain = 1

Adjust surface transfer coefficients!



# Example A: Initial Conditions

## Input: Component – Initial Conditions

WUFI Pro 6.5

Project Inputs Run Outputs Options Database Result Analysis ?

Project

- Case: 1 Green Roof without additional Insulation
  - Component
    - Assembly/Monitor Positions
    - Orientation
    - Surface Transfer Coeff.
    - Initial Conditions
  - Control
  - Climate

Case: Green Roof without additional Insulation

Assembly/Monitor Positions Orientation/Inclination/Height Surface Transfer Coeff. Initial Conditions

Initial Moisture in Component

☒ Constant Across Component

☐ In each Layer

☐ Read from File

Initial Temperature in Component

☒ Constant Across Component

☐ Read from File

Initial Relative Humidity [-] 0.8 Initial Temperature in Component [°C] 20

Initial Water Content in Different Layers

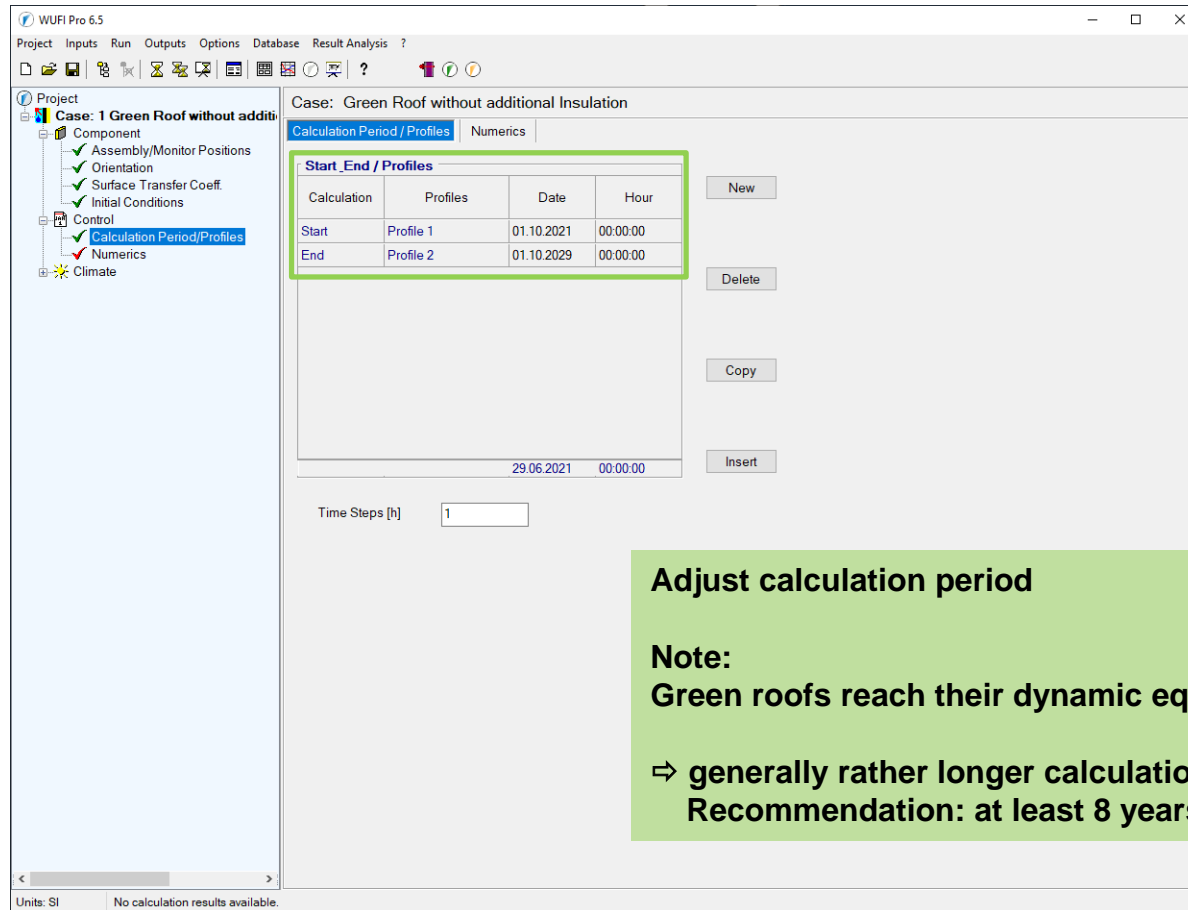
No.	Material Layer	Thickn. [m]	Water Content [kg/m³]
1	generic substrate	0.06	12.0
2	vapour retarder (sd=300m)	0.001	0.0
3	Softwood	0.025	60.0
4	Mineral Wool (heat cond.: 0.04 W/mK)	0.24	1.79
5	ISOVER Vario KM Duplex	0.001	3.5
6	Gypsum Board	0.0125	6.3

Units: SI No calculation results available.

No changes required

# Example A: Calculation Period

Input: Control – Calculation Period/ Profiles



**Adjust calculation period**

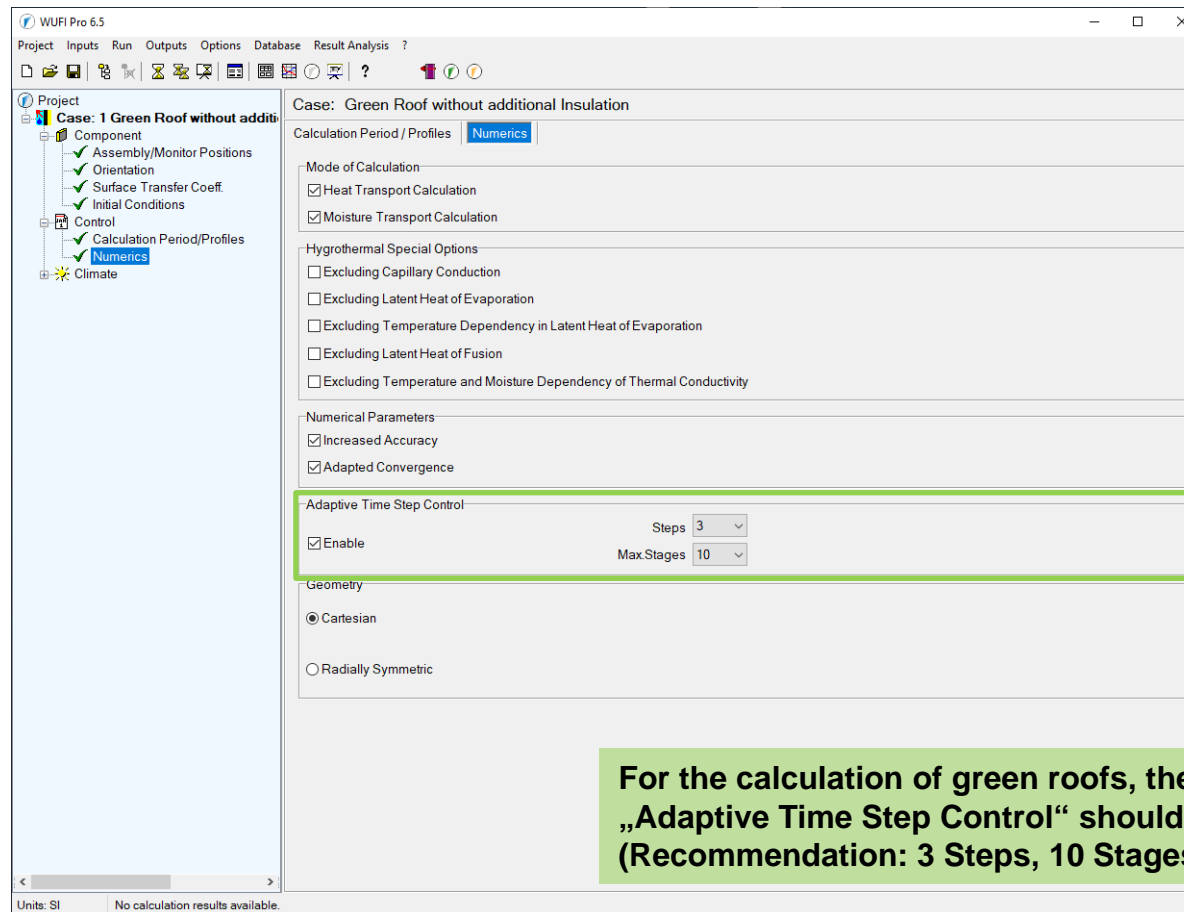
**Note:**

**Green roofs reach their dynamic equilibrium very slowly**

⇒ **generally rather longer calculation periods are required**  
**Recommendation: at least 8 years**

# Example A: Numerical Settings

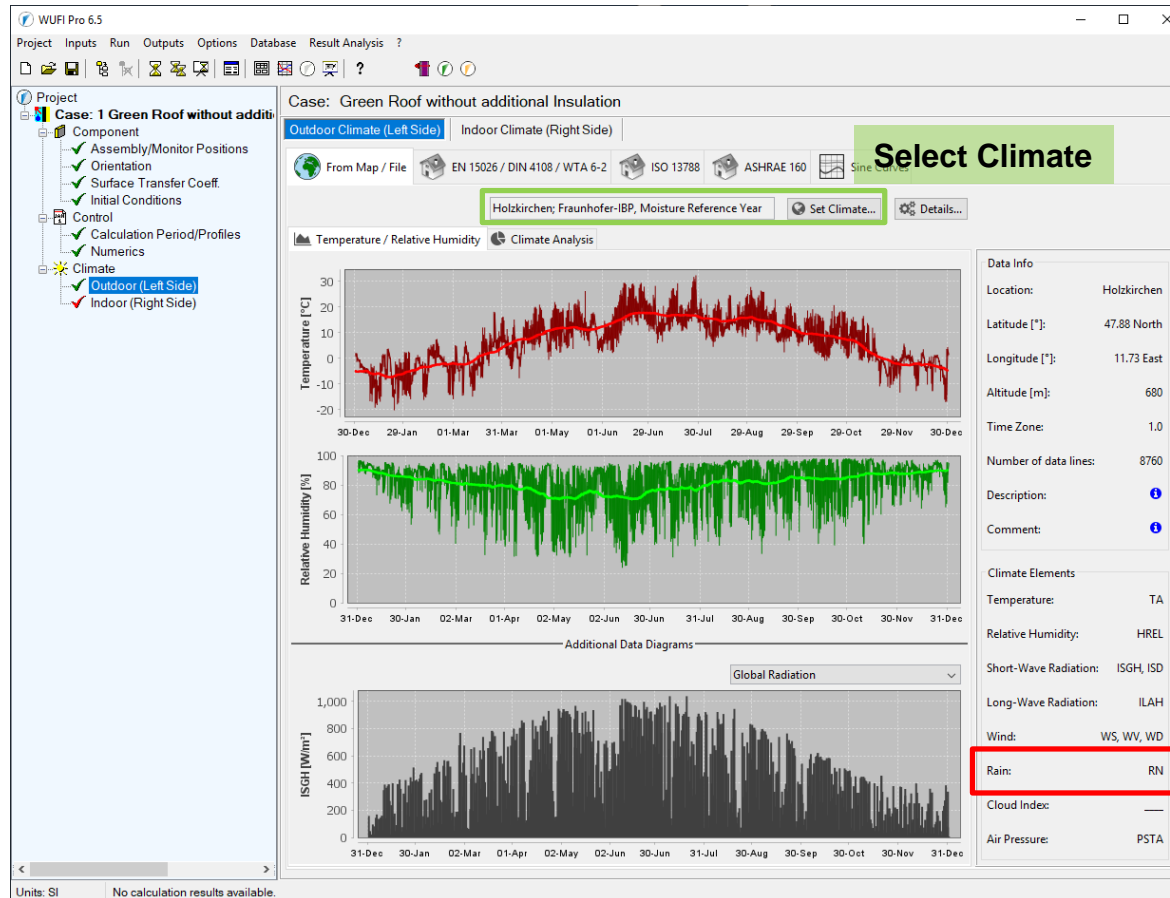
## Input: Control – Numerics



**For the calculation of green roofs, the „Adaptive Time Step Control“ should be enabled! (Recommendation: 3 Steps, 10 Stages)**

# Example A: Outdoor Climate

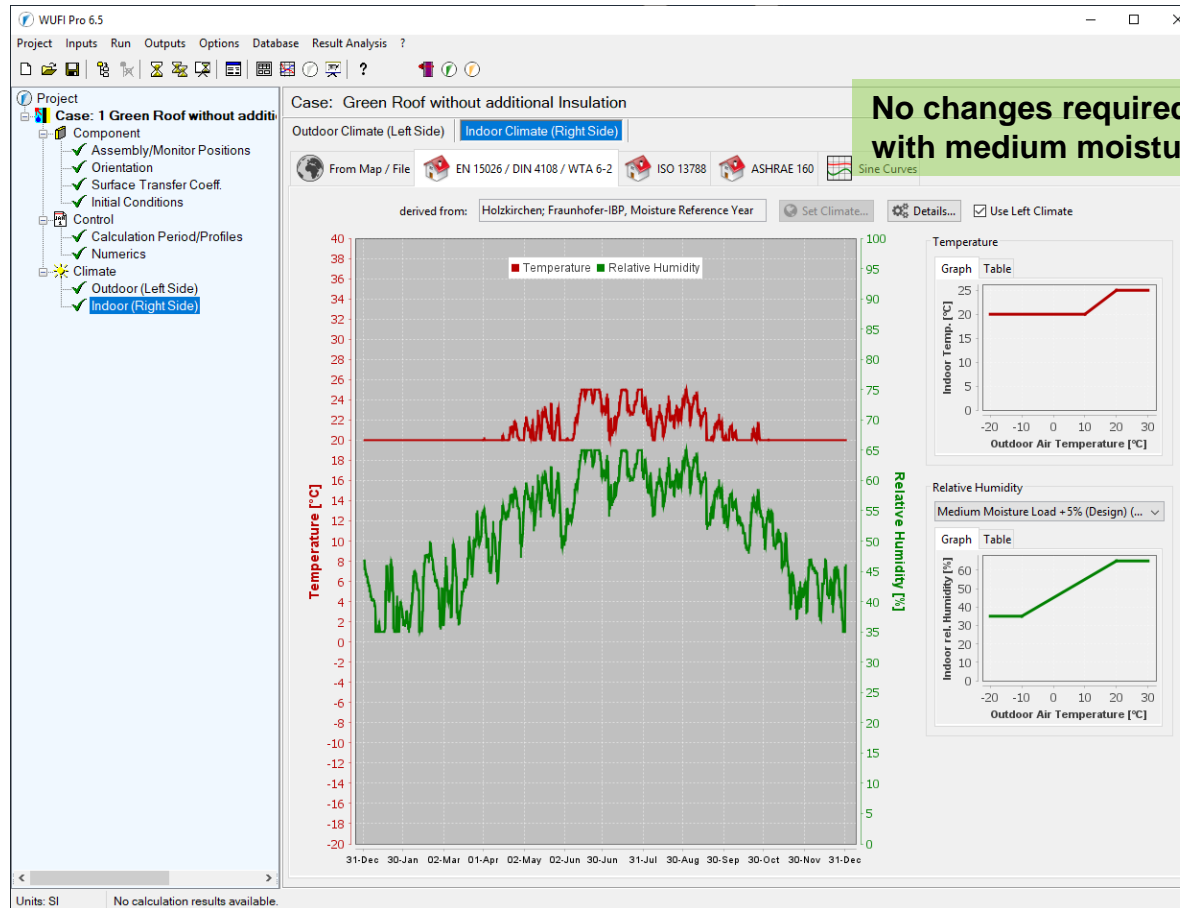
## Input: Climate – Outdoor (Left Side)



**Note:**  
The generic green roof model is also suitable for climate data without long-wave radiation. Rain data is necessary!

# Example A: Indoor Climate

## Input: Climate – Indoor (Right Side)



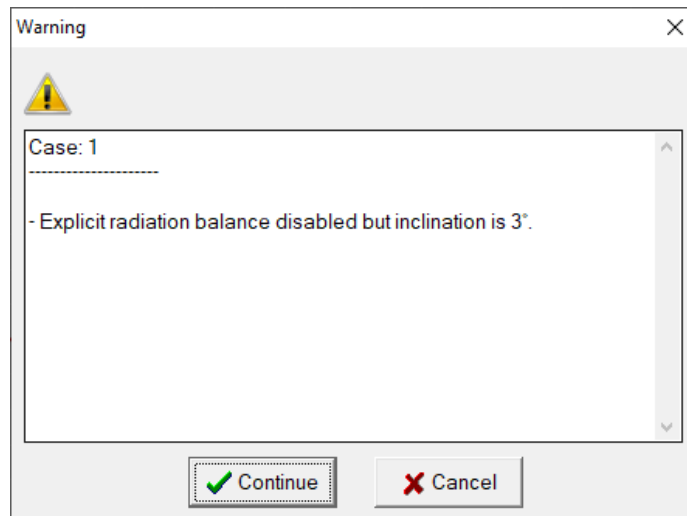
## Example A: Note when Calculation Start

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### Calculation Start:

### Note:

After calculation start this warning appears:



→ this warning can be ignored for the calculation of a green roof with the generic model!

# Example A: Evaluation Calculation Quality

## Status of Last Calculation:

Status of Last Calculation

Status of Calculation

Calculation: Time and Date	29.06.2021 10:14:37
Computing Time	6 min,39 sec.
Begin / End of calculation	01.10.2021 / 01.10.2029
No. of Convergence Failures	0

Check for numerical quality

Integral of fluxes, left side (kl,dl)	[kg/m²]	-641,99 -449,31
Integral of fluxes, right side (kr,dr)	[kg/m²]	2,2E-7 -0,91
Balance 1	[kg/m²]	16,91
Balance 2	[kg/m²]	16,77

Water Content [kg/m²]

	Start	End	Min.	Max.
Total Water Content	2,73	19,93	2,66	22,24

Water Content [kg/m³]

Layer/Material	Start	End	Min.	Max.
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☐ Calculation locked

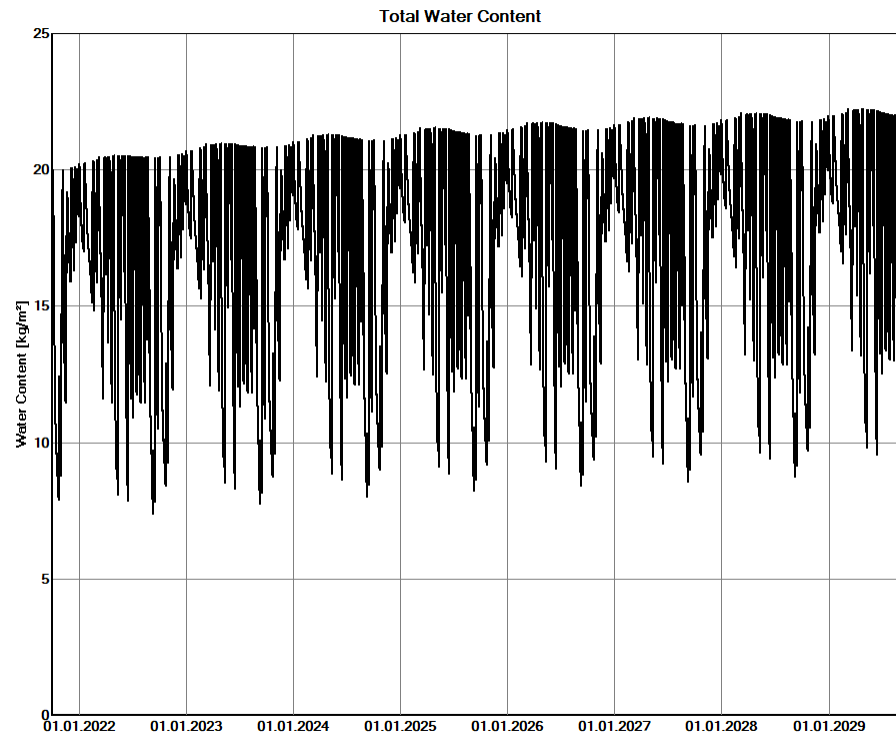
Close

Help

**No convergence failures!**  
**Balance differences acceptable!**

## Example A: Evaluation Total water content

Evaluation with the help of the Quick Graphs:  
Total Water Content



### Evaluation:

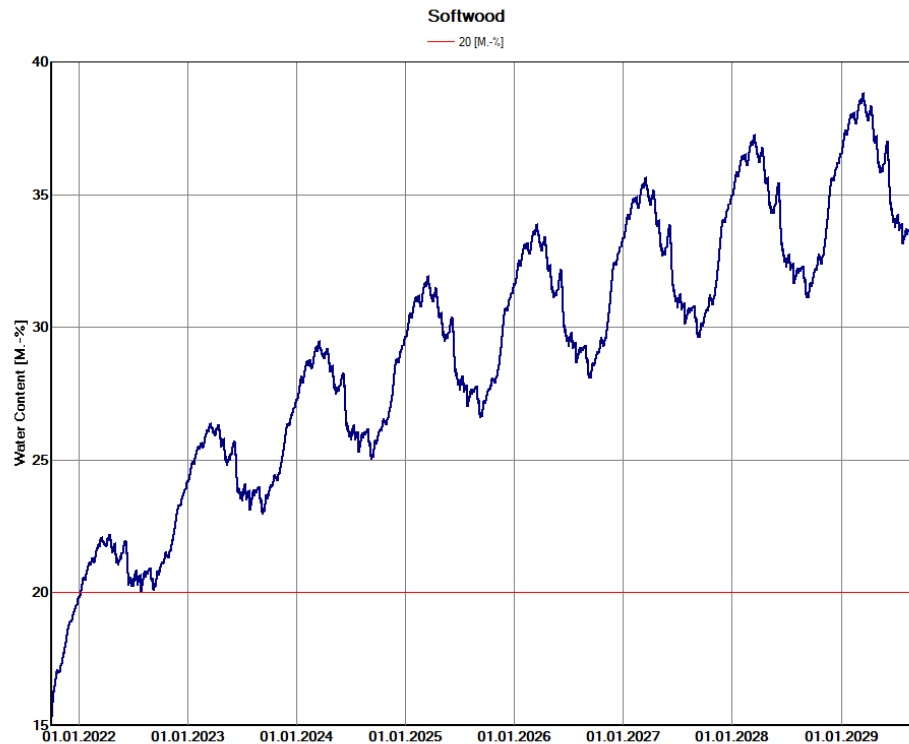
The total water content for green roofs is hardly conclusive because of the large amount of moisture in the substrate.

→ Evaluation of the single layers of the substructure



## Example A: Evaluation Wooden Sheathing

Evaluation with the help of the Quick Graphs:  
Water Content in the wooden sheathing



### Evaluation:

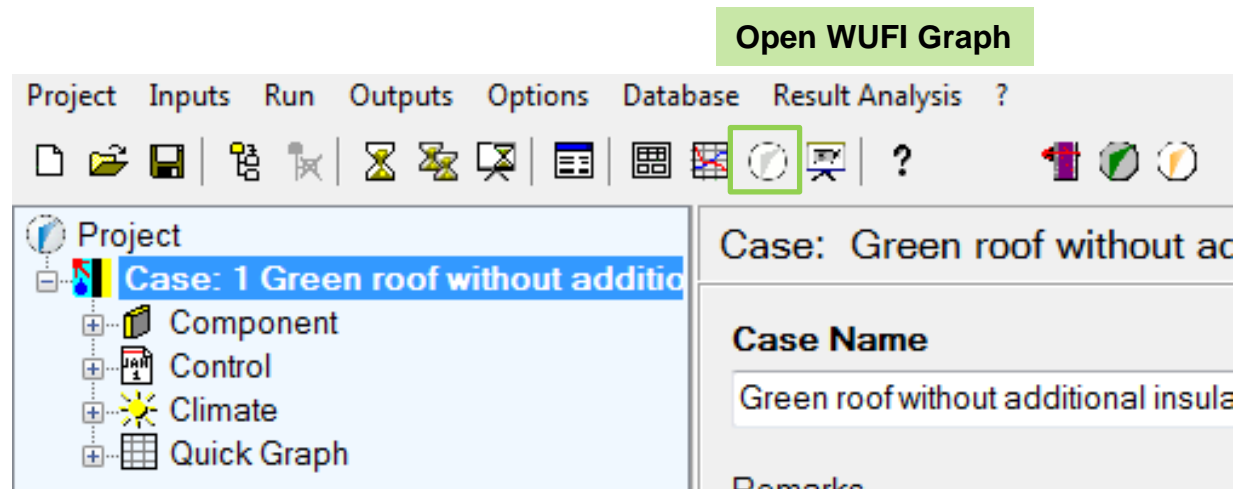
The water content in the wooden sheathing increases over the calculation period and exceeds the limit value of 20 % by mass clearly.

→ Evaluation of the wood moisture according to WTA

## Example A: Evaluation Wood Moisture Content with WUFI® Graph

Evaluation with the help of WUFI® Graph:

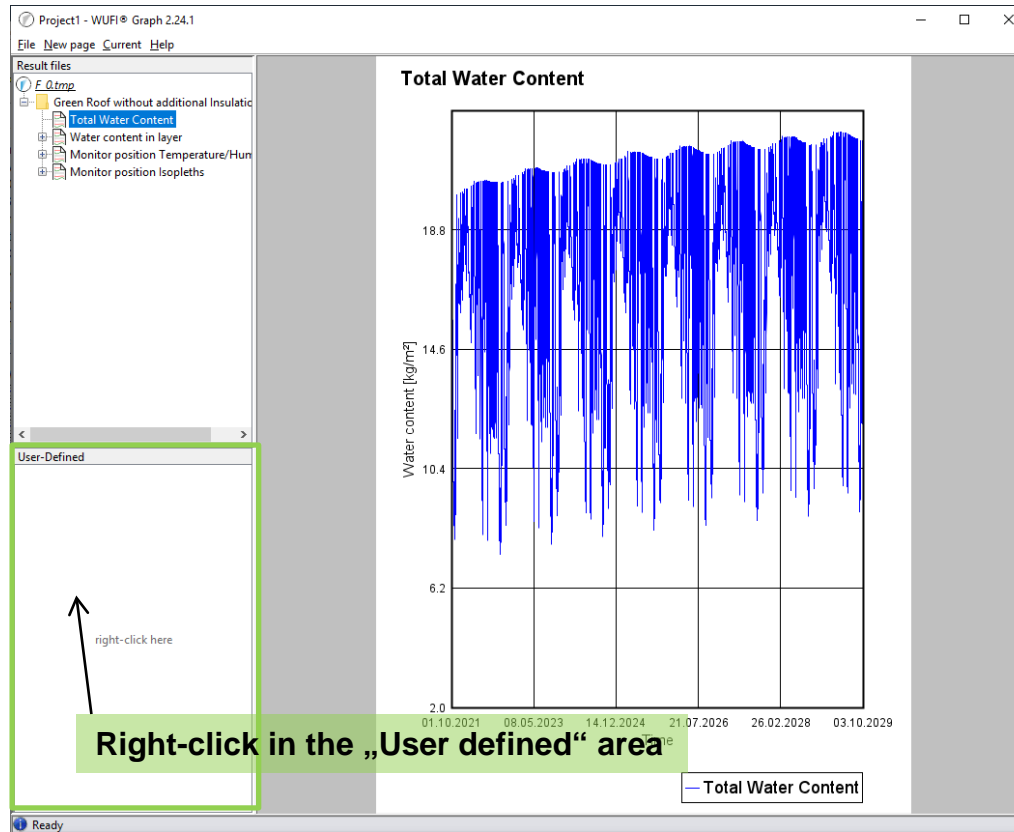
Wood moisture in the wooden sheathing according to WTA 6-8



## Example A: Evaluation Wood Moisture Content with WUFI® Graph

Evaluation with the help of WUFI® Graph:

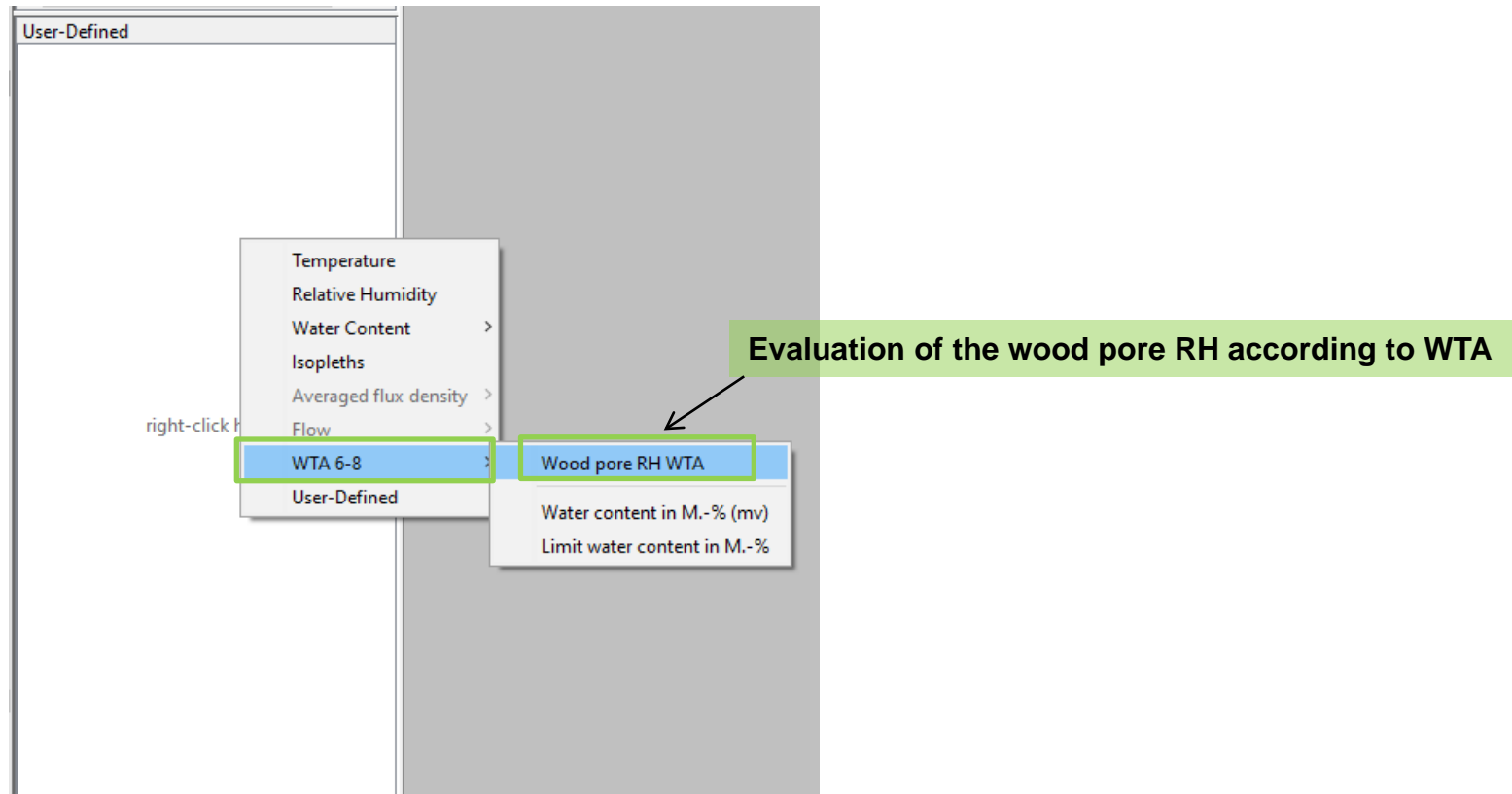
Wood moisture in the wooden sheathing according to WTA 6-8



## Example A: Evaluation Wood Moisture Content with WUFI® Graph

Evaluation with the help of WUFI® Graph:

Wood moisture in the wooden sheathing according to WTA 6-8

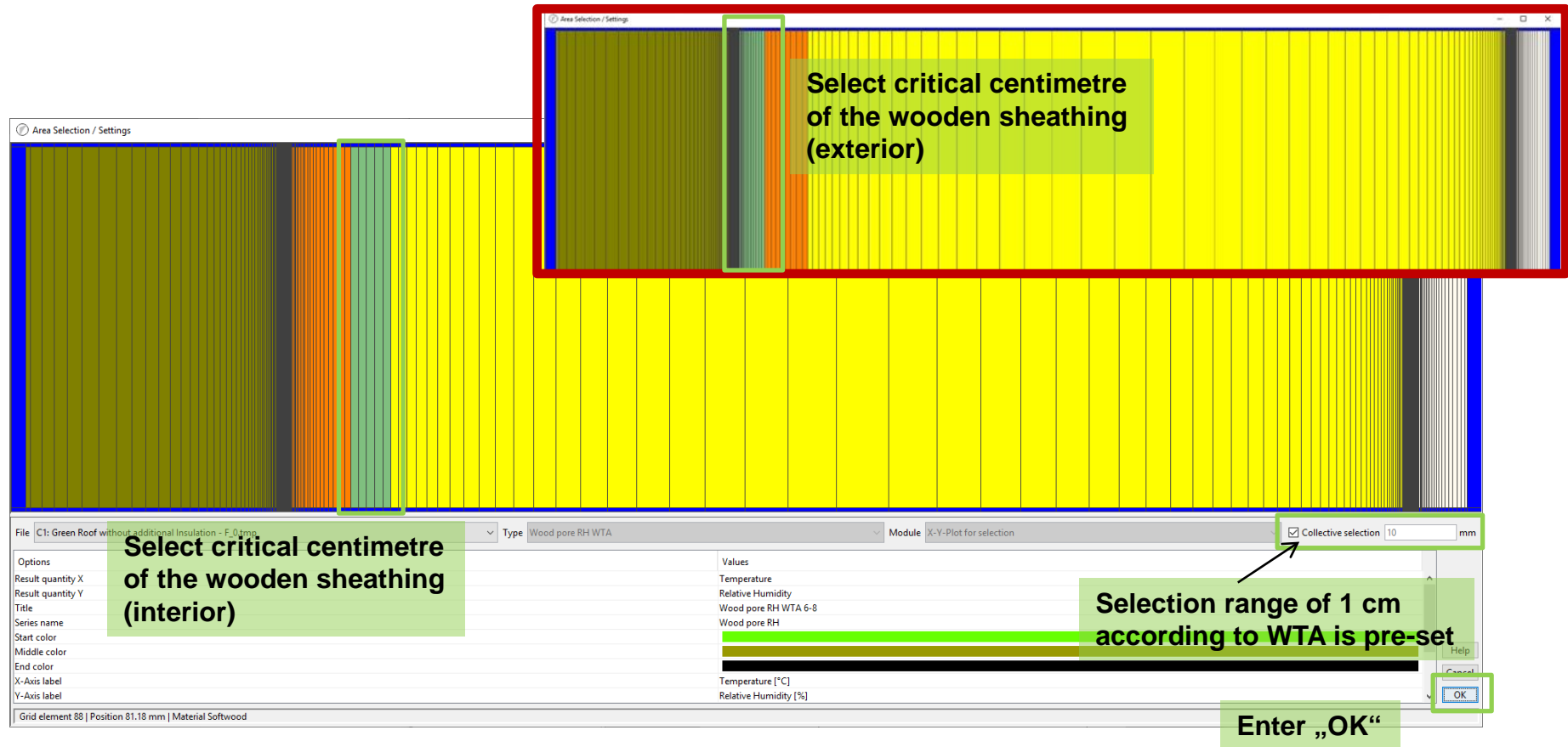


# Example A: Evaluation Wood Moisture Content with WUFI® Graph

Evaluation with the help of WUFI® Graph:

Wood moisture in the wooden sheathing according to WTA 6-8

*Evaluation in the most critical centimetre (in case of doubt consider both sides)*



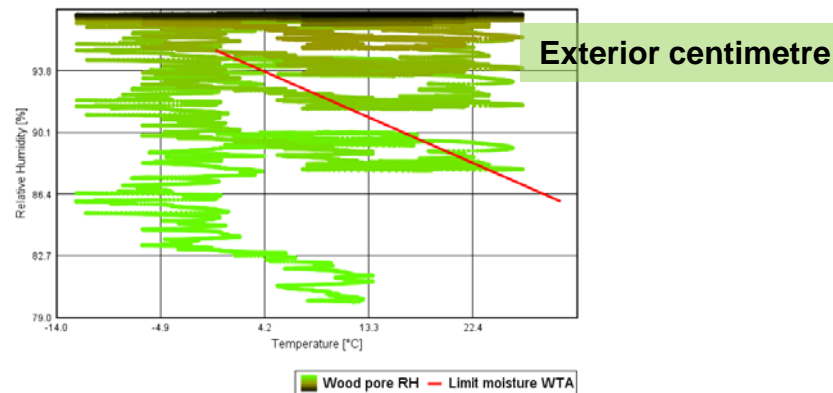
# Example A: Evaluation Wood Moisture Content with WUFI® Graph

## Evaluation with the help of WUFI® Graph:

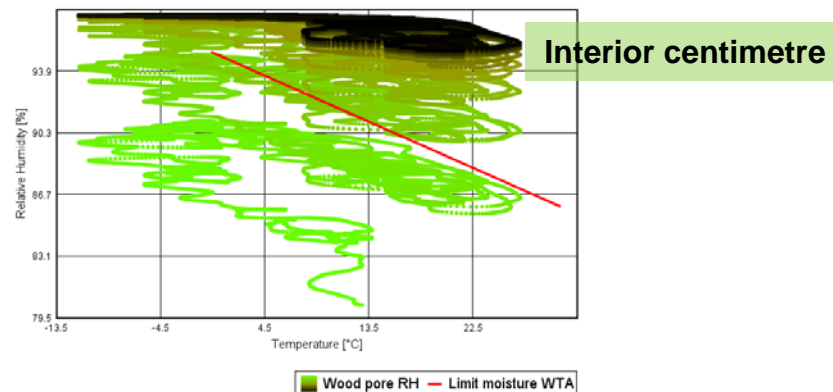
Wood moisture in the wooden sheathing according to WTA 6-8

*Evaluation in the most critical centimetre (in case of doubt consider both sides)*

Wood pore RH WTA 6-8



Wood pore RH WTA 6-8



## Evaluation:

The relative pore air moisture in the interior and the exterior centimetre of the sheathing exceeds the limit moisture according to WTA also clearly.

→ High risk regarding damage of the wood

## Example B: Assembly

---

Assembly (from outside to inside):

- Generic Substrate 0.06 m
- Roofing Membrane ( $s_d = 300\text{m}$ ) 0.001 m
- EPS (heat cond.:  $0.04 \text{ W/mK}$  - density:  $30\text{kg/m}^3$ ) 0.1 m
- Wooden Sheathing (Softwood) 0.025 m
- Mineral Wool (heat cond.:  $0.04 \text{ W/mK}$ ) 0.24 m
- Moisture-variable Vapour Retarder (Vario KM Duplex) 0.001 m
- Gypsum Board 0.0125 m

## Example B: Boundary Conditions

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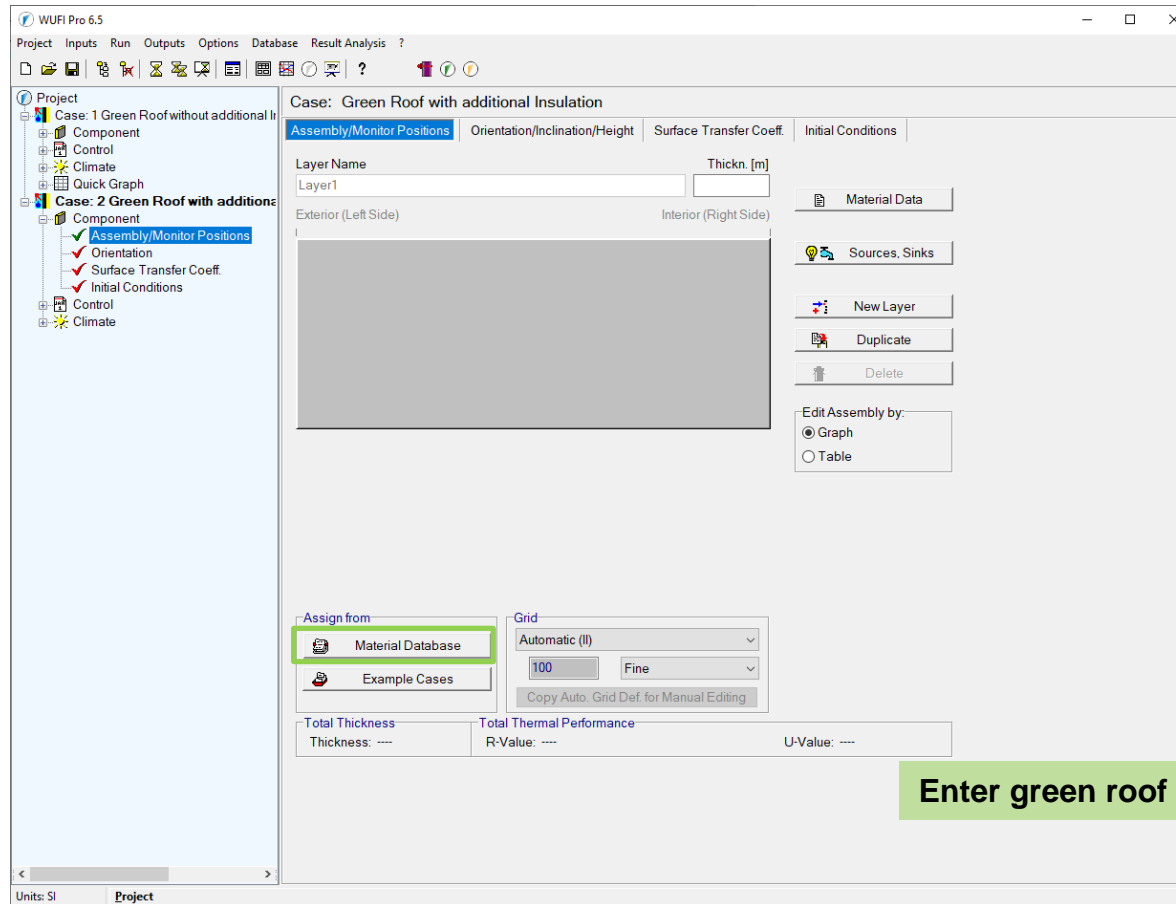
### Boundary Conditions:

- Flat roof (3° to the North)
- Short-Wave Radiation Absorptivity / Long-Wave Radiation Emissivity: according to the Generic Green Roof Model
- Outdoor Climate: Holzkirchen
- Indoor Climate: Medium Moisture Load + 5 %  
according to DIN 4108-3
- Air Tightness of the Envelope:  $q_{50} = 3 \text{ m}^3/\text{m}^2\text{h}$
- Stack Height: 5 m



# Example B: Component Assembly

Input: Component – Assembly / Monitor Positions



## Example B: Component Assembly

Input: Component – Assembly / Monitor Positions

The screenshot shows the WUFI materials database interface. On the left, a tree view lists various material sources, with 'Green and Gravel Roofs' highlighted under the 'WUFI' category. The main panel displays a table of materials with columns for Material Name, Bulk density, Porosity, Heat Cap., Therm. Co., and Vap. Res. The 'generic substrate' material is selected and highlighted in blue. Below the table, the 'Material Information' tab is active, showing details for the 'generic substrate' (thickness <= 15 cm). The information includes a note about moisture source input and a description of the material properties developed within a research project. A green callout box with the text 'Enter green roof layer' points to the 'generic substrate' row in the table.

Material Name	Bulk density [kg/m³]	Porosity [m³/m³]	Heat Cap. [J/kgK]	Therm. Co... [W/mK]	Vap. Res. [-]
generic gravel	1400	0.3	1000	0.7	1
<b>generic substrate</b>	<b>1500</b>	<b>0.5</b>	<b>1500</b>	<b>0.9</b>	<b>5</b>
Optigreen Economy Roof 1 (protection mat) 3-3	83	0.95	840	0.035	1
Optigreen Economy Roof 1 (sedum planting) 1-3	1500	0.5	1000	0.2	5
Optigreen Economy Roof 1 (substrate type M incl. FKD) 2-3	900	0.65	1000	0.4	3.3
Optigreen Economy Roof 2 (protection mat) 3-3	83	0.95	840	0.035	1
Optigreen Economy Roof 2 (sedum planting) 1-3	1500	0.5	1000	0.2	5
Optigreen Economy Roof 2 (substrate type M) 2-3	900	0.65	1000	0.4	3.3

**Material Information** | Hygrothermal Functions

substrate (thickness <= 15 cm)

NOTE: Input of a moisture source ("fraction of driving rain") in the lowest 2 cm of the layer which deposits 40 % of the rain with clipping to free water saturation.

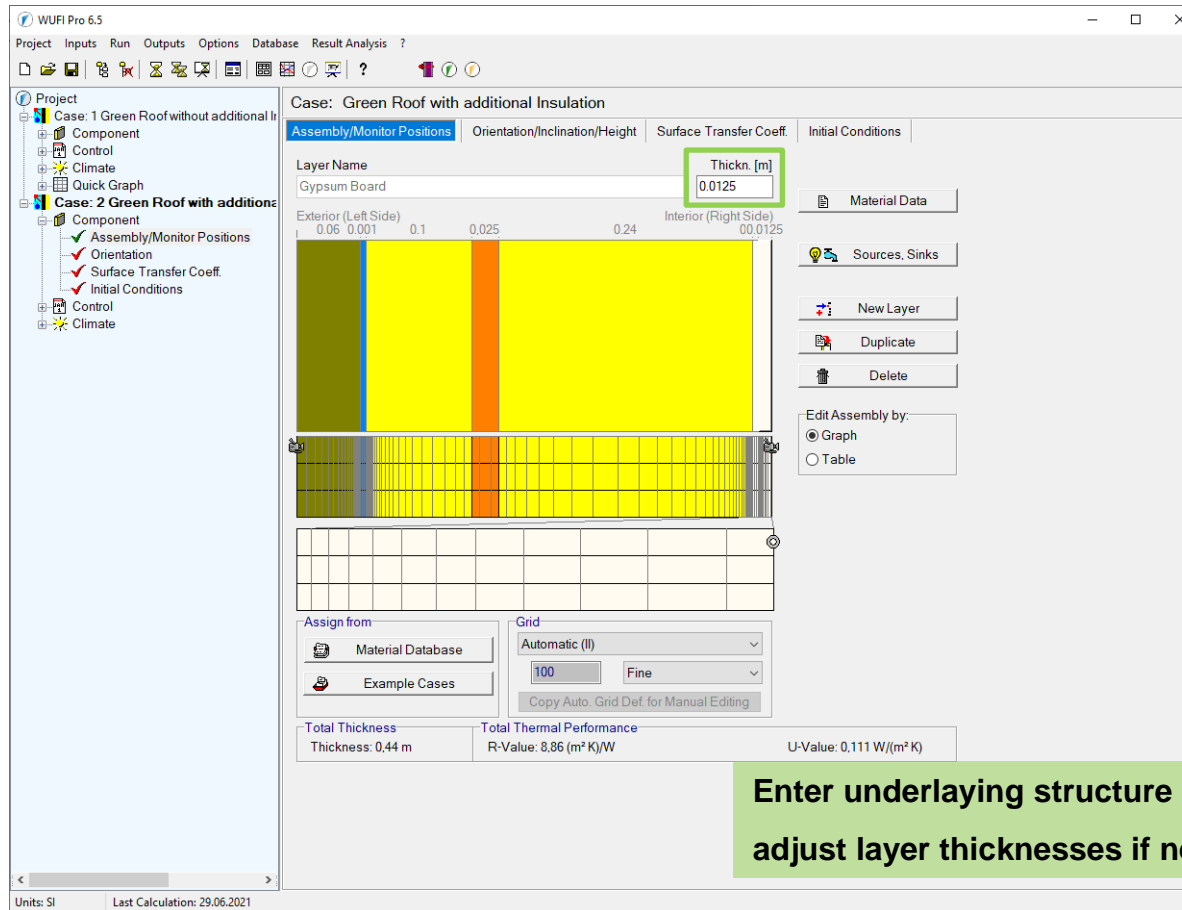
The material properties were developed within the research project "Zuverlässige Beurteilung der hygrothermischen und energetischen Auswirkungen von Gründächern" (SF-10.08.18.8 / II 3-F20-10-1-100), funded by the research program "Zukunft Bau" of the Bundesinstitut für Bau-, Stadt- und Raumforschung (German Federal Ministry of Transport, Building and Urban development).

Added to DB: 24.07.2013  
Last update: ---

Import Export Thickness [m]: 0.06 Assign Cancel Help

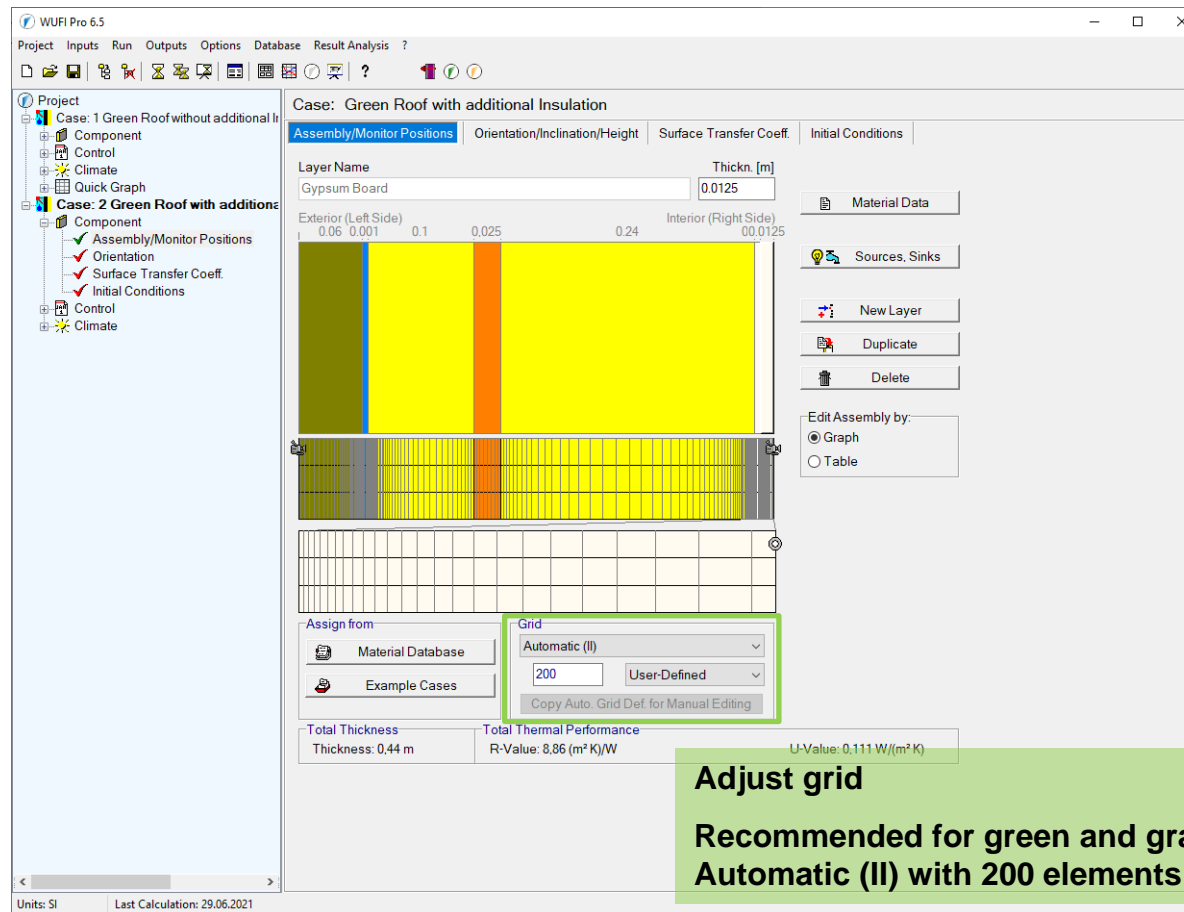
# Example B: Component Assembly

Input: Component – Assembly / Monitor Positions



## Example B: Grid

Input: Component – Assembly / Monitor Positions



**Adjust grid**

**Recommended for green and gravel roofs:  
Automatic (II) with 200 elements (user-defined)**

## Example B: Moisture Source in the Substrate Layer

Input: Component – Assembly / Monitor Positions

Enter moisture source in the layer „Generic Substrate“.

The screenshot displays the WUFI Pro 6.5 software interface. The main window shows a cross-section of a green roof assembly with various layers. A green box labeled "Select component layer" points to the "generic substrate" layer in the assembly list. Another green box labeled "Sources, Sinks" points to the "Sources, Sinks" button in the right-hand panel. The "Hygrothermal Sources" dialog box is open, showing the "generic substrate" layer selected. The dialog has a table for "Hygrothermal Sources" with columns "Nr.", "Type", and "Name". A green box labeled "New Moisture Source" points to the "New Moisture Source ..." button in the dialog. The dialog also includes buttons for "New Heat Source ...", "New Air Change Source ...", "Edit ...", and "Delete". At the bottom of the dialog are "OK", "Abort", and "Help" buttons.

WUFI Pro 6.5

Project Inputs Run Outputs Options Database Result Analysis ?

Case: Green Roof with additional Insulation

Assembly/Monitor Positions Orientation/Inclination/Height Surface Transfer Coeff Initial Conditions

Layer Name generic substrate Thicken. [m] 0.06

Material Data

Sources, Sinks

New Layer Duplicate Delete

Edit Assembly by: Graph Table

Assign from: Material Database Example Cases

Grid: Automatic (B) 200 User-Defined

Copy Auto: Grid Def. for Manual Editing

Total Thickness Thickness: 0.44 m Total Thermal Performance R-Value: 8.86 (m² K/W) U-Value: 0.111 W/(m² K)

Hygrothermal Sources

Layer/Material Name generic substrate

Hygrothermal Sources

Nr.	Type	Name
-----	------	------

New Heat Source ...

New Moisture Source ...

New Air Change Source ...

Edit ...

Delete

OK Abort Help

## Example B: Moisture Source in the Substrate Layer

Input: Component – Assembly / Monitor Positions

Moisture source in the  
lowest 2 cm of the layer  
„Generic Substrate“.

The screenshot shows the 'Moisture Source' dialog box with the following settings and annotations:

- Name:** moisture source in the substrate (Annotated with: **Lowest 2 cm in the substrate**)
- Spread Area:**
  - ☐ One Element
  - ☒ Several Elements (Annotated with a green box)
  - ☐ Whole Layer
- Start Depth in Layer [m]:** 0.04 (Annotated with a green box)
- End Depth in Layer [m]:** 0.06 (Annotated with a green box)
- Source Type:**
  - ☐ Transient from File
  - ☒ Fraction of Rain Load (Annotated with a green box)
  - ☐ Air Infiltration model IBP
  - ☐ Constant Monthly Moisture Load
- Source Term Cut-Off [kg/m³]:**
  - ☐ No Cut-Off
  - ☐ Cut-Off at Max. Water Content
  - ☒ Cut-Off at Free Water Saturation
  - ☐ User-Defined
- Fraction [%]:** 40 (Annotated with a green box)
- Method:** User-Defined (Annotated with a green box)
- Annotation:** Enter fraction of the driving rain (Annotated with a green box)
- Buttons:** OK, Cancel, Help

## Example B: Infiltration Source

Input: Component – Assembly / Monitor Positions

Infiltration source according to DIN 68800 in the wooden sheathing.

The screenshot displays the WUFI Pro 6.5 software interface. The main window shows a cross-section of a building assembly with various layers. A green box highlights a specific layer, labeled "Select component layer". Another green box highlights the "Sources, Sinks" button in the top right, labeled "Sources, Sinks". A third green box highlights the "New Moisture Source ..." button in the "Hygrothermal Sources" dialog box, labeled "New Moisture Source".

The "Hygrothermal Sources" dialog box is open, showing the "Layer/Material Name" field set to "Softwood". The dialog includes a table for "Hygrothermal Sources" with columns "Nr.", "Type", and "Name". The table is currently empty. The dialog also features buttons for "New Heat Source ...", "New Moisture Source ...", "New Air Change Source ...", "Edit ...", and "Delete". At the bottom of the dialog are "OK", "Abort", and "Help" buttons.

The main window shows the following details:

- Project: Case: 1 Green Roof without additional insulation
- Case: 2 Green Roof with additional insulation
- Assembly/Monitor Positions: Orientation/Inclination/Height, Surface Transfer Coeff., Initial Conditions
- Layer Name: Softwood, Thickness [m]: 0.025
- Material Data: Sources, Sinks
- Buttons: New Layer, Duplicate, Delete
- Assign from: Material Database, Example Cases
- Grid: Automatic (H), 200, User-Defined
- Total Thickness: 0.44 m, Total Thermal Performance: R-Value: 8.86 (m² K/W), U-Value: 0.111 W/(m² K)

## Example B: Infiltration Source

Input: Component – Assembly / Monitor Positions

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

The screenshot shows the 'Moisture Source' dialog box with the following settings and annotations:

- Name:** infiltration source
- Spread Area:** ☒ Several Elements
- Start Depth in Layer [m]:** 0.02
- End Depth in Layer [m]:** 0.025
- Source Type:** ☒ Air Infiltration model IBP
- Source Term Cut-Off [kg/m³]:** ☒ Cut-Off at Free Water Saturation
- Envelope Infiltration q50 [m³/(m² h)]:** 3
- Air Tightness Class B (DIN 4108, tested <= 3 m³/m²h):** (dropdown menu)
- Stack Height [m]:** 5
- Mechanical Ventilation Overpressure [Pa]:** 0

Annotations in green boxes highlight the following areas:

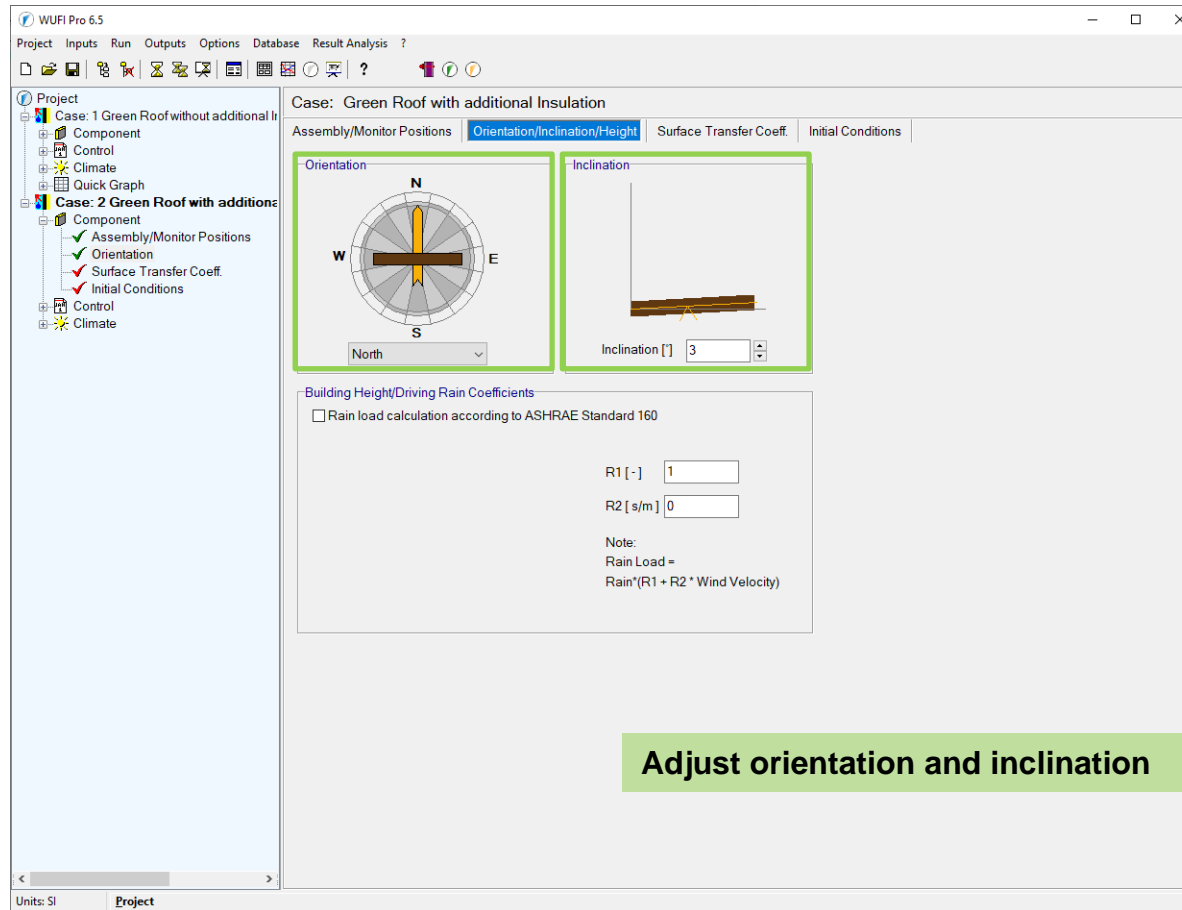
- Interior 5 mm of the sheathing** (pointing to the depth fields)
- Adjust infiltration source** (pointing to the infiltration model and envelope infiltration fields)

Buttons at the bottom: OK, Cancel, Help.



## Example B: Orientation / Inclination

Input: Component – Orientation



## Example B: Surface Transfer Coefficients

Input: Component – Surface Transfer Coeff.

WUFI Pro 6.5

Project Inputs Run Outputs Options Database Result Analysis ?

Project

- Case: 1 Green Roof without additional Insulation
  - Component
  - Control
  - Climate
  - Quick Graph
- Case: 2 Green Roof with additional Insulation
  - Component
  - Assembly/Monitor Positions
  - Orientation
  - Surface Transfer Coeff.
  - Initial Conditions
  - Control
  - Climate

Case: Green Roof with additional Insulation

Assembly/Monitor Positions Orientation/Inclination/Height **Surface Transfer Coeff.** Initial Conditions

Exterior Surface (Left Side)

Heat Transfer Coefficient [W/(m² K)] 19 Roof

includes long-wave radiation parts [W/(m² K)] 6.5

wind-dependent ☐

sd-Value [m] No coating

Note: This setting does not affect rain absorption

Short-Wave Radiation Absorptivity [-] 0.3 Green roof, generic model

Long-Wave Radiation Emissivity [-] 0.3

Reduction factors caused by shading:

for absorptivity [-] No shading

for emissivity [-]

Explicit Radiation Balance ☐ Note: This option takes radiative cooling due to long-wave emission into account. Sensitive cases may require sufficiently accurate counter-radiation data in the weather file.

Ground Short-Wave Reflectivity [-] 0.2 Standard value

Adhering Fraction of Rain [-] 1.0 Depending on inclination of component

Interior Surface (Right Side)

Heat Transfer Coefficient [W/(m² K)] 8 (Roof)

sd-Value [m] No coating

Units: SI No calculation results available.

Heat Transfer Coefficient  
for Roof = 19 W/m²K

Radiation Absorptivity and Emissivity:  
Green roof, generic model

No use of the Explicit Radiation Balance

Adhering Fraction of Rain = 1

Adjust surface transfer coefficients!

# Example B: Initial Conditions

## Input: Component – Initial Conditions

WUFI Pro 6.5

Project Inputs Run Outputs Options Database Result Analysis ?

Project

- Case: 1 Green Roof without additional Insulation
  - Component
  - Control
  - Climate
  - Quick Graph
- Case: 2 Green Roof with additional Insulation
  - Component
  - Assembly/Monitor Positions
  - Orientation
  - Surface Transfer Coeff.
  - Initial Conditions
  - Control
  - Climate

Case: Green Roof with additional Insulation

Assembly/Monitor Positions Orientation/Inclination/Height Surface Transfer Coeff. Initial Conditions

Initial Moisture in Component

☒ Constant Across Component

☐ In each Layer

☐ Read from File

Initial Temperature in Component

☒ Constant Across Component

☐ Read from File

Initial Relative Humidity [-] 0.8 Initial Temperature in Component [°C] 20

Initial Water Content in Different Layers

No.	Material Layer	Thickn. [m]	Water Content [kg/m³]
1	generic substrate	0.06	12.0
2	vapour retarder (sd=300m)	0.001	0.0
3	EPS (heat cond.: 0.04 W/mK - density: 30kg/m³)	0.1	1.79
4	Softwood	0.025	60.0
5	Mineral Wool (heat cond.: 0.04 W/mK)	0.24	1.79
6	ISOVER Vario KM Duplex	0.001	3.5
7	Gypsum Board	0.0125	6.3

Units: SI Last Calculation: 29.06.2021

No changes required

## Example B: Calculation Period

Input: Control – Calculation Period/ Profiles

WUFI Pro 6.5

Project Inputs Run Outputs Options Database Result Analysis ?

Case: Green Roof with additional Insulation

Calculation Period / Profiles Numerics

Calculation	Profiles	Date	Hour
Start	Profile 1	01.10.2021	00:00:00
End	Profile 2	01.10.2029	00:00:00

New

Delete

Copy

Insert

29.06.2021 00:00:00

Time Steps [h] 1

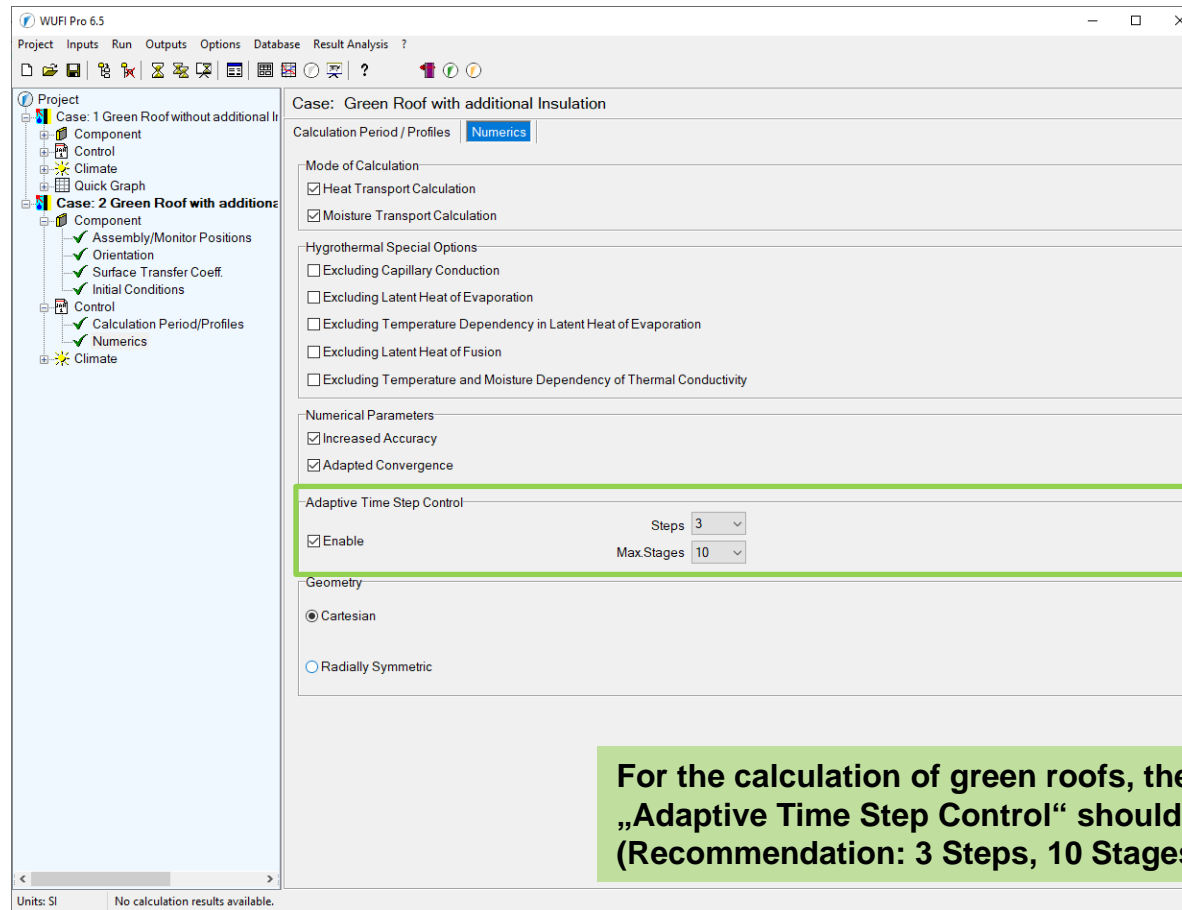
Units: SI No calculation results available.

**Adjust calculation period**

**Note:**  
Green roofs reach their dynamic equilibrium very slowly  
⇒ generally rather longer calculation periods are required  
Recommended: at least 8 years

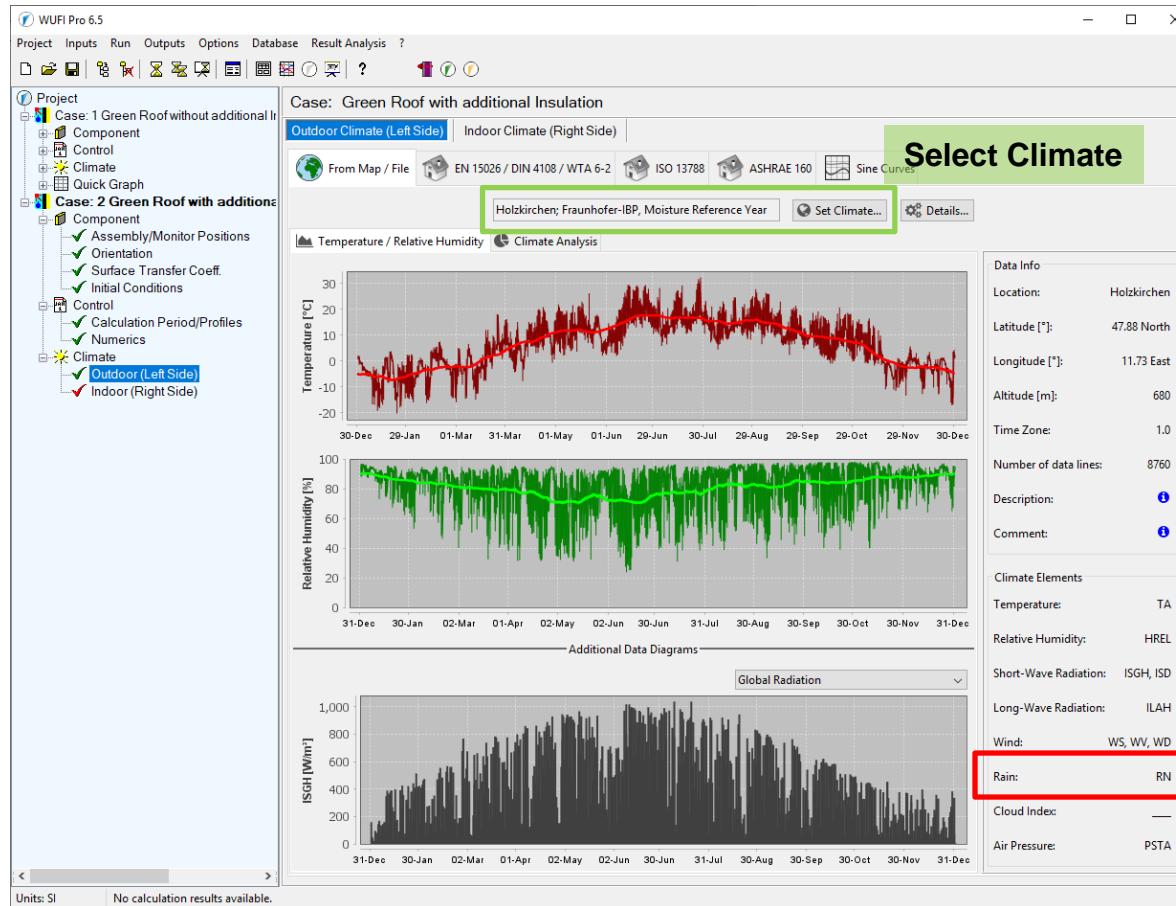
# Example B: Numerical Settings

## Input: Control – Numerics



# Example B: Outdoor Climate

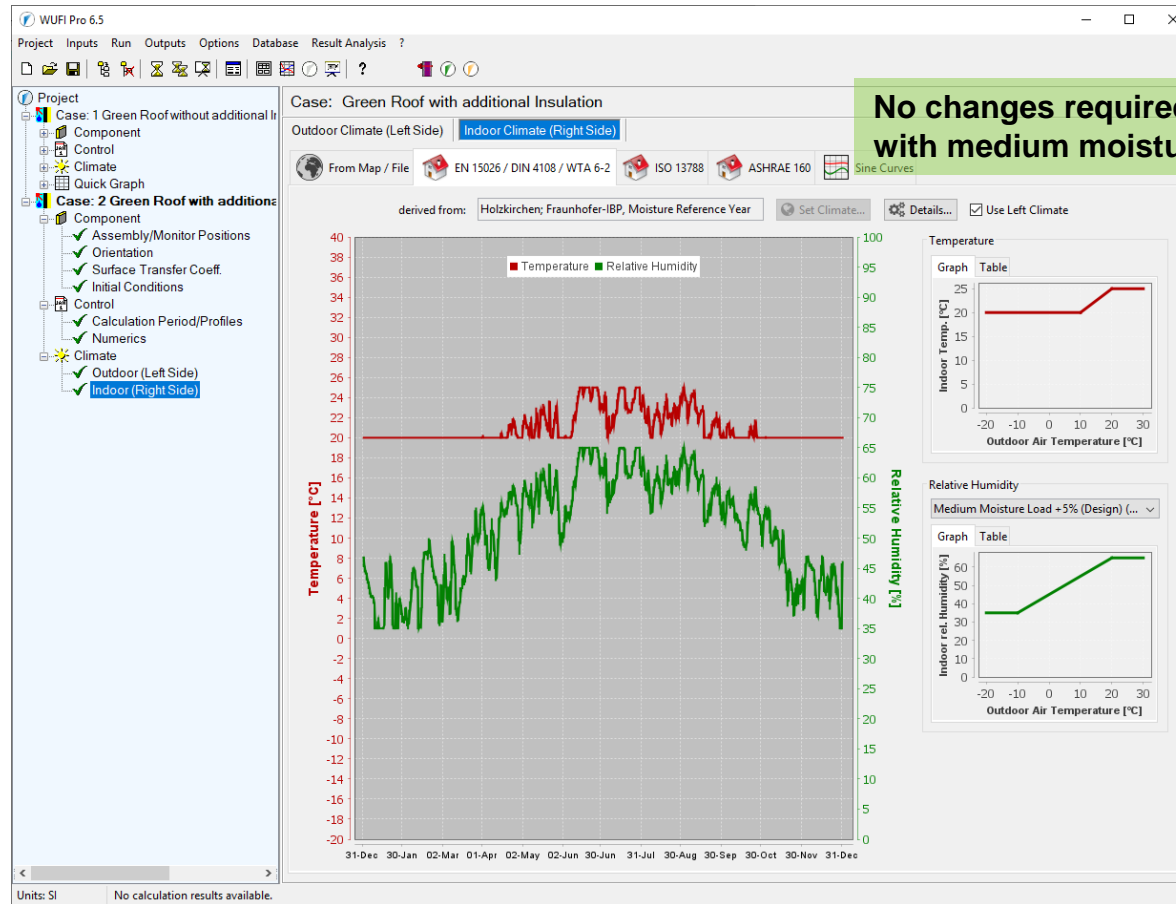
## Input: Climate – Outdoor (Left Side)



**Note:**  
The generic green roof model is also suitable for climate data without long-wave radiation. Rain data is necessary!

# Example B: Indoor Climate

## Input: Climate – Indoor (Right Side)



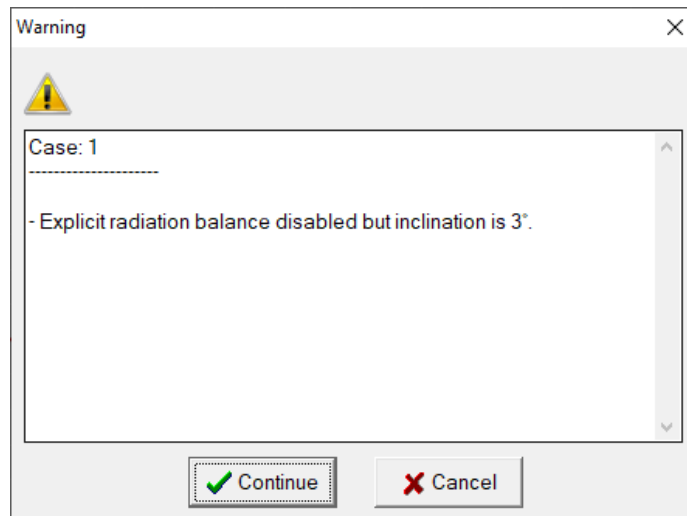
## Example B: Note when Calculation Start

---

### Calculation Start:

### Note:

After calculation start this warning appears:



→ this warning can be ignored for the calculation of a green roof with the generic model!



## Example B: Evaluation Calculation Quality

### Status of Last Calculation:

Status of Last Calculation

Status of Calculation

Calculation: Time and Date	29.06.2021 11:59:53
Computing Time	4 min,14 sec.
Begin / End of calculation	01.10.2021 / 01.10.2029
No. of Convergence Failures	0

Check for numerical quality

Integral of fluxes, left side (kl,dl)	[kg/m²]	332,11 -386,38
Integral of fluxes, right side (kr,dr)	[kg/m²]	1,5E-7 -0,51
Balance 1	[kg/m²]	15,48
Balance 2	[kg/m²]	15,55

Water Content [kg/m²]

	Start	End	Min.	Max.
Total Water Content	2,91	18,83	2,83	21,05

Water Content [kg/m³]

Layer/Material	Start	End	Min.	Max.
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☐ Calculation locked

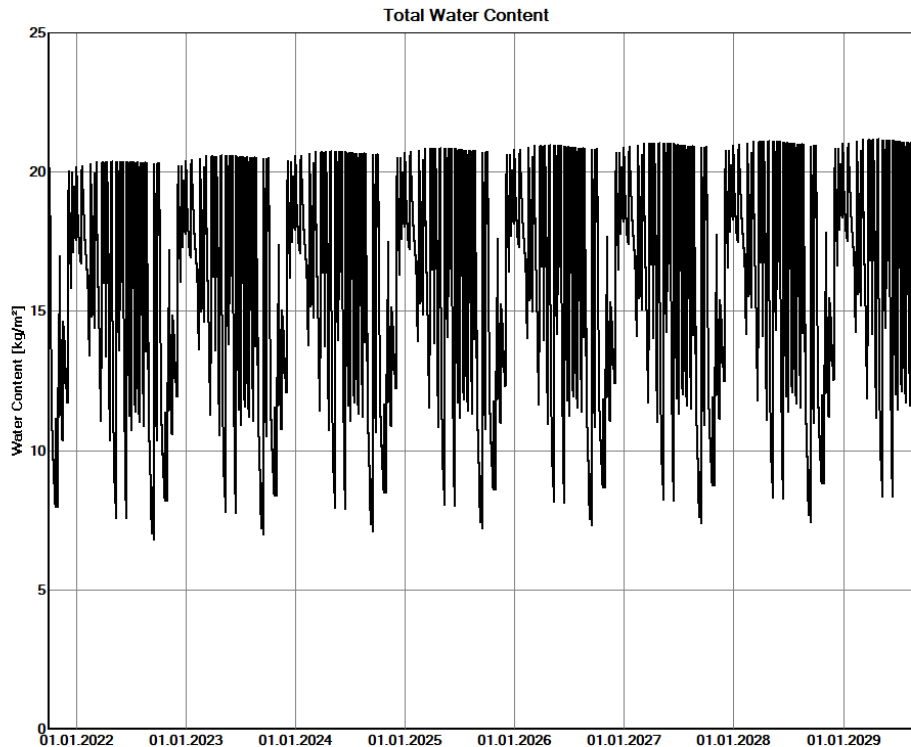
Close

Help

**No convergence failures!**  
**Balance differences acceptable!**

## Example B: Evaluation Total Water Content

Evaluation with the help of the Quick Graphs:  
Total Water Content



### Evaluation:

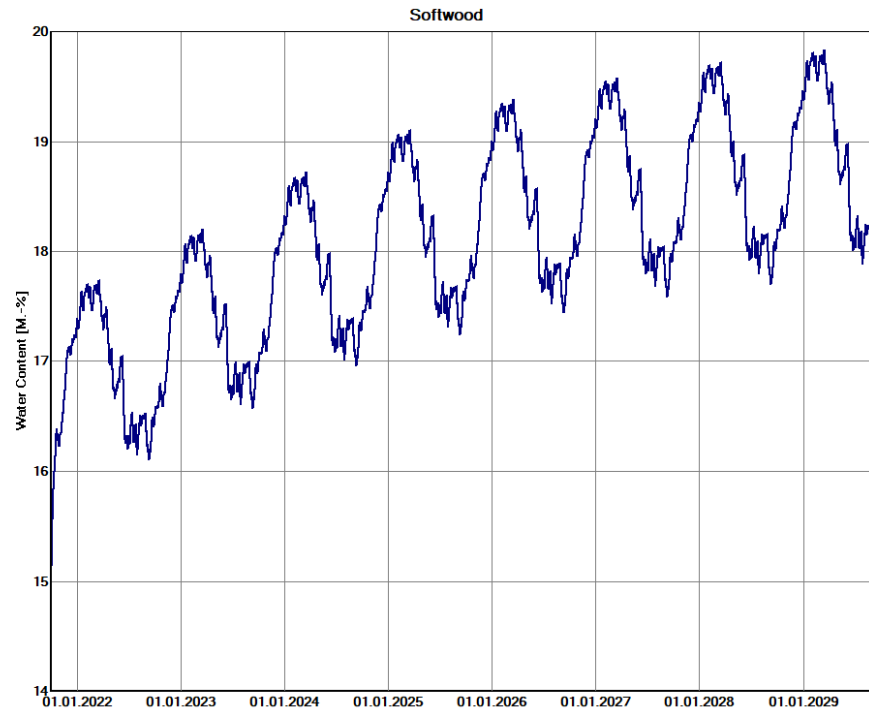
The total water content for green roofs is hardly conclusive because of the large amount of moisture in the substrate.

→ Evaluation of the single layers of the substructure

## Example B: Evaluation Wooden Sheathing

Evaluation with the help of the Quick Graphs:

Water Content in the wooden sheathing



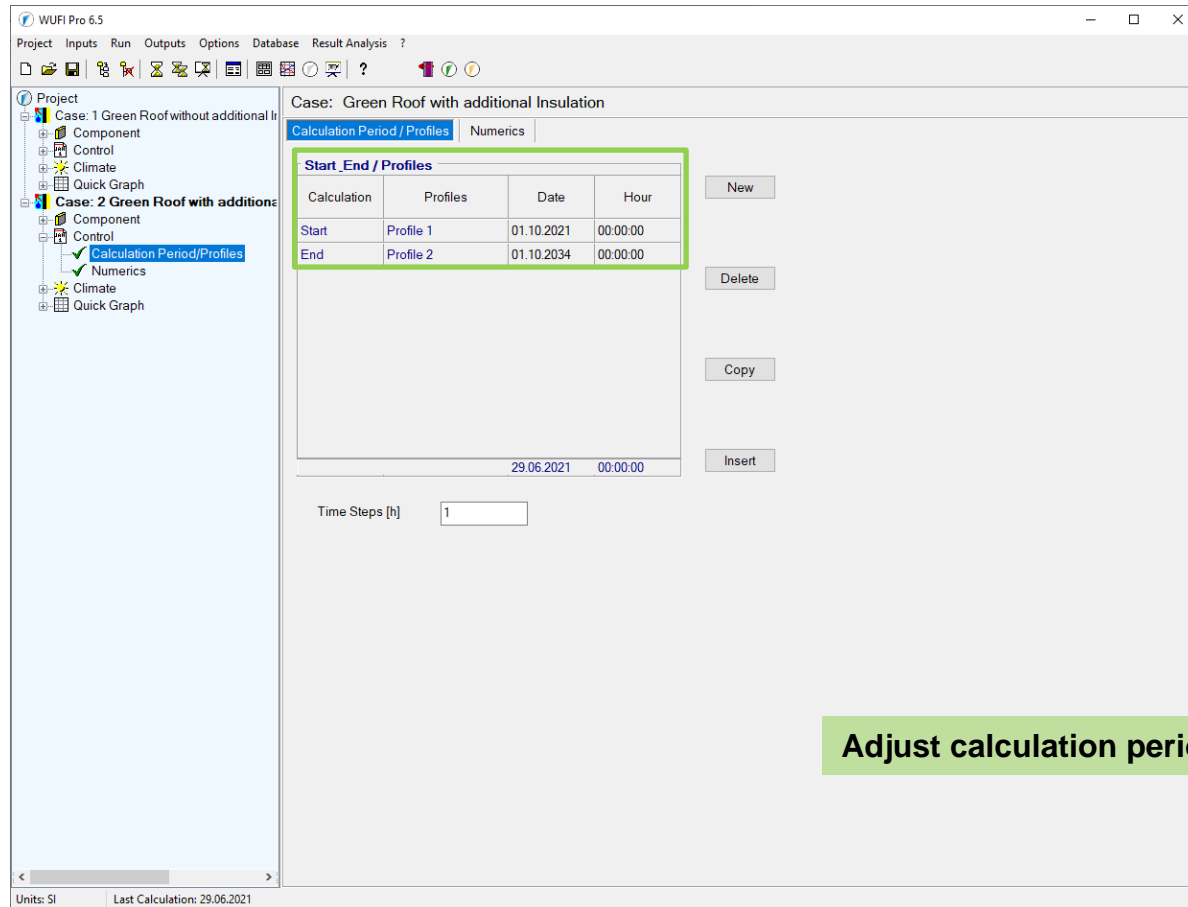
### Evaluation:

The water content in the wooden sheathing increases over the calculation period slowly and doesn't reach the dynamic equilibrium after 8 years.

→ Longer calculation period is necessary

## Example B: Calculation Period

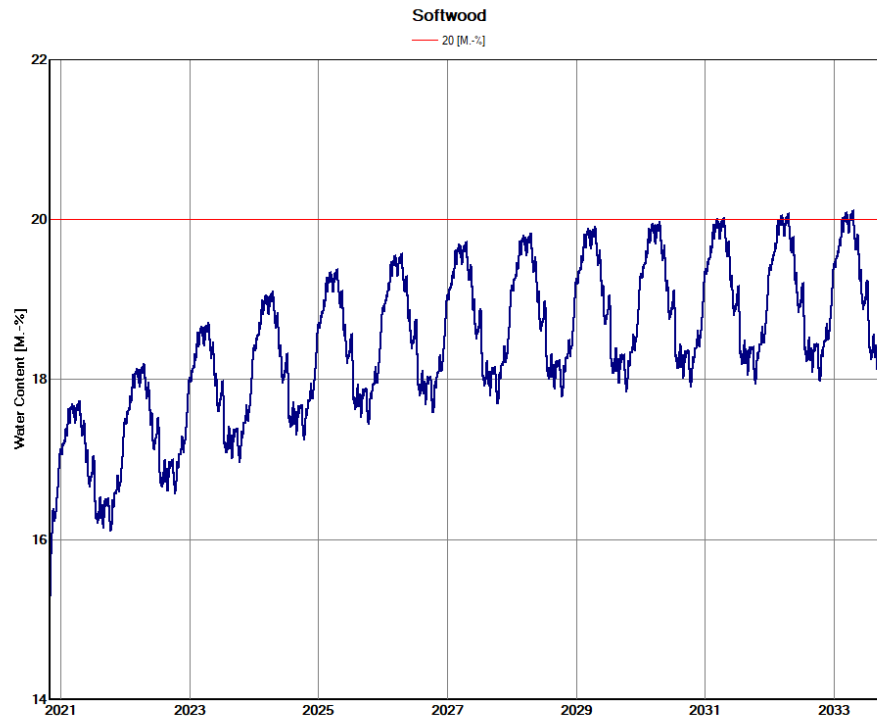
Input: Control – Calculation Period/ Profiles



## Example B: Evaluation Wooden Sheathing

Evaluation with the help of the Quick Graphs:

Water Content in the wooden sheathing



### Evaluation:

The water content in the wooden sheathing reaches the dynamic equilibrium after 12 years with maximum values of just over 20 % by mass.

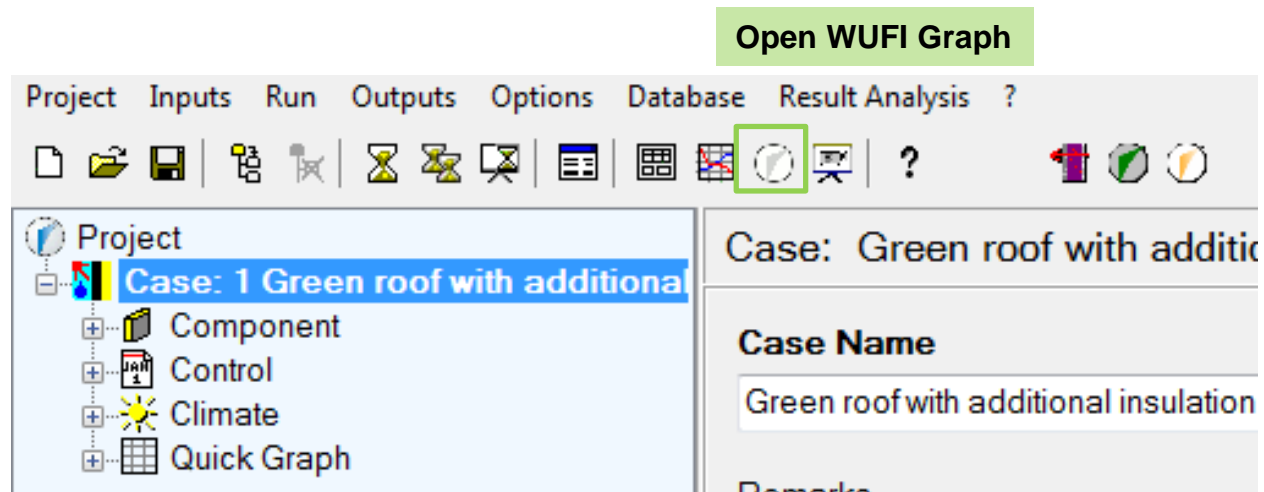
The limit value according to DIN 68800 of 20 % by mass is minimally exceeded.

→ Evaluation of the wood moisture according to WTA

## Example B: Evaluation Wood Moisture Content with WUFI® Graph

Evaluation with the help of WUFI® Graph:

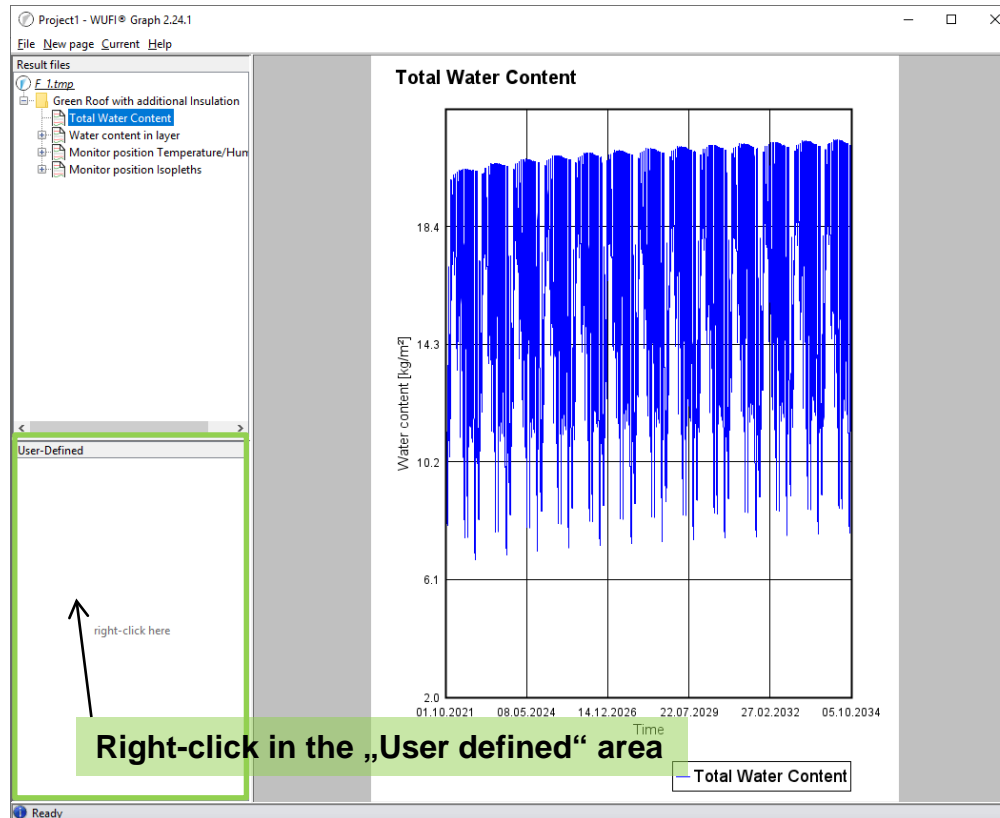
Wood moisture in the wooden sheathing according to WTA 6-8



## Example B: Evaluation Wood Moisture Content with WUFI® Graph

Evaluation with the help of WUFI® Graph:

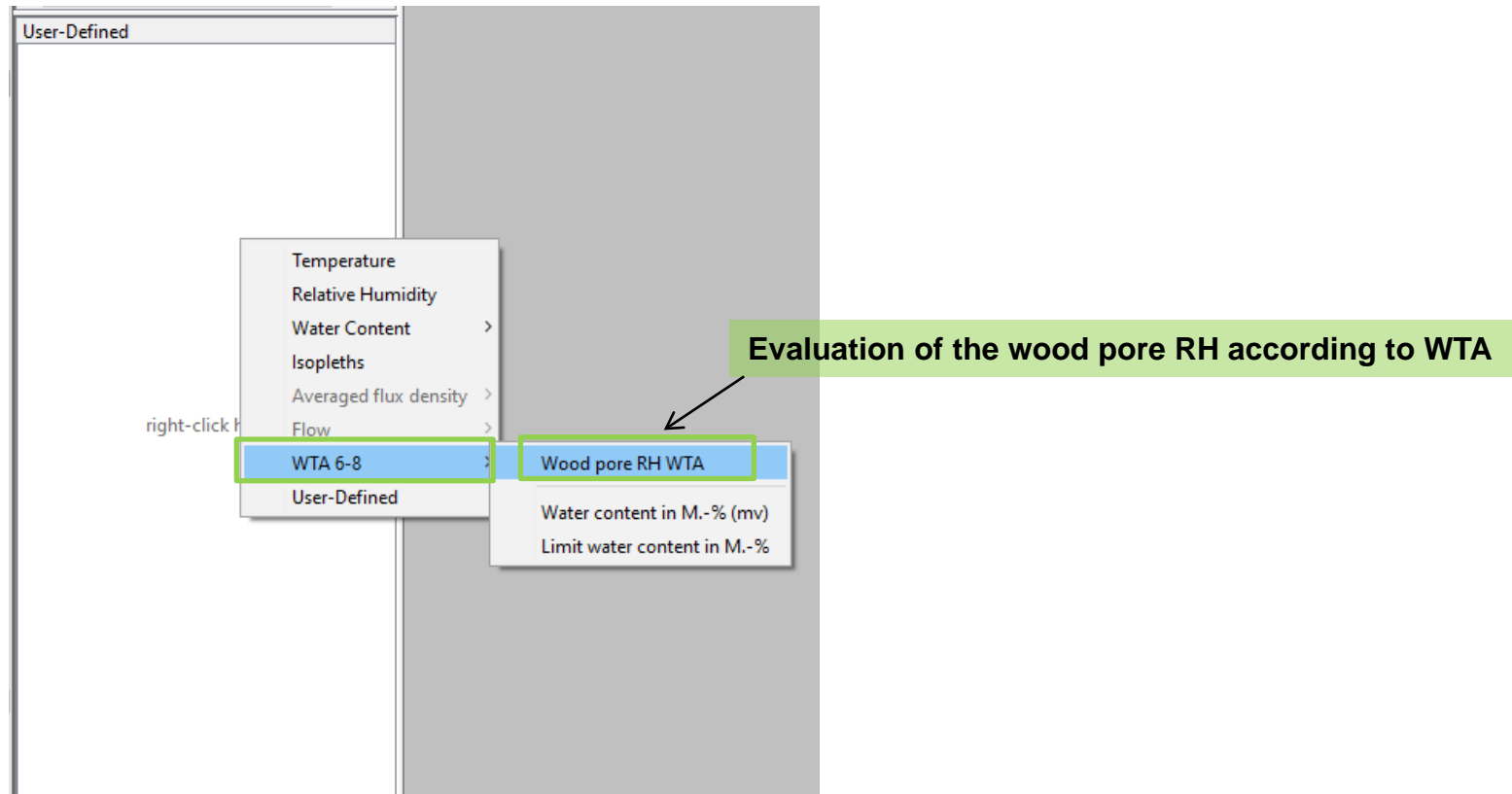
Wood moisture in the wooden sheathing according to WTA 6-8



## Example B: Evaluation Wood Moisture Content with WUFI® Graph

Evaluation with the help of WUFI® Graph:

Wood moisture in the wooden sheathing according to WTA 6-8





## Example B: Evaluation Wood Moisture Content with WUFI® Graph

Evaluation with the help of WUFI® Graph:

Wood moisture in the wooden sheathing according to WTA 6-8

*Evaluation in the most critical centimetre (in case of doubt consider both sides)*



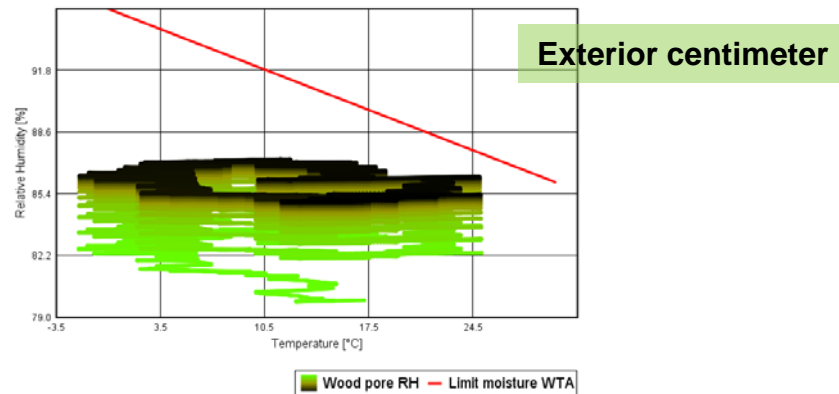
## Example B: Evaluation Wood Moisture Content with WUFI® Graph

Evaluation with the help of WUFI® Graph:

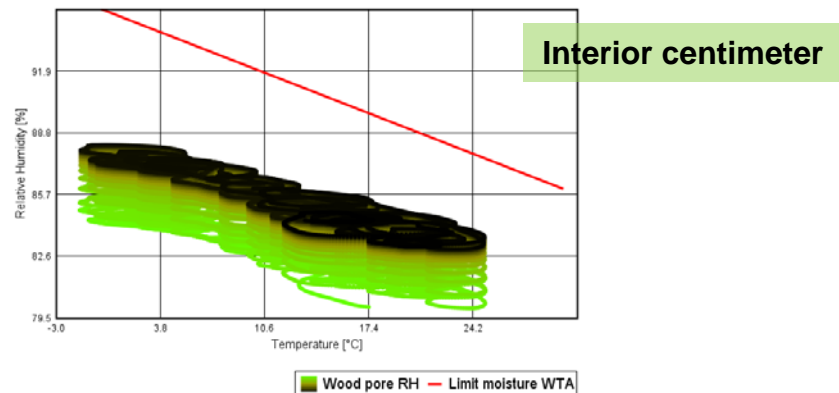
Wood moisture in the wooden sheathing according to WTA 6-8

*Evaluation in the most critical centimetre (in case of doubt consider both sides)*

Wood pore RH WTA 6-8



Wood pore RH WTA 6-8



Evaluation:

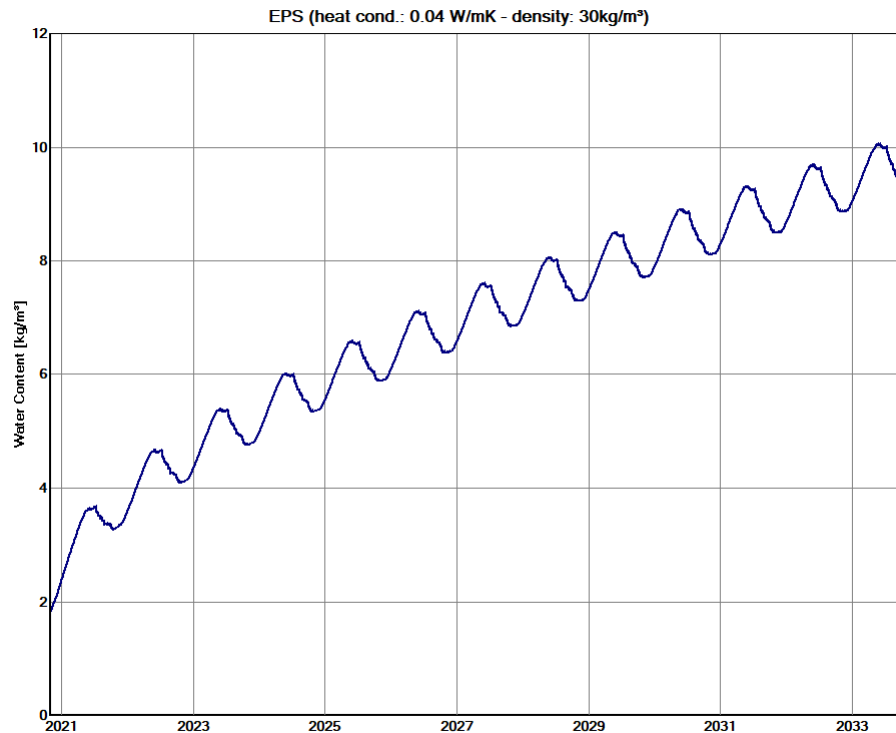
The relative pore air moisture in the interior and the exterior centimetre of the sheathing doesn't exceed the limit moisture according to WTA.

→ No damage by wood-decay fungi

## Example B: Evaluation Water Content Additional Insulation

Evaluation with the help of the Quick Graphs:

Water Content in the additional insulation



### Evaluation:

The water content in the additional insulation also increases over 13 years.

A relevant increase of the thermal conductivity occurs only from a water content of about 20 kg/m<sup>3</sup> and should be considered if the insulation is taken in account for the R-value.

Otherwise a slight moisture accumulation has no negative effect on this material.