Condensation Tool
Passive House Institute

Passive House Institute

Sinfonia

Contents

1 Introduction

Introduction

The **Condensation Tool** is the new tool developed by Passive House Institute, in the commonly used Excel format *.xlsx.
This tool is based on the International Standard ISO 13788:2012 and provides simplified calculation methods that enable calculation of:

- The hygrothermal performance of building components and building elements;
- Internal surface temperature to avoid critical surface humidity;
- Temperature and vapour pressure inside the component to estimate interstitial condensation.

The moisture transfer theory is complex and requires information that is typically hard to gather; the theory requires highly specific knowledge of hygrothermal calculation.
The most common values available for the building materials are not sufficient for describing the moisture transfer process accurately. The designer needs more data e.g. moisture and capillarity function, moisture content of the material, inclination of the component, short and long-wave radiations, hourly climate data etc., to obtain more precise and complete results.
This method brings more reliable results for lightweight and airtight components that do not contain materials with a large water storage capacity.

This method (Glaser Method) and this tool are based on simplified calculations. Users should note that where a component is not verified following this methodology, it could in theory be verified using different and more detailled methods e.g. dynamic calculations according to EN 15026.
The method is an assessment rather than an accurate prediction tool.

The ISO 13788:2012 is a monthly calculation and does not take into account:

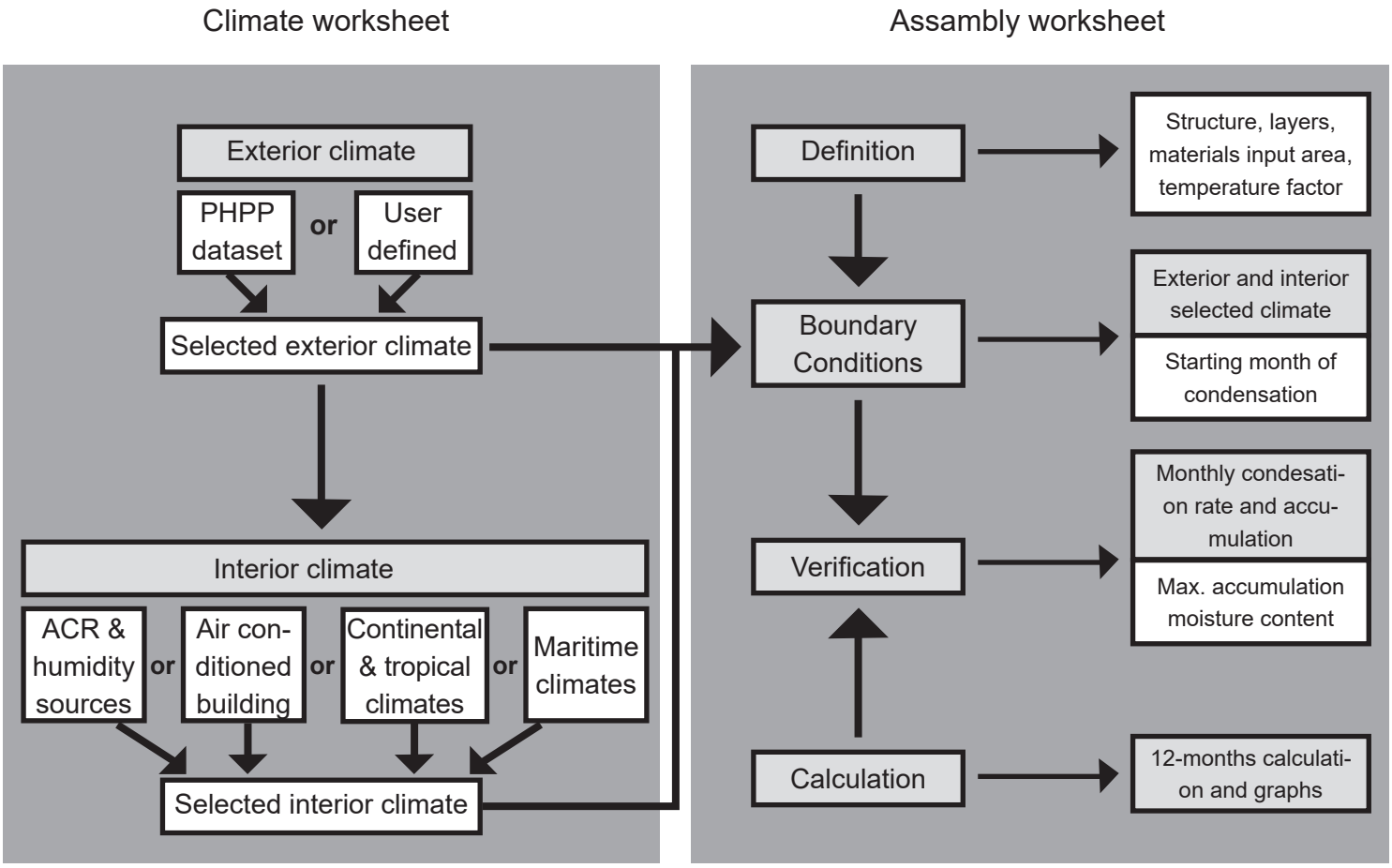
- The variation of thermal conductivity, heat transport and other moisture content and temperature properties;
- Capillary suction, sorption coefficient, liquid transfer and moisture capacity of materials;
- Three- or two-dimensional moisture transport;
- Air leakages through the various layers of the component;
- External climate conditions as solar radiation, rainfall, wind exposure;
- Air, rising damp, rain or underground infiltrations;
- Gravity;
- Moisture transport other than vapour diffusion;

Condensation Tool is composed by these worksheets:

- **Instructions:** It containes the general information and the necessary instructions about how to use the tool.
- **Climate:** there are the options to define the exterior and interior climates to use for the verification.
- **Assembly:** In this worksheet the designer inserts the structure, materials and hygrothermal data of the component to verify.

2 Input sequence

Input sequence



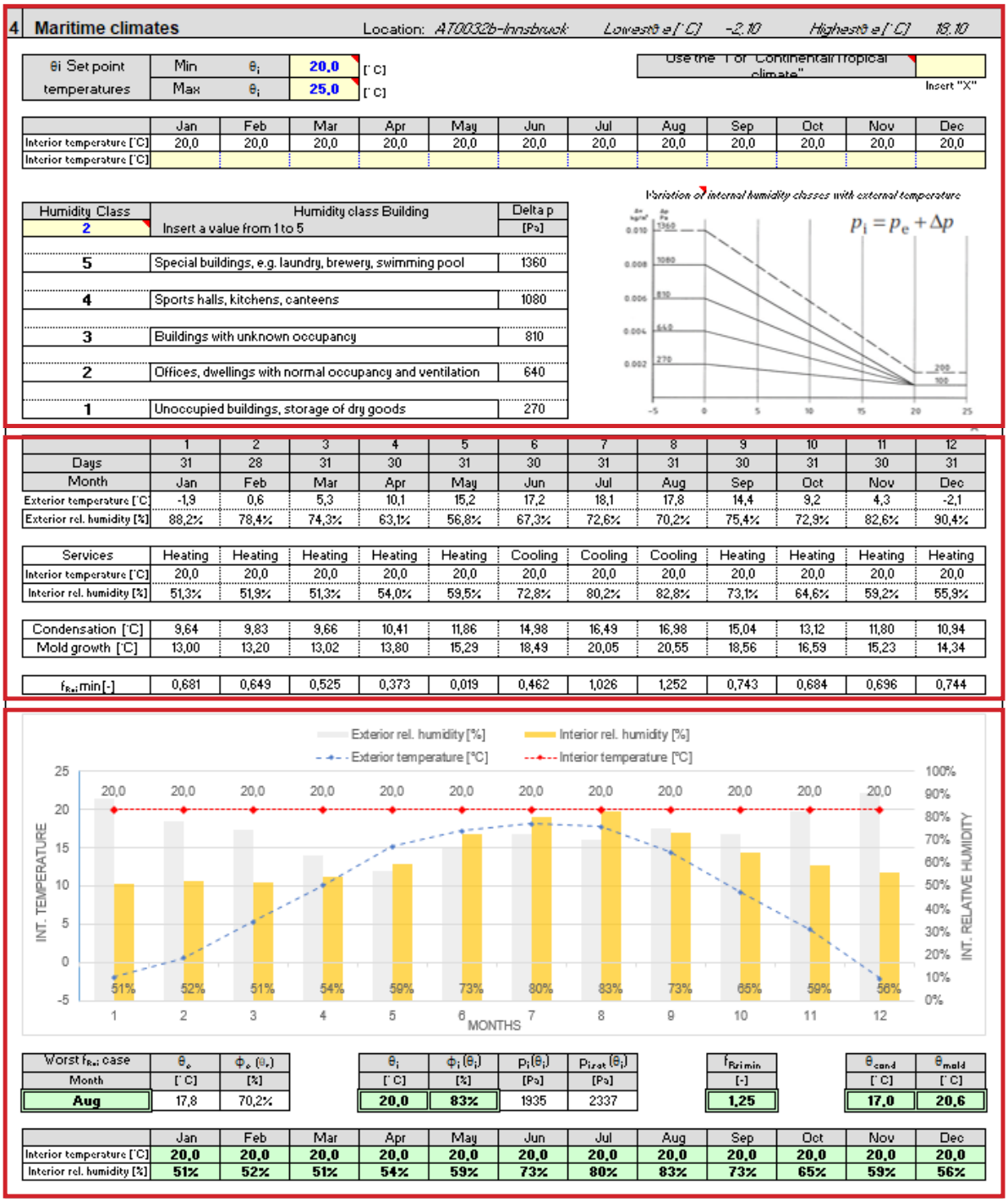
Input required

Not input required

3 Climate worksheet

Climate worksheet

The climate worksheet is divided into exterior and interior climate types.
To keep comprehension of the worksheet as easy as possible, the structure and layout are the same for all issues as shown in the image below.

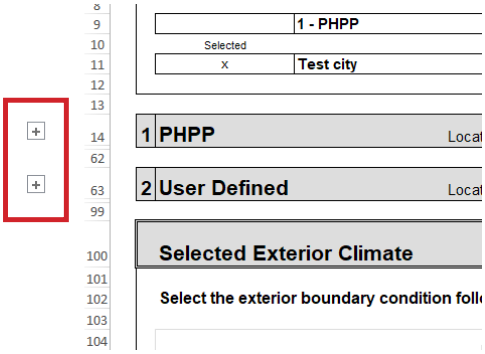


Input area

Main calculation results and details

Main results

At the top of each option, the temperature and/or relative humidity set point data are inputted.
Below, the main calculations and details for the selected boundary condition are shown.
At the bottom of each section, a graph is shown describing the main results for the selected climate.
The input values for the different climate options, can be displayed using the plus sign on the left hand of the working area (see the picture below).

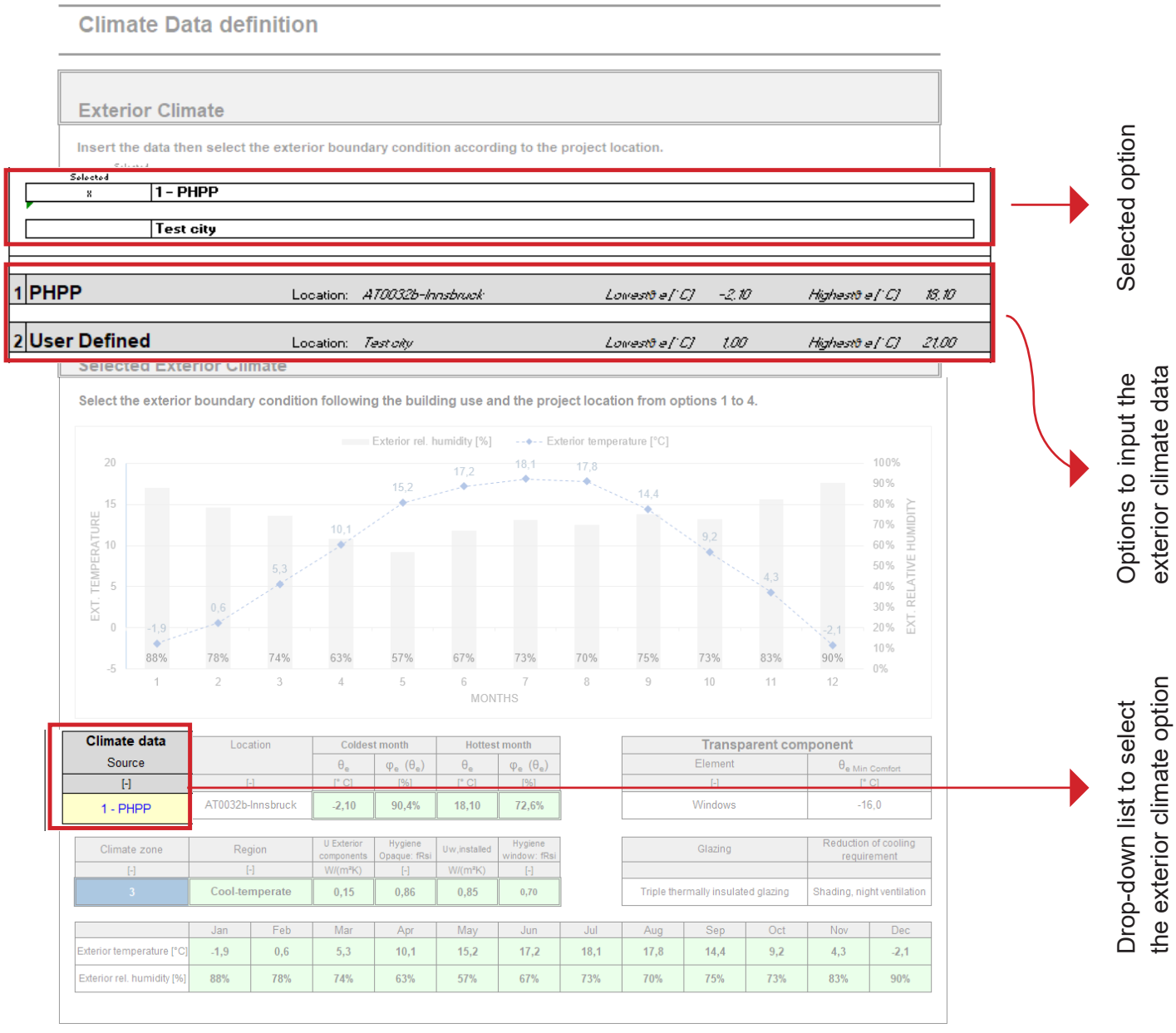


Exterior climate

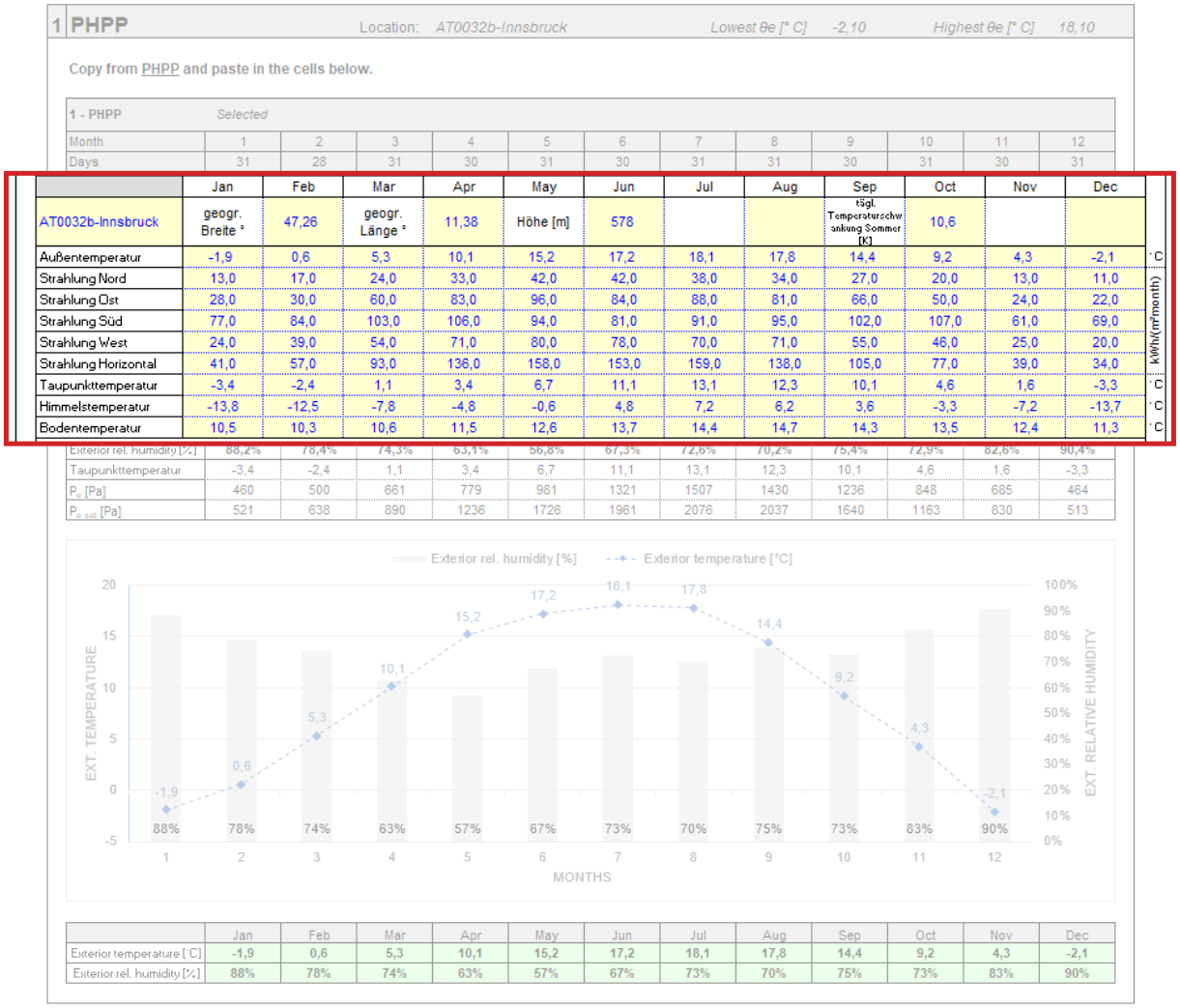
The external temperature is the monthly mean external air temperature at the project location.
For the calculation of roofs, the tool automatically takes into account the simplified methodology given in ISO 13790, where the external monthly temperature is reduced by 2 K. This is a simplified method to take in account cooling by long wave radiation.
At the top a cell shows which option is selected.
A graph is shown at the bottom of each section that describes the main results.
In the exterior climate area, the user has **two options** to input the exterior climate data of the building location:

1. **PHPP DATASET;**
2. **USER DEFINED.**

Clicking on the plus sign on the left hand, the respective area is shown.



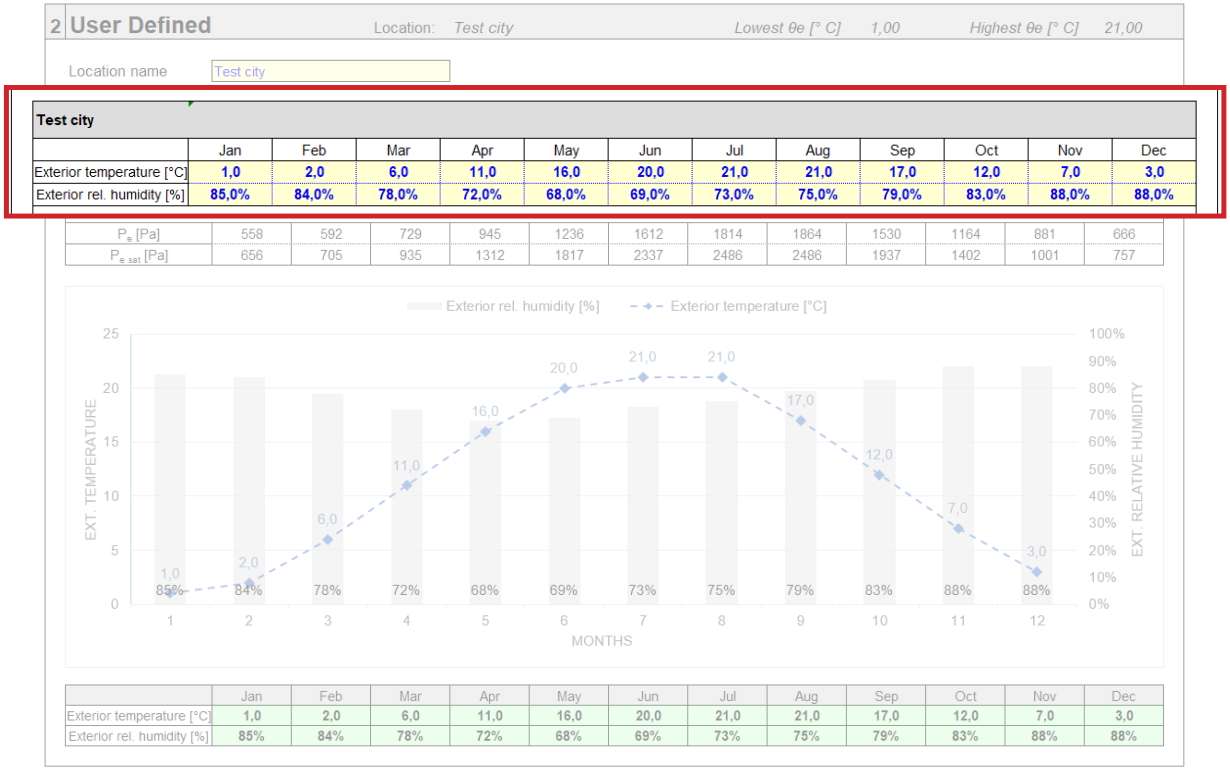
PHPP dataset



Copy from an existing PHPP dataset and paste in the relative field.

NOTE: Select the area from location name cell to december ground temperature cell.
The tool automatically calculates the relative humidy of the location from the dew point temperature.

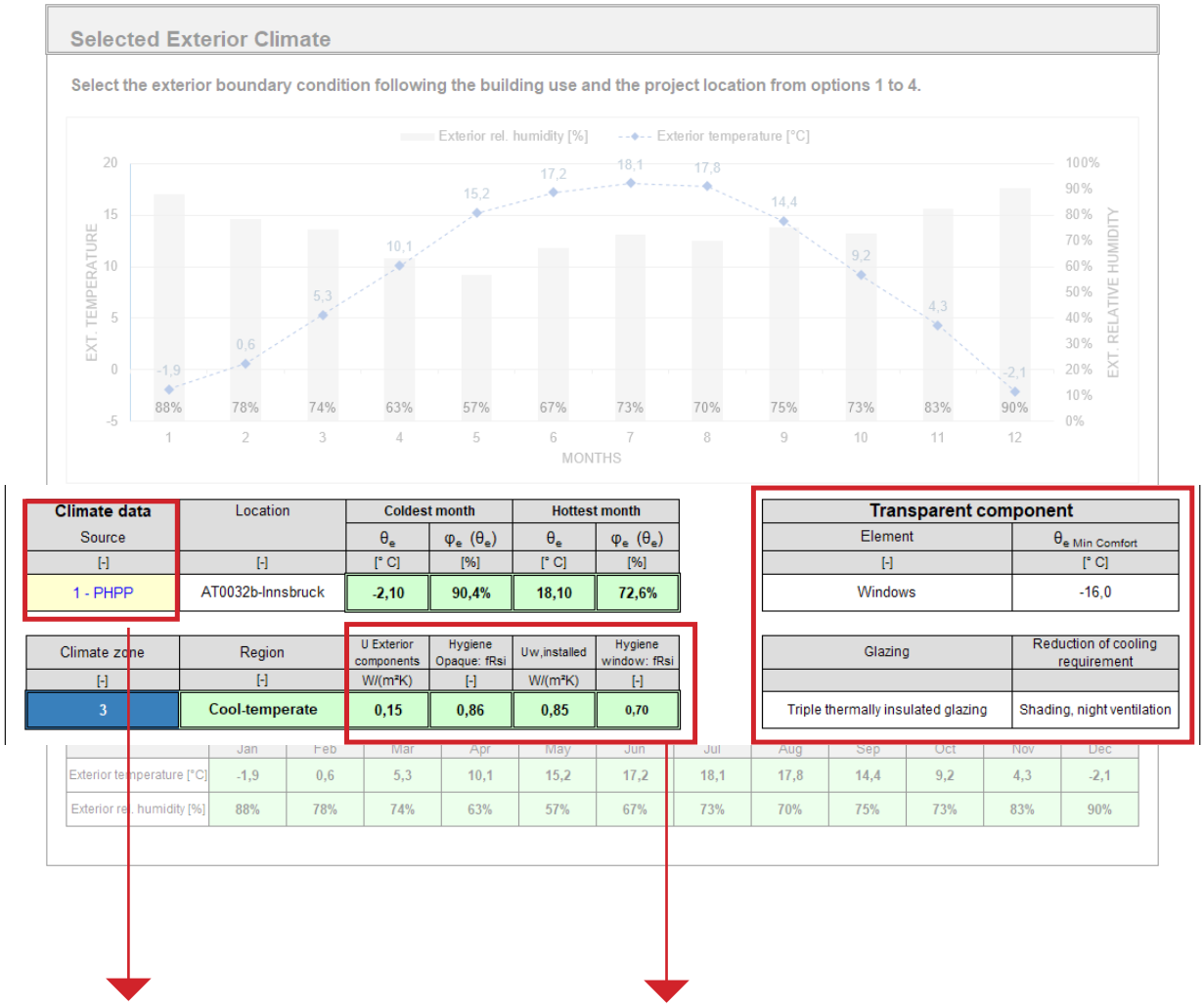
User defined



Manual input of the exterior values of monthly mean temperature and monthly mean relative humidity.

Selected exterior climate

The selected Exterior and interior climate inputs used for the yearly calculation are always visible.
Select the dataset chosen as exterior boundary condition between the previous options.
These values are the parameters used for the monthly calculation in the „Assembly“ worksheet.
The tool shows the graph and the main parameters related to the selected climate. If the PHPP climate data is selected, more information regarding Passive House Components appear.



Drop-down list for selecting the exterior climate to use in the yearly verification

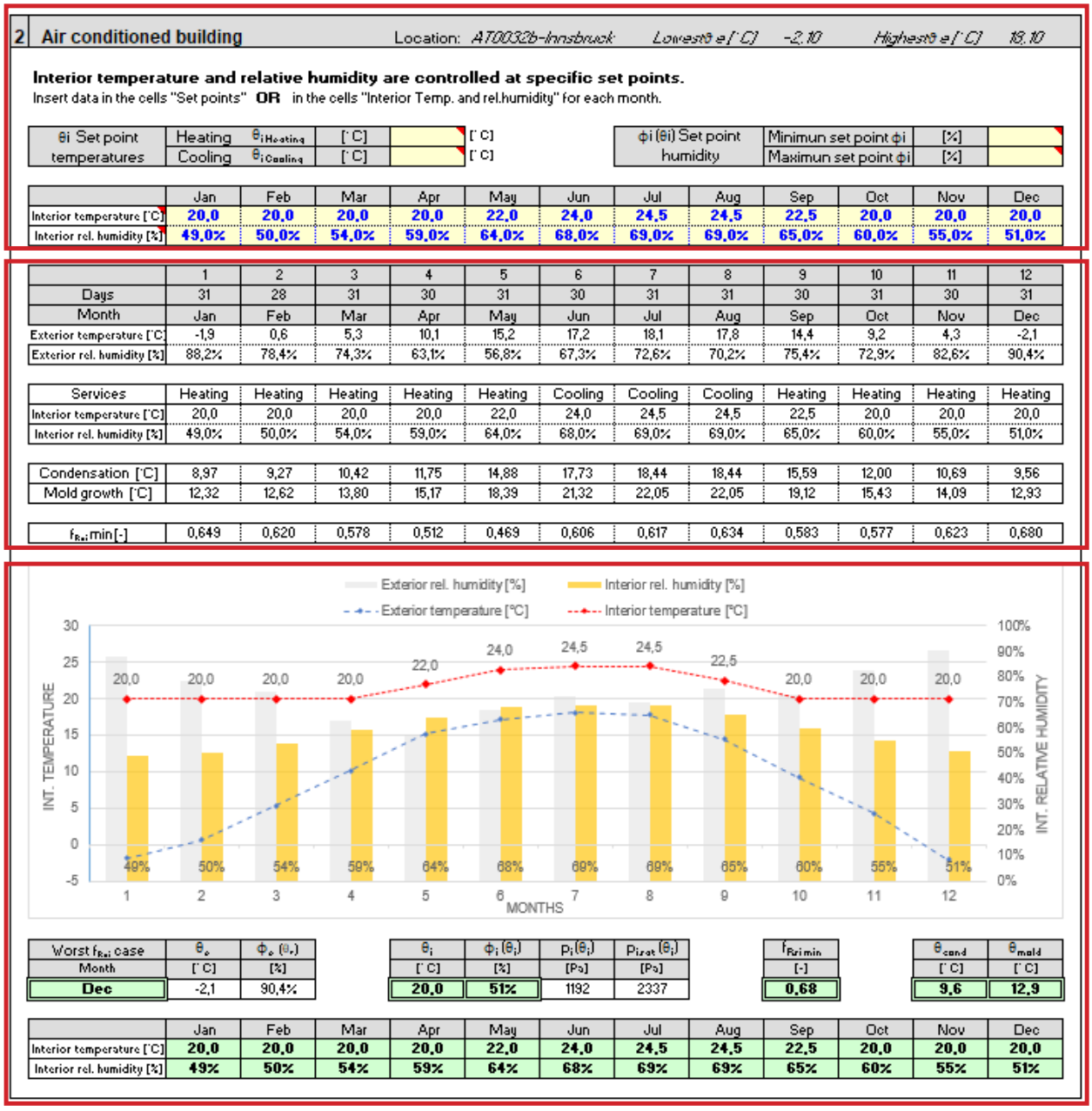
Information regarding Passive House Components according to the climate data

Interior climate

The following interior climate parameters are considered:

1. **ACR and humidity sources;**
2. **Air conditioned building;**
3. **Contineltal and tropical climates (ISO 13788);**
4. **Maritime climates (ISO 13788).**

At the top of each option, the temperature and/or relative humidity set point data are inputted.
Below, the main calculations for the selected boundary condition are shown.
At the bottom of each section, a graph is shown describing the main results for the selected climate.



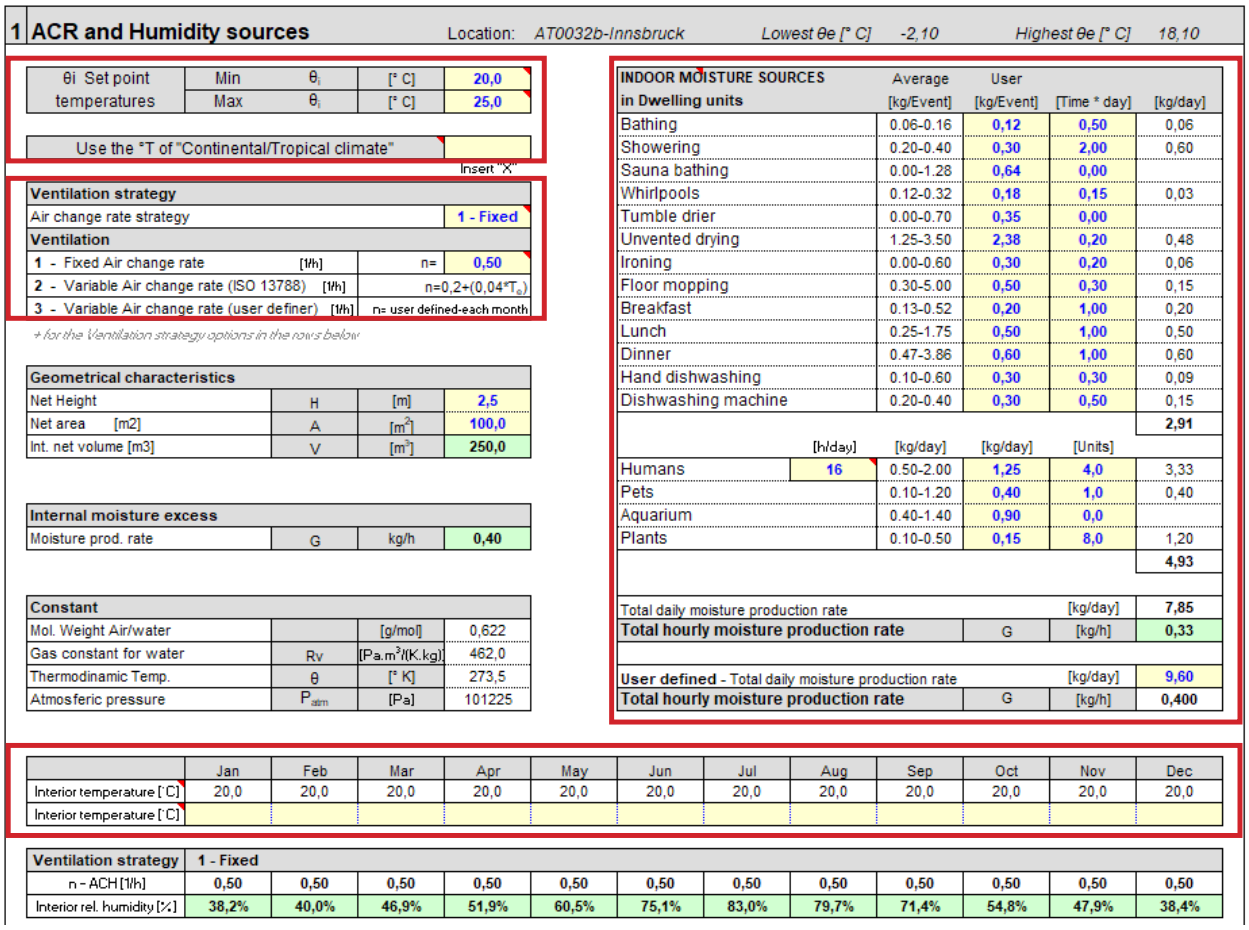
Input area

Main calculation results and details

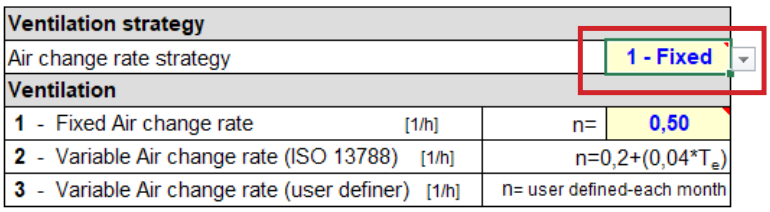
Main results

ACR and humidity sources

The user can insert the air change rate (ACR) and humidity sources, according to the expected use of the building. The input are is shown in the picture below.



Clicking on the Drop-down list, the user has three options for inserting the ACR:



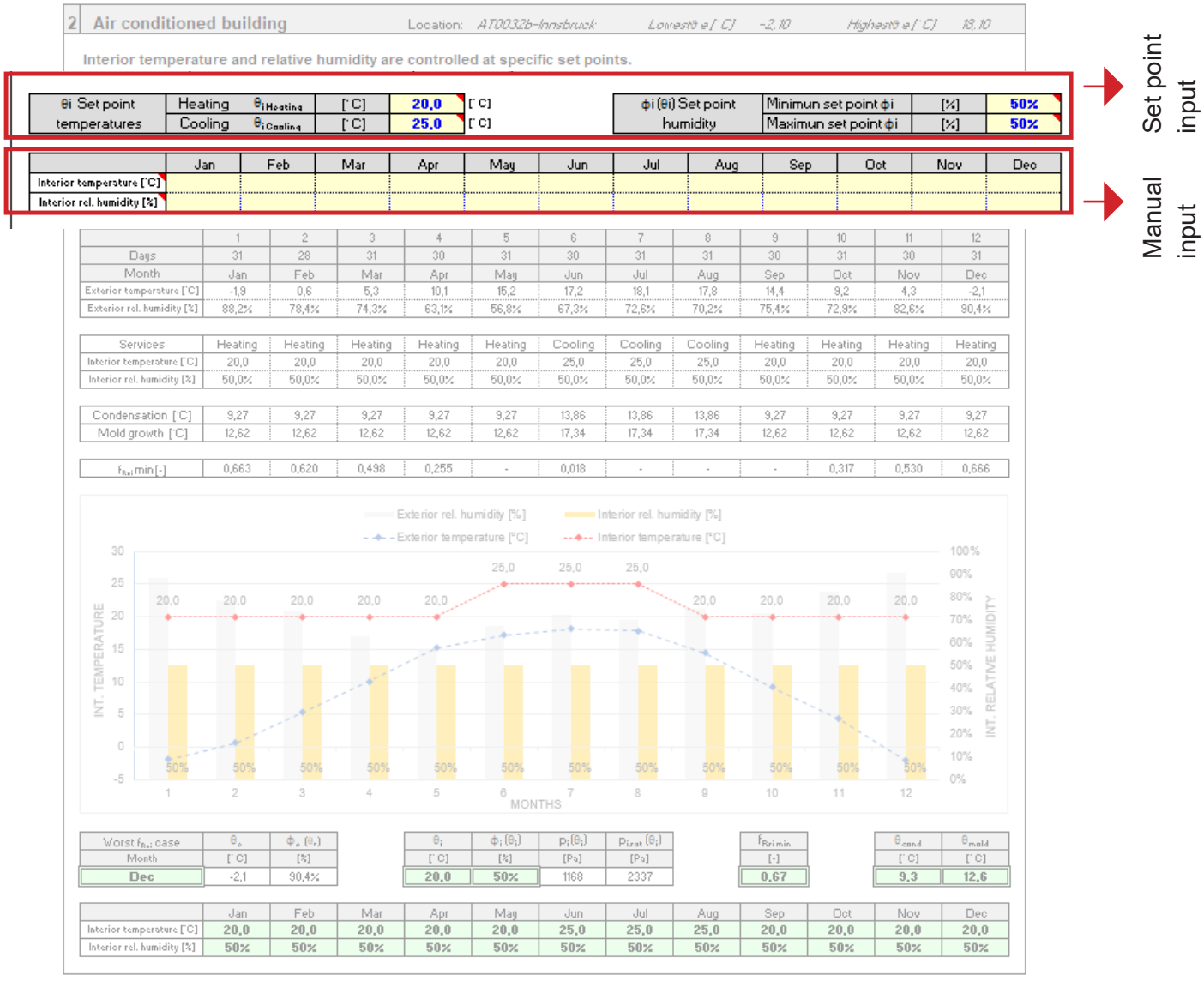
1. Fixed Air change rate [1/h]: the user inserts one value for the whole year;
2. Variable Air change rate [1/h]: the value is calculated using the following formula (n = 0,2 + 0,04 θe) where **n** is the air change rate per hour.
3. Variable Air change rate (user defined) [1/h]: the user can insert a specific ACR for each month.

The designer can use the table of „Indoor moisure sources“ or insert manually the value for the „Total daily moisture production rate“ [kg/day] that defines the internal moisture excess to add to the exterior moisture, which is necessary to find the interior relative humidity.

NOTE: Without precise information, the designer may use the values written in the column „Average“ as a suggestion.

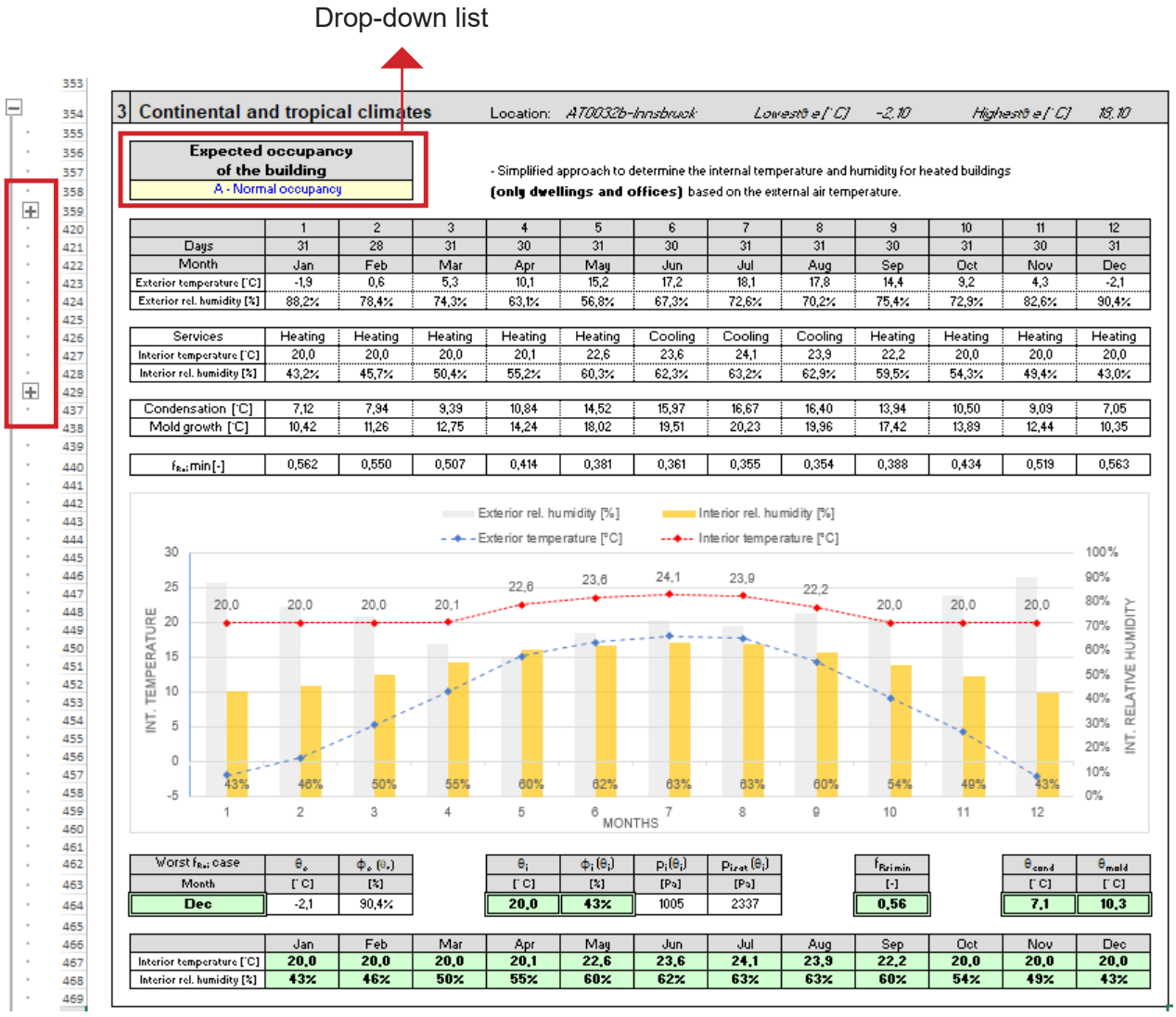
Air conditioned building

The designer can insert the temperature and relative humidity values either using the set point (if the values are the same for the whole 12 months), or by inputting both parameters manually for each month.



Continental and tropical climates

In the absence of well-defined internal air conditions, ISO 13788 allows the interior temperature and relative humidity for heated building to be determined. The internal air conditions are derived from external air temperature. This is a simplified approach to determine the internal temperature and humidity for heated buildings suitable for dwellings and offices.



	1	2	3	4	5	6	7	8	9	10	11	12
Days	31	28	31	30	31	30	31	31	30	31	30	31
Month	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Exterior temperature [°C]	-1,9	0,6	5,3	10,1	15,2	17,2	18,1	17,8	14,4	9,2	4,3	-2,1
Exterior rel. humidity [%]	88,2%	78,4%	74,3%	63,1%	56,8%	67,3%	72,6%	70,2%	75,4%	72,9%	82,6%	90,4%

Services	Heating	Heating	Heating	Heating	Heating	Cooling	Cooling	Cooling	Heating	Heating	Heating	Heating
Interior temperature [°C]	20,0	20,0	20,0	20,1	22,6	23,6	24,1	23,9	22,2	20,0	20,0	20,0
Interior rel. humidity [%]	43,2%	45,7%	50,4%	55,2%	60,3%	62,3%	63,2%	62,9%	59,5%	54,3%	49,4%	43,0%

Condensation [°C]	7,12	7,94	9,39	10,84	14,52	15,97	16,67	16,40	13,94	10,50	9,09	7,05
Mold growth [°C]	10,42	11,26	12,75	14,24	18,02	19,51	20,23	19,96	17,42	13,89	12,44	10,35

f_{Rsi}min[-]	0,562	0,550	0,507	0,414	0,381	0,361	0,355	0,354	0,388	0,434	0,519	0,563

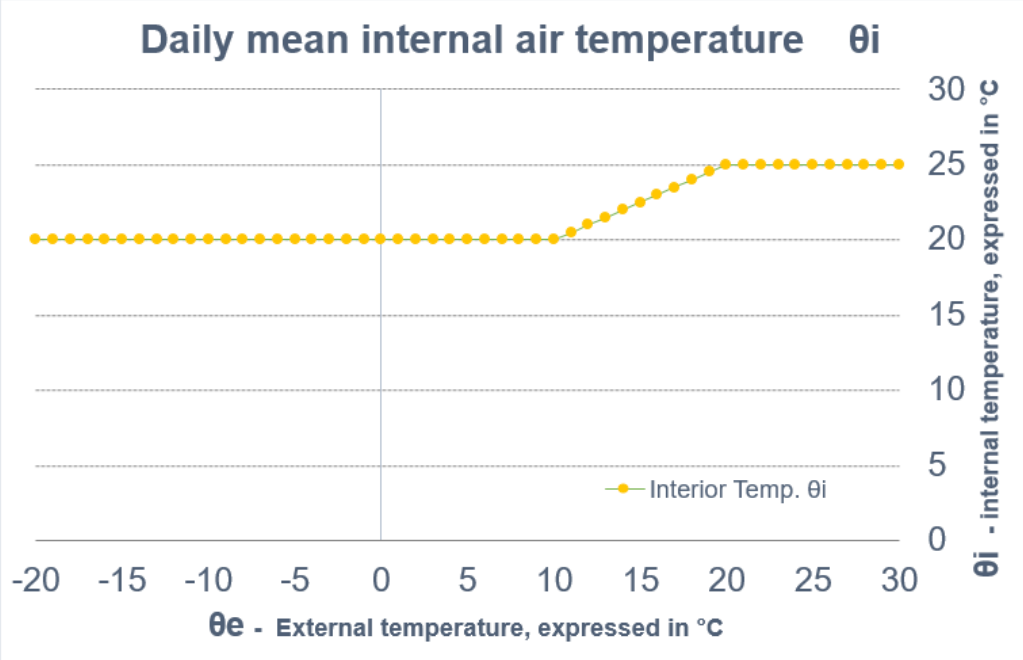
Worst f_{Rsi} case	θ_e	ϕ_e (θ_e)	θ_i	ϕ_i (θ_i)	p_i(θ_i)	$p_{i,sat}$ (θ_i)	$f_{Rsi,min}$	θ_{cond}	θ_{mold}
Month	[°C]	[%]	[°C]	[%]	[Pa]	[Pa]	[-]	[°C]	[°C]
Dec	-2,1	90,4%	**20,0**	**43%**	1005	2337	**0,56**	**7,1**	**10,3**

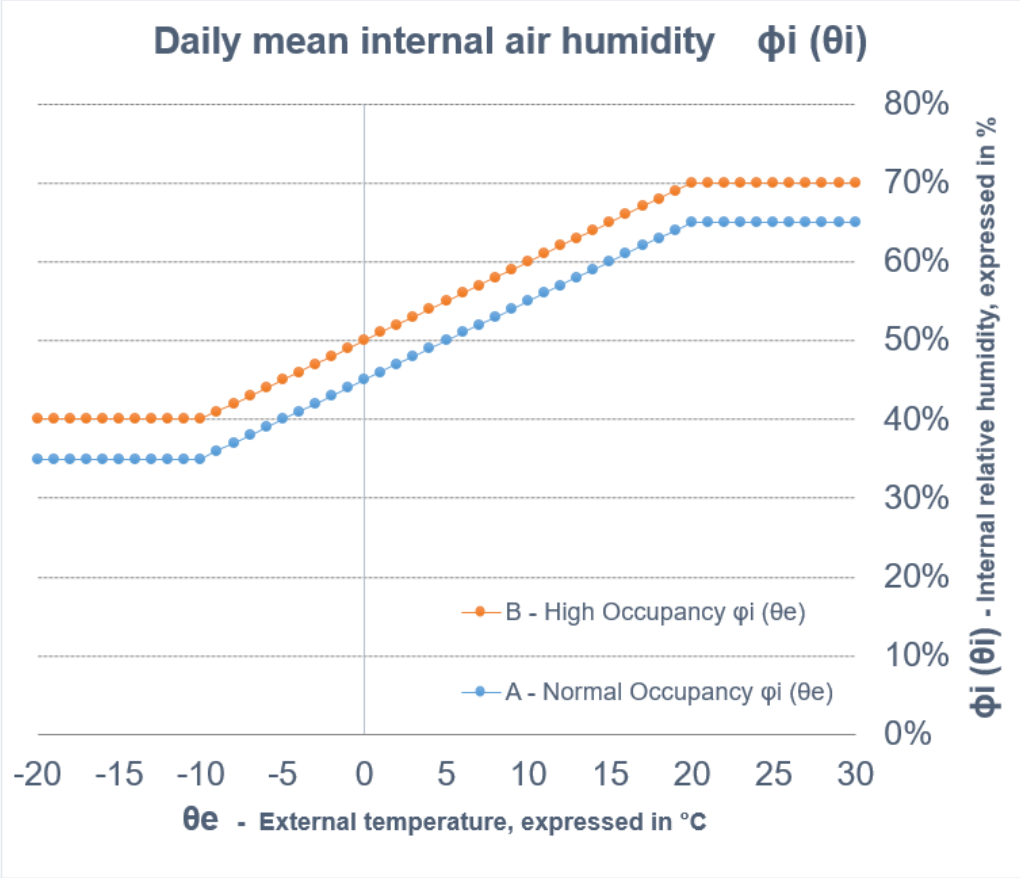
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Interior temperature [°C]	**20,0**	**20,0**	**20,0**	**20,1**	**22,6**	**23,6**	**24,1**	**23,9**	**22,2**	**20,0**	**20,0**	**20,0**
Interior rel. humidity [%]	**43%**	**46%**	**50%**	**55%**	**60%**	**62%**	**63%**	**63%**	**60%**	**54%**	**49%**	**43%**

Clicking on the Drop-down list, the user has two option:

1. **A – Normal occupancy;**
2. **B – High occupancy;**

Clicking on the plus sign on the left hand, the calculation area with the graps is shown.
The interior temperature and the interior relative humidity are derived from the exterior temperature.

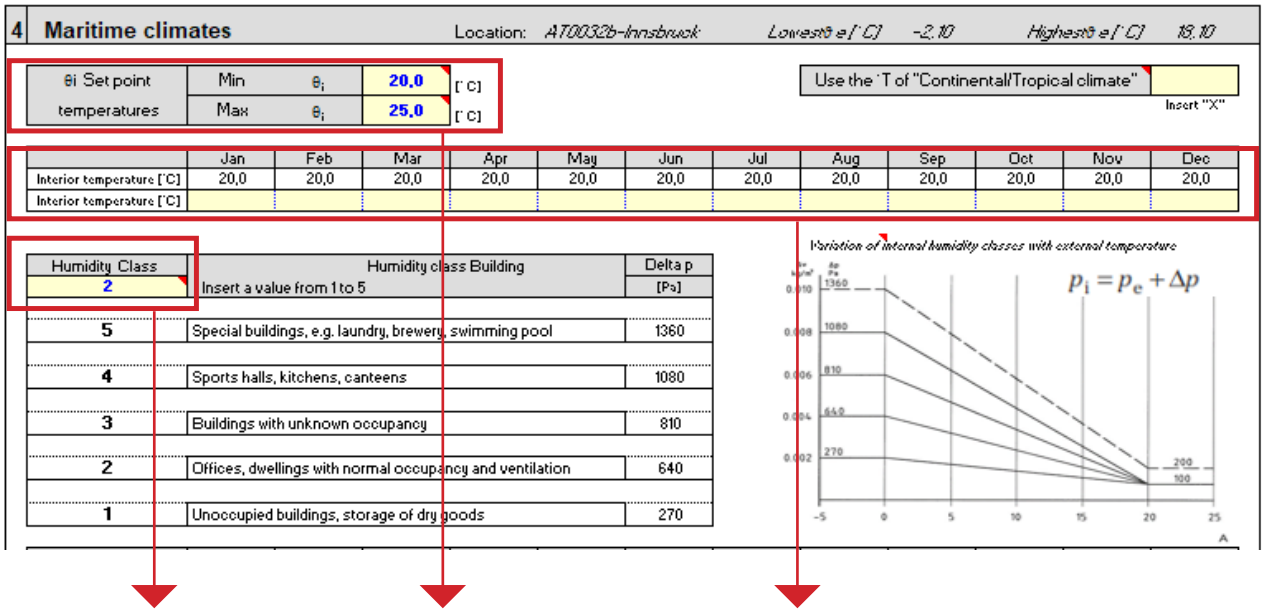




The interior humidity **level** derives from the expected occupancy of the building (normal occupancy HR from 35% to 65% or high occupancy from 40% to 70%).

Maritime climates

The designer can insert the interior temperature either using the set point (if the values are the same for the whole 12 months), or by inputting them manually for each month, or insering a “x” in the cell *“Use the Temp. of Continental and tropical climate”* (if these data are suitable for the project).
The relative humidity level is described by humidity classes. Each class is related to a predicted usage of the building and has a specific moisture load, which is added to the exterior moisture level.
The designer can select the number of the predicted humidity class from 1 (dry) to 5 (very humid) using the drop-down list.
The moisture load data are derived from buildings in Western Europe and are suitable for buildings near costal areas.



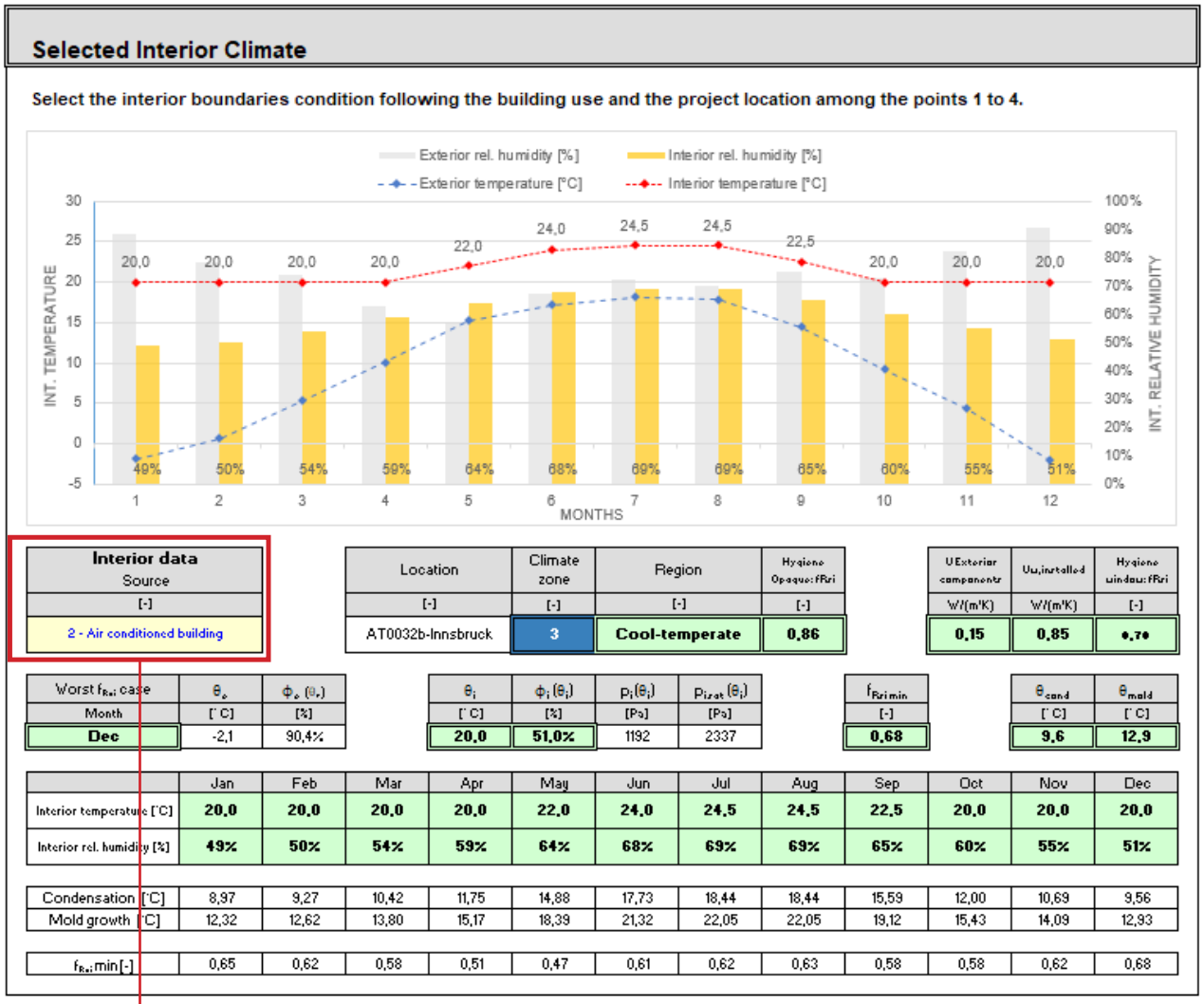
Drop-down list humidity classes

Set point input

Manual input

Selected interior climate

Select here the data set chosen as interior boundary condition among the previous options. These values are the parameters used for the monthly calculation in the „Assembly“ worksheet. The tool shows the graph and the main parameters related to the selected climate.



Drop-down list for selecting the exterior climate to use in the yearly verification

4 Assembly worksheet

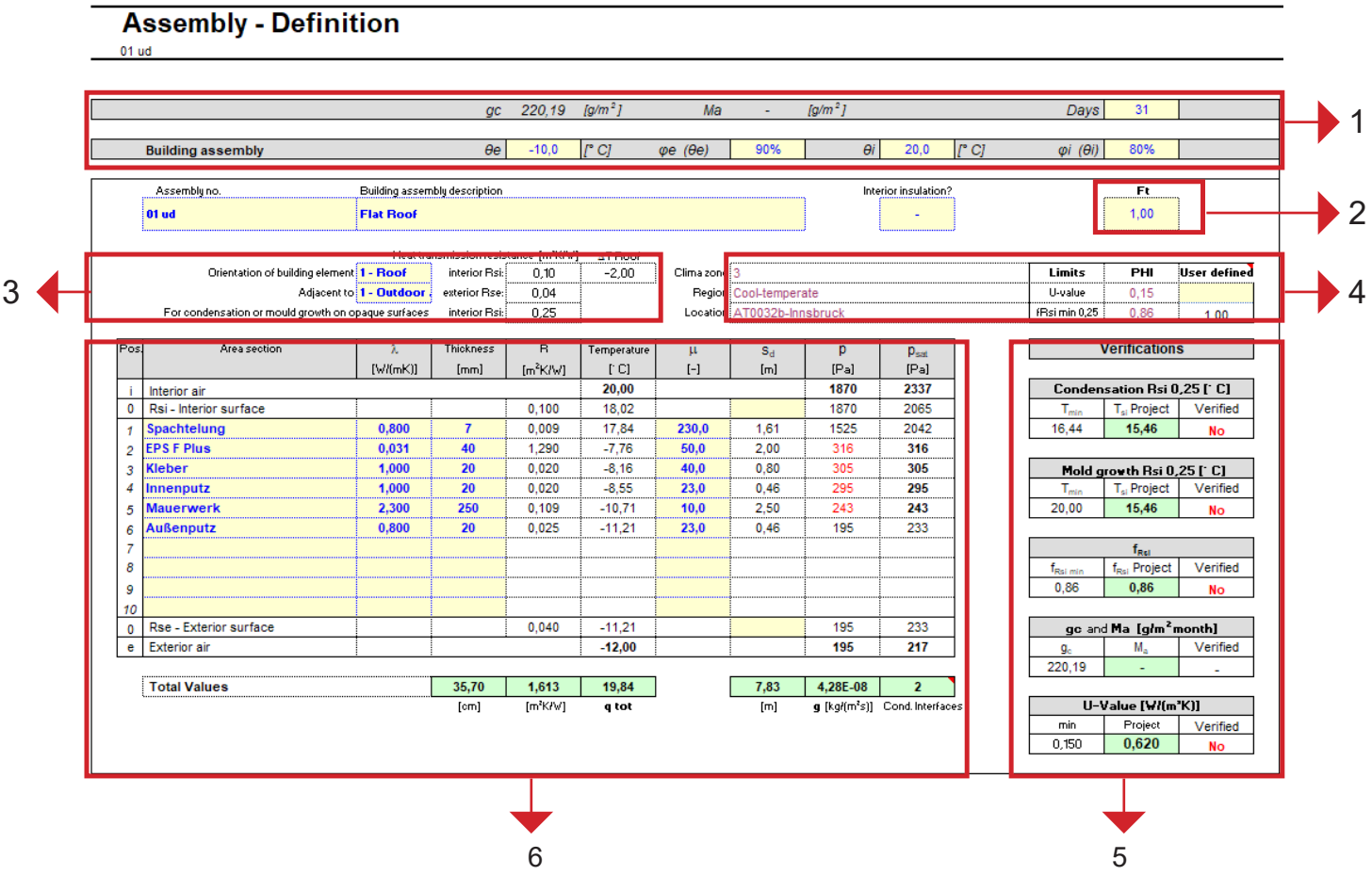
Assembly worksheet

The structure of this worksheet enables it to be copied and pasted as much as needed, as per the number of assemblies, components etc.
Each copy is connected to the climate worksheet, so the designer has only to define the materials in the *„Assembly Definition“* area, select the starting month of calculation in *„Assembly - Boundary conditions“*, to get the hygrothermal performance of this new assembly in Assambly-Verification and Calculation areas.

This worksheet is composed by:

1. **Assembly – Definition;**
2. **Assembly - Boundary conditions - 12 months;**
3. **Assembly – Verification;**
4. **Assembly – Calculations;**

Assembly - Definition



1. Temperature and relative humidity User input area
2. Temperature factor
3. Surface thermal resistances
4. Limits
5. Verification area
6. Structure, layers, materials input area

In this area is it possible insert the data needed to describe the component to be verified in terms of the number of layers, thickness of each layer, lambda and vapor resistance values.
User defined temperature and relative humidity can be inputted above the building assembly description (Nr.1); the results and associated graphs are shown on the right hand side. These inputted values do not affect the following area *„Boundary conditions - 12 months“* and *„Verification“* results. These cells allow to insert different exterior condition than the climate data selected in the worksheet “CLIMATE” as a stress test for the component, e.g. Passive House temperature criteria, design temperature, etc.

NOTE: ISO 13788 uses the monthly mean external temperature for the location of the building.

In the cell **Ft** is it possible input the temperature factor of the component e.g. if the exerior boundary condition is an unheated space (Nr. 2).
The orientation of building elements, the exterior and interior surface thermal resistances are automatically set (Nr. 3).

If the assembly is a roof, the exterior temperature is automatically decreased by 2 K.
ISO 13788 suggests use of the thermal resistance taken from ISO 6946 and S_d value of 0,01 m for air cavities, independent of the real dimensions and orientation of the cavity.
On the right hand side of the assembly input area, there are several verification fields that allow checking of the following parameters (Nr. 4):

- **Condensation Rsi 0,25 [° C]:**

Condensation Rsi 0,25 [° C]		
T_{min}	T_{si} Project	Verified
9,27	**17,51**	**Yes**

These cells compare the temperature when condensation occurs with the project's interior surface temperature. If the condensation temperature is below the project temperature, *„Yes"* appears in the verification cell, meaning the parameter is positively verified; if the temperature is higher than the project temperature, *„No"* will appear.

- **Mould growth Rsi 0,25 [° C]:**

Mold growth Rsi 0,25 [° C]		
T_{min}	T_{si} Project	Verified
12,62	**17,51**	**Yes**

These cells compare the temperature when mould growth is predicted and the project interior surface temperature. If the mould growth temperature is below the project temperature, *„Yes"* appears in the verification cell, meaning the parameter is positively verified; if the temperature is higher than the project temperature, *„No"* will appear.

- **fRsi:**

f_{Rsi}		
$f_{Rsi\ min}$	f_{Rsi} Project	Verified
0,86	**0,93**	**Yes**

These cells compare the fRsi minimum acceptable temperature factor and the project fRsi factor. If the project fRsi factor is above thefRsi minimum value, *„Yes"* appears in the verification cell, meaning the parameter is positively verified; if the factor is higher than the project fRsi, *„No"* will appear.

- **gc and Ma [g/m²month]:**

gc and Ma [g/m²month]		
g_c	M_a	Verified
0,51	-	-

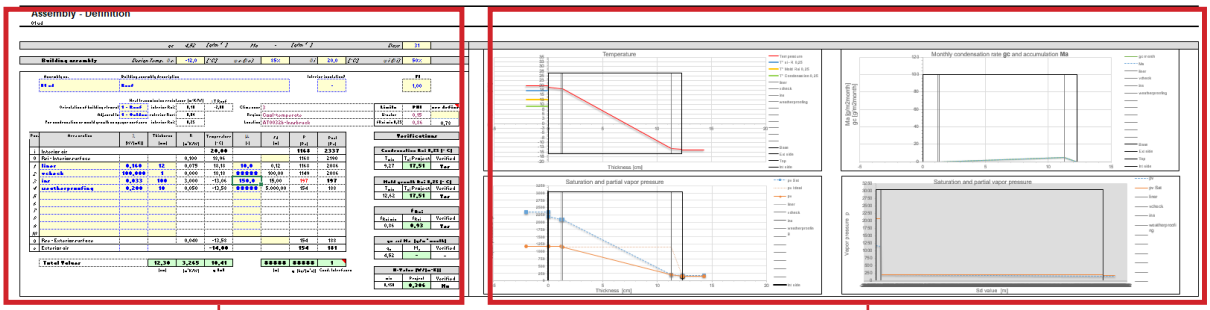
These cells contain the gc - density of water flow rate [g/m²] for each month and the Ma - accumulated moisture content [g/m²]. The gc value is related to the current selected month, the Ma is the sum of every posivite or negative gc value from the starting month of calculation selected in *„Boundary conditions - 12 months: Monthly condensation rate: Starting month of condensation"* area.

- **U-Value [W/(m²K)]:**

U-Value [W/(m²K)]		
min	Project	Verified
0,150	**0,306**	**No**

with the minimum recommended value. If the exterior climate is taken from PHPP, the minimum value following the PHI criteria and limits for PHI components automatically appears. If the exterior climate is user defined, the designer can input the minimum acceptable value in the yellow cell *„User defined U-Value-Limits“*. If the project U-Value is below the recommended U-Value, *„Yes“* appears in the verification cell, meaning the parameter is positively verified; if the U-Value is higher than, *„No“* will appear.

On the right hand side of the verification cells there are four graphs:

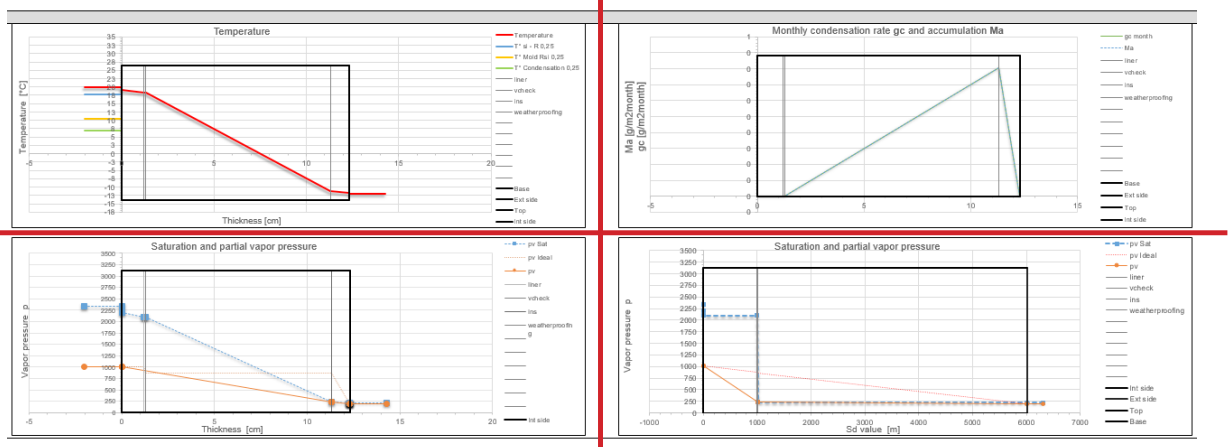


Input area

Graphs area

a) Temperature

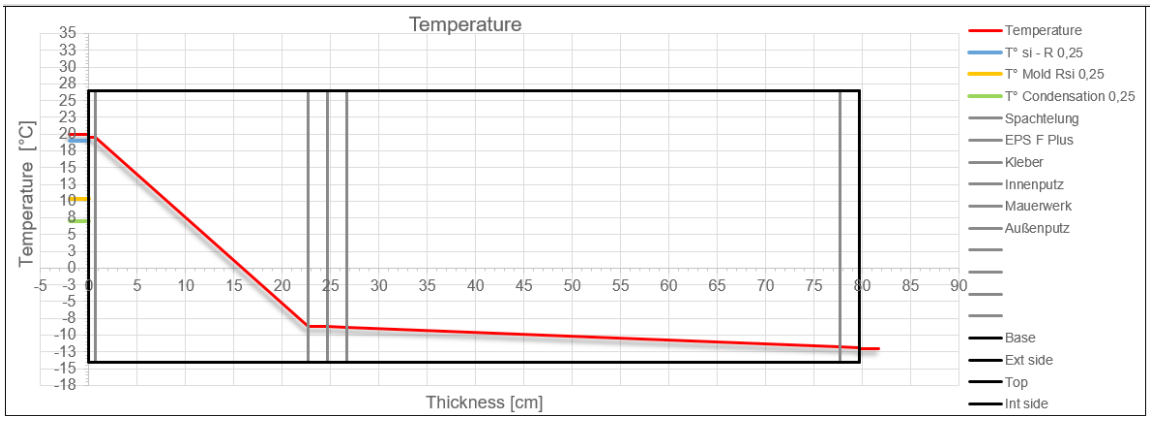
b) Monthly condensation rate **gc** and accumulation **Ma**



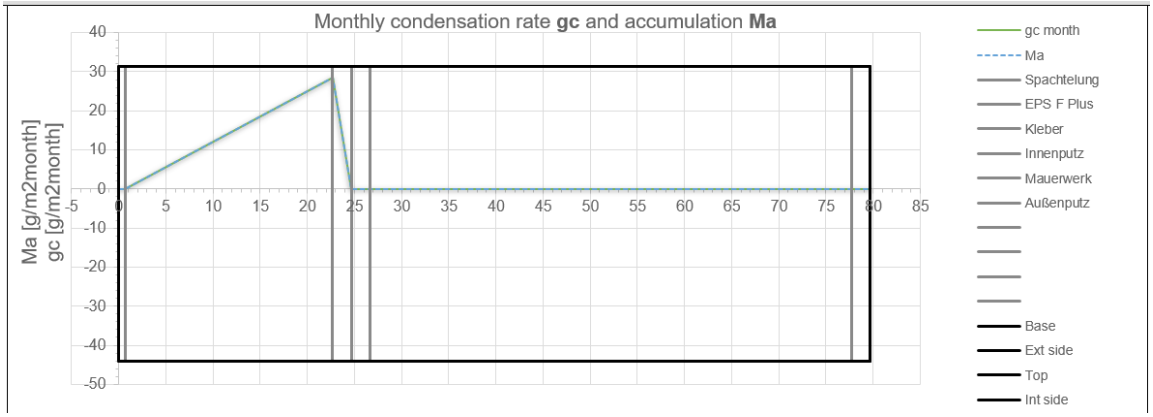
c) Saturation and partial vapour pressure - x-axis in cm

d) Saturation and partial vapour pressure - x-axis in S_d

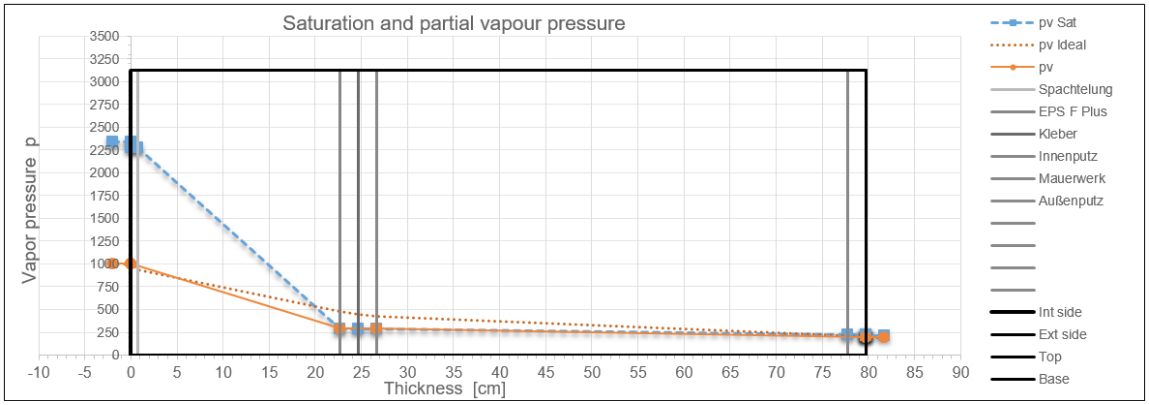
a) Temperature: this shows the temperature through the layers, from the interior to the exterior boundary conditions. At the left hand side of the graph (interior B.C.) the threshold temperatures for mold growth, condensation and surface temperature are shown, using as 0,25 m^2K/W internal resistance instead of 0,13 m^2K/W.



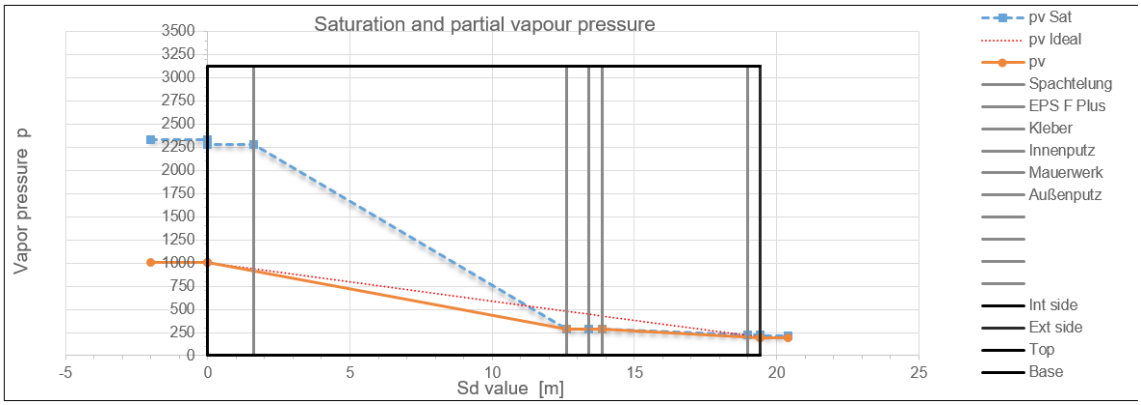
b) Monthly condensation rate gc and accumulation Ma;



c) Saturation and partial vapour pressure. The x-axis uses the real thickness in cm of the building assembly. Here the saturation and partial pressure through the building component are shown. The *„pv ideal“* dotted line represents the partial pressure without any condensation.



d) Saturation and partial vapour pressure. The x-axis uses the S_d value in m of the building assembly.



NOTE: The interior of the component is always on the left side of the graph.

Assembly - Boundary conditions - 12 Months

Assembly - Boundary conditions - 12 months

01 ud

Exterior Climate Location: 1 - PHPP

1 - PHPP	1	2	3	4	5	6	7	8	9	10	11	12
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Exterior temperature [°C]	-1,9	0,6	5,3	10,1	15,2	17,2	18,1	17,8	14,4	9,2	4,3	-2,1
Exterior rel. humidity [%]	88,2%	78,4%	74,3%	63,1%	56,8%	67,3%	72,6%	70,2%	75,4%	72,9%	82,6%	90,4%

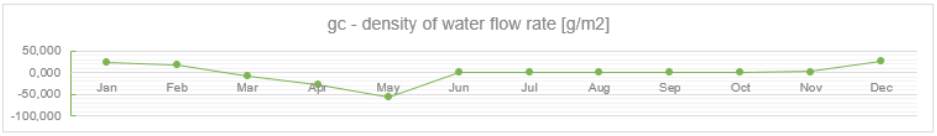
Interior Climate Location: 2 - Air conditioned building

2 - Air conditioned building	1	2	3	4	5	6	7	8	9	10	11	12
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Interior temperature [°C]	20,0	20,0	20,0	20,0	22,0	24,0	24,5	24,5	22,5	20,0	20,0	20,0
Interior rel. humidity [%]	49,0%	50,0%	54,0%	59,0%	64,0%	68,0%	69,0%	69,0%	65,0%	60,0%	55,0%	51,0%
Condensation [°C]	8,97	9,27	10,42	11,75	14,88	17,73	18,44	18,44	15,59	12,00	10,69	9,56
Mold growth [°C]	12,32	12,62	13,80	15,17	18,39	21,32	22,05	22,05	19,12	15,43	14,09	12,93
f_{Rsi} min [-]	0,65	0,62	0,58	0,51	0,47	0,61	0,62	0,63	0,58	0,58	0,62	0,68

Monthly condensation rate: Starting month of condensation

Select the first month when condensation occurs
Month
Oct

+ Condensation occurs; - Evaporation occurs.



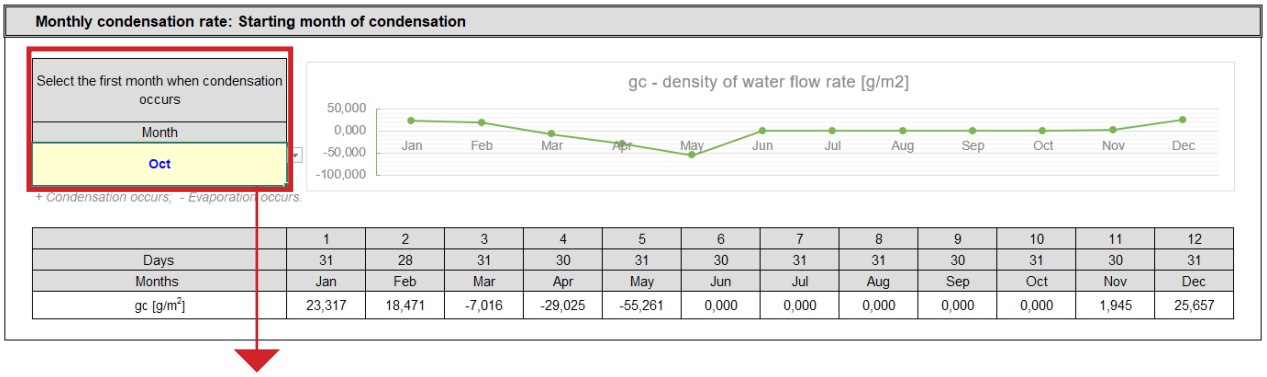
	1	2	3	4	5	6	7	8	9	10	11	12
Days	31	28	31	30	31	30	31	31	30	31	30	31
Months	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
gc [g/m²]	23,317	18,471	-7,016	-29,025	-55,261	0,000	0,000	0,000	0,000	0,000	1,945	25,657

1
2

1. Exterior and interior boundary conditions selected in the „Climate“ worksheet
2. „Monthly condensation rate: Starting month of condensation“ area

This area shows the selected exterior and interior boundary conditions selected in the *„Climate“* worksheet as the main boundary conditions to verify and to analyse the component through the following 12 months in the area *„Verification“*.
In the area *„Monthly condensation rate: Starting month of condensation“* the designer has to select the first month when condensation appears following the gc values shown on the table and on the graph *„gc - density of water flow rate”* [g/m^2].

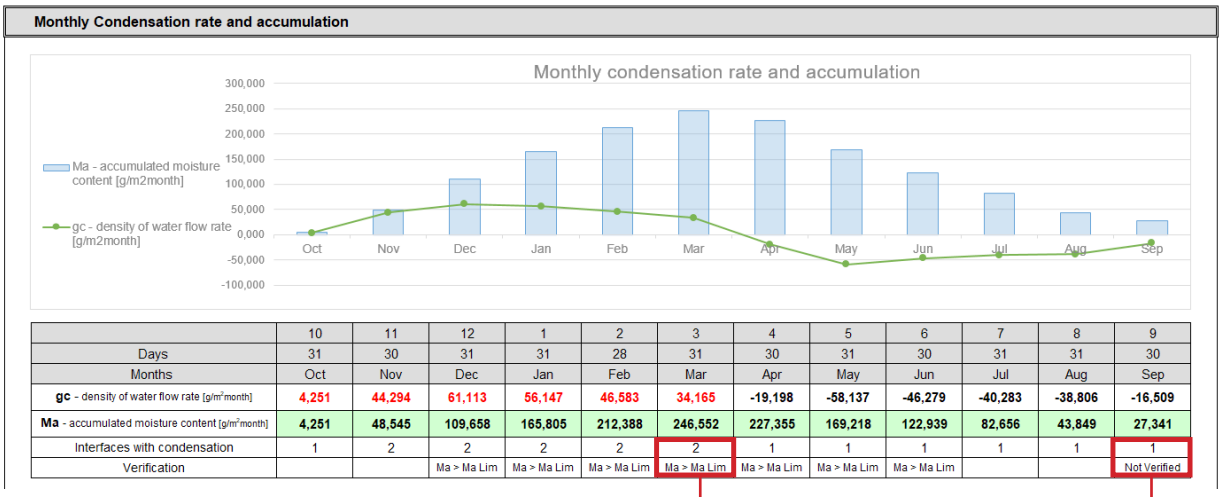
NOTE: in climate areas where the heating and cooling periods are well defined, the trial month should be just before the coldest period.



	1	2	3	4	5	6	7	8	9	10	11	12
Days	31	28	31	30	31	30	31	31	30	31	30	31
Months	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
gc [g/m^2]	23,317	18,471	-7,016	-29,025	-55,261	0,000	0,000	0,000	0,000	0,000	1,945	25,657

Drop-down list for selectiong the first month when condensation appears

If no condensation has been found in any month, the interstitial condensation verification is positive.
If condensation occurs in several months, select the month before the month with condensation.
If condensation occurs in all months without having complete evaporation after 12 months, the assembly is not verified because the amount of water inside the structure will increase years upon year.



	10	11	12	1	2	3	4	5	6	7	8	9
Days	31	30	31	31	28	31	30	31	30	31	31	30
Months	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
gc - density of water flow rate [g/m^{2}month]	4,251	44,294	61,113	56,147	46,583	34,165	-19,198	-58,137	-46,279	-40,283	-38,806	-16,509
Ma - accumulated moisture content [g/m^{2}month]	4,251	48,545	109,658	165,805	212,388	246,552	227,355	169,218	122,939	82,656	43,849	27,341
Interfaces with condensation	1	2	2	2	2	2	1	1	1	1	1	1
Verification			Ma > Ma Lim	Ma > Ma Lim	Ma > Ma Lim	Ma > Ma Lim	Ma > Ma Lim	Ma > Ma Lim	Ma > Ma Lim			Not Verified

The accumulated moisture is more than the Ma limit.

After 12 months condensation is not completely evaporated

Assembly - Verification

There are several criteria to assess the assembly:

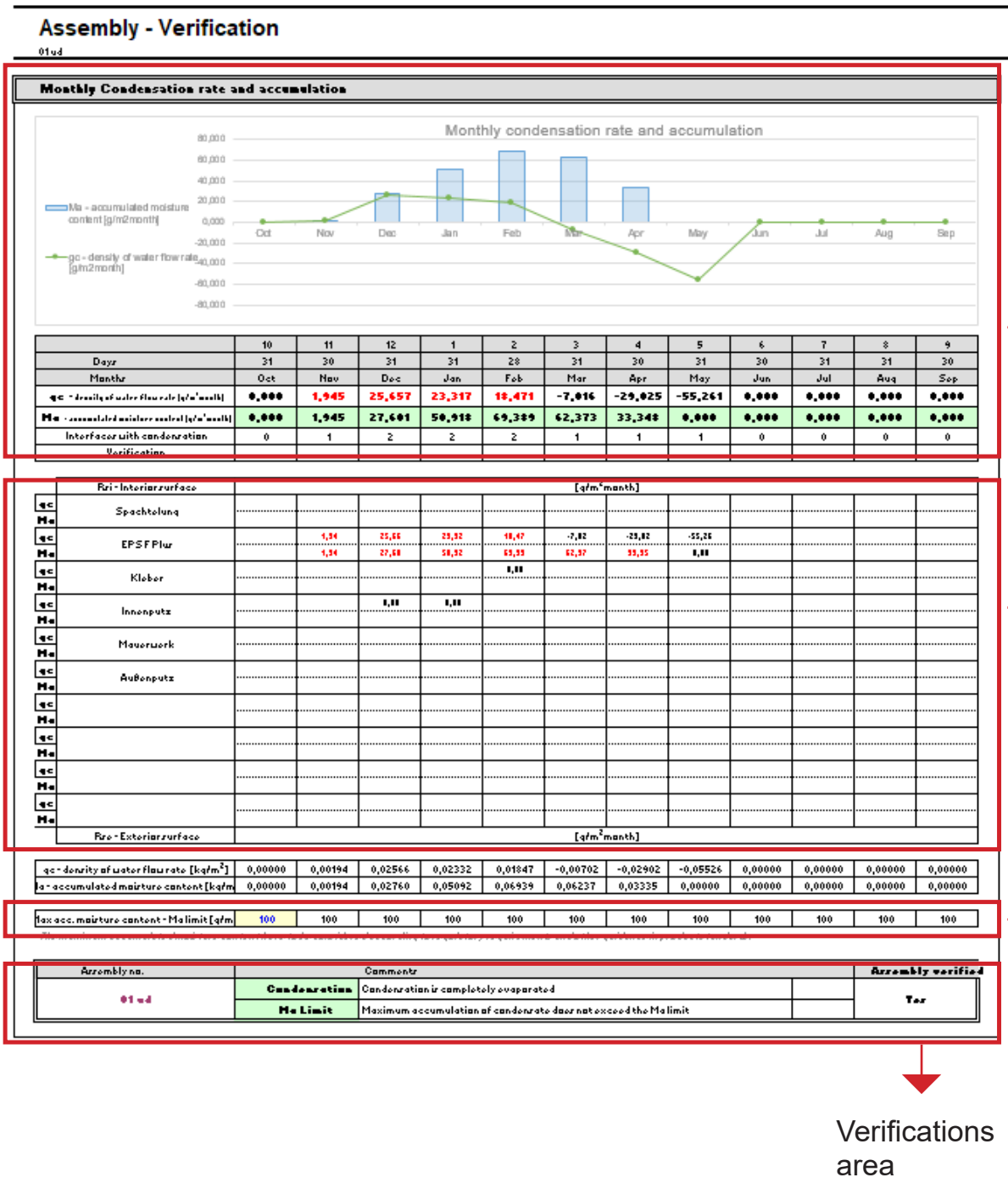
a) No condensation occurs at any interface in any month. The assembly is verified.

b) Condensation occurs in some interfaces and before the end of 12 months, all the accumulated moisture evaporates. The assembly is verified.

c) Condensation occurs in one or some interfaces and completely evaporates before the end of the 12 months, but the accumulated moisture was greater than the the maximum amount allowed (Ma Limit). The assembly is not verified.

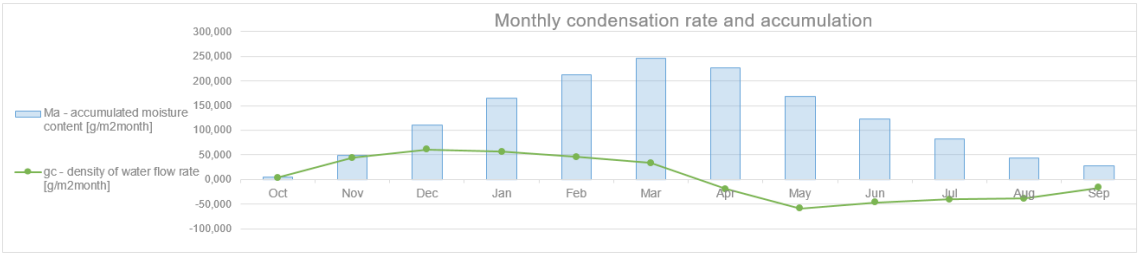
d) Condensation occurs in some interfaces, in some months, but after 12 months is not completely evaporated. The assembly is not verified.

The Verification area contains the results of the calculation. A graph shows visually the numbers in the cells below, which contain the monthly values of **gc**, **Ma**, number of interfaces where condensation occurs and the verification remark *„Not Verified“* if the value does not meet the requirements.



A table shows in detail the **gc** and **Ma** values for each interfaces and each month.
If condensation occurs, the number become red.
If evaporation occurs, the values are negative.

Monthly Condensation rate and accumulation



	10	11	12	1	2	3	4	5	6	7	8	9
Days	31	30	31	31	28	31	30	31	30	31	31	30
Months	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
gc - density of water flow rate [g/m²month]	**4,251**	**44,294**	**61,113**	**56,147**	**46,583**	**34,165**	**-19,198**	**-58,137**	**-46,279**	**-40,283**	**-38,806**	**-16,509**
Ma - accumulated moisture content [g/m²month]	**4,251**	**48,545**	**109,658**	**165,805**	**212,388**	**246,552**	**227,355**	**169,218**	**122,939**	**82,656**	**43,849**	**27,341**
Interfaces with condensation	1	2	2	2	2	2	1	1	1	1	1	1
Verification			Ma > Ma Lim	Ma > Ma Lim	Ma > Ma Lim	Ma > Ma Lim	Ma > Ma Lim	Ma > Ma Lim	Ma > Ma Lim			Not Verified

In the cell *„Max acc. moisture content - Ma limit [g/m²]“* the designer has to insert the maximum value of accumulated moisture allowed for the material where condensation occurs. More detailed information can be found in a national building standards or product requirements.

Max acc. moisture content - Ma limit [g/m²]	100	100	100	100	100	100	100	100

The maximum accumulated moisture content have to be considered according to regolatory requirements and other guidance in product standards.

NOTE: For non-absorbent building materials where condensation is above 200 g/m², the risk of run-off is very high.

At the bottom of this area the verifications are shown:

a) **Condensation:** check if condensation occurs and whether it is completely evaporated at the end of the 12 months.

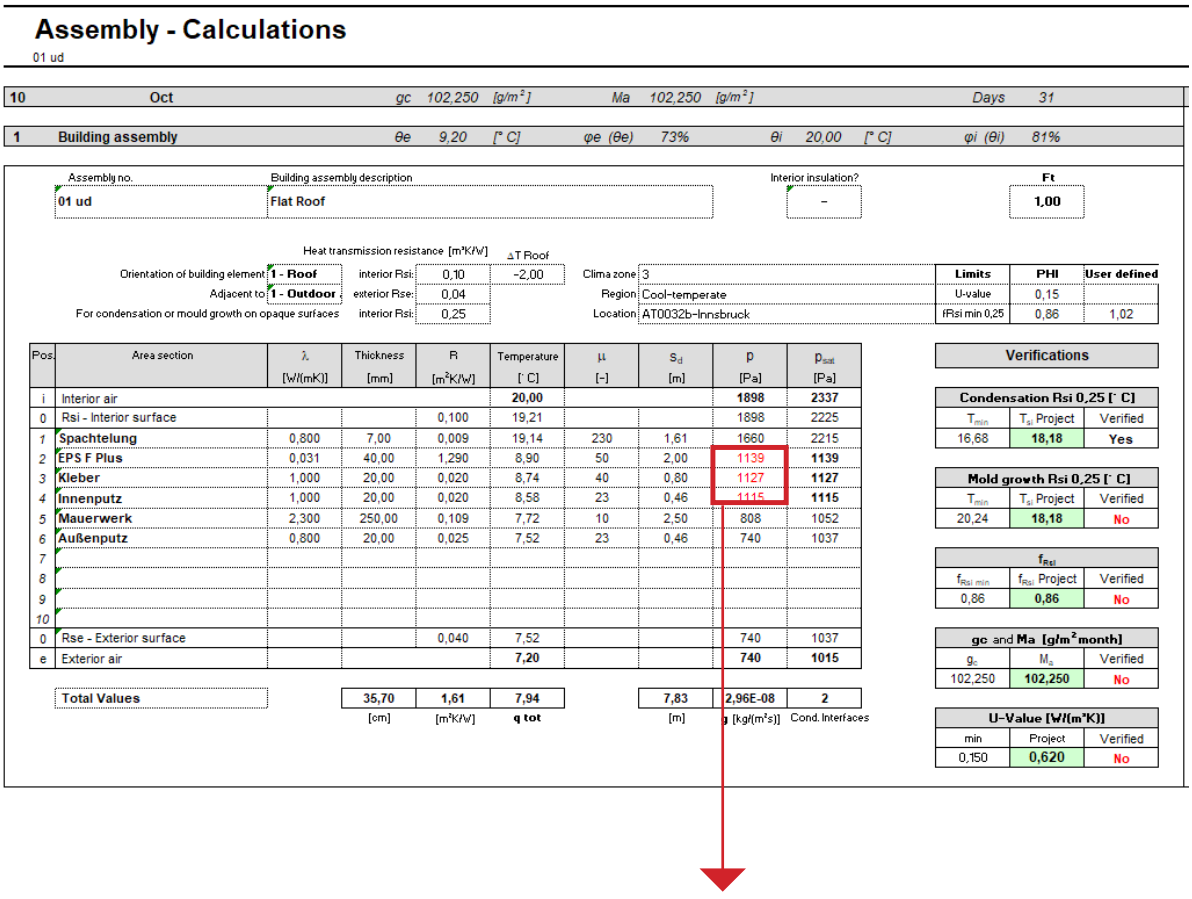
b) **Ma limit:** ensure that condensation does not exceed the „*Ma limit*“, i.e. the maximum amount of accumulated moisture that occurs at each interface.

Assembly no.	Comments			Assembly verified
01 ud	**Condensation**	Condensation is completely evaporated		**Yes**
	Ma Limit	Maximum accumulation of condensate does not exceed the Ma limit		

Assembly no.	Comments			Assembly verified
01 ud	**Condensation**	Condensation does not completely evaporate		**Assembly not verified**
	Ma Limit	Maximum accumulation of condensate exceeds the Ma limit		

Assembly - Calculations

This area contains the detailed results and verifications of each month.
The layout is the same as the *„Assembly definition“*, but here the user can find the different condensation and mould growth temperature limits, graphs and results for every month of the year.
The first month shown is the month selected as starting month in the area *„Assembly boundary conditions - 12 months“*.



Assembly - Calculations

01 ud

10	Oct	gc 102,250 [g/m²]	Ma 102,250 [g/m²]	Days 31
1	Building assembly	θe 9,20 [° C]	φe (θe) 73%	θi 20,00 [° C]	φi (θi) 81%

Assembly no.	Building assembly description	Interior insulation?	Ft
01 ud	Flat Roof	-	1,00

Heat transmission resistance [m²K/W] | ΔT Roof

						Limits	PHI	User defined
Orientation of building element:	1 - Roof	interior Rsi:	0,10	-2,00	Clima zone: 3	U-value	0,15	
Adjacent to:	1 - Outdoor	exterior Rse:	0,04		Region: Cool-temperate	fRsi min 0,25	0,86	1,02
For condensation or mould growth on opaque surfaces		interior Rsi:	0,25		Location: AT0032b-Innsbruck			

Pos.	Area section	λ [W/(mK)]	Thickness [mm]	R [m²K/W]	Temperature [° C]	μ [-]	s_d [m]	p [Pa]	p_{sat} [Pa]
i	Interior air				20,00			1898	2337
0	Rsi - Interior surface			0,100	19,21			1898	2225
1	Spachtelung	0,800	7,00	0,009	19,14	230	1,61	1660	2215
2	EPS F Plus	0,031	40,00	1,290	8,90	50	2,00	1139	1139
3	Kleber	1,000	20,00	0,020	8,74	40	0,80	1127	1127
4	Innenputz	1,000	20,00	0,020	8,58	23	0,46	1115	1115
5	Mauerwerk	2,300	250,00	0,109	7,72	10	2,50	808	1052
6	Außenputz	0,800	20,00	0,025	7,52	23	0,46	740	1037
7									
8									
9									
10									
0	Rse - Exterior surface			0,040	7,52			740	1037
e	Exterior air				7,20			740	1015
	Total Values		35,70 [cm]	1,61 [m²K/W]	7,94 q tot		7,83 [m]	2,96E-08 g [kg/(m²s)]	2 Cond. Interfaces

Verifications

Condensation Rsi 0,25 [° C]		
T_{min}	T_{si} Project	Verified
16,68	18,18	Yes

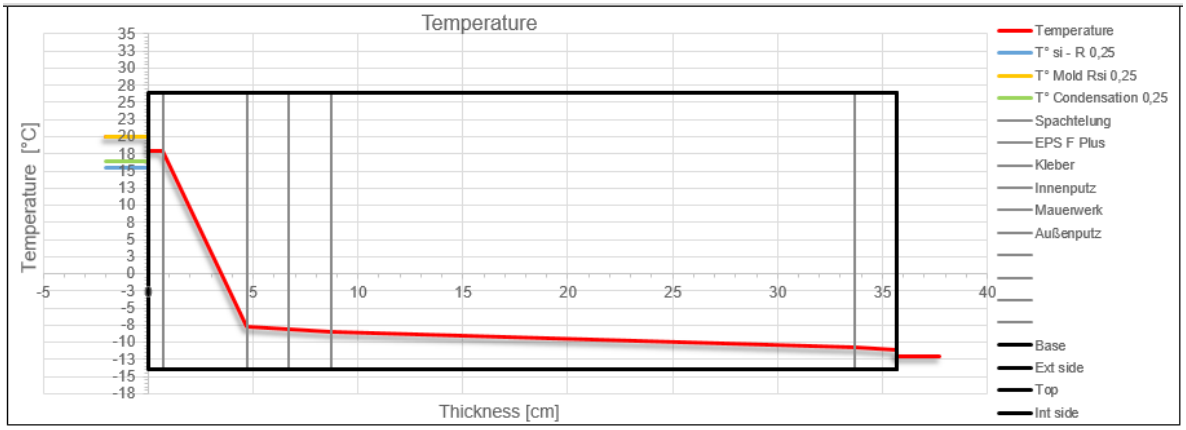
Mold growth Rsi 0,25 [° C]		
T_{min}	T_{si} Project	Verified
20,24	18,18	No

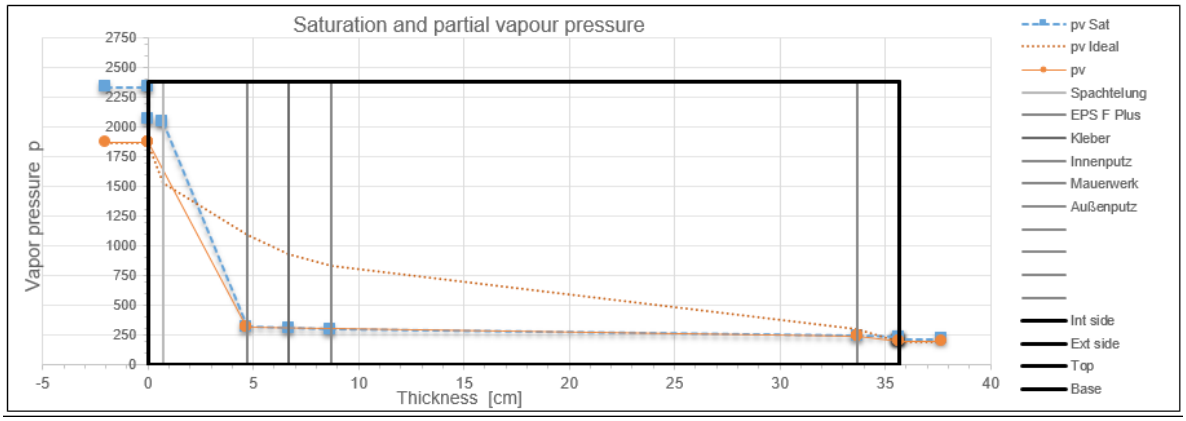
f_{Rsi}		
$f_{Rsi\ min}$	f_{Rsi} Project	Verified
0,86	0,86	No

gc and Ma [g/m²month]		
g_c	M_a	Verified
102,250	102,250	No

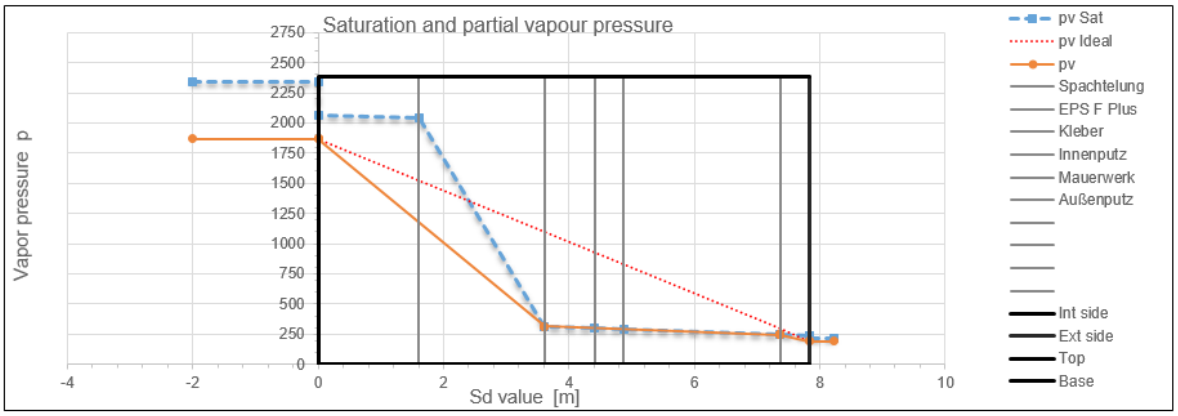
U-Value [W/(m²K)]		
min	Project	Verified
0,150	0,620	No

The numbers are red where condensation occurs


Temperature
Temperature [°C]
Thickness [cm]
Temperature
T° si - R 0,25
T° Mold Rsi 0,25
T° Condensation 0,25
Spachtelung
EPS F Plus
Kleber
Innenputz
Mauerwerk
Außenputz
Base
Ext side
Top
Int side


Saturation and partial vapour pressure
Vapor pressure p
Thickness [cm]
pv Sat
pv Ideal
pv
Spachtelung
EPS F Plus
Kleber
Innenputz
Mauerwerk
Außenputz
Int side
Ext side
Top
Base


Monthly condensation rate gc and accumulation Ma
Ma [g/m2month]
gc [g/m2month]
gc month
Ma
Spachtelung
EPS F Plus
Kleber
Innenputz
Mauerwerk
Außenputz
Base
Ext side
Top
Int side


Saturation and partial vapour pressure
Vapor pressure p
Sd value [m]
pv Sat
pv Ideal
pv
Spachtelung
EPS F Plus
Kleber
Innenputz
Mauerwerk
Außenputz
Int side
Ext side
Top
Base

References

ISO 13788:2012, Hygrothermal performance of building components and building elements - Internal surface temperature to avoid critical surface humidity and interstitial condensation - Calculation methods.

ISO 6946:2007, Building components and building elements — Thermal resistance and thermal transmittance — Calculation method.

ISO 9346, Hygrothermal performance of buildings and building materials — Physical quantities for mass transfer — Vocabulary.

ISO 15927-1, Hygrothermal performance of buildings — Calculation and presentation of climatic data — Part 1: Monthly means of single meteorological elements.

Criteria and Algorithms for Certified Passive House Components: Opaque Construction Systems. Version 2.11x_en, 10.06.2015 Passive House Institute, Darmastadt, DE.

Criteria for the Passive House, EnerPHit and PHI Low Energy Building Standard,version 9f, revised 15.08.2016 Passive House Institute, Darmastadt, DE.

PHPP, Passive House Planning Package, Version 9 (2015), Manual, Passive House Institute, Darmastadt, DE.

PHPP Passive House Planning Package, Version 9.6 (2015), Passive House Institute, Darmastadt, DE.

Proceedings of Building Simulation 2011: 12th Conference of International Building Performance Simulation Association, Sydney, 14-16 November. 366-373. STOCHASTIC MODELING OF MOISTURE SUPPLY IN DWELLINGS BASED ON MOISTURE PRODUCTION AND MOISTURE BUFFERING CAPACITY. Simon Pallin, Pär Johansson, and Carl-Eric Hagentoft Department of Civil and Environmental Engineering, Chalmers University of Technology, Gothenburg, SWEDEN

Imprint and Disclaimer

Published by
Published by Passive House Institute
Rheinstr. 44 - 46
64283 Darmstadt
Germany
Tel.: +49 (0) 6151-82699-0
Fax: +49 (0) 6151-82699-11
mail@passiv.de
www.passivehouse.com

1. Edition, Darmstadt, March 2019

Editing and content
Roberto Iannetti

Scope of content and exclusion of liability
The “Condensation Tool” is intended to guide the Passive House Designers and Consultants to better understand the thermal bridge influence into the thermal energy balance and the typical Ψ-values of common connections in a building.
The “Condensation Tool” was compiled with the greatest care and to the best of our knowledge and belief. However, no liability can be accepted for any content-related shortcomings or errors. Any liability for the accuracy and completeness of the contents and data and in particular for any damage or consequences arising from the use of the information presented here is therefore excluded

Acknowledgements
The “Condensation Tool” was completed in the frame of the SINFONIA projects:

SINFONIA stands for „Smart INitiative of cities Fully cOmmitted to iNvest In Advanced large-scaled energy solutions“. This project has received funding from European Union’s Seventh Programme for research, technological development and demonstration under grant agreement No 609019.

The sole responsibility for the content of this publication lies with the authors. It does not necessarily reflect the opinion of the European Commission are responsible for any use that may be made of the information contained therein.