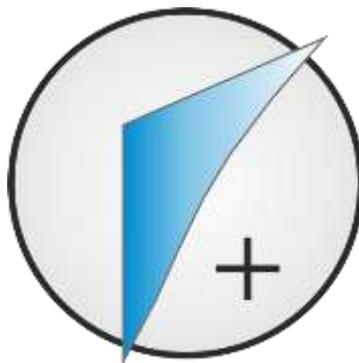


# WUFI® Plus 3.0

## Manual



### Authors:

Florian Antretter

Marcus Fink

Matthias Pazold

Jan Radon

Matthias Winkler

## Preamble

This manual describes the installation and the main features of WUFI® Plus.

Using an imaginative building as an example, it also shows how to create a 3D visualization of the building, how to set boundary and initial conditions and finally how to calculate and assess this example. Some hints will be given at each step. It's advisable to follow this example when working with WUFI® Plus for the first time.

For detailed information please refer to our WUFI®-Wiki ([www.wufi-wiki.com](http://www.wufi-wiki.com)).

Throughout this manual three recurring design elements can be found, which will help in finding important information:

### Controls box

#### Controls box

These grey boxes show information about the menus of WUFI® Plus.



Green Information Boxes like this one give hints for further information about the current topic.



Orange Attention Boxes like this one include important information about calculation settings.

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# 1 Introduction

WUFI® Plus is the most comprehensive tool of the WUFI®-family and simulates both the hygrothermal conditions in a building component and the interior climate. Thus it can also be used to evaluate comfort conditions and energy demand. It uses the outdoor climate, occupancy patterns, and HVAC systems to quantify temperature, humidity, and other conditions for the building and its components.. The simulation of the interaction of the building, its usage and HVAC-systems allows a holistic evaluation of indoor climate, hygienic conditions, thermal comfort, indoor air quality and damage proofing of all components. This is connected with the calculation of heating and cooling energy as well as the humidification and dehumidification demand.

WUFI® Plus allows the switching of different calculation scopes at any time. Building inputs that are applicable to the different scopes are carried from one scope to the other, which eliminates double entry.. The scopes within WUFI® Plus are:

- WUFI® Plus: This scope provides access to the full capabilities of WUFI® Plus, as described in this manual.
- Passive House Verification: This scope offers the complete passive house design and verification method according to PHIUS which is used in WUFI® Passive. Please refer to the WUFI® Passive manual for further information.
- DIN 4108-2 Thermal Protection / Building Simulation: The German thermal protection standard DIN 4108-2 describes verification methods to reduce overheating during summer. One of these methods is thermal building simulation with boundary conditions defined by the standard. This scope of WUFI® Plus can be used to perform calculations according to the standard. After the simulation is finished a report with all results and a classification according to the standard can be exported for every zone. Please refer to chapter 9 for further information.

Furthermore, WUFI® Plus is coupled with additional models which are also calculated dynamically:

- 3D Thermal Bridges can be calculated dynamically in WUFI® Plus. This allows for example an assessment of their impact on energy demand or moisture-related problems on the surface. The model was validated under steady-state conditions according to DIN EN ISO 10211. Please refer to chapter 4.5.10 for further information.
- In addition to the predefined air volume flow rate, or air change rates for each zone, WUFI® Plus is able to simulate the wind velocity and density (temperature) of driven air flow through the building depending

on the air permeability of the building components and their states (opened or closed).

- Several predefined HVAC-models are included in WUFI® Plus, which allow a detailed simulation of the whole HVAC systems and its devices. Please refer to chapter 4.6 for further information.
- Explicit Radiation balance: WUFI® Plus can calculate the long-wave radiation exchange on exterior surfaces with an explicit full radiation balance method which allows the quantitative computation of nighttime overcooling. Please refer to chapter 4.5 and our [WUFI®-Wiki](#) for further information.

## 2 Installation

### 2.1 System Requirements

IBM compatible computer, CPU at least 1.6 GHZ

RAM (Memory): 4 GB or better

Hard Drive: At least 8 GB free space

Graphic Card: At least 128 MB, OpenGL support

Operating System: Windows XP Service Pack 2 or higher; Windows 7; Windows 8; Windows 10

.NET Framework: 3.5 with Service Pack 1

### 2.2 Installation & Update



This installation procedure must be executed for a new installation of WUFI® Plus and for updates. When an update is performed, the existing settings and database-entries will be transferred to the new version of WUFI® Plus automatically. User-defined database-entries will be transferred, too.

After the download of WUFI® Plus is complete, unzip the downloaded file into a new folder. It's crucial to unzip the file or, the WUFI® Database won't be installed and WUFI® Plus cannot be started. This folder can be deleted after the installation has completed successfully.

Start the WUFI® Plus setup by double-clicking the Setup-File. The setup-dialog will open. Click "Next" to continue with the installation and "Cancel" to end it:



Figure 1:  
Installation: Start the setup.

Please read the License Agreement. You must accept the terms of this agreement before continuing with the installation.

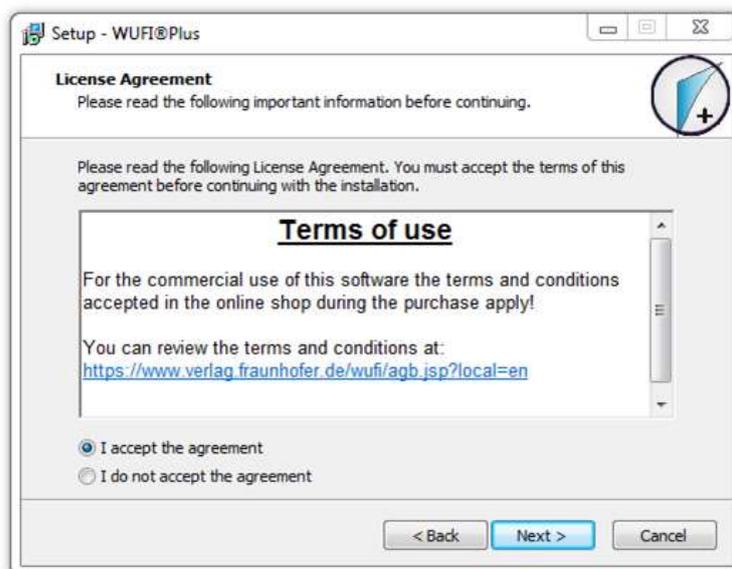


Figure 2:  
Installation: Terms of use.

Please make sure that your computer meets the system requirements:

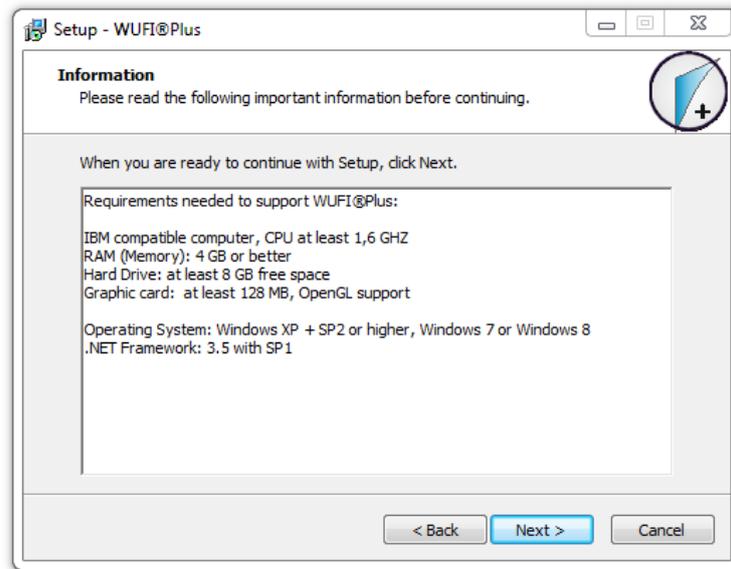


Figure 3:  
Installation: System requirements.

Input your license information from the Purchase-Email. Please note, that the license key from the Purchase-Email must be entered in the "Serial Number" field. It is recommended to copy the license information directly from your Purchase-Email to avoid input errors:

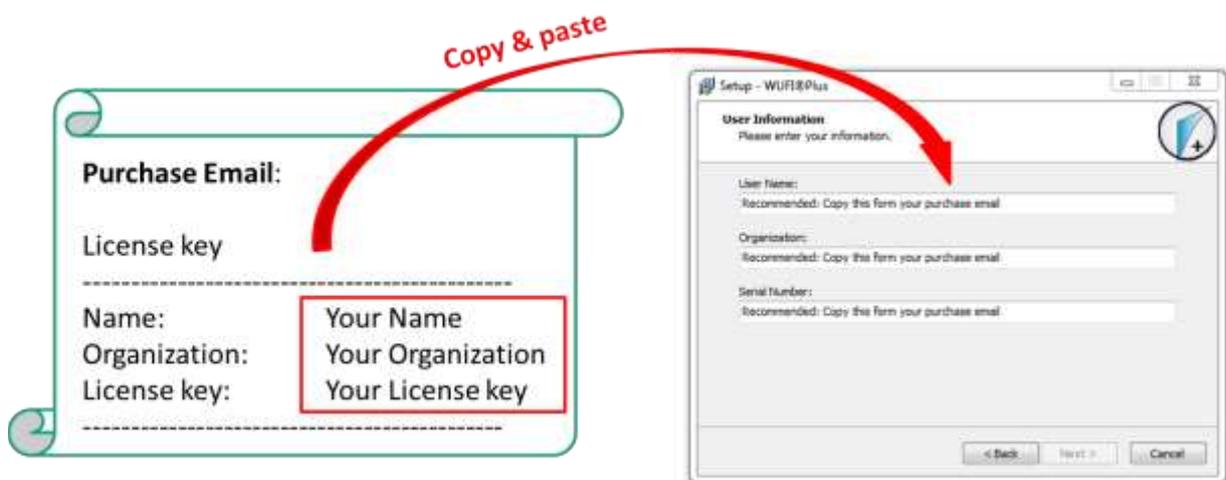


Figure 4:  
Installation: Enter your license data.

If the license information was entered correctly, the "Next"-button can be selected and the installation folder can be chosen. WUFI® Plus setup will create an entry in the Windows Start Menu. Its name can be entered in the next dialog:

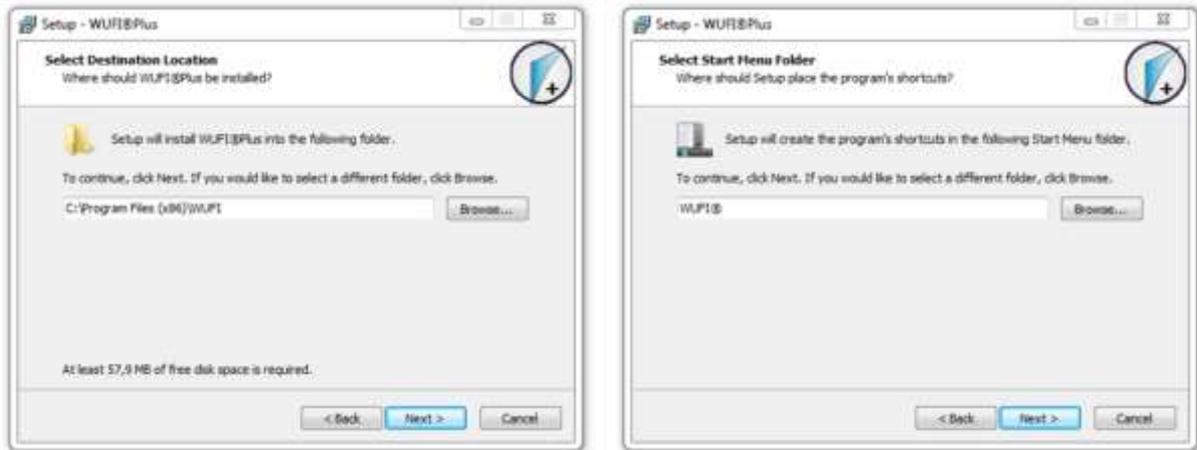


Figure 5:  
Installation: Select the installation folder and create an entry in the Windows Start Menu.

There is also an option to create a desktop icon:

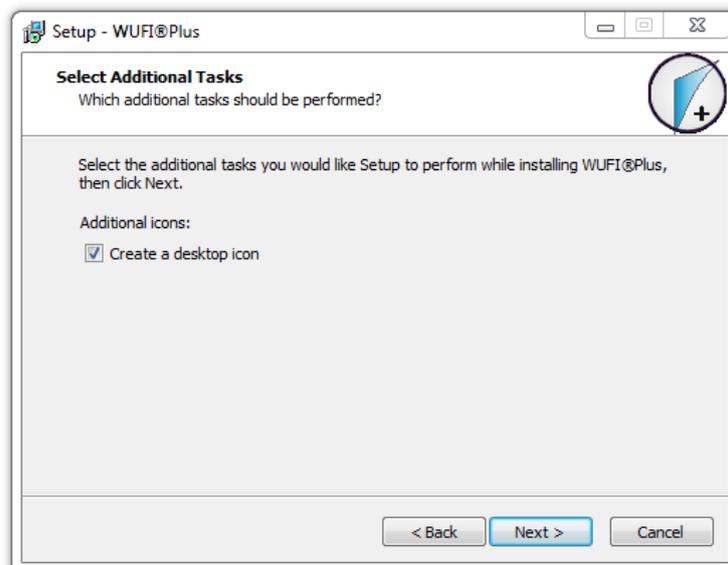


Figure 6:  
Installation: Create a desktop icon.

An info-screen sums up all settings for the installation-process. Please check these settings and use the "Back"-button to change any part of the installation. After all settings are entered correctly, click "Install" to continue with the installation.

After the installation of WUFI® Plus has finished successfully, a second setup-dialog for the WUFI® Database opens:



Figure 7:  
Installation: Start the installation of the WUFI® Database.

Select the installation folder for the WUFI® Database:

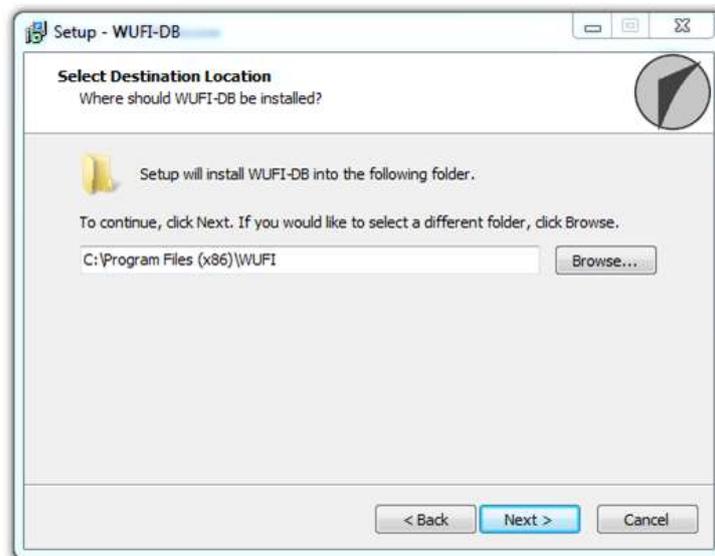


Figure 8:  
Installation: Select the folder for the installation of the WUFI® Database.

An info-screen sums up all settings for the installation-process. Please check these settings and use the "Back"-button to change any part of the installation. After all settings are entered correctly, click "Install" to continue with the installation.

After both installations are finished, click the "Finish"-button to complete the setup-process.



Figure 9:  
Finish the installation of WUFI® Plus and the WUFI® Database.

WUFI® Plus can now be started from the Windows Start Menu or from the desktop icon (if created).

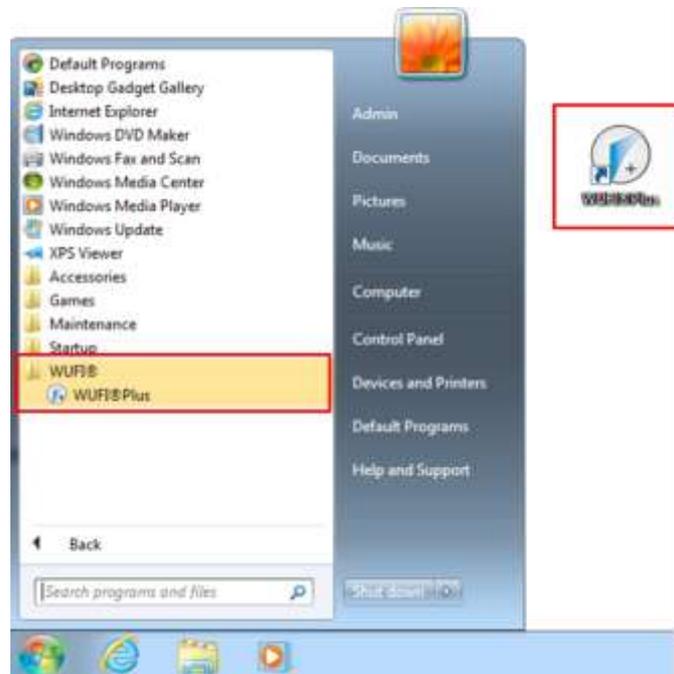


Figure 10:  
Starting WUFI® Plus either from the Windows Start Menu or the desktop shortcut.

### 3 Menus

This chapter gives a short overview of WUFI® Plus and its menu structure.

#### 3.1 Main Window

After starting WUFI® Plus, the main window appears, as shown below. This window provides access to all dialogs and menus. A short description of each element follows.

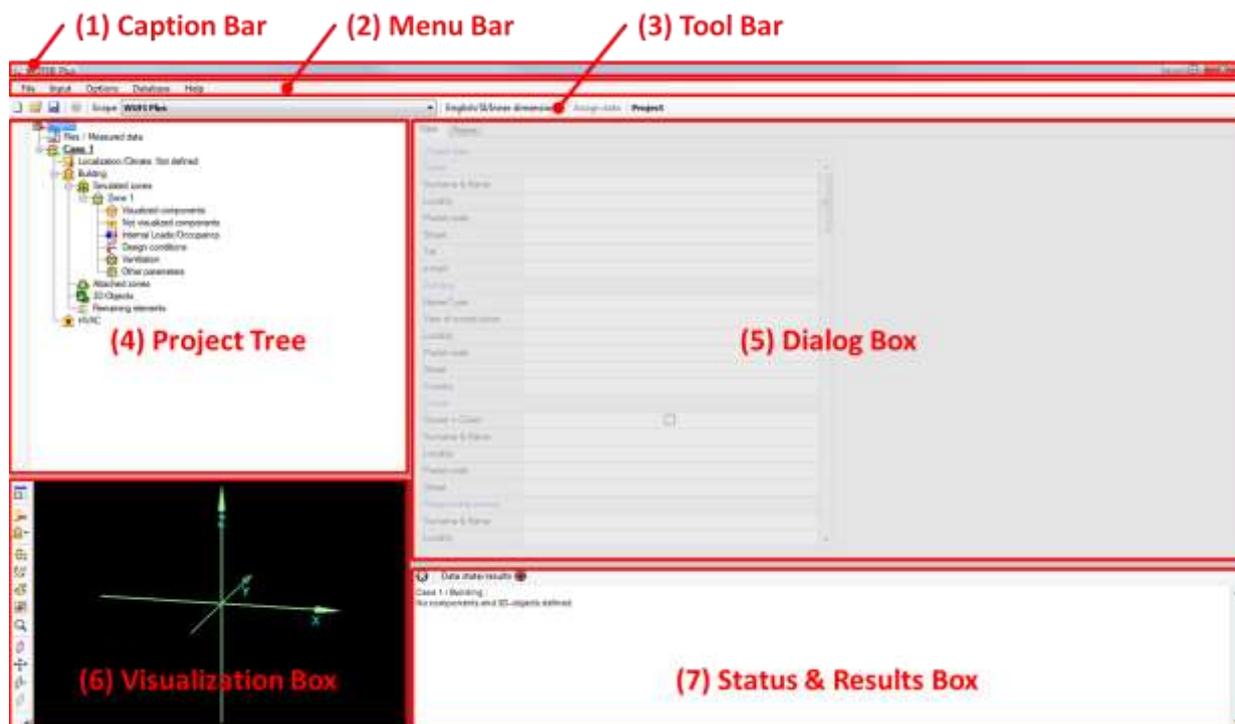


Figure 11:  
Main Window of WUFI® Plus.

#### Elements of the Main Window

**(1) Caption Bar**

The product name (WUFI® Plus) and its version number are shown here together with the name of the current project.

**(2) Menu Bar**

The menu bar contains different main menus. To see individual menu items and submenus please open the main menus.

**(3) Tool Bar**

Very basic and frequently used commands can be quickly reached using the tool bar. It also allows switching through the different calculation scopes of WUFI® Plus.

<b>(4) Project Tree</b>	As an alternative to the <i>"Input"</i> menu in the tool bar, the project tree offers easy and quick access to different panels. It is advised to follow the project tree structure while working on a project to ensure that no important information is left out.
<b>(5) Dialog Box</b>	Dependent of the selections in the <i>"Project Tree"</i> or <i>"Input"</i> menu, all user inputs or simulation results will be shown in this box. Chapter 4 and its subsections explain them in detail.
<b>(6) Visualization Box</b>	The geometry of the building is visualized here. The 3D Editor menu is located along the left side of this box. Its functions are described in chapter 3.4.
<b>(7) Status &amp; Results Box</b>	Missing user inputs or errors in the simulation are displayed here. After all necessary data is input, the output of main calculation results are shown.

### 3.2 Menu Bar

Five different menus are available in the Menu Bar. These are called *"File"*, *"Input"*, *"Options"*, *"Database"* and *"Help"*.

### 3.2.1 File

## Controls

<b>New Project</b>	The memory will be reset and a new empty project will be created.
<b>Open</b>	<p>The standard Windows dialog for opening a project file will be shown.</p> <p>WUFI® Plus supports four types of file formats for opening:</p> <ul style="list-style-type: none"><li>▪ .mwp: The standard WUFI® Plus file format.</li><li>▪ .xml: Alternative WUFI® Plus file format. Files in xml-format can be opened, viewed and modified with other programs, for example text editors.</li><li>▪ .wpp: The old format for WUFI® Plus Project Files.</li><li>▪ .wps: These files contain geometry-information exported from "SketchUp" with the "WUFI® Plus SketchUp Plugin", see chapter 6.1.</li></ul>
<b>Reopen</b>	Enables quick access to the last ten projects.
<b>Save</b>	<p>Saves the project input data and the calculated results if a simulation has already been completed. The project should be saved before calculating to back up input data and after the calculation to save results. The file type can be selected, too.</p> <p>WUFI® Plus supports two types of file formats for saving:</p> <ul style="list-style-type: none"><li>▪ .mwp: The standard WUFI® Plus file format.</li><li>▪ .xml: Saves a file in the WUFI® Plus .xml-format. Files in xml-format can be opened, viewed and modified with other programs, for example text editors.</li></ul>
<b>Save as</b>	<p>Saves the current project with a new name, while the original project will remain unchanged with its original name. The file type can be selected, as well.</p> <p>WUFI® Plus supports two types of file formats for saving:</p> <ul style="list-style-type: none"><li>▪ .mwp: The standard WUFI® Plus file format.</li><li>▪ .xml: Saves a file in the WUFI® Plus .xml-format. Files in xml-format can be opened, viewed and modified with other programs, for example text editors.</li></ul>
<b>Exit</b>	Closes WUFI® Plus. If any input has been changed, a safety query will ensure that no data is lost.

### 3.2.2 Input

This menu allows fast navigation, as clicking on one of the items makes the program jump to the corresponding entry in the project tree. For further information refer to chapter 4.

### 3.2.3 Options

#### Options Categories

<b>General</b>	General settings, including language, unit system, user-information and the default project directory. This menu also has a very important option, which defines if the visualized geometry displays the outer or inner surfaces of the building.
<b>Colors</b>	Direct link to the color setting menu for the visualized geometry.
<b>View</b>	Direct link to the view properties menu for the visualized geometry.
<b>Edit data</b>	Settings concerning tool tips and result export in batch-mode. See chapter 10 for further information about batch-mode.
<b>SketchUp plugin</b>	Options for the WUFI® Plus SketchUp plugin, see chapter 6.1 for further information

### 3.2.4 Database

This menu leads to the subsections of the WUFI® Plus database.

#### Controls

<b>Materials</b>	List of predefined building materials and their physical properties; these materials can be used and new materials can be created.
<b>Assemblies</b>	List of predefined combinations of the materials above mentioned. New assemblies can be created, as well.
<b>Windows</b>	List of predefined window data. New entries can be added.
<b>Emission sources</b>	List of sources of heat, moisture or carbon dioxide emissions for the calculation of internal loads. New entries can be added.
<b>Day profiles</b>	List of predefined day profiles representing the usage of a zone or design conditions. New entries can be added.
<b>Climates</b>	List of all entries of the climate database. New entries can be added.



Visit our WUFI®-Wiki ([www.wufi-wiki.com](http://www.wufi-wiki.com)) to learn more about the database. Its usage is described on our Wiki-pages and a tutorial movie shows in detail how to work with the database.

### 3.2.5 Help

## Controls

<b>About</b>	Information about the current WUFI® Plus installation, including its program and database version.
<b>WUFI Wiki</b>	Link to the WUFI®-Wiki ( <a href="http://www.wufi-wiki.com">www.wufi-wiki.com</a> ) where additional information and tutorials can be found.
<b>WUFI Forum</b>	Link to the WUFI®-Forum ( <a href="http://www.wufi-forum.com">www.wufi-forum.com</a> ), which can be used to discuss and exchange information about the WUFI®-family with other users.

WUFI® Plus offers tool tips for many input parameters. These tool tips explain the current input and give hints to recommended values or further sources of data. Tool tips appear, if the mouse is held for one second over an input field:



The screenshot shows the 'General' tab of the WUFI Plus software interface. A tooltip is displayed over the 'Type' field of the 'Simulated zone' parameter. The tooltip text reads: 'Simulated Zone: used for calculation/simulation. Attached Zone: unheated adjacent zone.' The interface includes a table for 'Geometry' with columns for 'Specification', 'Setting way', and 'Value'. The 'Floor area [m²]' field is highlighted. The 'Inner climate' dropdown menu is set to 'Simulate inner climate conditions'.

Specification	Setting way	Value
Visualized volume [m³]	From visualized geometry	
Gross volume [m³]	User defined	
Net volume [m³]	User defined	
Floor area [m²]	User defined	

### 3.3 Tool Bar

The Tool Bar provides access to some commonly used functions:

Controls	
	<b>New</b> The memory will be reset and a new empty project will be created.
	<b>Open</b> The standard Windows dialog for opening a project file will be shown.
	<b>Save</b> Saves the project input data and the calculated results if a simulation has already been completed. The project should be saved before calculating to back up input data and after the calculation to save results.
	<b>Help</b> Opens the WUFI® Help. Currently not active.
	<b>Scope</b> This dropdown-menu allows switching through different scopes of WUFI® Plus: <ul style="list-style-type: none"><li>▪ WUFI® Plus</li><li>▪ Passive House verification</li><li>▪ DIN 4108-2 Thermal protection / Building simulation</li></ul> Please refer to chapter 1 for information about these scopes.
	<b>Current Settings</b> This dialog shows the current settings of language, unit-system and if the visualization represents inner or outer dimensions. Clicking on this dialog opens the General Options, described in chapter 3.2.3.
	<b>Assign Data</b> This function allows the application of settings or user input to multiple elements in the project tree at once. Chapter 11.5.1 of the example case demonstrates how this very useful feature can be used.
	<b>Navigation Info</b> The last dialog in the Tool Bar shows which section in the project tree is open.

### 3.4 Visualization Box

The Visualization Box shows a 3D-visualization of the active case. Its important functions include displaying the geometry, establishing windows/ openings and creating and modifying the building-model. The view of the model can be changed with the command buttons along the left side. Also, the model can be moved by clicking and holding the left mouse-button and then moving the mouse.

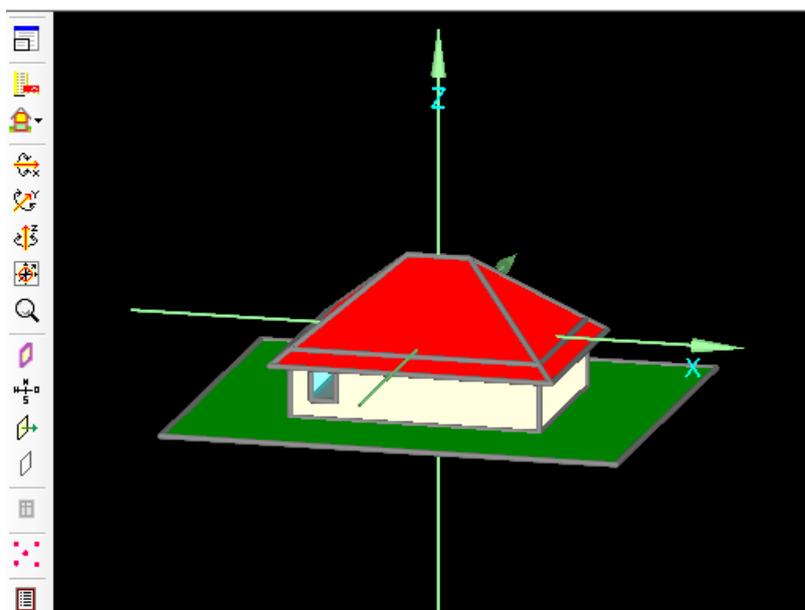


Figure 12:  
Visualization Box.

#### Controls



##### Expand/Shrink

Allows expanding the "Visualization Box". It's advised to use this option, as it facilitates using the "Visualization Box".



##### Building Wizard

Clicking this button opens the "Building Wizard". See chapter 4.5.1 and the example case, chapter 11.3, for more information about this feature.



##### Zones

By clicking this button, already existing zones can be re-named and new ones can be created.  
By holding the mouse on this button, individual zones can be selected with the effect that only the components belonging to the selected zone are shown in the "Visualization Box".  
For more information on zones see the chapter 4.5.2.

	<b>Rotating</b>	<p>These Buttons allow rotating the building around all three axes (X,Y &amp; Z).  Clockwise and counterclockwise rotation is possible by clicking with the left or right mouse-button.  Also the building can be rotated around an axis by clicking on the axis and then using the scroll wheel of the mouse.</p>
	<b>Center</b>	<p>Centers the view of the "<i>Visualization Box</i>" to its original position.</p>
	<b>Zoom</b>	<p>This Button allows zooming in (left mouse button) and zooming out (right mouse button). The zoom function can also be used by clicking the button and scrolling with the mouse wheel.</p>
	<b>Transparency</b>	<p>With this button viewing of components can be changed from transparent to opaque.  Transparent mode allows users to look "through" components to see some otherwise hidden components.</p>
	<b>Orientation</b>	<p>The orientation of the building can be displayed by left clicking this button.  Right clicking opens the "<i>Change orientation</i>" window, where orientation of the building can be altered.</p>
	<b>Normal vector</b>	<p>The normal vector of every component can be viewed as well. It is visualized as a green arrow on the selected component and points from the inner side of a component to its outer side. This is important for setting the attachments of every component, see chapters 3.4.2 and 4.5.3.</p>
	<b>Conditionally not visible/ selectable</b>	<p>This button makes a component conditionally not "<i>visible/selectable</i>", for example to make hidden components accessible.  The difference of this button to the "<i>transparent/opaque</i>" button is, that after clicking on this button, the component is neither visible nor selectable, whereas it is still selectable if only the view is switched from opaque to transparent.  In order to use this button for a component, it is important to checkmark the Option "<i>conditionally not visible/selectable</i>" in its properties, which can be accessed by right-clicking on the component in the "<i>Visualization Box</i>".</p>
	<b>Windows &amp; Openings</b>	<p>Creates new windows and openings. See chapter 3.4.1 for further information.</p>
	<b>Vertices</b>	<p>Shows or hides the vertices. Chapter 3.4.2 shows how vertices can be used to create or modify a building.</p>
	<b>Options</b>	<p>Settings for the "<i>Visualization Box</i>", as described in chapter 3.2.3.</p>

### 3.4.1 Inserting Windows and Openings

It is advisable to expand the "Visualization Box" before creating new windows and openings.

Before inserting windows or openings into a component, please select the component by left-clicking the component in the visualization box. Then press the "Windows & Openings"-Button or right-click on the component and select "Windows/Openings" and the "Component Openings" dialog will appear:

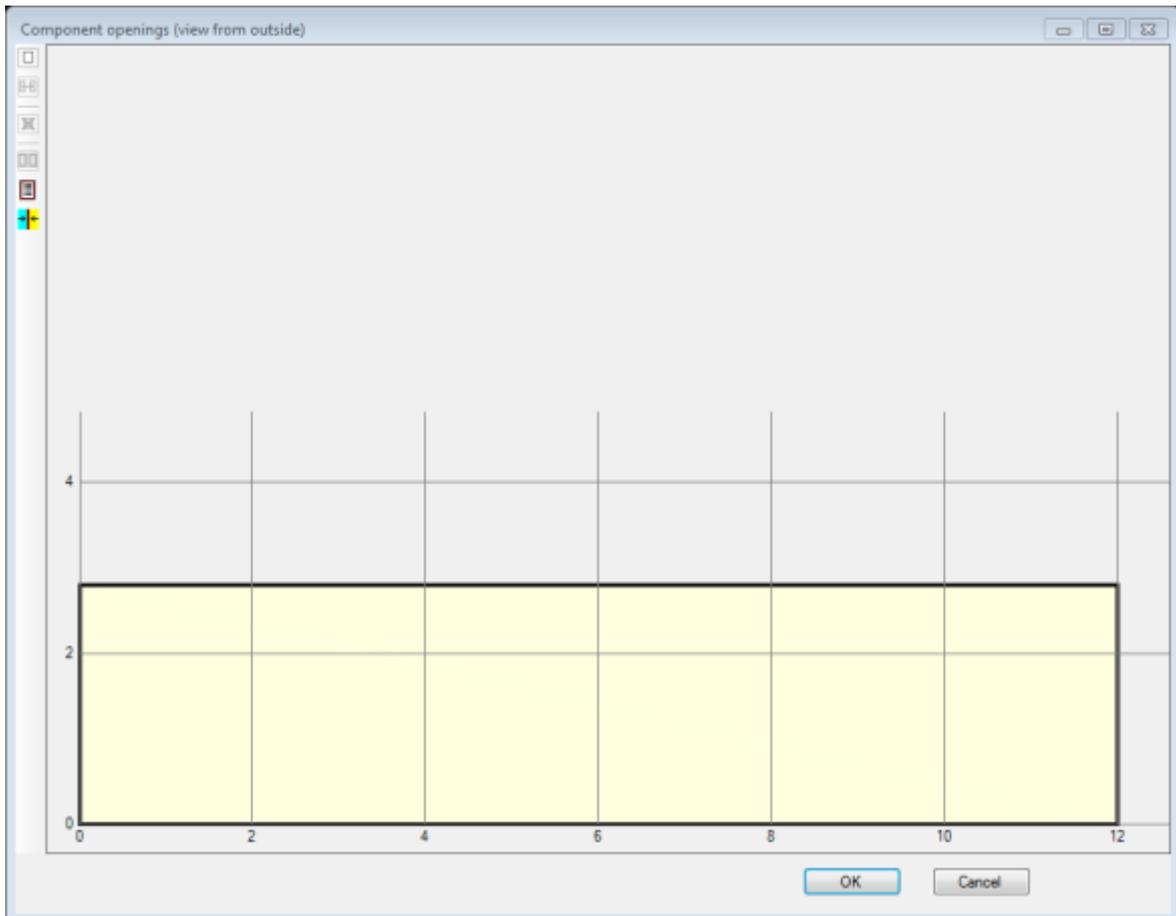


Figure 13:  
Component openings window.

#### Controls



##### **New**

New windows or openings can be created with this button. The "Opening" dialog will appear.  
*Hint: New windows or openings can also be created by right-clicking on the component.*



##### **New/copy move**

Allows copying or moving the selected window or opening.

	<b>Delete</b>	Delete the selected window or opening. <i>Hint: Selected windows or openings can also be deleted by pressing the "Delete"-Button on the keyboard.</i>
	<b>Select All</b>	Select all windows and openings in this component.
	<b>Edit list</b>	Shows a list of all windows and openings and allows editing or adding new windows and openings.
	<b>Change view</b>	Change the view of the component. The currently active view is displayed in the caption bar of this menu.

New windows or openings can be created by clicking the "New"-Button or by right-clicking on the component. The "Opening" dialog appears and the window type (1), its position along the grid (2) and its measurements (3) can be entered, shown in the figure below:

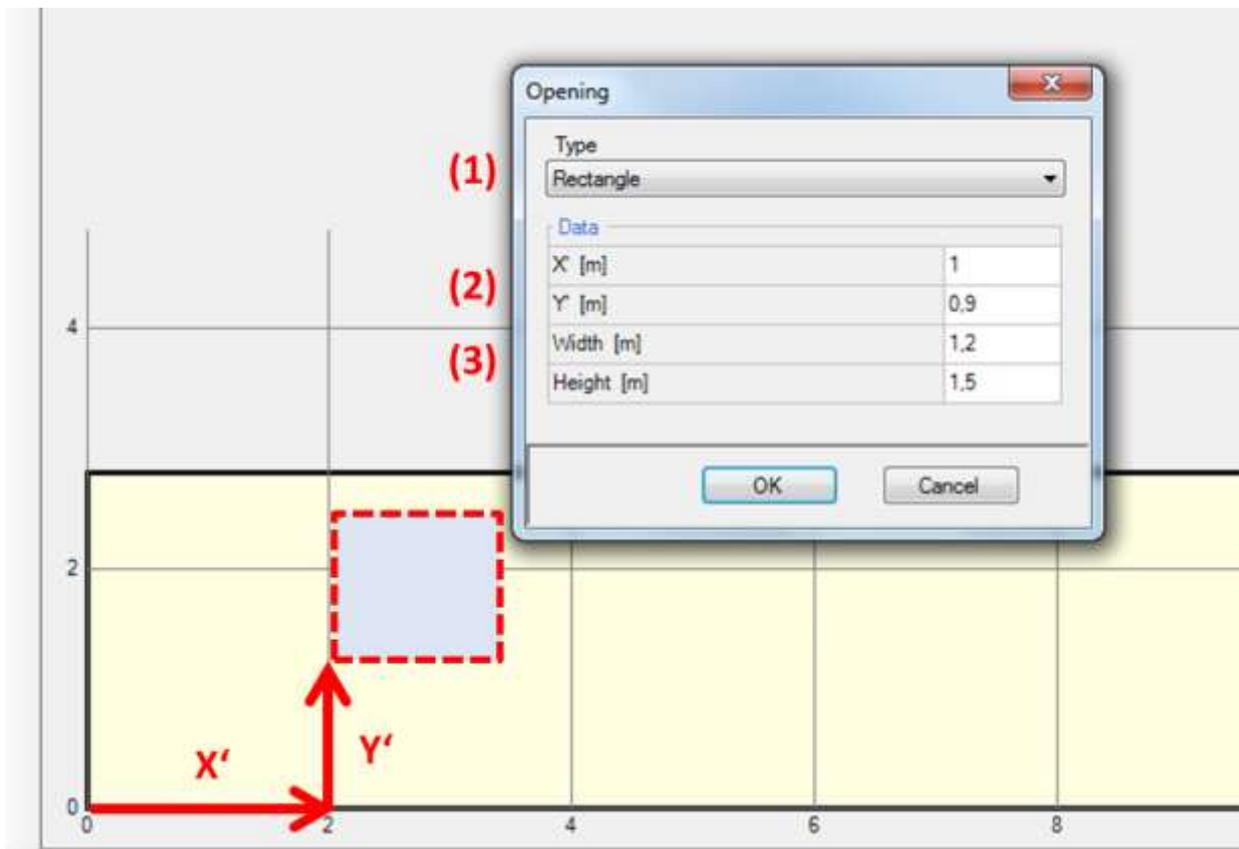


Figure 14:  
Creating a new window or opening.

With the "Opening" dialog these types of window geometry can be entered:

- Rectangle

- Triangle
- Circle
- Rectangle with arch above

Existing windows or openings can be moved or copied by selecting the window or opening and then clicking "New/ copy move"-Button. This also allows copying multiple windows or openings by changing the "Count" dialog.

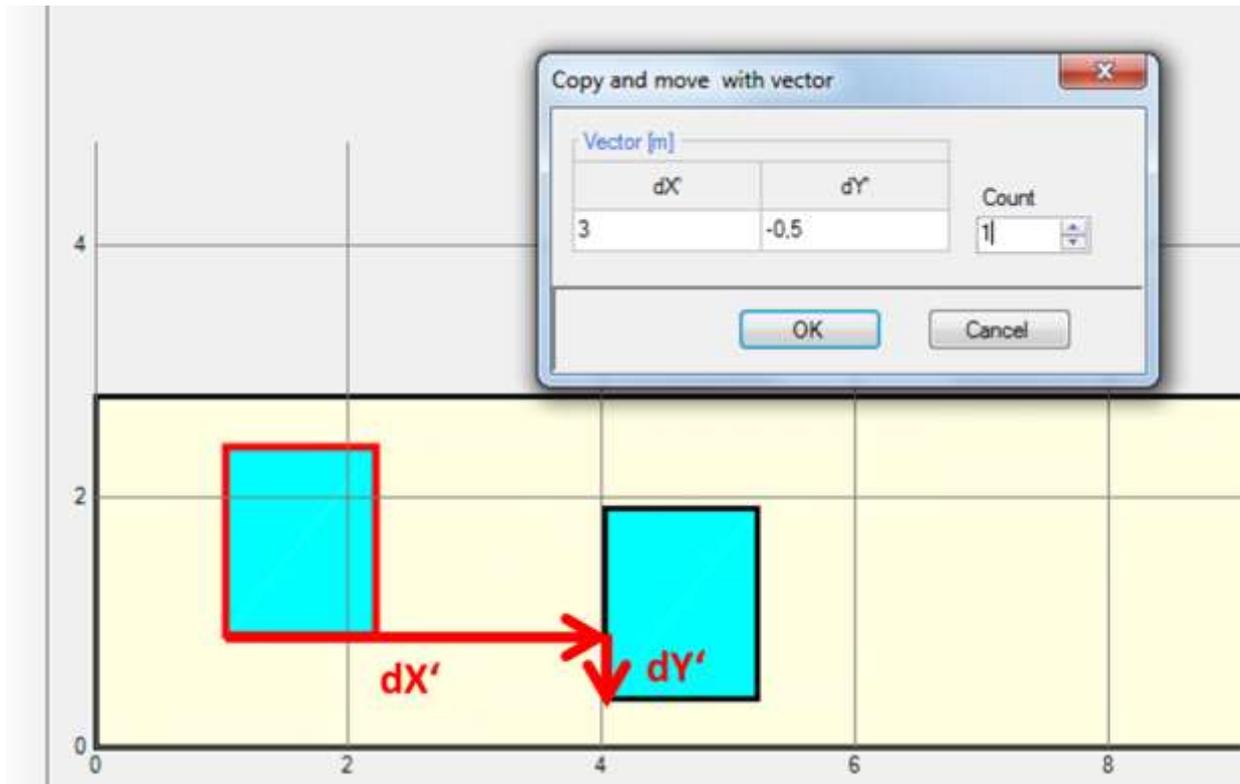


Figure 15:  
Copy a window or opening.

Windows or openings can also be created or edited with the "Edit list" button. All windows and openings in the current component are displayed in a tabular form and can be edited there. Also new windows or openings can be created, or existing ones can be deleted or copied and inserted.

## Controls



**New**

Create a new element in this list.



**Delete**

Delete the selected element.



### Copy

Copy the selected element



### Insert

Insert a copied element. The *"Insert Position"* specifies where the copied element will be positioned.

### Insert Position

Controls where a copied element will be inserted:

- *"after"* the selected element
- *"before"* the selected element
- *"exchange"* the selected element with the copied one



Visit our WUFI®-Wiki ([www.wufi-wiki.com](http://www.wufi-wiki.com)) to learn more about this feature. A tutorial movie shows in detail how to insert windows in components.

### 3.4.2 Creating and Modifying the Building Geometry

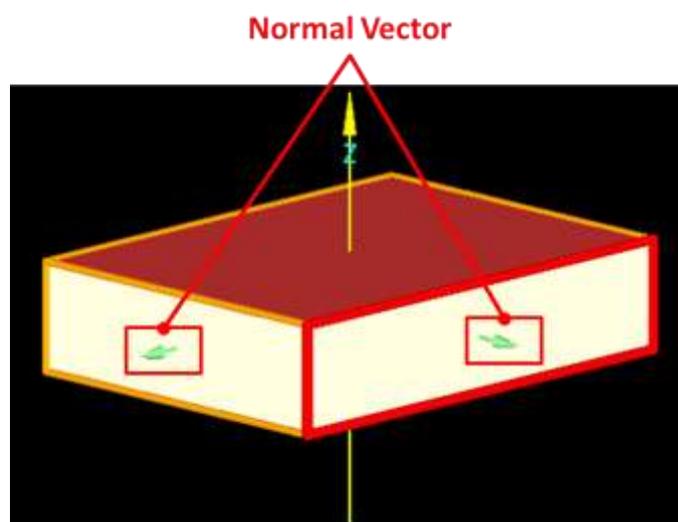
The geometry of the building can be expanded and changed in the “*Visualization Box*”, by using vertices and connecting them to components. This 3D editing allows the input of complex building shapes within WUFI® Passive and can also be used to create the whole building geometry.

It is advisable to first expand the “*Visualization Box*” and also the vertices must be switched to visible with the “*Vertices*” button.

New vertices can be defined by right clicking into the “*Visualization Box*”, choosing “*New Vertices*” and then entering the coordinates. By clicking on existing vertices, the “*Vertex Operations*” become available, which allows for example copying and moving or making components from vertices. By selecting two vertices, the “*Two Point Operations*” become available, which will find intersection points or show the distance between the two vertices, for example.

Also components can be edited in the “*Visualization Box*”. The options are for example showing the component properties, grouping or ungrouping them. Another important feature is changing their inner and outer orientation, which is visualized with a little green arrow that points from the inside to the outside of a component.

Always check the orientation and the normal vector of your components in the “*Visualization Box*”, as this definition is used throughout WUFI® Passive for the inner and outer sides of assemblies. This aspect is extremely important for windows, as the normal vector defines their orientation. For example, an incorrect normal vector could change a southern oriented window to a northern oriented window, resulting in completely different solar gains. The normal vector always starts at the inner side and points to the outer side of an assembly or window.





Please refer to our WUFI®-Wiki ([www.wufi-wiki.com](http://www.wufi-wiki.com)) for detailed information about 3D editing in WUFI® Plus. It also shows how to edit a building using vertices in a tutorial video.

### 3.5 Status & Results Box

The “*Status & Results Box*” helps the user during the process of creating a building, shows the current status of a calculation and gives a brief summary of its main results.

Controls	
	<b>Close/ Reestablish</b> Hides or shows the “ <i>Status &amp; Results Box</i> ”.
	<b>Status indicator</b> The status indicator shows if all necessary input was entered. As soon as WUFI® Plus has all input to perform calculations it turns from red to green. If WUFI® Plus detects possibly missing or unrealistic input, warnings are shown and the status indicator turns yellow.
	<b>Start/ Pause/ Continue</b> This button starts the calculation. It can also be used to pause it and continue later.
	<b>Cancel</b> This button cancels a running or paused simulation. Already calculated results are saved.
	<b>Maximum speed / Show results</b> In default, the progress of a WUFI® Plus calculation can be watched during the simulation process, see section 9.1. As this feature requires computation power, it is possible to disable it with this button, to speed up the simulation time.
	<b>Scope/ Sequence</b> Opens an options dialog that controls which basic results are shown in the “ <i>Status &amp; Reports Box</i> ” after a calculation.
	<b>Calculation Progress</b> A progress bar shows the status of the current calculations. In addition the start and end date is plotted besides the progress bar.
	<b>Only Thermal Calculation</b> If WUFI® Plus performs only thermal calculations, this message will appear on the status bar.

As long as there is still input data missing, the “*Status and Results Box*” shows error messages, see figure below. Double clicking on an error message guides the user to the cause of the error. The error messages are constructed according to the structure of the “*Project Tree*”, so navigating to the cause is just a matter of tracing the error message in the “*Project Tree*”.

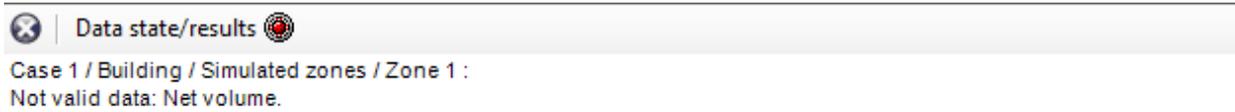


Figure 16:  
Error Messages in the "Status & Results Box".

After all essential data has been entered, the calculation can be started by clicking the "Start"-Button. During the calculation a progress bar shows the current status.

Data state/results		Pause	✖ Cancel	Maximum speed	01.01.2015 : 00	28.02.2015 : 03 (16 %)	01.01.2016 : 00	Only thermal calculation
Last calculation	[date/time]				Date & time of last calculation			
Calculation period	[h]							
Heating	[kWh]				Calculated sum of heating energy			
Cooling	[kWh]				Calculated sum of cooling energy			
Humidification	[kg]				Calculated sum of humidification			
Dehumidification	[kg]				Calculated sum of dehumidification			
Min. Ti	[°C]				Minimal inner temperature			
Max. Ti	[°C]				Maximal inner temperature			
Min. RHi	[%]				Minimal inner rel. humidity			

Figure 17:  
"Status & Results Box" during a calculation.

After the calculation a first brief summary containing some basic information can be found in the "Status and Results Box", see figure below:

Last calculation	[date/time]	11.03.2015 15:46:37	Date & time of last calculation
Calculation period	[h]	744	01.01.2015 : 00 - 01.02.2015 : 00
Heating	[kWh]	2034,3	Calculated sum of heating energy
Cooling	[kWh]	0	Calculated sum of cooling energy
Humidification	[kg]	0	Calculated sum of humidification
Dehumidification	[kg]	0	Calculated sum of dehumidification
Min. Ti	[°C]	20	Minimal inner temperature
Max. Ti	[°C]	20	Maximal inner temperature
Min. RHi	[%]	55	Minimal inner rel. humidity
Max. RHi	[%]	55	Maximal inner rel. humidity
Max. iterations	[-]	1	Maximal count of iterations
Calculation time	[d,h,min,sec]	8sec	Total calc. time
Convergence errors	[-]	0	Count of convergence errors
Air balance errors	[-]	0	Count of air balance errors
Convergence error	[date/time]	---	Date & time of last convergence error

Figure 18:  
Summary of main calculation results in the "Status & Results Box".

## 4 Project Tree

The “*Project Tree*” offers easy and quick access to all dialogs, which are necessary for defining a WUFI® Plus project. It is advisable to follow its structure while working on a project to ensure that no important information is left out.

Clicking on a symbol in the “*Project Tree*” opens the corresponding menus in the “*Dialog Box*”.

### Elements of the Project Tree

	<b>Project</b>	General information about the current project. See chapter 4.1.
	<b>Files / Measured Data</b>	Importing external data. See chapter 4.2.
	<b>Case</b>	General settings for a case. See chapter 4.3.
	<b>Localization / Climate</b>	Selection of external and optional climates. See chapter 4.4.
	<b>Building</b>	Provides access to building geometry creation or import, settings for the “ <i>Air Flow Model</i> ” and general calculation settings. See chapter 4.5.
	<b>Simulated Zones</b>	Lists all simulated zones. See chapter 4.5.2.
	<b>Zone</b>	General settings and information about a zone. See chapter 4.5.2.
	<b>Visualized components</b>	Lists all visualized components in a zone. See chapter 4.5.3.
	<b>Visualized Component</b>	Definition of a visualized component. See chapter 4.5.3. Components are automatically categorized, depending on their orientation and boundary conditions: <ul style="list-style-type: none"><li>▪ Roof</li><li>▪ Wall against unheated attic</li><li>▪ Ceiling against unheated attic</li><li>▪ Flat roof</li><li>▪ Exterior Wall</li><li>▪ Opening</li><li>▪ Window</li><li>▪ Interior wall between two heated zones</li><li>▪ Interior wall against an unheated zone</li><li>▪ Interior wall within a heated zone</li><li>▪ Ceiling between two heated zones</li><li>▪ Ceiling against an unheated zone</li><li>▪ Floor against an unheated zone</li><li>▪ Floor against air</li><li>▪ Floor against unheated cellar</li></ul>

		<ul style="list-style-type: none"> <li>▪ Wall against ground</li> <li>▪ Floor against ground</li> </ul>
	<b>Not visualized components</b>	Lists all not visualized components in a zone. See chapter 4.5.4.
   	<b>Not visualized component</b>	Definition of a not visualized component. See chapter 4.5.4.
	<b>Internal Loads / Occupancy</b>	Definition of internal loads. See chapter 4.5.6.
	<b>Design Conditions</b>	Definition of design conditions, like temperature or humidity setpoints. See chapter 4.5.7.
	<b>Ventilation</b>	Ventilation settings. See chapter 4.5.8.
	<b>Other parameters</b>	Additional calculation settings for a zone. See chapter 4.5.9.
	<b>Attached zones</b>	List of all attached zones. See chapter 4.5.5.
     	<b>Attached Zone</b>	General settings and information about an attached zone. See chapter 4.5.5. Available types: <ul style="list-style-type: none"> <li>▪ Unheated Space</li> <li>▪ Unheated Cellar</li> <li>▪ Space under suspended floor (crawlspcace)</li> <li>▪ Wintergarden, not heated</li> <li>▪ Unheated Attic</li> <li>▪ Conditioned Space</li> </ul>
	<b>3D-Objects</b>	List of all 3D-objects in the building. See chapter 4.5.10.
	<b>3D-Object</b>	Definition of a 3D-Object. See chapter 4.5.10.
	<b>Remaining elements</b>	List of all elements which are not connected to a zone. See chapter 4.5.11.
	<b>Remaining component</b>	Properties of a remaining component. See chapter 4.5.11.
	<b>HVAC</b>	List of all HVAC systems. See chapter 4.6.
	<b>System</b>	Settings for a specific HVAC system. See chapter 4.6.



## Device

Settings for a specific HVAC device. See chapter 4.6.

Available devices:

- User defined. Allows a combination of space heating and cooling as well as air humidification and dehumidification
- Mechanical ventilation
- Electric Heating / DHW
- Boiler
- Combined Heat and Power (CHP)
- District Heating
- Heat Pump
- Solar Collector
- Water storage
- Photovoltaics (only considered in the passive house calculation)



## New/ Copy Current Case

This button appears on the left side of the "Project Tree" when a "Case" is selected. By clicking this button the current case is copied and inserted as the last case in the "Project Tree".



## Delete Current Case

This button appears on the left side of the "Project Tree" when a "Case" is selected and there are at least two "Cases" in a project. By clicking this button the current case will be deleted.



The example case in chapter 10 shows how to create a project and how its results can be evaluated and exported. It's highly recommended to work through this example case when using WUFI® Plus for the first time.

## 4.1 Project Information

Information about the current project can be entered with this dialog, including the client, the building, its owner and your personal information. Also a picture of the building can be added, either from the current view from the “*Visualization Box*” or from an external image.

The data entered in this dialog will appear on the results report, which can be created and exported after a simulation. Please refer to chapter 9.8 for further information about the results reports.



If you add your personal information in the “*General Options*”, see chapter 3.2.3, it will be filled in the “*Project Information*” automatically.

## 4.2 File Import

If a project requires the use of external weather files or any other external data it can be included in WUFI® Plus with the dialog "*Files / Measured Data*".

Controls	
	<b>New</b> Create a new element in this list. The " <i>Edit file</i> " dialog will open.
	<b>Delete</b> Delete the selected element.
	<b>Copy</b> Copy the selected element
	<b>Insert</b> Insert a copied element. The " <i>Insert Position</i> " specifies where the copied element will be positioned.
	<b>Insert Position</b> Controls where a copied element will be inserted: <ul style="list-style-type: none"><li>▪ "<i>after</i>" the selected element</li><li>▪ "<i>before</i>" the selected element</li><li>▪ "<i>exchange</i>" the selected element with the copied one</li></ul>
	<b>Edit</b> Edit the selected external file. The " <i>Edit file</i> " dialog will open.

After the "*Edit file*" dialog opens, see figure below, external data can be entered in several ways:

- Data can be written directly into the "*Editor/ Viewer*" pane (1).
- Data can be pasted into the "*Editor/ Viewer*" pane (1) from an external source.
- An external file can be loaded. Necessary settings can be found in (2).

For all external data, its structure has to be specified (3). Also a data visualization is available in form of simple diagrams (4).

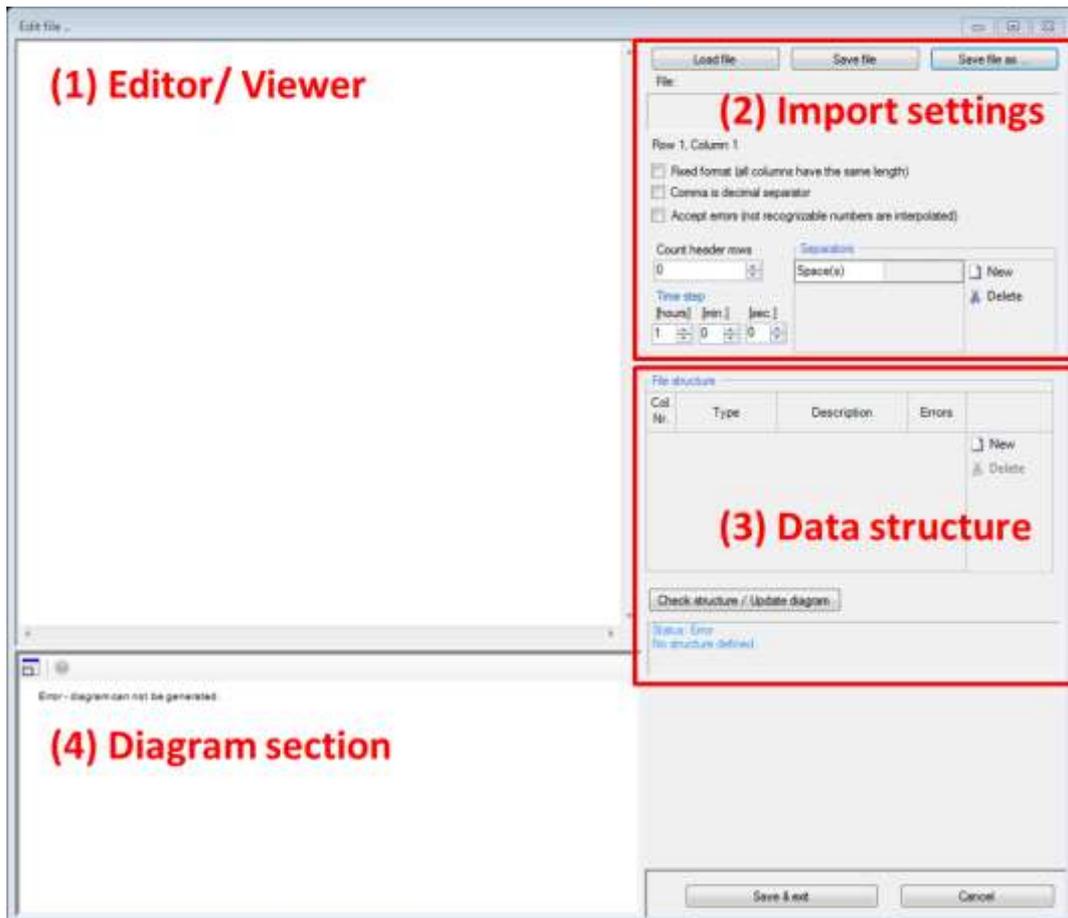


Figure 19:  
Edit File dialog.



A tutorial video on our WUFI®-Wiki ([www.wufi-wiki.com](http://www.wufi-wiki.com)) shows how external data can be inserted in WUFI® Plus and how this data can be used in simulations.

## 4.3 Case Menu

The “Case Menu” dialog shows general settings which control the simulations and are valid for all zones of this case. It also provides access to reports of successful simulations. For further information about assessing the simulation results and reports refer to chapter 9.

A WUFI® Plus Project can contain several cases. This can be used for example to create variants of a simulation.

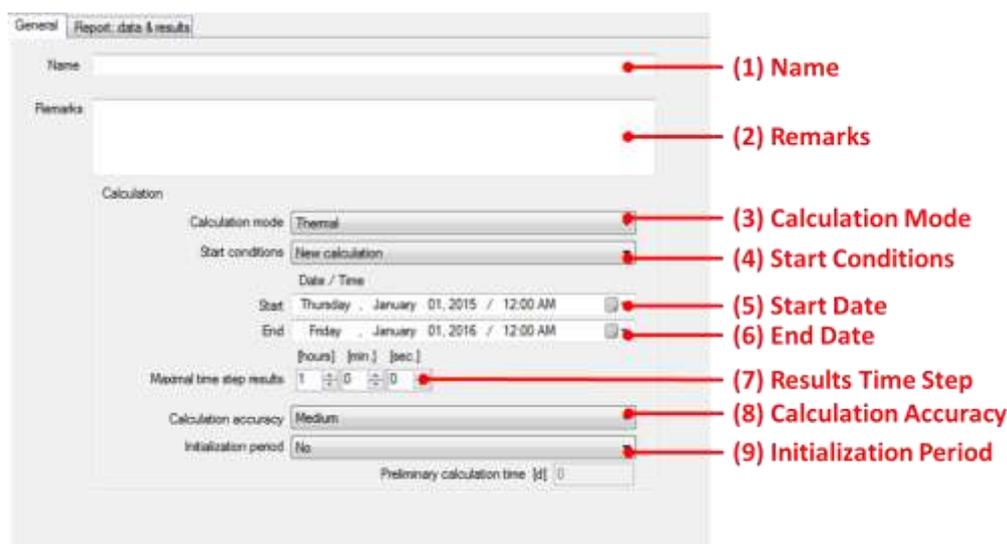


Figure 20:  
General Settings for a Case.

### Controls

- |                             |  |
|-----------------------------|--|
| <b>(1) Name</b>             | Allows naming the current case.  |
| <b>(2) Remarks</b>          | A place for annotations.   |
| <b>(3) Calculation mode</b> | Switching between thermal and hygrothermal simulations. Thermal simulations neglect the coupled heat and moisture transport processes in the components and only the energy transport will be considered. This will accelerate the calculation process but causes unreasonable results especially for the moisture balance as hygric interactions with the components are neglected. The humidity conditions inside the components are also not available. |
| <b>(4) Start conditions</b> | Three possibilities can be set here: <ul style="list-style-type: none"><li>▪ New calculation</li></ul>   |

- Continue last calculation
- New calculation with initial conditions from last calculation

<b>(5) Start date</b>	Setting the start date. Clicking on the calendar sign opens a calendar widget which allows setting the start date without typing.
<b>(6) End date</b>	Setting the date when the calculation will end.
<b>(7) Max. time step results</b>	This setting is used for showing and exporting the simulation results.
<b>(8) Calculation accuracy</b>	Changing the calculation accuracy influences calculation time.
<b>(9) Initialization period</b>	An initialization period before the simulation can be set.

#### 4.4 Localization & Climate

At each of its surfaces every building component is exposed to the climatic boundary conditions which have a profound effect on its hygrothermic and inner climate behavior. WUFI® Plus needs data for each time step on rain and radiation load as well as on the exterior and interior temperature and on the exterior and interior relative humidity.

The designed building in WUFI® Plus touches the external climate with its outer side. Each of the surfaces of the components must be assigned to their respective boundary conditions.

The WUFI® Plus "*Climate Section*" distinguishes between two types of climate files:

- Weather data of external climate and
- Optional climate.



This manual only shows how climate data is used in WUFI® Plus. For further background information about external and optional climate, additional files and sources how to get them as well as limitations coming with certain file types please refer to our [WUFI®-Wiki](#).

## 4.4.1 Weather Data

Weather data of an external climate can be selected in the "Climate Section", which can be accessed by clicking the "Localization/ Climate" button in the "Project Tree" or the "Input" menu. The following dialog appears:

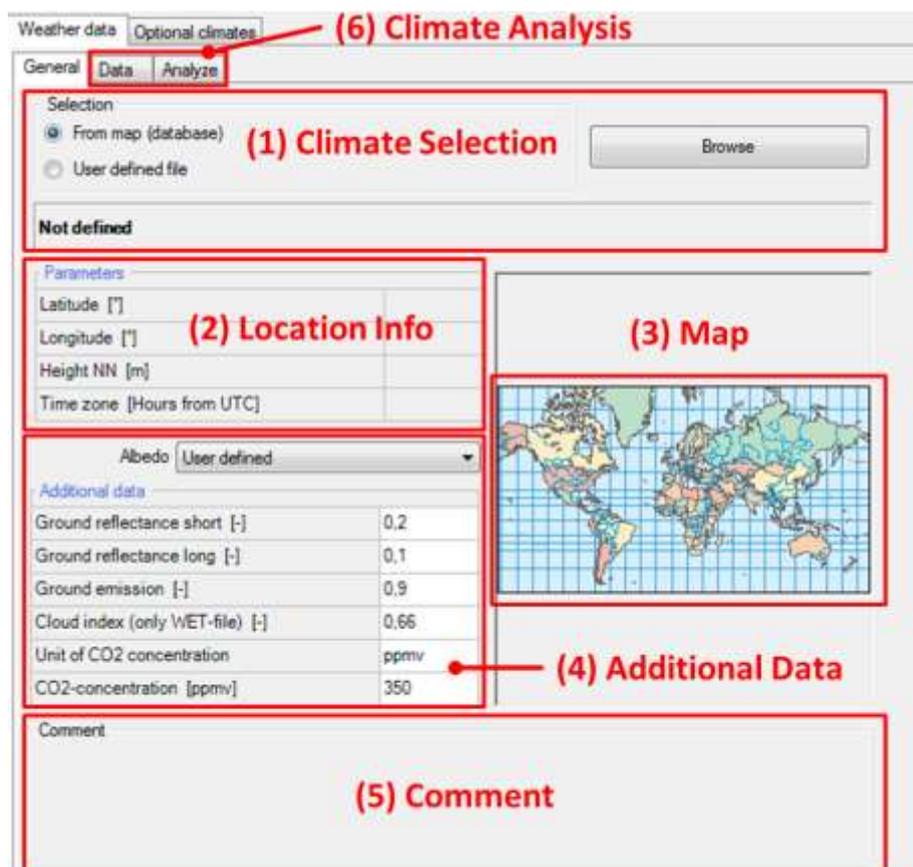


Figure 21:  
Weather Data dialog.

## Controls

### Climate Selection

An external climate can be selected in two ways:

- Loading data from the WUFI® Plus "Climate Database". Clicking the "Browse" button opens the "Climate Database".
- Loading a "User defined file". Clicking the "Browse" button opens the standard windows dialog for opening a file. Supported file-types are listed below.

### Location Info

Information about the location of the climate data.

### Map

The map visualizes the location of the climate data.

The colors of the available locations indicate the file format of the respective weather files. Predefined locations for which weather data can be purchased separately are initially grey. Please copy such a file into WUFI® Plus's Climate folder; on the next start WUFI® Plus will recognize the file and display the location in color.

**Additional Data**

Additional settings for external climate.

**Comment**

Comments coming with climate data, like its origin, are displayed here.

**Climate Analysis**

Analysis of the current climate data, include temperature, relative humidity, radiation and driving rain.



WUFI® Plus supports these formats for "*User defined files*": .wet, .try, .dat, .wac, .iwc, .wbc, .kli. Visit our [WUFI® Wiki](#) for further information. If the weather file is in .txt-format it has to be loaded with the "*Files / Measured Data*"-dialog and defined as an optional climate.

The "*Climate Database*" allows the selection of climate files which are delivered with WUFI® Plus, see figure below. It can be browsed by "*Regions*" (1) and "*Locations*" (3). The database can be searched with the "*Search pattern*" (2), too. Also locations can be selected by clicking their yellow representation on the map (4).

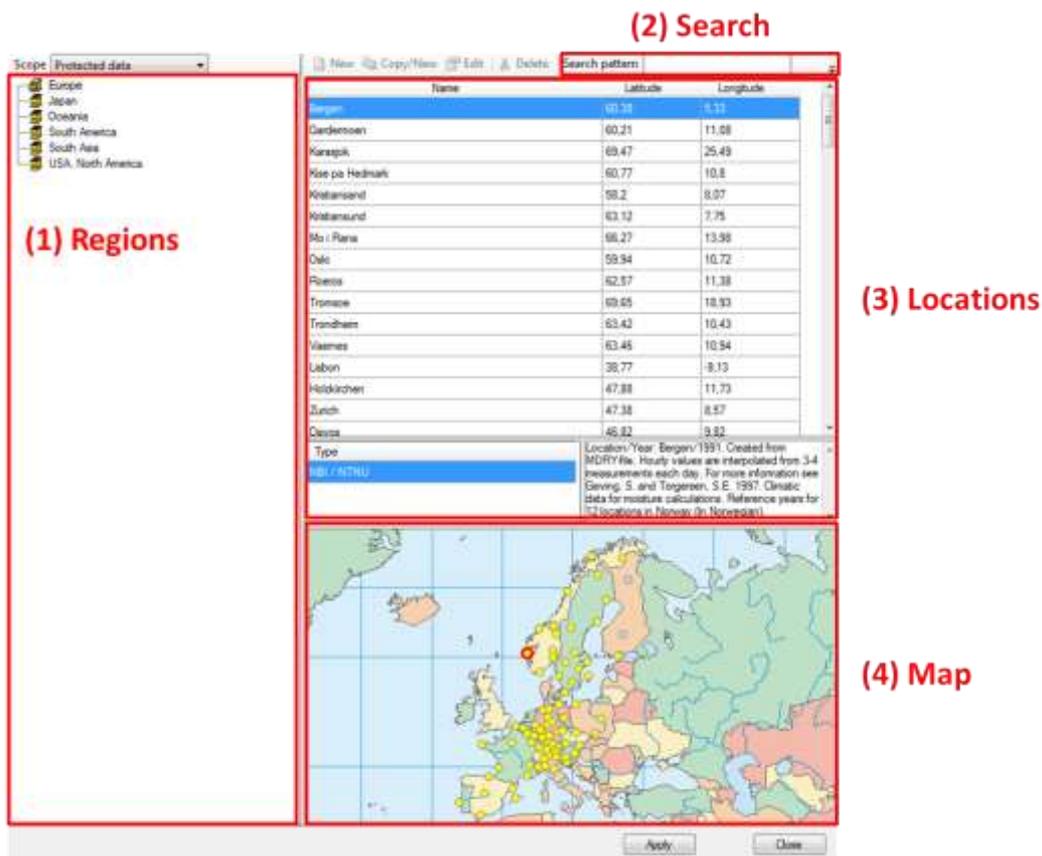


Figure 22:  
Climate Database.

#### 4.4.2 Optional Climates

WUFI® Plus also allows the definition of *Optional Climates*, which can be used to define additional boundary conditions for example for the ground climate.

Several options are available for the definition of *Optional Climates*:

- *File based* refers to a previously uploaded climate file in *Files/Measured Data*.
- Simple temperature and moisture profiles can be specified as a *sine curve*.
- *DIN EN ISO 13788*: Allows the generation of indoor temperature and humidity profiles by choice of temperature and humidity classes as described by the standard.
- *EN 15026* allows generating indoor temperature and humidity profiles by choice of moisture load.

- “ASHRAE 160” (ANSI / ASHRAE 160 2009): The parameters that can be determined by ASHRAE 160 are extensive. In the field of temperature, the type of climate control is selected. Set values must be specified. The moisture can be determined by ASHRAE 160 to the number of bedrooms, or custom. In this selection, an air exchange rate must also be entered.

## Controls

	<b>New</b>	Create a new element in this list.
	<b>Delete</b>	Delete the selected element.
	<b>Copy</b>	Copy the selected element
	<b>Insert</b>	Insert a copied element. The “Insert Position” dropdown-menu specifies where the copied element will be positioned
	<b>Insert Position</b>	Controls where a copied element will be inserted: <ul style="list-style-type: none"> <li>▪ “after” the selected element</li> <li>▪ “before” the selected element</li> <li>▪ “exchange” the selected element with the copied one</li> </ul>



Visit our WUFI®-Wiki ([www.wufi-wiki.com](http://www.wufi-wiki.com)) for further information and tutorial videos about optional climates.

## 4.5 Building Menu

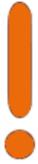
All user inputs which describe a building are grouped in this section. The “*General*”-tab provides access to available elements of the building, gives methods for geometry creation or import and allows orientation adjustment:

- Available elements: Lists available elements of the current building. Double-clicking on an element opens the corresponding dialog.
- Building Wizard: Opens the “*Building Wizard*” which helps to create simple geometries by combining predefined footprints, roof and foundation constructions. Refer to chapter 4.5.1 for further information.
- Change orientation: Changes the orientation of the building.
- 3-D Editor: Creates or modifies a building geometry directly in WUFI® Plus. Clicking this button expands the “*Visualization Box*” to facilitate working with the 3-D Editor. Refer to chapter 3.4.2 for further information.
- SketchUp-Import: Importing geometry data from a wps-file created with the WUFI® Plus SketchUp-plugin. Refer to chapter 6.1 for further information.
- gbXML-Import: Importing geometry data from a gbXML-file. Refer to chapter 6.2 for further information.

The “*Numerics*”-tab allows general settings for certain calculation methods:

- Include shading calculation: Activates shading calculation for all visualized components. Shading can either be calculated in a preprocess before the simulation or it can be calculated during the simulation. Using preprocess can be useful, because its results can be re-used for further simulations.
- Include air flow calculation: Activates the air flow calculation. Please refer to chapter 7 for further information.
- Explicit radiation balance on external surfaces: Activates the explicit radiation balance on all external surfaces. Please pay attention to the warnings below before using this feature.
- Wind dependent heat transfer on external surfaces: Activates the wind dependent calculation of heat transfer resistance on external surfaces. Please refer to chapter 5.1.6 for further information.

- Rain load on external surfaces: Activates rain load calculation for all external components. Please refer to chapter 5.1.7 for further information.



Make sure to have appropriate values for atmospheric counter radiation in the climate file you use before enabling the explicit radiation balance. Otherwise unrealistic temperatures may result at the exterior surface. In addition, please read the help on our [WUFI® Wiki](#) about the “*Long-wave Radiation Exchange*”, before using this feature.

#### 4.5.1 Creating a Building Geometry

WUFI® Plus offers multiple ways to create or import 3D-geometries, which can all be accessed by clicking the “*Building*”-entry in the “*Project Tree*”:

- Building Wizard, as described in this chapter.
- Modifying Vertices, as described in chapter 3.4.2.
- Importing a SketchUp-Geometry, see chapter 6.1.
- Importing gbXML-data, see chapter 6.2.

The “*Building Wizard*” is the easiest way to create a building in WUFI® Plus. It uses a collection of predefined footprints (1) as well as roof (2) and foundation (3) constructions to create a building geometry, see figure below. The dimensions of these presets can be changed by the user.

On the bottom side of the dialog, the orientation of the main facade needs to be defined either by means of the main orientations or by Azimuth (4). The main facade depends on the footprint of the building and is shown in the selection graph of the footprint selection.

On the right side there are two other options, which allow grouping of similar components and dividing components by stories (5). Components can be ungrouped in the “*Visualization Box*” by right-clicking on them.

Geometries created with the “*Building Wizard*” can be modified with the 3D editing methods described in chapter 3.4.2.

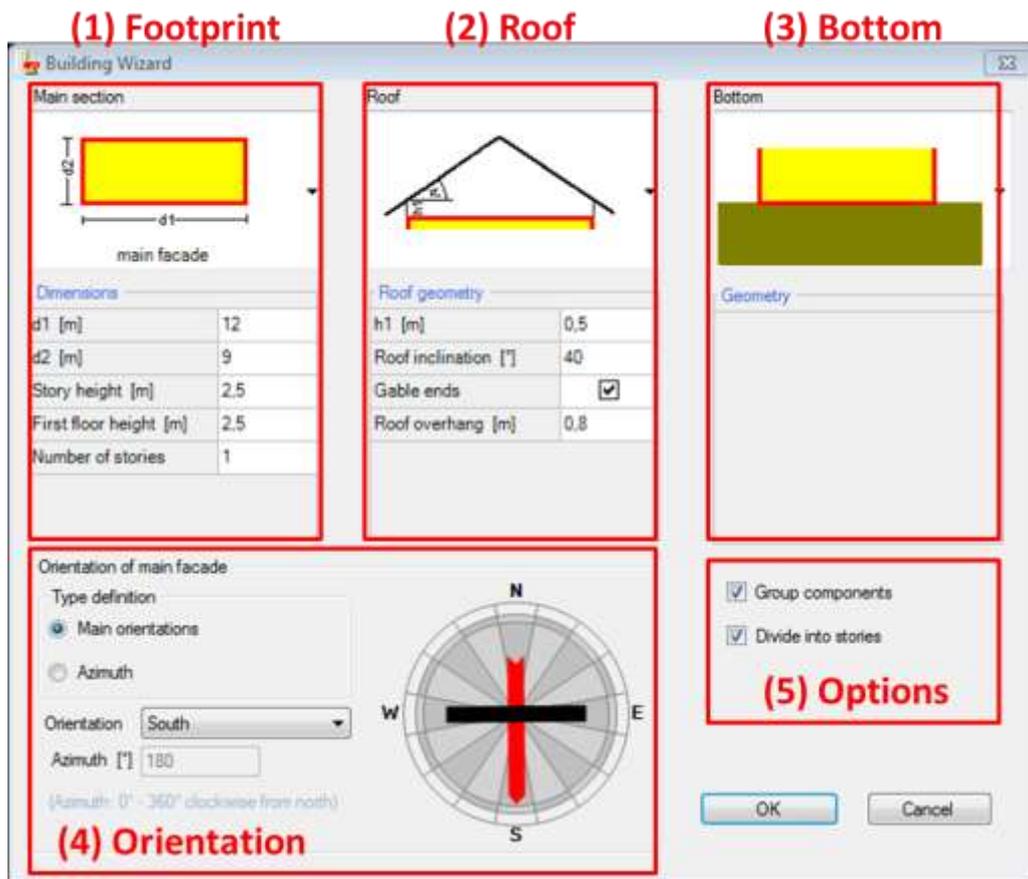


Figure 23:  
Building Wizard.



Here, only the "Building Wizard" is explained, as the other three ways for creating a building geometry are described in separate sections of this manual.

Visit our WUFI®-Wiki ([www.wufi-wiki.com](http://www.wufi-wiki.com)) for tutorial videos of all ways of creating or importing geometries for buildings.

## 4.5.2 Simulated Zones

In WUFI® Plus a building is created and then calculated. To achieve this, a simulation volume must be entered using zones. In general, there are two kinds of zones:

- Heated zones (= “*Simulated zones*”) belong to the simulation volume. They will be calculated during a simulation.
- “*Attached Zones*” are areas that do not belong to the simulation volume, for example an unheated attic. These zones are not considered in the balance of the simulations. They influence, however, the conditions in the simulation area and must be precisely defined. See chapter 4.5.5 for further information.

These zones and climates must be assigned to components of the building. Refer to chapter 5 for more information about components.

Clicking on a simulated zone in the “*Project Tree*” opens the “*Simulated Zones*” dialog, which provides access to general settings for this zone and to simulation results and reports. The figure below shows this dialog.

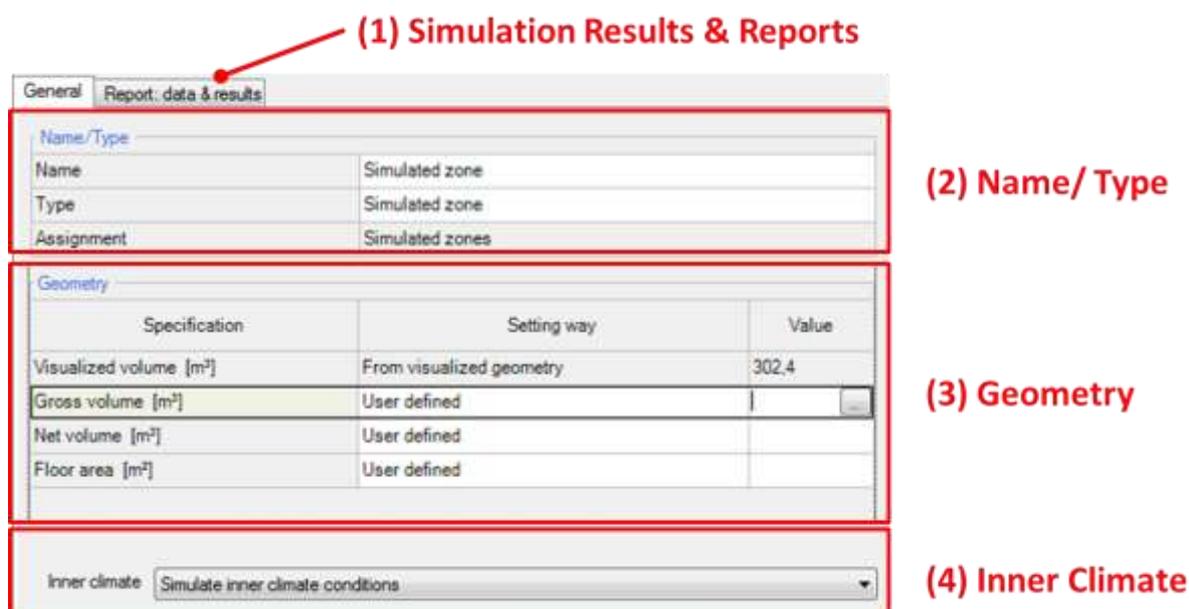


Figure 24:  
Simulated Zone – General Tab.

## Controls

### (1) Results & Reports

This menu provides access to results and automatically created reports once a simulation has finished. See chapter 9 for more information.

**(2) Name / Type**

The name and the type of the zone can be changed.

**(3) Geometry**

Data concerning the zonal geometry (Gross volume, Net volume, Floor area) must be entered here, as they are necessary to perform calculations. These values can either be derived automatically from WUFI® Plus or entered manually, which is recommended. A calculator can be started by clicking  to assist the user in calculating the values. The visualized volume is calculated automatically from the visualized geometry.

**(4) Inner Climate**

This option defines if the inner climate of this zone

- should be simulated completely,
- corresponds to the defined "*Design Conditions*", or
- is defined by an "*Optional Climate*".



Always double-check if the geometry data was entered correctly, as these values have a huge impact on simulation results. Also check the orientation of all components as described in chapter 3.4.2.

### 4.5.3 Visualized Components

All components of the current zone requiring a definition of structure, material or environment are listed as "*Visualized Components*" and need to be edited here. Clicking on the respective component in the entry window table or the in the "*Project Tree*" opens the "*Component*" dialog, where its properties are defined. WUFI® Plus distinguishes three component types:

- Opaque components, for example walls, ceilings or roof construction.
- Transparent components, like windows.
- Openings, which won't be discussed here, as they need no further user input, as long as the air flow model is not activated. Please refer to chapter 7.5 for further information.

Depending on the selected component type, there are various subsections to input all necessary data. These are described in detail in chapter 5. Also the example case at the end of this manual shows how components can be entered into WUFI® Plus, see chapter 11.5.



Visit our WUFI®-Wiki ([www.wufi-wiki.com](http://www.wufi-wiki.com)) for detailed information about components and tutorial videos about creating, simulating and assessing them.

#### 4.5.4 Not Visualized Components

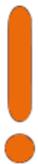
These components are not enclosing the simulation volume and can't be seen in the "Visualization Box" but their properties affect the calculation. So in "Not Visualized Components" components affecting the indoor environment can be included in the simulation, for example partitions or furniture.

"Not Visualized Components" can be entered in the list of this dialog. The definition of these components, their properties and parameters is the same as that of "Visualized Components".

The list entry "Inside component" defines, that a "Not Visualized Component" is included in another "Not Visualized Component", allowing "windows" and "openings" in inner walls.

### Controls

	<b>New</b>	Create a new element in this list.
	<b>Delete</b>	Delete the selected element.
	<b>Copy</b>	Copy the selected element
	<b>Insert</b>	Insert a copied element. The "Insert Position" specifies where the copied element will be positioned.
	<b>Insert Position</b>	Controls where a copied element will be inserted: <ul style="list-style-type: none"><li>▪ "after" the selected element</li><li>▪ "before" the selected element</li><li>▪ "exchange" the selected element with the copied one</li></ul>



Don't forget to input the area of "Not Visualized Components" or they will not be taken into account in the simulation.

#### 4.5.5 Attached Zones

*"Attached Zones"* are areas that are not part of the simulation volume, for example an unheated attic. These zones are not directly considered in the simulations. However, they influence the conditions in the simulation area and must be precisely defined. The adjacent zones can be named and the type of the zones can be selected in the drop-down menu. The climate for each zone can be selected. You may choose between the previously defined *"Outer Climate"*, use data from an external climate file, or use an optional climate.

*"Attached zones"* can include visualized and not visualized components.

Please refer to the example case, chapter 11.10, to learn how *"Attached zones"* can be included in WUFI® Plus.

#### 4.5.6 Internal Loads & Occupancy

If additional loads occur in a "Simulated Zone" they have to be defined in the dialog "Internal Loads/ Occupancy". Subsequently they are considered in the simulation.

Internal loads can either be entered as external files, see chapter 4.2, or as "Periodic day profiles", a method that allows entering data as a time schedule: Different utilization profiles can be assigned to custom periods which are defined by date and day. Each period is connected to a day-profile that describes the usage which is repeated for every day in this period.

Here, the daily profiles describe the internal loads occurring in the periods. The heat, divided into convective and radiant, humidity and CO<sub>2</sub> loads are defined hourly in the profile, which describes a utilization of one day. The unit of each load can be selected on the drop-down menu. The figure below shows the "Internal Loads/ Occupancy" dialog. The example case at the end of this manual explains how "Internal Loads" can be entered in WUFI® Plus, see chapter 11.7.


Selection: Periodic day profiles

Periods											
Nr.	Begin	End	Mo	Tu	We	Th	Fr	Sa	Su		
1	01.01.2015	01.01.2016	<input checked="" type="checkbox"/>	New							
2	01.01.2015	01.01.2016	<input checked="" type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	Delete				
3	01.08.2015	23.08.2015	<input checked="" type="checkbox"/>	Copy							
4	14.05.2015	17.05.2015	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	Insert
5	21.12.2015	31.12.2015	<input checked="" type="checkbox"/>	New/Insert:							

WUFI® Plus prioritizes the different periods depending on their entry in the list: Higher numbers (1<sup>st</sup> column) have a higher priority than lower numbers in case they cover the same time period. This means that WUFI® Plus always checks the row at the bottom of the list first (= period with highest number). If this row doesn't cover the whole calculation period, the next higher row (= period with second highest number) is taken into account and so on. To make sure that there is at least one period that covers the whole simulation, there is always one predefined row at the top of the list with a day-profile of the constant value 0 (can be modified).

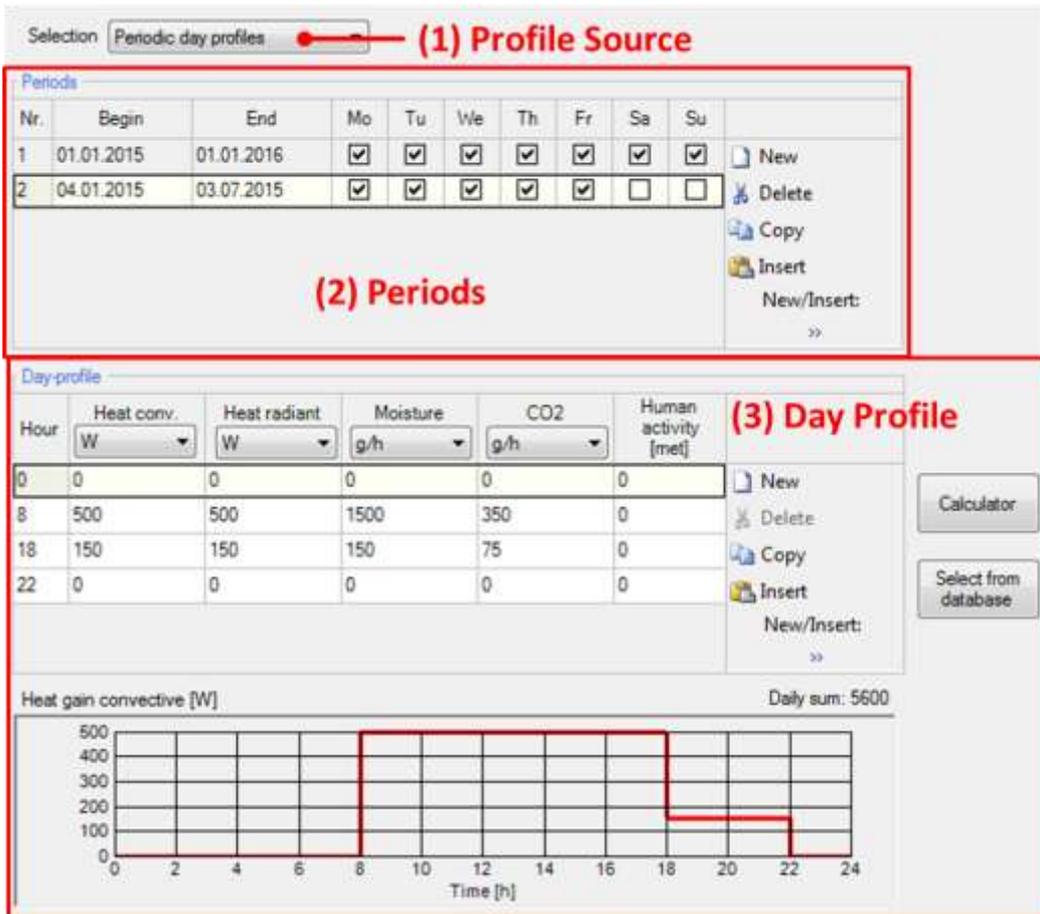


Figure 25:  
Internal Loads/ Occupancy dialog

## Controls

### (1) Profile Source

"Inner Loads" can either be entered with "Periodic Day Profiles" or they can be loaded from an "External File".

### (2) Periods

Periods can be defined by calendar dates and days.

### (3) Day Profile

"Day-Profiles" can be entered in three ways:

- The values can be typed directly into the list.
- The "Inner Loads Calculator" can be used to sum up and combine values from the "Emissions Database".
- Pre-defined "Day-Profiles" can be loaded from the "Day Profiles Database".

The active "Day-Profile" is visualized at the bottom of this dialog.



**New**

Create a new element in this list.



**Delete**

Delete the selected element.



### Copy

Copy the selected element



### Insert

Insert a copied element. The *"Insert Position"* specifies where the copied element will be positioned.

### Insert Position

Controls where a copied element will be inserted:

- *"after"* the selected element
- *"before"* the selected element
- *"exchange"* the selected element with the copied one



Setting *"Periodic Day Profiles"* for internal loads and occupancy is explained on our WUFI® Wiki ([www.wufi-wiki.com](http://www.wufi-wiki.com)). There, you can also find a tutorial movie about this topic.

## 4.5.7 Design Conditions

Setpoints for temperature, relative humidity, and CO<sub>2</sub>-concentration can be entered in this dialog by using "Periodic Day Profiles" or "External Files". HVAC systems will try to maintain these setpoints, as long as they are available and can provide sufficient capacity. The example case in this manual explains how "Design Conditions" can be set in WUFI® Plus, see chapter 11.8.

The figure below shows the "Design Conditions"-dialog and its functions are explained afterwards.

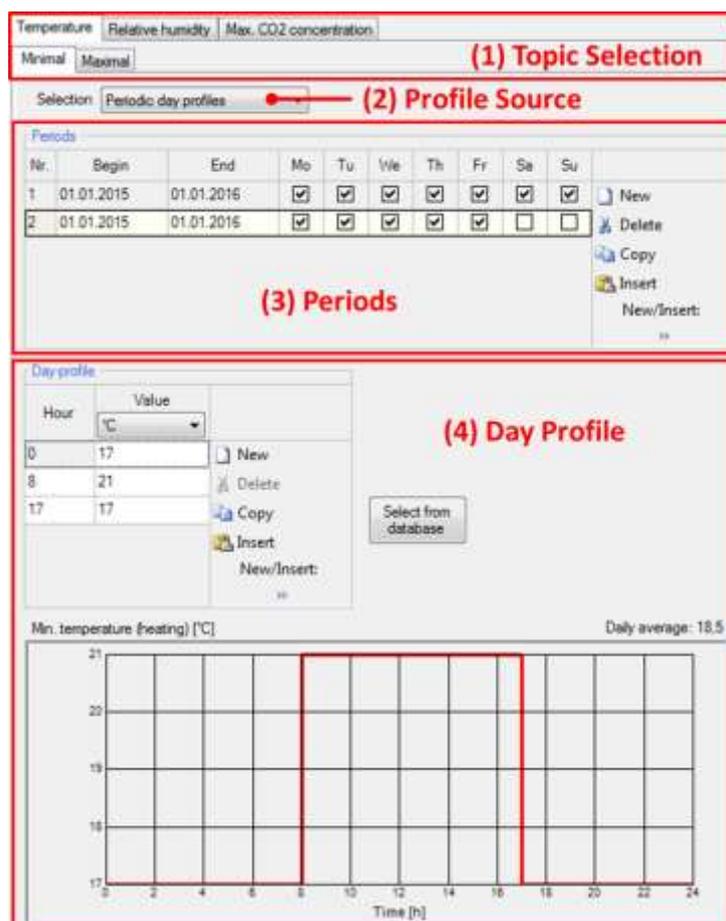


Figure 26:  
Design Conditions dialog

## Controls

### (1) Topic Selection

Design conditions can be set for temperature, relative humidity and CO<sub>2</sub>-concentration, in each case minimum and maximum values. Also the type of heating control can be changed from maintaining the minimum temperature to humidistat heating.

### (2) Profile Source

Setpoints can either be entered with "Periodic Day Profiles"

or they can be loaded from an *“External File”*.

### (3) Periods

Periods can be defined by calendar dates and days.

### (4) Day Profile

*“Day-Profiles”* can be entered in two ways:

- Typing the values directly into the list
- Selecting predefined thresholds from the WUFI® Plus database. All values from the database were taken from standards.

The active *“Day-Profile”* is visualized at the bottom of this dialog.



**New**

Create a new element in this list.



**Delete**

Delete the selected element.



**Copy**

Copy the selected element



**Insert**

Insert a copied element. The *“Insert Position”* specifies where the copied element will be positioned.

### **Insert Position**

Controls where a copied element will be inserted:

- *“after”* the selected element
- *“before”* the selected element
- *“exchange”* the selected element with the copied one



Setting *“Periodic Day Profiles”* for design conditions is explained on our WUFI® Wiki ([www.wufi-wiki.com](http://www.wufi-wiki.com)). There, you can also find a tutorial movie about this topic.

## 4.5.8 Ventilation

WUFI® Plus supports three different types of ventilation:

- *"Natural ventilation"*, including infiltration. Window openings can be entered as a time schedule.
- *"Mechanical ventilation,"* which can be driven by an operation schedule and by ventilation control.
- *"Interzone ventilation"* considers air interchange between two zones.



If using *"Mechanical Ventilation"*: Remember, to include a *"Mechanical Ventilation"*-device in the *"HVAC"*-dialog, see chapter 4.6. If not, *"Mechanical Ventilation"* cannot be considered.

Data can either be entered manually for each ventilation type or data from *"External Files"* can be used instead. The figure below shows the *"Ventilation"*-dialog. The example at the end of this manual explains how ventilation data can be entered into this dialog, see chapter 11.9 and 11.11.

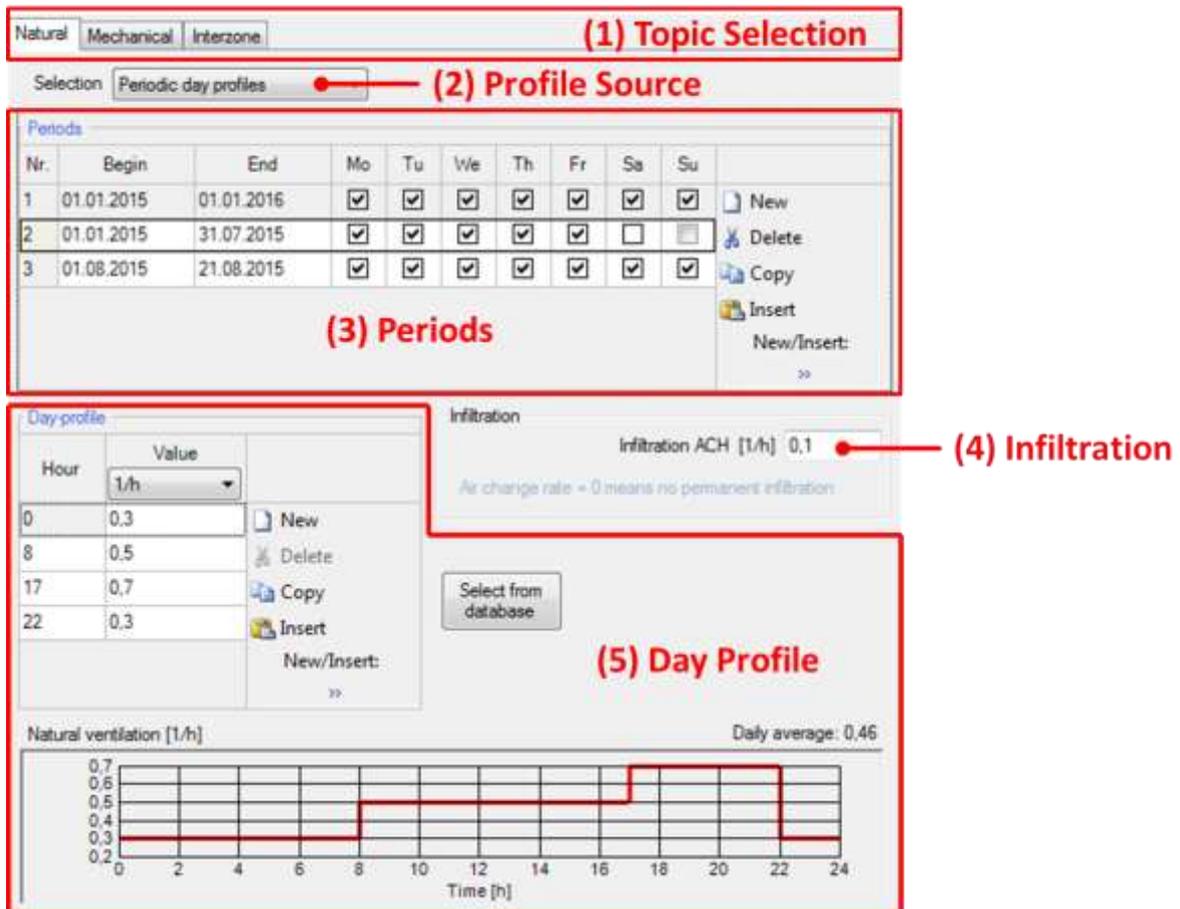


Figure 27:  
Ventilation dialog

## Controls

- |                             |  |
|-----------------------------|--|
| <b>(1) Topic Selection</b>  | Changing between the three ventilation types.  |
| <b>(2) Profile Source</b>   | Ventilation profiles can either be entered with " <i>Periodic Day Profiles</i> " or they can be loaded from an " <i>External File</i> ".   |
| <b>(3) Periods</b>          | Periods can be defined by calendar dates and days.   |
| <b>(4) Infiltration ACH</b> | Value for permanent air change from infiltration. Setting this value to 0 means that no permanent infiltration occurs. This value is added to all other air changes defined in the " <i>Ventilation</i> "-dialog.                                |
| <b>(5) Day Profile</b>      | <p>"<i>Day-Profiles</i>" can either be entered in two ways:</p> <ul style="list-style-type: none"> <li>▪ Typing the values directly into the list</li> <li>▪ Selecting predefined "<i>Day-Profiles</i>" from the WUFI® Plus database.</li> </ul> |

	The active " <i>Day-Profile</i> " is visualized at the bottom of this dialog.
 <b>New</b>	Create a new element in this list.
 <b>Delete</b>	Delete the selected element.
 <b>Copy</b>	Copy the selected element
 <b>Insert</b>	Insert a copied element. The " <i>Insert Position</i> " specifies where the copied element will be positioned.
<b>Insert Position</b>	Controls where a copied element will be inserted: <ul style="list-style-type: none"> <li>▪ "<i>after</i>" the selected element</li> <li>▪ "<i>before</i>" the selected element</li> <li>▪ "<i>exchange</i>" the selected element with the copied one</li> </ul>
<b>(1) Mechanical: Ventilation control</b>	In the " <i>Mechanical Ventilation</i> " subsection an additional dropdown menu allows setting control mechanisms for mechanical ventilation. Different control types are available: <ul style="list-style-type: none"> <li>▪ Temperature control</li> <li>▪ Relative humidity control</li> <li>▪ Max. CO<sub>2</sub> control</li> <li>▪ Max. relative humidity control and minimum exterior temperature setpoint</li> <li>▪ Max./ Min. relative humidity control</li> </ul> <p>The mechanical ventilation is activated as soon as the threshold values defined by the control types are exceeded.</p>
<b>(1) Interzone: From zone</b>	This menu in the " <i>Interzone Ventilation</i> " subsection selects from which other zone the ventilation is considered.



A detailed explanation and a tutorial video on our WUFI®-Wiki ([www.wufi-wiki.com](http://www.wufi-wiki.com)) show how "*Ventilation Profiles*" can be entered.

#### 4.5.9 Other Parameters

This dialog allows the user to alter some parameters that are connected to this particular zone. These are:

- Initial conditions in the zone, including temperature, relative humidity and CO<sub>2</sub> concentration.
- It can be decided, if the distribution of solar gains should be proportional to area or user defined. If choosing user defined a solar gain value has to be entered for each component of the zone. This can be done under "*Surface*" in the "*Thermal*" subsection of the "*Component*"-dialog. The sum of all individual solar gains has to equal 1.
- A factor for solar radiation directly to the inner air can be entered. This factor is explained best in an example: The factor shall be 0.2. This means that 80% of solar radiation through a window will be distributed to the inner surfaces of the zone's components. The radiation on a component's surface is calculated by its solar gain factor, see chapter 5.1.6, which shall be 0.3 in this example. In the end, the resulting fraction of the total solar radiation on this component is 24 % ( $0.8 * 0.3 = 0.24$ ).
- It can be decided whether calculations should be aborted or continued with increased air supply from outer air if a negative air balance occurs.

#### 4.5.10 3D-Objects

WUFI® Plus offers the possibility to model 3D thermal bridges. These “3D Objects” can be inserted, deleted or copied in the list of the “3D Objects”-dialog. Clicking on a “3D Object” in the “Project Tree” opens a new dialog, see figure below. Here, the geometry and all additional settings of the “3D Object” can be defined. During a calculation temperature distribution inside a “3D Object” can be observed by the user in viewing direction of all axes and for all divisions. “Show fine division” controls if the display of the distributions is smoothed during the calculation; however this has no effect on the results. Results for user defined “Monitor Positions” can be found in the export-section after the calculation.

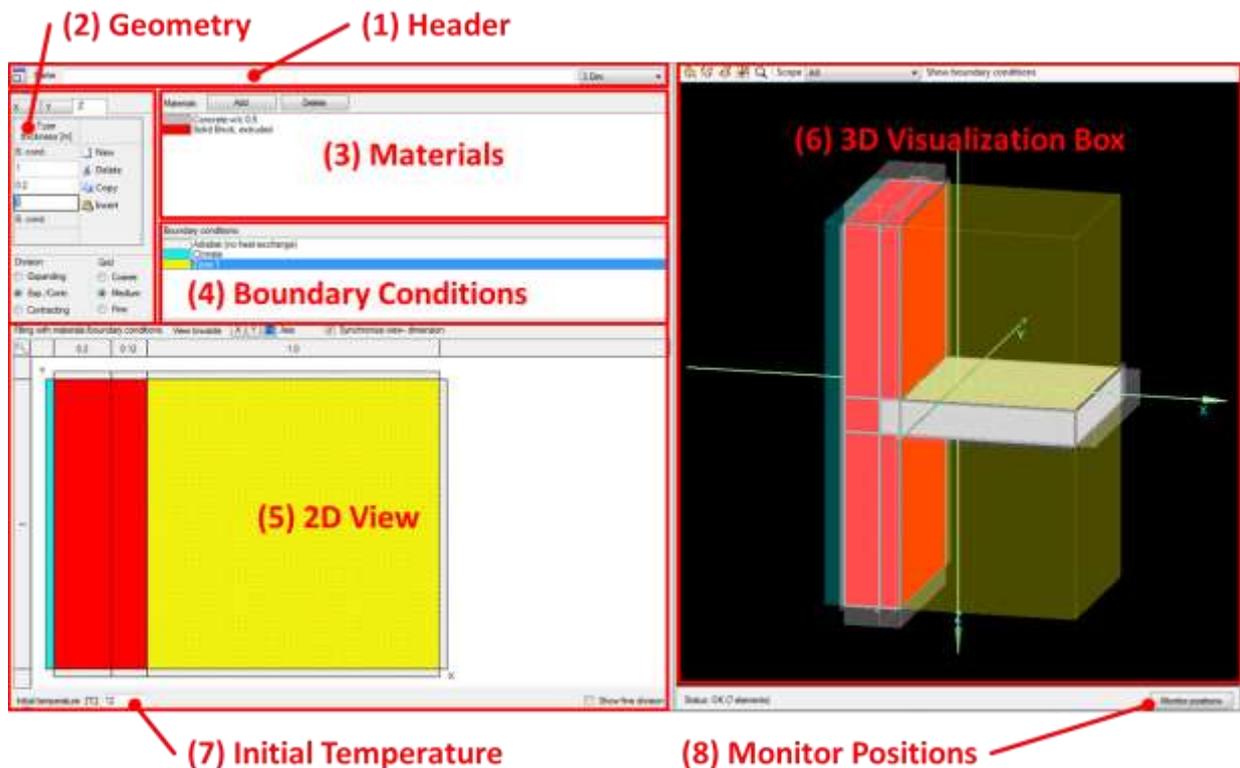


Figure 28:  
3D Objects dialog

### Controls

#### (1) Header

Shows the name of the object. The window can be expanded or shrunk with the “Expand/ Shrink” button (  ) to facilitate working with this dialog. Also changing between a 2D or 3D thermal bridge is possible.

#### (2) Geometry

The geometry of a “3D Object” can be entered through X,Y and Z coordinates.

- |                                 |   |
|---------------------------------|---|
| <b>(3) Materials</b>            | A list of materials which can be applied to the "3D Object". Materials can be added from the "Material database" by clicking the "Add" button.  |
| <b>(4) Boundary Conditions</b>  | A list of available boundary conditions which can be applied to the "3D Object". This is a very important input, as it's the only point where an interaction with the indoor climate of a zone can be defined. The indoor climate does not only influence the "3D Object", it's influenced by the "3D Object", too. |
| <b>(5) 2D View</b>              | Shows 2D views for the three directions X,Y and Z. "Materials" and "Boundary Conditions" can be applied to the geometry of the "3D Object" by clicking inside this 2D view. They are shown in their corresponding colors. Also "Monitor Positions" are visualized inside this 2D view.                              |
| <b>(6) 3D Visualization Box</b> | Shows a 3D visualization of the "3D Object". The controls for this window are similar to the "Visualization Box" for the whole building, see section 2.4.   |
| <b>(7) Initial Temperature</b>  | Sets the initial temperature inside the "3D Object".  |
| <b>(8) Monitor Positions</b>    | Creates and manages user defined "Monitor Positions". Results are only exported for "Monitor Positions".  |



A detailed explanation and a tutorial video on our WUFI®-Wiki ([www.wufi-wiki.com](http://www.wufi-wiki.com)) show how a "3D Object" is constructed and how its results can be assessed.

#### 4.5.11 Remaining Elements

This dialog lists all elements which are not connected to a zone. These components are for visualization purpose only and do not directly affect the simulation, except for shading calculation.

In addition, they can be used to create a reference for automated detection of height above ground for other components, see figure below. To do this, define the inner side of a remaining component as "Ground" and the outer side as "Outer air". Switch the height above ground to "From visualized geometry". WUFI® Plus will now use this component as ground-reference with a height of 0. Please refer also to chapter 5.1.1, which describes how the automated height detection can be activated for a component. Geometries created with the "Building Wizard" always include a remaining component that visualizes the ground level, if the bottom-construction is in contact with the ground.



Figure 29:  
Using remaining objects to define a reference for the ground level.

## 4.6 HVAC Menu

In this element of the "Project Tree" the "HVAC - Heating, Ventilating & Air Conditioning" systems of a building can be defined. With "New" a new "HVAC-System" is created and its "System Type" (1) can be selected from a dropdown-menu, see figure below. In general, WUFI® Plus supports two categories of "System types":

- User defined systems (ideal systems)
- Predefined systems

The example at the end of this manual explains how "HVAC Systems" can be entered in WUFI® Plus, see chapter 11.11.

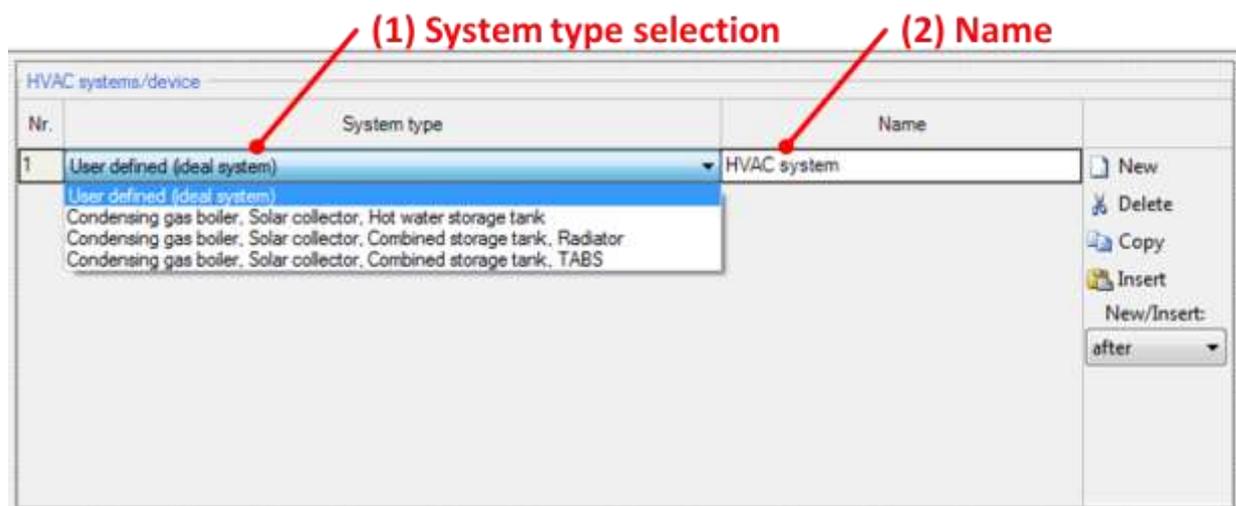


Figure 30:  
HVAC dialog

### Controls

#### (1) System type selection

Selection of a "System Type". These types can be divided into two groups:

- User defined systems (ideal systems) and
- Predefined HVAC systems.

Currently, the use of user defined systems (ideal systems) is recommended, as described in chapter 4.6.2.

#### (2) Name

This field allows naming the selected system type.



#### New

Create a new element in this list.



#### Delete

Delete the selected element.



## Copy

Copy the selected element.



## Insert

Insert a copied element. The *"Insert Position"* dropdown-menu specifies where the copied element will be positioned.

## Insert Position

Controls where a copied element will be inserted:

- *"after"* the selected element
- *"before"* the selected element
- *"exchange"* the selected element with the copied one

## 4.6.1 Ideal User-Defined Systems

"User-defined HVAC-Systems" in WUFI® Plus allow a custom combination of certain idealized devices of a "HVAC-System" to be input. Idealized devices provide their full power instantly. New "Devices" can be added with the "New"-Button and their "Type" can be specified with a dropdown menu. These devices are assigned to different uses, specified by clicking on the check-boxes.

General | Share zone(s) | Report: Data, results
(1) Topic Selection

Name

Device/Equipment

Nr.	Type	Used for						
		Space heating	DHW	Space cooling	Space ventilation	Air humidification	Air dehumidification	
1	User defined	<input checked="" type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>		<input type="checkbox"/>	<input type="checkbox"/>	<div style="text-align: right;">  New   Delete   Copy   Insert                      New/Insert:                      &gt;&gt;                 </div>
2	Boiler	<input checked="" type="checkbox"/>	<input type="checkbox"/>					
3	Mechanical ventilation				<input checked="" type="checkbox"/>			

(2) Device List

Figure 31:  
List of HVAC Devices

## Controls

### (1) Topic selection

Changing between:

- "General Settings": Defining the devices of a "HVAC System".
- "Share Zone(s)": Specifies how devices are distributed throughout different zones of a building.
- "Report": A report containing the settings of all devices.

### (2) Device List

This table lists all devices of the user-defined HVAC-system. Their types and usage is defined here by selecting the appropriate settings.



**New**

Create a new element in this list.



**Delete**

Delete the selected element.



**Copy**

Copy the selected element



**Insert**

Insert a copied element. The "Insert Position" specifies

where the copied element will be positioned.

### Insert Position

Controls where a copied element will be inserted:

- "after" the selected element
- "before" the selected element
- "exchange" the selected element with the copied one

After "HVAC-Devices" were created in the above described table, they appear in the "Project Tree". Selecting one of them opens a new dialog where the properties of a "Device" can be entered by using either "Periodic Day Profiles" or "External Files", see figure below:

**(1) Topic Selection**

General Space heating capacity

Selection Periodic day profiles **(2) Profile Source**

Periods										
Nr.	Begin	End	Mo	Tu	We	Th	Fr	Sa	Su	
1	01.01.2015	01.01.2016	<input checked="" type="checkbox"/>	New						
2	01.08.2015	01.10.2015	<input checked="" type="checkbox"/>	Delete						
3	01.08.2015	01.09.2016	<input checked="" type="checkbox"/>	Copy						

**(3) Periods**

Day-profile

Hour	Value	
0	0	New
7	50	Delete
18	0	Copy

**(4) Day Profile**

Max. heating power [kW] Daily average: 22.92

Time [h]

Figure 32:  
Settings for a HVAC Device.

## Controls

### (1) Topic Selection

Switching between "General settings" and a definition of

the properties of the current device. For mechanical ventilation devices their thermal and moisture recovery efficiency can be entered here.

**(2) Profile Source**

HVAC settings can either be entered with "*Periodic Day Profiles*" or they can be loaded from an "*External File*".

**(3) Periods**

Periods can be defined by calendar dates and days.

**(4) Day Profile**

"*Day-Profiles*" can either be entered in two ways:

- Typing the values directly into the list
- Selecting predefined "*Day-Profiles*" from the WUFI® Plus database.

The active "*Day-Profile*" is visualized at the bottom of this dialog.



**New**

Create a new element in this list.



**Delete**

Delete the selected element.



**Copy**

Copy the selected element



**Insert**

Insert a copied element. The "*Insert Position*" specifies where the copied element will be positioned.

**Insert Position**

Controls where a copied element will be inserted:

- "*after*" the selected element
- "*before*" the selected element
- "*exchange*" the selected element with the copied one



A detailed explanation and a tutorial video on our WUFI®-Wiki ([www.wufi-wiki.com](http://www.wufi-wiki.com)) show how "*Ideal user-defined HVAC systems*" can be entered in WUFI® Plus. Also the example at the end of this manual shows how this is done, see chapter 11.11.

## 4.6.2 Detailed Predefined Systems

WUFI® Plus also offers several predefined and detailed “HVAC-Systems”:

- Ventilation system with cooling, dehumidification, humidification and reheating
- Condensing gas boiler, Solar collector, Hot water storage tank
- Condensing gas boiler, Solar collector, Combined storage tank, Radiator
- Condensing gas boiler, Solar collector, Combined storage tank, TABS

These predefined system allow a detailed dynamic simulation of each of their parts in the dynamic simulations of WUFI® Plus. These detailed HVAC systems were created by Fraunhofer ISE and are currently implemented in WUFI® Plus. All single parts of these systems were already validated by Fraunhofer ISE. However, the implementation in WUFI® Plus is not fully validated, yet. So, these detailed HVAC systems must be regarded as experimental and provide a view on future improvements of WUFI® Plus. Currently, their usage is not recommended and is at the risk of the user.

Currently more detailed HVAC systems are developed. As soon as all systems are included and validated, an additional manual will explain their usage.



Please refer to our WUFI®-Wiki ([www.wufi-wiki.com](http://www.wufi-wiki.com)) for detailed information about predefined HVAC-Systems.

## 5 Components

Clicking on the respective component in the entry window table or the in the “*Project Tree*” opens the “*Component*” dialog, where its properties are defined. WUFI® Plus distinguishes three component types:

- “*Opaque Components*”, like for example walls, ceilings or roof construction.
- “*Transparent Components*”, like windows.
- “*Openings*”, which won’t be discussed here, as they need no further user input.

Depending on the selected component type, there are various tabs to input all necessary data. These are described in detail in the following subsections of this chapter. The example at the end of this manual shows how components can be entered into WUFI® Plus, see chapter 11.5.



Please refer to our WUFI®-Wiki ([www.wufi-wiki.com](http://www.wufi-wiki.com)) for detailed information about “*Components*”, their settings and the physical background behind the calculations.

### 5.1 Opaque Components

Various steps are necessary for the definition of an “*Opaque Component*”. Clicking on a component opens a dialog with six tabs:

- General
- Assembly
- Surface
- Initial Conditions
- Numerics
- Report: Data & Results

These tabs are explained in detail in the next chapters.

### 5.1.1 General Settings

This dialog allows changing some general settings and gives a short summary about the component.

The screenshot shows the 'General' tab of the 'General Settings' dialog. The sections are as follows:

- (1) Name:** A text input field for the component name.
- (2) Type/Attachment:** A table with columns for 'Type', 'Inner side', and 'Outer side'. The values are 'Opaque', 'Zone 1: Simulated zone', and 'Outer air' respectively.
- (3) Data:** A table with columns for 'Area [m²]', 'Inclination [°]', and 'Orientation'. The values are '31,8 / 115,8', '90', and 'S (27 %), E (22 %), W (22 %), N (29 %)' respectively.
- (4) Parameters:** A table with columns for 'Rsi [m²K/W]', 'Rse [m²K/W]', 'Thermal resistance [m²K/W]', and 'U [W/m²K]'. The values are '0,13', '0,04', '4,211', and '0,2283' respectively.
- (5) Height:** A table with columns for 'Specification', 'Setting way', and 'Value'. The 'Specification' is 'Height above ground [m]', 'Setting way' is 'User defined', and 'Value' is an empty field.

Figure 33:  
Opaque Component – General Settings.

## Controls

- |                       |  |
|-----------------------|--|
| <b>(1) Name</b>       | Name of the component.   |
| <b>(2) Type</b>       | Definition of the components type (opaque, transparent or opening) and the boundary conditions on the inner and outer side.  |
| <b>(3) Data</b>       | Summary of the components geometry.  |
| <b>(4) Parameters</b> | Summary of general properties of this component. Thermal resistance and U-Value are added after the assembly was defined.  |
| <b>(5) Height</b>     | Definition of the components height, which is necessary for the "Air Flow Model" and calculation of "Driving Rain". This can either be "user defined" or WUFI® Plus can calcu- |

late it "*from the visualized geometry*". For the last option, an element with the height 0 must be defined as a reference value, as described in chapter 4.5.11.

## 5.1.2 Assembly – Selection

The construction of a component can be entered in the “*Assembly*” tab, see figure below. At the top of this dialog, the assigned assembly (1) is shown. This assembly can be replaced by a previously defined assembly from the “*Database*” or it can be built up from scratch with the “*Edit*”-Button, see chapter 5.1.3. Below, a list shows all assemblies that are used in this project (2). Selecting an assembly in this list and clicking on the “*Assign*”-Button replaces the active assembly with the one from the list (Double-clicking the assembly in the list has the same effect). At the bottom of this dialog a graphic sums up the most important information about the selected assembly (3).

The screenshot shows the 'Assembly' tab of the WUFI Plus software interface. It is divided into three main sections:

- (1) Assigned Assembly:** A table with columns 'Name' and 'R [m²K/W]'. The entry 'Lightweight timber framed wall #1' has a value of 4.211. Buttons for 'Select from database' and 'Edit' are present.
- (2) Available Assemblies:** A table with columns 'Name' and 'R [m²K/W]'. Entries include 'Inclined Roof #1' (4.062) and 'Lightweight timber framed wall #3' (6.695). A context menu with 'New', 'Delete', 'Copy', 'Insert', and 'New/Insert' is visible. An 'Assign' button is on the right.
- (3) Summary:** A section showing 'Homogenous layers' with 'Thermal resistance: 4.211 m²K/W' and 'Heat transfer coefficient (U-value): 0.23 W/m²K'. It includes a cross-section diagram with 'Thickness [m]' values and a table of material layers.

Nr.	Material/Layer (from outside to inside)	$\rho$ [kg/m³]	$c$ [J/kgK]	$\lambda$ [W/mK]	Thickness [m]	Color
1	Mineral Plaster (stucco, A-value: 0.1 kg/m²h0.5)	1900	850	0,8	0,01	
2	Oriented Strand Board (density: 630 kg/m³)	630	1500	0,13	0,025	

Figure 34:  
Opaque Components – Assembly Selection



Assemblies that were created in a project can't be saved in the database. So, if you want to re-use an assembly in another project, you have to create it in the database first. Afterwards it can be included in the current and in future projects. Visit our WUFI®-Wiki ([www.wufi-wiki.com](http://www.wufi-wiki.com)) to learn more about the database.



Only the assigned assembly can be edited. So, if you want to edit an assembly that is listed as an "*available assembly*" (2) it has to be selected first. As an alternative, switch to a component that uses the desired assembly.

### 5.1.3 Assembly – Editing

Clicking the “Edit”-Button in the “Assembly”-Tab, see chapter 5.1.2, opens the “Edit assembly” window, see figure below:

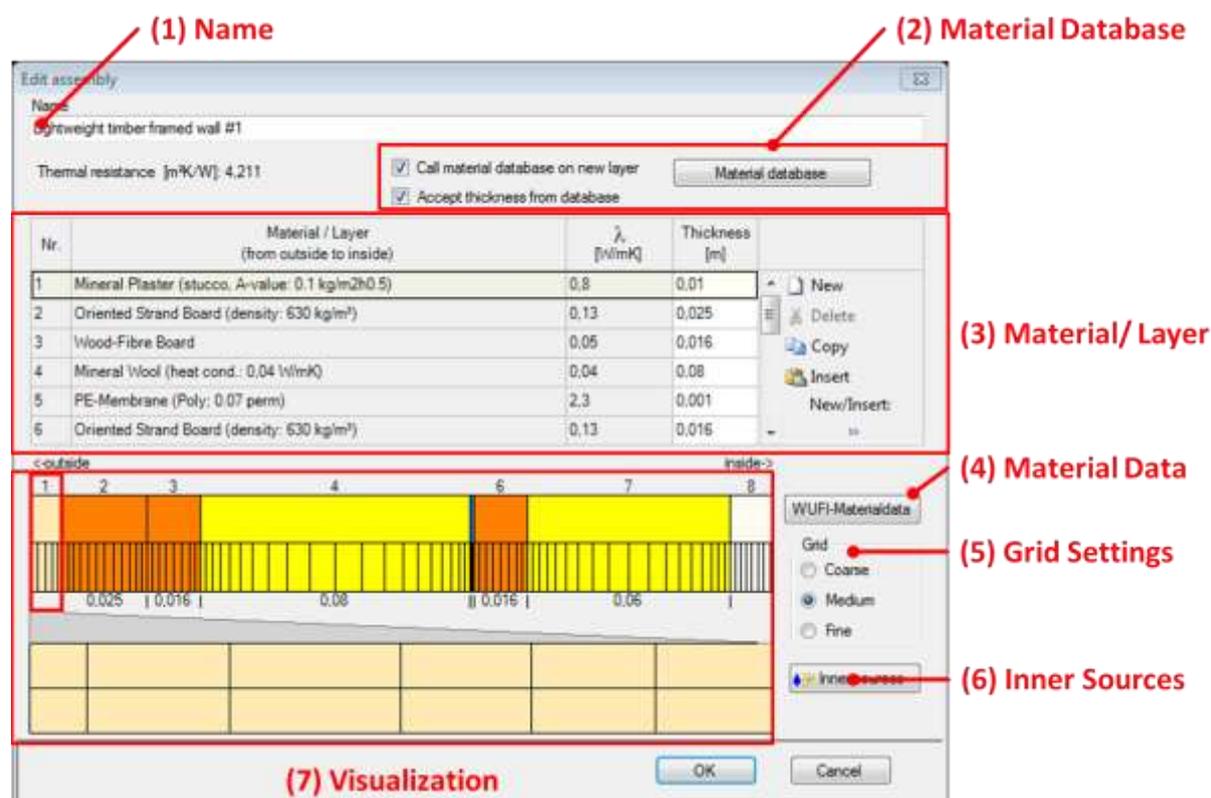


Figure 35:  
Opaque Component – Edit Assembly

## Controls

- |                              |   |
|------------------------------|---|
| <b>(1) Name</b>              | Name of the assembly.   |
| <b>(2) Material Database</b> | Opens the “Material Database” and replaces the currently active material. Also controls if the “Material Database” is opened if a new layer is added and if a predefined thickness for a material should be accepted. |
| <b>(3) Material/ Layer</b>   | A component is built from several material layers. Here, all layers are listed in a table and their thickness can be modified by clicking the corresponding element.  |
| <b>(4) Material Data</b>     | Clicking this button opens the “Materialdata”-window, see chapter 5.1.4.  |
| <b>(5) Grid Settings</b>     | Sets the size of the numerical grid. Fine grid is more precise, but increases computation time and vice versa. However, in  |

most cases the effect is negligible and only relevant if there is a deeper investigation of certain layers in the component.

#### **(6) Inner Sources**

Heat, moisture and air change occurring inside a component can be included in the calculation as an *"Inner Source"*. See chapter 5.1.5 for more information.

#### **(7) Visualization**

Here, a visualization of the assemblies' layers can be found. Also the *"Grid"* and *"Inner Sources"* are shown. It can also be used to change order of the layers by holding the left mouse button and drag the selected layer to the desired position.



#### **New**

Create a new element in this list.



#### **Delete**

Delete the selected element.



#### **Copy**

Copy the selected element



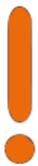
#### **Insert**

Insert a copied element. The *"Insert Position"* specifies where the copied element will be positioned.

#### **Insert Position**

Controls where a copied element will be inserted:

- *"after"* the selected element
- *"before"* the selected element
- *"exchange"* the selected element with the copied one



Pay attention that your assemblies are built in the correct order. The table (3) always lists the material layers from outside to inside. You can also use the visualization (7) to check your components.

## 5.1.4 Assembly – Material Data

Clicking the “WUFI Materialdata”-Button in the “Edit Assembly”-window (chapter 5.1.3) opens the “Edit Materialdata”-window, see figure below:

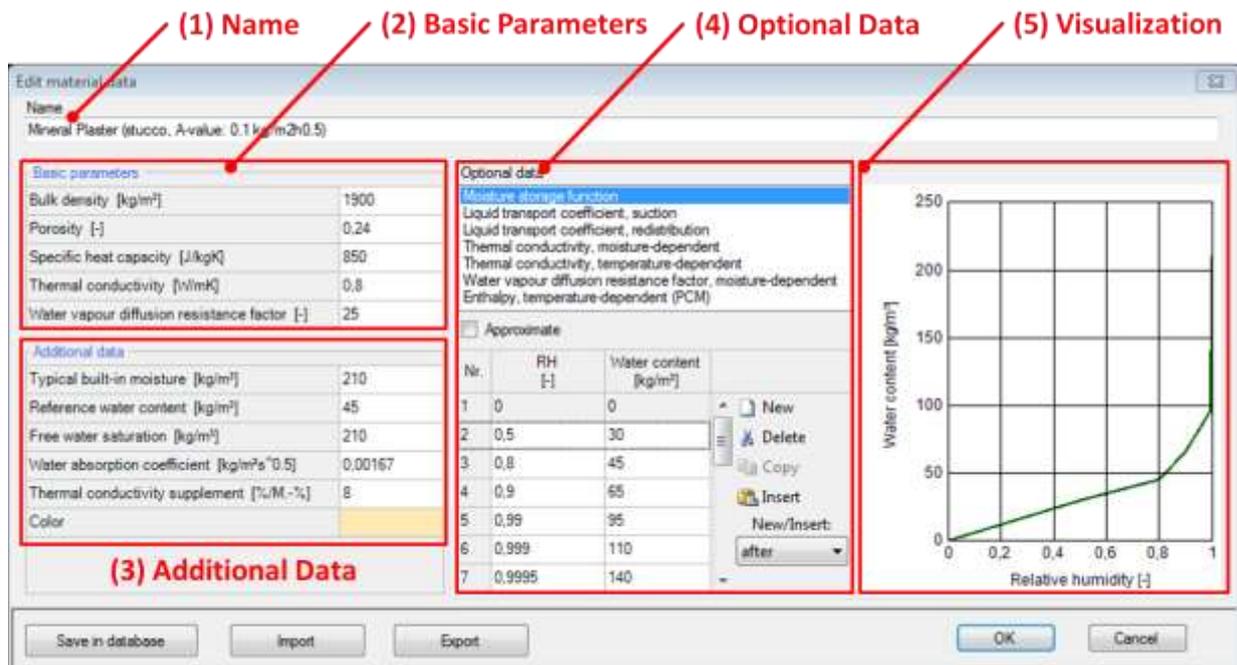


Figure 36:  
Edit Material Data.

## Controls

- |                             |  |
|-----------------------------|--|
| <b>(1) Name</b>             | Name of the material.  |
| <b>(2) Basic Parameters</b> | This material data constitutes an indispensable minimum without which a calculation is not possible. |
| <b>(3) Additional Data</b>  | Additional, constant parameters that can be provided.  |
| <b>(4) Optional Data</b>    | Moisture- and temperature-dependent data.  |
| <b>(5) Visualization</b>    | Here, a visualization of the selected “Optional Data” (4) is found.                                  |

- |   |   |
|---|---|
|  <b>New</b>    | Create a new element in this list.  |
|  <b>Delete</b> | Delete the selected element.  |
|  <b>Copy</b>   | Copy the selected element   |
|  <b>Insert</b> | Insert a copied element. The “Insert Position” specifies where the copied element will be positioned. |

### Insert Position

Controls where a copied element will be inserted:

- *"after"* the selected element
- *"before"* the selected element
- *"exchange"* the selected element with the copied one



Visit our [WUFI®-Wiki](#) for detailed information and physical background about material data.

### 5.1.5 Assembly – Inner Sources

Heat, moisture and air change occurring inside a component can be included in the calculation as an internal source, see figure below. The type of the source can be selected in the drop-down menu in the "Sources List" and named (1). Heat and moisture sources can be attached to one or more elements of a layer or to the entire layer under "Spread Area" (2). Additional data is necessary to define the location of the "Inner Source" (3). "Inner Sources" can either be calculated as a fraction of already available data or read from an "External File" (4). For more information about "External Files" see chapter 4.2.

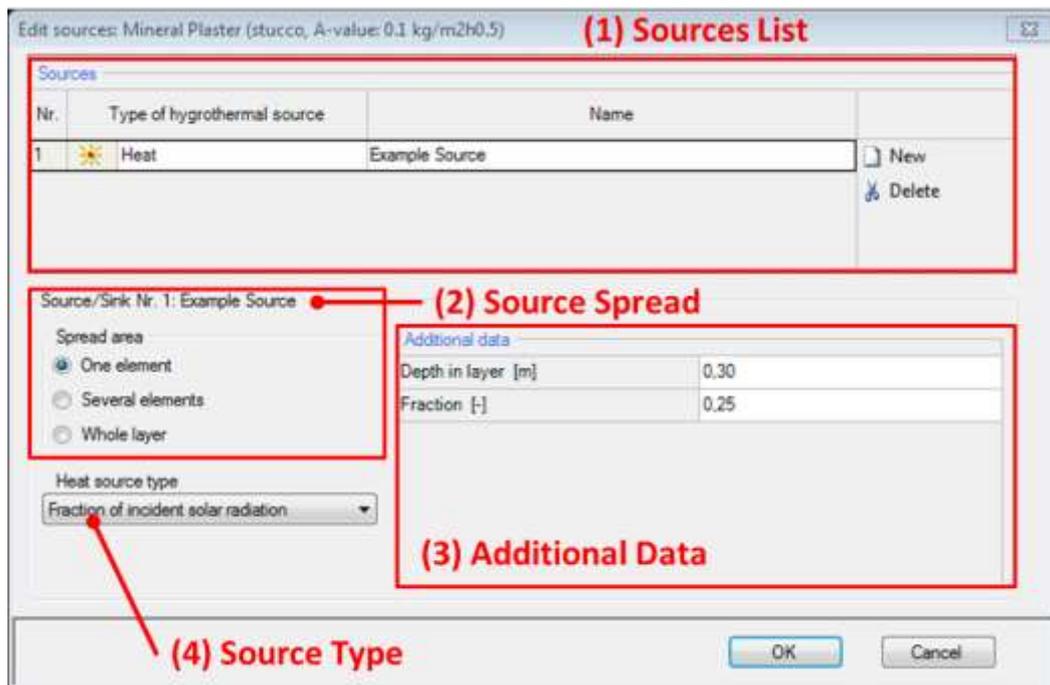


Figure 37:  
Internal Sources in Components



Please refer to our WUFI®-Wiki ([www.wufi-wiki.com](http://www.wufi-wiki.com)) for detailed information and physical background about inner sources in assemblies.

## 5.1.6 Surface – Thermal

Thermal options for the inner and outer surfaces can be changed in this dialog, see figure below:

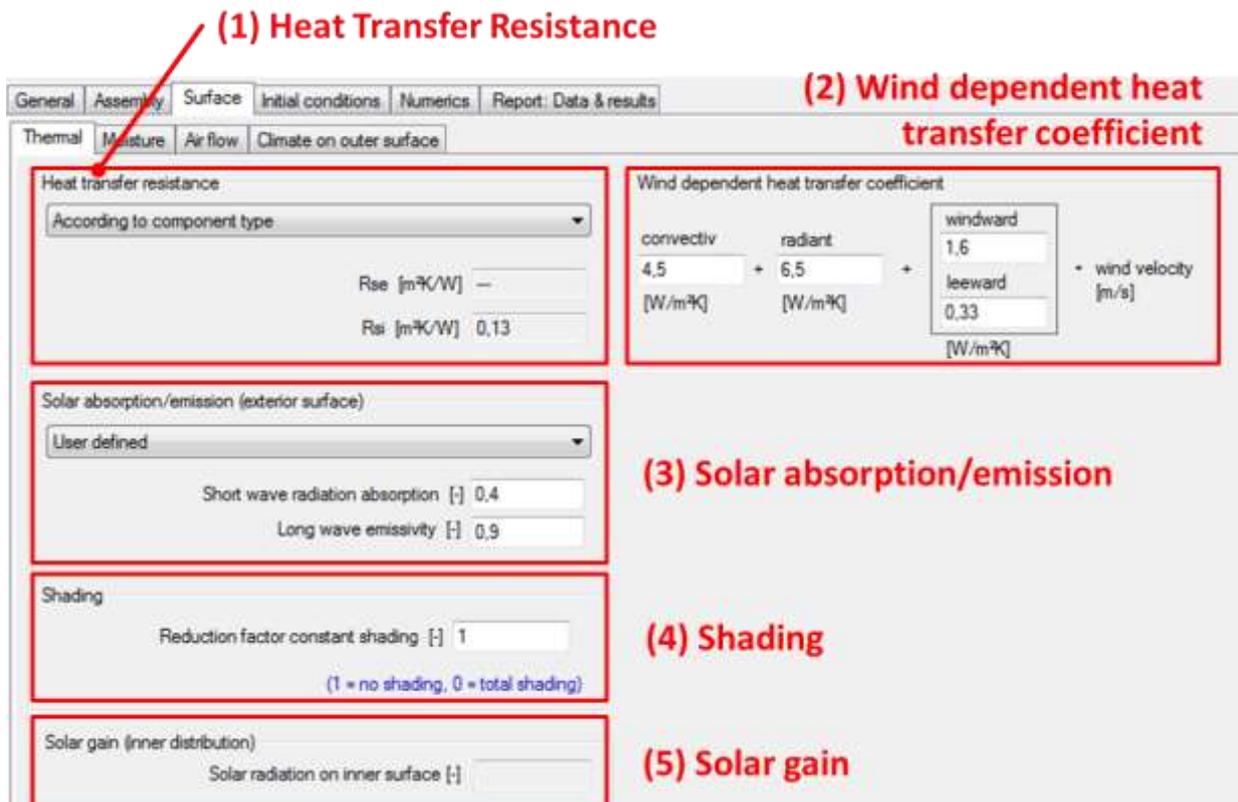


Figure 38:  
Opaque Component – Thermal surface settings.

## Controls

### (1) Heat Transfer Resistance

The "Heat Transfer Resistance" can either be entered user-defined or it can be derived automatically according to the component type.

### (2) Wind dependent heat transfer coefficient

The heat transfer coefficient on exterior surfaces can be calculated wind dependent. Please refer to our [WUFI® Wiki](#) for further information.

This input is only available if the respective setting was activated in the "Building – Numerics"-tab, see chapter 4.5. The component must also be exposed to the exterior air, like an exterior wall or a roof.

### (3) Solar absorption/

These factors are used to calculate the radiation. If there

**emission**

are no user defined values available you can select predefined values from a list with typical exterior surfaces.

**(4) Shading**

The shading factor is a permanent reduction of solar radiation on the component, for example, by planting or other buildings. The factor is set to 1 (no shading) by default but can be altered.

**(5) Solar Gain**

Solar Gain on the inner surface is usually calculated by WUFI® Plus. But it can also be entered manually, if "*user defined*" is selected for the distribution of solar gains in "*Other Parameters*", see chapter 4.5.9.

### 5.1.7 Surface – Moisture

In the tab "Moisture" hygric properties of the component surfaces are defined, see figure below. A sd-value can be specified for the interior and exterior surfaces of the component (1), when the coating is not already included in the assembly. Again there is a list of predefined coatings to choose from or a user defined value can be entered.

If the rain load is taken into account (2) it is calculated from normal rain, wind and the driving rain coefficients. The rain absorption is generated depending on the component orientation. The rain load calculation can be activated in the "Building – Numerics"-tab, see chapter 4.5.



When rain load is calculated, the height of the component above ground must be defined in the "General"-tab, as described in chapter 5.1.1. Calculation of the rain load considers the height above ground and if this value is not defined correctly, the resulting calculations also can be incorrect.

**(1) sd-Value**

**(2) Rain Load**

Figure 39:  
Opaque Component – Moisture surface settings.

### 5.1.8 Surface – Climate on Outer Side

For each component an inner and an outer side is defined. The inner side corresponds to the zone the component belongs to. The outer side has to be specified in this tab. There are three possibilities to choose from:

- *“According to component type (outer attachment)”*: Information about the inner and outer side of a component was already made in the tab *“General”*. Choosing this option, WUFI® Plus calculates according to this information.
- *“Optional climate”*: An *“Optional climate”*, see chapter 4.4.2, can be assigned to the outer side of the component as well. Amongst others this is necessary for all components that are in contact with the ground like for example the base plate. It has *“ground”* as information about its outer side and then needs a soil climate attached to it, which must be defined as an *“Optional Climate”*.
- *“Outer climate = Inner climate”*: Choosing this option causes WUFI® Plus to assume that the climate on the outer surface is the same as that on the inner. This corresponds to adiabatic conditions. However, the heat and moisture storage functions are still considered.

### 5.1.9 Surface – Air Flow

If the air flow model was activated in the *“Building – Numeric”*-tab, settings for each component can be specified in this tab. Please refer to chapter 7 for further information.

### 5.1.10 Further Settings

Additional settings include the "*Initial Conditions*" for the assembly and special calculation options in the "*Numerics*" tab.

The "*Initial Conditions*" are important to start the calculation. Initial temperature and moisture in the building must be set. The humidity can be assumed constant over the component or defined for each layer.

Under "*Numerics*" it can be selected whether the heat transport and/ or moisture transport are to be calculated. Special hygrothermal options such as "*capillary conduction*", "*latent heat of evaporation*" or "*latent heat of fusion*" can be turned on and off. The incidence of convergence errors may require an adjustment of numerical parameters. By choosing "*increased accuracy*" and "*adapted convergence*" this can be avoided. However, before doing this, the adjustment of the numerical grid should be checked.

### 5.1.11 Reports & Results

The tab "*Report: Data & Results*" sums up all settings and after the calculation, results for the respective "*Component*" can be found here. If "*Retain calculation results*" is check marked, all results, films and graphs are retained and exporting these results is possible, too. Please note, that this takes a lot of memory and slows the calculation. For more information refer to chapter 9.4.

## 5.2 Transparent Components

The procedure for defining "*Transparent Components*" is very similar to that of "*Opaque Components*", yet there are differences.



Chapter 3.4.1 describes how geometries of "*Transparent Components*" or "*Openings*" can be entered into WUFI® Plus.

### 5.2.1 General Settings

The settings in this dialog are more or less the same as for "*Opaque Components*", so please refer to chapter 5.1.1.

## 5.2.2 Window Parameters

Windows can be selected from the "Window Database" or their parameters can be set manually: After clicking the "Edit"-Button the "Window Parameters" dialog opens, see figure below:

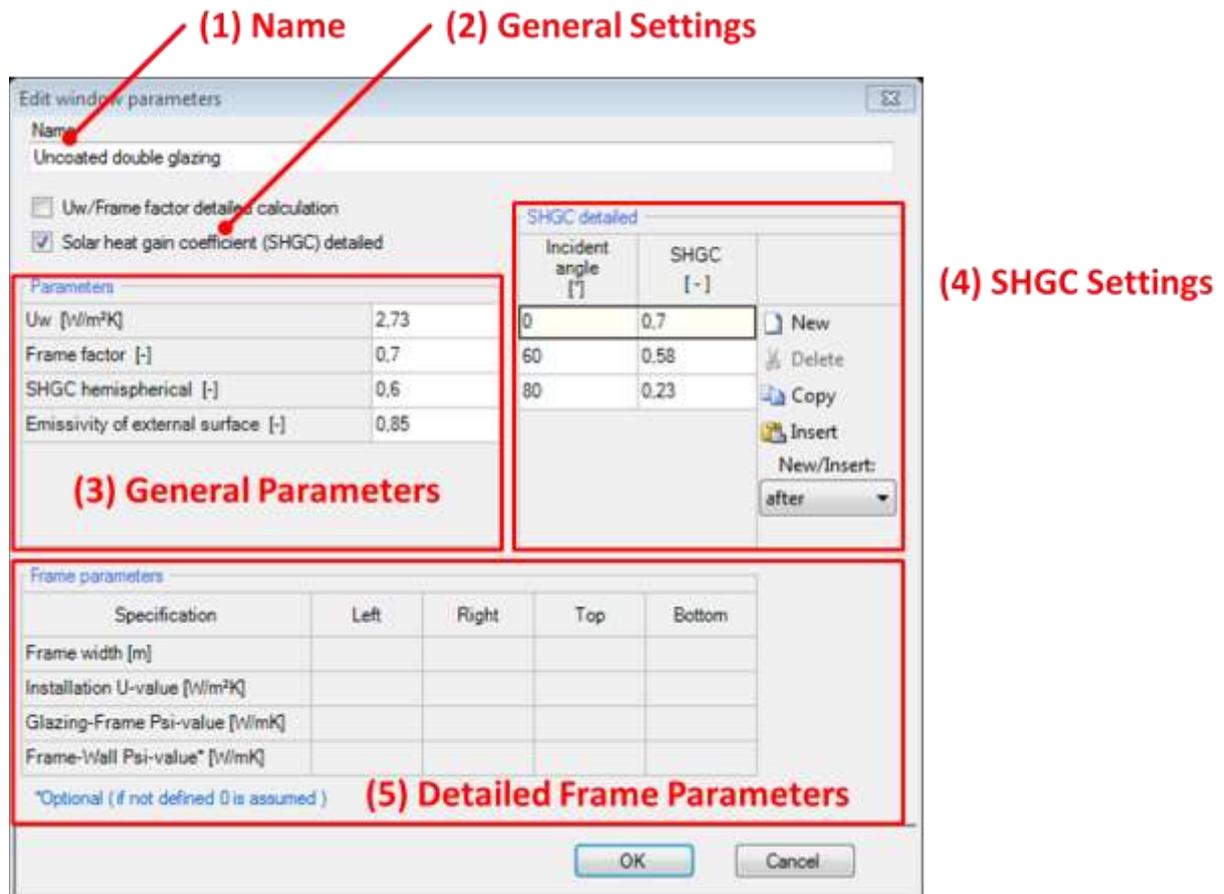


Figure 40:  
Edit Window Parameters.

## Controls

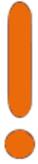
- |                               |   |
|-------------------------------|---|
| <b>(1) Name</b>               | Naming the current window parameters.   |
| <b>(2) General Settings</b>   | These checkboxes allow entering more detailed window parameters, see (4) and (5).   |
| <b>(3) General Parameters</b> | Here, general parameters that describe the window can be entered.   |
| <b>(4) SHGC Settings</b>      | Besides the constant value in (2), the "Solar heat gain coefficient (SHGC)" can be entered in detail, which allows setting SHGC-coefficients according to incident angle of solar radiation. This option is available when the "Solar heat gain |

		<i>coefficient (SHGC) detailed</i> " -checkbox in the "General Settings" (2) is activated.
	<b>(5) Detailed Frame Parameters</b>	Here, detailed parameters of the frame construction can be entered. These settings can be changed, if the " <i>U<sub>w</sub>/Frame factor detailed calculation</i> " checkbox in section (2) is activated.
	<b>New</b>	Create a new element in this list.
	<b>Delete</b>	Delete the selected element.
	<b>Copy</b>	Copy the selected element
	<b>Insert</b>	Insert a copied element. The " <i>Insert Position</i> " specifies where the copied element will be positioned.
	<b>Insert Position</b>	Controls where a copied element will be inserted: <ul style="list-style-type: none"> <li>▪ "<i>after</i>" the selected element</li> <li>▪ "<i>before</i>" the selected element</li> <li>▪ "<i>exchange</i>" the selected element with the copied one</li> </ul>

 According to the values entered in (5), the total  $U_w$  is calculated. Please note that the final U-value shown under "General Settings"(chapter 5.2.1) might differ from the one shown in this tab. The final U-value of the installed window is calculated with the correct dimensions, whereas the  $U_w$  in this tab is estimated by standard dimensions. Thus it is possible to use the defined window type for multiple transparent components.

### 5.2.3 Surface

The “*Surface*” settings are almost identical for “*Opaque*” and “*Transparent Components*”, except that “*Moisture*” is not considered for “*Transparent Components*”. Please refer to chapters 5.1.6, 5.1.8 and 5.1.9 for further information.



A constant shading factor can be entered in the “*Surface – Thermal*” tab. This factor is multiplied with settings made in the “*Solar Protection*” tab, see chapter 5.2.4.

It’s recommended to use this constant shading factor only if the shading will not change throughout the whole calculation, e.g. when using curtains or for dirt on the window surface. For every other case, the settings in the “*Solar Protection*” tab should be used.

## 5.2.4 Solar Protection

WUFI® Plus supports two solar protection types: “Sunscreen Devices” and “Window Overhangs”.

Settings for “Sunscreen Devices” can be changed by clicking the “Edit”-button in the “Sunscreen Device” tab. The “Edit Solar Protection Device” dialog opens, see figure below:

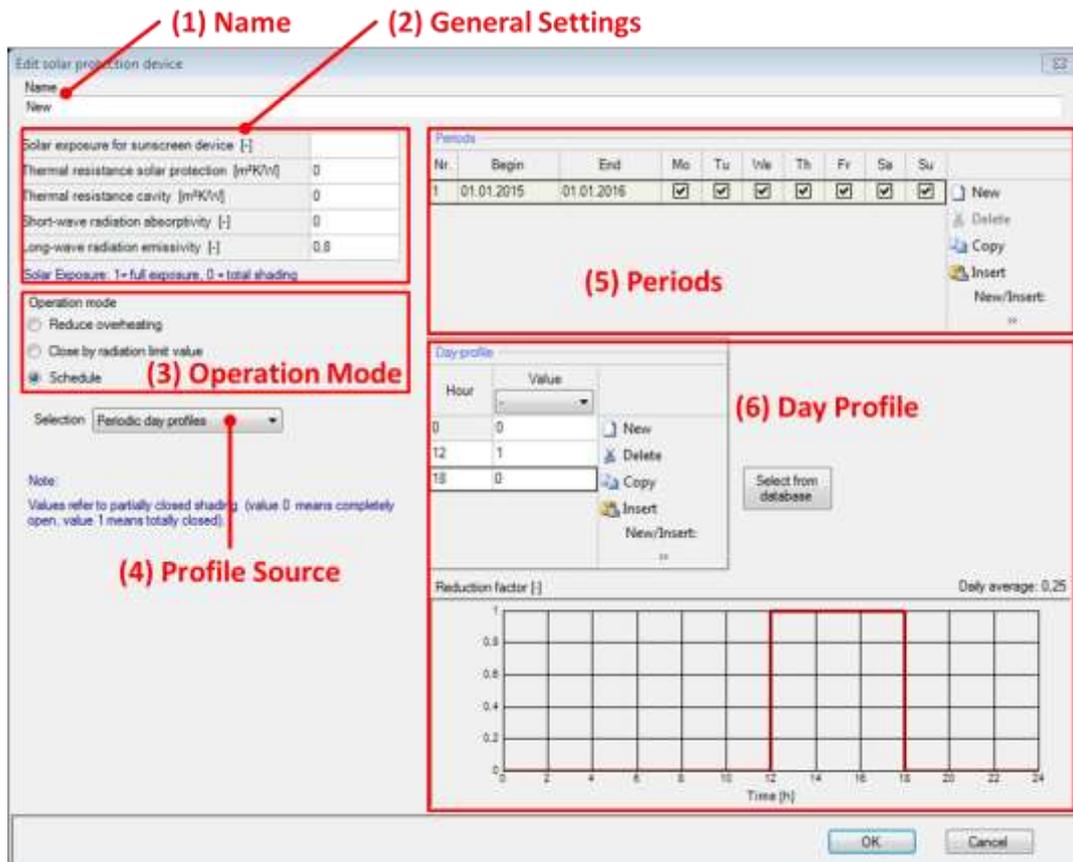


Figure 41: Settings for Solar Protection on Transparent Components if the Operation Mode “Schedule” is chosen.

### Controls

- |                             |   |
|-----------------------------|---|
| <b>(1) Name</b>             | Switching between “General settings” and a definition of the properties of the current device.  |
| <b>(2) General Settings</b> | General settings concerning the “Solar exposure for sunscreen device” and “Thermal resistance supplement”.  |
| <b>(3) Operation Mode</b>   | <p>WUFI® Plus supports three operation modes for “Sunscreen devices”:</p> <ul style="list-style-type: none"> <li>▪ “Reduce overheating”: The “Sunscreen device” will</li> </ul> |

close as long as the maximum temperature defined in the *"Design Conditions"* (chapter 4.5.7) is exceeded.

- *"Close by radiation limit"*: A value for the maximum radiation can be entered. As long as the solar radiation excels this value, the *"Sunscreen device"* will stay closed.
- *"Schedule"*: A schedule for the *"Sunscreen device"* can be entered. It can be loaded from an *"External File"* or entered by using *"Periodic Day Profiles"*.

#### (4) Profile Source

Operation plans for *"Sunscreen Devices"* can either be entered with *"Periodic Day Profiles"* or they can be loaded from an *"External File"*.

Please note: Here, the values refer to partially closed shading, so value 0 means completely open and value 1 means totally closed. Intermediate values are also possible. These values are multiplied with the value entered in (2).

#### (5) Periods

Periods can be defined by calendar dates and days.

#### (6) Day Profile

*"Day-Profiles"* can either be entered in two ways:

- Typing the values directly into the list
- Selecting predefined *"Day-Profiles"* from the WUFI® Plus database.

The active *"Day-Profile"* is visualized at the bottom of this dialog.

Please note: Here, the values refer to partially closed shading, so value 0 means completely open and value 1 means totally closed. Intermediate values are also possible. These values are multiplied with the value entered in (2).



**New**

Create a new element in this list.



**Delete**

Delete the selected element.



**Copy**

Copy the selected element



**Insert**

Insert a copied element. The *"Insert Position"* specifies where the copied element will be positioned.

#### **Insert Position**

Controls where a copied element will be inserted:

- *"after"* the selected element
- *"before"* the selected element
- *"exchange"* the selected element with the copied one



Please check the input in the *"Surface"* tab, as there is a dialog where a *"Constant Shading Factor"* can be defined. This factor will be multiplied with the input made in the *"General Settings"* of the *"Sunscreen Device"* (2).

The geometry of a *"Window Overhang"* can be defined after clicking the *"Edit"*-button in the *"Window Overhang"* tab. It is also shown in the *"Visualization Box"*.

### 5.2.5 Reports & Results

The tab *"Report: Data & Results"* sums up all settings and after the calculation results for the respective *"Component"* can be found here. If *"Retain calculation results"* is check marked, all results, films and graphs are retained and exporting these results is possible. Please note, that this takes a lot of memory and slows the calculation. For more information check the results chapter 9.4.

## 6 Importing geometry data

WUFI® Passive imports 3D geometries from other applications:

- SketchUp: A plugin for SketchUp allows defining zones and properties of components directly in SketchUp. This geometry data is then transferred directly to WUFI® Plus.
- gbXML: With the gbXML-format, geometry data can be imported from CAD-programs like Revit®.

### 6.1 SketchUp plugin

WUFI® Plus imports 3D geometries from [SketchUp](#) by using a plugin.

The plugin has to be installed manually after the installation of WUFI® Plus and requires an existing installation of SketchUp version 8 or higher. To install the plugin, open "Menu Bar > Options > WUFIplus SketchUp plugin", as described in chapter 3.2.3. The following dialog appears:

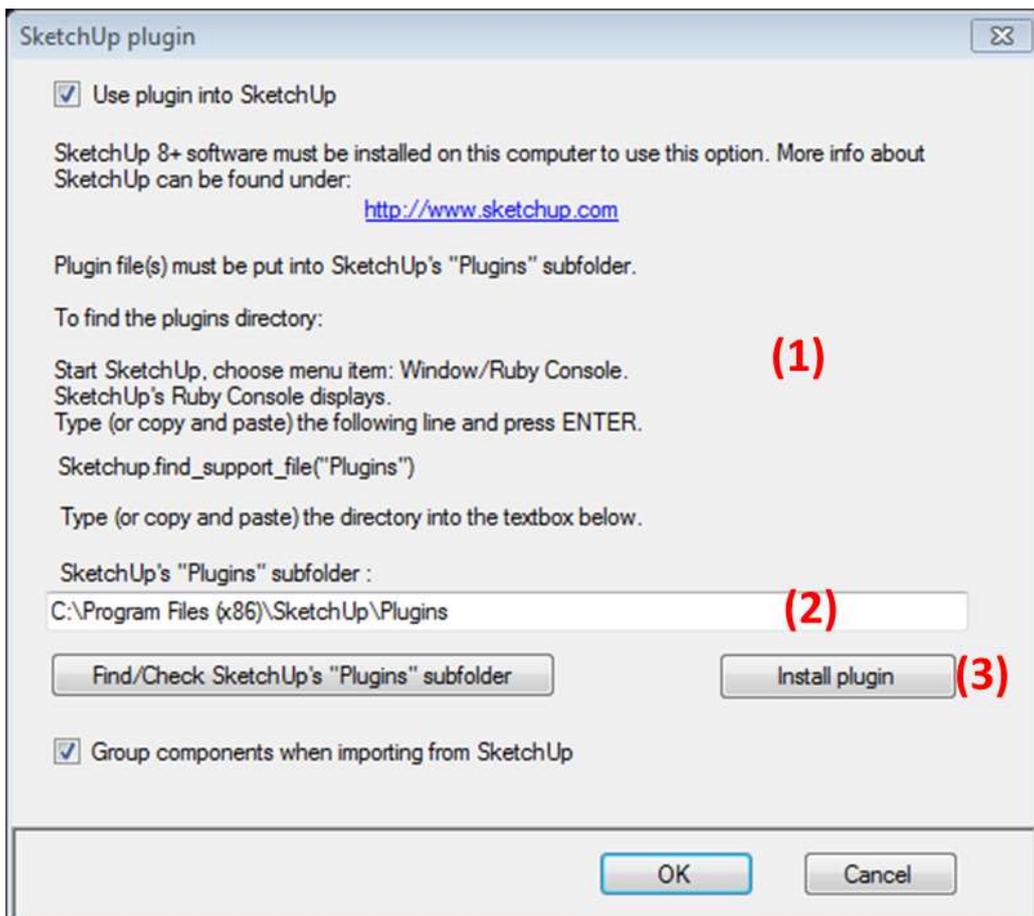


Figure 42:  
Options for the WUFI® Plus SketchUp Plugin.

Find SketchUp's plugins subfolder as described in the dialog (1). Then enter the path to SketchUp's plugins subfolder in (2) and click "Install plugin" (3) to complete the installation of the plugin. Afterwards it can be found in SketchUp's Menu Bar under "Plug-ins", see figure below. This menu provides access to three functions:

- Zones (1): Enter the number your buildings number of zones. Always open the "Zones"-dialog and adjust the number of zones before setting the properties of objects. Or, the number of zones must be altered afterwards.



Due to a bug in SketchUp, the number of zones is not imported, if SketchUp is started by double-clicking on a ".skp"-File. The properties of all objects are still saved correctly, but will only show up, if you enter the correct number of zones.

**This problem can be avoided by first starting SketchUp and open the ".skp"-File afterwards.**

- Export geometry (2): Exports the current geometry directly to WUFI® Plus. If WUFI® Plus is already running, the current geometry will be overwritten, so be careful when using this function. If WUFI® Plus isn't running, it will be prompted open when selecting this option.
- Save geometry (3): Saves the geometry as a .wps-file which can be imported in WUFI® Plus through the "Building"-dialog, as described in chapter 4.5. It's recommended to use this function instead of the direct export (2).

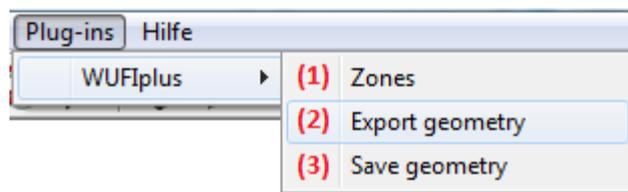


Figure 43:  
Dialogs in SketchUp for the WUFI® Plus SketchUp Plugin.

The properties of all objects which should be imported into WUFI® Plus have to be defined. This can be done by right-clicking on a surface (1) and setting the properties (3), see figure below. A red arrow represents the normal vector, which shows from the inner side of the object to its outer side (2). This helps to check if its orientation is correct.

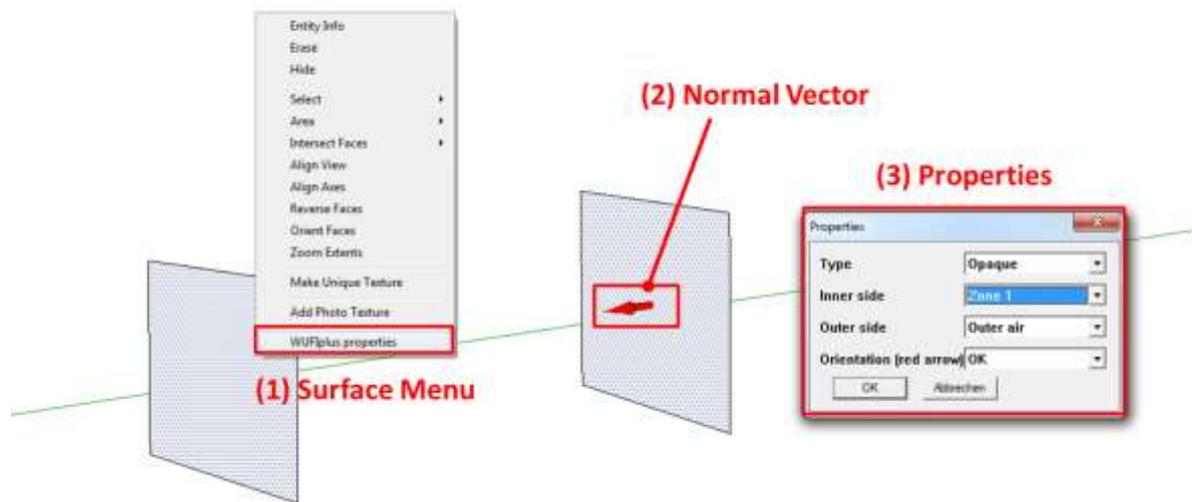


Figure 44:  
Setting the properties of an object in the WUFI® Plus SketchUp Plugin.



Always check your models after importing a SketchUp-geometry into WUFI® Plus to make sure that all parts are imported in the right way. Also, always check the orientations of all of your components as described in chapter 3.4.2.



Visit our WUFI®-Wiki ([www.wufi-wiki.com](http://www.wufi-wiki.com)) to learn more about this feature. A tutorial movie shows in detail how to import the 3D geometries of a building from SketchUp to WUFI® Plus.

## 6.2 gbXML-Import

gbXML-files can be imported with an external program, found in the “Tools”-folder of the WUFI® Plus main installation folder. This folder is defined during the installation process described in chapter 2.2. The external program is called “*gbXML\_project\_import.exe*”. With this tool gbXML Project files can be converted to WUFI® Plus XML project files which can be read from WUFI® Plus. This chapter explains the import-process.



Always check your analytical gbXML Project model export via your CAD software. If the analytical model is not well prepared, the tool can't import a usable model.

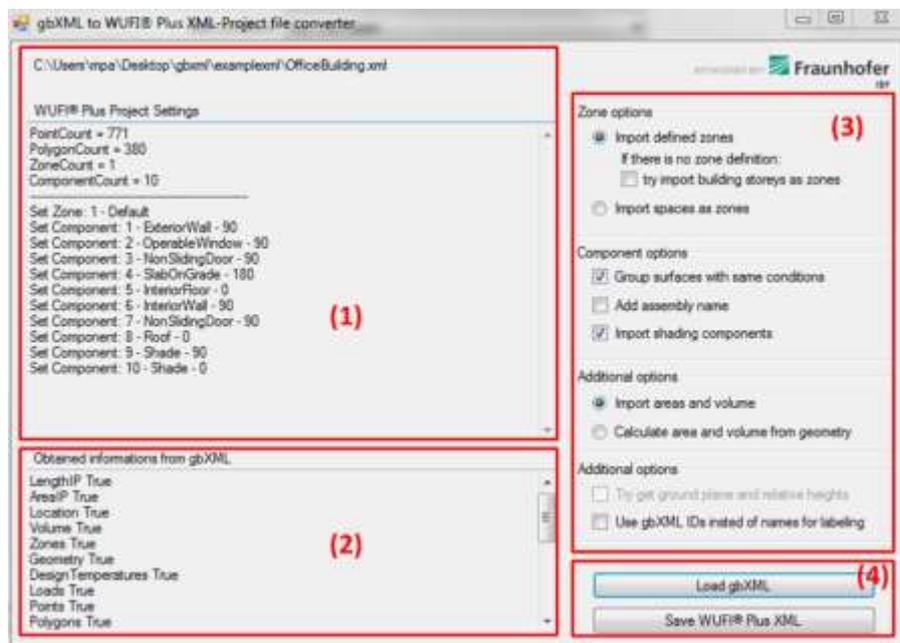


Figure 45:  
External program for gbXML-import.

### Controls

- |                          |   |
|--------------------------|---|
| <b>(1) Result screen</b> | General information about imported zones and components |
| <b>(2) Informations</b>  | Information about obtained data from the gbXML Project  |

translated to the WUFI® Plus Project

### (3) Import options

General settings concerning the import of the gbXML geometry, zone definition, and additional data. Further information about these options is provided below the box.

### (4) Load and Save options

Two functions are available:

- *"Load gbXML"*: Choose the gbXML file you want to use with WUFI® Plus.
- *"Save WUFI® Plus XML Project"*: Saves the loaded gbXML Project with the defined import options, as WUFI® Plus XML Project, openable in WUFI® Plus.

Some import options (2) are available:

Zone options:

- *"Import defined zones"*: Import the zones defined (in Revit the Export Category should be set to MEP-spaces for the gbXML-Project export). If you have set the Export Category to architecture rooms, you can import different building stories as WUFI® Plus zones, else the building consist of only one zone.
- *"Import spaces as zones"*: Ignores zone definition in the gbXML-Project (may not obtainable). All defined rooms or spaces are imported as separate WUFI® Plus - zones.

Component options:

- You can *"Group surfaces with same conditions"* for a tidy project tree. If you uncheck this option, each Surface of the building will be a new WUFI® Plus component.
- The import tool tries to get the construction information (assembly) of each component. If you check *"Add Assembly Name"* the Name of the construction will be added to the component Name.

Additional options:

- *"Import areas and volume"*: - ordinary the area and volume of each space, is calculated with the CAD software (Revit) and stored in gbXML. You can import this information, or you can let WUFI® Plus calculate it, depending on the building geometry data.
- *"Use gbXML IDs instead of names for labelling"*: If no names for zones or components defined within the gbXML project, you can take the IDs for labelling.

## Open WUFI® Plus xml project files

- Click on open in the WUFI® Plus "*Menu Bar*", choose "*XML Project Files (\*.xml)*" as data type and search for the WUFI Plus XML Project file you have saved before with the Convert-Tool. Refer to chapter 3.2.1 for further information.
- Another option is found in the "Building"-entry of the "Project Tree". There, choose "*gbXML Import*" and select and search for the WUFI Plus XML Project file you have saved before with the Convert-Tool. Refer to chapter 4.5 for further information.

## 7 Air Flow Model

The implemented Air flow model allows the calculation of the air flow across the building components depending on the air permeability of the components, wind and buoyancy. By using the air flow model, the input for the predefined air flow rates described in chapter 4.5.8 is not relevant, but some more information for the components and the building is necessary, and is described in the following chapter.

The air flow model calculates the pressure driven air flow rates via defined building components. Flow parameters describe the flow rate as a function of the pressure difference. Not fully airtight components are coupled to the zones and result in a building air flow network. For each simulated time step, with knowledge about the density, wind velocity and direction, the pressure within each zone is calculated by solving the air mass balance and vice versa the flow rates, depending on the zone pressure differences, to constitute the mass balance. This is iteratively solved for each simulated time step.



The usage of the air flow model could have a great impact on the whole building simulation. Check the input parameters in detail, do the implemented "*Pressurization test*", and check the resulting air flow rates after the end of a simulation!

Make sure that your climate data contains information about the wind velocity, direction and the barometric pressure.

## 7.1 Global Air Flow Parameters

To use the air flow model, it has to be activated for the building model in the “Building”-entry of the “Project Tree” (1). Switch to the “Numerics”-tab and activate the respective checkbox (2), as shown in the figure below:

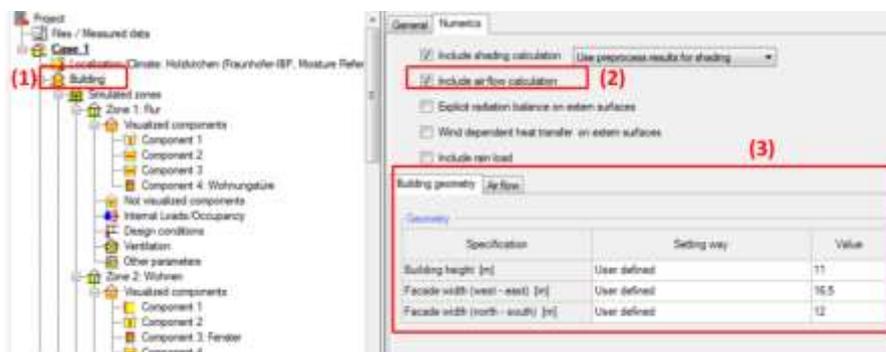


Figure 46:  
Activating the air flow model.

By activating the checkbox (2) new settings for the air flow model (3) appear in the “Numerics”-tab. The information about the building geometry is necessary to calculate the wind pressure coefficients and furthermore the wind pressure on the facade for each envelope component:

- The *Building height* is the distance of the highest point of the building above the ground,
- *Facade width (west-east)* is the average building width from the west- to the east-side of the building (viewing from north or south of the building),
- *Facade width (north-south)* is the average building width from north to south, viewing from west or east of the building.



Besides the whole building geometry data, the height above the ground information is required for each component, relevant for air flow, to calculate the height varying hydrostatic pressure for each component and zone. Chapter 4.5.11 describes how WUFI® Plus can calculate the heights automatically.

The implemented wind pressure coefficient approximation is for square building shapes. The wind pressure on the roof, or in small building gaps, or corners may not be appropriate

In the additional “Air flow”-tab the most important “Air flow settings” have to be defined. The air flow paths including the air permeability of envelope com-

ponents may be estimated by a global whole building air permeability definition, or they can be set individually:

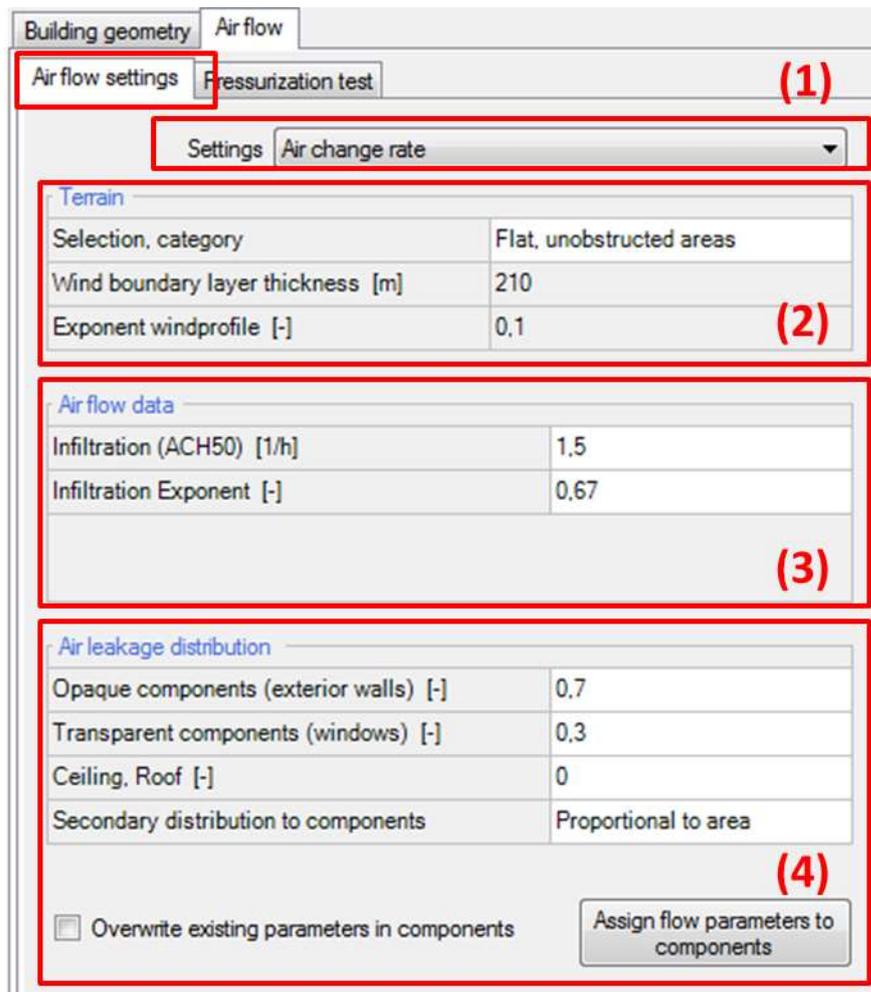


Figure 47:  
Setting global whole building information for the air flow model.

## Controls

### (1) Settings

This choice allows *individual settings* of air flow parameters for each component. Besides the special parametrization of each component, the air permeability of envelope components can be estimated with whole building parameters:

- whole building *air change rate*,
- global *flow parameters*,
- or building *effective leakage area*.

### (2) Terrain

Typical terrain surrounding the building. Used to estimate the building site wind velocity from the measured wind ve-

locity within the climate data, which is regarded as measured at a flat, unobstructed area.

### **(3) Air flow data**

Whole building air flow parameters. Used to estimate the air permeability of the envelope components, depending on the selected setting (1).

### **(4) Air leakage distribution**

Additional information for the air leakage distribution of the whole building data (3) to the components. First the air permeability is distributed to the components depending on their component type (*opaque, transparent, ceiling, roof*). In addition a "*secondary distribution to components*" is possible. Per default it is set as "*proportional to the component*" area. It can also be changed to a "*user defined*" air leakage distribution.

With the button "*Assign flow parameters to components*" the flow parameters for opaque and transparent envelope components are calculated. If "*Overwrite existing parameters in components*" is checked, optional already designed flow parameter input for envelope components is overwritten with the "*assign*"-button.



Make sure to have at least two air flow paths within each zone (components relevant for air-flow, see next chapter) coupled to two different zones. The air must have the ability to flow (enter via one flow path, and leave the zone via another one).

The global air flow setting (1) in doesn't set the inner components air permeability, so check inner components!

## 7.2 Informative Pressurization Test (Blower Door Test)

If the air flow parametrization is done, an informative pressurization test can be simulated, to check the defined air flow parameters and settings of the building model. Open the "Pressurization test"-tab:

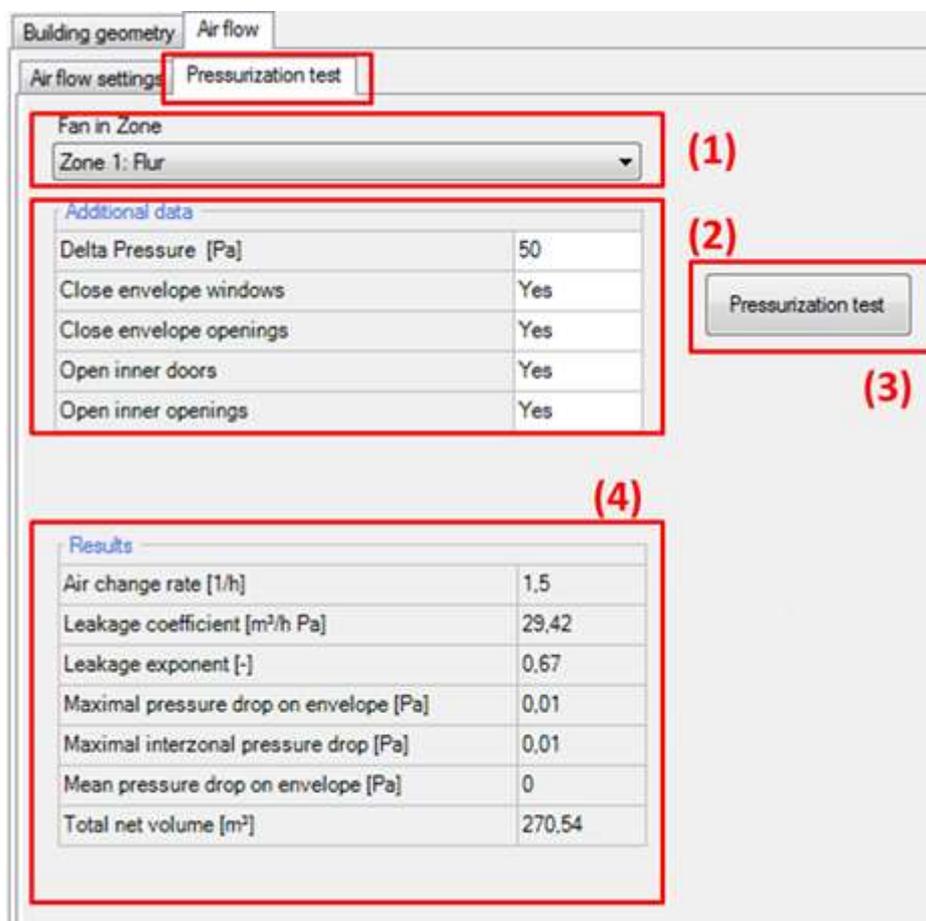


Figure 48: Informative pressurization test (Blower Door Test) to investigate and check the defined building air flow network.

### Controls

#### (1) Fan in Zone

It has to be defined in which zone the Fan (Blower door) for the pressurization test is installed.

#### (2) Additional data

Additional pressurization test data:

- *Delta pressure* is the pressure difference the blower door fan has to establish, and the result values are calculated for.
- To setup the blower door test for the whole building, *Close envelope windows*, *Close envelope open-*

*ings, Open inner doors and Open inner openings* can be used.

- If *No* is chosen, the state (first value in the schedule) of each component is used for the test.

**(3) Pressurization test**

This will run the pressurization test.

**(4) Results**

Past a successful pressurization test, the informative test results are shown in this list.

## 7.3 Opaque Component Air Flow Parameters

To parametrize the air flow properties, the *Air flow* Tab appears below the *Surface* Tab for each component (if the air flow model is used) the input mask may vary depending on the global settings, and component type (exterior component, inner component):

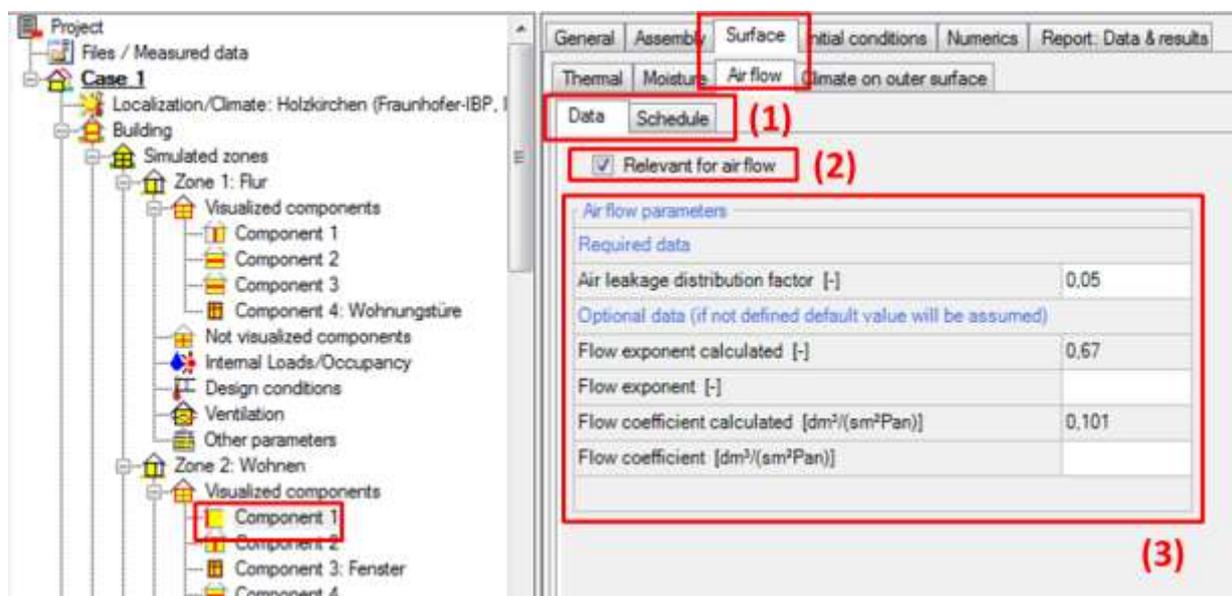


Figure 49:  
Air flow parametrization of opaque components.

### Controls

- (1) Data & Schedule** Only *Data* is required for opaque components, the *Schedule* is not relevant.
- (2) Relevant for air flow** Check if the component is not fully air-tight. Depending on global settings, this is automatically checked for envelope components (if not "*Individual settings*" are used, as in the figure above). Mostly it has to be checked for inner components, which are not automatically checked with the global settings.
- (3) Air flow parameters** Depending on the global air flow settings these parameters are optional or required.

The *Air leakage distribution* occurs for envelope components if the secondary component distribution is set to user defined. In sum, for all not air-tight components those factors should equal 1. It is the percentage of the whole building air permeability specially for the actual component.

*Flow exponent calculated, Flow coefficient calculated* are informative results of the global air flow setting. If no optional input is done for the following *Flow exponent* and *Flow coefficient* those parameters are used for the calculation.

*Flow exponent* vary from 0,5 for large openings where the flow is dominated by dynamic effects and 1,0 for narrow openings dominated by viscous effects. It describes the exponential decrease of the air flow rate by increasing pressure differences. A default value for Walls including joints is about 0,67

Flow coefficient is the magnitude of the air flow rate according to the pressure difference.

## 7.4 Transparent Component Air Flow Parameters

For transparent components, different assumptions can be regarded. At first, they can have a different state during the simulation, they might be openable, so they can be opened or closed.

If they are opened, the resulting opening is mostly large. The air flow through such large openings is probably not equal across the whole opening cross-section. The model used for these opened windows can regard air flow in two directions simultaneously. For example, the air might leave the building in the upper part of the opening, but enter the building in the lower part of the opening due to buoyancy effects and rising temperature differences. This is simulated with the model for transparent components.

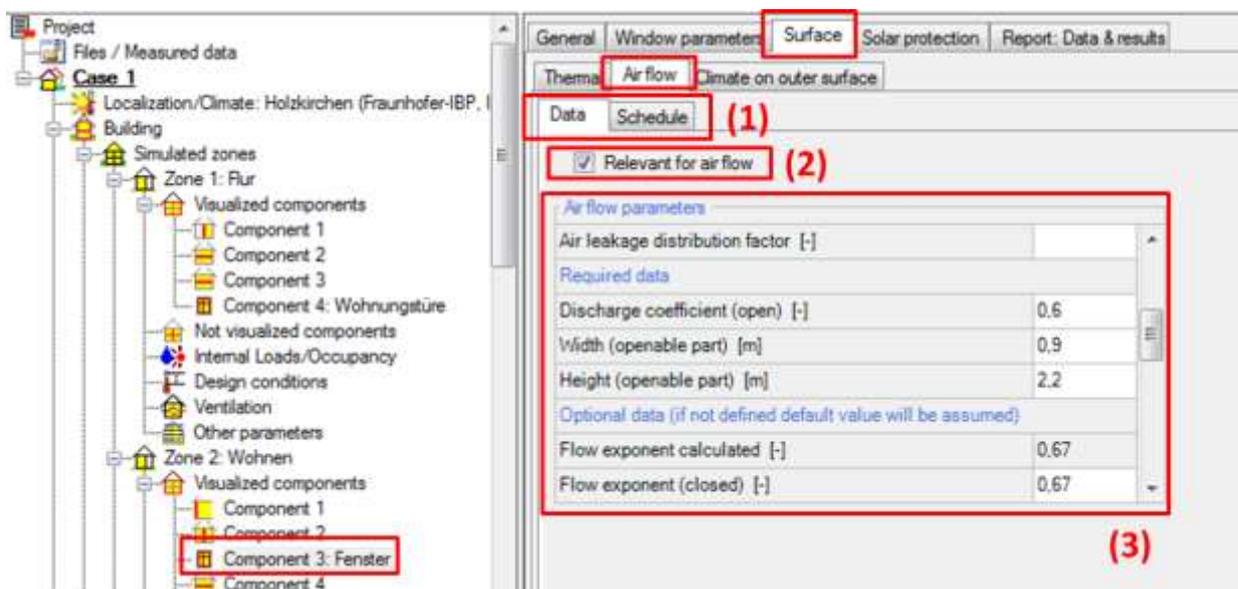


Figure 50:  
Air flow parametrization of transparent components.

### Controls

#### (1) Data & Schedule

The "Data"-tab is for parametrizing the air permeability of transparent components with varying states (opened or closed). The actual state can vary during the simulation. This can be defined in the "Schedule"-tab.

#### (2) Relevant for air flow

Check if the transparent component is not fully air-tight. Depending on global settings, this is automatically checked for envelope components (if not *Individual settings* are used, as in the figure above). Mostly it has to be checked for inner components, which are not automatically checked with the global settings.

### **(3) Air flow parameters**

Besides quite similar parameters for closed windows as for opaque components (see chapter 7.3), some additional parameters for the open-state (opened windows) are required:

- *Discharge coefficient (open)* is related to dynamic effects on the edges of an opening. Typically it is 0,6 for sharp-edged openings
- *Width and height (openable part)* are the resulting dimensions of the opening (without the frame by windows).

## 7.5 Opening Air Flow Parameters

Besides not fully airtight opaque components (the walls including joints) and transparent components, there might be special desired or unwanted openings within the building. They have to be regarded for the air flow model and can be defined with the third, the "Opening" Component type.

Fans and ducts can be designed with these component type, too.

They might not be visualized within the building model and can be added as "not visualized components":

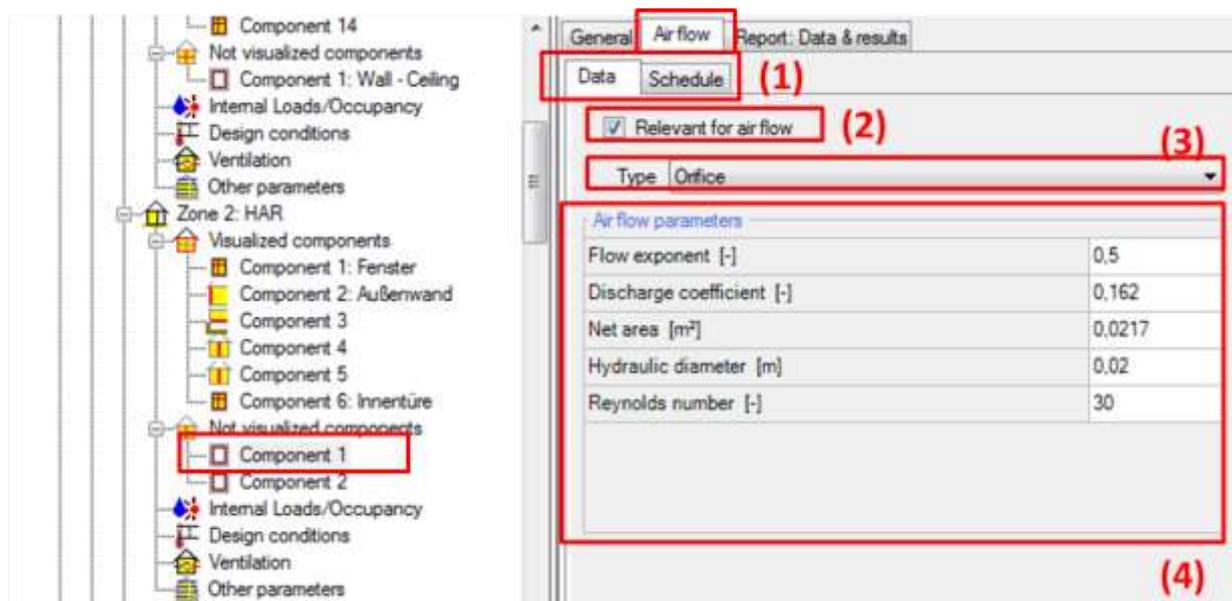


Figure 51:  
Air flow parameters of openings.

### Controls

- (1) Data & Schedule** The "Data"-tab is for parametrizing the air permeability of transparent components with varying states (the can be opened or closed). The actual state can vary during the simulation defined in the "Schedule"-tab.
- (2) Relevant for air flow** Check if the opening component should be regarded in the air flow network.
- (3) Opening type** Sets the type of the openings. The parameters below depend on this decision. Beside openings, ducts and fans can be defined with this component type.

**(4) Air flow parameters** The parameters vary depending on the type selected in (3):

- Orifice:

*Flow exponent:* mostly 0,5 for openings where the flow is dominated by dynamic. It describes the exponential decrease of the air flow rate by increasing pressure differences.

*Discharge coefficient:* is related to dynamic effects on the edges of an opening. Typically it is 0,6 for sharp-edged openings

*Net area:* The observable area of the opening

*Hydraulic diameter:* The hydraulic diameter is equal to  $(4 \text{ Net Area} / \text{Perimeter})$ . Only used for totally laminar flow (very low flow rates) with a very little impact on the calculation!

*Reynolds number:* The transition from laminar flow to turbulent flow occurs over a very broad range of Reynolds numbers with the flow being fully laminar approximately below 100. Only used for totally laminar flow (very low flow rates) with a very little impact on the calculation!

- Crack:

*Width:* The average width of a crack, or gap

*Length:* The length of the crack, or gap

- Leakage area:

*Flow exponent:* The flow coefficient for the leakage area at the reference pressure difference. The flow exponent is not reported and therefore must be estimated. For openings associated with infiltration, measurements usually indicate an exponent between 0.6 and 0.7.

*Discharge coefficient:* The discharge coefficient for the leakage area at the reference pressure difference. Default values are: Discharge coefficient of 1.00 at a reference pressure difference of 4.0 Pa and Discharge coefficient of 0.6 at a reference pressure difference of 10 Pa.

*Reference pressure difference:* Be sure to check the reference condition for the defined leakage area

*Leakage area:* The assumed leakage area per area of the opening.

- Duct:  
*Duct length:* The length of the duct from the inlet, to the outlet.  
  
*Cross sectional area:* The horizontal cross-sectional area of the duct.  
  
*Hydraulic diameter:* The hydraulic diameter is equal to  $(4 * \text{cross-sectional area} / \text{Duct cross-sectional perimeter})$ .  
  
*Sum of dynamic loss coefficients:* The overall sum of all dynamic loss coefficients, regarding the inlet, outlet and corners. Typical value from 0,01 to 0,4  
*Roughness dimension:* The roughness of the inner duct wall. Typical values: 1; 2; 3 mm
  
- Fan with constant volume flow:  
*Direction:* Supply – The fan transport the air from the Outer side Zone to the Inner side Zone. Exhaust mean the other way.  
  
 Maximal volume flow: The constant volume flow rate without pressure difference dependence, but may modified by the schedule
  
- Fan with constant mass flow:  
*Direction:* Supply – The fan transport the air from the Outer side Zone to the Inner side Zone. Exhaust mean the other way.  
  
 Maximal mass flow: the constant mass flow rate without pressure difference dependence, but may modified by the schedule
  
- Fan with performance curve:  
*Direction:* Supply – The fan transport the air from the Outer side Zone to the Inner side Zone. Exhaust mean the other way.  
  
*Performance data:* Input four points from the performance curve of the fan (the achievable volume flow rate of the fan at different pressure differences). The performance curve is calculated regarding this points. Make sure to fit the curve, that it not contain points of contraflechure.

## 8 DIN 4108-2 Thermal Protection/ Building Simulation

WUFI® Plus comes with a special calculation mode for simulations used in context of the German thermal protection standard DIN 4108-2. These simulations differ from "usual" WUFI® Plus simulations as some user-inputs are pre-allocated with default values and some calculation options cannot be chosen, according to the assumptions made by the standard. After the calculation a report is created which sums up the results. The most important differences are:

- Only thermal simulations.
- Calculation time is predefined and can't be changed.
- For exterior climate data only three German Test-Reference-Years can be chosen. These are representative for climate regions A, B and C defined in the standard.
- In the "Case"-Dialog and the "Zone"-Dialog the building-category must be specified as "Residential" or "Non-residential".
- The "Floor Area" must be entered in the "Zone"-dialog.
- Calculation options in the "Numeric"-Tab of a component are preset and can't be changed.
- "Internal Loads" are predefined and can't be changed.
- "Design Conditions" are predefined and can't be changed.
- Predefined "Ventilation" profiles can be set according to the standard.
- A special "DIN 4108-2 Verification"-Report is created after a simulation. It can be accessed from the "Results"-Tab in the "Case"-Dialog. The report sums up all necessary data according to the standard and evaluates if the simulation results fulfill its criteria. This report includes the results of all simulated zones. The figure below shows an example of this report.

GENERAL INFORMATION	
Software	WUFI® Plus
Calculation method	Thermal building simulation according DIN4108-2
Overheating Degree Hours	1813,4 kWh (> 500 demand value)
BUILDING INFORMATION	
General information	
Type	Non-residential
Year of construction	
Building geometry	
Envelope volume	385 m³
Total area envelope	334 m²
Air ratio	0,07
Traced floor area	108 m²
	
BOUNDARY CONDITIONS	
Boundary conditions	
Internal heat gains	13,1 W/m²
Internal temperature	21 °C
Overheat temperature	26 °C
Ventilation	
Natural	
During residence time	0,2 1/h (No increased day ventilation)
Other using time	1,5 1/h
Night ventilation	No increased night ventilation
Mechanical	
Night ventilation	No night mechanical ventilation
CLIMATE	
Climate: Climate region B	
Latitude	52,4 °
Longitude	13,1 °
Height above sea	91 m
Timezone	+1 h
Ground reflectance short	0,2
Ground reflectance long	0,1
Ground emission	0,9

Figure 52:  
Report for a calculation according to DIN 4108-2.

## 9 Simulation & Results

Once WUFI® Plus is supplied with all necessary data it can calculate the temporal evolution of the temperature and moisture fields in the building components and the inner climate conditions. Results can be obtained for the whole building and for each individual component.



Visit our WUFI®-Wiki ([www.wufi-wiki.com](http://www.wufi-wiki.com)) to learn more about working with the results of WUFI® Plus calculations and exporting them.

### 9.1 Executing a Simulation

A simulation can be started and controlled with the *"Status & Results Box"*, see chapter 3.5. During a simulation its progress can be monitored in several ways. The *"Dialog Box"* shows a general *"Calculation Info"* about the progress as soon as the calculation starts, see figure below. This dialog can also be opened by clicking on the *"Case"*-Entry in the *"Project Tree"*.

Date/Time/Progress	
Count steps	810
Date/Time	03.02.2015 : 18
Progress [%]	9.2

Convergence errors	
Count errors	0
Date/Time (last error)	—

Other errors	
Count air balance errors	0

Figure 53:  
Calculation Info

During a calculation not only general information can be observed. The following visualizations are available and can be selected from the *"Project Tree"* while a simulation is running.

- Zone
  - Inner, outer and surface temperature

- Heat fluxes
- Moisture flows
- Opaque Component
  - Profiles showing hygrothermal conditions
  - Solar radiation for every component to outer air
- Transparent Component
  - Solar radiation for every component to outer air
- 3D Object
  - Temperature distribution in X-, Y- and Z-Direction and for all divisions
- HVAC
  - Behavior of “*HVAC-Devices*” for detailed “*HVAC-Systems*”

Please refer to chapters 9.3 to 9.6 for examples of these visualizations.



The “*Maximum Speed*”-Button in the “*Status & Results Box*” can be used to increase the simulation speed. However, the simulation progress can’t be observed anymore, as the visualizations during a simulation are disabled in this mode.

## 9.2 Case Results

During a calculation the “Case”-dialog shows some general information about the calculation progress, as mentioned in chapter 9.1.

After the calculation, the results of all zones and monitor positions of 3D Objects can be accessed through the “Report: Data & Results”-Tab in the “Case”-dialog, see figure below. For editing graphs, please refer to chapter 9.7.

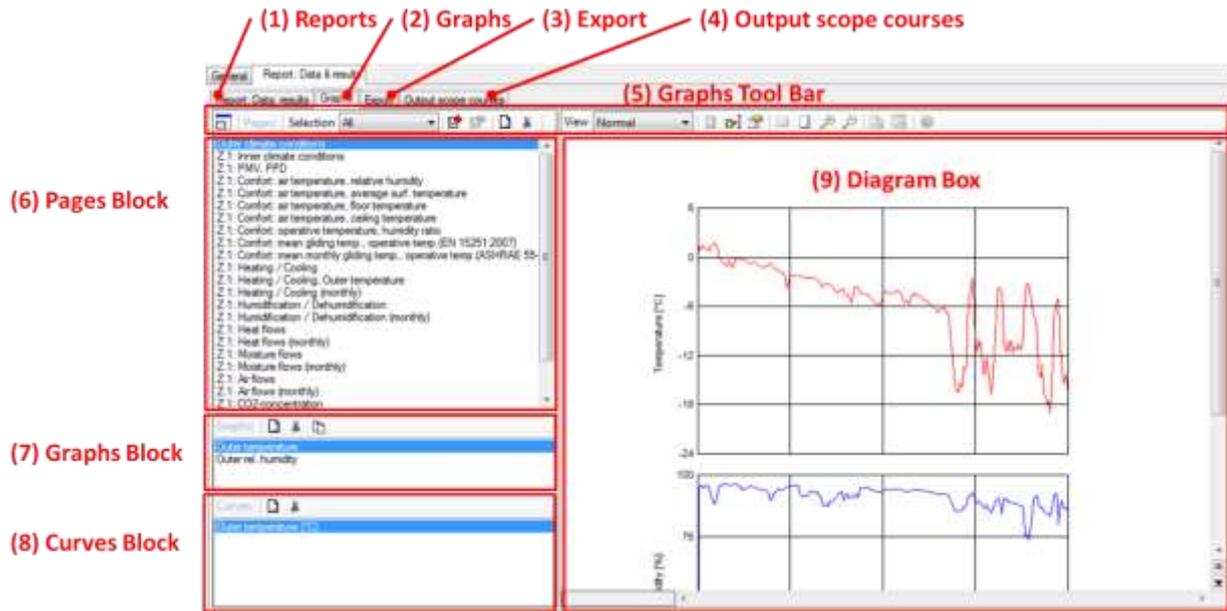


Figure 54:  
Graphs of case results.

### Controls

- |                                 |   |
|---------------------------------|---|
| <b>(1) Reports</b>              | WUFI® Plus creates automatically various reports after a calculation is finished. They can be accessed from the “Reports”-Tab. Please refer to chapter 9.8 for further information. |
| <b>(2) Graphs</b>               | The “Graphs”-Tab shows diagrams of the calculation results. Its functionality is explained in this chapter.   |
| <b>(3) Export</b>               | The calculated results can be exported in the “Export”-Tab. Please refer to chapter 9.9 for further information.  |
| <b>(4) Output scope courses</b> | Allows selecting specific calculation results for output for calculations made in Batch-Mode.   |
| <b>(5) Graphs Tool Bar</b>      | This tool bar allows selecting, modifying, printing and exporting individual reports. The buttons in this tool bar are explained below.   |

	<b>Expand/ Shrink Window</b>	Allows expanding the "Graph"-Tab.
	<b>Selection</b>	Allows switching through different types of graphs (All, Climate, Comfort, Energy, Humidity).
	<b>Retain current settings</b>	Remembers the current settings for graphs. This feature is useful in combination with "Restore retained settings", if changes to a graph should be undone.
	<b>Restore retained settings</b>	Restores remembered settings for graphs.
	<b>New</b>	Creates a new and blank page, which can be filled with custom diagrams. This button can also be found in the "Graphs Block" (7) and the "Curves Block" (8) and creates there a new graph or curve.
	<b>Delete current</b>	Deletes the selected page. This button can also be found in the "Graphs Block" (7) and the "Curves Block" (8) and deletes the selected graph or curve.
	<b>View</b>	Allows changing between two options: <ul style="list-style-type: none"> <li>▪ "Normal": The standard graph viewer in WUFI® Plus.</li> <li>▪ "Print layout" shows how the graph will look, when it's printed.</li> </ul>
	<b>Page Setup</b>	Defines the page layout. Only available if "View" is set to "Print Layout".
	<b>Scope/ Sequence</b>	Allows choosing specific elements.
	<b>Options</b>	Settings for the appearance of the graph.
	<b>Whole width</b>	Zooms on the whole width of the graph in the Diagram Box (9).
	<b>Whole page</b>	Shows the whole page in the Diagram Box (9).
	<b>Zoom in/ out</b>	Zooming in or out in the Diagram Box (9).
	<b>Print all</b>	Prints the current report with the default printer. Only available if "View" is set to "Print Layout".
	<b>Print dialog</b>	Opens a standard Windows printer-dialog, where the printer and its properties can be selected.

Only available if "View" is set to "Print Layout".

**(6) Pages Block**

List of all pages that were created by WUFI® Plus after the end of the calculation. Also user-defined pages will appear here. A page can contain several graphs, which are listed in the "Graphs Block" (7).

**(7) Graphs Block**

List of all graphs that belong to the selected page. A graph can contain several curves, which are listed in the "Curves Block" (8).



**Copy to clipboard**

The selected graph is copied and can be inserted into any other applications that supports "Copy & Paste", like for example your office program.

**(8) Curves Block**

List of all curves that belong to the selected graph.

**(9) Diagram Box**

Shows the diagrams that belong to the selected page (6).



Please refer to our WUFI®-Wiki ([www.wufi-wiki.com](http://www.wufi-wiki.com)) for further information about "Graphs". There you can also learn how to create new graphs that can be fully customized to your needs.

### 9.3 Zonal Results

During a calculation the following predefined visualizations can be observed, see figure below:

- Inner, outer and surface temperature
- Heat fluxes
- Moisture flows

The dropdown menu on top allows switching through the different visualizations. With the checkboxes on the right side, graphs can be excluded or included in the visualization.

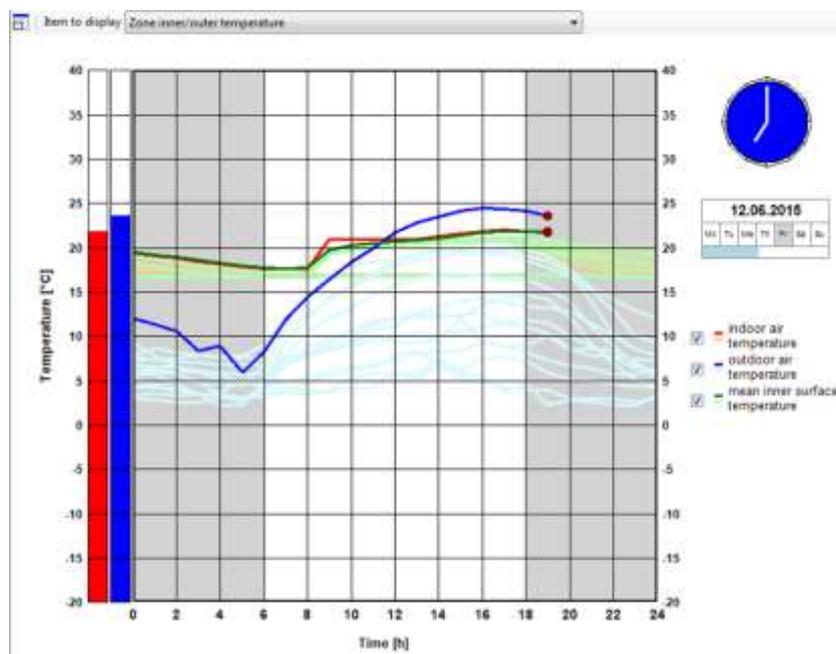


Figure 55:  
Zonal visualization during a calculation

After a calculation, the results of a specific zone can be assessed by selecting the "Zone" in the "Project Tree", open the "Report: Data, results"-Tab and select "Graphs". For this specific zone, the same results can be found that are summed up in the "Case" results described in chapter 9.2. For working with "Graphs", please refer to chapter 9.2 and for editing "Graphs" refer to chapter 9.7.

## 9.4 Component Results

Component results are only saved, if the "Retain Calculation Results" option in the "Report: Data & Results"-Tab was check marked. Else, only general reports are available. For more information about reports refer to chapter 9.8.

If the calculation results are saved, the component results can be accessed in several ways:

- *Graphs*: "Graphs" concerning the component can be found here. To distinguish between graphs for different components the orientation, the azimuth and the area of the component is listed in the name of each graph. For working with "Graphs", please refer to chapter 9.2 and for editing "Graphs" refer to chapter 9.7.
- *Films*: The films show temperature and relative humidity courses inside an opaque component, the same as during a calculation. If several components are grouped together the requested one can be selected under "Item to display". The film dialog is described below.
- *Export*: The results can also be exported. Please refer to chapter 9.9 for further information.

If films for a component are saved, they can be watched after the calculation in the "Film"-Tab, like in the figure below:

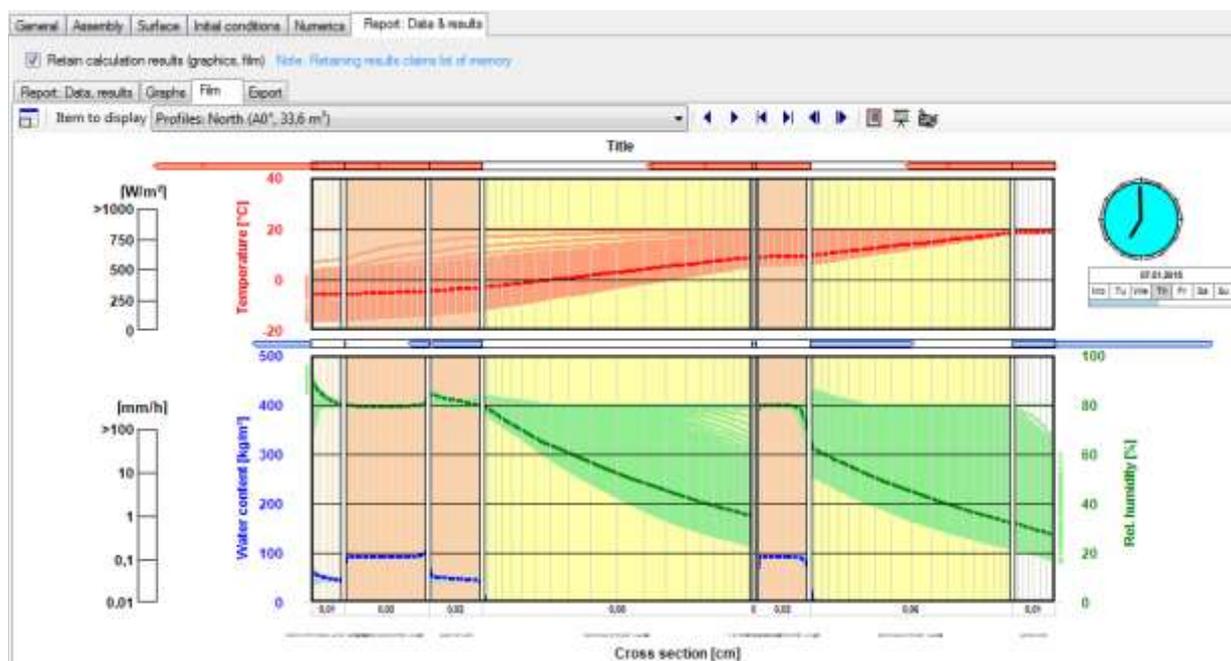


Figure 56:  
Component Film.

## Controls

	<b>Expand/ Shrink Window</b>	Allows expanding the "Film Box".
	<b>Backward</b>	Makes the film run backward.
	<b>Forward</b>	Makes the film run forward.
	<b>Pause</b>	This button appears while the film is running forward or backward. It allows pausing the film at the current timestep.
	<b>Back one step</b>	Sets the film one timestep backward.
	<b>Forward one step</b>	Sets the film one timestep forward.
	<b>Scroll to start</b>	Jumps to the start of the film.
	<b>Scroll to end</b>	Jumps to the end of the film.
	<b>Settings</b>	Allows altering the appearance of the film.
	<b>Extended Animation</b>	<p>Exports the current film to the additional program "WUFI® Animation 1D" and opens it. This tool allows an extended analysis of the film, like for example:</p> <ul style="list-style-type: none"><li>▪ Watch the WUFI® Film with custom speed</li><li>▪ Watch WUFI® Films of several components at the same time</li><li>▪ Customize the WUFI® Film and its displayed data</li><li>▪ Include additional graphs into the WUFI® Film, like for example dew-point temperature</li><li>▪ Create graphs for every grid position</li><li>▪ Export graphics and films</li><li>▪ Export data directly to postprocessors like for example WUFI® Bio, which allows the evaluation of mold growth risks on surfaces.</li></ul> <p>Please refer to our WUFI® Wiki for further information about this very helpful tool.</p>
	<b>Export AVI-Film</b>	Exports the film as an avi-file. A standard Windows Save-dialog opens and the file path can be selected.



Please refer to our WUFI®-Wiki ([www.wufi-wiki.com](http://www.wufi-wiki.com)) for detailed information about working with these films.



The films of components can be saved, by check marking "*Retain Calculation Results*" in the respective "*Report*"-Tab. However, this claims a lot of memory and slows down the calculation.

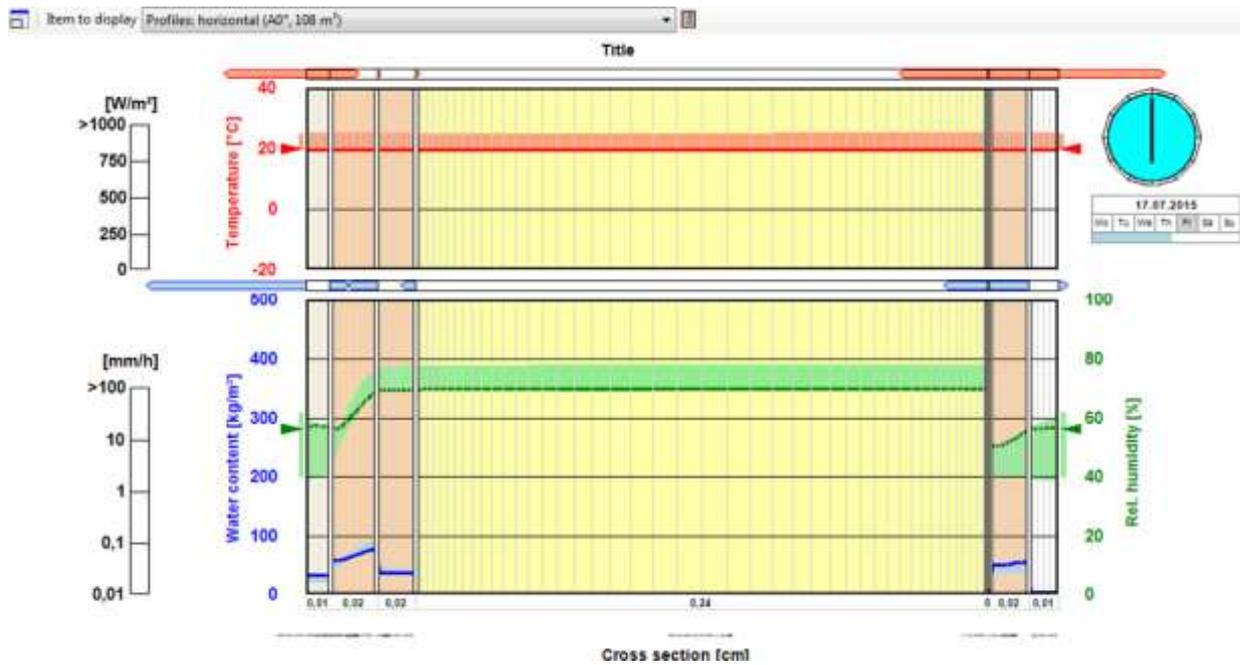


Figure 57:  
Visualization for opaque components during a calculation

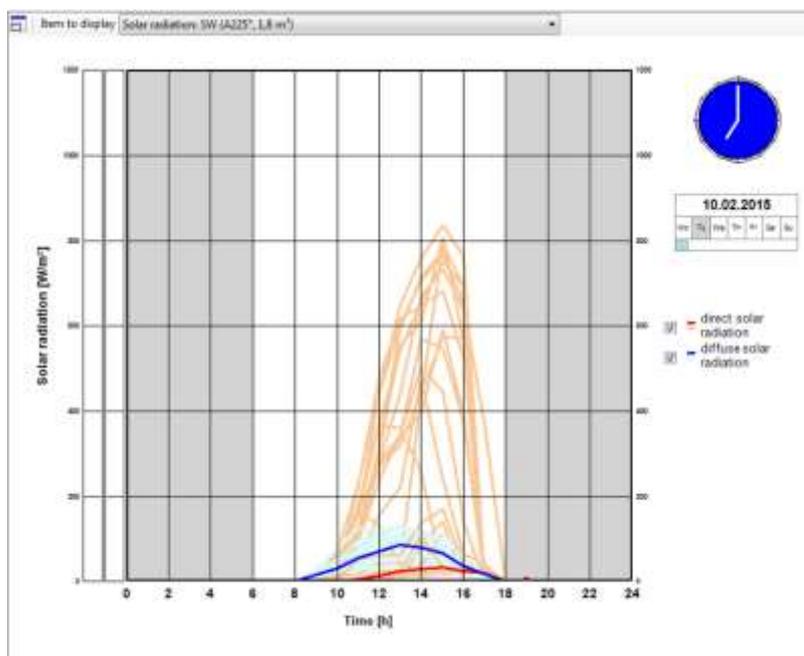


Figure 58:  
Visualization for transparent components during a calculation

## 9.5 HVAC Results

During a simulation the courses of heating and cooling demand can be watched for every zone, as mentioned in chapter 9.3. Also the results of the detailed HVAC-systems are visualized during the calculation:

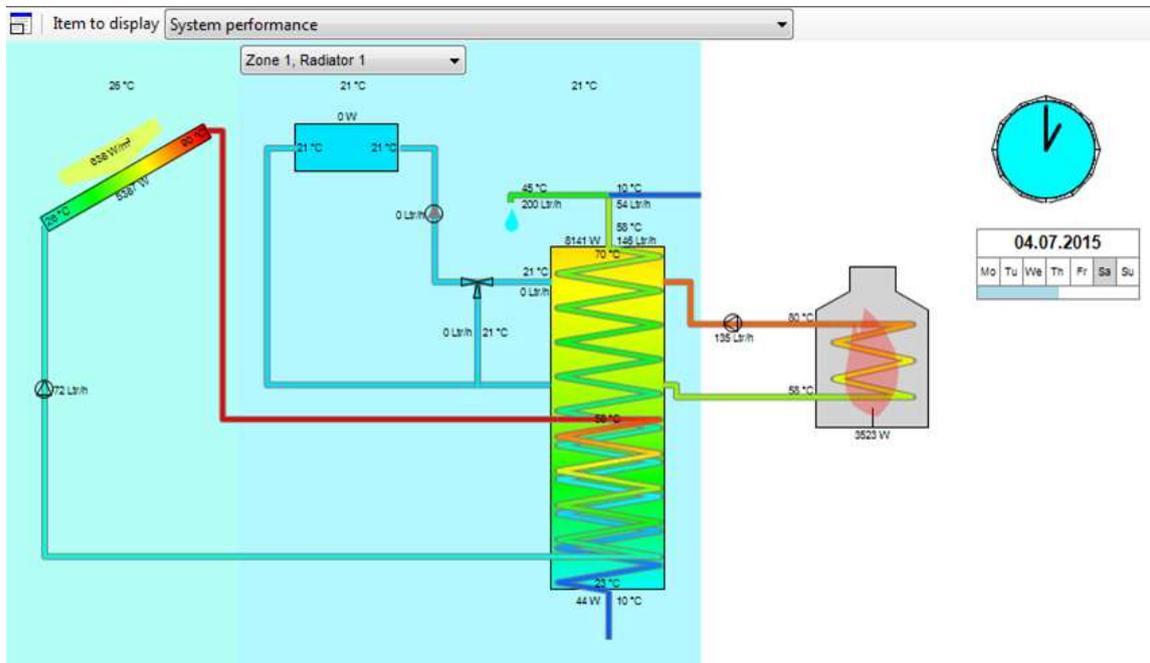


Figure 59:  
Visualization of a predefined HVAC-system during a simulation.

After a simulation, results for heating, cooling, humidification and dehumidification demand can be accessed through graphs in case or zone results, as described in chapter 8.2 and 8.3. The figure below shows an example. For working with "Graphs", please refer to chapter 9.2 and for editing "Graphs" refer to chapter 9.7.

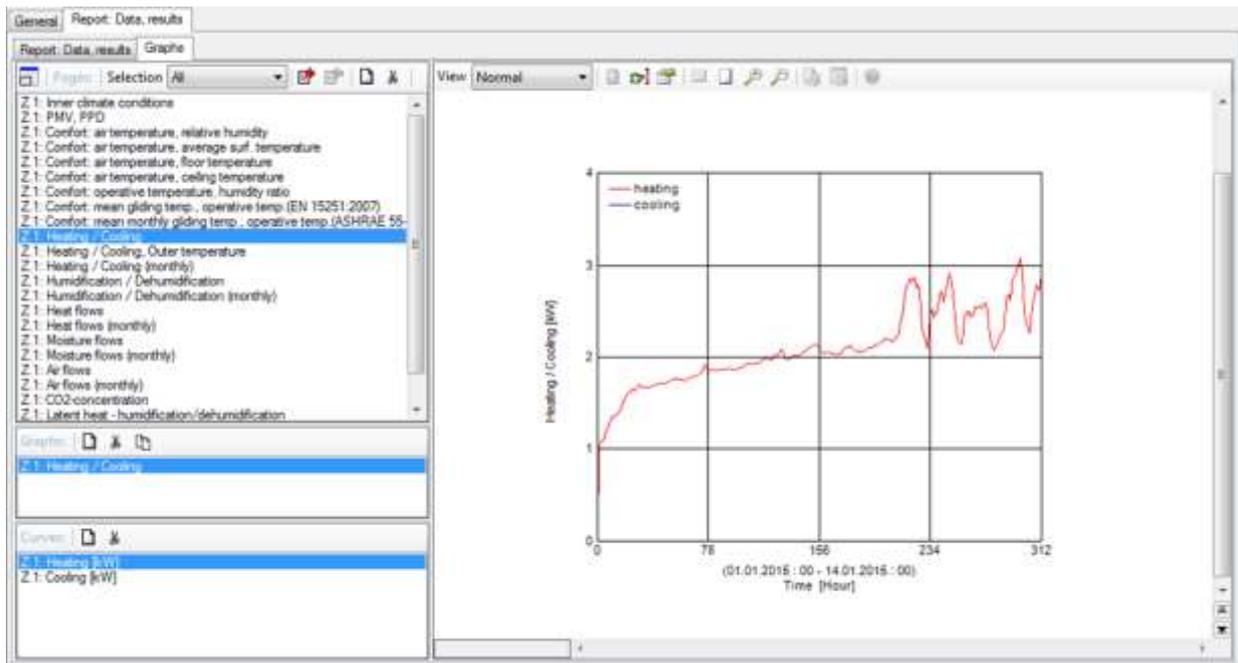


Figure 60:  
Graphs for heating and cooling demand found in Zone-Results.

For the predefined HVAC-systems further results are available as graphs, like for example boiler or radiator temperatures. They can be accessed by selecting the HVAC-system in the "Project Tree" and switching to the "Results"-tab. A report with the main results is available, too. The visualizations of the detailed HVAC-systems can also be re-watched as a film in the respective tab.

## 9.6 Results of 3D Objects

During a calculation temperature distribution inside a “3D Object” can be observed by the user in viewing direction of all axes and for all divisions, see figure below. If “smooth” is checked, the display of the distributions is smoothed during the calculation, however this has no effect on the results.

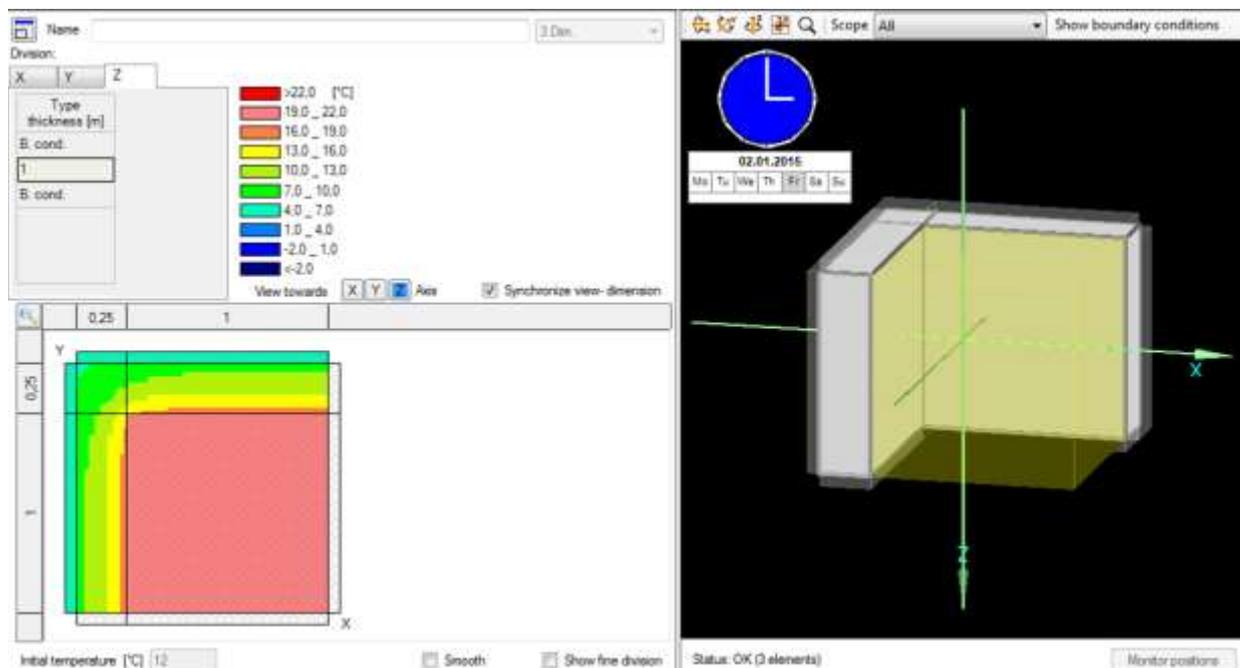


Figure 61:  
Visualization of a 3D-Object during calculation.

After a calculation only the results of the user-defined “Monitor Positions” can be used for further analysis. They can be found in the “Case”-Results under the “Graphs”-Tab. Also, they can be exported with the “Export”-Function, described in chapter 9.8.

## 9.7 Editing the Results Graphs

The results graphs show predefined data visualizations of calculation results. However, they can be customized. Double-clicking on a results-graph opens the "Edit diagram"-window, as in this figure:

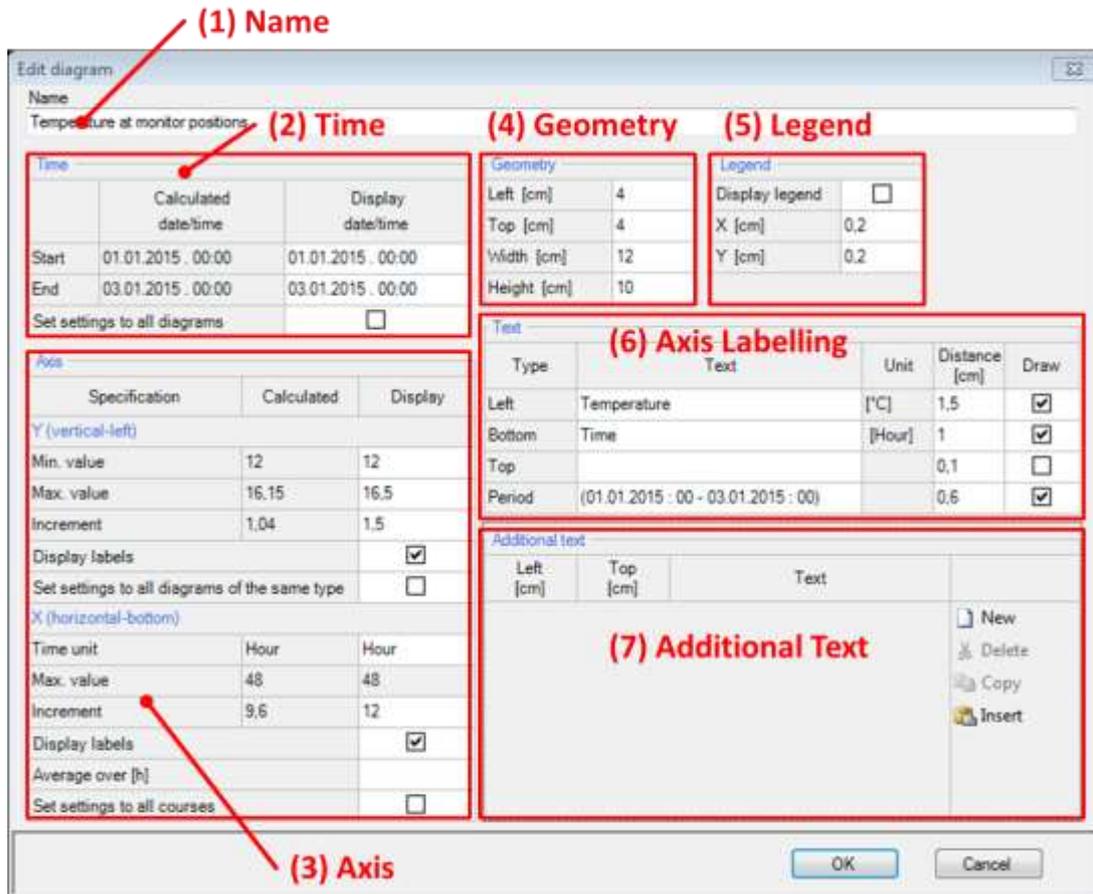


Figure 62:  
Edit diagram window.

## Controls

- |                     |  |
|---------------------|--|
| <b>(1) Name</b>     | Name of the plot. Is shown in the "Graphs"-Box, described in chapter 9.2.  |
| <b>(2) Time</b>     | Controls the timeframe which is plotted.                                   |
| <b>(3) Axis</b>     | Specifies the axis settings, e.g. minimum and maximum values or increment. |
| <b>(4) Geometry</b> | Controls the size of the plot.   |

<b>(5) Legend</b>	Controls if a legend is plotted and specifies its location.
<b>(6) Axis Labelling</b>	Modifies the Axis Labels.
<b>(7) Additional Text</b>	Includes additional annotations at user-defined positions.
 <b>New</b>	Create a new element in this list.
 <b>Delete</b>	Delete the selected element.
 <b>Copy</b>	Copy the selected element.
 <b>Insert</b>	Insert a copied element.

## 9.8 Reports

WUFI® Plus comes with a large selection of predefined reports that can be printed or exported. The table at the end of this chapter summarizes and describes all available reports of the main calculation scope. For Passivehouse verification and DIN 4108-2 calculations additional reports are available. Reports can be accessed by clicking on the "Report: Data, results" tab on a corresponding element of the "Project Tree", as in this figure:

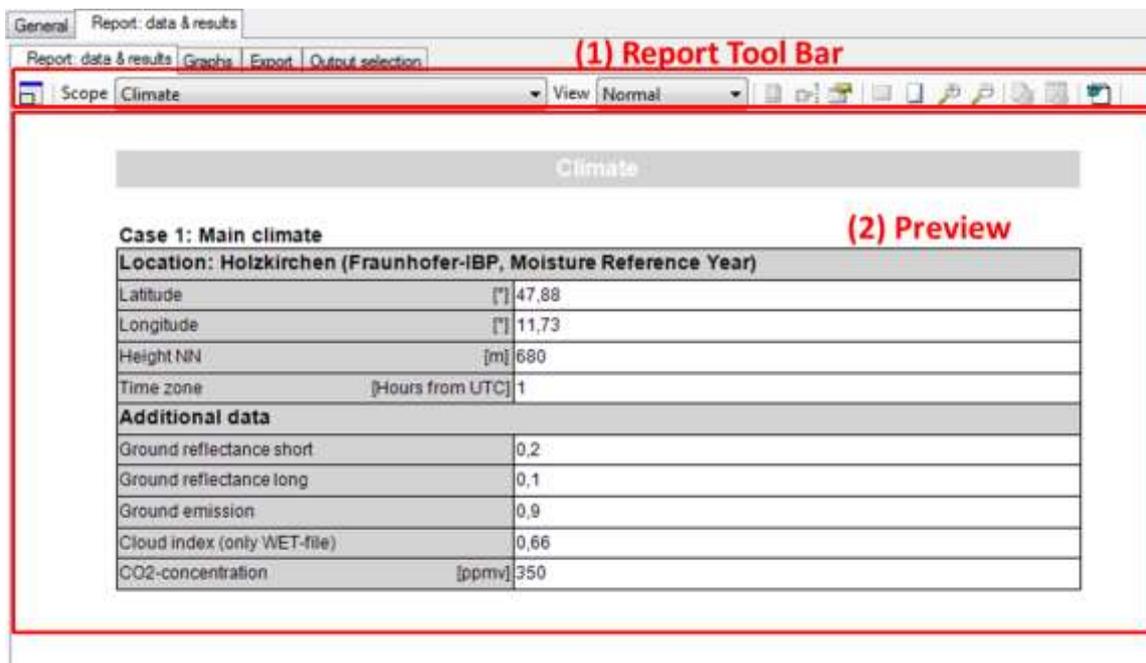


Figure 63:  
Report dialog.

### Controls

#### (1) Report Tool Bar

This tool bar allows selecting, modifying, printing and exporting individual reports. The buttons in this tool bar are explained below.



#### Expand/ Shrink Window

Allows expanding the "Report Box".

#### Scope

Allows switching through different types of reports. The table at the end of this chapter lists all available reports.

#### View

Allows changing between two options:

- "Normal": The standard report viewer in WUFI® Plus.
- "Print layout" shows how the report will look, when it's printed.

	<b>Page Setup</b>	Defines the page layout. Only available if "View" is set to "Print Layout".
	<b>Scope/ Sequence</b>	If a "User defined" report is selected it can be customized with this button.
	<b>Options</b>	Settings for the appearance of the report.
	<b>Whole width</b>	Zooms on the whole width of the report in the Preview Box (2).
	<b>Whole page</b>	Shows the whole page in the Preview Box (2).
	<b>Zoom in/ out</b>	Zooming in or out in the Preview Box (2).
	<b>Print all</b>	Prints the current report with the default printer. Only available if "View" is set to "Print Layout".
	<b>Print dialog</b>	Opens a standard Windows printer-dialog, where the printer and its properties can be selected. Only available if "View" is set to "Print Layout".
	<b>Word Export</b>	Saves the report as an Microsoft Office (2007+) .docx-file. A standard Windows save-dialog opens and the file can be named.
	<b>(2) Preview</b>	Shows how the selected report looks like.

Table 1:  
Available reports in WUFI® Plus.

<b>Case</b>		
	"Project Data"	Summarizes the information entered in the "Project Information", see chapter 4.1.
	"Climate"	Summary of location and settings made in "additional data", see chapter 4.4.
	"Conditioned Zones"	Summarizes general input data of all zones in the building, their design conditions, inner loads and components.
	"Assemblies"	List of all assemblies of opaque components in the building.
	"Material Data"	Gives a detailed report about all materials used in this case and their hygrothermal properties
	"Results"	Sums up the main results of the whole building.
	"HVAC"	Summary of input data of HVAC system.
	"User defined"	Allows a custom combination of the previously described reports.
<b>Conditioned Zone</b>		
	"Input Data"	Summarizes general input for a specific zone, its design conditions, inner loads and components.
	"Assemblies"	List of all assemblies of opaque components in a specific zone.
	"Material Data"	Gives a detailed report about all materials used in this zone and their hygrothermal properties
	"Results"	Sums up the main results of a specific zone.
	"User defined"	Allows a custom combination of the previously described reports.
<b>Opaque Components</b>		
	"Input Data"	Summarizes general input for an assembly and shows its construction.
	"Material Data"	Gives a detailed report about the used materials in this component and their hygrothermal properties.
	"Results"	Sums up the main hygrothermal results of a component, solar radiation and shading.
	"User defined"	Allows a custom combination of the previously described reports.
<b>Transparent Components</b>		
	"Input Data"	Summarizes general input for a window and shows its parameters.
	"Results"	Summarizes results for solar radiation and shading.
	"User defined"	Allows a custom combination of the previously described reports.
<b>HVAC-Systems</b>		
	"Summary"	Summary of HVAC system.

## 9.9 Export

All calculation results and graph curves can be exported as text- or Excel-files with the dialog shown in this figure:

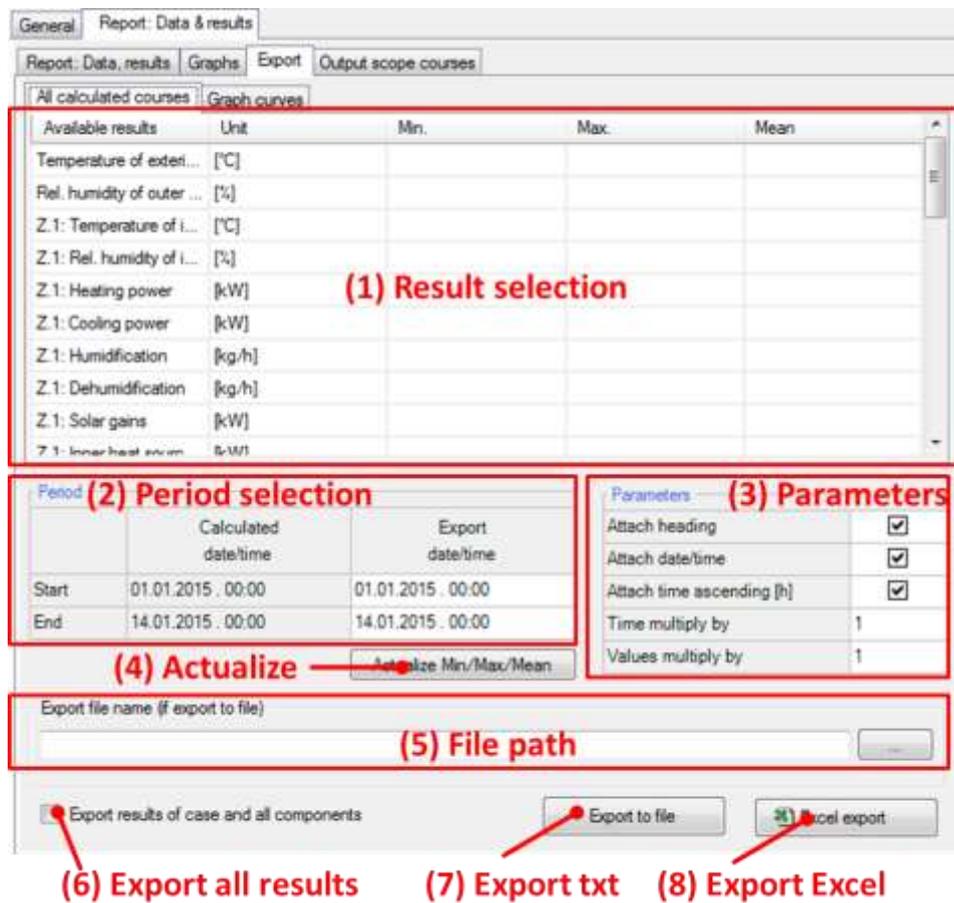


Figure 64:  
Export Results.

### Controls

- |                             |   |
|-----------------------------|---|
| <b>(1) Result selection</b> | Allows selecting specific results for the export. Multiple results can be chosen by holding the "Ctrl"-key and clicking on the desired results. |
| <b>(2) Period selection</b> | Allows the selection of a certain time period. Data will only be exported for this period.  |
| <b>(3) Parameters</b>       | Setting parameters for the file that will be exported.  |
| <b>(4) Actualize</b>        | If this button is clicked, the minimum, maximum and mean will be calculated for every results and shown in the result section (1).              |

**(5) File Path**

For exporting to a text-file, a path must be defined. This path must include the name of the file that will be exported. The path can also be selected with a standard Windows-dialog, that opens when the button on the right side is clicked.

**(6) Export all results**

If this option is check marked, the results of all cases, zones and components will be exported in one file.

**(7) Export txt**

Export the selected results as a text-file, which is saved in the directory specified in (5).

**(8) Export Excel**

Export the selected results as to Microsoft Excel. Excel will open as soon as all results are exported.

## 10 Batch Mode

WUFI® Plus can be executed from the command line, so multiple projects can be processed automatically with an appropriate batch file. For example, this allows running extensive calculations such as parametric studies over the weekend.

Follow this syntax to call WUFI® Plus from the command line:

**“Path to WUFIplus.exe” “Parameters” “Path to Project File(s)”**

- The first element of the batch-file must be the path to the WUFIplus.exe. (Default: *“C:\Program Files (x86)\WUFI\masterWUFI\WUFIplus\WUFIplus.exe”*)
- After that, some options for the calculation can be adjusted through parameters, which are explained below.
- Then add the path(s) of the project file(s). Both “.mwp” and “.xml” projects can be used for calculations in batch-mode.
- Each of the elements explained above must be written inside quotation marks (“...”). They have to be separated by a space character.

### Parameters

**“C”**

Calculate all Project Files. After the simulations have finished, the results are saved in a “.res”-file and only the main results are exported in a separate “.txt”-file. This parameter is always necessary.

**“R”**

Export the simulation results for all zones and the selected components as “.txt”-files after the simulations have finished. The “.txt”-files are saved in the same folder as the WUFI® Plus Project File. The data saved in the “.txt”-files can be adjusted in the *“Output selection”*-tab, as shown in the figure below. Calculation results of components are only exported if *“Retain calculation results”* is activated, as explained in chapter 5.1.11. The result output of components can be adjusted in the *“Options”* of WUFI® Plus, see chapter 3.2.3 for further information.

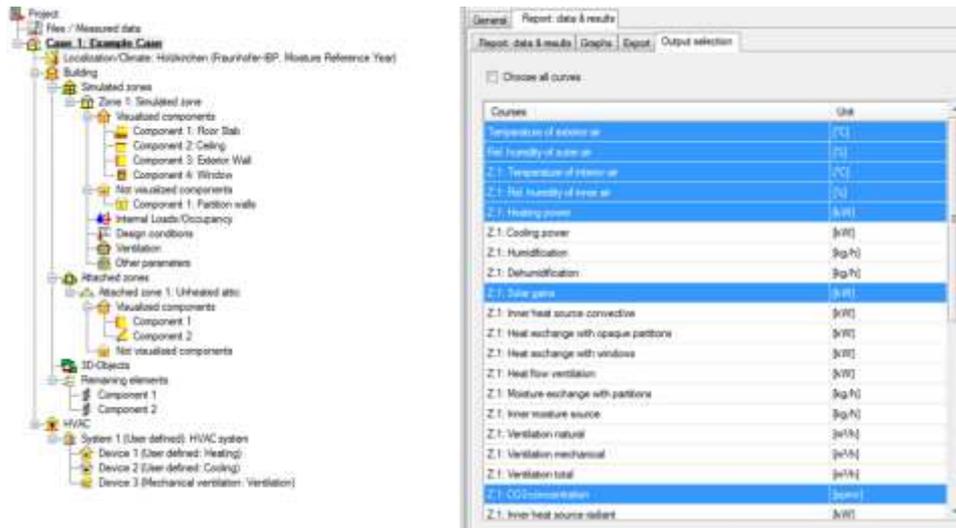


Figure 65:  
Output selection for Batch-Mode.

This example shows how a batch-file for WUFI® Plus looks like:

```

"C:\Program Files (x86)\WUFI\masterWUFI\WUFIplus\WUFIplus.exe"
"C" "R" "D:\MyProject1.mwp" "D:\MyProject2.xml"

```

## 11 Example Case

This example provides a step by step guide on how to input and calculate a case.

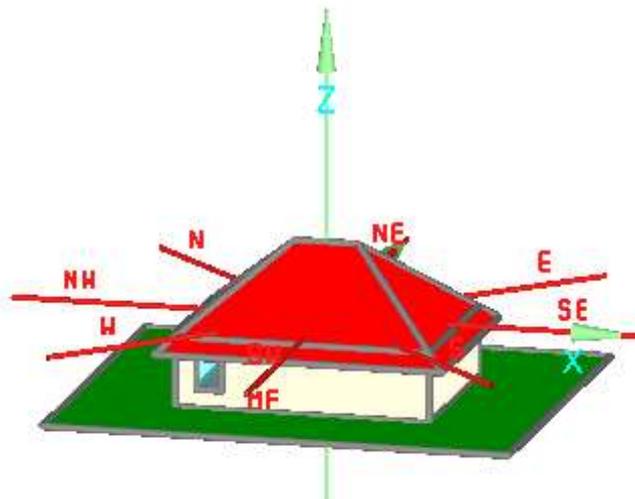


Figure 66:  
Visualization of the example case.

Additional information:

- Measurements:
  - Footprint: 12.0 m x 9.0 m
  - 1 story, height 2.8 m, slab on ground
  - roof inclination 40°, hipped roof
- Used as an office building. Occupied from Monday until Friday from 8 am to 5 pm with 3 persons. No usage on weekends.
- Heating & Cooling systems
- Mechanical Ventilation
- Located in Holzkirchen, Germany



A tutorial video on our WUFI®-Wiki ([www.wufi-wiki.com](http://www.wufi-wiki.com)) shows how this example was created.

WUFI® Plus comes with a project file of this example. It can be found the "Projects" folder of the main installation directory of WUFI® Plus.

## 11.1 Step 01: Creating a new project

Start a new project by clicking the “*New project*”-button (1). Then open the “*Case*”-dialog (2) and enter general settings for the simulation: Give a significant name (3) and adjust the start and end date for the calculation (5) so that the simulation time is one year. In this example we use the hygrothermal calculation mode, make sure that this option is set (4).

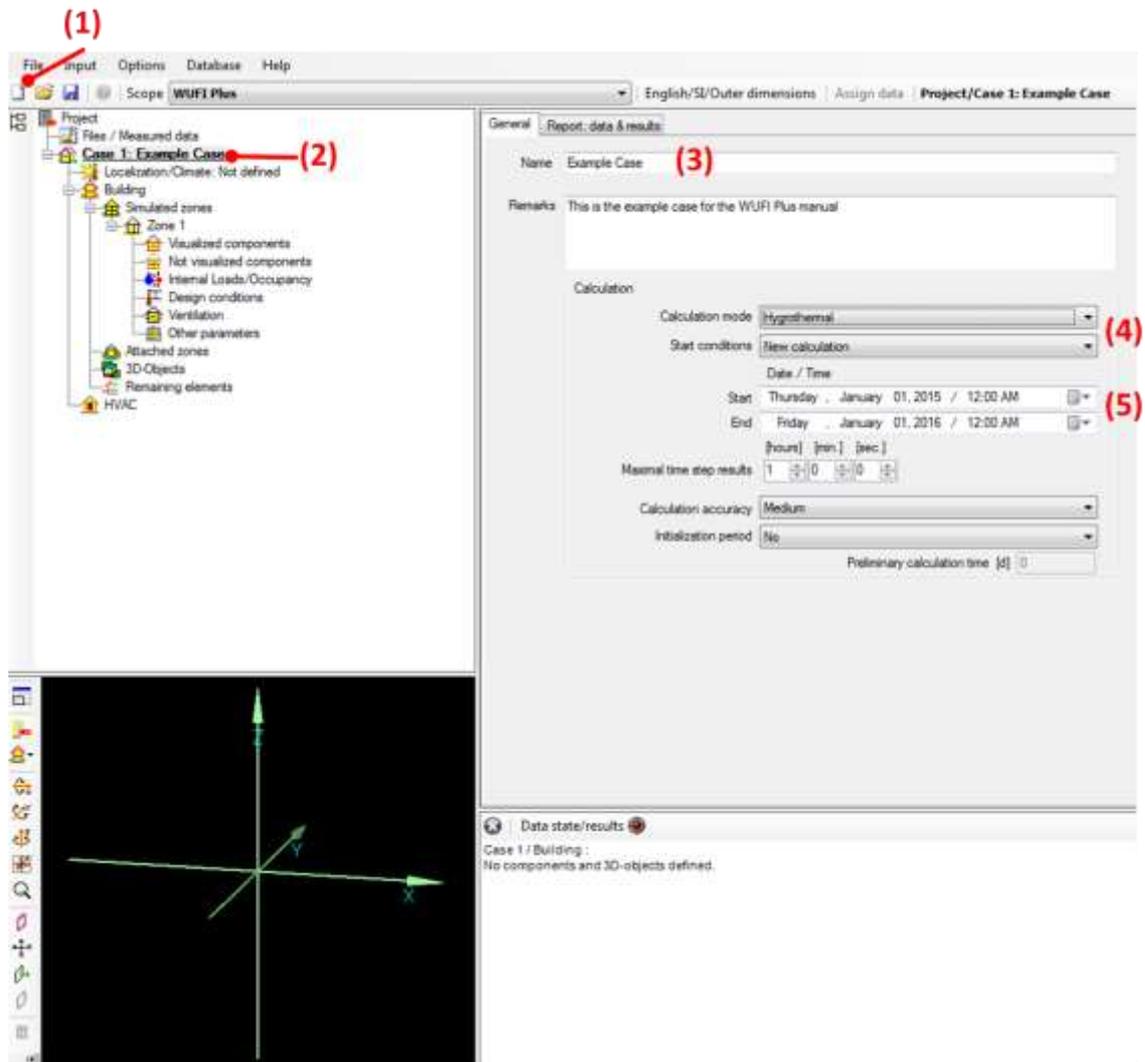


Figure 67:  
Example Case Step 01: Create a new project

## 11.2 Step 02: Defining climatic conditions

In the second step we adjust the outdoor climatic conditions in the “*Localization/ Climate*”-dialog. In this example we use a climate file from the WUFI® Database, which can be opened by selecting “*From map (database)*” (1) and then clicking the “*Browse*”-button (2). In the “*Database*”-Window select the “*Moisture Reference Year*” for the location “*Holzkirchen*” in Europe (4). The database can easily be searched by name with the “*Search pattern*” (3).

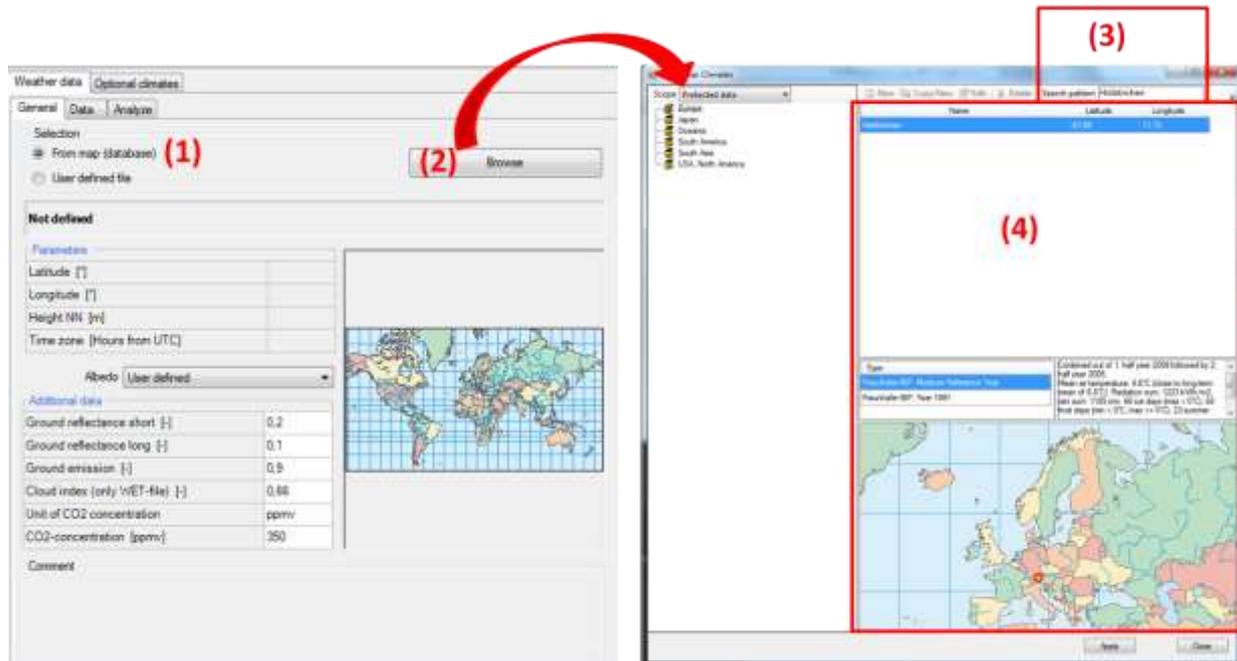


Figure 68:  
Example Case Step 02: Select location and outdoor climate.

After the outdoor climate was selected a summary of temperature, moisture, radiation and rain can be seen in the “*Data*” and “*Analyze*”-tab.

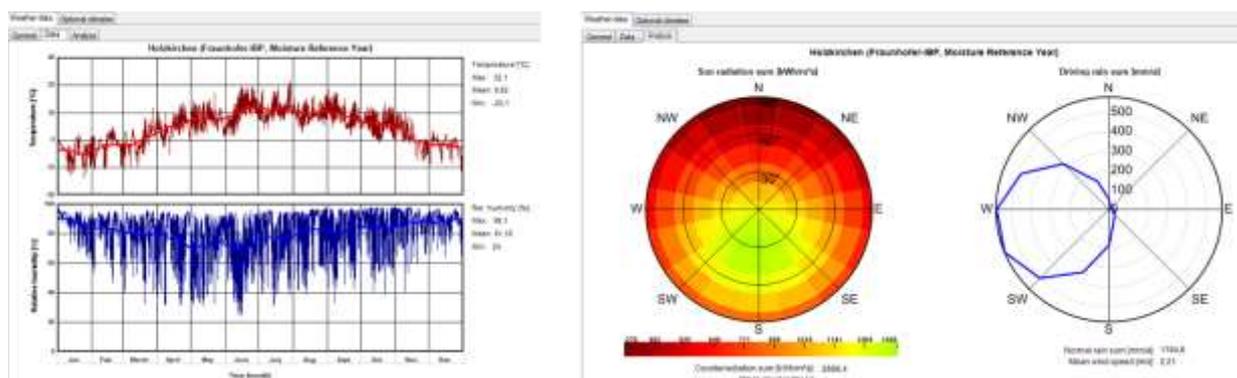


Figure 69:  
Example Case Step 02: Visualizations of the selected outdoor climate.

Furthermore an optional climate has to be defined which represents the soil climate in this example. It will be applied to all components in contact with the

ground. An optional climate can be defined in the “Optional Climates”-tab (1) by clicking the “New”-button (2). Now its type has to be selected (3). Sine curves are a good way to describe the soil climate, so we use this type and give it an appropriate name (4).

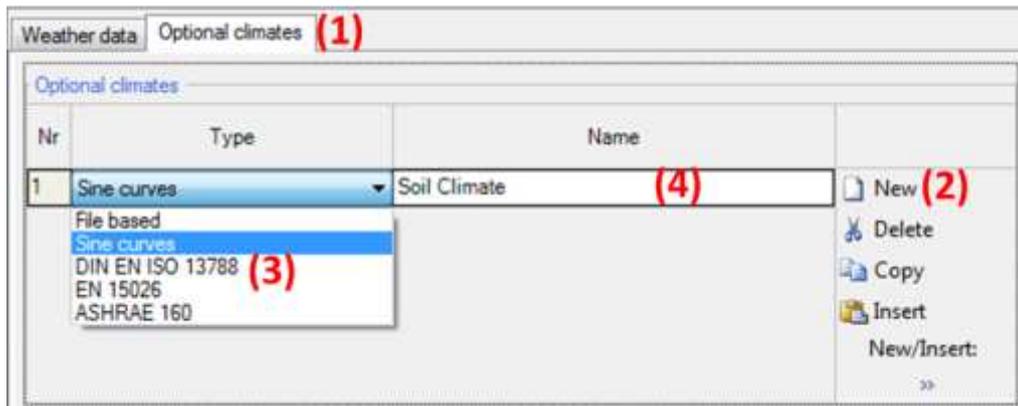


Figure 70:  
Example Case Step 02: Define an optional climate

As none of the preset sine curves represent soil climate, we define a “User defined sine curve” (1) and enter these values (2):

- Temperature: sine curve; mean value 6 °C; amplitude 5.5 K; day of maximum 16<sup>th</sup> of August.
- Relative Humidity: constant; mean value 99 % RH.

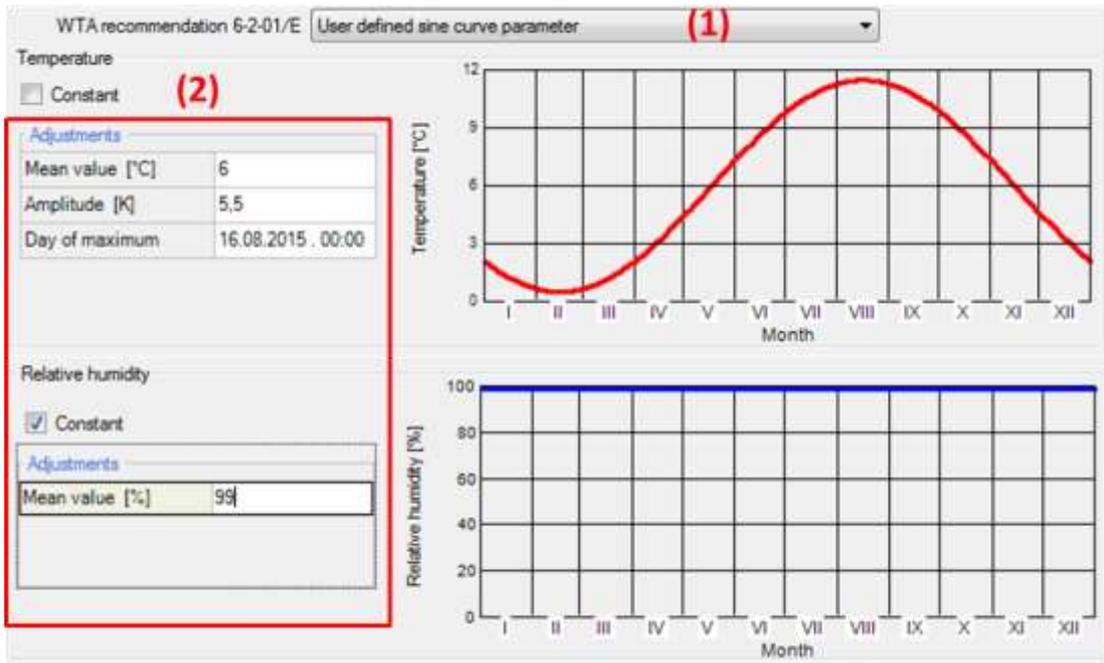


Figure 71:  
Example Case Step 02: Parameters of optional soil climate

Please note that the values entered in this dialog depend strongly on your selected location and therefore should not be used in other projects.

### 11.3 Step 03: Creating building geometry

In this example we use the "Building Wizard" to create the geometry of our building. This is one of multiple options to enter a building geometry into WUFI® Plus, please refer to chapter 4.5.1 for further information about the other ones.

Start the "Building Wizard" by clicking on the respective button in the "Building"-dialog. The example building has a rectangular footprint, an unheated attic and a slab on ground. The orientation of the main-facade is south-west. This information can be entered into the "Building Wizard" together with the associated measurements:

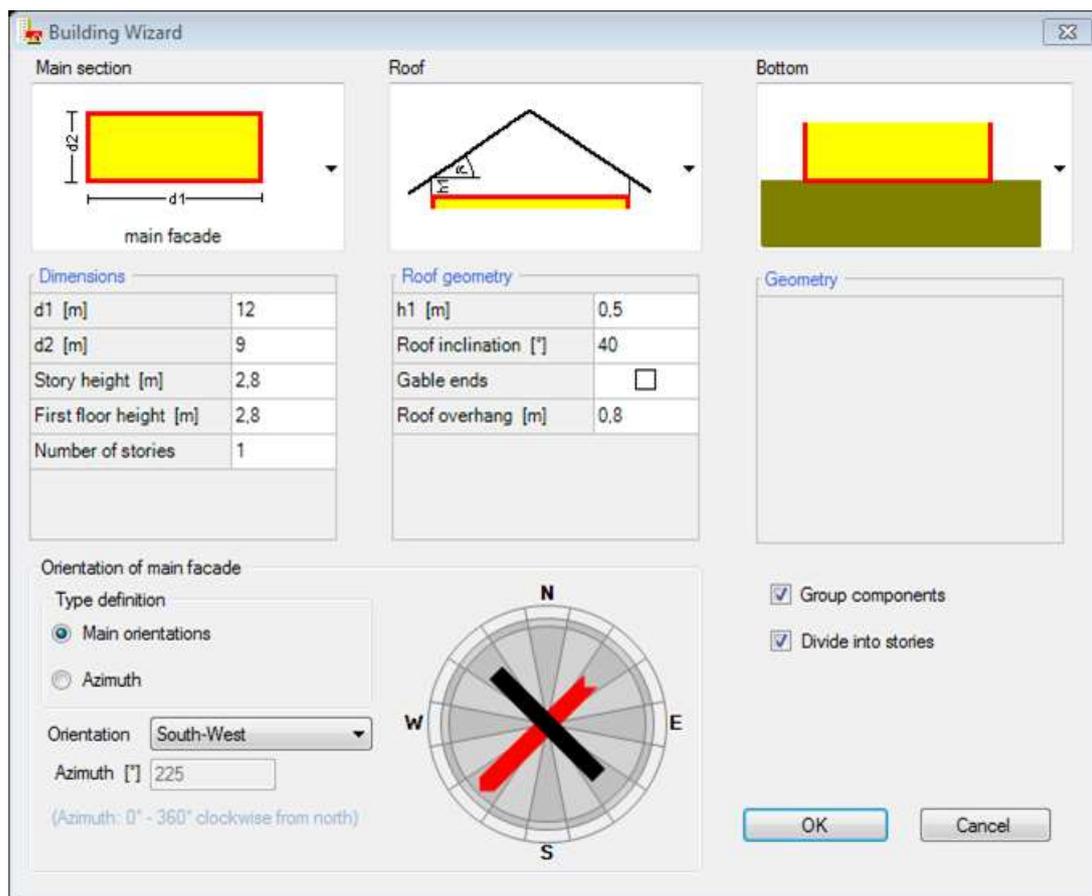


Figure 72:  
Example Case Step 03: Building wizard

Close the "Building Wizard" with the "OK"-button and the geometry of the building is created automatically: All zones and components are generated according to the input in the "Building Wizard" and can be selected in the "Project Tree". Also, a 3D-visualization is shown in the "Visualization Box".

No advanced calculation options will be used in this example. So no user input is necessary in the "Numerics"-tab of the "Building"-dialog. Only the checkbox for "Include shading calculation" should be check marked.

## 11.4 Step 04: Including a window

In this step a window is included into the south-western wall of the example building. To create a window select the respective wall in the "Visualization Box", check its normal vector as described in chapter 3.4.2 and then click the "Windows/ Openings"-button:

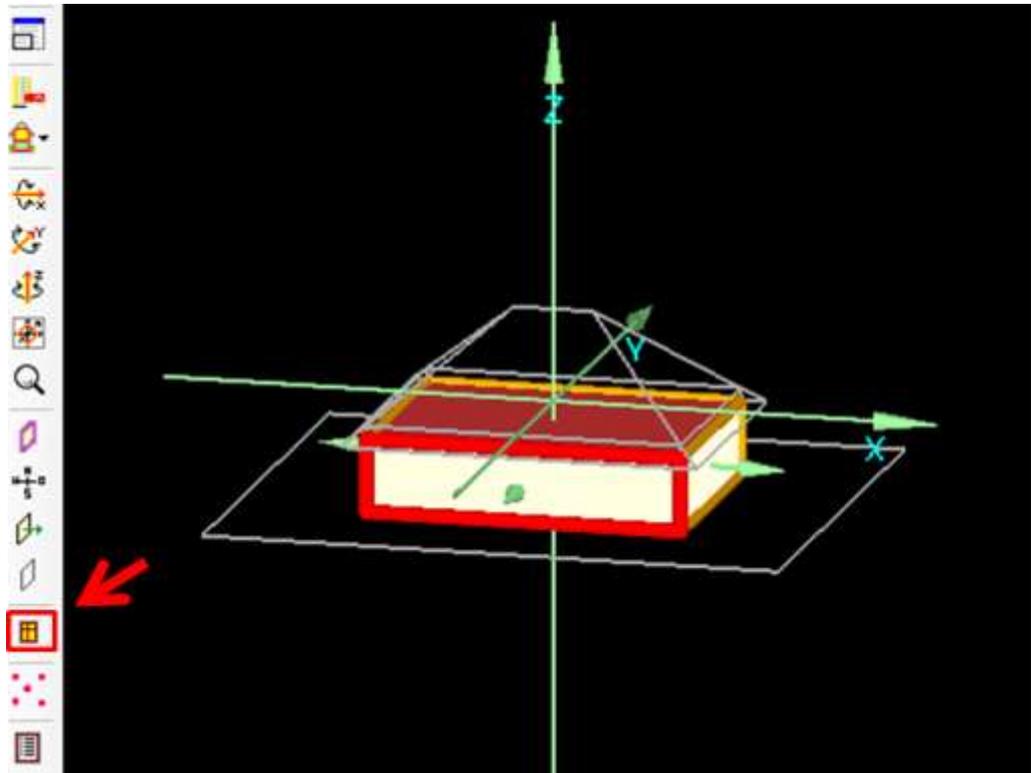


Figure 73:  
Example Case Step 04: Starting the "Windows/ Openings"-dialog from the "Visualization Box".

The "Component openings"-dialog opens. First, check the direction of the view on the component (1), to ensure that the entered window appears in the desired place. The view-direction can be switched with the "Change View"-button (3). In this example, we use the view from outside. Next, click the "New"-button (2) to add the type (4), position (5) and size (6) of the window in this wall. Confirm your input with the "OK"-button and the new window is inserted in the wall and appears both in visualization and the "Project Tree".

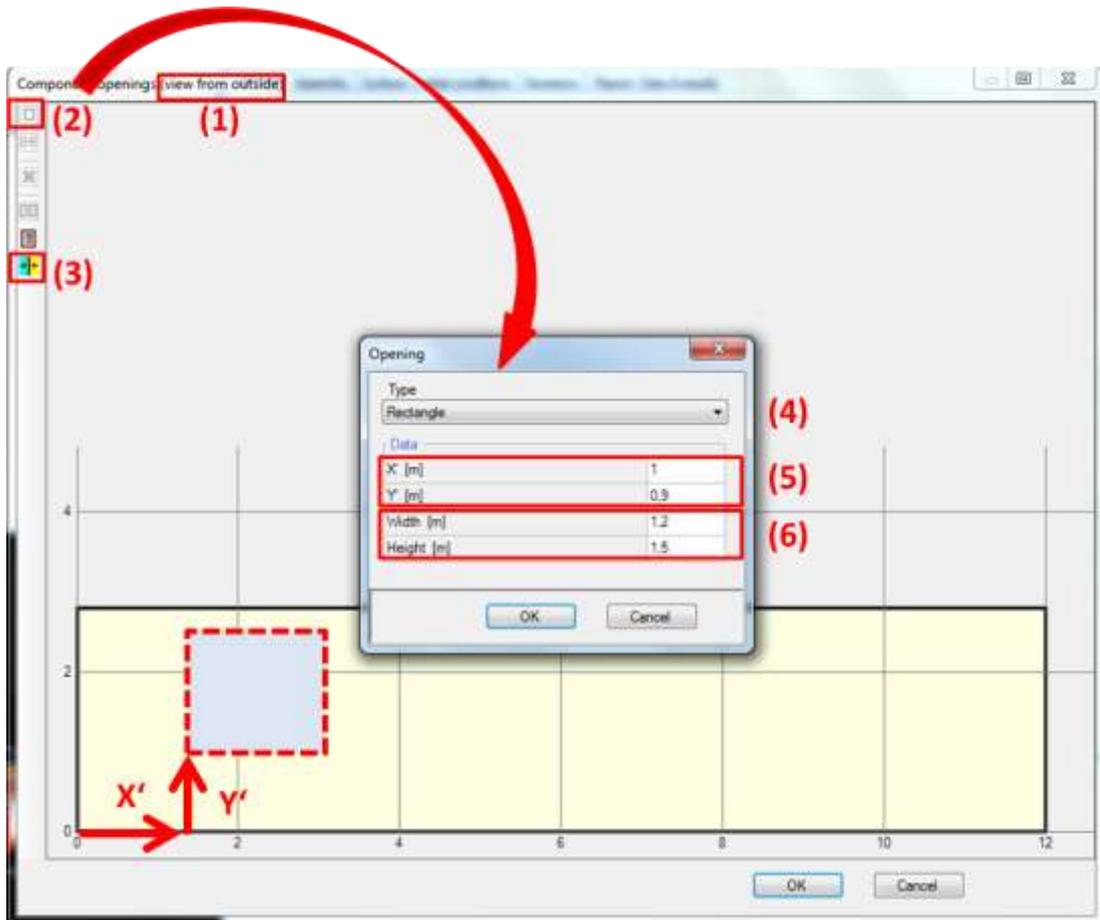


Figure 74:  
Example Case Step 04: Including a window.

No other windows are included in this simple example.

## 11.5 Step 05: Defining the visualized components

The example building consists of four visualized components that surround the simulated zone: Floor slab, ceiling, exterior wall and the window. In this step we define the assemblies and additional parameters of these four components.

### 11.5.1 Exterior Walls

We start with the exterior walls. Select the component in the "Project Tree" (1) and its general information is shown. Enter a significant name (2) and check if the type and attachments on the inner and outer sides (3) are correct. The name of the component appears also in the "Project Tree" to facilitate navigation in the project.

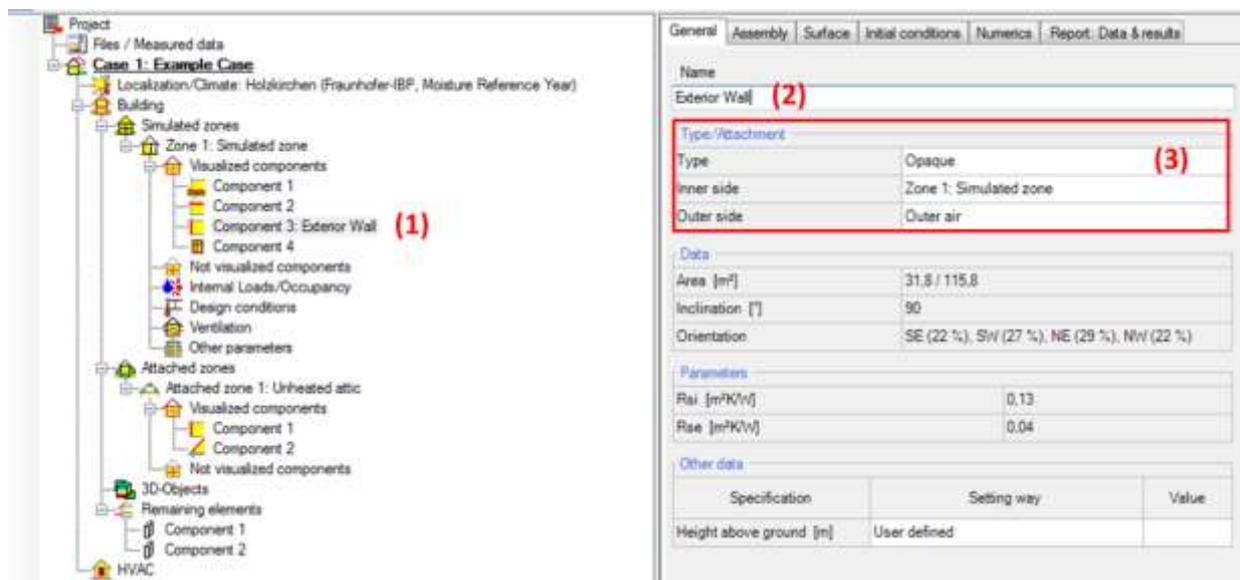


Figure 75:  
Example Case Step 05: General settings for the exterior walls.

Next, the assembly of the component has to be defined, so switch to the "Assembly"-tab. For this example, we use a predefined assembly from the WUFI® Plus Database, a lightweight timber framed wall. Click "Select from Database" (1) and the Database opens. Use the "Search pattern" (2) to find the desired assembly ("Lightweight timber framed wall"), as shown in the figure below. By clicking the "Apply"-button (3) the selected assembly from the database is applied to the exterior walls of our example.

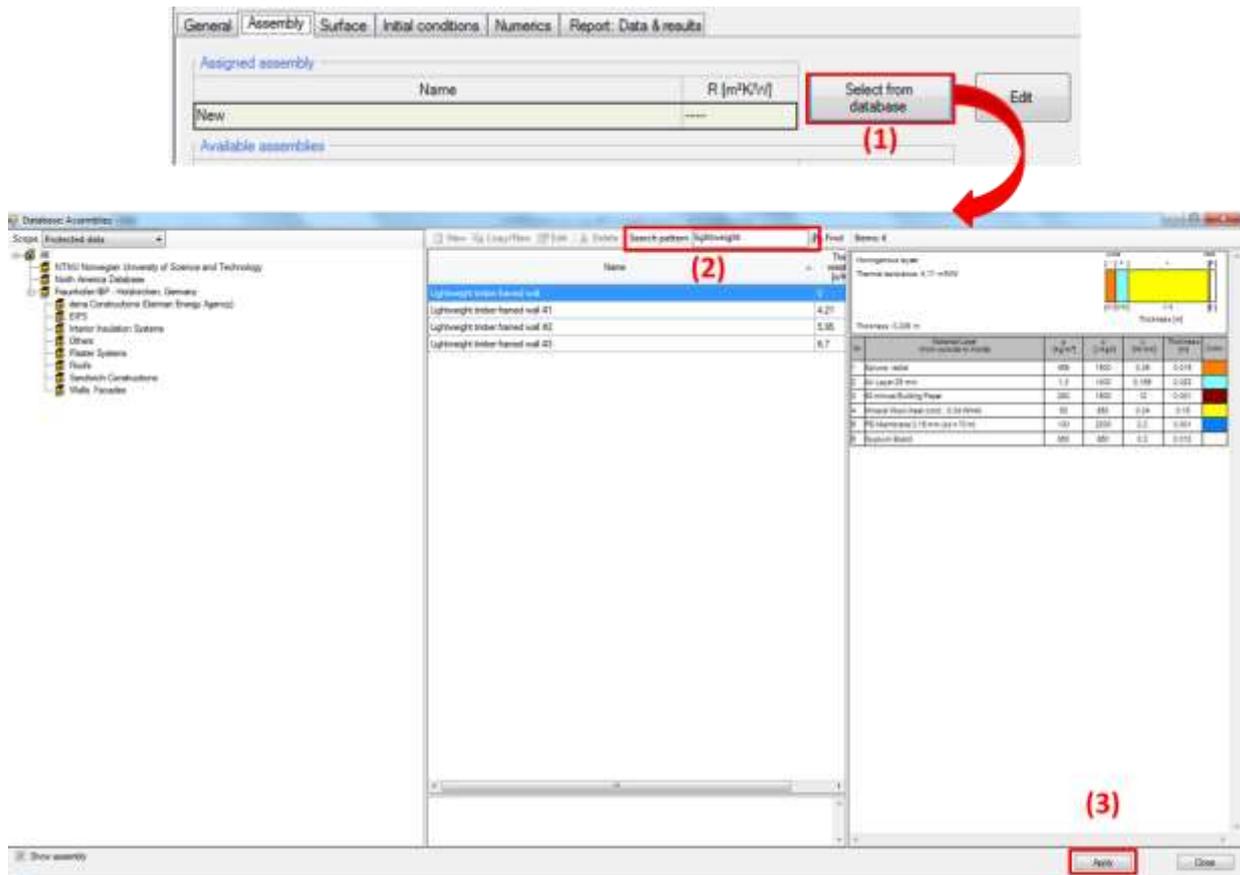


Figure 76:  
Example Case Step 05: Select an assembly from the WUFI® Plus database.

Settings for the hygrothermal conditions on the components surfaces can be defined in the "Surface"-tab. On the "Thermal" side we adjust the solar absorption and emission coefficients for the exterior surface and select predefined values for "Stucco, normal bright":

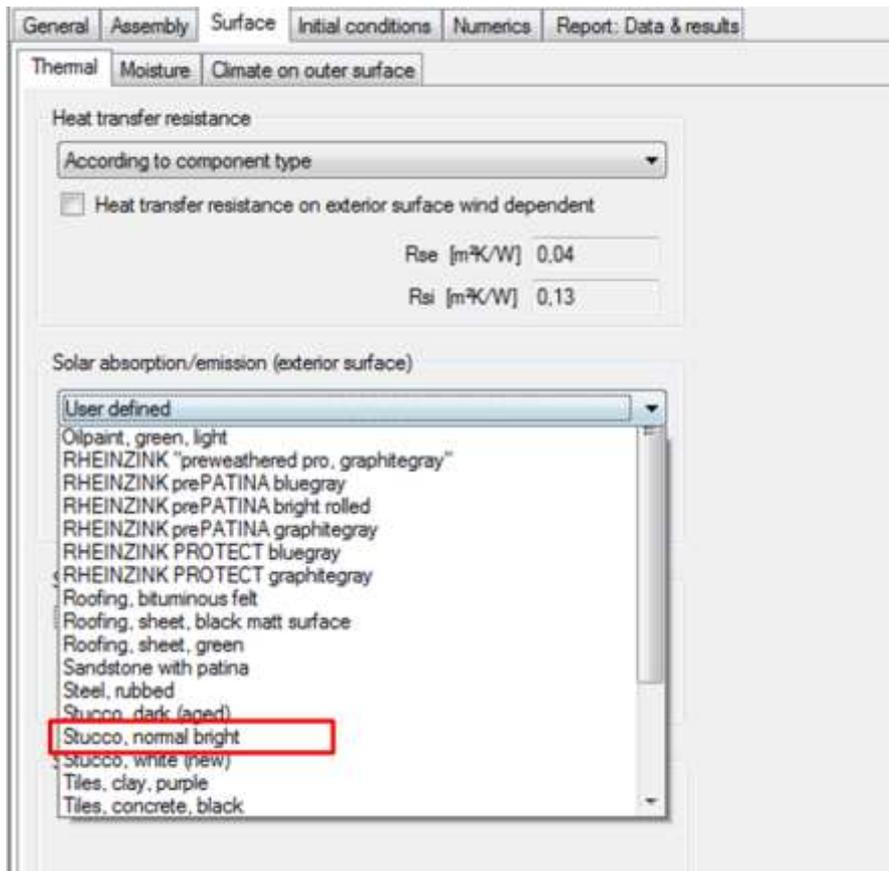


Figure 77:  
Example Case Step 05: Settings for the surface conditions of the exterior walls.

For this component, the surface conditions for *“Moisture”* and *“Climate on outer surface”* remain unchanged. Also, settings for the *“Initial Conditions”* and special calculation options in the *“Numerics”*-tab stay with their preset standard values.

In the *“Report: Data & results”*-tab the option *“Retain calculation results”* is check marked. Now WUFI® Plus saves all calculation results for this component and they can be evaluated after the simulation.

As we want to retain the calculation results for all other components of the simulated zone, too, we use the *“Assign data”*-function to set this option for them. This function saves time, as it allows setting certain parameters for a selection of other components automatically. Click the *“Assign data”*-button (1) in the *“Tool Bar”* and the *“Assign data”*-window opens as in the figure below. On the right side (3), all parameters are listed that can be assigned to other components, in this case, only *“Retain calculation results”* is listed. On the left side (2), all available components are listed. Select all components of the simulated zone, then click the *“OK”*-button and confirm in the next dialog, that the existing settings of the other components will be overwritten. Now, the calculation results of all components will be retained after the simulation.

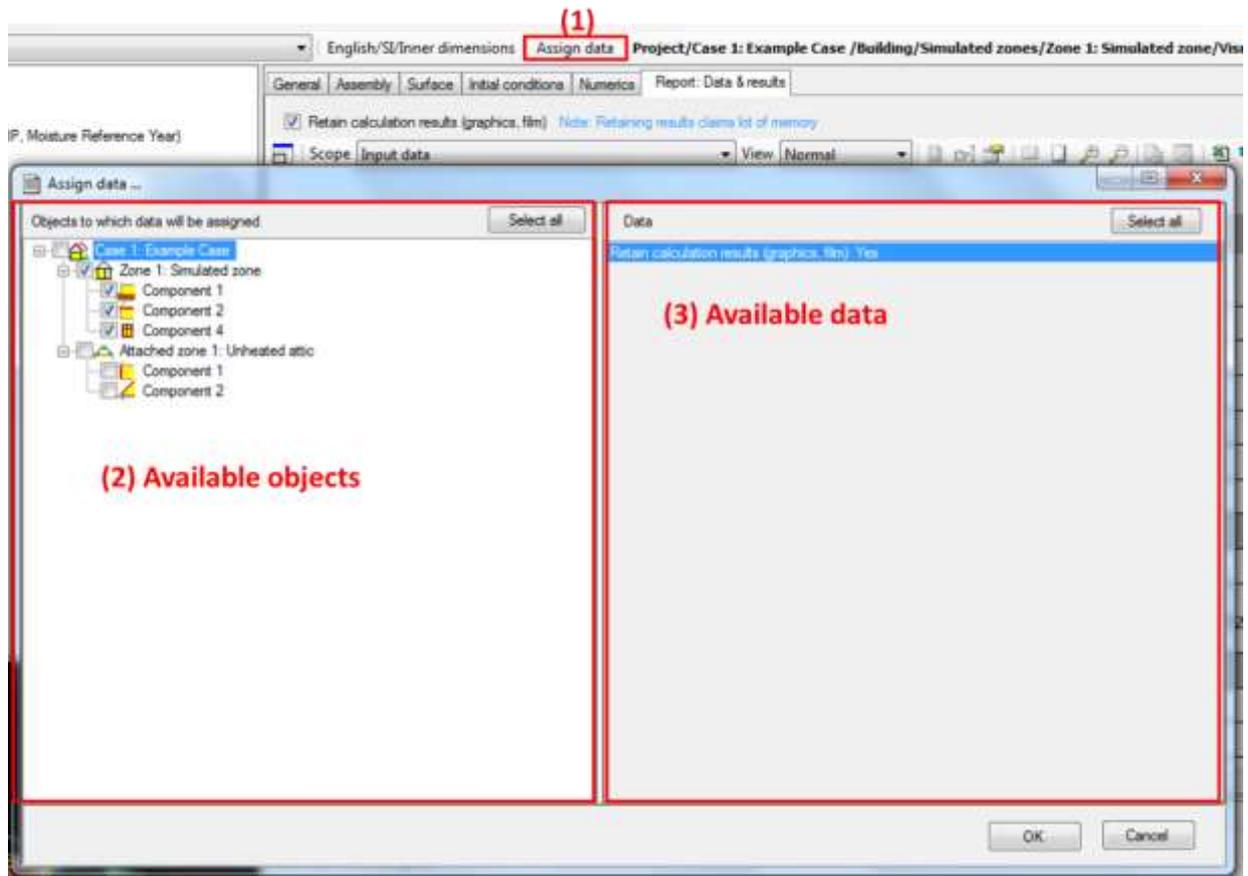


Figure 78:  
Example Case Step 05: Using the “Assign data”-function to retain calculation results of all visualized components.

The settings for the exterior wall are complete. Proceed with the next component.

## 11.5.2 Ceiling

The next assembly is the ceiling. We proceed in the same way as for the exterior wall: Name the component, check the type and the inner and outer attachments.

Again, use an assembly from the database. Search for "Flat Roof#1" and assign this assembly:

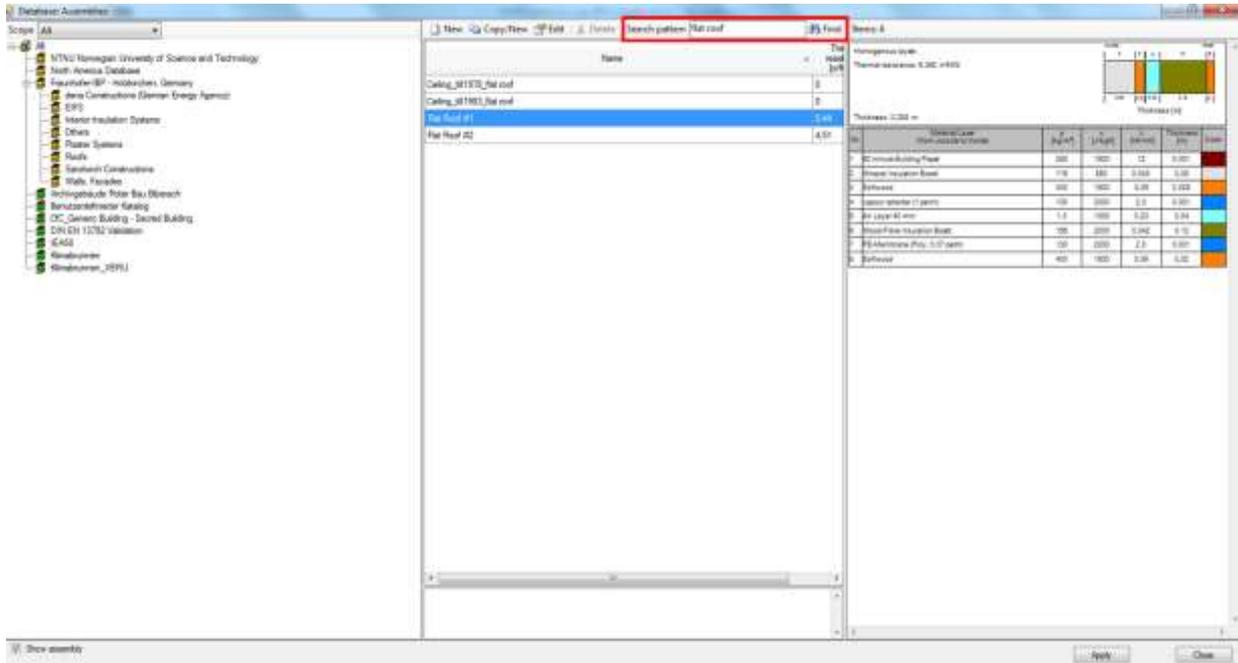


Figure 79:

Example Case Step 05: Select the assembly for the ceiling from the WUFI® Plus database.

All other settings for this component remain at their default values. As the "Assign data"-function was used before, the calculation results for the ceiling will be retained.

### 11.5.3 Window

For the window we proceed as before: First, naming and checking the data in the "General"-tab. Then select a window type from the database, which works the same as with the assemblies described before. Search for "Uncoated double glazing" and apply the window:

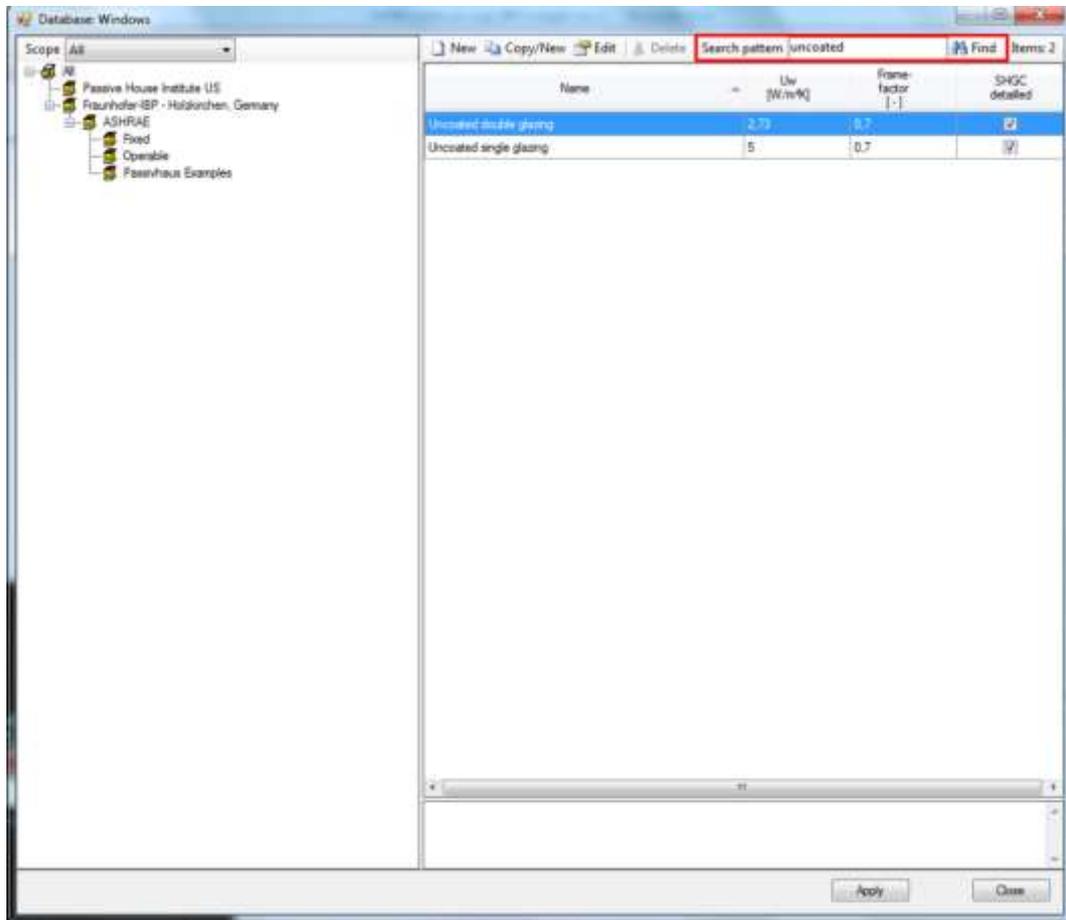


Figure 80:  
Example Case Step 05: Select a window from the WUFI® Plus database.

Window parameters can be altered by clicking the "Edit"-button in the "Window parameters"-tab. However, in this example the settings from the database remain unchanged. Also no settings are made in the "Surface"-tab and no solar protection is added.

## 11.5.4 Floor Slab

The last component is the floor slab. Name it and check the settings in the "General"-tab. This time no assembly from the database is used hence a new one has to be defined. Click the "Edit"-button in the "Assembly"-tab and the "Edit assembly"-window opens:

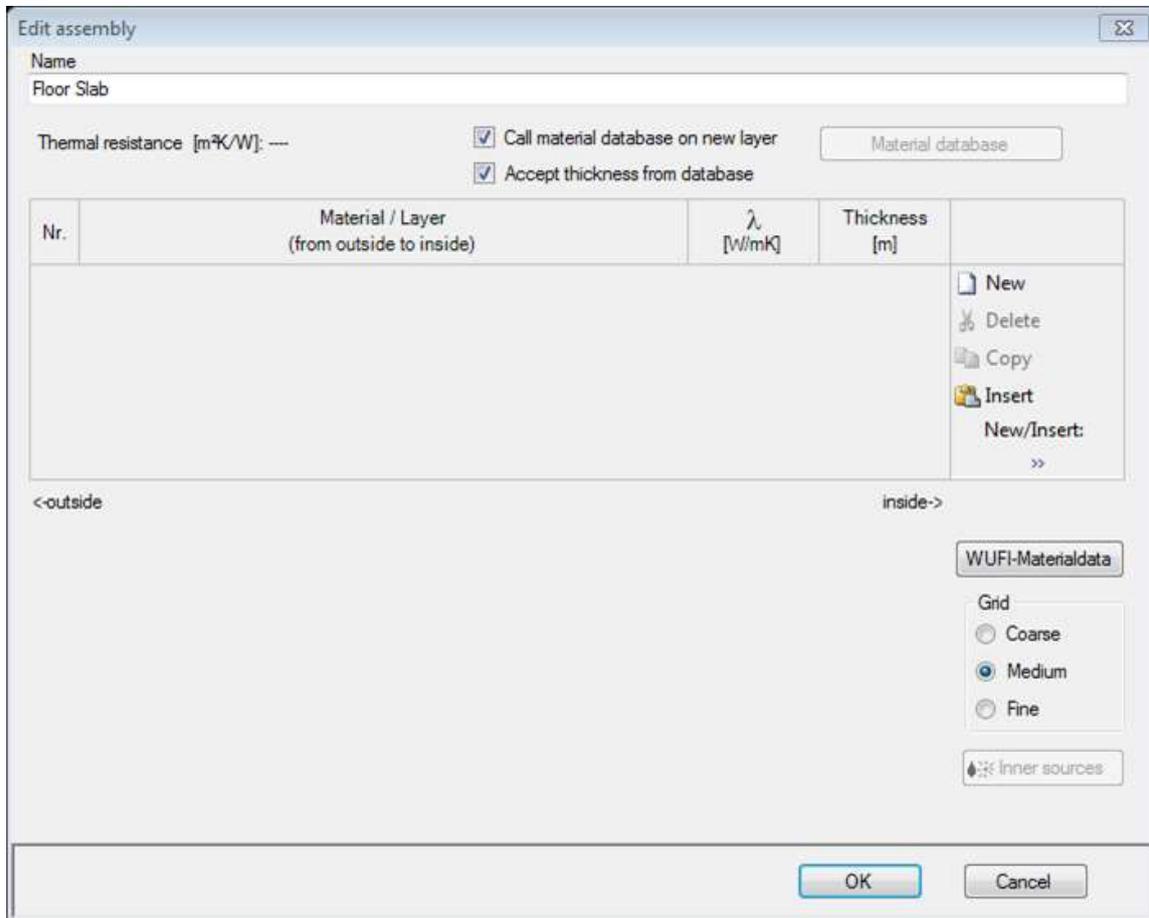


Figure 81:  
Example Case Step 05: Edit assembly dialog.

At first, name the assembly, in this case "Floor Slab" (1). Each assembly is built from different material layers. The construction of the exemplary floor slab is summarized in this table, starting from outside to inside:

Nr.	Material (as named in WUFI® Plus Database)	Thickness [m]
1	XPS Surface Skin (heat cond.: 0,03 W/mK)	0,010
2	XPS Core (heat cond.: 0,03 W/mK)	0,220
3	XPS Surface Skin (heat cond.: 0,03 W/mK)	0,010
4	PE-Membrane 0,2 mm (sd = 87 m)	0,001
5	Concrete, w/c=0,5	0,200

Click the "New"-button (2) to add a new material layer. The "Material Database" will open. Search for "XPS Surface Skin" and add this material to the assembly by clicking the "Apply"-button:

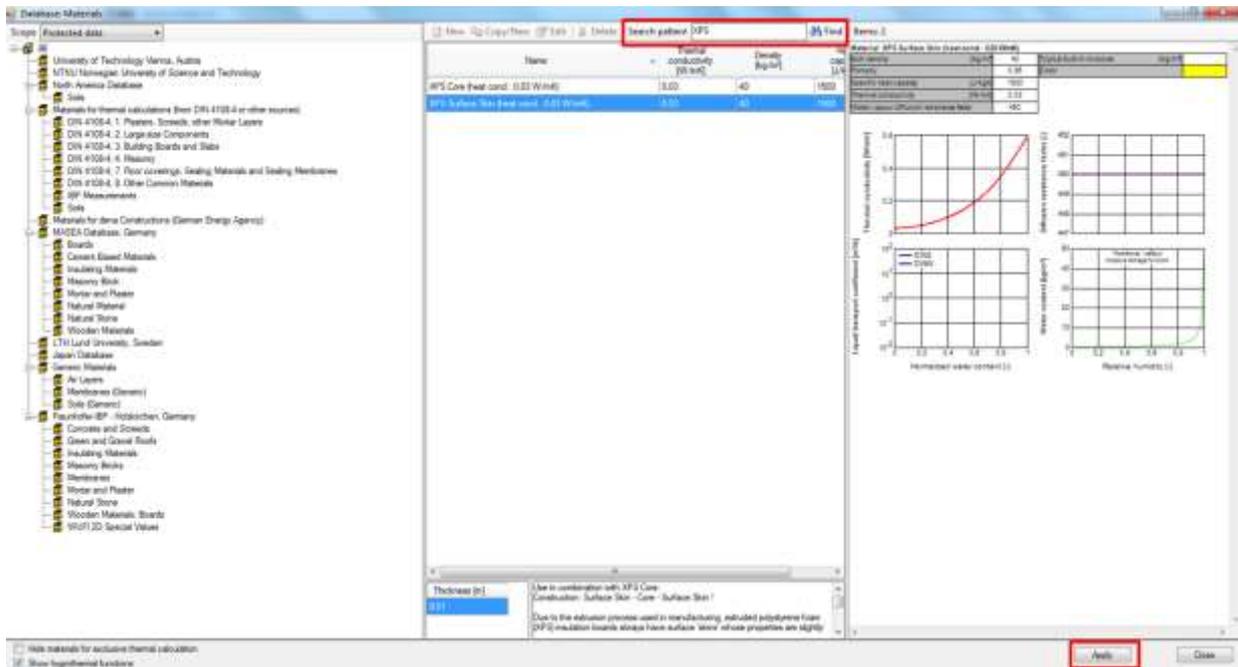


Figure 82:  
Example Case Step 05: Select a material from the WUFI® Plus database.

The material appears now in the "Edit assembly"-window. Check, if the thickness is entered correctly and alter it, if necessary:

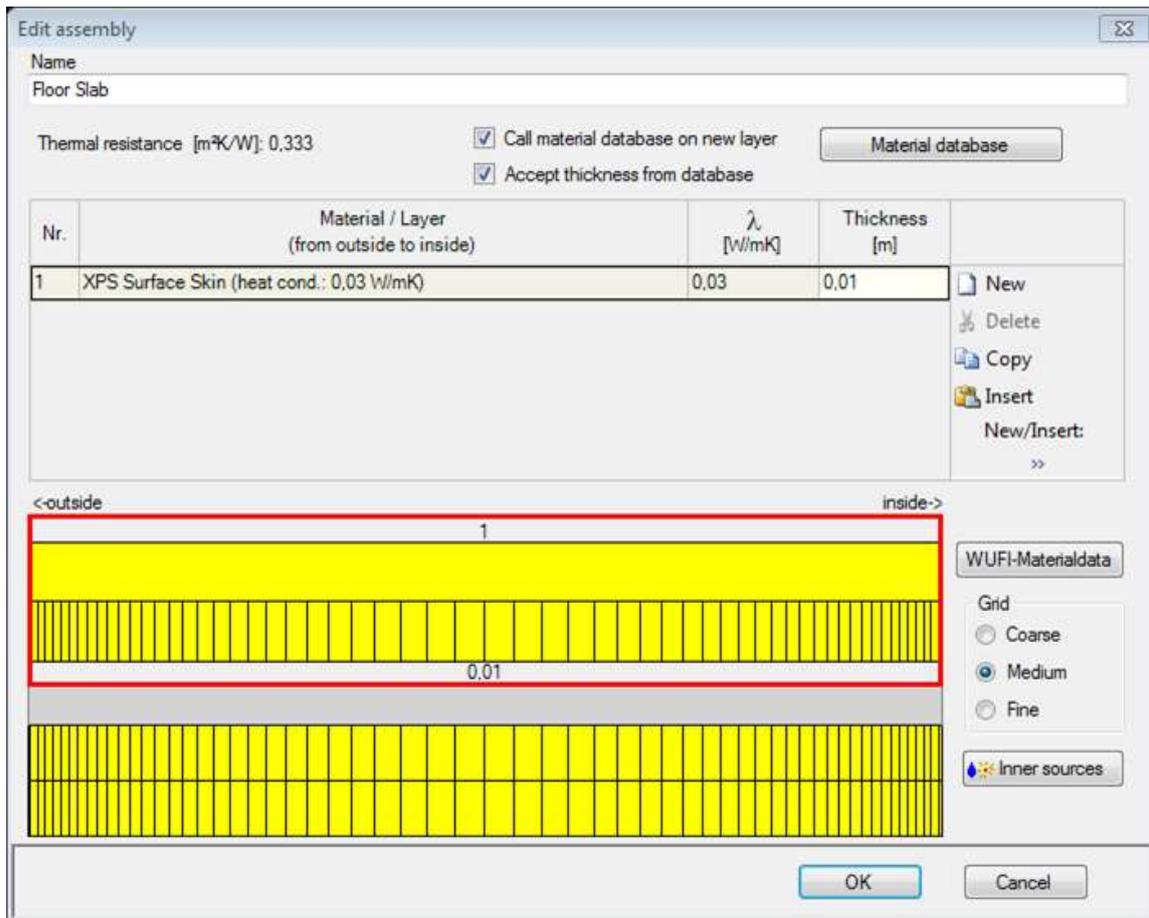


Figure 83:  
Example Case Step 05: Creating the assembly for the floor slab.

Proceed like this and add all other material layers. When finished, the assembly should look like this:

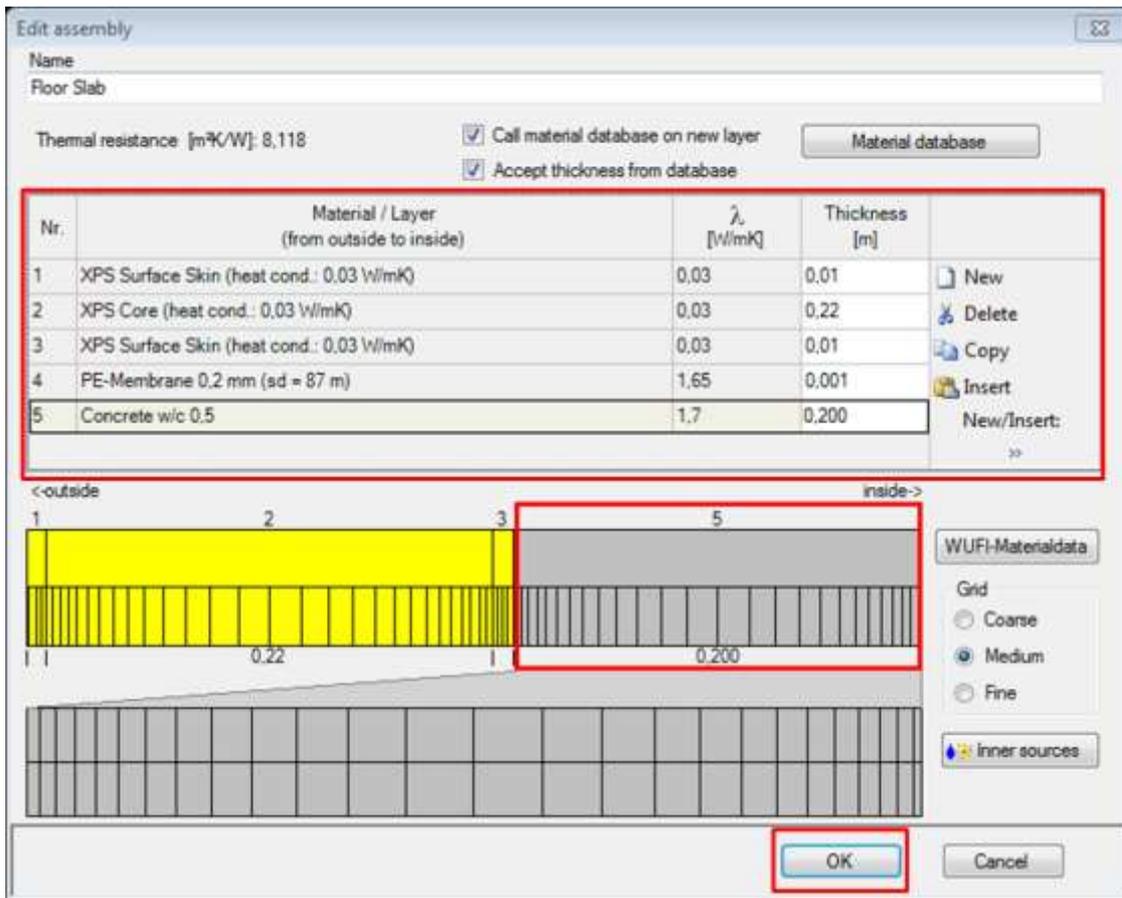


Figure 84:  
Example Case Step 05: Assembly for the floor slab.

Click the "OK"-button and the assembly is assigned to the component.

As the floor slab is attached to the ground on its exterior side, the climate on the exterior surface of the component has to be defined separately. This can be done in the "Surface"-tab under "Climate on outer surface". Click on the dropdown-menu besides "Optional Climate" and select the optional soil climate which was defined in Step 02 of this tutorial:

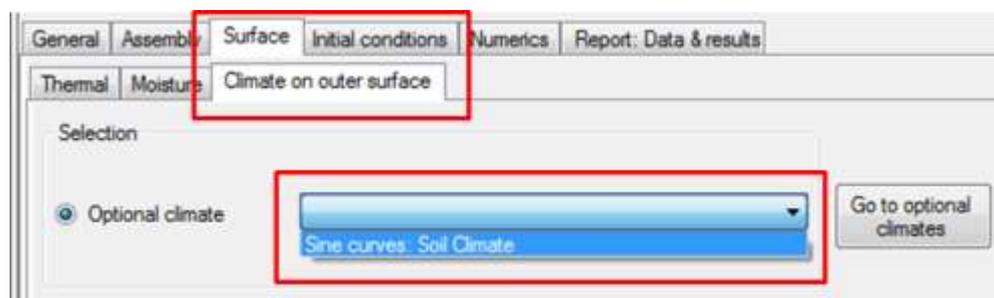


Figure 85:  
Example Case Step 05: Setting optional climate conditions for the exterior surface of the floor slab.

## 11.6 Step 06: Defining the not-visualized components

Besides the visualized components also not-visualized components can be added in a zone. These components are not shown in the “*Visualization Box*”, but they have an impact on the hygrothermal behavior of the building. In this example partition walls inside the zone are added as not-visualized components.

To add a new not-visualized component, open the “*Not-visualized components*”-dialog (1) in “*Project Tree*” and click on the “*New*”-button (2). This creates a new entry in the list. Name it (3), check its type (4) and enter the area (5) of the partition walls, which is 25.2 m<sup>2</sup> in this example. Remember to use the outer dimensions when calculating the area of not-visualized components.



Figure 86:  
Example Case Step 06: Creating not-visualized components.

After that the assembly of the partition walls has to be defined. Select the newly created not-visualized component in the “*Project Tree*” and proceed the same way as with visualized components. Again, a custom assembly has to be created. Its construction is summarized in the following table, starting from outside to inside:

Nr.	Material (as named in WUFI® Plus Database)	Thickness [m]
1	Gypsum Board	0,020
2	Solid Brick Masonry	0,080
3	Gypsum Board	0,020

In the end, the assembly should look like this:

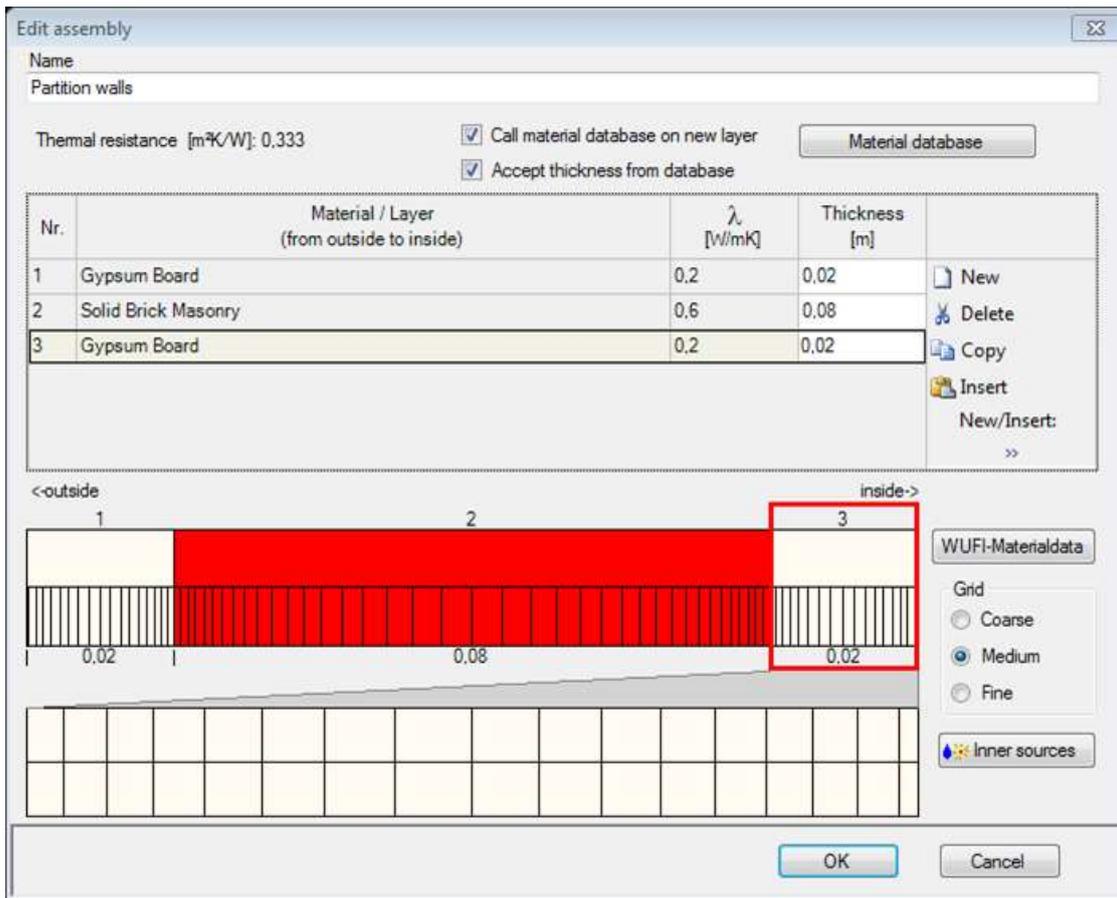


Figure 87:  
 Example Case Step 07: Assembly of the not-visualized component “Partition walls”.

Further settings are not necessary for this component.

## 11.7 Step 07: Setting internal loads and occupancy schedule

After all inputs concerning the zones geometry and its components are complete, the usage of the zone should be described. This is done by defining internal loads, coming for example from human activity or electronic devices. WUFI® Plus uses internal heat-, moisture- and CO<sub>2</sub>-sources. Their amount and duration is defined in the "Internal Loads/ Occupancy"-dialog in the "Project Tree" through periodic day-profiles: Utilization profiles are assigned to custom periods which are defined by date and day. Each period is connected to a day-profile that describes a usage which is repeated for every day in this period. By combining multiple periods and day-profiles complex schedules can be created.

In this example, two usage situations will be defined:

- Weekend: No internal loads occur during the weekend.
- Working days: Three adults are working from 8 am to 5 pm in an office job. During the remaining hours of the day no internal loads occur.

To include these profiles open the "Internal Loads/ Occupancy"-dialog in the "Project Tree":

The screenshot shows the 'Internal Loads/ Occupancy' dialog box. At the top, there is a 'Selection' dropdown menu set to 'Periodic day profiles'. Below this is the 'Periods' section, which contains a table with columns: Nr., Begin, End, Mo, Tu, We, Th, Fr, Sa, Su. The first row (Nr. 1) has '01.01.2015' for Begin, '01.01.2016' for End, and checkboxes for Mo, Tu, We, Th, Fr, Sa, and Su, all of which are checked. To the right of this table are icons for 'New', 'Delete', 'Copy', 'Insert', and 'New/Insert: >>'. Below the 'Periods' section is the 'Day-profile' section, which has a table with columns: Hour, Heat conv. [W], Heat radiant [W], Moisture [g/h], CO2 [g/h], and Human activity [met]. The first row (Hour 0) has values 0, 0, 0, 0, and 0. To the right of this table are icons for 'New', 'Delete', 'Copy', 'Insert', and 'New/Insert: >>'. To the right of the 'Day-profile' section are two buttons: 'Calculator' and 'Select from database'. At the bottom of the dialog is a graph titled 'Heat gain convective [W]' with a y-axis from -3 to 2 and an x-axis from 0 to 24. A red horizontal line is drawn at 0 W. The text 'Daily sum: 0' is displayed to the right of the graph.

Figure 88:  
Example Case Step 07: Internal loads dialog.

By default, a profile with zero internal loads is defined throughout the simulation time. As no internal loads occur during the weekend, we can use this default profile for our weekend situation without entering further data.

Now we have to define a profile for the working days. Add a new period by clicking the "New"-button (1). Make sure that the begin and end date are within the simulation time (2). As this profile is only valid for the working days, exclude Saturday and Sunday (3) as in the figure below:

Nr.	Begin	End	Mo	Tu	We	Th	Fr	Sa	Su		
1	01.01.2015	01.01.2016	<input checked="" type="checkbox"/>	New (1)							
2	01.01.2015 (2)	01.01.2016 (2)	<input checked="" type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>		Delete, Copy, Insert, New/Insert: (3)				

Figure 89:  
Example Case Step 07: Defining periods for internal loads.



WUFI® Plus prioritizes the different periods depending on their entry in the list: Higher numbers (1<sup>st</sup> column) have a higher priority than lower numbers in case they cover the same time period. This means in our example, that the profile for the working days has a higher priority than the default profile. Its day-profile is used instead of the one of the default profile.

Now, the day-profile for the working days has to be defined as in the figure below. First, the day-profile has to be defined by hours. Include new lines with the "New"-button (1). In this example three lines are necessary. Values for the internal loads can either be entered directly or the "Internal Loads Calculator" can be used. In this example, we do the latter. Select the line where internal loads occur (2<sup>nd</sup> line in this example) and click the "Calculator"-button (2) which opens the "Internal loads calculator". Click the button in the "Specification" column (3) to open the internal loads database and search for "Adult, sitting person, working". As three people are working in this zone raise the person counter to three (4). Confirm the calculation with the "OK"-button and it is included in the day-profile.

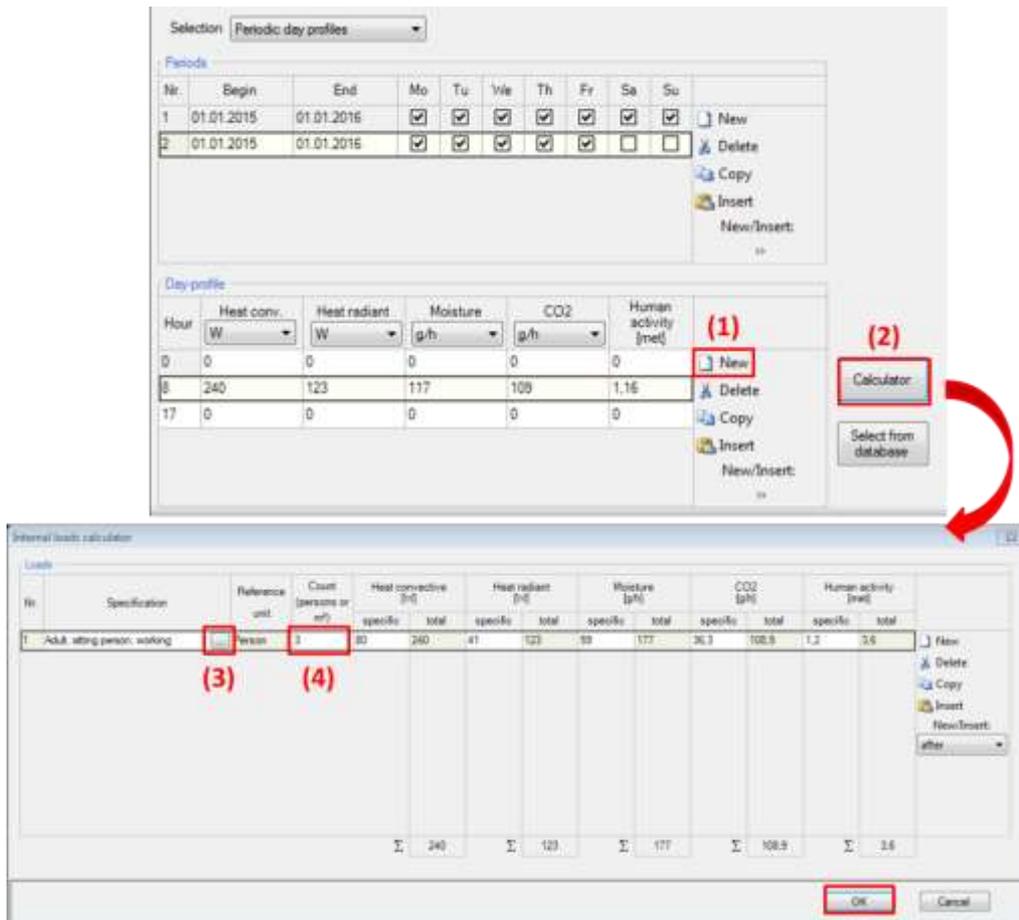


Figure 90:  
Example Case Step 07: Creating a day-profile for internal loads by using the “Internal loads calculator”.

Now, both usage situations are defined.



WUFI® Plus also comes with a large variety of predefined day-profiles for different occupancy and usage situations. These depend on well-known standards like for example DIN 18599-100 or DIN EN ISO 13790.

The preset day-profiles can be selected by clicking on “*Select from database*” instead of “*Calculator*”.

## 11.8 Step 08: Defining design conditions

In the "Design conditions" setpoints for temperature, relative humidity and CO<sub>2</sub>-concentration are defined. The HVAC-system will maintain these setpoints as long as it's capable of it. So, the settings in the "Design conditions"-dialog are strongly connected to the HVAC-settings, which will be defined in Step 11 of this tutorial. Also, they should be adjusted to the usage of the building or zone, which was defined in Step 07.

In this example only temperature will be controlled through a heating and a cooling system. As long as the three adults are present (8am to 5pm), temperature setpoints are set to 21°C (Minimum) and 24°C (Maximum). In the remaining time this interval is set to a wider range of 17°C (Minimum) and 27°C (Maximum). The minimum-setpoints correspond to the heating system, which will be activated if the indoor temperature would fall below this setpoint. And the maximum-setpoints refer to the cooling system, which starts cooling if the setpoint would be exceeded.

Now it's time to define these setpoints in WUFI® Plus. Select the "Design Conditions"-dialog in the "Project Tree". As only temperature is controlled, input is only necessary in the "Temperature – Minimum"- and "Temperature – Maximum"-tabs. The setpoints are entered with the help of "Periodic day profiles", the same way as in Step 07. So, proceed as before: Create a second period for the working days and enter the day-profile as describe above. Also adjust the value for the weekend-profile. Repeat these steps for the maximum-temperature. In the end, the profiles should look like this:

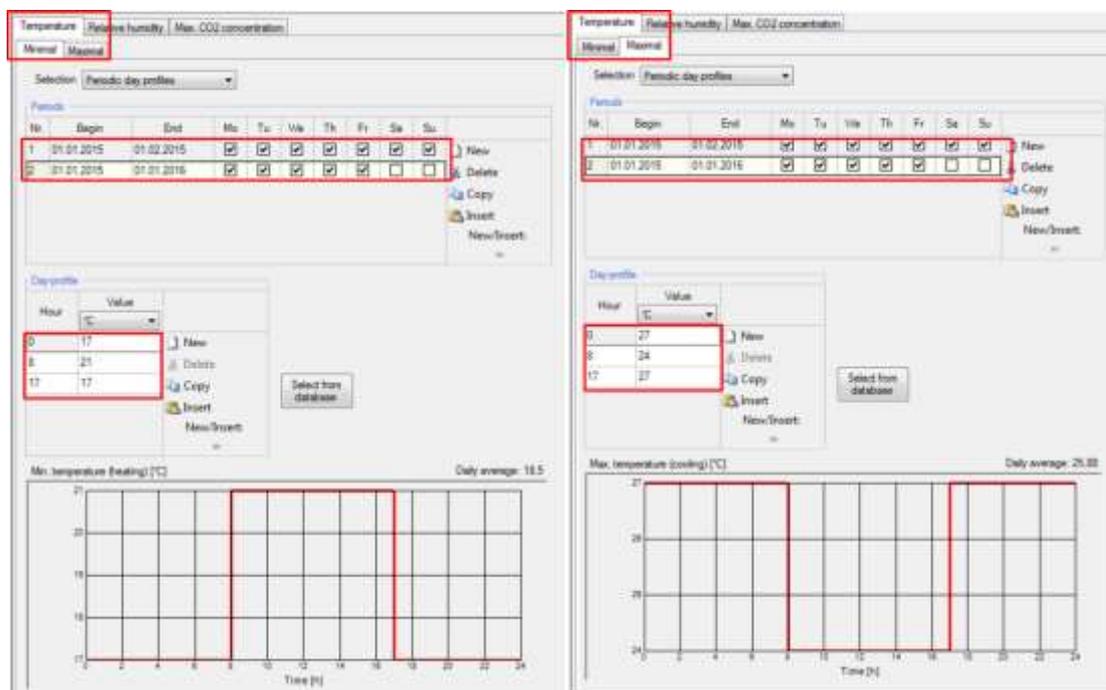


Figure 91:  
Example Case Step 08: Defining design conditions for indoor temperature.



When defining schedules for design conditions always remember to also include a HVAC-system that is capable of executing those setpoints. For example, if there is no heating device, the minimum temperature can't be maintained.

## 11.9 Step 09: Creating ventilation profiles

Now the ventilation needs to be defined. WUFI® Plus differs between three ventilation-types:

- Natural ventilation includes the air infiltration through building leakages and window openings.
- Mechanical ventilation systems.
- Interzone ventilation between simulated and attached zones.

The example building uses a mechanical ventilation system. So, this has to be defined together with permanent air infiltration through building leakages. Interzone ventilation between the simulated zone and the attached attic is not considered in this example.

At first, start with the air change through infiltration. Open the "Ventilation"-dialog by clicking the respective entry in the "Project Tree". In the "Natural"-tab (1) the air change rate for permanent infiltration can be entered (2), which shall be  $0.1 \text{ h}^{-1}$  in this example. No other natural ventilation is considered, so make sure, that the day-profile is set to zero (3).

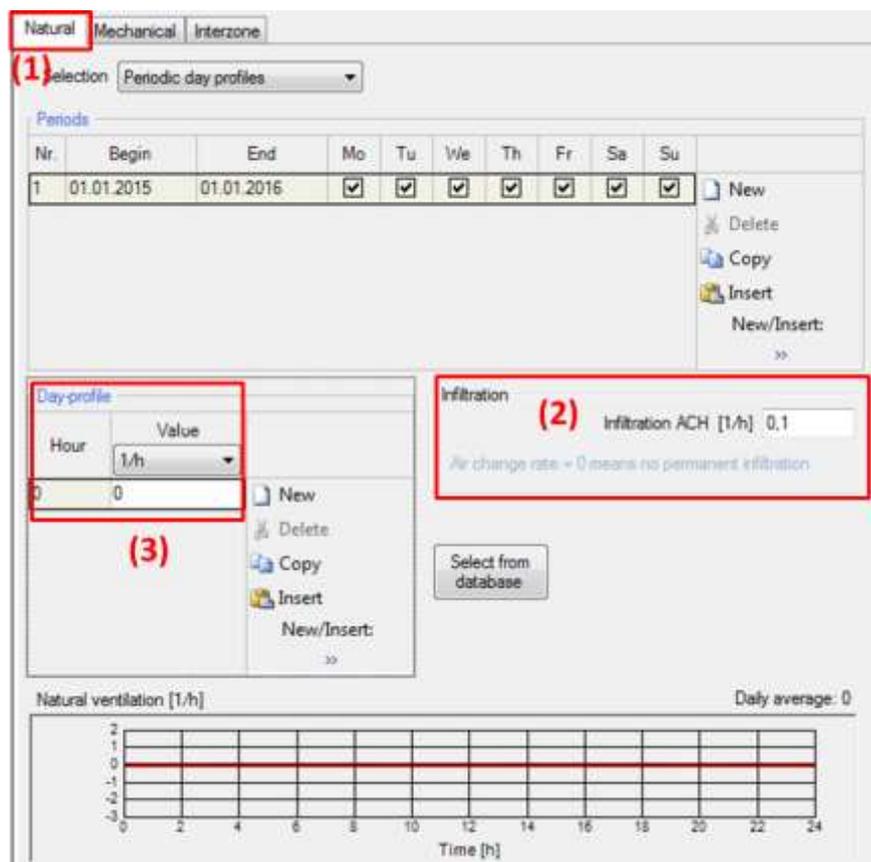


Figure 92:  
Example Case Step 09: Defining natural ventilation.

Next, the operation schedule for mechanical ventilation is defined. Switch to the “Mechanical”-tab (1). The ventilation system should provide a minimum air change rate of  $0.4 \text{ h}^{-1}$  at any time except the working hours (8am to 5pm from Monday to Friday) where it increases to  $0.8 \text{ h}^{-1}$ . Enter these values by using periodic day-profiles (2 & 3) the same way as described in Step 07 and Step 08. In the end, the operation schedule for mechanical ventilation should look like this:

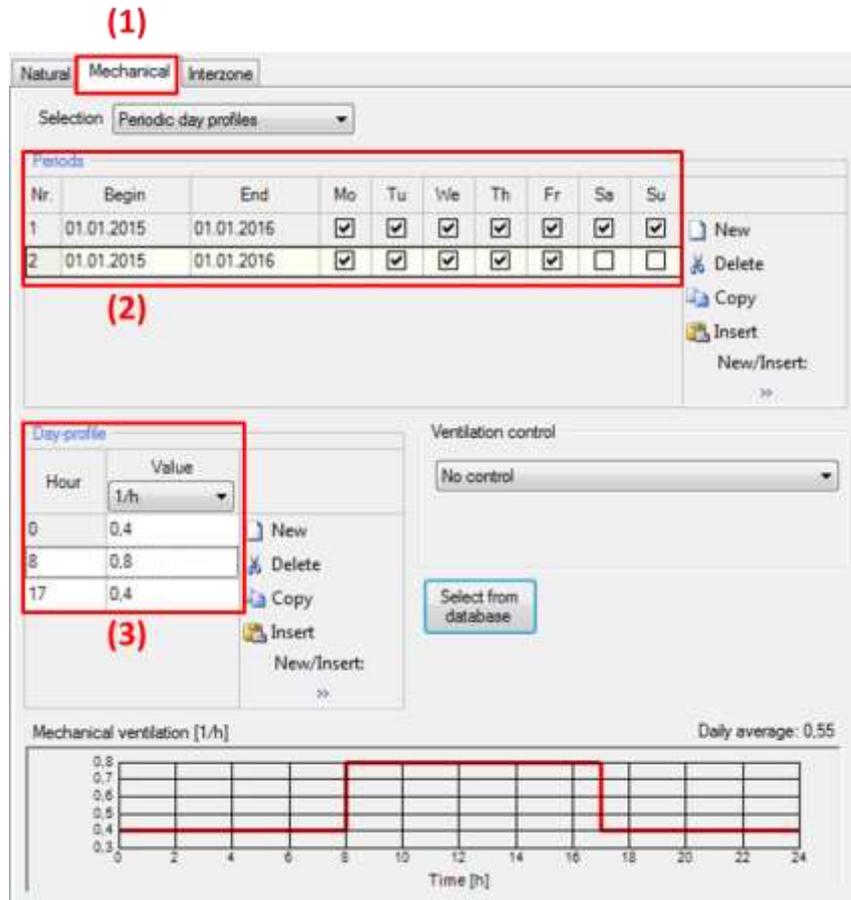


Figure 93:  
Example Case Step 09: Defining a schedule for mechanical ventilation.

No input has to be made for interzone ventilation in this example.



Always remember to include a mechanical ventilation device in the HVAC-dialog and assign it to the desired zone when defining schedules for mechanical ventilation. Else, these schedule can't be executed.

## 11.10 Step 10: Climatic conditions in attached zone

The climatic conditions in attached zones can be defined as an optional climate or they can be set to the outdoor climate. In this example, the latter option will be used for the unheated attic. Open the "Attached zone 1: unheated attic" in the "Project Tree" and alter the settings as in the figure below:

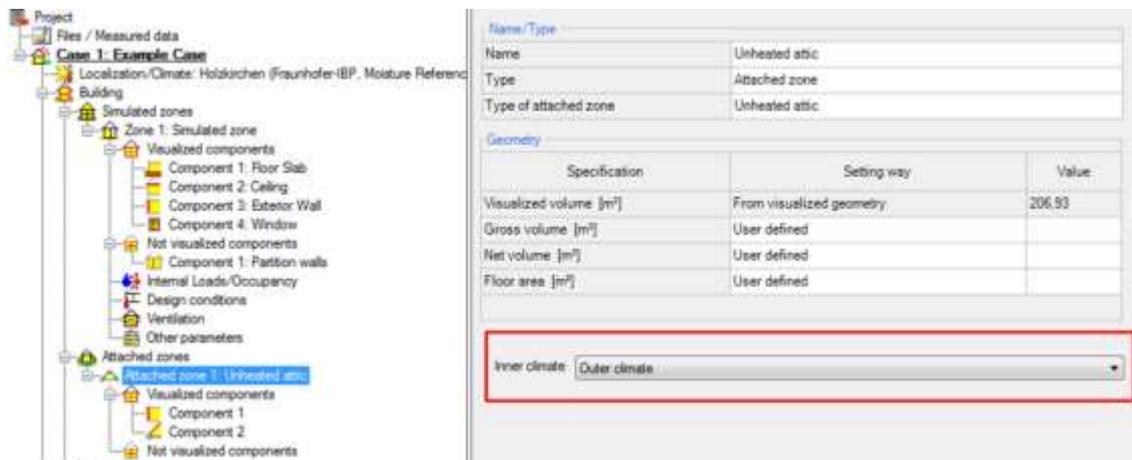


Figure 94:  
Example Case Step 10: Defining the climatic conditions of the unheated attic.

## 11.11 Step 11: Including HVAC

Now, the HVAC-system is defined. The example building needs devices for heating, cooling and mechanical ventilation, so the setpoints defined in Step 08 and the mechanical ventilation of Step 09 can be supplied.

Select the "HVAC"-dialog (1) in the "Project Tree" and create a new HVAC-system by clicking the "New"-button (2). In this example, a custom system is used, so select the system-type "User defined (idealized)" (3).

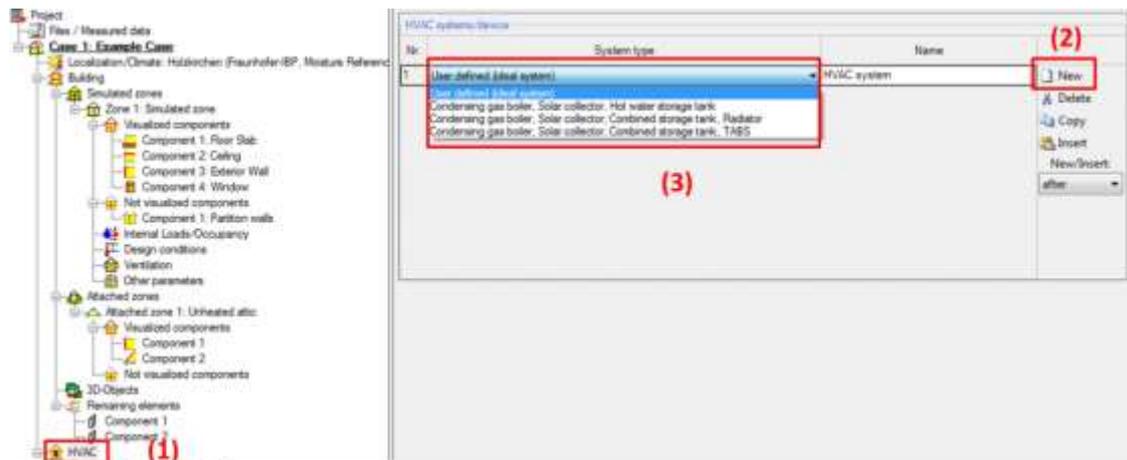


Figure 95:  
Example Case Step 11: Including a user defined HVAC-system.

The new HVAC-system appears now in the "Project Tree" (1). Select it and the "HVAC-System"-dialog opens where the system can be named (2) and its different HVAC-devices can be added. Click the "New"-button (3) to add a HVAC-device and check mark its usage-type in the table (4). In this example three different devices are necessary: One for space heating, one for space cooling and a mechanical ventilation. In the end, the input for the HVAC-devices looks like this:

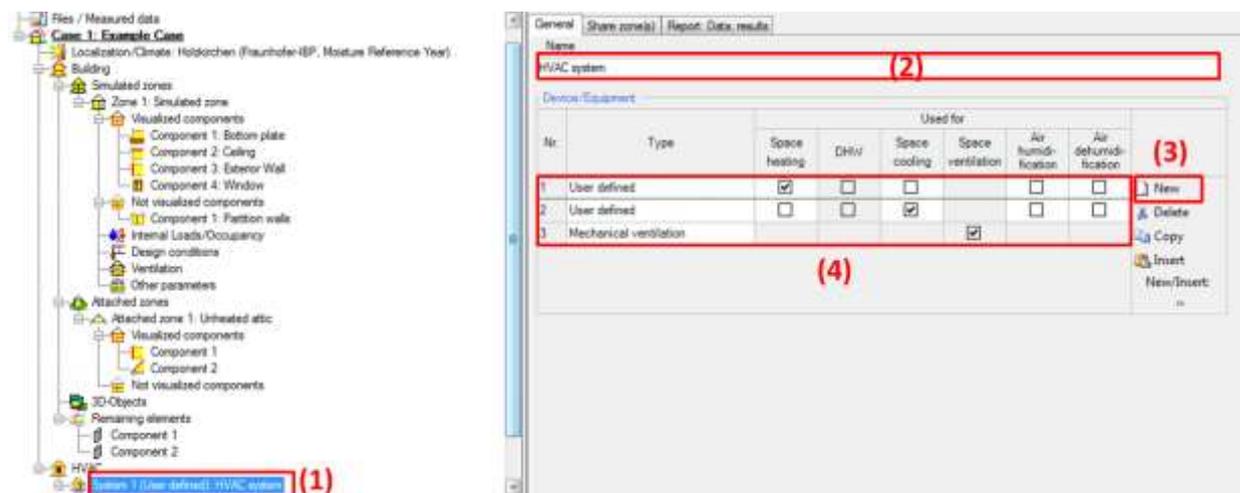


Figure 96:  
Example Case Step 11: Defining the devices of the HVAC-system.

Each device is now also listed in the "Project Tree" (1). It can be selected and its properties can be altered to these constant values in (2 & 3):

- Space heating capacity: 40 kW
- Cooling capacity: 40 kW
- Ventilation capacity: 500 m<sup>3</sup>/h. Heat recovery rate of 60 %.

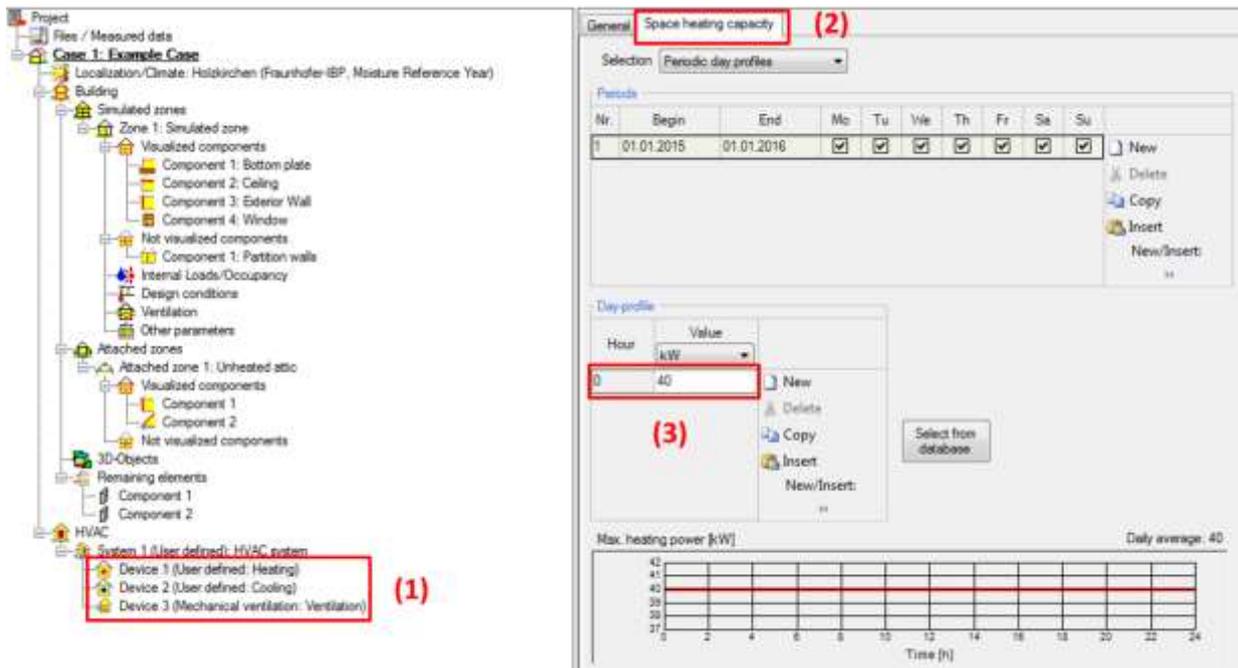


Figure 97:  
Example Case Step 11: Setting the properties of the space heating HVAC-device.

## 11.12 Step 12: Filling missing data

All necessary data should be entered by now. However, the “*Status & Results Box*” hints that some data is still missing. Double-clicking the “*Status & Results Box*” always guides you automatically to the source of the problem: Here, the net volume of the zone is still missing. Select the option “*From gross volume and components*” and WUFI® Plus calculates it automatically from the visualized geometry and the visualized components. However, this value should always be checked by the user if it was calculated correctly, as it has a huge impact on the calculations.

The screenshot shows the WUFI Plus interface. On the left is a project tree with a red box around 'Zone 1: Simulated zone'. On the right is the 'Report: data & results' window. The 'Geometry' table is as follows:

Specification	Setting way	Value
Visualized volume [m³]	From visualized geometry	302,4
Gross volume [m³]	From visualized volume and components	373,88
Net volume [m³]	From visualized volume and components	283,82
Floor area [m²]	From visualized geometry	108

Figure 98:  
Example Case Step 12: Fill in the missing data.

### 11.13 Step 13: Simulation

Now that really all necessary data is entered the *"Status & Results Box"* changes its appearance and the simulation can be started by clicking the *"Start"*-button:

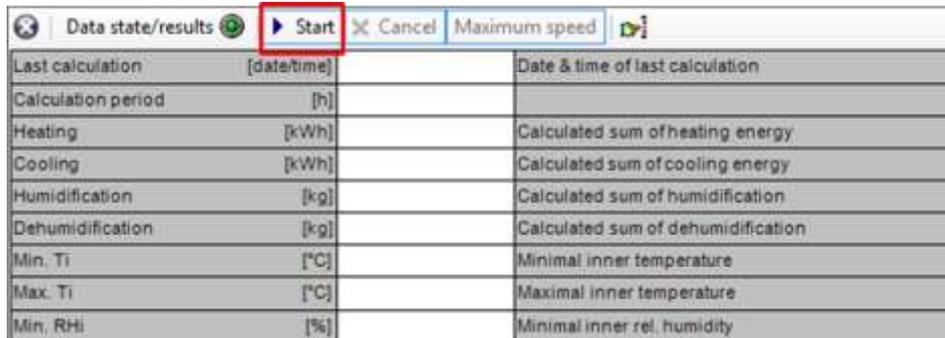


Figure 99:  
Example Case Step 13: Starting the simulation.

During a simulation the calculation process can be observed in many ways:

- A progress bar in the *"Status & Results Box"* shows the overall calculation progress
- Selecting the *"Case"*-entry in the *"Project Tree"* gives a summary of the current calculation.
- Selecting a zone in the *"Project Tree"* shows graphs of current simulation results.
- Selecting a component in the *"Project Tree"* shows the WUFI® Film with the temperature and humidity conditions inside the component.

The visualizations during a simulation can be deactivated to increase calculation speed. To do this, click the *"Maximum speed"*-button in the *"Status & Results Box"*.



Figure 100:  
Example Case Step 13: Monitoring the simulation status from the “Case”-dialog.

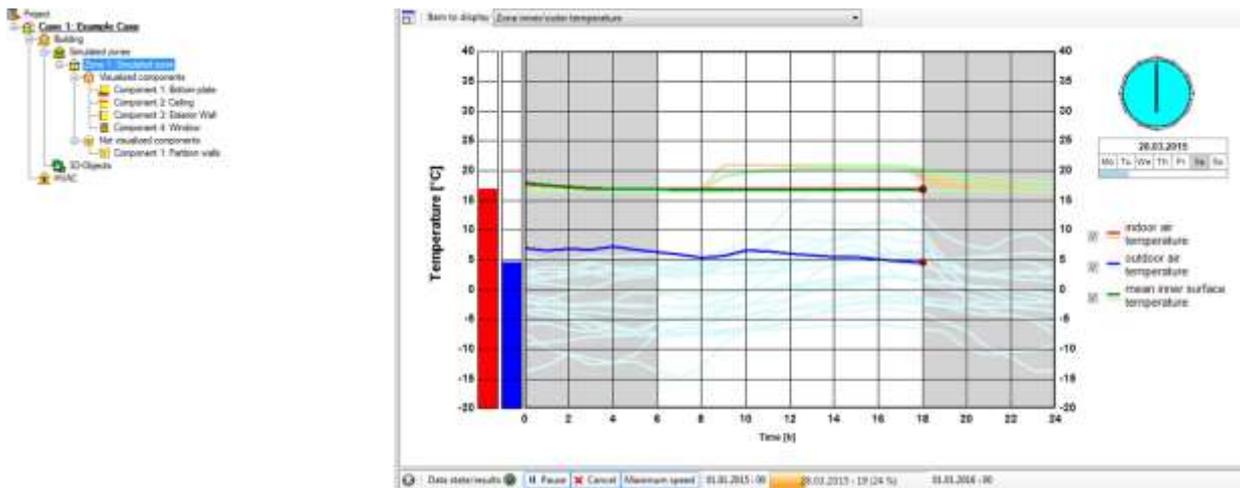


Figure 101:  
Example Case Step 13: Film of the zonal results during the simulation.

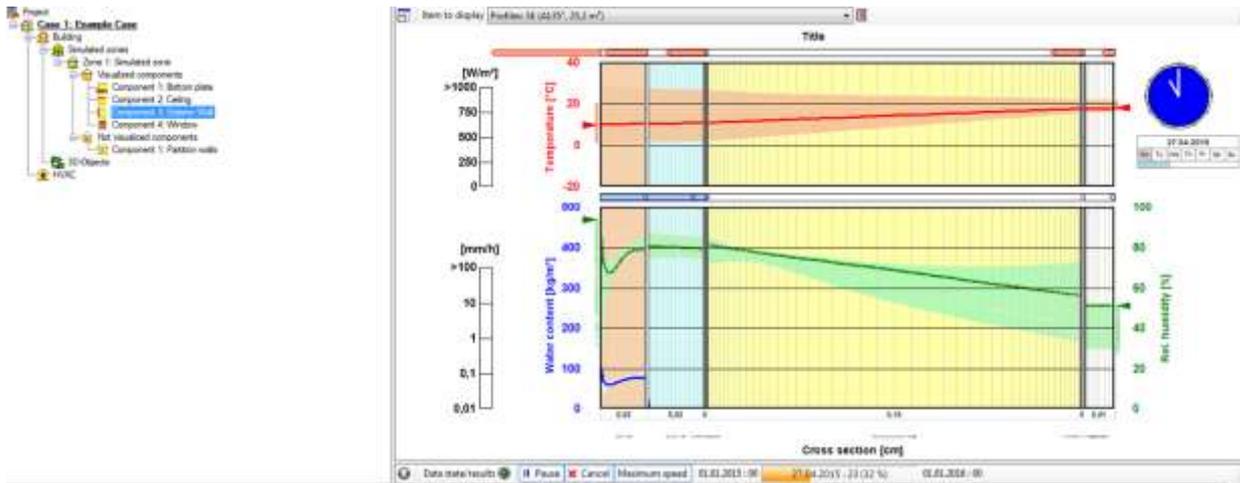


Figure 102:  
 Example Case Step 13: WUFI® Film of the hygrothermal conditions of a component during the simulation.

## 11.14 Step 14: Assessing the results

After the simulation is finished its results can be assessed in detail in WUFI® Plus. They can be exported to external applications, too. Also predefined reports can be viewed, printed and exported to Microsoft Word or Excel. Some exemplary evaluation methods are described below. Please refer also to chapter 9 where all possibilities of working with WUFI® Plus results are described in more detail.

In this example results are available for the simulated zone and for each component. We will create a report and export it to Microsoft Office, view result graphs and export the calculation results as a text-file.

At first, a report with the general calculation results is viewed. Select the "Case"-dialog in the "Project Tree" and open the "Report: Data & results"-tab (1). Switch to different preset reports by changing the "Scope" (2). Select the "Results" report and have a look at the main results. All reports can be exported to Microsoft Excel and Word by clicking the respective buttons (3). To print a report change the view to "Print layout" (4) and click one of the "Print"-buttons (5).

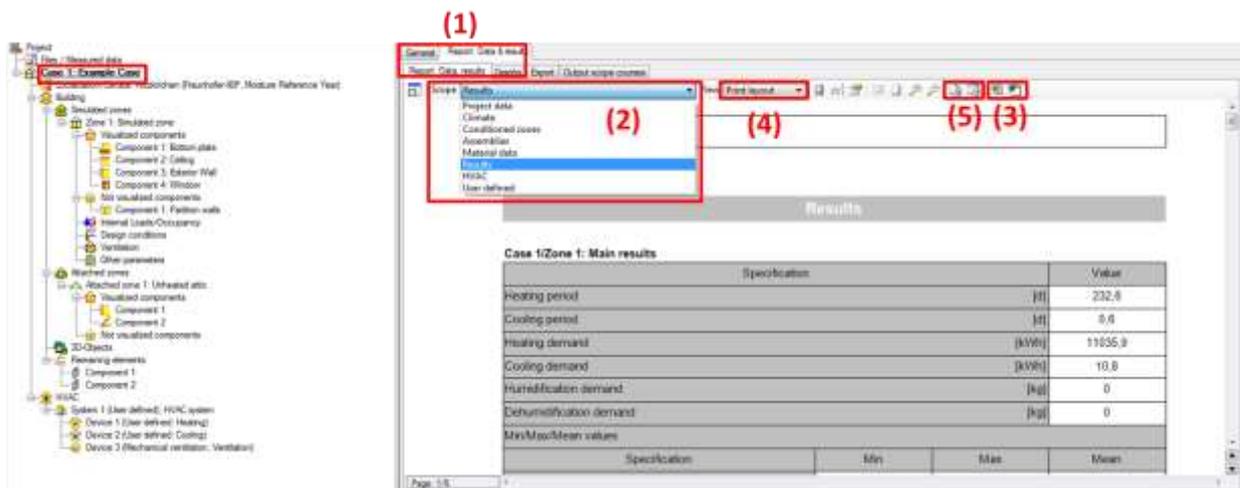


Figure 103:  
Example Case Step 14: Selecting a report.

Next, graphs with the calculated hourly results are viewed. Switch to the "Graphs"-tab (1). Here, different preset graphs can be selected (2). Please have a detailed look at the simulation results and view the different graphs. The graphs can also be printed by changing the view to the print layout (3) and clicking one of the "Print"-buttons (4). With the "Copy to clipboard"-button (5) the active graph is copied and can be inserted in any other application. The preset graphs can also be modified or custom ones can be created as described in chapter 9.

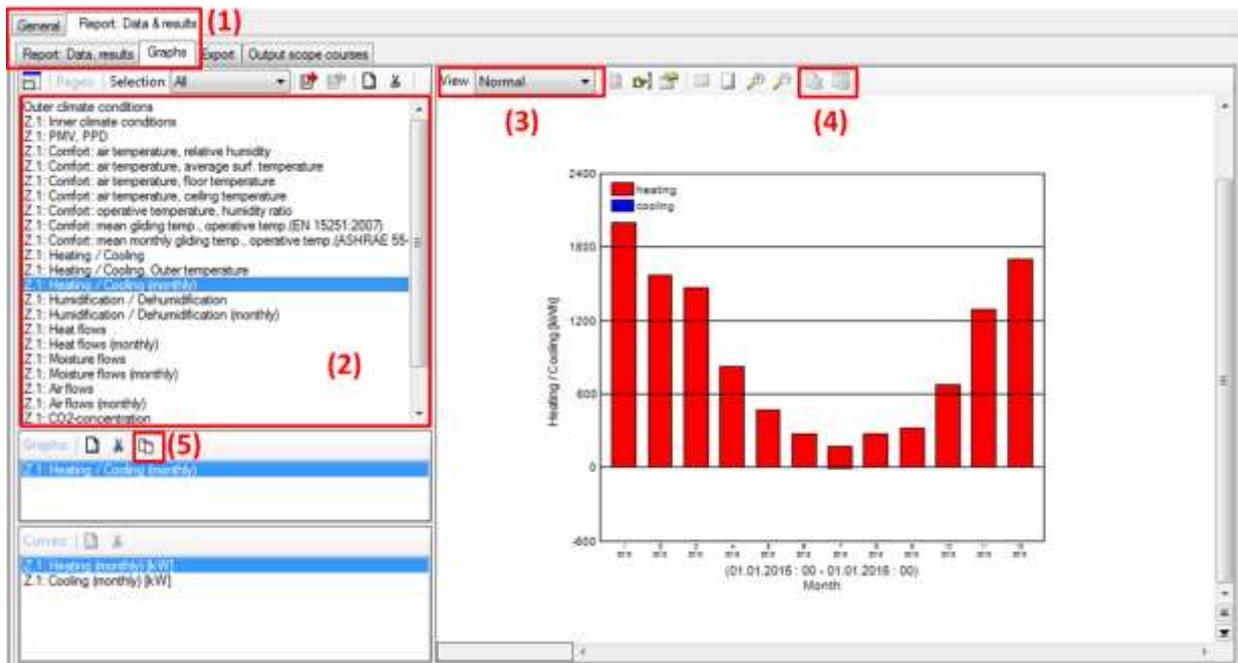


Figure 104:  
Example Case Step 14: Viewing graphs of the calculation results.

The results can also be exported to Microsoft Excel or as a text-file. These are powerful options to evaluate the calculated results as it enables the user to use external analysis programs. To export the calculation results switch to the "Export"-tab (1). The table (2) lists all available results that can be exported. Select multiple lines by clicking on them while pressing the "Ctrl"-key. These blue marked lines will be exported. Also an option exists which selects all available calculation results including results of components (3). To export the results to an external text-file, a save-path has to be created first (4). Afterwards, the results can be exported to this file by clicking the "Export to file"-button (5). The selected results can also be exported to Microsoft Excel by clicking the respective button (6). For this option no save path has to be defined and Excel starts automatically with the exported results.

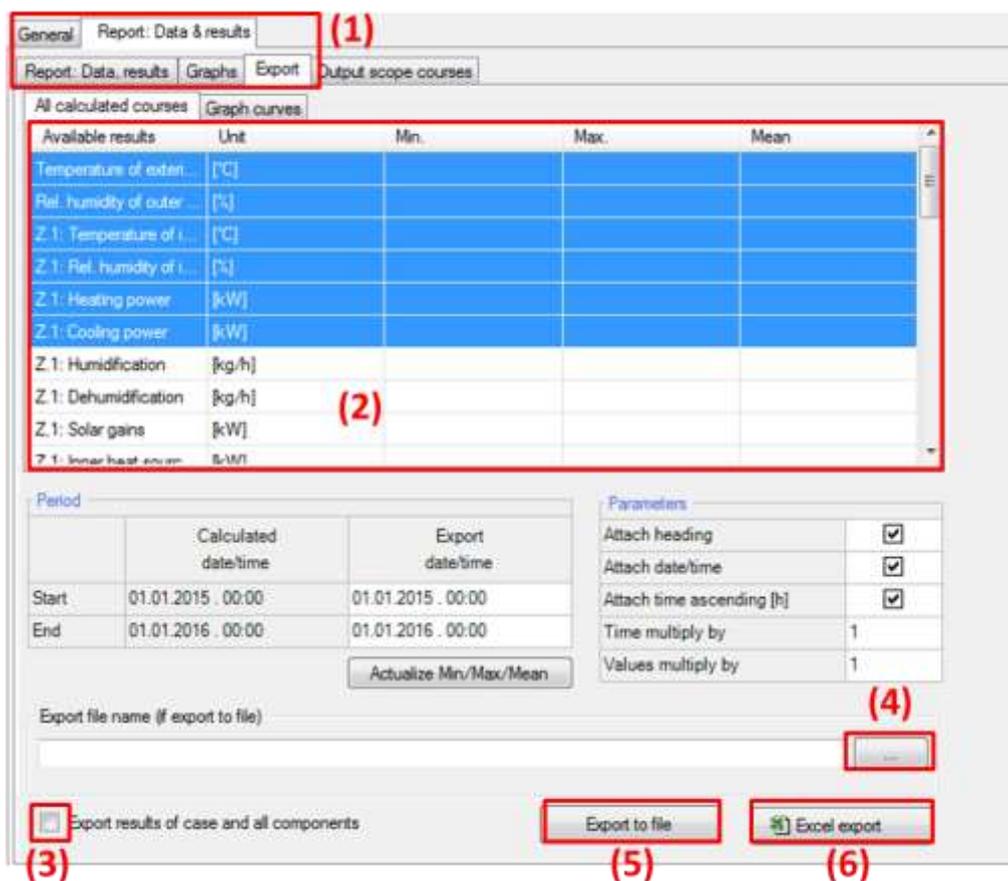


Figure 105:  
Example Case Step 14: Exporting selected simulation-results.

As the "Retain calculation results"-option was activated in Step 05 for all components, their results can now be viewed. Also the WUFI® Film is saved for each component. To view the results of a component select it in the "Project Tree" and switch to the "Report: Data & results"-tab. There reports, graphs and the WUFI® Film of the component can be found in the respective tabs. The results can also be exported in the "Export"-tab. Now let's have a look at the WUFI® Film of the exterior wall oriented in south-west direction. Select the respective component (1) and open the "Film"-tab in the "Report"-section (2). The dropdown-menu above the film allows switching through different grouped components (3). Select the south-western wall. This can also be done by clicking on the component in the "Visualization Box". Now the film can be watched (4), exported as a movie-file in the .avi-format (5) or exported to the "Extended animation"-tool (6) that is shipped with WUFI® Plus. This external tool is an even more detailed assessment option for component results and serves as a bridge for postprocessors like for example WUFI® Bio, which allows the evaluation of mold growth risks on surfaces. Please refer to chapter 9.4 for further information about the capabilities of this tool.

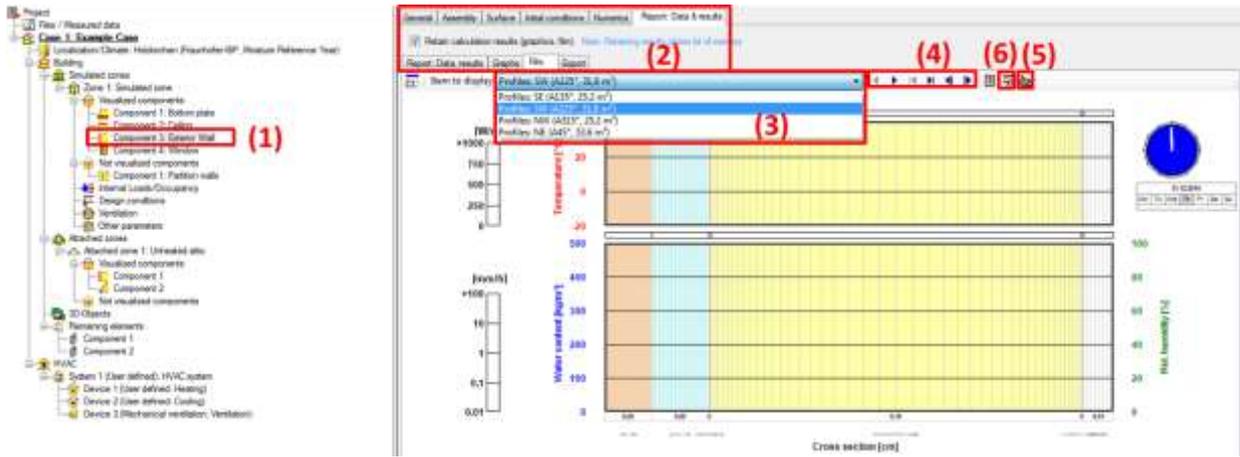


Figure 106:  
Example Case Step 14: WUFI® film of components.

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