entwickelt am Fraunhofer IBP

WUFI® Plus 3.1

Manual

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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 is advisable to follow this example when working with WUFI® Plus for the first time.

For detailed information please refer to the WUFI® -Wiki (www.wufi-wiki.com) an the Fundamentals Manual.

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.

Contents

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 it's 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 to switch between 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 dynamic hygrothermal building simulation 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 Passive House Institute US (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 8 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 4.5.11 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, moisture) 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.

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 7;
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 is crucial to unzip the file or the WUFI® Database will not 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:

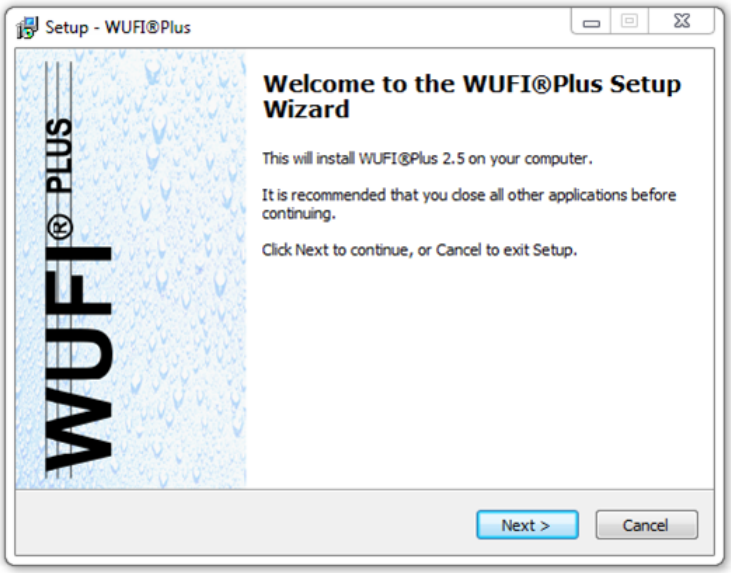


Figure 1: Installation: Start the setup

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

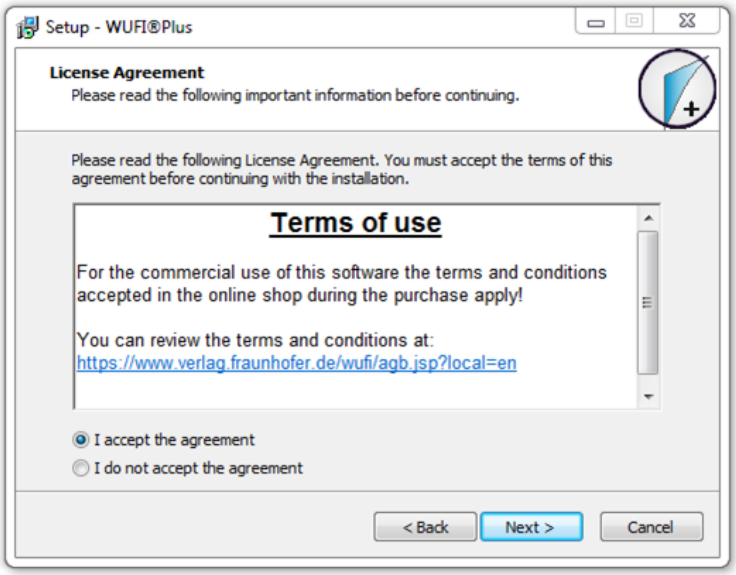


Figure 2: Installation: Terms of use

Please make sure that your computer meets the system requirements:

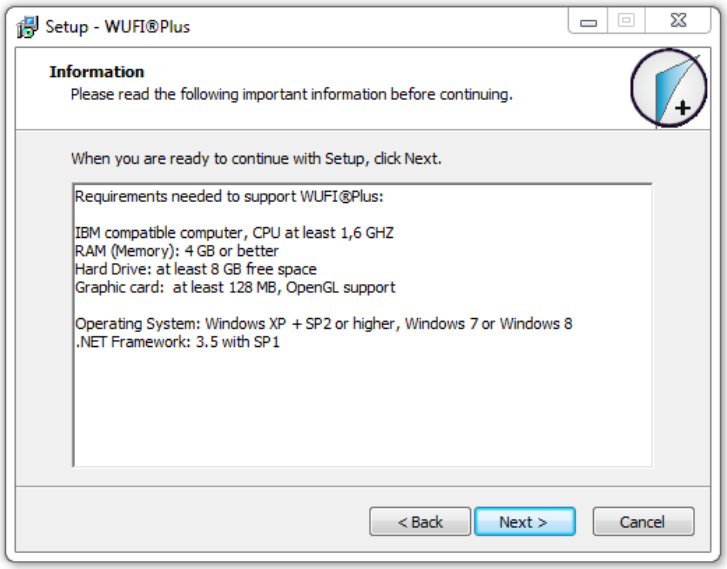


Figure 3: Installation: System requirements

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 our Purchase-Email to avoid input errors:

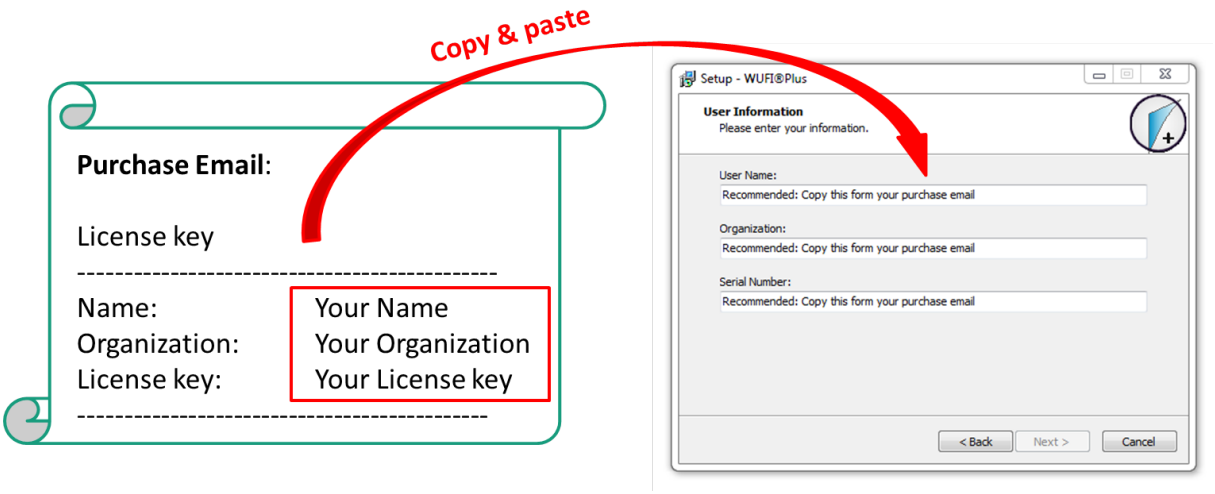


Figure 4: Installation: System requirements

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:

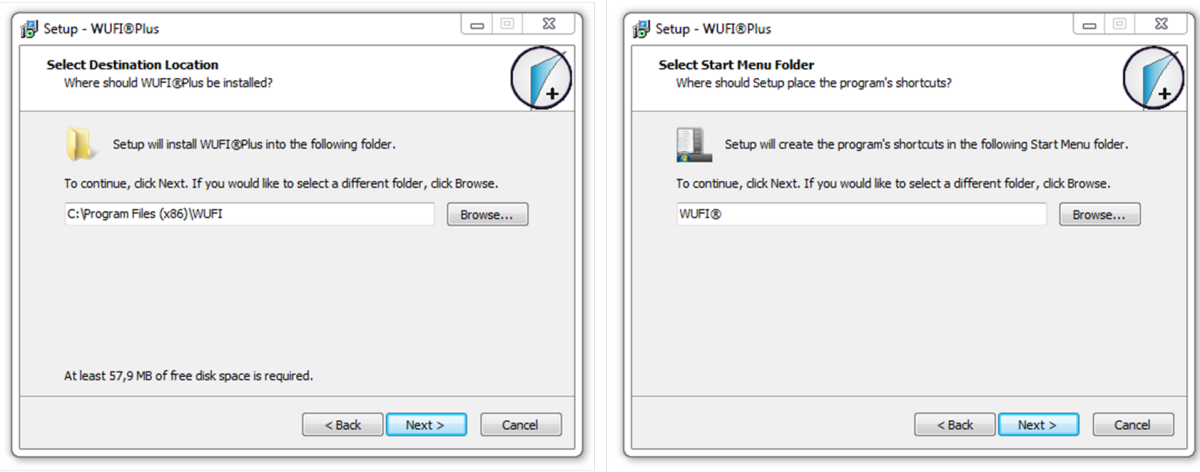


Figure 5: Installation: Select the installation folder and create an entry in the Windows Start Menu.

There is also an option to create a desktop icon:

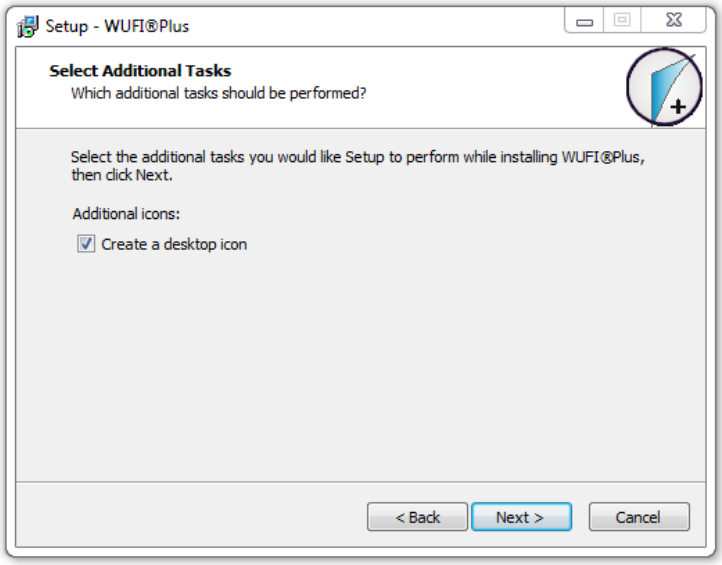


Figure 6: Installation: Create a desktop icon

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:

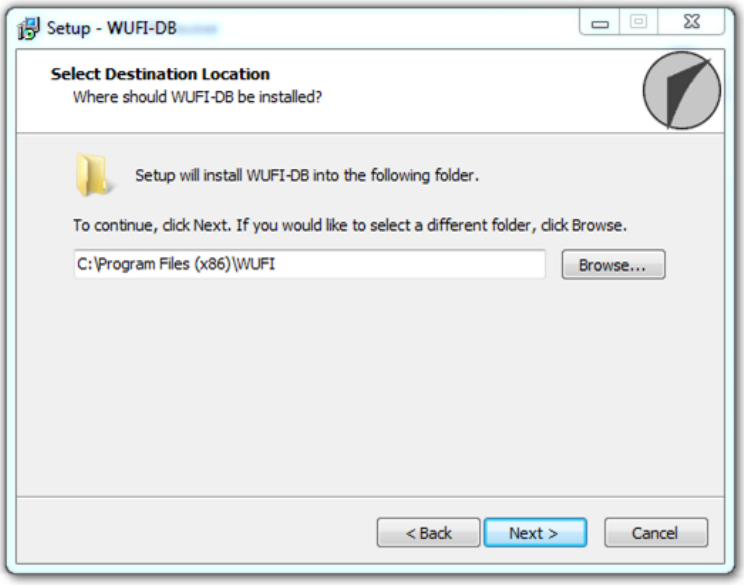


Figure 8: Installion: Select the folder for the installation of the WUFI® Database.

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.

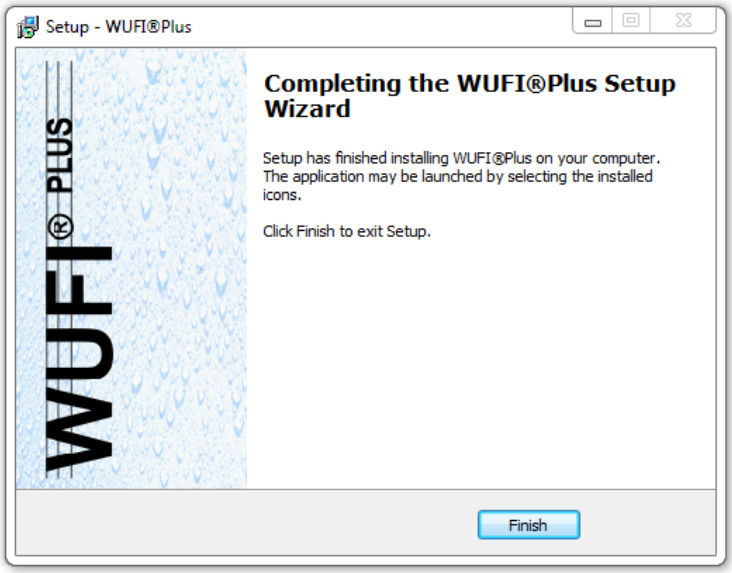


Figure 9: Installion: Finish the installation of WUFI® Plus and the WUFI® Database.

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

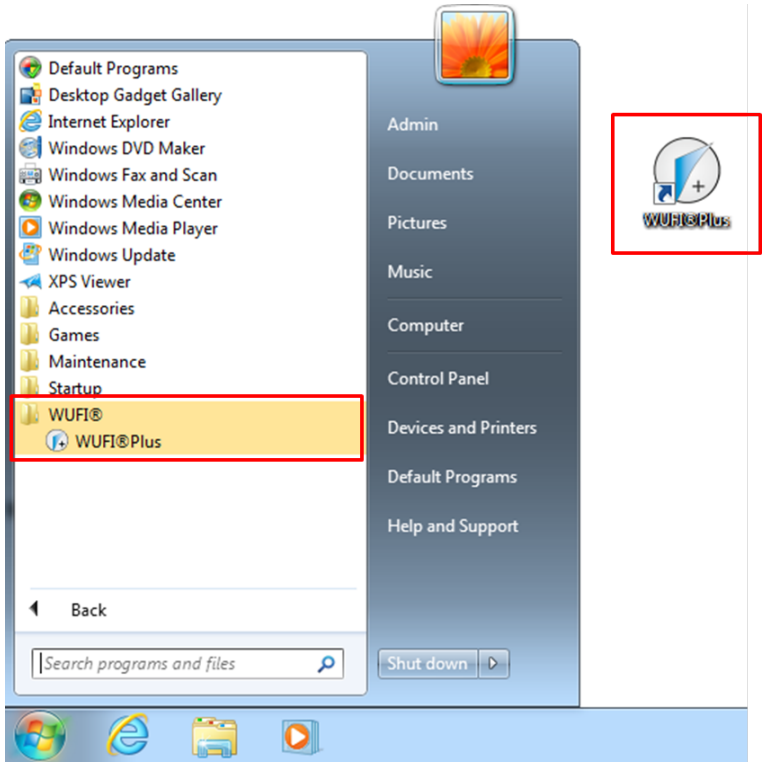


Figure 10: Installion: Starting WUFI® Plus either from the Windows Start Menu or the desktop shortcut.

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.

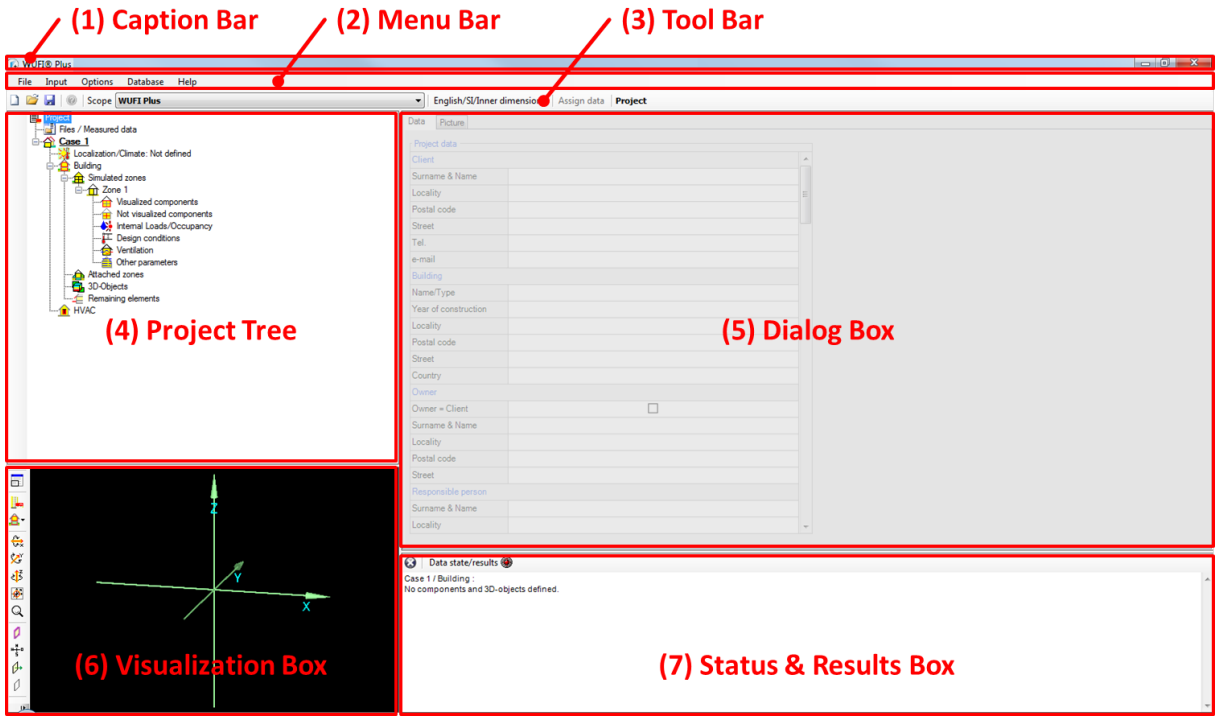


Figure 11: Main Window of WUFI® Plus.

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.
(4) Project Tree	As an alternative to the *Input* 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.
(5) Dialog Box	Dependent of the selections in the *Project Tree* or *Input* menu, all user inputs or simulation results will be shown in this box. Chapter 4 and its subsections explain them in detail.
(6) Visualization Box	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.
(7) Status and Results Box	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

New Project	The memory will be reset and a new empty project will be created.
Open	The standard Windows dialog for opening a project file will be shown. WUFI® Plus supports four types of file formats for opening: • .mwp: The standard WUFI® Plus file format. • .xml: Alternative WUFI® Plus file format. Files in xml-format can be opened, viewed and modified with other programs, for example text editors. • .wpp: The old format for WUFI® Plus Project Files. • .wps: These files contain geometry-information exported from *SketchUp* with the *WUFI® Plus SketchUp Plugin*, see chapter 6.1.
Recover Data	Lists the last autosaves of the project, that can be recovered. The auto-save options of WUFI® Plus are described in 3.2.3.
Reopen	Enables quick access to the last ten projects.
Save	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. WUFI® Plus supports two types of file formats for saving: • .mwp: The standard WUFI® Plus file format. • .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.
Save as	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. WUFI® Plus supports two types of file formats for saving: • .mwp: The standard WUFI® Plus file format. • .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.
Exit	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	
General	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.
Colors	Direct link to the color setting menu for the visualized geometry.
View	Direct link to the view properties menu for the visualized geometry.
Usability	Settings concerning tool tips and comments. The time interval between two auto-saves and the maximum amount of projects saved at the same time can also be set here.
Export	Settings concerning result exports.
Passive	Allows changing the passive certification criteria between the Default Standard and the PHIUS+ 2015 standard.
SketchUp plugin	Options for the WUFI® Plus SketchUp plugin, see chapter 6.1 for further information.

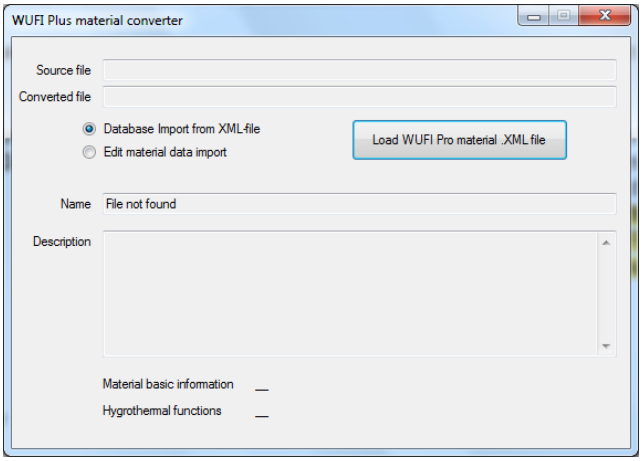
The data recovery option allows you to set the time interval after which WUFI® Plus automatically makes a copy of the current project. The maximum amount of auto saves can also be defined. When using the recover data option, see chapter 3.2.1, you can choose between the latest saves.
Auto-saves will only be created when input-parameters were entered or changed by the user.
The auto-saves are saved temporary in WUFI® Plus main installation folders subfolder ”zres”. They will be deleted when WUFI® Plus is closed.

Comments can be made to every dialog of the user interface of the dialog box. The comments can be displayed at the right corner of the dialog box, at the bottom right of the dialog box and in a separate window. When choosing this option, a new ”Comments” button appears next to the ”Assign data” button.

3.2.4 Database

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

Controls	
Materials	List of predefined building materials and their physical properties; these materials can be used and new materials can be created.
Assemblies	List of predefined combinations of the materials above mentioned. New assemblies can be created, as well.
Windows	List of predefined window data. New entries can be added.
Emissions sources	List of sources of heat, moisture or carbon dioxide emissions for the calculation of internal loads. New entries can be added.
Day Profiles	List of predefined day profiles representing the usage of a zone or design conditions. New entries can be added.
Climates	List of all entries of the climate database. New entries can be added.
Export into XML-file/ Import from XML-file	User-defined database entries can be exported or imported with these dialogs. This way user-defined database entries can be shared with other users or computers. WUFI® Pro Material data can also be imported with this function.



The WUFI® Plus material converter formats xml material data of WUFI® Pro to the appropriate WUFI® Plus xml format. After clicking ”Load WUFI Pro material .XML file” and searching the associated file, the tool automatically creates a new xml-file according to the selected task:

1. Database import from xml-file: Creates a new xml-file with the suffix .plusImportToDB.xml. This file can be imported into the WUFI® Plus Material Database with the function Import from XML-file.

2. Edit material data import: Creates a new xml-file with the suffix .xml.plusMaterial.xml. This file can be imported into WUFI® Plus from the Edit Material dialog. See chapter 5.1.4 for further information.

The WUFI® Plus material converter is installed together with WUFI® Plus. It can be found in the ”Tools”-folder of your WUFI® Plus installation.

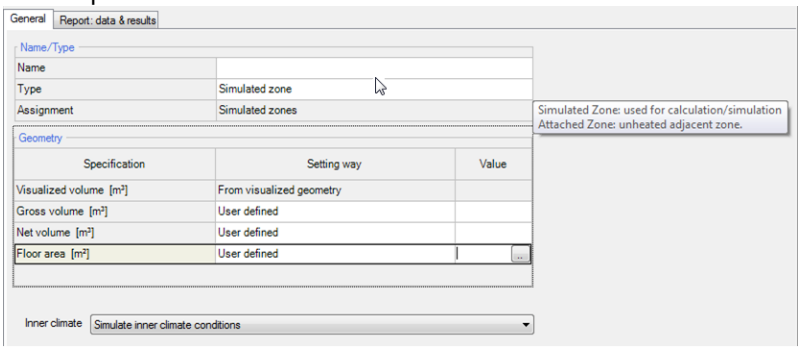
Visit the WUFI® -Wiki (www.wufi-wiki.com) to learn more about the database. Its usage is described on our Wiki-pages and a tutorial movie shows in detail how to work with the database.

3.2.5 Help

Controls

About	Information about the current WUFI® Plus installation, including its program and database version.
WUFI® Plus Manual/ WUFI® Passive Manual	Opens the manuals. The manuals can also be opened by pressing the F1-button on your keyboard, by clicking the Help-button in the Toolbar (see chapter 3.3) or by clicking in Help-buttons in selected menus. The latter three ways are context-sensitive, i.e. the help will automatically link the currently opened menu with the fitting help-chapter.
Wufi Wiki	Link to the WUFI® -Wiki (www.wufi-wiki.com) where additional information and tutorials can be found.
Wufi Forum	Link to the WUFI® -Forum (www.wufi-forum.com/) , 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 about recommended values or further sources of data. Tool tips appear, if the mouse is held for one second over an input field and can be enabled/disabled in the options:



3.3 Toolbar

The Tool Bar provides access to some commonly used functions:

Controls	
 **New**	The memory will be reset and a new empty project will be created.
 **Open**	The standard Windows dialog for opening a project file will be shown.
 **Save**	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.
 **Help**	Opens the WUFI® Help. This button is context-sensitive, i.e. the help will automatically link the currently opened menu with the fitting help-chapter. Pressing the F1-button on the keyboard does the same.
Scope	This dropdown-menu allows switching through different scopes of WUFI® Plus: • WUFI® Plus • Passive House verification • DIN 4108-2 Thermal protection / Building simulation Please refer to chapter 1 for information about these scopes.
Current Settings	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.
Assign Data	This function allows the application of settings or user input to multiple elements in the project tree at once.
Navigation info	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.

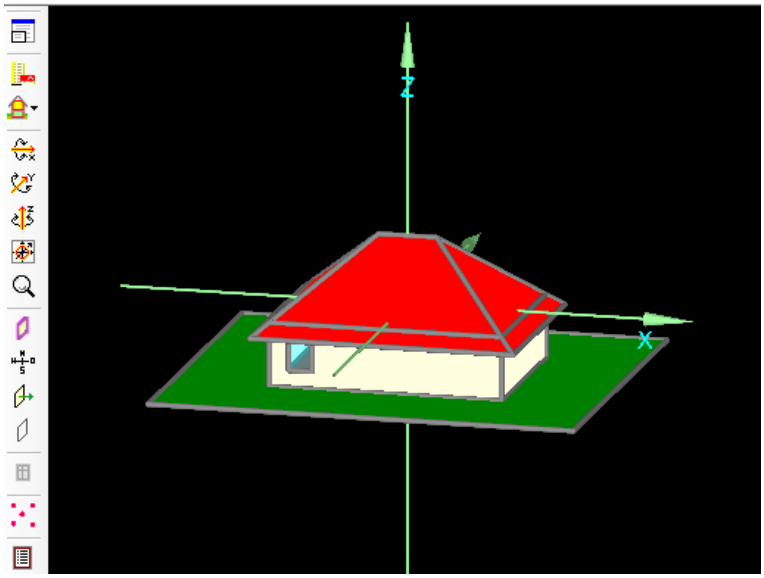


Figure 12: Visualization Box

Controls

Expand/Shrink	Allows expanding the *Visualization Box*. Its 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 for more information about this feature.
Zones	By clicking this button, already existing zones can be renamed 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.
Rotation	These Buttons allow rotating the building around all three axes (X,Y & 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.

Center	Centers the view of the *Visualization Box* to its original position.
Zoom	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.
Transparency	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.
Orientation	The orientation of the building can be displayed by left clicking this button. Right clicking opens the *”Change orientation”* window, where orientation of the building can be altered.
Normal vector	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
Conditionally not visible/ selectable	This button makes a component conditionally not *visible/ selectable*, for example to make hidden components accessible. The difference of this button to the *”transparent/opaque”* 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 *”conditionally not visible/ selectable”* in its properties, which can be accessed by right-clicking on the component in the *Visualization Box*.
Windows & Openings	Creates new windows and openings. See chapter 3.4.1 for further information.
Vertices	Shows or hides the vertices. Chapter 3.4.2 shows how vertices can be used to create or modify a building.
Options	Settings for the *Visualization Box*, as described in chapter 3.4.2.

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:

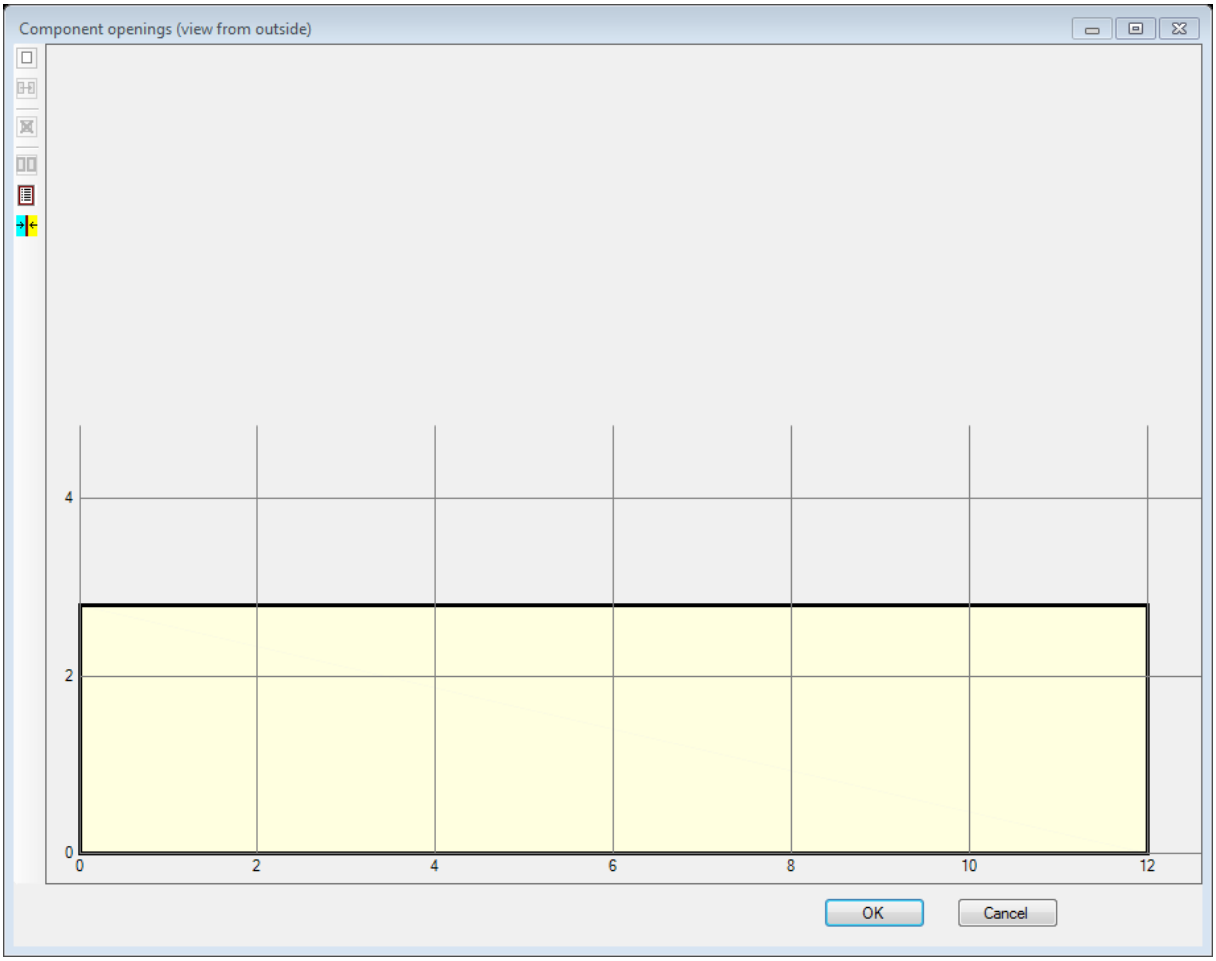


Figure 13: Component openings window

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.
Delete	Delete the selected window or opening. *Hint: Selected windows or openings can also be deleted by pressing the Delete-Button on the keyboard.*
Select All	Select all windows and openings in this component.
Edit list	Shows a list of all windows and openings and allows editing or adding new windows and openings.
Change view	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:

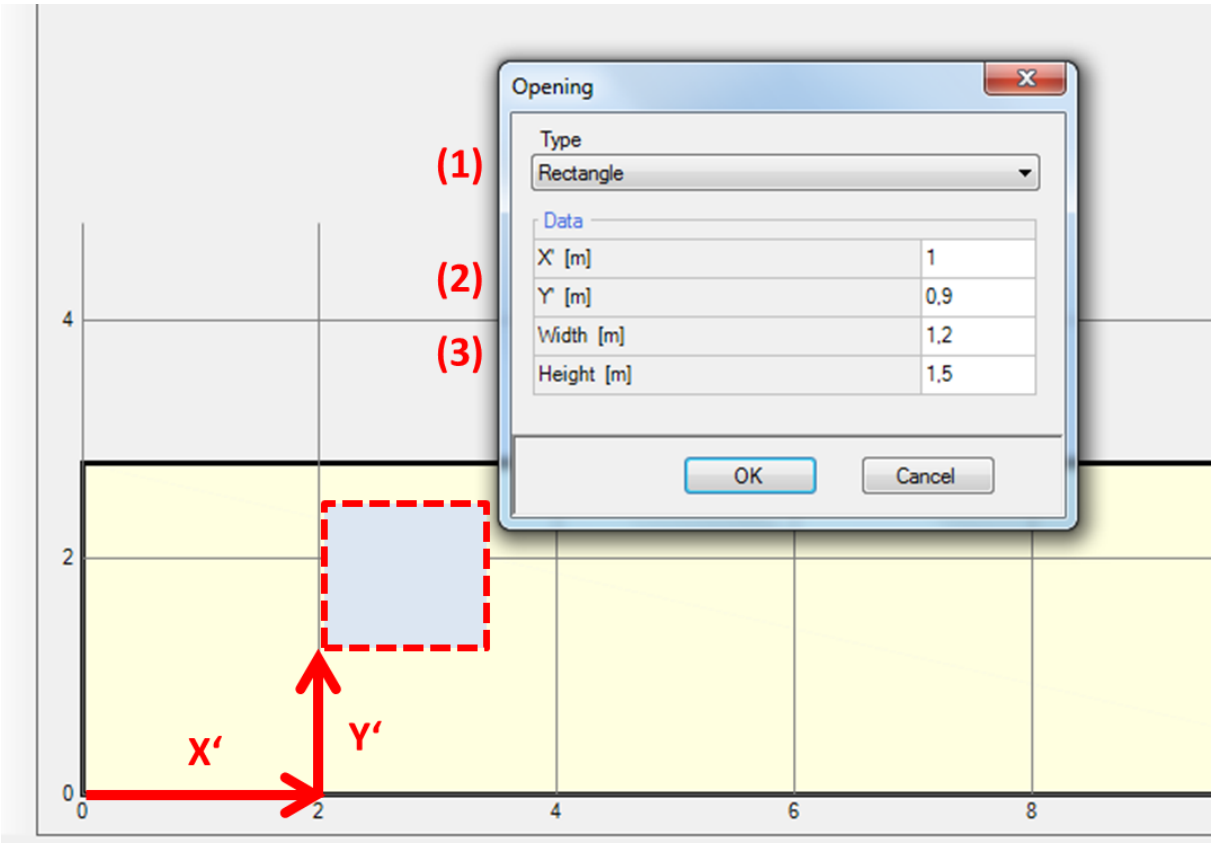


Figure 14: Creating a new window or opening.

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.

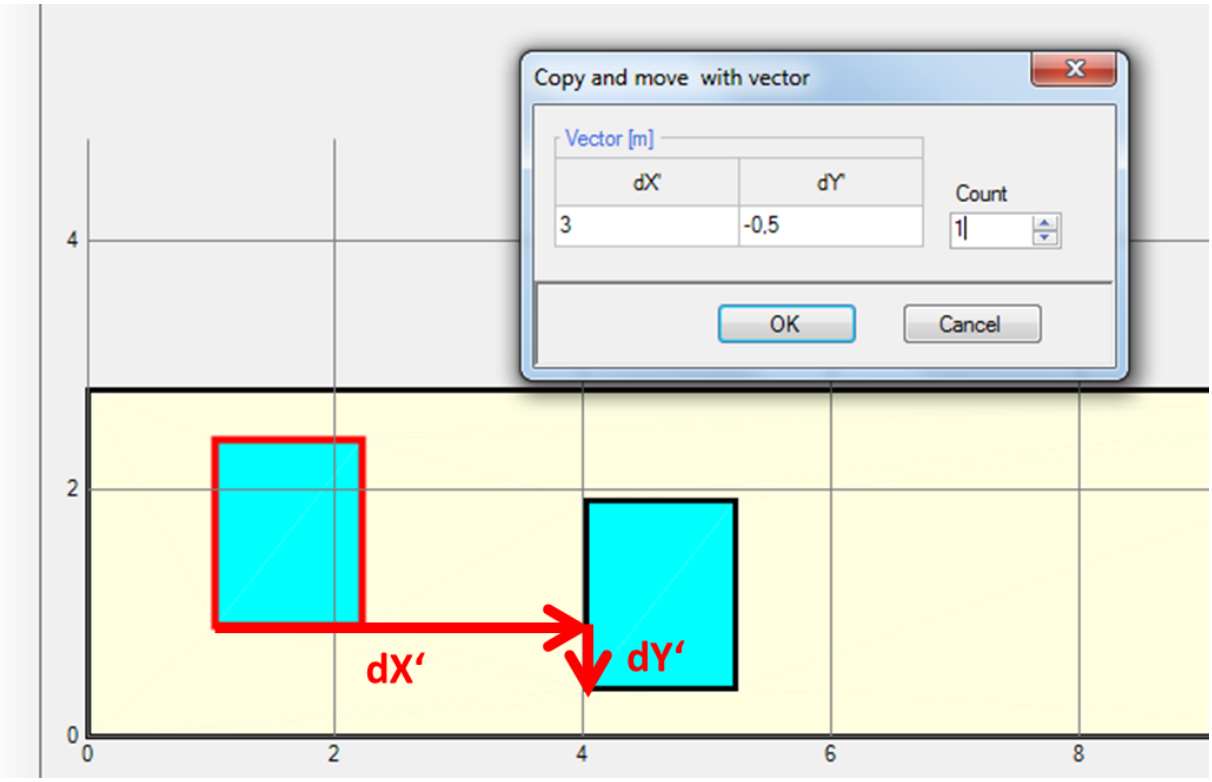


Figure 15: Copy a window or opening.

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.
Inner 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 the WUFI® -Wiki (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

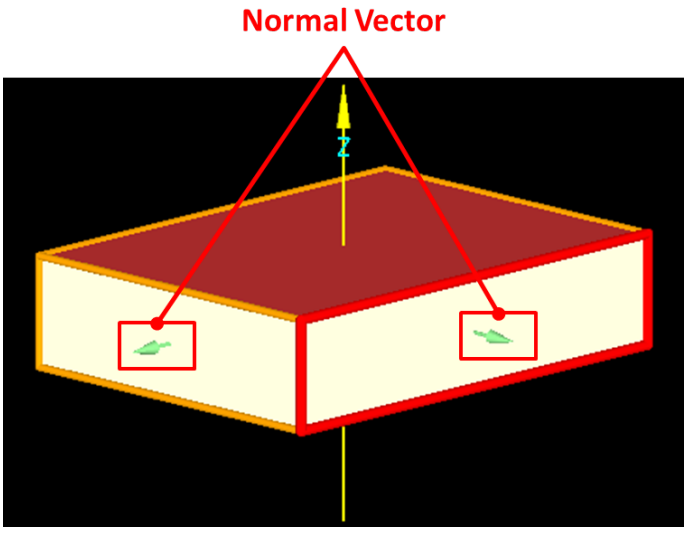
The geometry of the building can be expanded and changed in the *Visualization Box*, by using vertices and connecting them to components. This 3D editing allows the input of complex building shapes within WUFI® Plus and can also be used to create the whole building geometry.

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® Plus 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 the WUFI® -Wiki (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

Close/Reestablish	Hides or shows the *Status & Results Box*.
Status Indicator	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.
Start/ Pause/ Continue	This button starts the calculation. It can also be used to pause it and continue later. If the project consists of multiple cases, right-clicking on the start-button will automatically simulate all cases (one by one, starting with Case 1).
Cancel	This button cancels a running or paused simulation. Already calculated results are saved.
Maximum speed / Show results	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.
Scope/Sequence	Opens an options dialog that controls which basic results are shown in the *Status & Reports Box* after a calculation.
Calculation Progress	A progress bar shows the status of the current calculations. In addition the start and end date is plotted besides the progress bar.
Only Thermal Calculation	If WUFI® Plus performs only thermal calculations, this message will appear on the status bar. More information regarding only thermal calculation can be found in chapter 4.3.

As long as there is still input data missing, the *Status & 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.

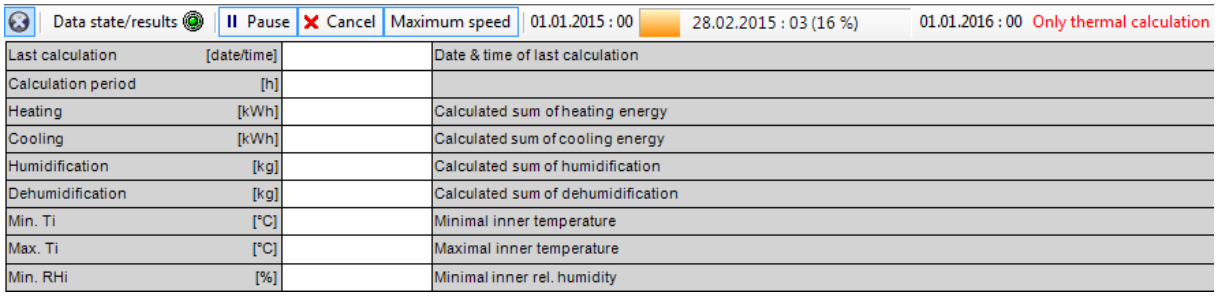


Figure 17: *Status & Results Box* during a calculation.

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 15:48:37	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 covergence 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.*

Controls

Project	General information about the current project. See chapter 4.1.
Files / Measured Data	Importing external data. See chapter 4.2.
Case	General settings for a case. See chapter 4.3.
Localization / Climate	Selection of external and optional climates. See chapter 4.4.
Building	Provides access to building geometry creation or import, settings for the *Air Flow Model* and general calculation settings. See chapter 4.5.
Simulated Zones	Lists all simulated zones. See chapter 4.5.2.
Zone	General settings and information about a zone. See chapter 4.5.2.
Visualized components	Lists all visualized components in a zone. See chapter 4.5.3.
Visualized Components	Definition of a visualized component. See chapter 4.5.3. Components are automatically categorized, depending on their orientation and boundary conditions: • Roof • Wall against unheated attic • Ceiling against unheated attic • Flat roof • Exterior Wall • Opening • Window • Interior Wall between two heated zones • Interior Wall against an unheated zone • Interior Wall within a heated zone • Ceiling between two heated zones • Ceiling against a unheated zone • Floor against an unheated zone • Floor against air • Floor against unheated cellar • Wall against ground • Floor against ground

Not visualized components	Lists all not visualized components in a zone. See chapter 4.5.4.
Not visualized component	Definition of a not visualized component. See chapter 4.5.4.
Thermal bridges	Definition of thermal bridges. See chapter 4.5.6.
Internal Loads / Occupancy	Definition of internal loads. See chapter 4.5.7.
Design conditions	Definition of design conditions, like temperature or humidi-ty setpoints. See chapter 4.5.8.
Ventilation	Ventilation settings. See chapter 4.5.9.
Other parameters	Additional calculation settings for a zone. See chapter 4.5.10.
Attached zones	List of all attached zones. See chapter 4.5.5.
Attached Zone	General settings and information about an attached zone. See chapter 4.5.5. Available types: • Unheated Space • Unheated Cellar • Space under suspended floor(crawlspace) • Wintergarden, not heated • Unheated Attic • Conditioned Space
3D-Objects	List of all 3D-objects in the building. See chapter 4.5.11.
3D-Object	Definition of a 3D-Object. See chapter 4.5.11.
Remaining elements	List of all elements which are not connected to a zone. See chapter 4.5.12.
HVAC	List of all HVAC systems. See chapter 4.6.
System	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.

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 measured data or any other external data it can be included in WUFI® Plus with the dialog *"Files / Measured Data"*. External files can be used as optional climates or daily profiles (e.g. internal loads, ventilation or HVAC).

Controls

New	Create a new element in this list. The *Edit file* dialog will open.
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.
Inner 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
Edit	Edit the selected external file. The *Edit file* 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): Each column must be assigned with its unit type to allow unit conversion and correct assignment of imported values in the simulations. The imported values can also be modified (multiplication & summation; both allow positive and negative values; multiplication will always be applied first) and named. Possible errors are shown, too.
Also a data visualization is available in form of simple diagrams (4).

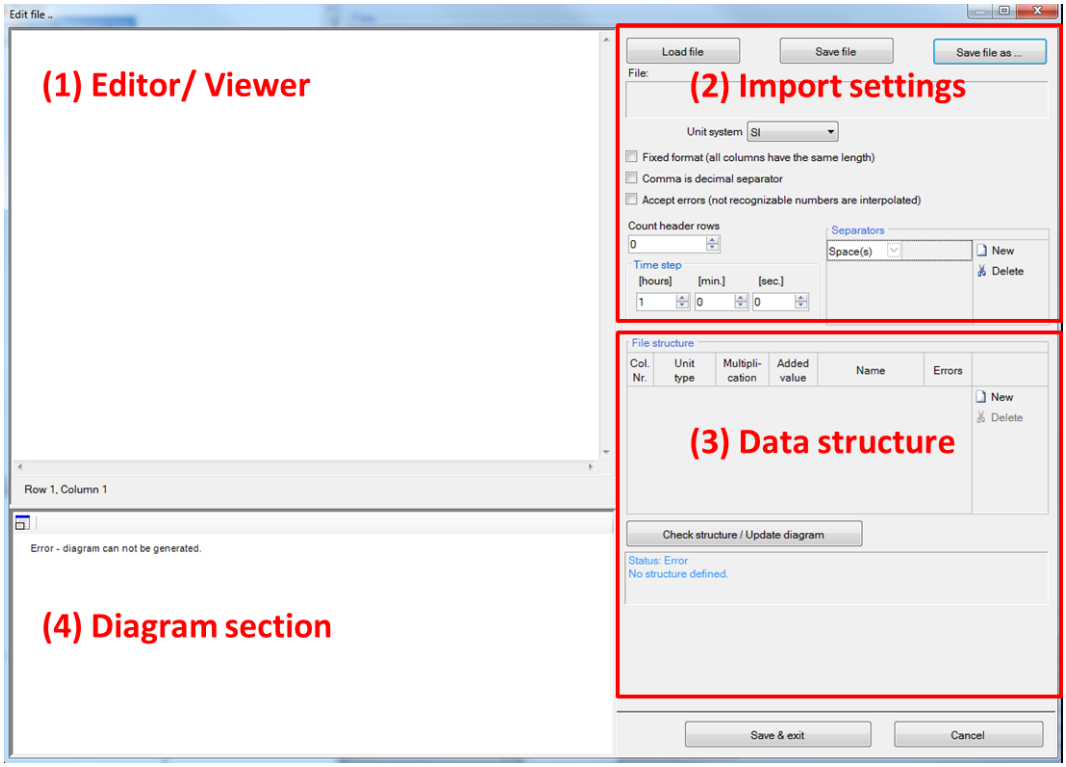


Figure 19: Edit File dialog.

A tutorial video on the WUFI® -Wiki (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.

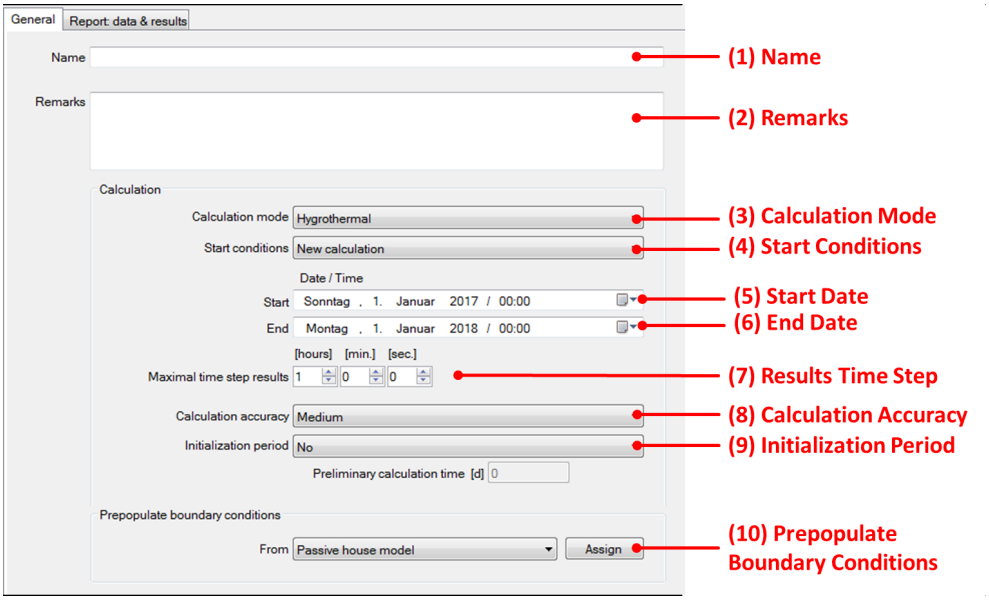


Figure 20: General Settings for a Case.

Controls Box

(1) Name	Allows naming the current case.
(2) Remarks	A place for annotations.
(3) Calculation Mode	Switching between thermal and hygrothermal simulations. Thermal simulations neglect the coupled heat and moisture transport processes in the components and their moisture exchange with the simulated zone. Only energy transport will be considered. This will accelerate the calculation process but causes unreasonable results for the moisture balance as hygric interactions with the components are neglected. The humidity conditions inside the components are also not available. The initial moisture in the components is constant through the simulation.
(4) Start conditions	Three possibilities can be set here: • New calculation • Continue last calculation • New calculation with initial conditions from last calculation
(5) Start date	Setting the start date. Clicking on the calendar sign opens a calendar widget which allows setting the start date without typing.
(6) End date	Setting the date when the calculation will end.
(7) Max. time step results	This setting is used for showing and exporting the simulation results.
(8) Calculation accuracy	Changing the calculation accuracy influences calculation time.
(9) Initialization period	An initialization period before the simulation can be set.
(10) Prepopulate boundary conditions	Set boundary conditions from a passive house model.

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 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 the 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:

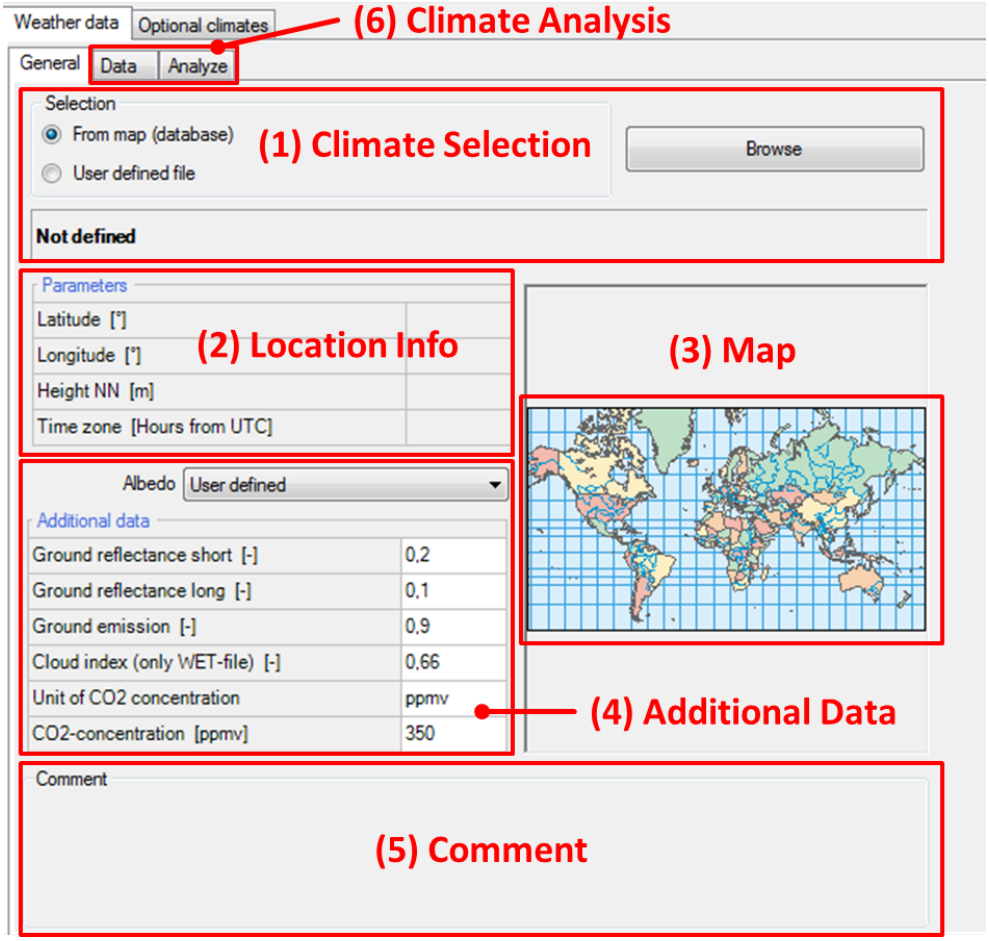


Figure 21: Weather Data dialog.

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 the 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).

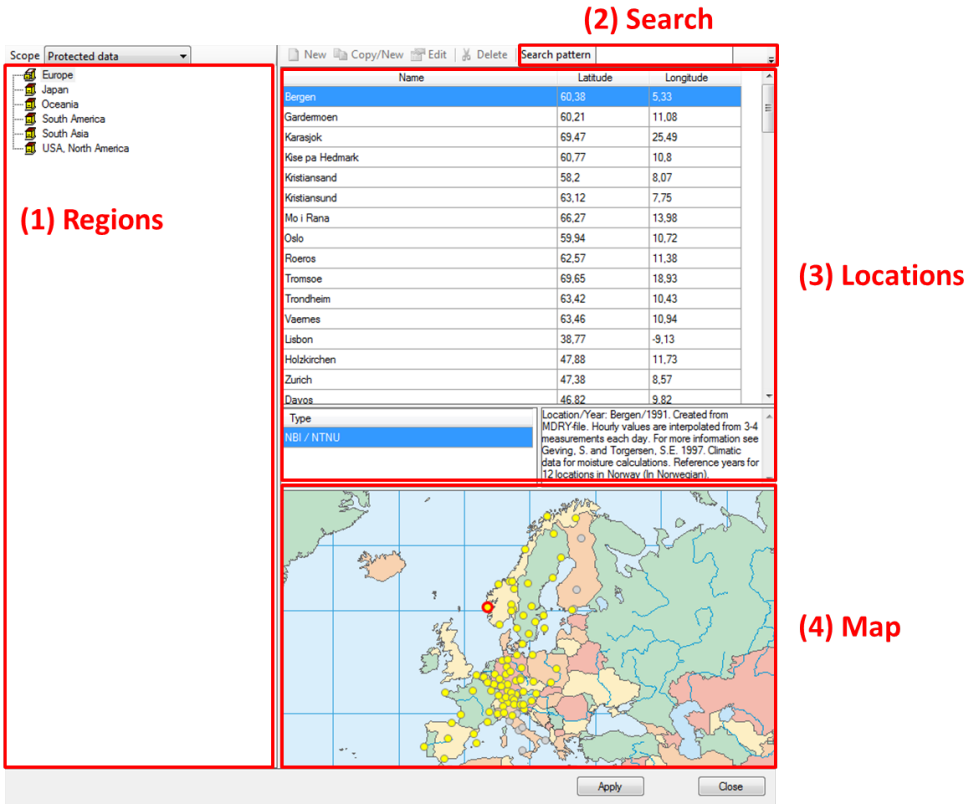


Figure 22: Climate Database.

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

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.
Inner 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 the WUFI® -Wiki (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 is faster and allows the reuse of calculated shading values for future simulation, but the shading cannot be visualized during the simulation. Calculating shading for each time step separately is more time consuming, but the shading can be observed during simulation.
- 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 the WUFI® -Wiki about the Longwave 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.

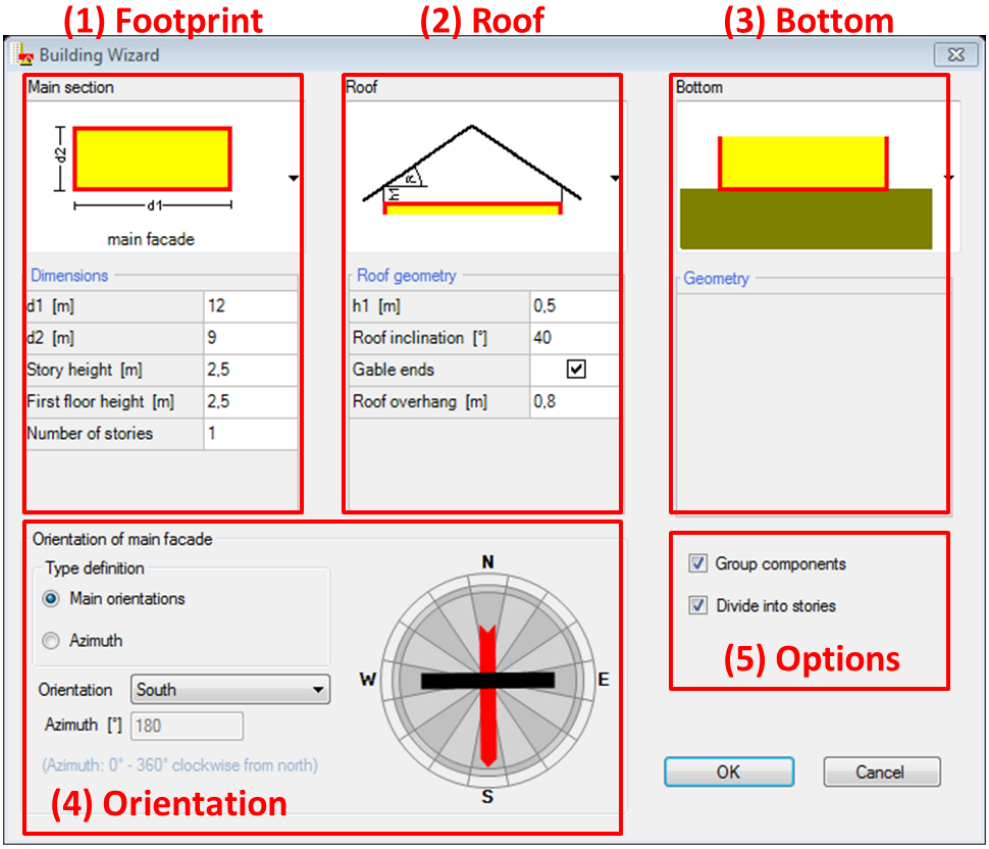


Figure 23: Building Wizard.

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 the WUFI® -Wiki (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 those zones and must be defined precisely. 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.

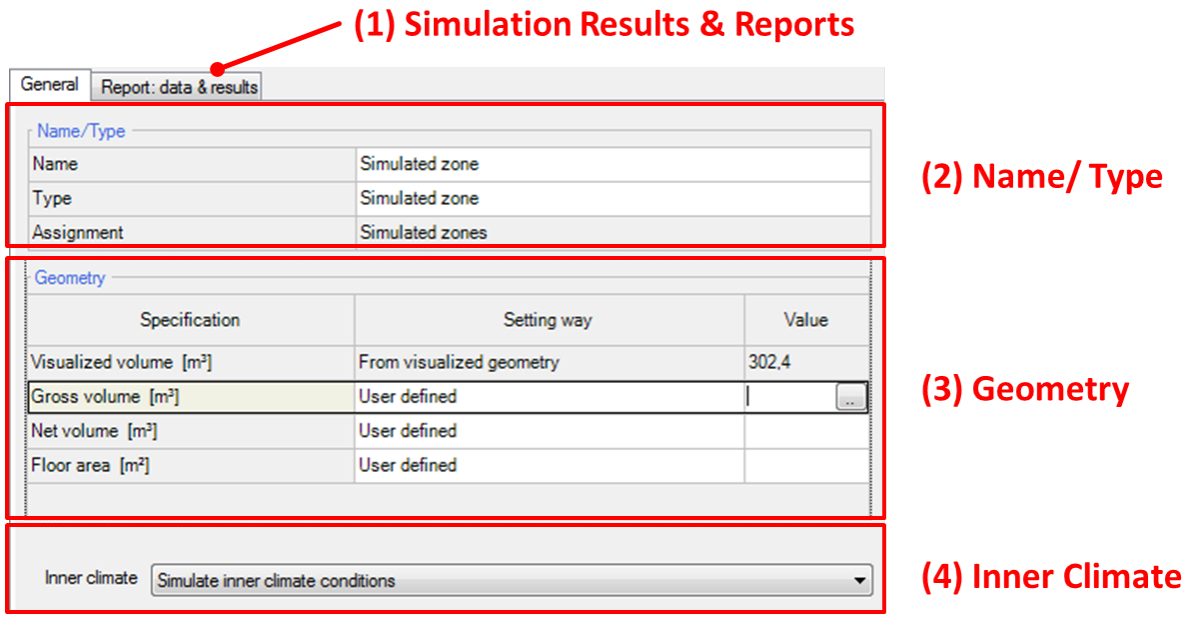


Figure 24: Simulated Zone - General Tab

Controls Box

(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. It is recommended to calculate and enter these values manually, as, depending on the complexity of the geometry of the zone, slight errors in the automatic calculation might add up. 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 (default setting),
- corresponds to the defined *"Design Conditions"*, or
- is defined by an *"Optional Climate"*. Usually, the inner climate should be simulated with WUFI® Plus. However, in special applications it can be desireable to use a predefined indoor climate. Then, the other two options can be used.

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 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.

Visit the WUFI® -Wiki (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

 **New**	Create a new element in this list. The *Edit file* dialog will open.
 **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.
Inner 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

4.5.5 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 those zones and must be defined precisely. 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.

4.5.6 Thermal Bridges

The ThermalBridges-dialog allows the input for thermal bridges of a zone. Thermal bridges are considered in the zone's energy balance as:

$$Q_{TB} = \sum_{i=1}^{n} \psi_i \cdot L_i \cdot (\vartheta_{attachment,i} - \vartheta_{zone,interior})$$

with

Q_{TB}:	Heat exchange with thermal bridges
N:	Number of thermal bridges
ψ:	Linear thermal heat transfer coefficient (Psi-value)
L:	Length of thermal bridge
ϑ:	Air temperature of zone and attached temperature

The following user-inputs are necessary when entering a new thermal bridge into this list:

- Name the thermal bridge (1).
- Enter its linear thermal heat transfer coefficient (Psi-value) (2).
- Enter the length of the thermal bridge (3).
- Define the attachment-type (4) on the exterior side of each thermal bridge.
- For attachment-types "'Perimeter"' and "'Basement floor"' an optional climate (5) has to be defined.

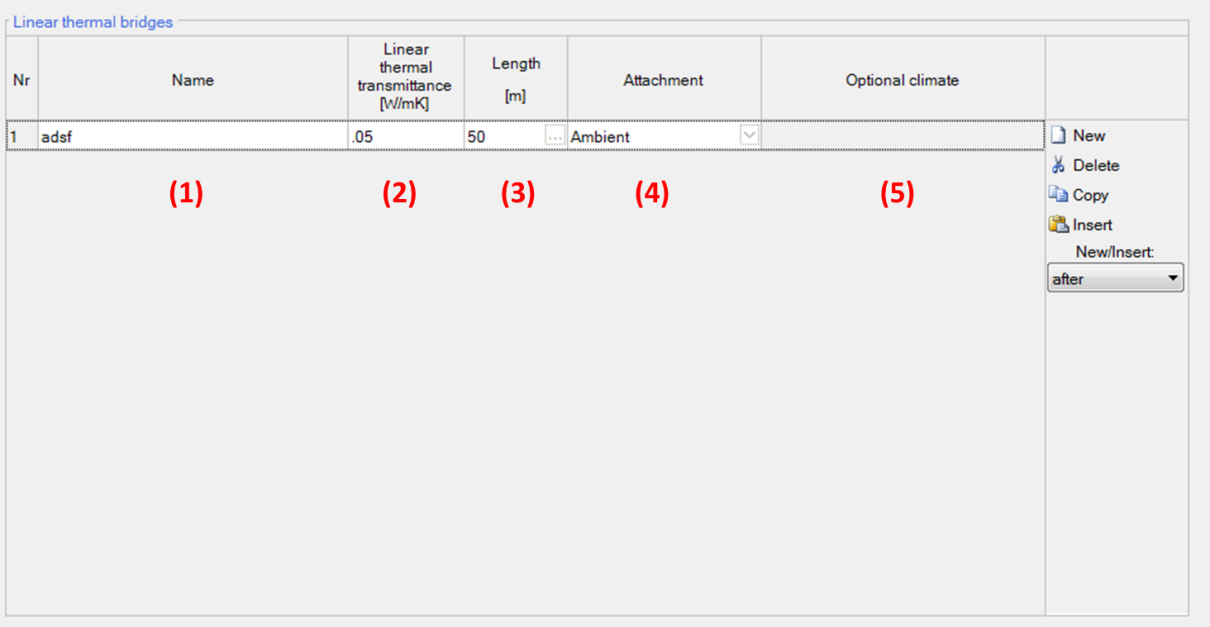


Figure 25: Thermal bridges dialog (WUFI® Plus scope)

Controls

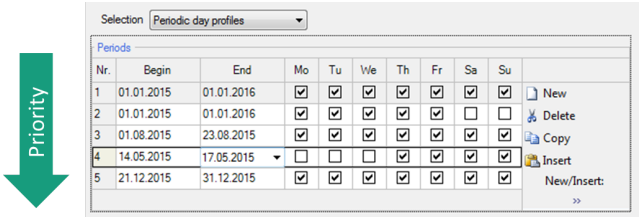
New	Create a new element in this list. The *Edit file* dialog will open.
Delete	Delete the selected element.
Copy	Copy the selected element.
Insert	Insert a copied element. The *Insert Position* specifies where the copied element will be positioned.
Inner position	Controls where a copied element will be inserted: • *"after"* the selected element • *"before"* the selected element • *"exchange"* the selected element with the copied one

4.5.7 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.

You can choose whether the internal loads are to be entered as external files, see chapter 4.2, or as *Periodic day profiles*, by selecting the corresponding option in the *Selection* drop-down menu. *Periodic day profiles* allow 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_2 loads are defined 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.



WUFI® Plus prioritizes the different periods depending on their entry in the list: Higher numbers (1st 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).

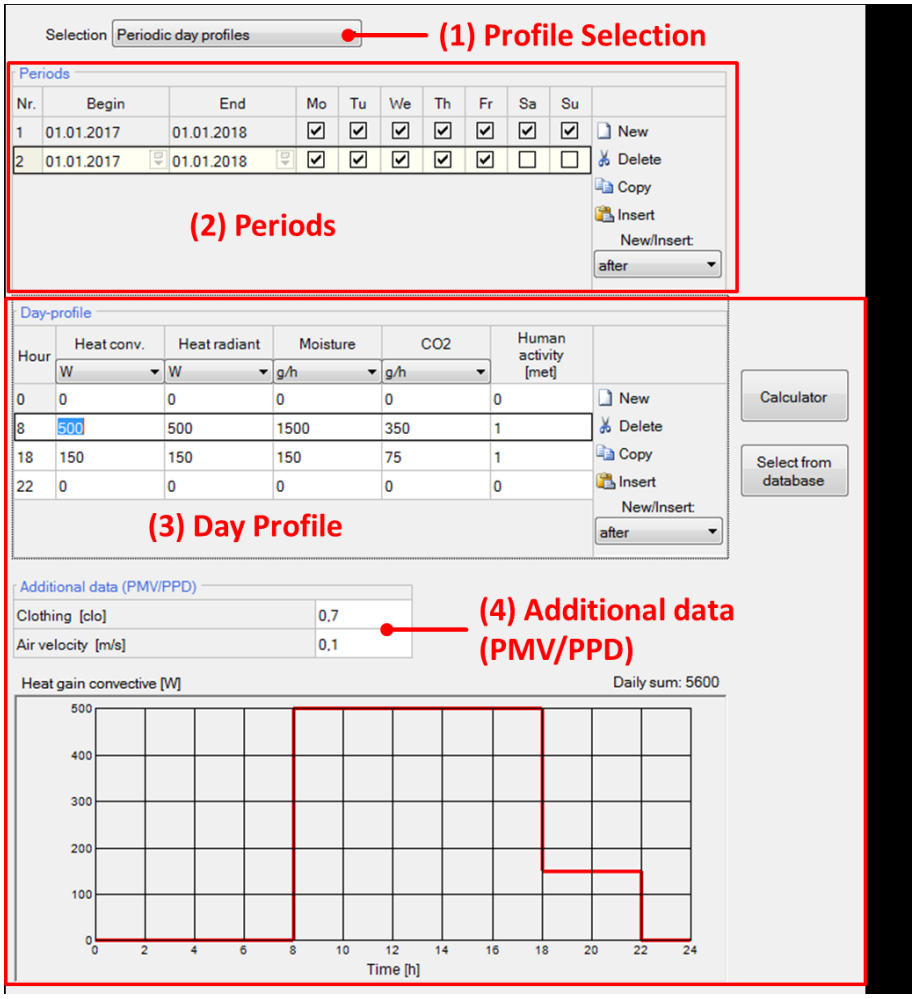


Figure 26: Internal Loads/ Occupancy dialog

Entries in the column ”Human activity” are necessary to enable calculation of PMV and PPD (Thermal comfort as in DIN EN ISO 7730). When a value for human activity is entered (> 0), additional data entries become available for this timestep to input the level of clothing and air velocity.

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 Data-base*. • Pre-defined *Day-Profiles* can be loaded from the *Day Profiles Database*. The active *Day-Profile* is visualized at the bottom of this dialog.
(4) Additional data (PMV/PPD)	This input is necessary for the calculation of PMV or PPD. It is only available for rows where human activity is defined (> 0). PMV or PPD are only calculated for timesteps where values for human activity, clothing and air velocity are defined (> 0).
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.
Inner 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 the WUFI® Wiki (www.wufi-wiki.com). There, you can also find a tutorial movie about this topic.

4.5.8 Design Conditions

Setpoints for temperature, relative humidity, and CO_2-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 figure below shows the *Design Conditions*-dialog and its functions are explained afterwards.

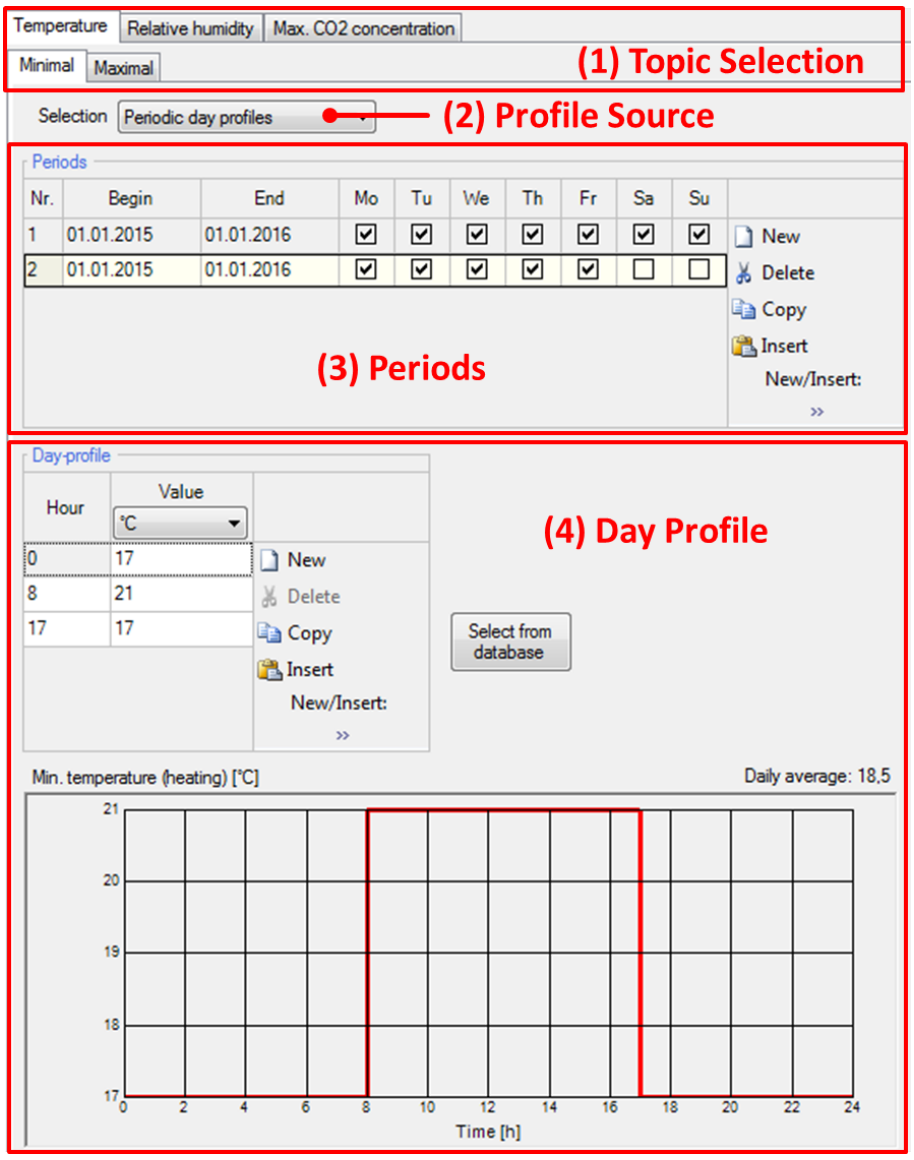


Figure 27: Design Conditions dialog

Controls

(1) Topic Selection	Design conditions can be set for temperature, relative humidity and CO_2-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. The *Edit file* dialog will open.
 **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.
Inner 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 the WUFI® Wiki (www.wufi-wiki.com). There, you can also find a tutorial movie about this topic.

4.5.9 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 the air flow model is activated for a zone, no input can be made here. For the necessary data and settings for the air flow model, see chapter 7 and the corresponding chapter in the Fundamentals manual.

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.

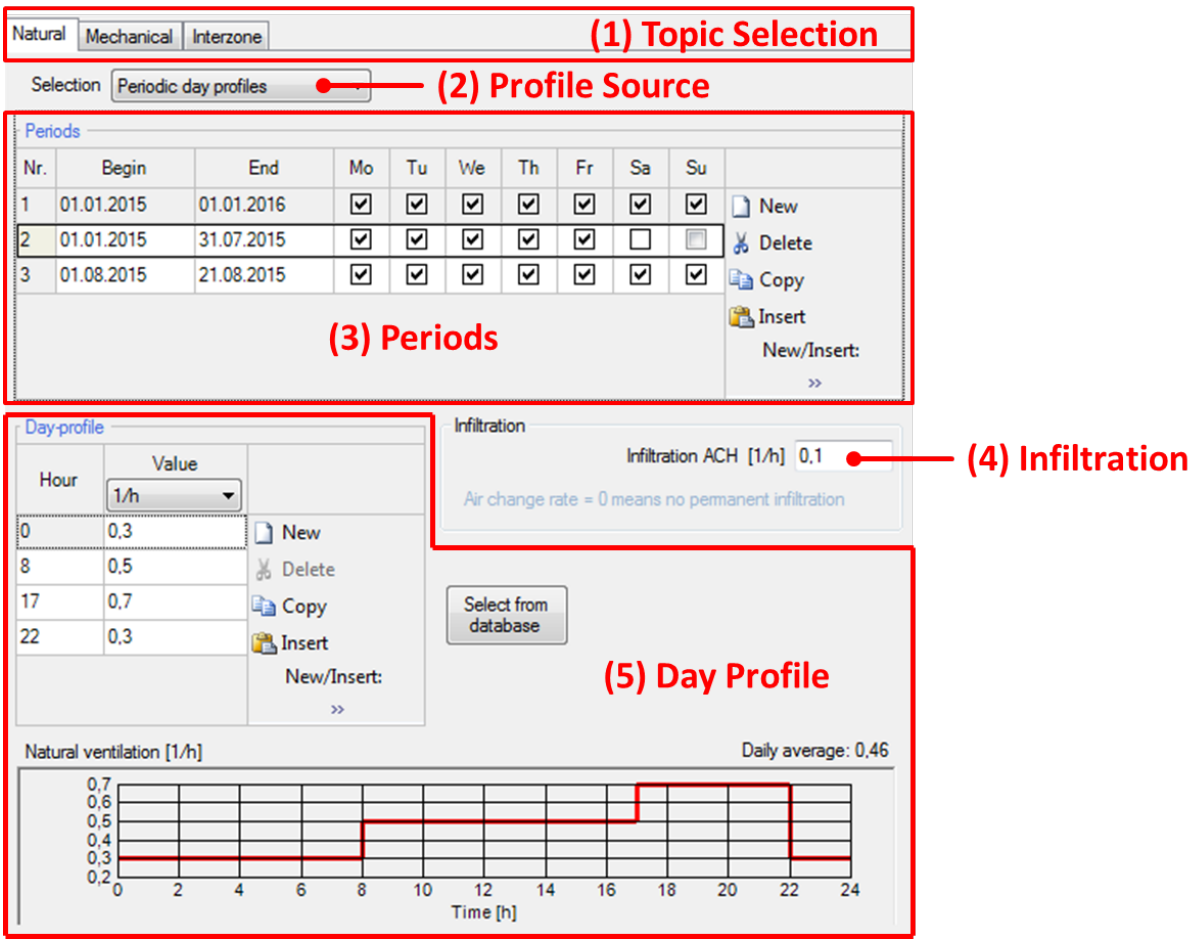


Figure 28: Ventilation dialog

Controls

(1) Topic Selection Changing between the three ventilation types.

(2) Profile Source Ventilation profiles 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) Infiltration ACH 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 *Ventilation*-dialog.

(5) Day Profile *Day-Profiles* can 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. The *Edit file* dialog will open.

 **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.

Inner 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

(1) Mechanical: Ventilation control In the *Mechanical Ventilation* subsection an additional dropdown menu allows setting control mechanisms for mechanical ventilation. Different control types are available:

- Temperature control
- Relative humidity control
- Max. CO_2 control

The mechanical ventilation is activated as soon as the threshold values defined by the control types are exceeded.

(1) Interzone: From zone This menu in the *Interzone Ventilation* subsection selects from which other zone the ventilation is considered.

A detailed explanation and a tutorial video on the WUFI® -Wiki (www.wufi-wiki.com) show how Ventilation Profiles can be entered.

4.5.10 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_2 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. A detailed description of this parameter can be found in the Fundamentals manual.
- It can be decided whether calculations should be aborted or continued with increased air supply from outer air if a negative air balance occurs.

4.5.11 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.

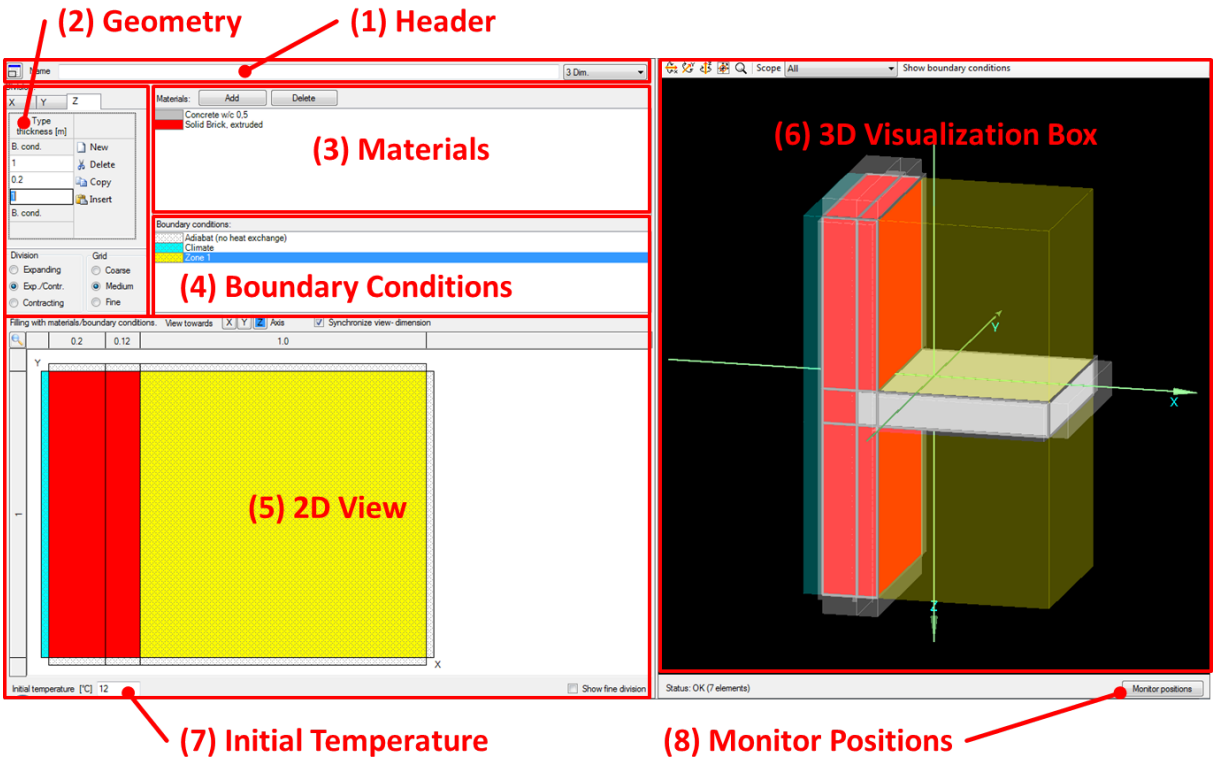


Figure 29: 3D Objects dialog

A detailed report regarding the functionality and possiblities of the 3D-Objects can be found in the Fundamentals manual and a tutorial video on the WUFI® Wiki shows the input of a 3D thermal bridge.

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.
(3) Materials	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.
(4) Boundary Conditions	A list of available boundary conditions which can be applied to the *3D Object*. This is a very important input, as its 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*, its influenced by the *3D Object*, too.
(5) 2D View	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.
(6) 3D Visualization Box	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.
(7) Initial Temperature	Sets the initial temperature inside the *3D Object*.
(8) Monitor Positions	Creates and manages user defined *Monitor Positions*. Results are only exported for *Monitor Positions*.

A detailed explanation and a tutorial video on the WUFI® -Wiki (www.wufi-wiki.com) show how a *3D Object* is constructed and how its results can be assessed.

4.5.12 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.

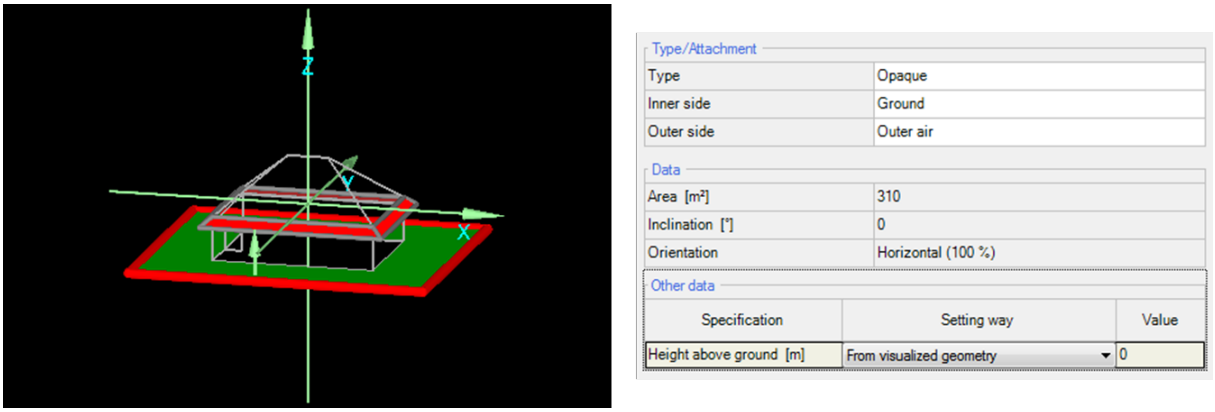


Figure 30: Using remaining objects to define a reference for the ground level.

4.6 HVAC Menu

In this element of the *Project Tree* (1) 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* (2) can be selected from a dropdown-menu (3), see figure below. In general, WUFI® Plus supports two categories of *System types*:

- User defined systems (ideal systems)
- Predefined systems

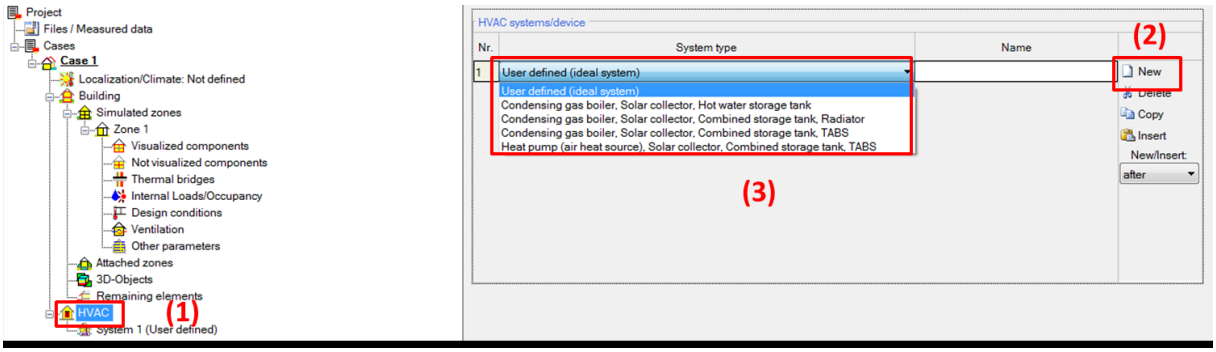


Figure 31: HVAC dialog

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* specifies where the copied element will be positioned.
Inner 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 checkboxes.

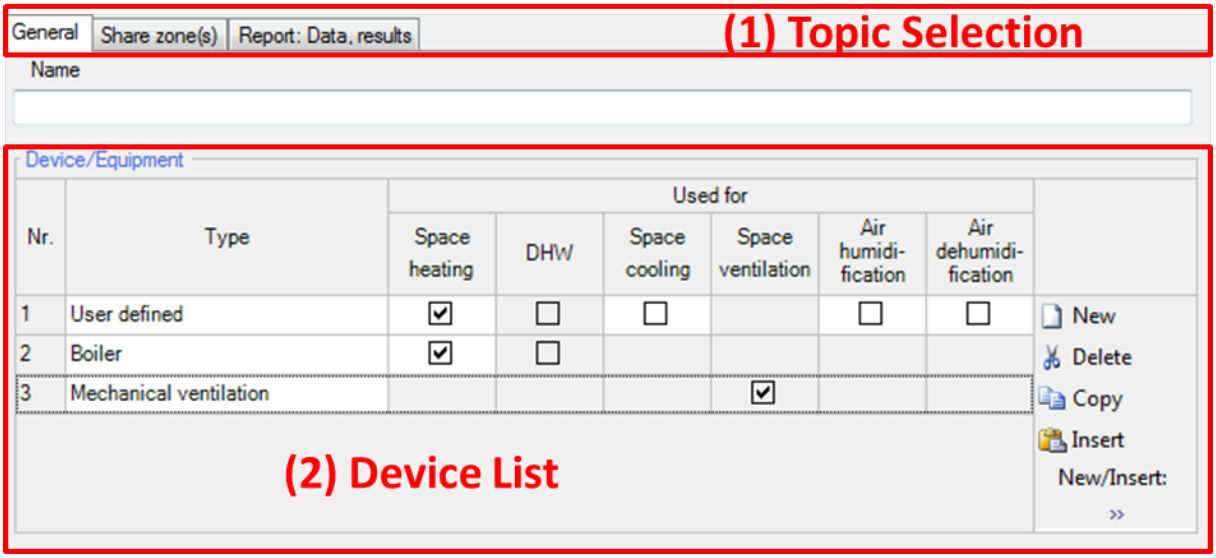


Figure 32: List of HVAC Devices

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.
Inner 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:

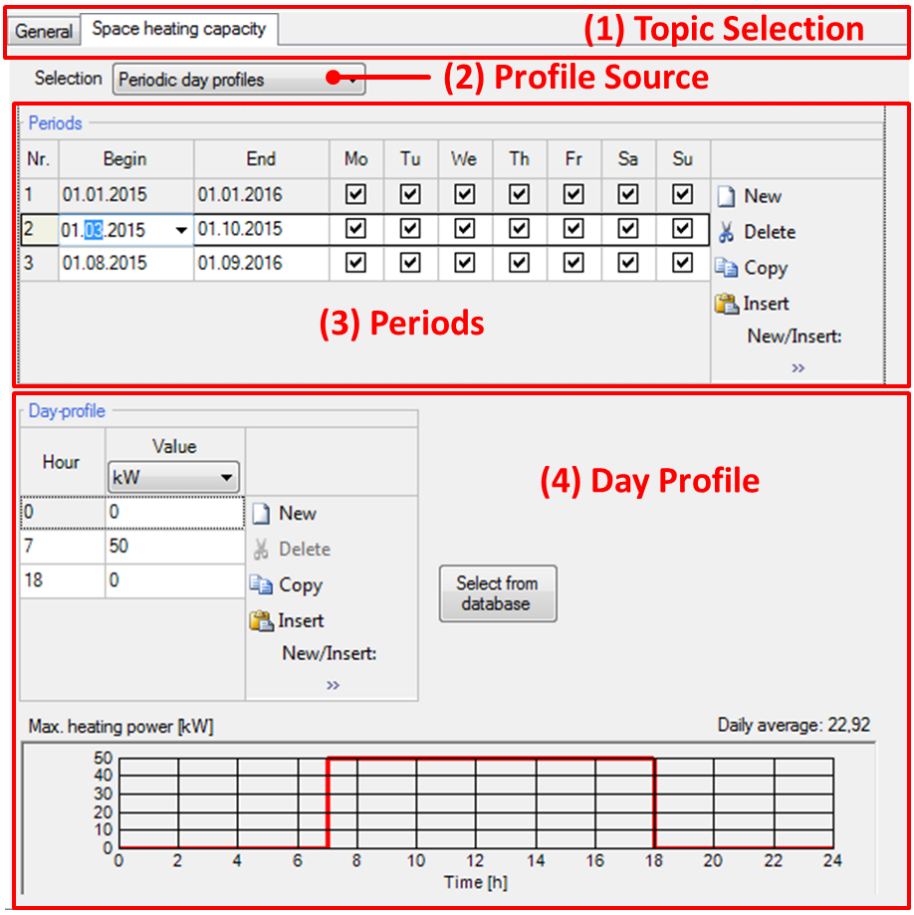


Figure 33: Settings for a HVAC Device.

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.
Inner 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 the WUFI® -Wiki (www.wufi-wiki.com) show how *Ideal user-defined HVAC systems* can be entered in WUFI® Plus.

4.6.2 Detailed Predefined Systems

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

- 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
- Heat pump (air heat source), 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.

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 wont 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.

Please refer to the WUFI® -Wiki (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.

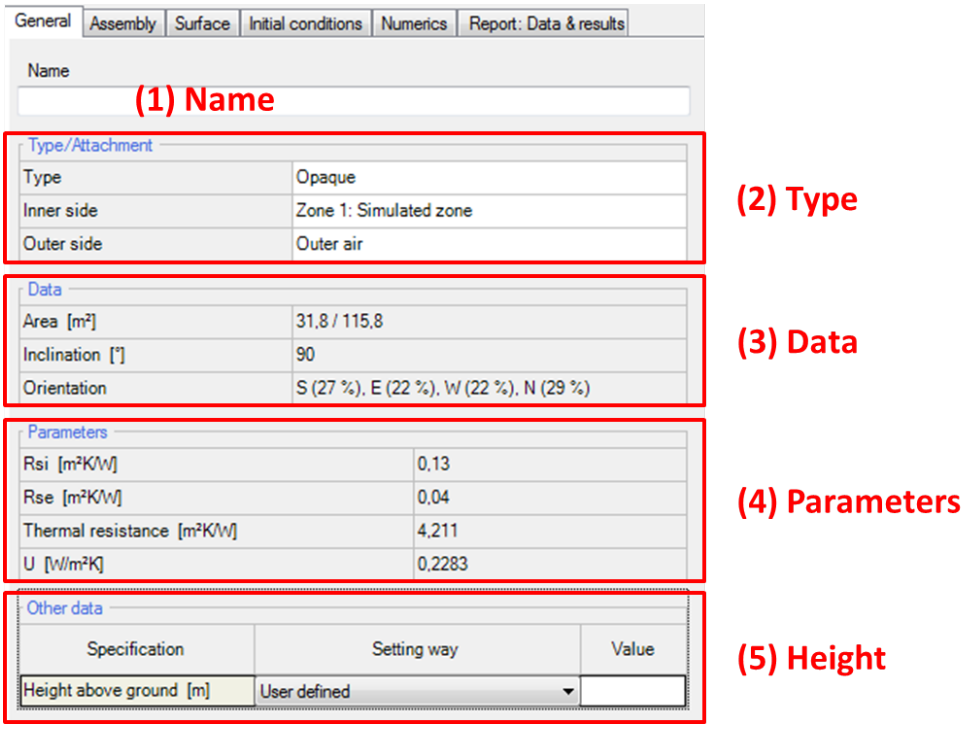


Figure 34: Opaque Component General Settings.

Controls

(1) Name	Name of the component.
(2) Type	Definition of the components type (opaque, transparent or opening) and the boundary conditions on the inner and outer side.
(3) Data	Summary of the components geometry.
(4) Parameters	Summary of general properties of this component. Thermal resistance and U-Value are added after the assembly was defined.
(5) Height	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 calculate 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 4.5.12.

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).

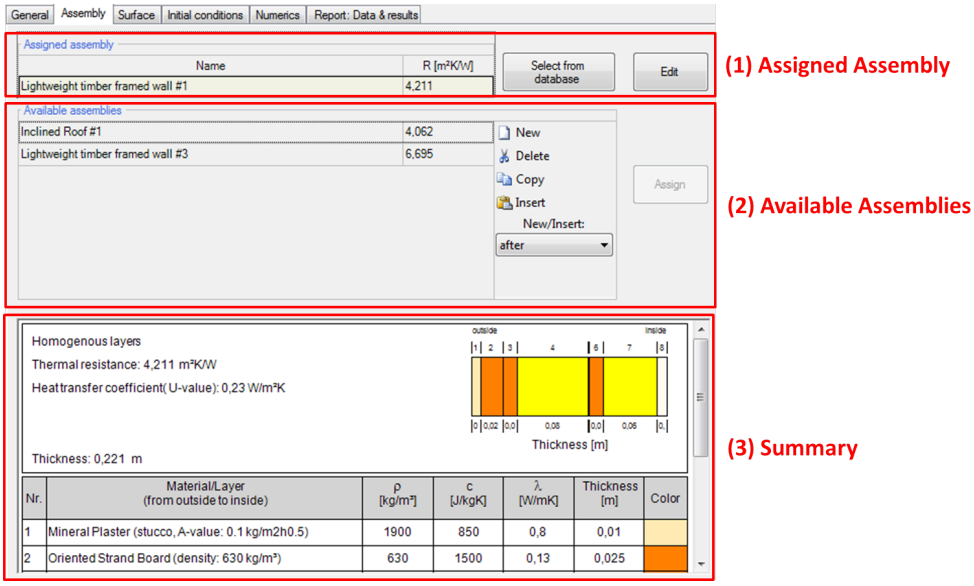


Figure 35: Opaque Component General Settings.

Assemblies that were created in a project cant be saved in the database. So, if you want to reuse 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 the WUFI® -Wiki (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:

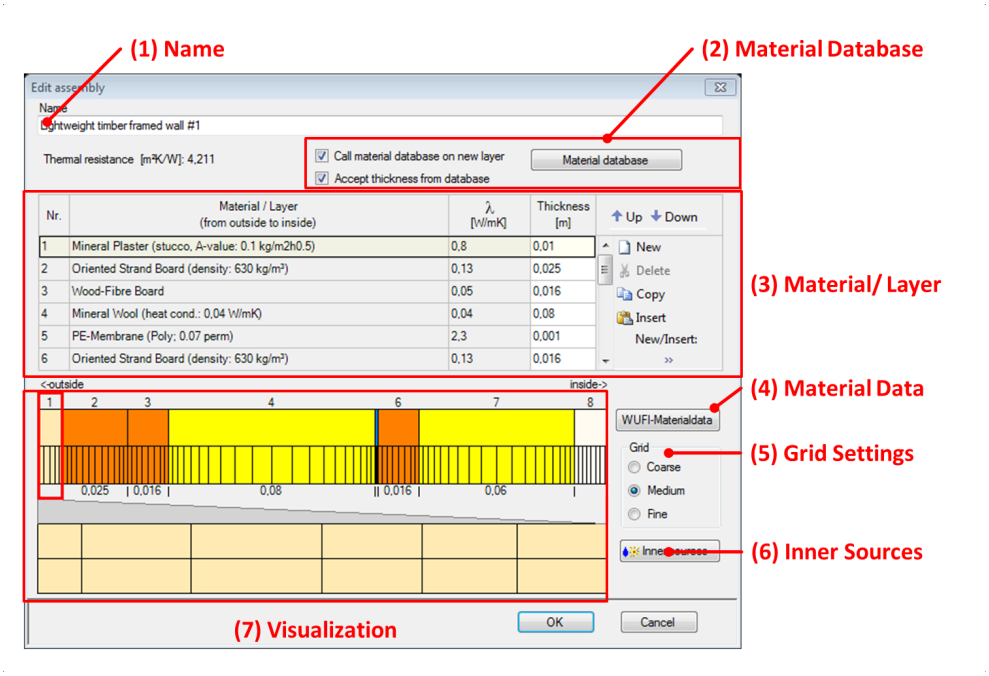


Figure 36: Opaque Component Edit Assembly.

Controls

(1) Name — Name of the assembly.

(2) Material Database — 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.

(3) Material/ Layer — 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.

(4) Material Data — Clicking this button opens the *Materialdata*-window, see chapter 5.1.4.

(5) Grid Settings — 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.
	**Up/Down**	These buttons allow to alter the position of the selected layer. It can either be moved up (towards component's outer side) or down (towards component's inner side).
	**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.
	Inner 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:

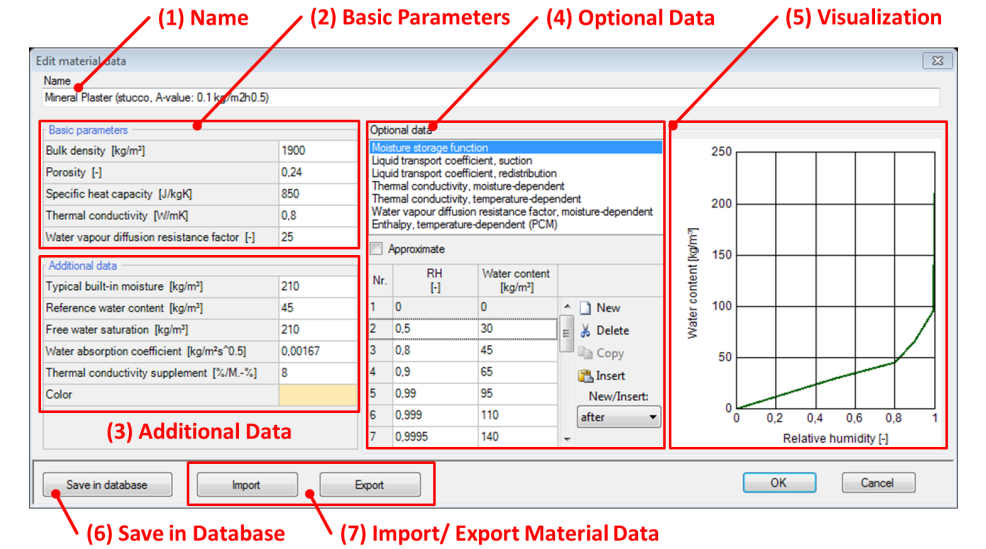
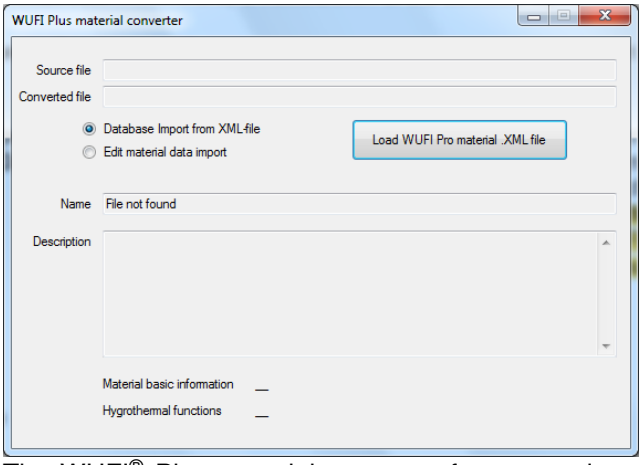


Figure 37: Edit Material Data.

Controls

(1) Name	Name of the material.
(2) Basic Parameters	This material data constitutes an indispensable minimum without which a calculation is not possible.
(3) Additional Data	Additional, constant parameters that can be provided.
(4) Optional Data	Moisture- and temperature-dependent data.
(5) Visualization	Here, a visualization of the selected *Optional Data* (4) is found.
(6) Save in Database	Save the current material and its parameters in the WUFI® Material Database.
(7) Import/Export Material Data	WUFI® material data can be exchanged as xml-files. These two buttons allow an import or export from these xml-files. Please note: WUFI® Pro and WUFI® Plus use different types of xml-files for their exchange of material data. We offer a simple tool that converts WUFI Pro material files into the WUFI® Plus format. This tool is called ”MaterialXML.exe”. It can be found in the subfolder ”Tools” of the WUFI® Plus Installation folder.
 **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.
Inner 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



The WUFI® Plus material converter formats xml material data of WUFI® Pro to the appropriate WUFI® Plus xml format. After clicking ”Load WUFI Pro material .XML file” and searching the associated file, the tool automatically creates a new xml-file according to the selected task:

1. Database import from xml-file: Creates a new xml-file with the suffix .plusImportToDB.xml. This file can be imported into the WUFI® Plus Material Database with the function Import from XML-file. See chapter 3.2.4 for further information.
2. Edit material data import: Creates a new xml-file with the suffix .xml.plusMaterial.xml. This file can be imported into WUFI® Plus from the Edit Material dialog.

The WUFI® Plus material converter is installed together with WUFI® Plus. It can be found in the ”Tools”-folder of your WUFI® Plus installation.

Visit the 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 dropdown 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.

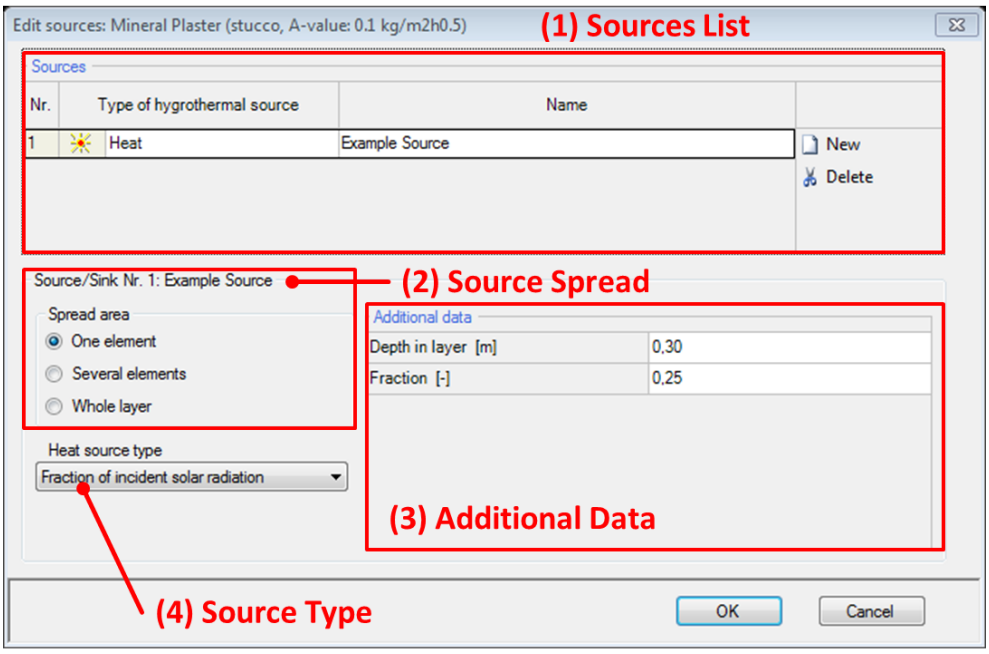


Figure 38: Internal Sources in Components.

Please refer to the WUFI® -Wiki (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:

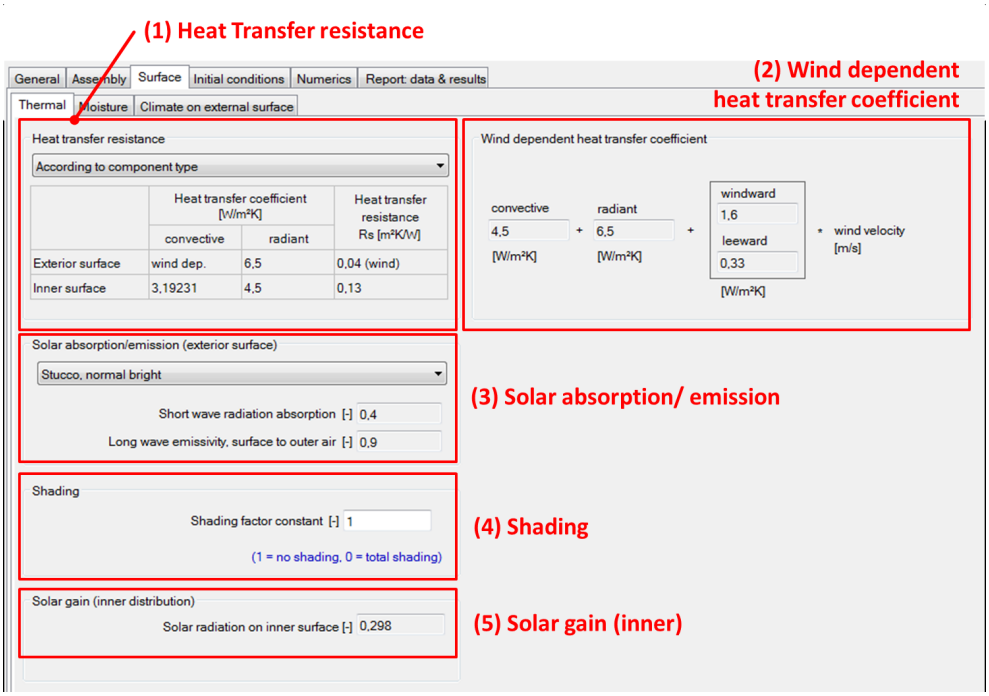


Figure 39: Opaque Component Themal surface settings.

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 the 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/ emission

These factors are used to calculate the radiation. If there 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 4.5.10.

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 can also be incorrect.

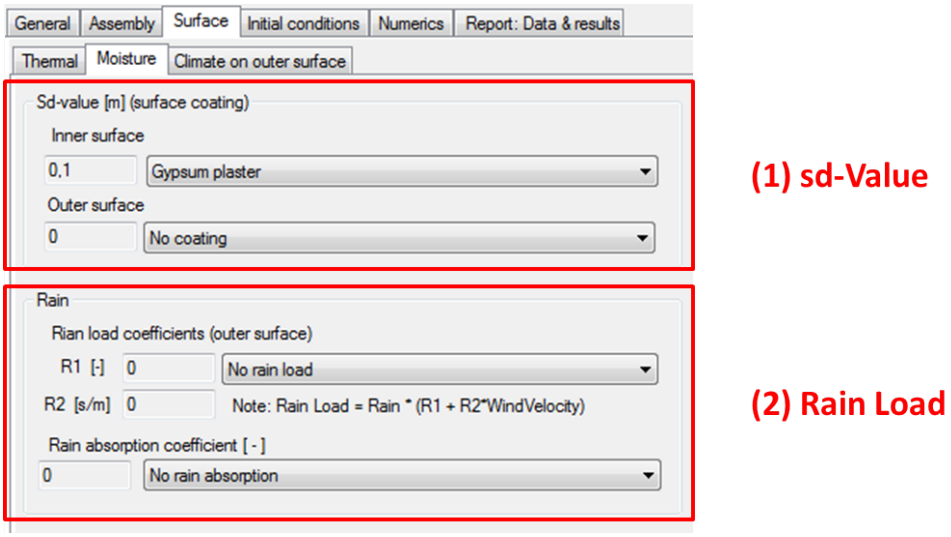


Figure 40: Opaque Component Moisture surface settings.

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 adiabat 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:

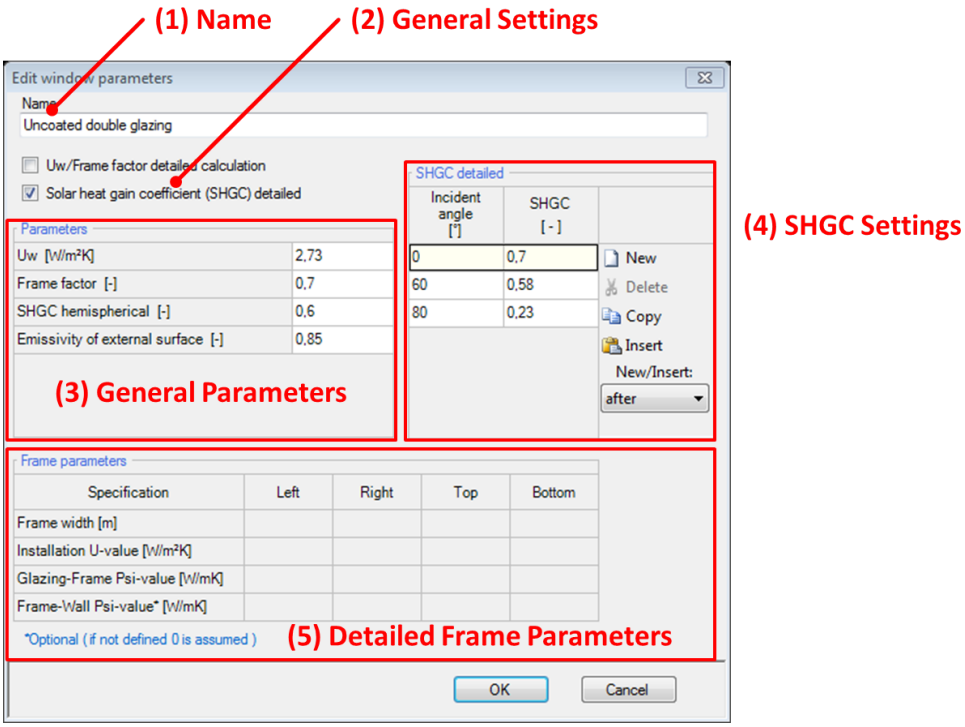


Figure 41: Edit Window Parameters.

Controls

(1) Name	Naming the current window parameters.
(2) General Settings	These checkboxes allow entering more detailed window parameters, see (4) and (5).
(3) General Parameters	Here, general parameters that describe the window can be entered.
(4) SHGC Settings	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 coefficient (SHGC) detailed*-checkbox in the *General Settings* (2) is activated.
(5) Detailed Frame Parameters	Here, detailed parameters of the frame construction can be entered. These settings can be changed, if the *Uw/Frame factor detailed calculation* checkbox in section (2) is activated.
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.
Inner 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

According to the values entered in (5), the total Uw 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 dimensions of the mounted window, whereas the Uw 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 is 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:

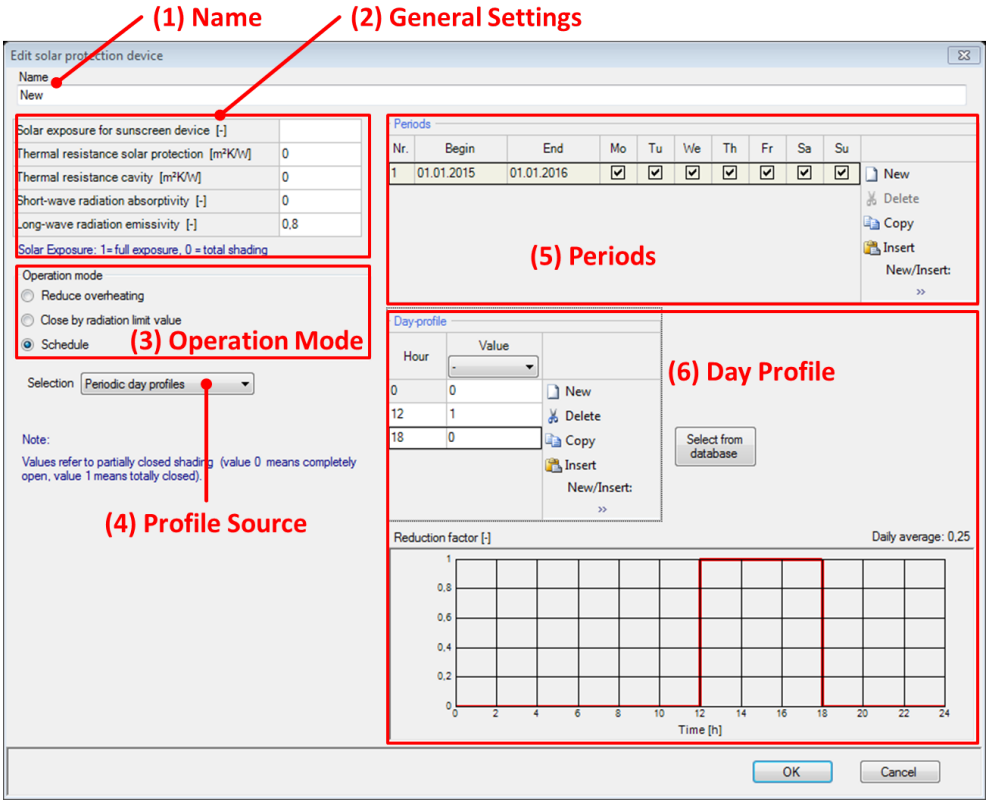
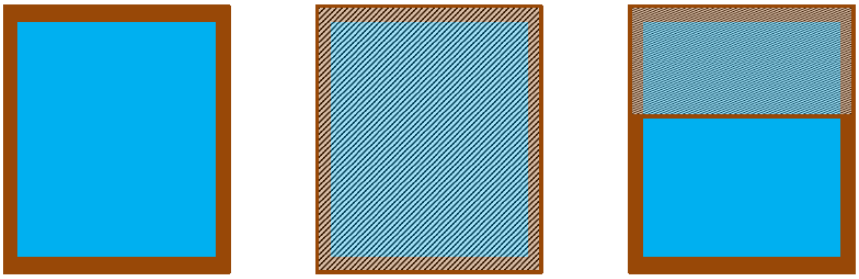


Figure 42: Settings for Solar Protection on Transparent Components if the Operation Mode *Schedule* is chosen.

Controls

(1) Name	Switching between *General settings* and a definition of the properties of the current device.
(2) General Settings	General settings concerning the *Solar exposure for sunscreen device* and *Thermal resistance supplement*.
(3) Operation Mode	WUFI® Plus supports three operation modes for *Sunscreen devices*: • *Reduce overheating*: The *Sunscreen device* will close as long as the maximum temperature defined in the *Design Conditions* (chapter 4.5.8) is excelled. • *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). Please note figure 43.
 **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.
Inner 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



Closing Factor = 0	Closing Factor = 1	Closing Factor = 0.33
Sunscreen completely open	Sunscreen completely closed	Sunscreen shades 33% of glazing area

Example: Solar Exposure for Sunscreen Device = 0.25		
Shading Factor = 1	Shading Factor = 0.25	Shading Factor = 0.7525

$$f_{sunscreen} = (1 - c) + c * F_{sunscreen}$$

$f_{sunscreen}$ ... *Total Shading Factor from Sunscreen*

$F_{sunscreen}$ ... *Solar Exposure for Sunscreen Device*

c ... *Closing Factor of Sunscreen Device*

Figure 43: Sunscreen schedule.

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® Plus 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:

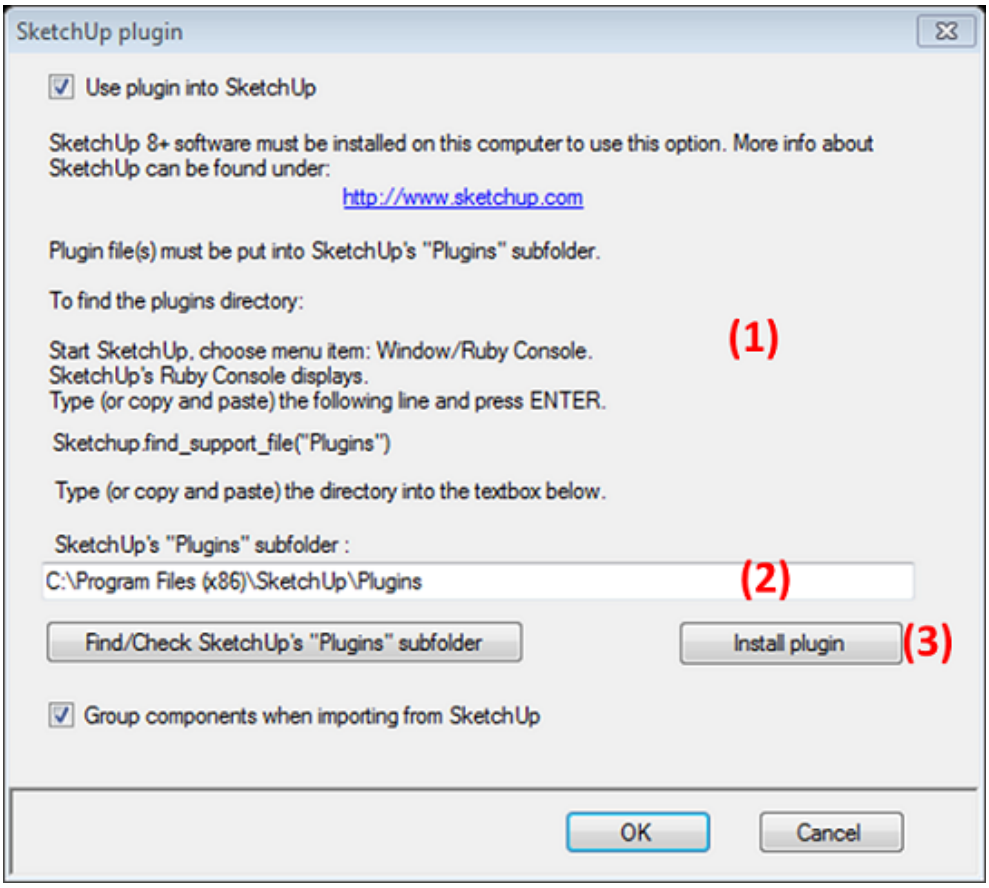


Figure 44: Options for the WUFI® Plus SketchUp Plugin.

Find SketchUps plugins subfolder as described in the dialog (1). Then enter the path to SketchUps plugins subfolder in (2) and click *Install plugin* (3) to complete the installation of the plugin. With SketchUp 2016, the installation requires further steps, which are described at the end of this chapter. Afterwards it can be found in

Sketch-Ups Menu Bar under *Plugins*, 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 Sketch-Up 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. Its recommended to use this function instead of the direct export (2).

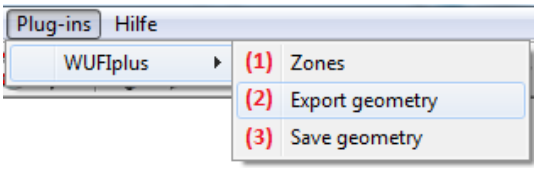


Figure 45: Dialogs in SketchUp for the WUFI® Plus SketchUp Plugin.

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.

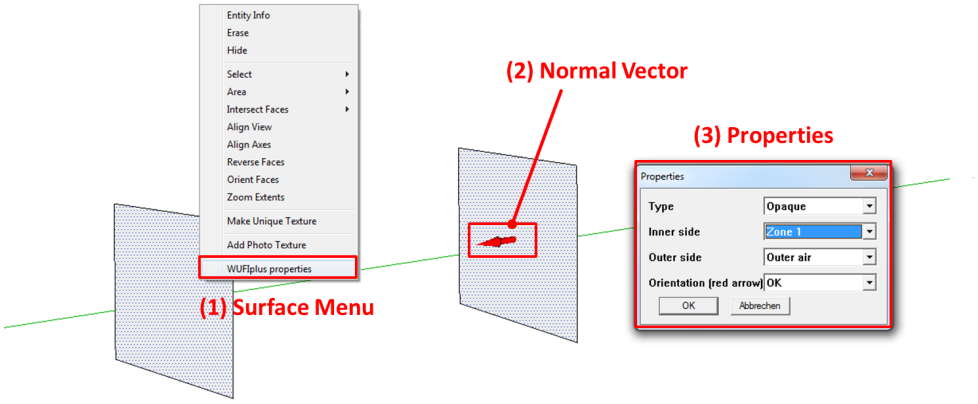


Figure 46: Setting the properties of an object in the WUFI® Plus SketchUp Plugin.

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) 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.

SketchUp 2016:
The installation in SketchUp 2016 differs because the Plug-Ins have to be set separately in this version:

1. Install the WUFI Plus SketchUp Plug-In in WUFI Plus as described above.
2. The open SketchUp 2016 and choose the menu item Window/ Preferences.
3. A list of preferences appears. There, click on Extensions and select Wufi from the list.

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 cannot import a usable model.

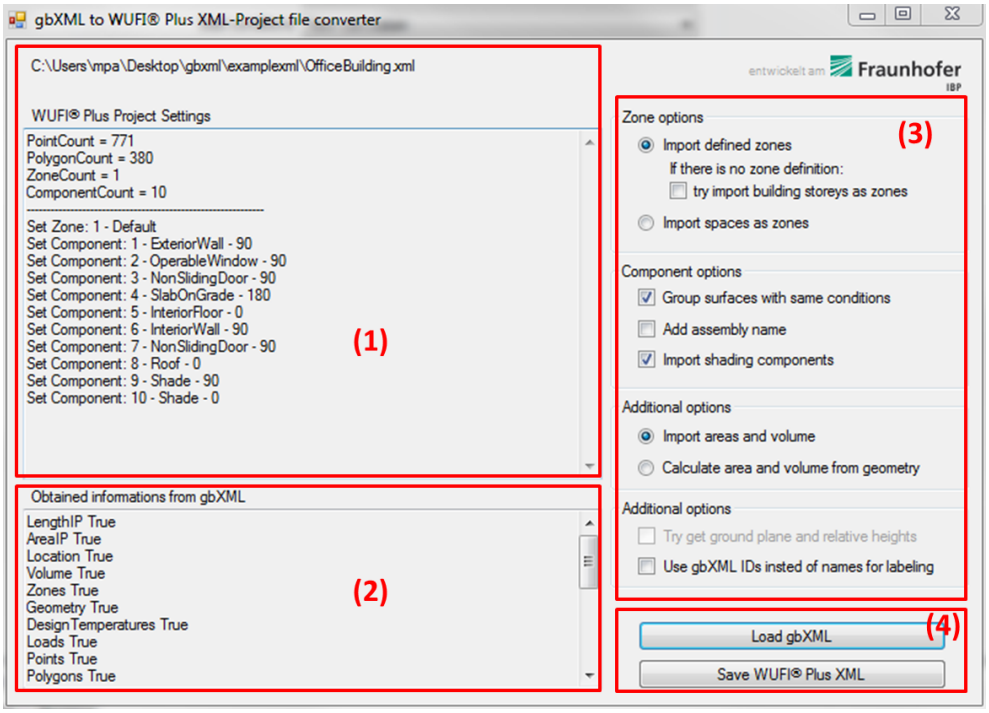


Figure 47: External program for gbXML-import.

Controls Box

(1) Results screen	General information about imported zones and components.
(2) Information	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 option	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 4.5.9 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:

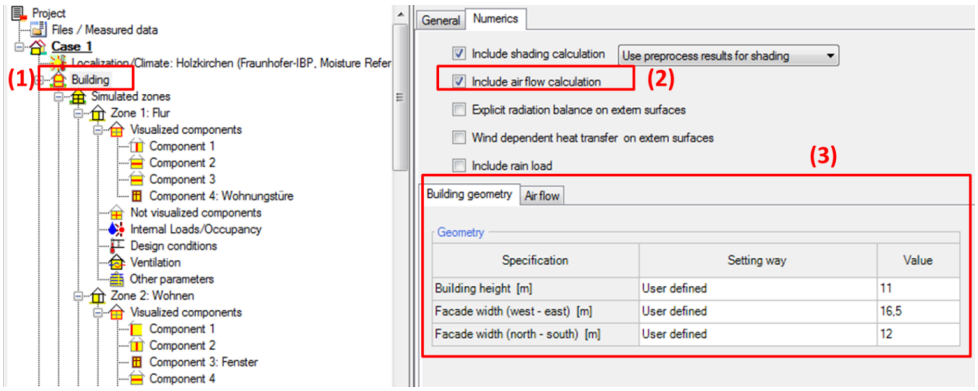


Figure 48: Activating the air flow model.

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

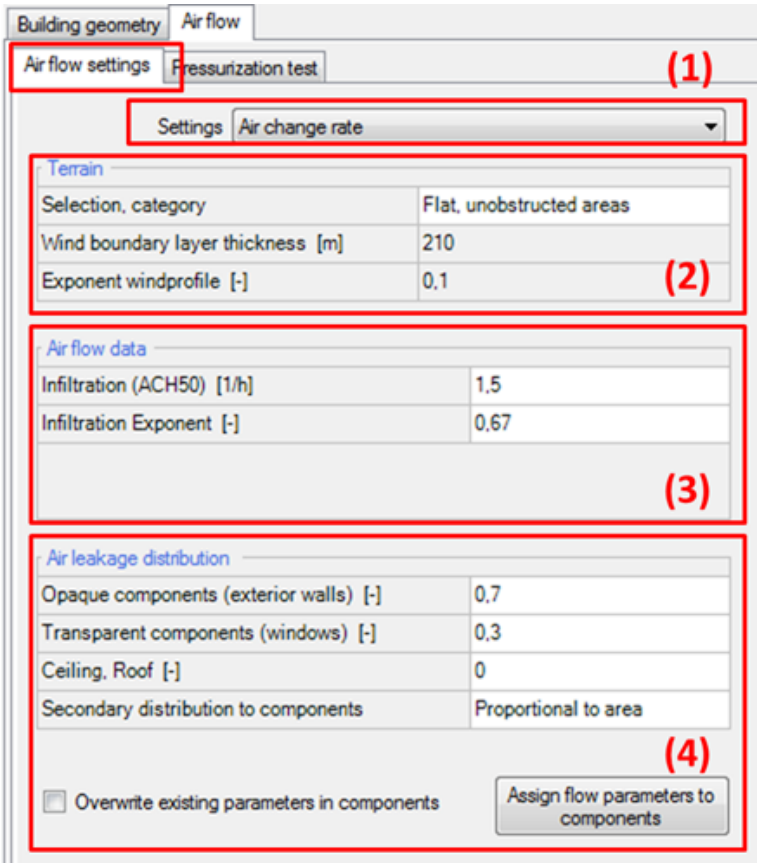


Figure 49: Setting global whole building information for the air flow model.

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 velocity 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 leackage 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 airflow, 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 doesnt 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:

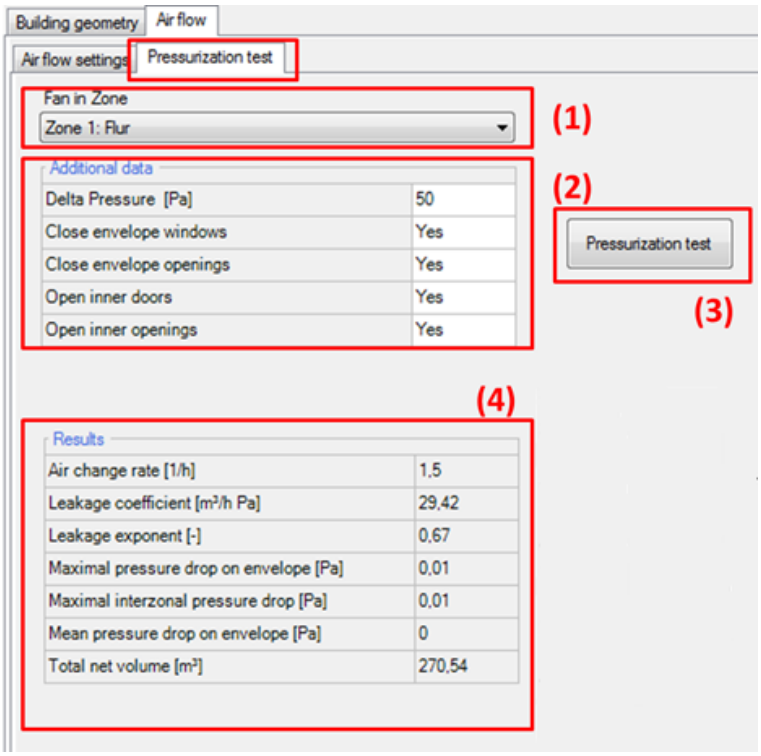


Figure 50: Informative pressurization test (Blower Door Test) to investigate and check the defined building air flow network.

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 openings*, *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):

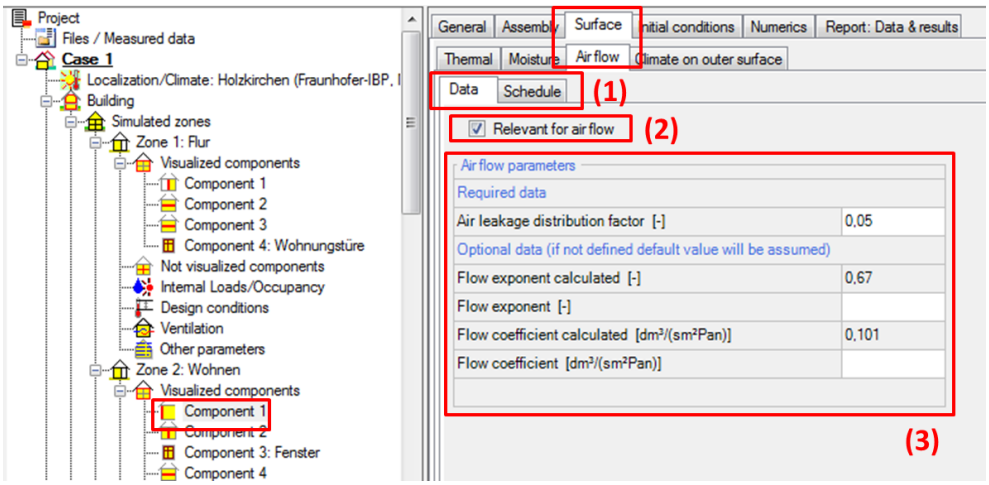


Figure 51: Air flow parametrization of opaque components.

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 calcultion.

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 crosssection. 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.

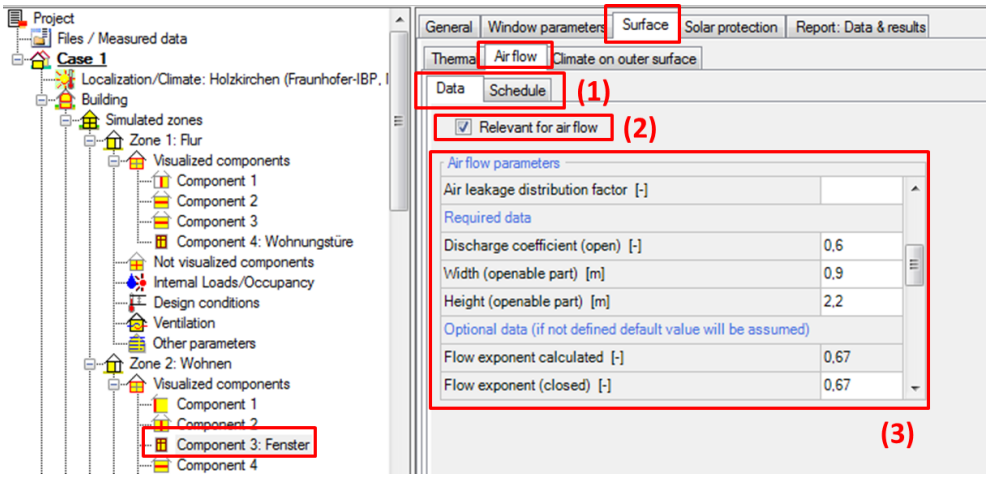


Figure 52: Air flow parametrization of transparent components.

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 the 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*:

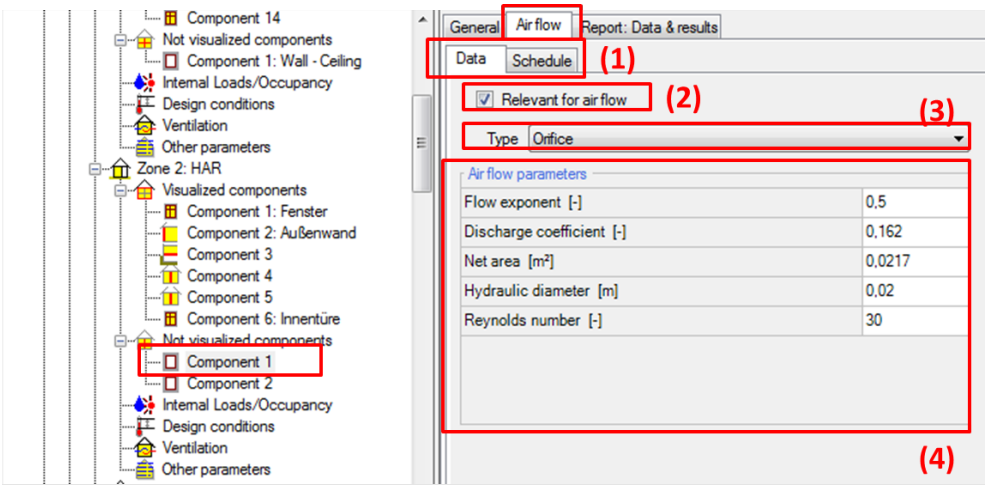


Figure 53: Air flow parameters of openings.

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 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 Net Area / 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 * cross-sectional area / 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 volume flow: The constant volume 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 contraflecture.

8 DIN 4108-2 Thermal Protection/ Building Simulation

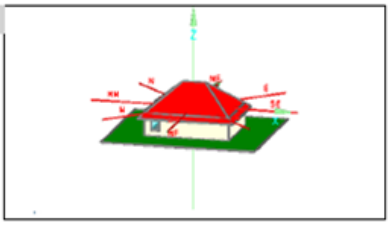
WUFI® Plus comes with a special calculation mode for simulations used in context of the German thermal protection standard DIN 4108-2:2013. These simulations differ from usual WUFI® Plus simulations as some user-inputs are pre-allocated with default values and some calculation options cannot be chosen, 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 cant 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 cant be changed.
- *Internal Loads* are predefined and cant be changed.
- *Design Conditions* are predefined and cant 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. This report sums up the most relevant input data and evaluates if the simulation results fulfill criteria of DIN 4108-2. A seperate report is created for each simulated zone. The figure below shows an example of this report.
- In order to create a full documentation of your project according to DIN 4108-2 we recommend further add at least the reports ”Conditioned Zones”, ”Assemblies / window types / solar protection” and ”HVAC” (if a mechanical ventilation system was used). You can use the ”User defined”-Report to combine multiple reports.

GENERAL INFORMATION

Software:	**WUFI® Plus**
Calculation method:	**Thermal building simulation according DIN4108-2**
Overheating Degree Hours:	**1813,4** kKh/a (> 500 demand value)

BUILDING INFORMATION



General information

Type:	**Non-residential**
Year of construction:	

Building geometry

Enclosed volume:	385	m³
Total area envelope:	334	m²
AV ratio:	0,87	
Treated floor area:	108	m²

BOUNDARY CONDITIONS

Boundary conditions

Internal heat gains:	13,1	W/m²
Interior temperature:	21	°C
Overheat temperature:	26	°C

Ventilation

Natural

During residence time:	0,2	1/h (No increased day ventilation)
Outer 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 NN:	81	m
Timezone:	+1	h
Ground reflectance short:	0,2	
Ground reflectance long:	0,1	
Ground emission:	0,9	

Figure 54: 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.
For a detailed description of all available output data see the appendix.

Visit the WUFI® -Wiki (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*.

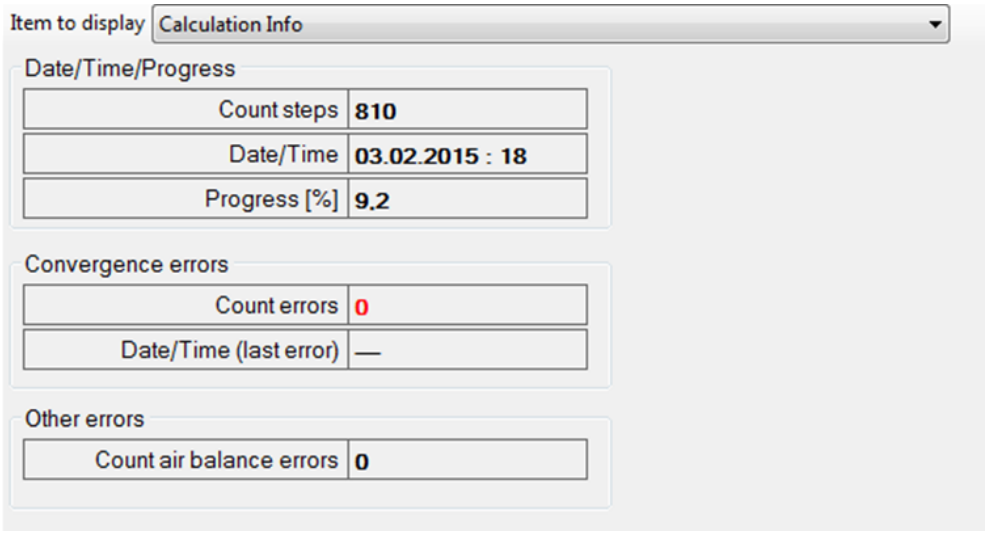


Figure 55: Calculation Info

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 detialed *"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 cant 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.

A summary of all available predefined graphs can be found in the appendix.

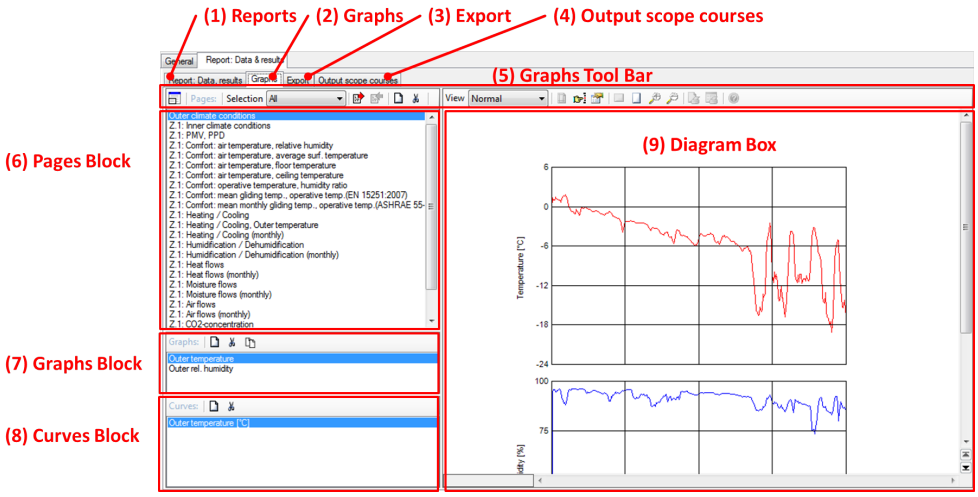


Figure 56: Graph of case results.

Controls

(1) Reports — 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.

(2) Graphs — The Graphs-Tab shows diagrams of the calculation results. Its functionality is explained in this chapter.

(3) Export — The calculated results can be exported in the Export-Tab. Please refer to chapter 9.9 for further information.

(4) Output scope courses — Allows selecting specific calculation results for output for calculations made in Batch-Mode.

(5) Graphs 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 *Graph*-Tab.

Selection — Allows switching through different types of graphs (All, Climate, Comfort, Energy, Humidity).

Retain current settings	Remembers the current settings for graphs. This feature is useful in combination with *Restore retained settings*, if changes to a graph should be undone.
Restore retained settings	Restores remembered settings for graphs.
New	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.
Delete current	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.
View	Allows changing between two options: • Normal: The standard graph viewer in WUFI® Plus. • Print layout shows how the graph will look, when its printed.
Page Setup	Defines the page layout. Only available if *View* is set to *Print Layout*.
Whole width	Zooms on the whole width of the graph in the Diagram Box (9).
Whole page	Shows the whole page in the Diagram Box (9).
Zoom in/ out	Zooming in or out in the Diagram Box (9).
Print all	Prints the current report with the default printer. Only available if *View* is set to *Print Layout*.
Print dialog	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 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 the WUFI® -Wiki (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.

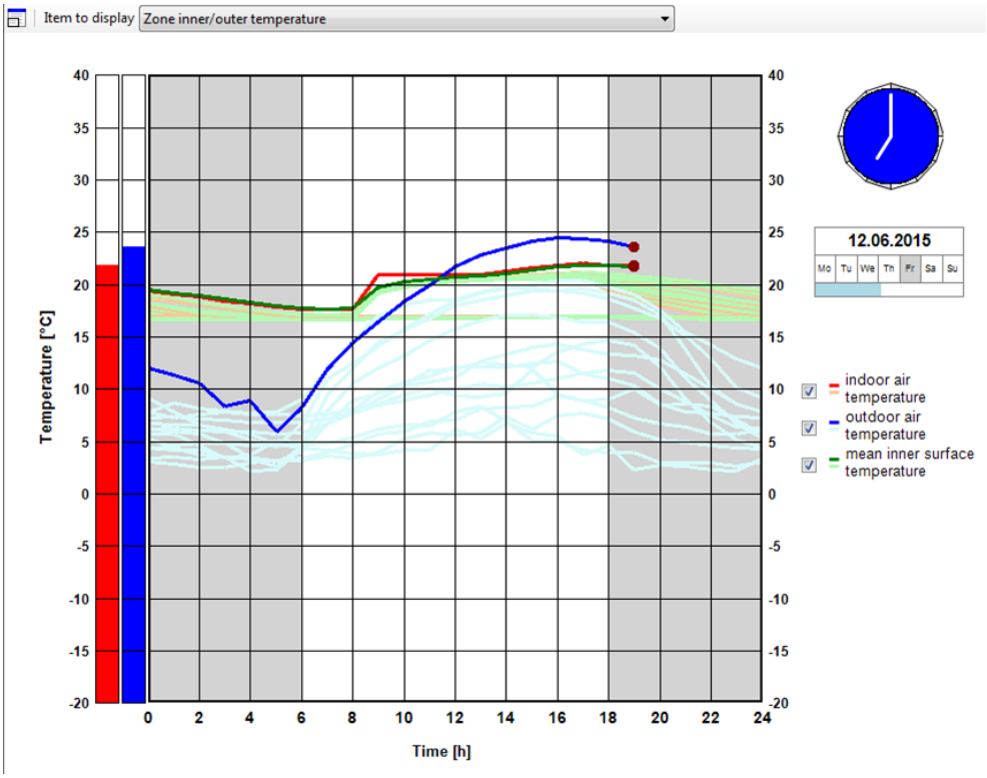


Figure 57: Zonal visualization during a calculation

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:

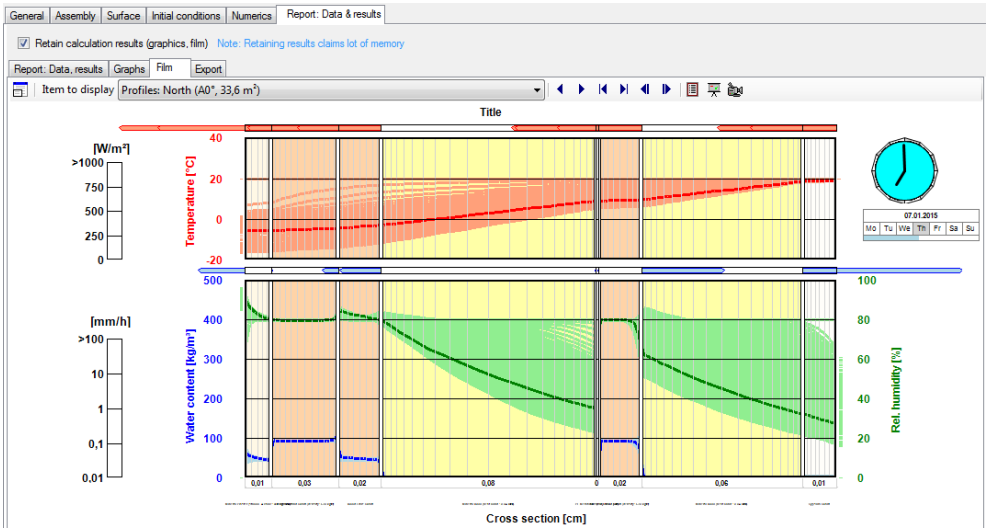


Figure 58: Component Film.

Controls

Expand/ Shrink Window	Allows expanding the *Film Box*.
Backward	Makes the film run backward.
Forward	Makes the film run forward.
Pause	This button appears while the film is running forward or backward. It allows pausing the film at the current timestep.
Back one step	Sets the film one timestep backward.
Forward one step	Sets the film one timestep forward.
Scroll to start	Jumps to the start of the film.
Scroll to end	Jumps to the end of the film.
Extended Animation	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: • Watch the WUFI® Film with custom speed • Watch WUFI® Films of several components at the same time • Customize the WUFI® Film and its displayed data • Include additional graphics into the WUFI® Film, like for example dewpoint temperature • Create graphs for every grid position • Export graphics and films • Export data directly to postprocessors like for example WUFI® Bio, which allows the evaluation of mold growth risks on surfaces. Please refer to the WUFI® -Wiki for further information about this very helpful tool.

Please refer to the WUFI® -Wiki (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.

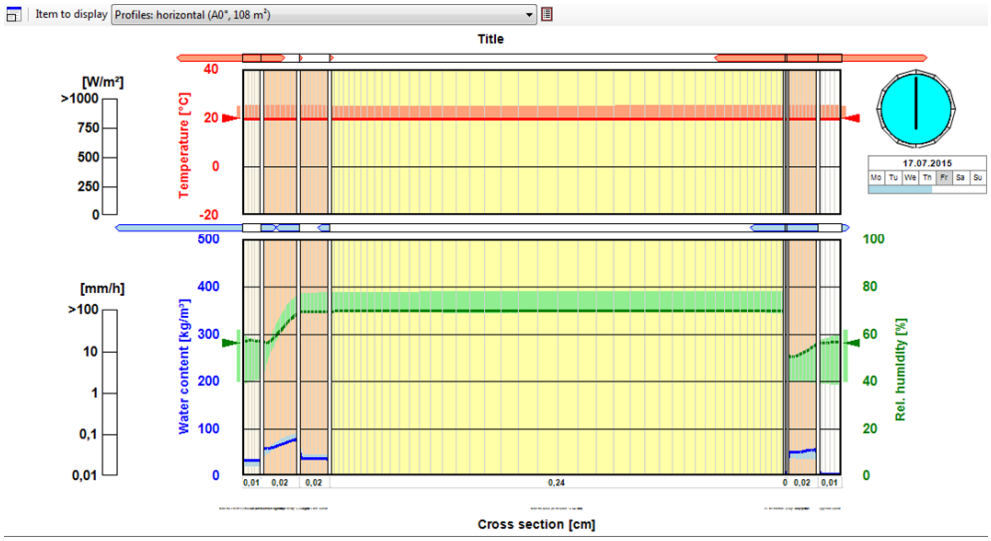


Figure 59: Visualization for opaque components during a calculation.

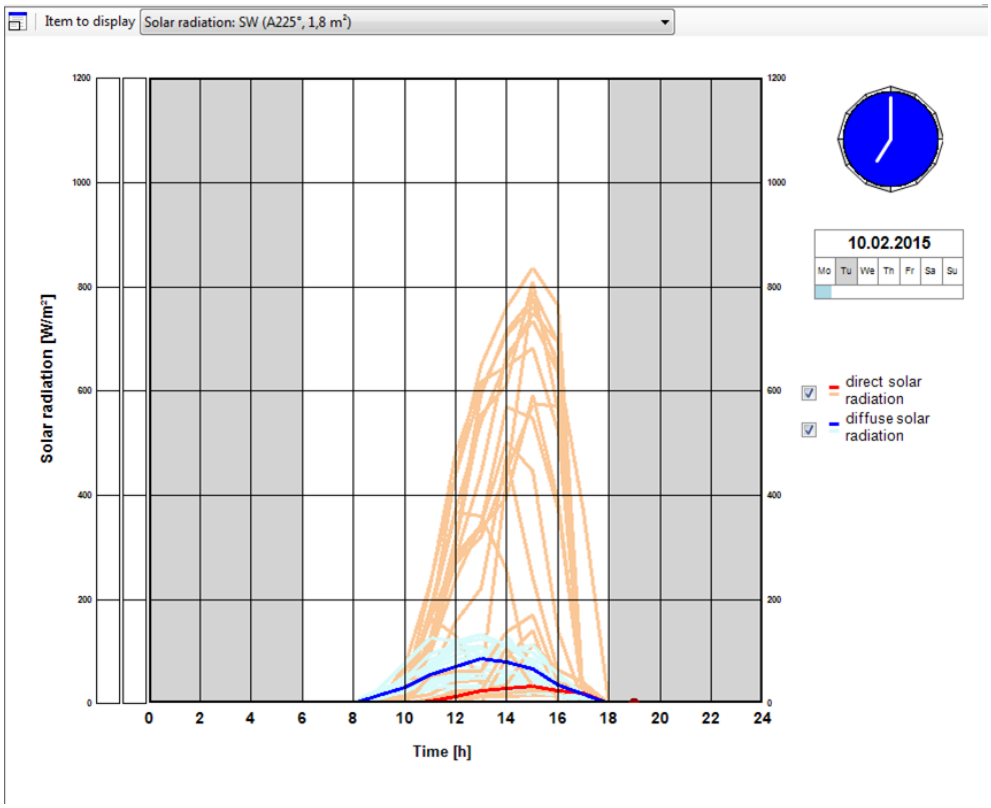


Figure 60: Visualization for transparent components during a calculation.

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:

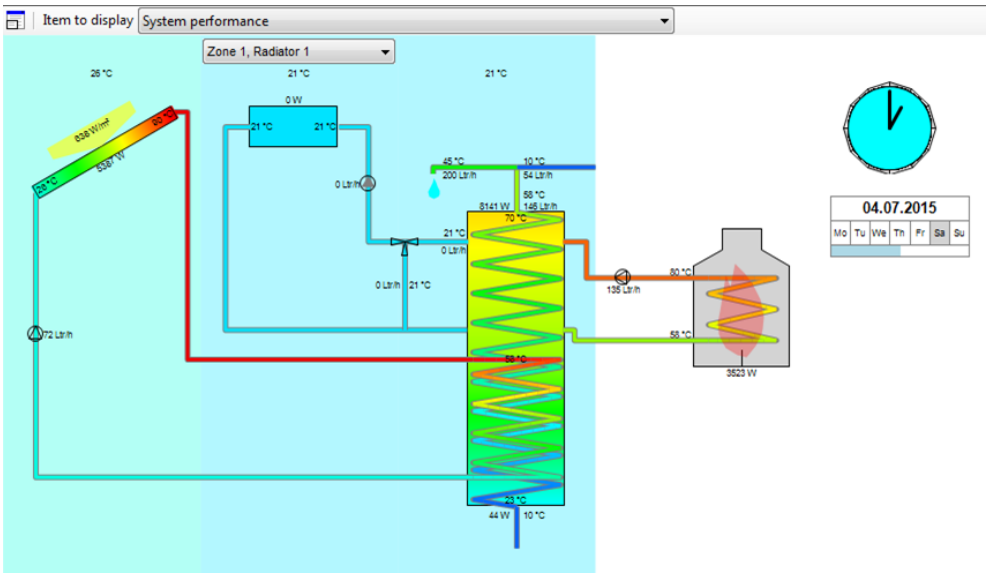


Figure 61: Visualization of a predefined HVAC-system during a simulation.

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.

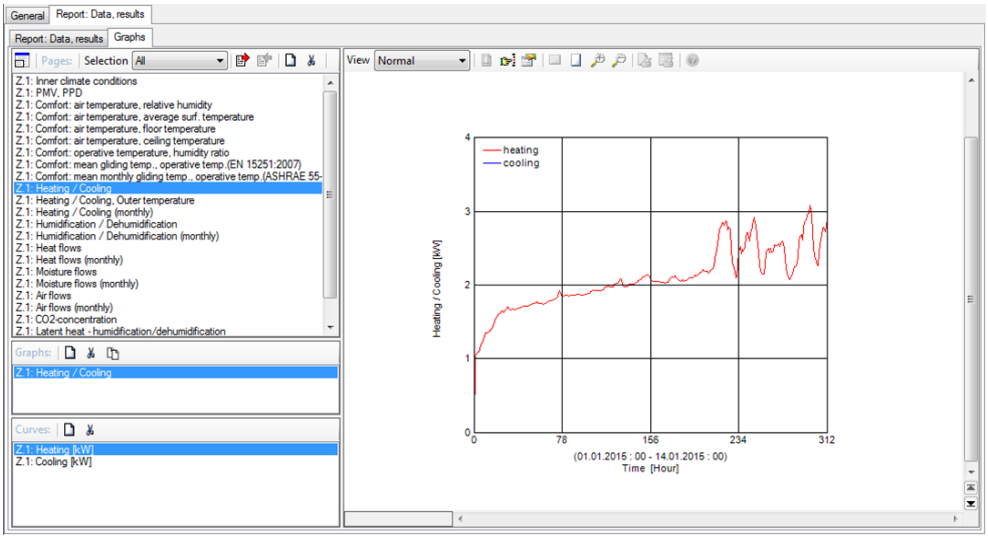


Figure 62: Graphs for heating and cooling demand found in Zone-Results.

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.

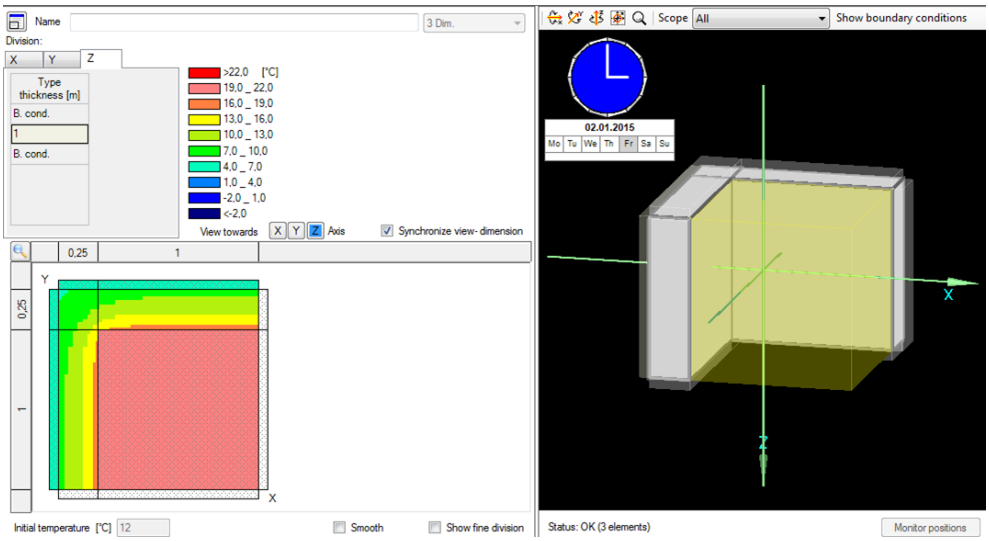


Figure 63: Visualization of a 3D-Object during calculation.

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 Graph

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:

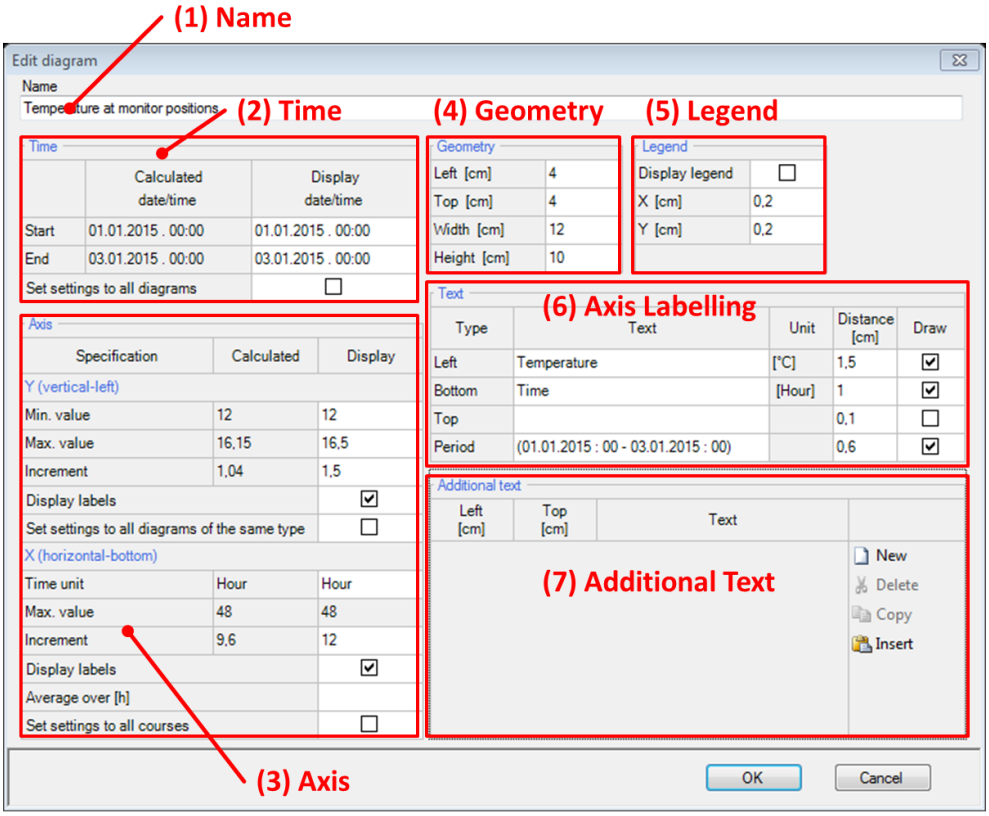


Figure 64: Edit diagram window.

Controls

(1) Name	Name of the plot. Is shown in the *Graphs*-Box, described in chapter 9.2.
(2) Time	Controls the timeframe which is plotted.
(3) Axis	Specifies the axis settings, e.g. minimum and maximum values or increment.
(4) Gemoetry	Controls the size of the plot.
(5) Legend	Controls if a legend is plotted and specifies its location.
(6) Axis Labelling	Modifies the Axis Labels.
(7) Additional Text	Includes additional annotations at userdefined positions.
 **New**	Create a new element in this list.
 **Delete**	Delete the selected element.
 **Copy**	Copy the selected element.
 **Insert**	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:

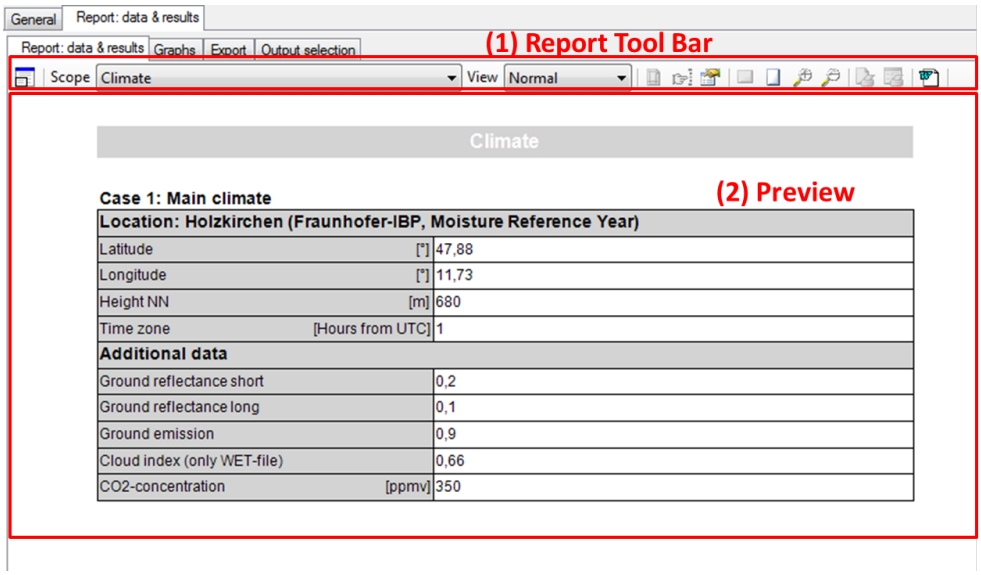


Figure 65: Report dialog.

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 its printed.

Page Setup — Defines the page layout.
Only available if View is set to Print Layout.

Scope/ Sequence — If a User defined report is selected it can be customized with this button.

	**Whole width**	Zooms on the whole width of the report in the Preview Box (2).
	**Whole page**	Shows the whole page in the Preview Box (2).
	**Zoom in/ out**	Zooming in or out in the Preview Box (2).
	**Print all**	Prints the current report with the default printer. Only available if View is set to Print Layout.
	**Print dialog**	Opens a standard Windows printer-dialog, where the printer and its properties can be selected. Only available if *View* is set to *Print Layout*.
	**Word & PDF Export**	Saves the report as an Microsoft Office .doc or .docx-file or as a PDF. A standard Windows save-dialog opens and the file can be named. The file-type (.doc, .docx, .pdf) can be selected.
	(2) Preview	Shows how the selected report looks like.

Case		
	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.
Conditioned Zone		
	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.
Opaque Components		
	"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.
Transparent Components		
	"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
HVAC-Systems		
	"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:

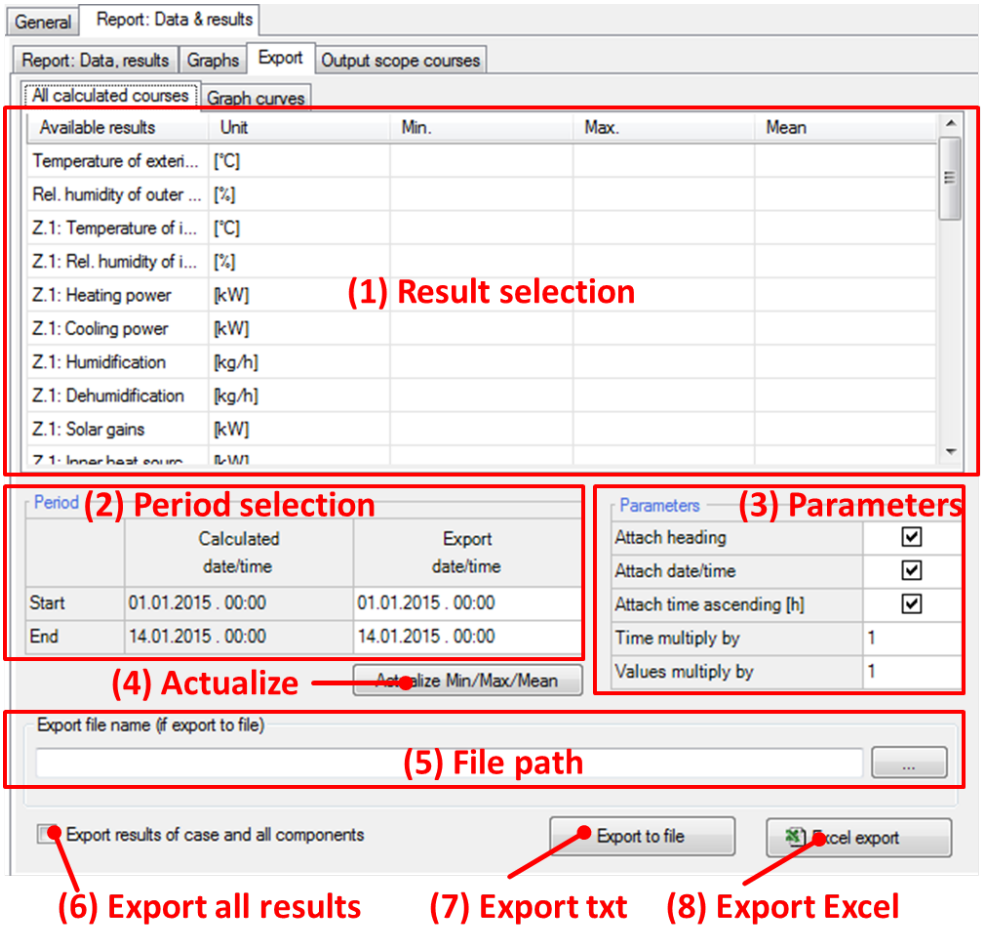


Figure 66: Export Results.

Controls

(1) Result selection	Allows selecting specific results for the export. Multiple results can be chosen by holding the Ctrl-key and clicking on the desired results.
(2) Period selection	Allows the selection of a certain time period. Data will only be exported for this period.
(3) Parameters	Setting parameters for the file that will be exported.
(4) Actualize	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.

Please note: Only selected results will be exported. By default, no results are selected. Thus, the user has to select the desired results manually before they can be exported. Some keyboard shortcuts can help with this task:

- Multiple results can be selected by holding the Ctrl-key and clicking on the desired results.
- Multiple results in a row can also be selected: Click on the first result, then hold the Shift-key and click on the last desired result. Now all results between these two are selected.
- First click into the results selection. Then, pressing the keys ”Ctrl” and ”A” simultaneously selects all available results.

9.10 Comparing results of multiple cases

When simulating multiple cases in one WUFI® file, the case results contain the results of all simulated cases. By then editing the graphs or creating user-defined graphs it is possible to compare the results in WUFI® . In the picture below the temperature and relative humidity of two simulations are shown. Case 2 has higher temperature thresholds in the design conditions and therefore lower humidity.

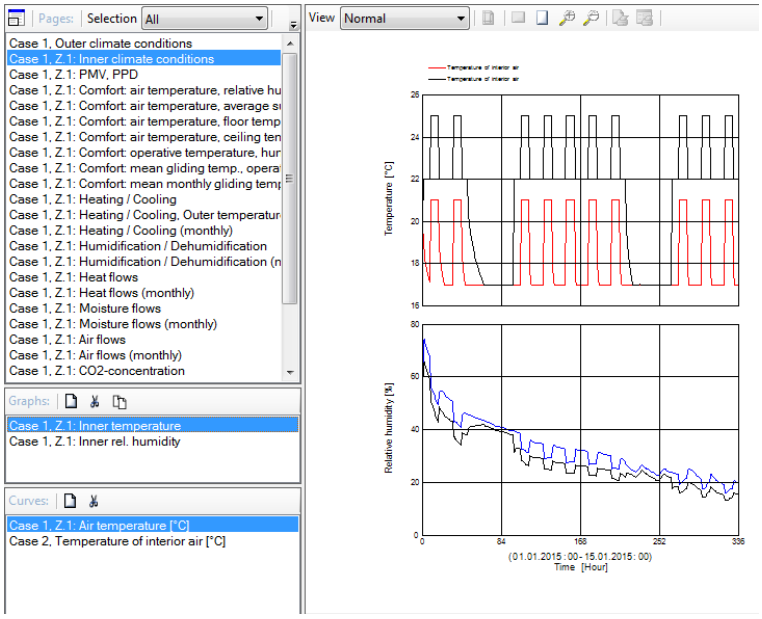


Figure 67: Comparing the results of two different cases with different temperature design conditions.

This feature has some limitations:

- Only time series data
- Only date can be displayed on the x-axis. To compare two different cases, the time period of both simulations have to overlapp
- Only variables of the same unit can be displayed in one graph, i.e. only temperature and temperature or rel. humidity and rel. humidity can be compared in one graph

10 Batch Mode

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

Please note: Batch-mode is only available in WUFI® Plus. It's not included in WUFI® Passive or the FREE-versions.

Batch calculations are currently available for calculation scopes WUFI® Plus and WUFI® Passive. Batch mode uses the calculation scope that was active when the project was saved last time.

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. Results from "WUFI(R) Passive" calculation scope are exported in an xml-file format. Further customization is not possible, as all user inputs and (intermediate) calculation results are exported.

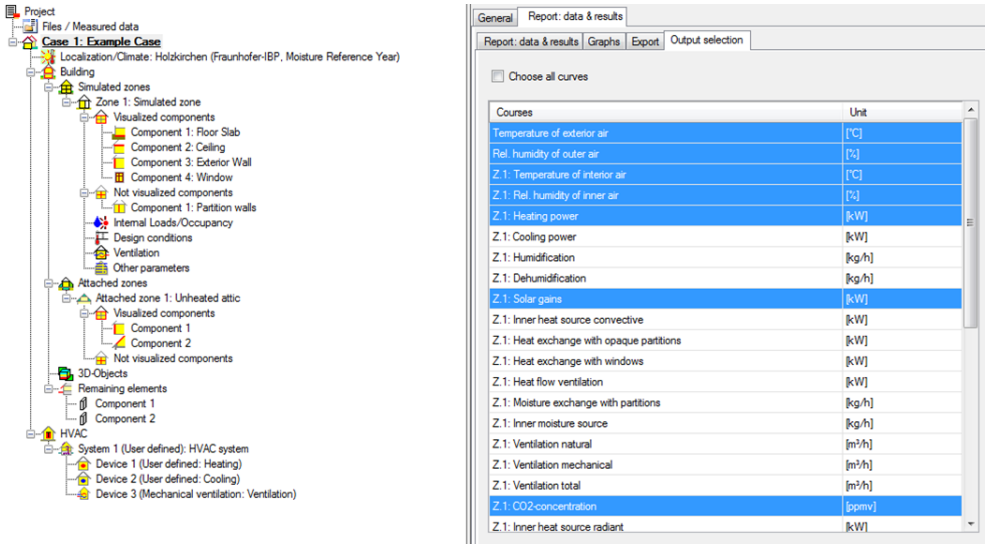


Figure 68: Output selection for Batch-Mode.

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 Appendix

WUFI® Plus provides various output data from the simulation, including graphs for comfort evaluation according to ASHRAE 55 and DIN EN 15251. In this appendix the available output is listed and described.

11.1 Case Results

The following values can be exported from WUFI® Plus from the case result tab.

11.1.1 All calculated Results

All results that are calculated during the simulations are listed in this dialog. They can be selected and exported as Text- or Excel-Files.

Outer climate

Temperature of exterior air	$°C$	Temperature of the outer air as defined by the exterior climate.
Rel. Humidity of exterior air	$\%$	Rel. Humidity of the outer air as defined by the exterior climate.
Global solar radiation	W/m^2	Global solar radiation as defined by the exterior climate.

Zonal Results

Temperature of interior air	$°C$	Temperature of the midpoint of a zone as calculated by WUFI® Plus.
Rel. Humidity of inner air	$\%$	Rel. Humidity in the midpoint of a zone as calculated by WUFI® Plus. If thermal mode is enabled, relative humidity will only be calculated by the zone's mass balance and inner air temperature. Interactions with the zone's components are neglected.
Heating Power	kW	Power provided by the heating device(s) defined in the HVAC section.
Cooling Power	kW	Power provided by the cooling device(s) defined in the HVAC section.
Humidification	kg/h	Amount of water added to to the inner zone by device(s) defined in the HVAC section.
Dehumidification	kg/h	Amount of water subtracted from the inner zone by device(s) defined in the HVAC section.
Solar gains	kW	Solar heat gains through transparent components.

Inner heat source convective	kW	Sum of convective heat sources as defined in the inner loads section.
Heat exchange with opaque components	kW	Sum of heat exchange with all opaque components assigned to the zone.
Heat exchange with windows	kW	Power added to or subtracted from the zone by windows assigned to the zone.
Heat flow ventilation	kW	Power added to or subtracted from the zone by mechanical, natural and interzone ventilation.
Moisture exchange with partitions	kg/h	Amount of water added to or subtracted from the zone through all assigned components.
Inner moisture source	kg/h	Sum of moisture source(s) as defined in the inner loads section.
Ventilation natural	m^3/h	Volume of air exchanged with the outer air through natural ventilation. Either as defined in the ventilation (natural) section or calculated with the air flow model.
Ventilation mechanical	m^3/h	Volume of air exchanged with the outer air through mechanical ventilation. Either as defined in the ventilation (mechanical) section or calculated with the air flow model.
Ventilation total	m^3/h	Total Volume of air exchanged with the outer air. Sum of natural and mechanical ventilation. Interzone ventilation ist NOT included.
CO2-concentration	$ppmv$	*Portion* of CO2 of the inner air in parts per million by volume. This value is influenced by ventilation and inner sources.
Inner heat source radiant	kW	Sum of radiant heat source(s) as defined in the inner loads section
Mean surface temperature	$°C$	Mean temperature of all surfaces adjacent to the zone; area weighted.
PMV	$-$	**P**redicted **M**ean **V**ote according to DIN EN ISO 7730.
PPD	$\%$	**P**redicted **P**ercantage of **D**issatisfied with the inner climate conditions according to DIN EN ISO 7730.
Mean floor temperature	$°C$	Mean temperature of all floors of the zone; area weighted.
Mean ceiling temperature	$°C$	Mean temperature of all ceilings of the zone; area weighted.
Operative temperature	$°C$	Operative temperature is defined as the uniform temperature of an enclosure in which an occupant would exchange the same amount of heat by radiation and convection as in the actual nonuniform environment. WUFI Plus calculates it as mean of indoor temperature und mean indoor surface temperature (DIN EN ISO 13791).
Absolute humidity of inner air	$-$	Mass of water vapor per mass of dry air in $[kg/kg]$. For more Information see WUFI® Fundamentals, chapter "Fundamentals of the transient heat and moisture balance of buildings".

Latent heat - humidification	kW	Power provided by latent heat flows due to humidification. This output is only generated when an appropriate HVAC-device is included in the zone.
Latent heat - dehumidification	kW	Power provided by latent heat flows due to dehumidification. This output is only generated when an appropriate HVAC-device is included in the zone.
Metabolism	met	Unit to describe the energy generated by a person due to metabolic acivity. $1met$ is $58.2W/m^2$ or $18.4Btu/(h*ft^2)$ emitted by a seated person at rest with a surface area of $1.8m^2$ or $19ft^2$.
Moisture flow due to natural ventilation & infiltration	kg/h	Amount of humidity added to or subtracted from the zone by natural ventilation and infiltration as defined in the ventilation (natural) section or calculated with the air flow model.
Moisture flow due to mechanical ventilation	kg/h	Amount of humidity added to or subtracted from the zone by mechanical ventilation as defined in the ventilation (mechanical) section or calculated with the air flow model.
Heat exchange with thermal bridges	kW	Heat exchange calculated from linear thermal bridges. These results only include the heat exchange from entries in the Thermal Bridges section. Heat exchange from 2D or 3D Objects is listed separately.
Heat flow interzone ventilation	kW	Power added to or subtracted from the zone by mechanical interzone ventilation as defined in the ventilation section.
Ventilation interzone	m^3/h	Volume of air exchange with other zone(s) as defined in the ventilation (interzone) section or calculated with the air flow model.
Moisture flow due to interzone ventilation	kg/h	Amount of humidity added to or subtracted from the zone by mechanical interzone ventilation as defined in the ventilation section or calculated with the air flow model.
Mean windows inner surface temperature	$°C$	Mean temperature of the inner surface of all windows; area weighted.
Dew point temperature of inner air	$°C$	Theoretical temperature of inner air at which relative humidity would reach 100% with the existing absolute humidity.
Design maximal inner air temperature	$°C$	Max. inner air temperature as defined in "'Design conditions"'.

3D Objects

The results of dynamic simulations of 3D Objects are added to the zonal results. They are saved for every monitor position of 2D or 3D objects. Thus, monitor positions have to be defined in order to retain calculation results of 2D or 3D objects:

Monitor position, temperature	$°C$	Temperature at the monitor position.

Monitor position, heat flux X	W/m^2	Heat flux at the monitor position in X-direction. The direction is defined by the 3D Object's local coordinate system.
Monitor position, heat flux Y	W/m^2	Heat flux at the monitor position in Y-direction. The direction is defined by the 3D Object's local coordinate system.
Monitor position, heat flux Z	W/m^2	Heat flux at the monitor position in Z-direction. The direction is defined by the 3D Object's local coordinate system. For 2D Objects, this result is constant zero.

Dynamic HVAC Simulation

The results of dynamic HVAC system simulations are added to the zonal results. Numerous results are retained, for example mass flows, temperature distributions of DHW, storage and circulation systems, heating power, ...

Please note: The dynamic HVAC system simulation is still in development. A detailed description of all available outputs will be added in future releases.

11.1.2 Graph Curves

Includes the results of all curves used in the Graphs-Section.

Outer climate

Outer temperature	$°C$	Temperature of the outer air as defined by the exterior climate.
Outer rel. Humidity	$\%$	Rel. Humidity of the outer air as defined by the exterior climate.

Zonal

Air Temperature	$°C$	Temperature of the midpoint of a zone as calculated by WUFI Plus.
Average surface temperature	$°C$	Mean temperature of all surfaces adjacent to the zone; area weighted.
Operative temperature	$°C$	Operative temperature is defined as the uniform temperature of an enclosure in which an occupant would exchange the same amount of heat by radiation and convection as in the actual nonuniform environment. WUFI Plus calculates it as mean of indoor temperature und mean indoor surface temperature (DIN EN ISO 13791).

Dew point temperature of inner air	$°C$	Theoretical temperature of inner air at which relative humidity would reach 100% with the existing absolute humidity.
Mean windows inner surface temperature	$°C$	Mean temperature of the inner surface of all windows; area weighted.
Inner rel. Humidity	$[\%]$	Rel. Humidity in the midpoint of a zone as calculated by WUFI Plus. If thermal mode is enabled, relative humidity will only be calculated by the zone's mass balance and inner air temperature. Interactions with the zone's components are neglected.
Predicted Mean Vote (PMV)	$-$	**P**redicted **M**ean **V**ote according to DIN EN ISO 7730.
Predicted Percentage of Dissatisfied (PPD)	$\%$	**P**redicted **P**ercantage of **D**issatisfied with the inner climate conditions according to DIN EN ISO 7730.
Heating	$[kW]$	Power provided by the heating device(s) defined in the HVAC section.
Cooling	$[kW]$	Power provided by the cooling device(s) defined in the HVAC section.
Humidification	kg/h	Amount of water added to to the inner zone by device(s) defined in the HVAC section.
Dehumidification	kg/h	Amount of water subtracted from the inner zone by device(s) defined in the HVAC section.
Solar gains	kW	Solar heat gains through transparent components.
Internal heat loading, convective	kW	Sum of convective heat sources as defined in the inner loads section.
Internal heat loading, radiant	kW	Sum of radiant heat source(s) as defined in the inner loads section
Exchange with opaque partitions	kW	Sum of heat exchange with all opaque components assigned to the zone.
Exchange with thermal bridges	kW	Heat exchange calculated from linear thermal bridges. These results only include the heat exchange from entries in the Thermal Bridges section. Heat exchange from 2D or 3D Objects is listed separately.
Heat flow through windows	kW	Power added to or subtracted from the zone by windows assigned to the zone.
Ventilation	kW	Heat added to or subtracted from the zone by mechanical, natural and interzone ventilation.
Ventilation interzone	kW	Heat added to or subtracted from the zone by mechanical interzone ventilation as defined in the ventilation section.
Opaque partitions	kg/h	Moisture added to or subtracted from the zone through all assigned components.

Natural Ventilation + infiltration	kg/h	Moisture added to or subtracted from the zone by natural ventilation and infiltration as defined in the ventilation (natural) section or calculated with the air flow model.
Mechanical ventilation	kg/h	Moisture added to or subtracted from the zone by mechanical ventilation as defined in the ventilation (mechanical) section or calculated with the air flow model.
Interzone ventilation	kg/h	Moisture added to or subtracted from the zone by mechanical interzone ventilation as defined in the ventilation section or calculated with the air flow model.
Internal loads	kg/h	Sum of internal moisture source(s) as defined in the inner loads section.
Natural	m^3/h	Volume of air exchanged with the outer air through natural ventilation. Either as defined in the ventilation (natural) section or calculated with the air flow model.
Mechanical	m^3/h	Volume of air exchanged with the outer air through mechanical ventilation. Either as defined in the ventilation (mechanical) section or calculated with the air flow model.
Total	m^3/h	Total Volume of air exchanged with the outer air. Sum of natural and mechanical ventilation. Interzone ventilation ist NOT included.
Interzone	m^3/h	Volume of air exchange with other zone(s) as defined in the ventilation (interzone) section or calculated with the air flow model.
CO2-concentration	$ppmv$	*Portion* of CO2 of the inner air in parts per million by volume. This value is influenced by ventilation and inner sources.
Latent heat - humidification	kW	Heat provided by latent heat flows due to humidification. This output is only generated when an appropriate HVAC-device is included in the zone.
Latent heat - dehumidification	kW	Heat provided by latent heat flows due to dehumidification. This output is only generated when an appropriate HVAC-device is included in the zone.

11.1.3 Graphs

WUFI® Plus contains its own set of predefined graphics of the result of the simulation. They can be altered by the user and are explained in the following.

Two graphs are displayed with this option; A time series of the temperature of the exterior climate and a time series of the relative humidity of exterior climate. These graphs always display the exterior climate defined in the Localization/Climate-Section.

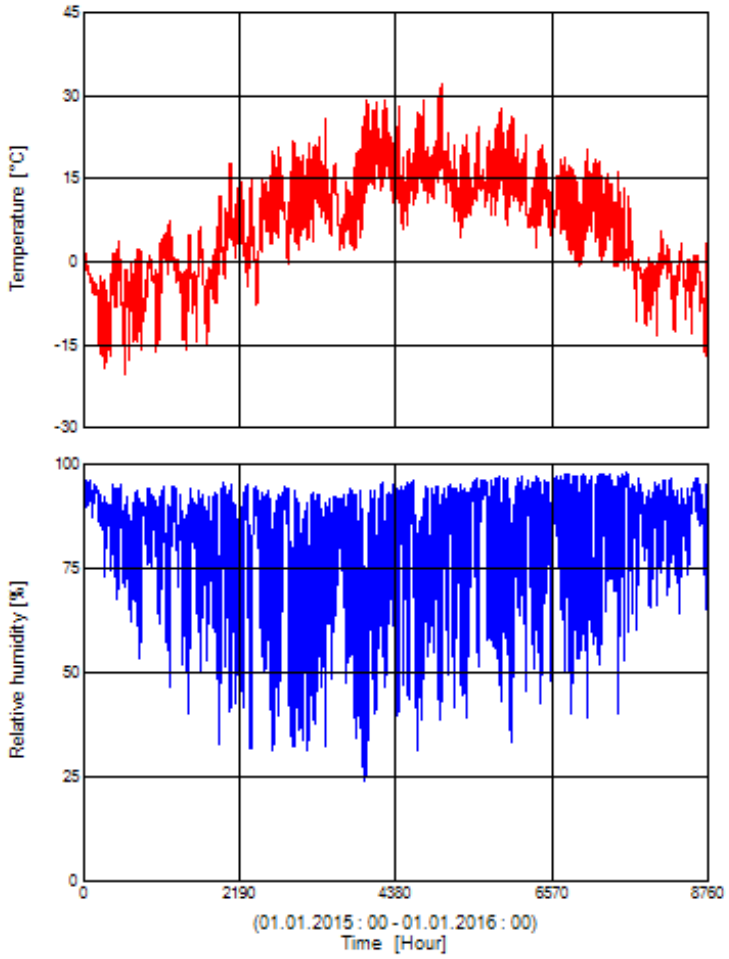


Figure 69: Outer climate conditions

Two graphs are displayed with this option; A time series of multiple temperature courves of the zone as calculated by WUFI® Plus (air temperature, mean surface temperature (weighted), operative temperature, mean window temperature (weighted), dew point temperature)and a time series of the relative humidity of the zone as calculated by WUFI® Plus. If thermal mode is enabled, relative humidity will only be calculated by the zone's mass balance and inner air temperature. Interactions with the zone's components are neglected.
Please refer to the above desribed "'Case Results"' for an exact definition of all listed temperatures.

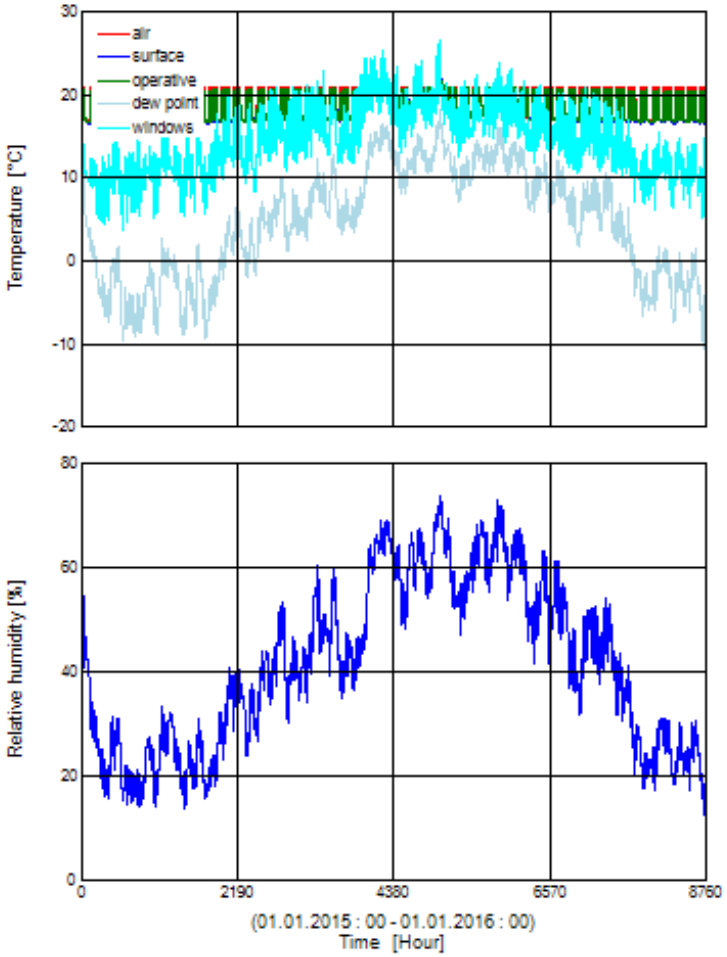


Figure 70: Inner climate conditions

Two graphs are displayed with this option: PMV and PPD, calculated according to DIN EN ISO 7730. Please note: PMV/PPD are only calculated if all necessary values are defined, as described in chapter "'Internal Loads"'.

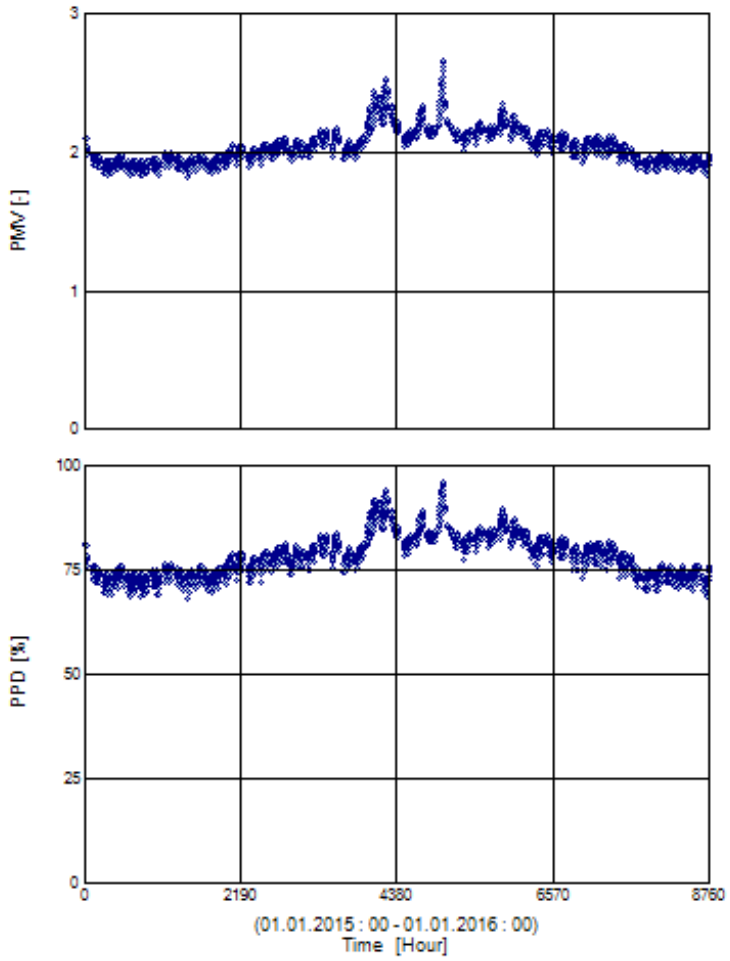


Figure 71: PMV and PPD

WUFI Plus offers several graphs for comfort assessment, e.g. from standards ASHRAE 55-2004 or DIN EN 15251:2007.

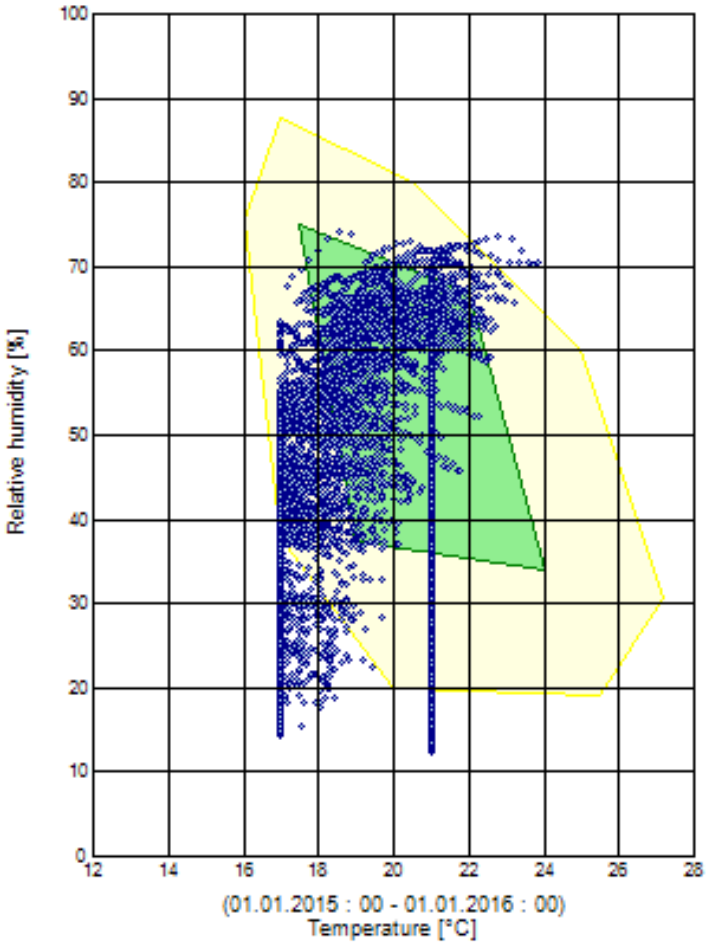


Figure 72: Comfort: Air temperature, relative humidity

This graph displays heating (red) and cooling (blue) loads for each simulation timestep. Heating is plotted on the positive axis and cooling on the negative one. Please note: WUFI® Plus defines cooling as ”negative heating” and therefore also exports cooling load values as negative values.

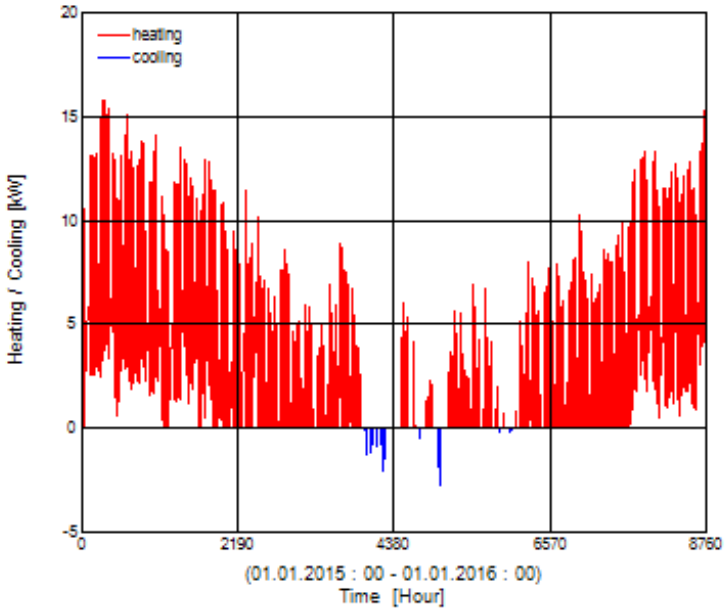


Figure 73: Heating

Two graphs are displayed, each a scatter plot of hourly heating and cooling values against the corresponding outer air temperature of its timestep.

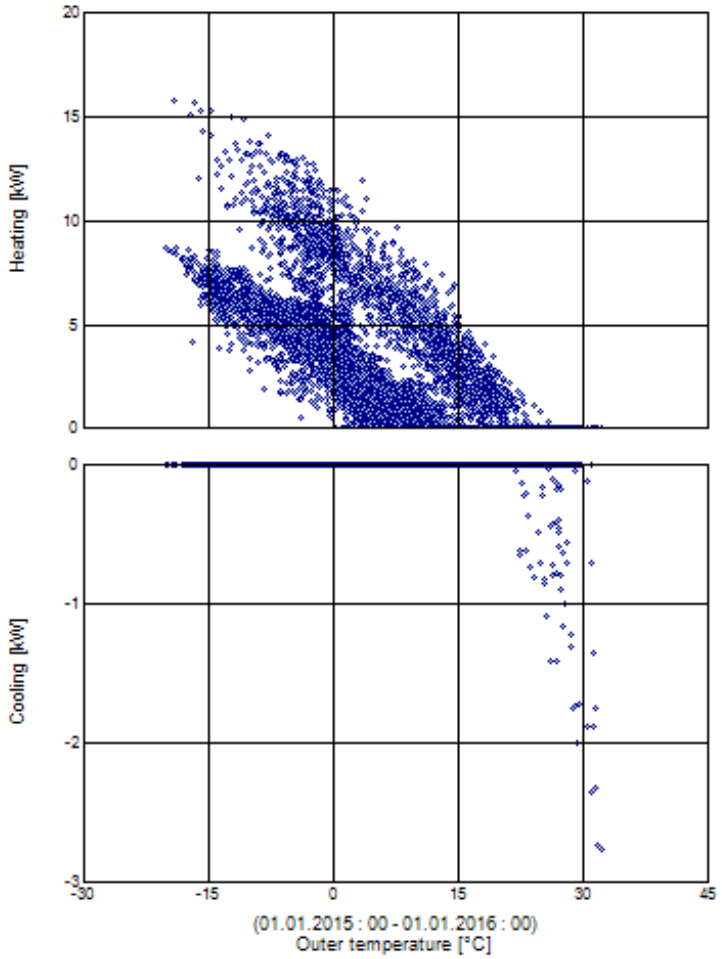


Figure 74: Heating Scatter

A bar plot of heating and cooling power summed up for each month. Heating is plotted on the positive axis and cooling on the negative one. Please note: WUFI® Plus defines cooling as ”negative heating” and therefore also exports cooling load values as negative values.

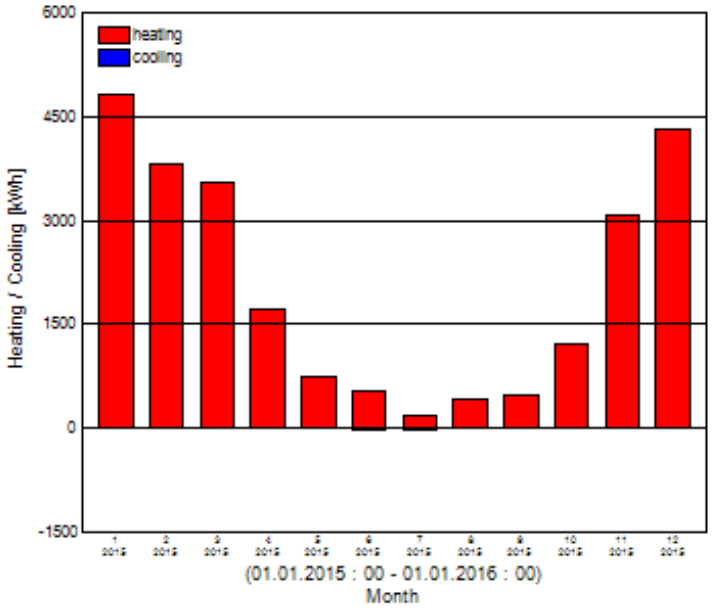


Figure 75: Monthly Heating

A time series of humidification and dehumidification as calculated by WUFI® Plus. Humidification is plotted on the positive axis and Dehumidification on the negative one.

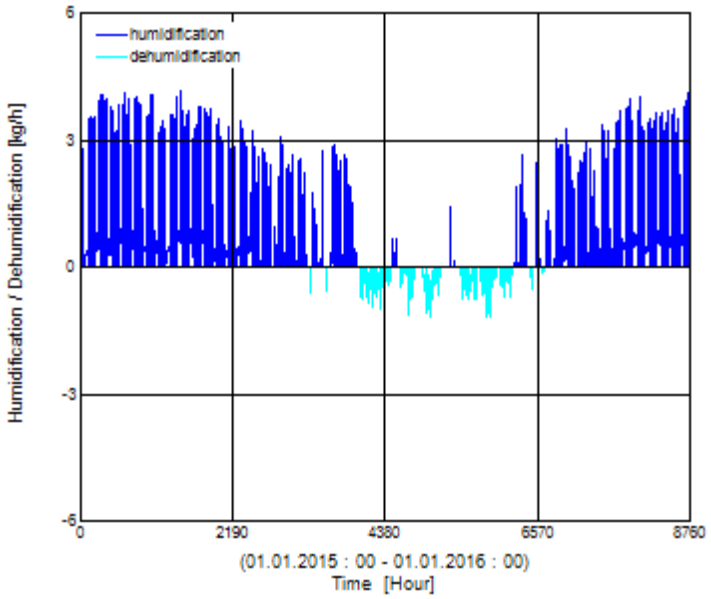


Figure 76: Dehumidification

A bar plot of humidification and dehumidification summed up for each month. Humidification is plotted on the positive axis and Dehumidification on the negative one.

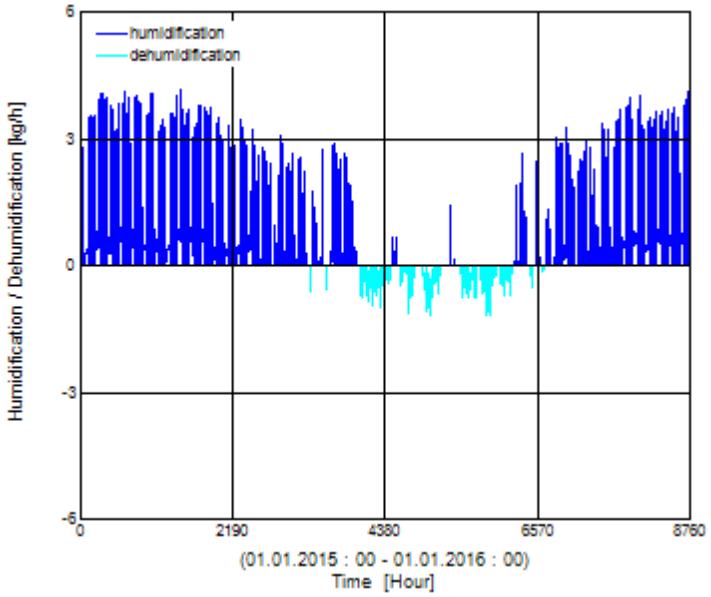


Figure 77: Monthly dehumidification

A time series of all heat flow courves of the zone as calculated by WUFI® Plus (solar gains, inner sources radiative and convective, exchange with partitions and windows, mechanical and interzone ventilation, thermal bridges). Positive values represent heat gains and negative values represent heat losses of the zone.

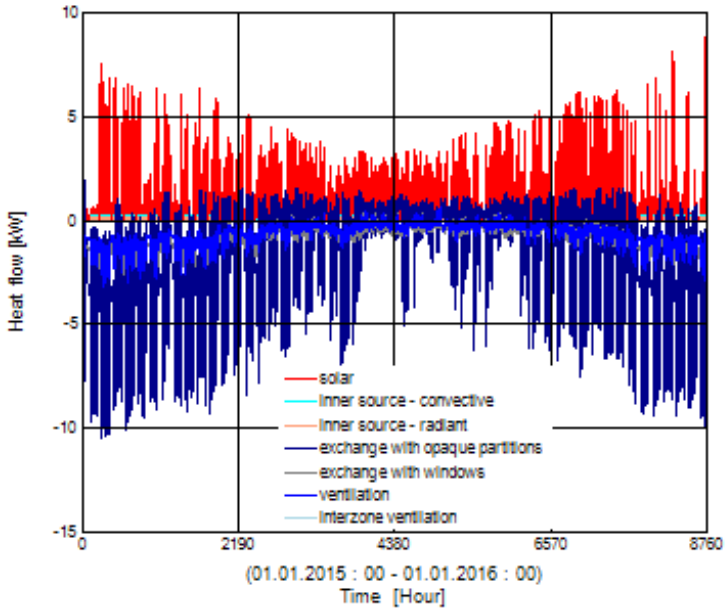


Figure 78: Heat flows

A bar plot of all heat flows summed up for each month. Positive values represent heat gains and negative values represent heat losses of the selected zone.

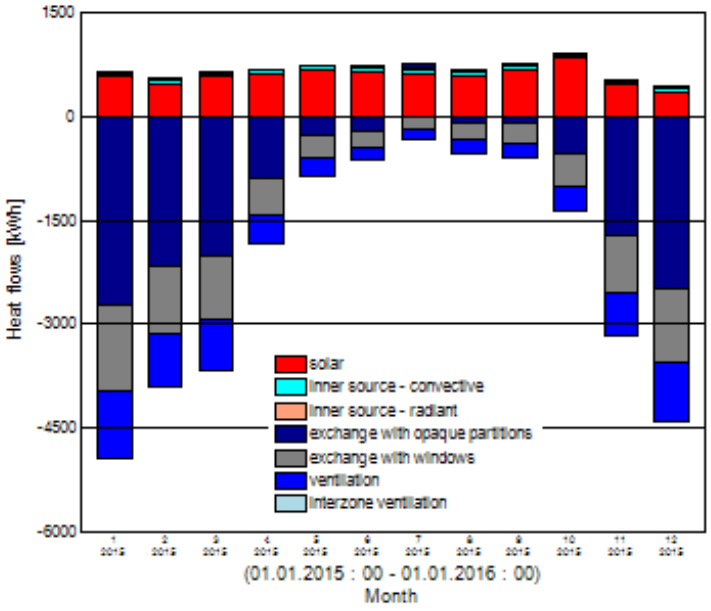


Figure 79: Monthly heat flows

A time series of all moisture flows of the zone as calculated by WUFI® Plus (inner loads, exchange with partitions, natural, mechanical and interzone ventilation). Positive values represent moisture added to the zone and negative values represent moisture leaving the zone.

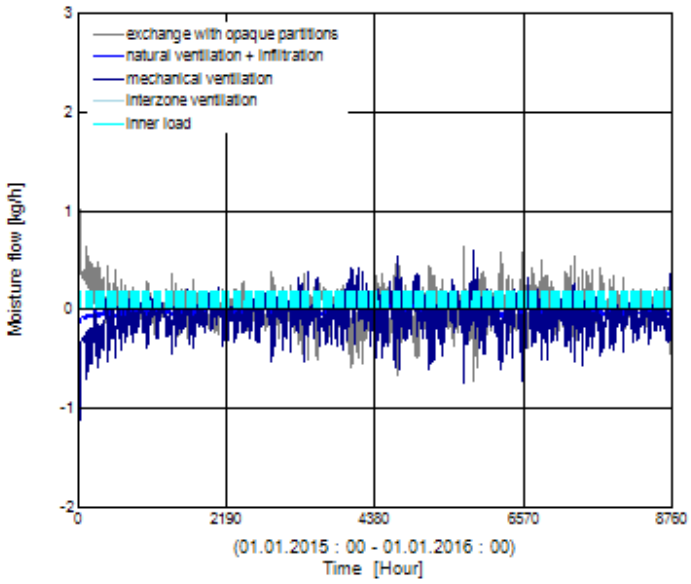


Figure 80: Moisture flows

Moisture flows (monthly)

A bar plot of all moisture flows summed up for each month. Positive values represent moisture added to the zone and negative values represent moisture leaving the zone.

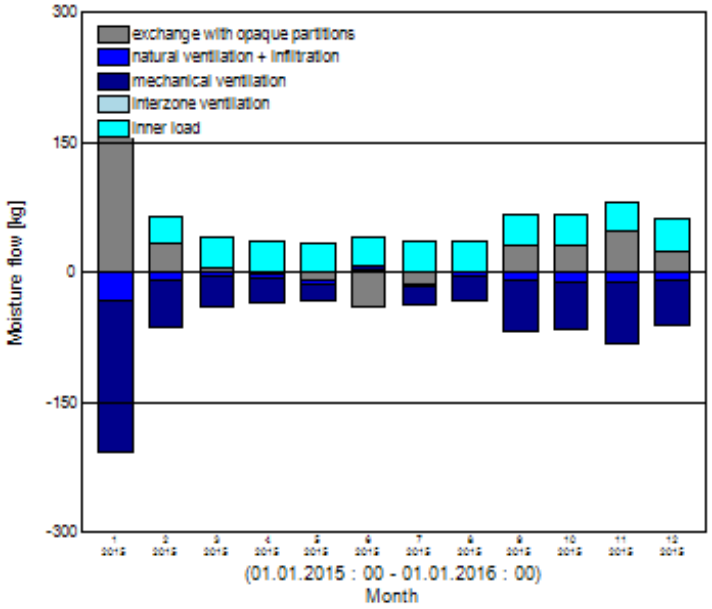


Figure 81: Monthly moisture flows

A time series of all air flow curves of the zone as calculated by WUFI® Plus (mechanical, natural, interzone, total).

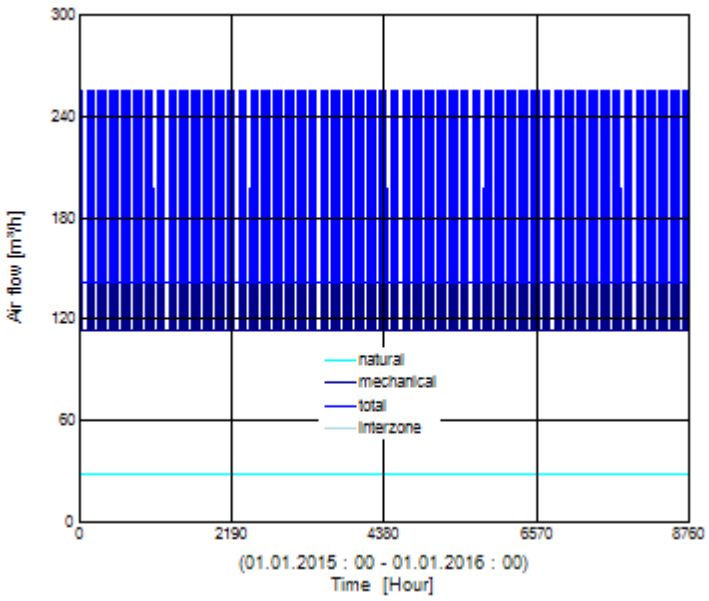


Figure 82: Air flows

Air flows (monthly)

A bar plot of all air flows summed up for each month.

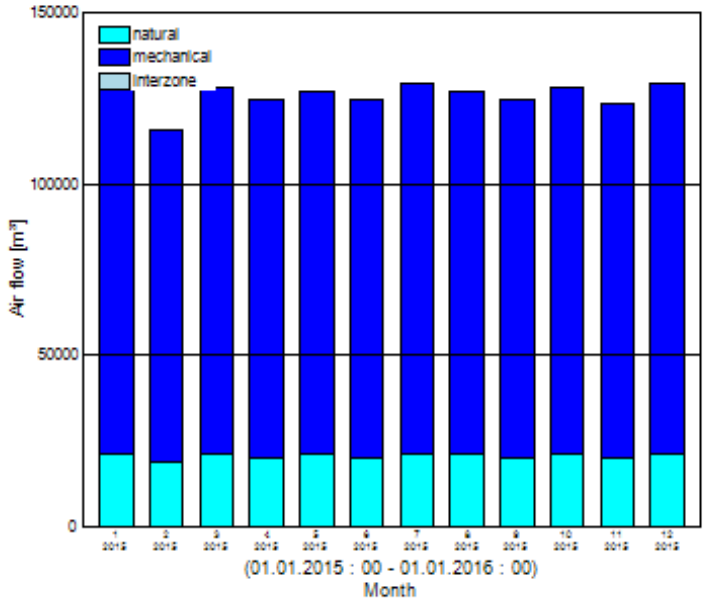


Figure 83: Monthly air flows

A time series of the CO_2-concentration in ppmv as calculated by WUFI® Plus.

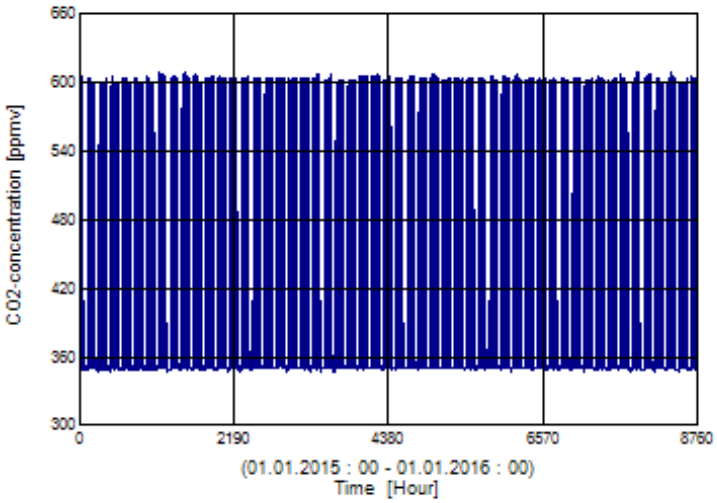


Figure 84: Co2-concentration

A time series of heat gains and losses through latent heat of humidification or dehumidifcation as calculated by WUFI® Plus. Positive values represent heat gains and negative values represent heat losses. Please note: Appropriate HVAC devices are necessary to create this graph.

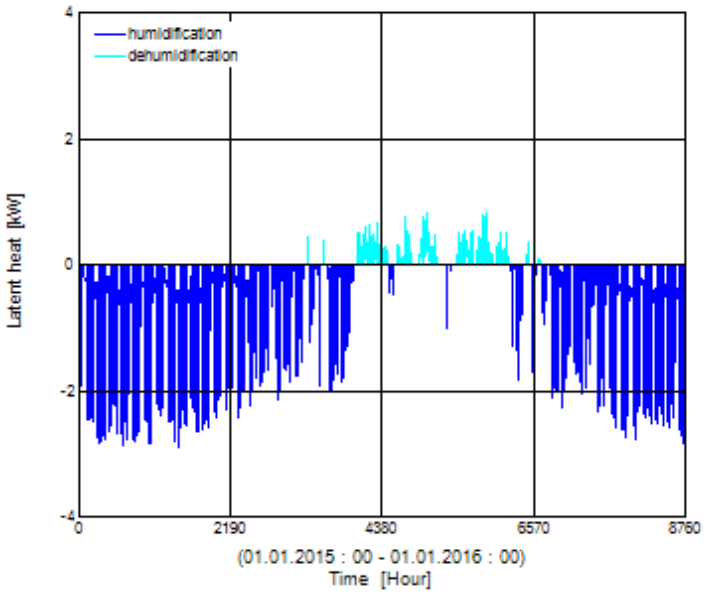


Figure 85: Latent heat gains

Latent heat - humidification/dehumidification (monthly)

A bar plot of all latent heat effects from humdification or dehumidification summed up for each month. Please note: Appropriate HVAC devices are necessary to create this graph.

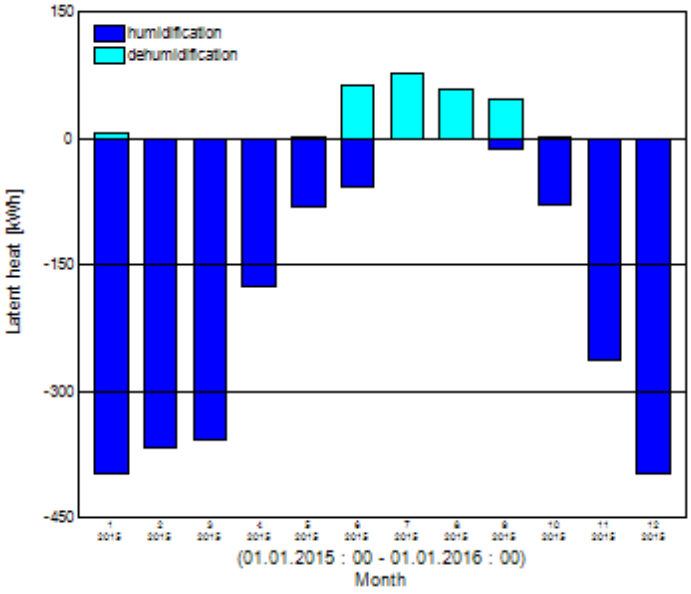


Figure 86: Monthly latent heat gains

Two graphs are displayed with this option. The first shows time series of exterior and interior temperature. For both temperatures the daily moving average is also shown. The second graph plots a timeseries of global solar radiation (from exterior climate) together with the zones daily mean solar gains.

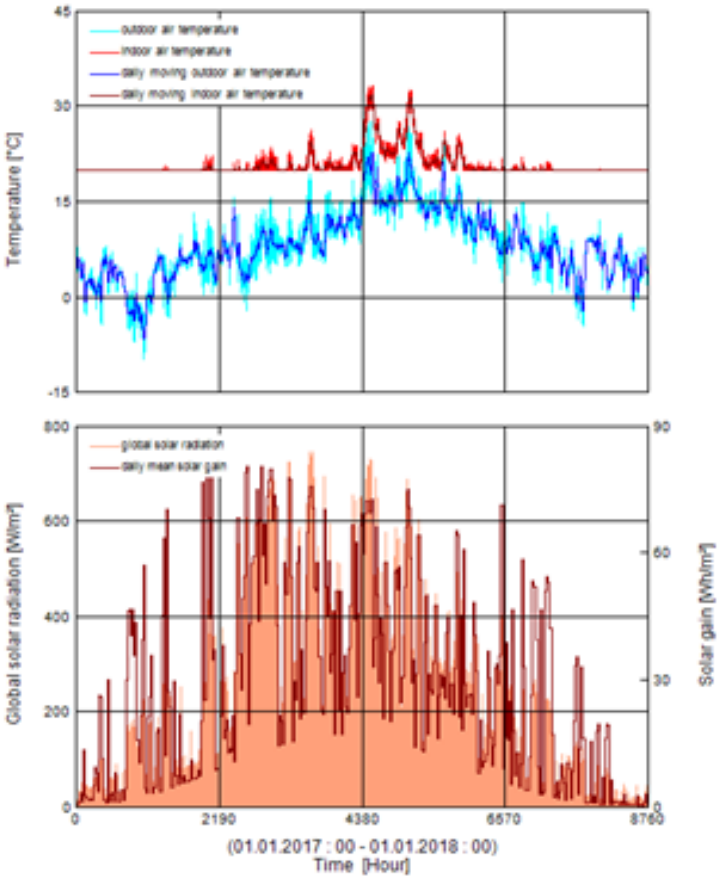


Figure 87: Monthly latent heat gains

Two graphs are displayed in this plot. The upper graph plots the simulated indoor temperature together with the zones maximum design temperature (as defined in the Design conditions). The second plot shows the simulated air change rate divided into natural and mechanical ventilation.

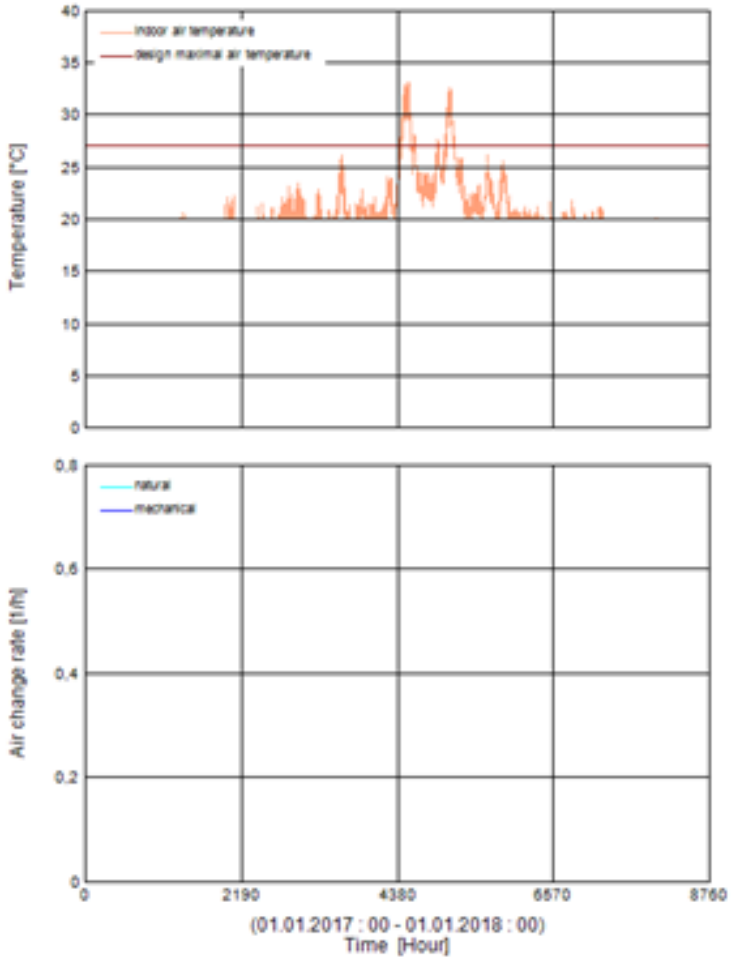


Figure 88: Monthly latent heat gains

Two graphs of indoor air temperature and operative temperature frequency are plotted here. The upper plot shows the hours of temperatures during the simulation time. The second plot shows the accumulated hours.

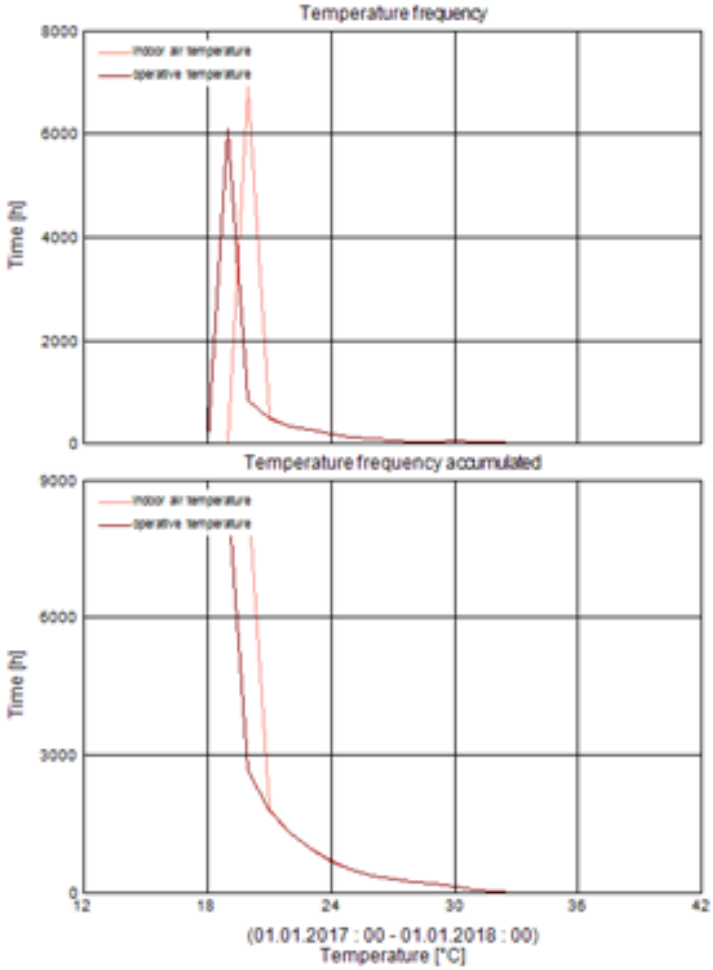


Figure 89: Monthly latent heat gains

11.2 Zonal Results

This option displayes the same graphs as explained in chapter 11.1.3 but only for the selected zone.

List of Figures