IDA Early Stage Building Optimization

(ESBO)

User guide

Document version 2.3, November 2019

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About this user guide

ESBO will often be accessed from a specific manufacturer or organization dealing with building indoor climate products. This ESBO provider will then supply documentation and tutorials to get you started. This user guide is independent of any single provider.

The guide addresses ESBO Light as well as the full (paid version of) ESBO. Therefore, some of the items discussed will not be found in the ESBO Light interface. Such passages are marked with a vertical line to the left, like this:

Example of paragraph which only pertains to full ESBO.

In the next section, a general overview of usage is given. After this follows a more detailed description with several screen shots and detailed instructions about each input dialog, presented roughly in the order they appear in the tabs.

How do I use ESBO?

ESBO will always start with showing a Portal page, which is customized to each provider of the ESBO service. Here you will find links to tutorial material, support etc. The language that you want to use is also specified here. From the Portal page, there may be a number of ways of starting an actual case:

1. By using a wizard, where you can select some very basic parameters to start off the further work or make simple simulations.
2. Links to re-start an old case, which you have previously worked with.
3. Links to other suitable start cases that have been proposed by the provider, such as typical office room, hospital room, residential building etc.

The present version of ESBO (v. 2.3) only has a single wizard, called Simple room. The details of the Simple room wizard are described in the next section. Here, we focus first on usage of the general interface, which opens after a wizard has been finished. (You will also get directly to this stage, if your start case has been saved after a wizard has been finished).

The general interface has three tabs: Rooms, Building and Simulation. The Room tab and the Building tab are where you define all the details of your building. Simulation experiments are carried out from the Simulation tab. The side bar to the left will show available components, different for each tab. The side bar can be opened and closed by clicking the ◫ symbol in the tool bar. To reopen the Portal page, press the ℹ symbol in the tool bar. The portal page can be left open while working with several models.

The first thing to do is to describe the typical rooms of the building. (NB! For ESBO Light, only a single rectangular room may be described.) This is done on the Room tab. Typical rooms are rooms that can be expected to have different indoor climate or service systems. If a building contains several identical rooms, only one of the rooms has to be modelled and that specific, typical room, can then be multiplied so that the total room area for that room type is correct. For example, if you have a building with 100 similar south facing offices, you only need to model a single one of these rooms. If you are only modelling a small building, you can describe all individual rooms of the building. However, for a large project, it is always better to model only a selection of rooms such as, for example, South facing single office room, North facing single office room, Open plan office, Conference room, Corridor space etc.

Windows and doors can be added to the room by dragging them from the left-hand palette directly to the surfaces in the 3D view. The exact size and position of the objects can be edited afterwards in separate dialogs. Windows and doors may only exist in external walls, i.e. walls facing outdoors. In fact, when you drag a window to a wall, that wall becomes external. Internal surfaces are light grey in the 3D view, while external have a brownish tone and they are generally thicker.

To redefine a surface from internal to external (or vice versa), you simply drag a construction of the right category to the surface. You can then double click on the surface to define the details of the construction.

Once the typical rooms have been described in terms of geometry on the Room tab, you enter the total floor area of each room type in the Rooms table at the bottom of the Room tab until the whole building floor space has been accounted for. Other significant total areas of the building are then automatically computed. By adapting the typical rooms slightly, e.g. by changing window areas or adding external wall area (use the Surface part object), you arrive at a model that matches the actual building in the key figures: total window area, total external wall, roof and ground area.

Once the typical rooms of the building have been defined, you describe internal heat gains for each typical room by selecting (and then possibly editing) usage patterns from a palette of common patterns. Similarly, the indoor climate standard for each typical room is selected.

At this stage, you switch to the **Building tab**.

In the Building tab, the first thing to do is to select the building location from the drop-down list. Select Download if you don’t find the appropriate location on the list. On the Internet site, you will find more than 3000 locations from all over the world.

Now, double click on the Ventilation system of the building. By default here, an air handling unit with a return air heat exchanger, a heating and a cooling coil has been defined. If you are happy with this setup, just select the heat exchanger efficiency and minimum discharge temperature (depending on defrosting), the pressure rise of the supply and return fans (or SFP). If you want a different type of system, drag it in from the palette. Note that air flows in the rooms have already been selected in the Room tab. The default central system will be able to supply any amount of tempered air. If you have selected exhaust only ventilation in the typical rooms (or unbalanced supply and return), the makeup air will come from increased infiltration.

Also in the Building tab, specify the domestic hot water consumption and the infiltration rate and then we are ready for a first simulation.

The rooms of the building are initially equipped with idealized room units for heating and cooling, called “Generic” units. These will heat and cool the rooms to maintain temperatures within requirements, *but are not connected to the water based central system* that is described on the Building tab. The Generic units provide heating and cooling to the rooms by directly converting some energy source (such as electricity, fuel or district heating). The systems that are described on the Building tab will supply hot or cold water needed by the air handling unit (AHU). When you start, a fixed efficiency boiler and similar chiller are present in the Building tab for this purpose.

If you don’t want mechanical cooling, remove the cooling systems from your typical rooms as well as the default chiller (that supplies the AHU cooling coil) from the Building tab. To remove the cooling coil from the air handling unit, just set its effectiveness to zero. It is nearly always best to make rough calculations with idealized systems first to compute needed sizes of other types of equipment.

To make a first set of simulations, switch to the Simulation tab. The first thing to do here is to simulate a severe winter day (Heating design). This will compute a heating need in all rooms that will later on be useful to select non-idealized room units and central systems.

Similarly, if you want to size a cooling system, run a summer day simulation (Cooling design). From version, 2.2 it is also possible to run an overheating study, and find the day with the highest temperature of each zone.

If you are in a truly early stage of the project and have not yet started to think about what particular supply systems to use for the building, go ahead with a whole-year energy simulation. This will enable you to optimize the building envelope first and then turn to a more sophisticated system description.

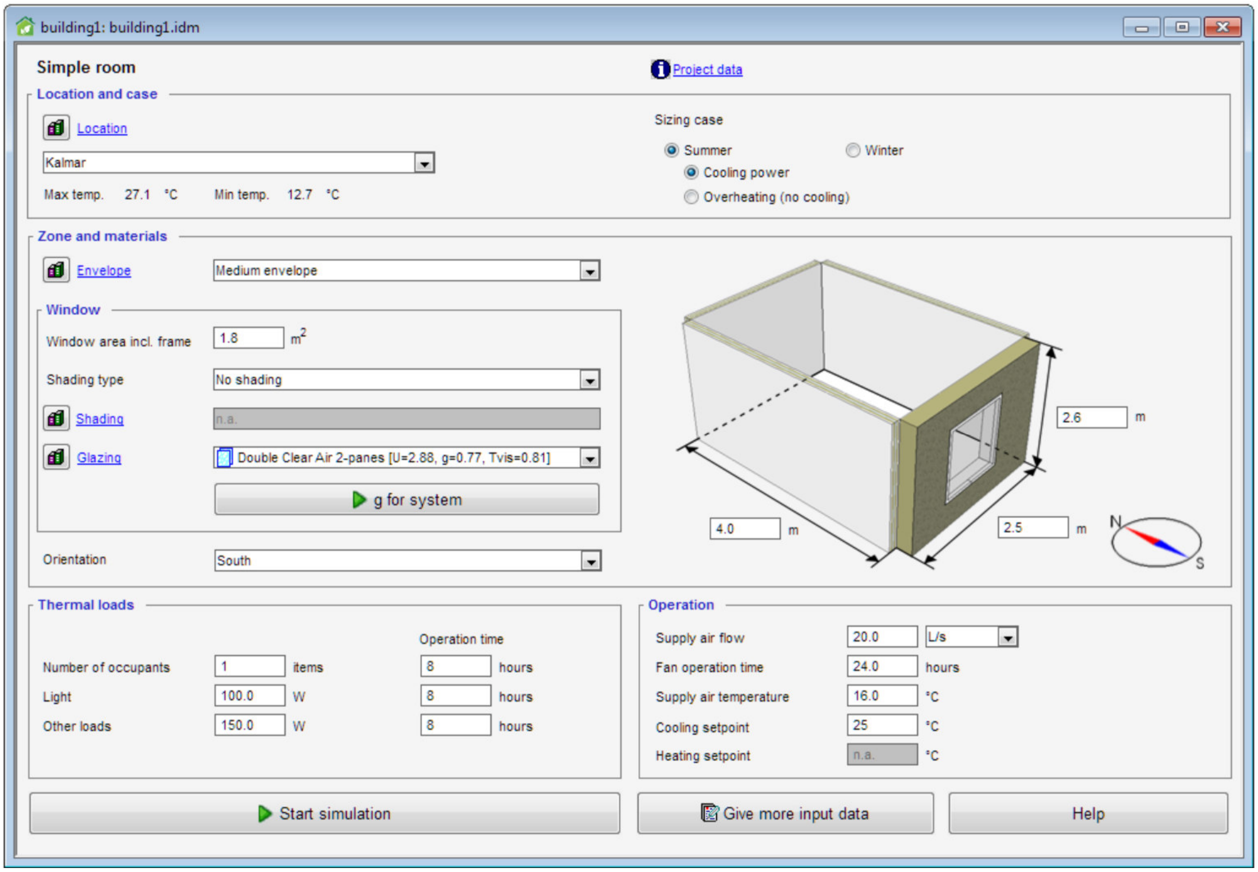
Once you are ready to start experimenting with different real system components, first go back to the Building tab. Here you specify the design temperatures of the air supply, the hot and, optionally, the cold water distribution systems. The next stop is the Room tab, where you replace the ideal room units with other options from the palette, such as radiators, fan coils or floor heating. In order to select a radiator or similar device, you must both have access to the heating demand of the room and of the system design temperatures. Note that the design power of most components, such as for example the radiator, are given with respect to a “rating condition”. If the actual temperature conditions differ from these, the emitted maximum power will not match the number that is given. Usually, the default rated conditions are standardized and will match those found in commercial technical data sheets. If you want the maximum power to match the given number, you can manually set the rated conditions to match the water and air temperatures of your simulation.

ESBO user interface

Simple room wizard

The Simple room wizard presents a minimum of inputs for making a single-day cooling, overheating or heating load study for a rectangular room with a single window. You can also easily compute the standardized performance (according to the standards EN ISO 52022-3, EN 410 and ISO 15099) of the window and shading assembly with a single click.

After inputting the requested data, you can either simulate directly, or go on to describe more in the full user interface (of ESBO Light or full ESBO, depending on what you are using.)



building1: building1.idm

Simple room

Location and case

Location: Kalmar

Max temp. 27.1 °C Min temp. 12.7 °C

Sizing case

● Summer ○ Winter

● Cooling power

○ Overheating (no cooling)

Zone and materials

Envelope: Medium envelope

Window

Window area incl. frame: 1.8 m^2

Shading type: No shading

Shading: n.a.

Glazing: Double Clear Air 2-panes [U=2.88, g=0.77, Tvis=0.81]

Orientation: South

Room dimensions: 2.6 m, 4.0 m, 2.5 m

Thermal loads

			Operation time	
Number of occupants	1	items	8	hours
Light	100.0	W	8	hours
Other loads	150.0	W	8	hours

Operation

Supply air flow	20.0	L/s
Fan operation time	24.0	hours
Supply air temperature	16.0	°C
Cooling setpoint	25	°C
Heating setpoint	n.a.	°C

Figure 1.

Location Location of the building. The geographical location can be selected from the database or downloaded. The object contains the coordinates of the location, as well as references to design day and hourly climate data. Click hyperlink to see details.

Max. temp. Information (not an input) about the maximum temperature of the (summer or winter) design day climate data. For summer conditions, the hottest day of the year is shown.

Min. temp. Information (not an input) about the minimum temperature of the (summer or winter) design day climate data. For summer conditions, the hottest day of the year is shown.

Sizing case, Summer Select to compute cooling load or overheating.

Cooling power Select to compute how much cooling power that is required in the room to maintain room air temperature below the Cooling setpoint temperature.

Overheating Select to compute how hot the room gets without any mechanical cooling.

Sizing case, Winter Select to compute how much heating power that is required in the room to maintain room air temperature above the Heating setpoint temperature.

Envelope Select the wall and floor constructions of the room. Click on link to see each element and then double click on element to edit details.

Window area incl. frame The window's total area (frame outside measurement.) 10 % is assumed to be taken up by the frame.

Shading type Select the type of solar protection to be used.

Shading Select the specific shading product. Click on link to change a specific aspect of the product, such as the fabric used.

Glazing Select the glazing system to be used. Click on link to edit the specific pane and gap combination.

Button: g for system Press this to compute the properties for the combination of shading and glazing at reference conditions according to the standards EN ISO 52022-3, EN 410 and ISO 15099. Only shading and glazing data is used for this calculation. For a further description of the computation, see page 14.

Room height Distance between the flooring and the ceiling.

Width Distance between the side walls, inside measurement.

Length Distance from the window wall to the opposite wall, inside measurement.

Orientation Selection of the compass point that the window faces.

Number of occupants Number of persons that load the room (dry and wet)

Light Rated input power when lights are on

Other loads Dry convective heating power from appliances in the room

Operation time Hours per day that each load is active. Load is assumed to be centered around 13:00

Supply air flow Total supply air flow= exhaust air flow (when fans are running)

Unit for air flows Select your preferred unit for air flows. The unit you select here will also apply in the general part of the program.

Fan operation time Hours per day for mechanical ventilation, centered around 13:00

Supply air temperature Temperature of in-blown air. For Overheating runs, no mechanical cooling is applied in the air handling unit and the temperature setpoint is therefore disabled.

Cooling setpoint Set value for the room thermostat for cooling

Heating setpoint Set value for the room thermostat for heating

The room has one external wall but is assumed to be otherwise surrounded by rooms with the same temperature conditions. The room is assumed to have a fully balanced mechanical supply and exhaust air system.

For cooling design and overheating studies, a statistically selected[1] clear and hot day is simulated over and over until the building has completely adapted, corresponding to a very long[2] spell of identical hot days. The process is repeated for each month of the year[3]. Results from the month where the maximum cooling (or overheating) in the zone occurs are presented. Note that the required cooling in the air handling unit is not included in the presented cooling power.

A trick to limit the simulation to only a single month is to open the Location object, press User-defined design days, and then press OK. This will limit the available climate data (and simulation) to a single month (the hottest).

The difference between a cooling power and an overheating study is that no mechanical cooling is used for the latter and the day with the highest room temperature is presented in the report.

A heating design study is similar to cooling design, but a bit simpler. Only a single cold spell is studied, and for this coldest month, a statistically selected cold day is repeated until the building has adapted. For the winter study, internal gains are assumed to be zero, and no solar radiation is allowed to enter the building.

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[1] Design day weather data is according to ASHRAE Fundamentals 2013, the 0.4% cumulative frequency level for cooling design and the 99.6% level for heating.

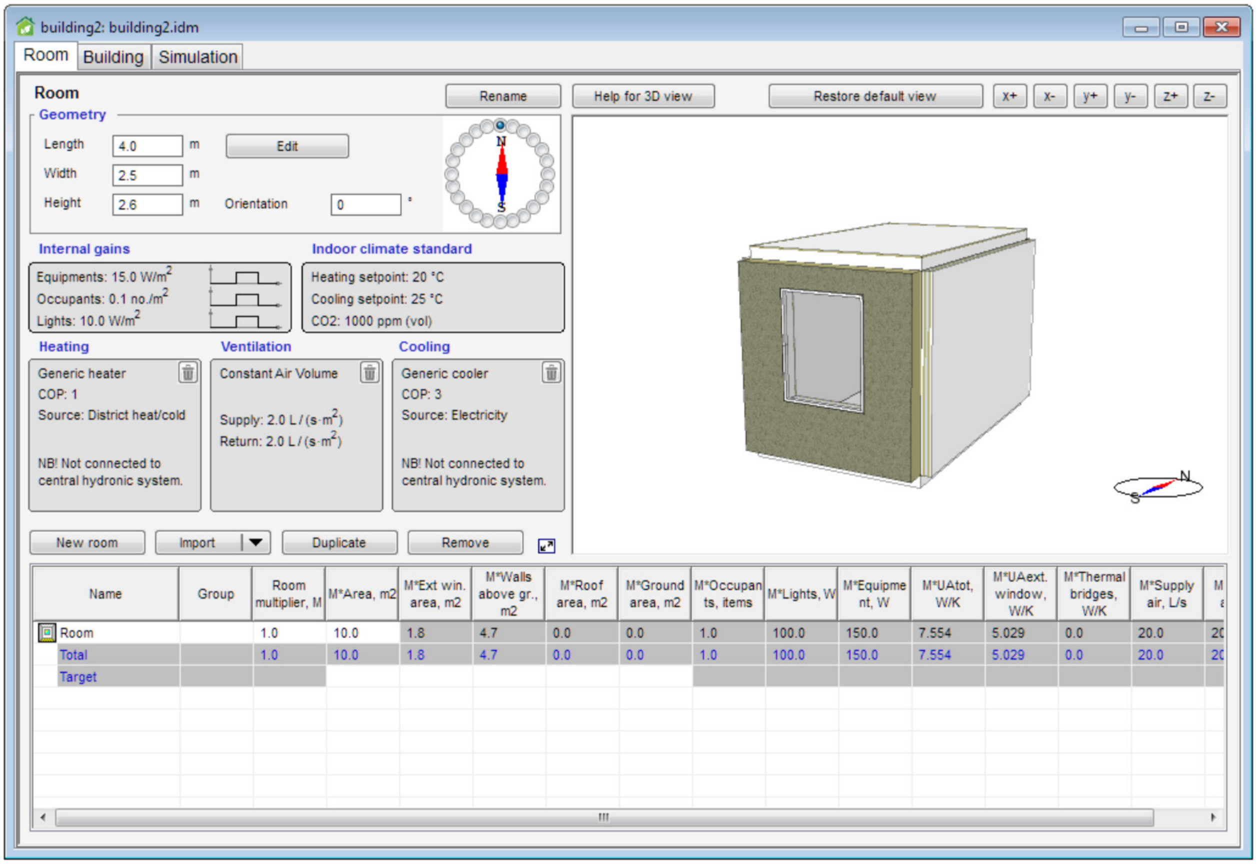
[2] Maximized to 14 days in ESBO. This is sufficient for most buildings to adapt.

[3] Process is terminated in fall/spring if heat load is decreasing from month to month.

Room tab

The room tab is active when a case is first opened (afresh or from a wizard).

Rooms can be either shoebox shaped, prismatic or have a locked arbitrary geometry that has been imported. In the Room tab, you describe the typical rooms of the building. Typical rooms are rooms that are expected to have different indoor climate or service systems. For example, if an office building has many identical rooms facing south, it's sufficient to model a single one of these rooms. In a smaller building all rooms might be described individually.



Room

Geometry

Length 4.0 m

Width 2.5 m

Height 2.6 m

Orientation 0 °

Internal gains

Equipments: 15.0 W/m^2

Occupants: 0.1 no./m^2

Lights: 10.0 W/m^2

Indoor climate standard

Heating setpoint: 20 °C

Cooling setpoint: 25 °C

CO2: 1000 ppm (vol)

Heating

Generic heater

COP: 1

Source: District heat/cold

NB! Not connected to central hydronic system.

Ventilation

Constant Air Volume

Supply: 2.0 L / (s·m^2)

Return: 2.0 L / (s·m^2)

Cooling

Generic cooler

COP: 3

Source: Electricity

NB! Not connected to central hydronic system.

Name	Group	Room multiplier, M	M*Area, m2	M*Ext win. area, m2	M*Walls above gr., m2	M*Roof area, m2	M*Ground area, m2	M*Occupants, items	M*Lights, W	M*Equipment, W	M*UAtot, W/K	M*UAext. window, W/K	M*Thermal bridges, W/K	M*Supply air, L/s
Room		1.0	10.0	1.8	4.7	0.0	0.0	1.0	100.0	150.0	7.554	5.029	0.0	20.0
Total		1.0	10.0	1.8	4.7	0.0	0.0	1.0	100.0	150.0	7.554	5.029	0.0	20.0
Target														

Figure 2.

Objects in the palette to the left on the screen can be used to replace the default objects in a room. Some objects, such as windows and doors, are inserted directly into the 3D view by dragging them. HVAC system objects and settings are dragged directly into the corresponding place in the form. Most of the default objects can either be removed, e.g. remove the default generic cooler to study a room without cooling, or replaced with other objects with different properties. The generic objects that are described in this help text are always available. In addition to these, there may be objects that represent products of given manufacturers. There may also be combination objects that fulfil more than a single function, for example a four-pipe fan coil that can both heat and cool the room.

Geometry

Here you can edit the geometry and the orientation of the room. Any changes will be visible directly in the 3D view.

Length The length of the room, inside measurement [m]. Editable for shoebox shaped rooms.

Width The width of the room, inside measurement [m]. Editable for shoebox shaped rooms.

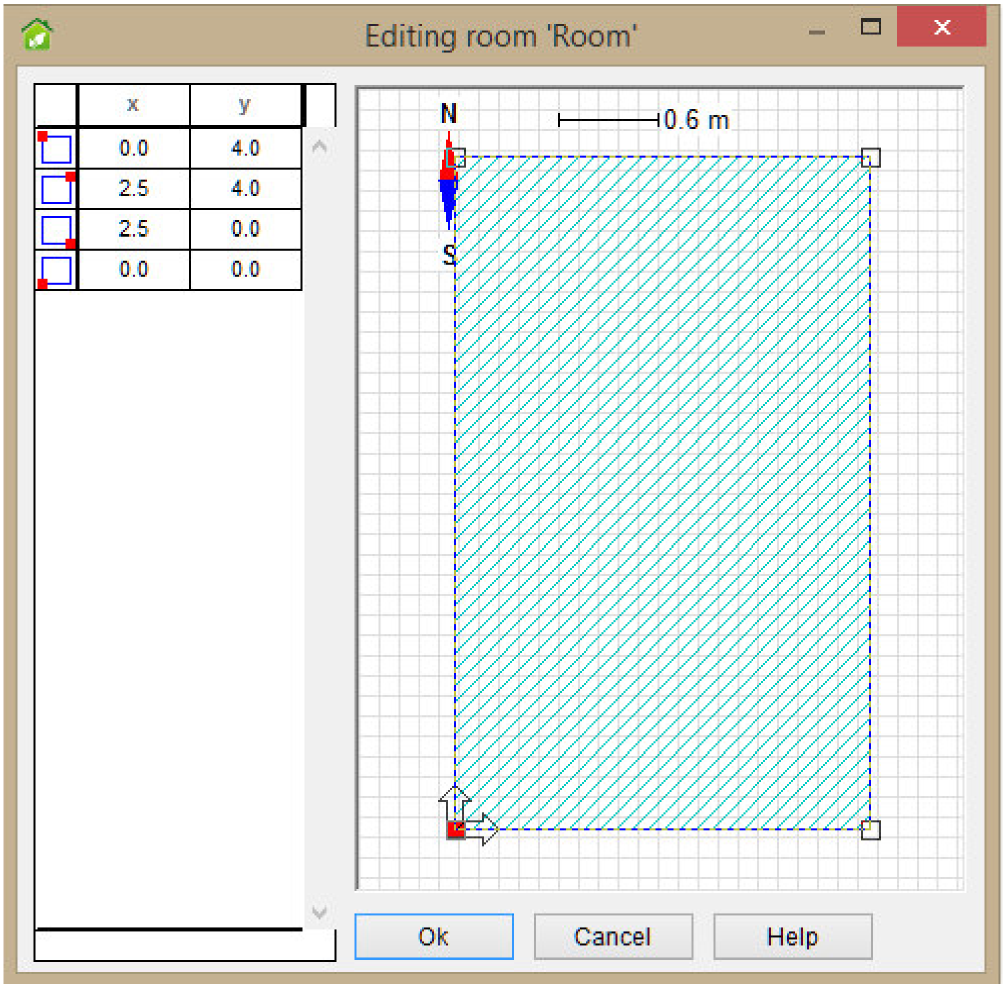
Height The height of the room, inside measurement [m]. Editable for shoebox shaped and prismatic rooms.

Editing room geometry

Clicking the **"Edit"** button will open a 2D editor where the rectangular shape of a prismatic room can be edited into an arbitrary polygon. This option is unavailable for rooms with locked geometry. The perimeter of the room is shown as a polyline. A polyline consists of line segments and break points, the latter marked by small rectangles. The polyline can be edited as follows, generally using the left mouse button:

- Its breakpoints can be dragged to the desired positions for the room's corners.
- Its line segments can be dragged to the desired positions for the room's walls.
- A new breakpoint can be introduced by clicking on or close to the line.
- An existing breakpoint can be deleted by clicking on it.
- Breakpoints for non-right-angled corners can be introduced by holding down the Ctrl-key and simultaneously clicking on a line segment.

Coordinates of each breakpoint is shown in the table to the left. Here, more exact numerical values of coordinates may be entered directly.



x	y
0.0	4.0
2.5	4.0
2.5	0.0
0.0	0.0

Figure 3.

Room multiplier The number of identical rooms in the building. Used to scale the load of a room to provide an appropriate load for the systems.

Floor area The total floor area of the room/rooms in the building. Changing this will only affect the Room multiplier.

Orientation Change the orientation of the room with respect to north [°].

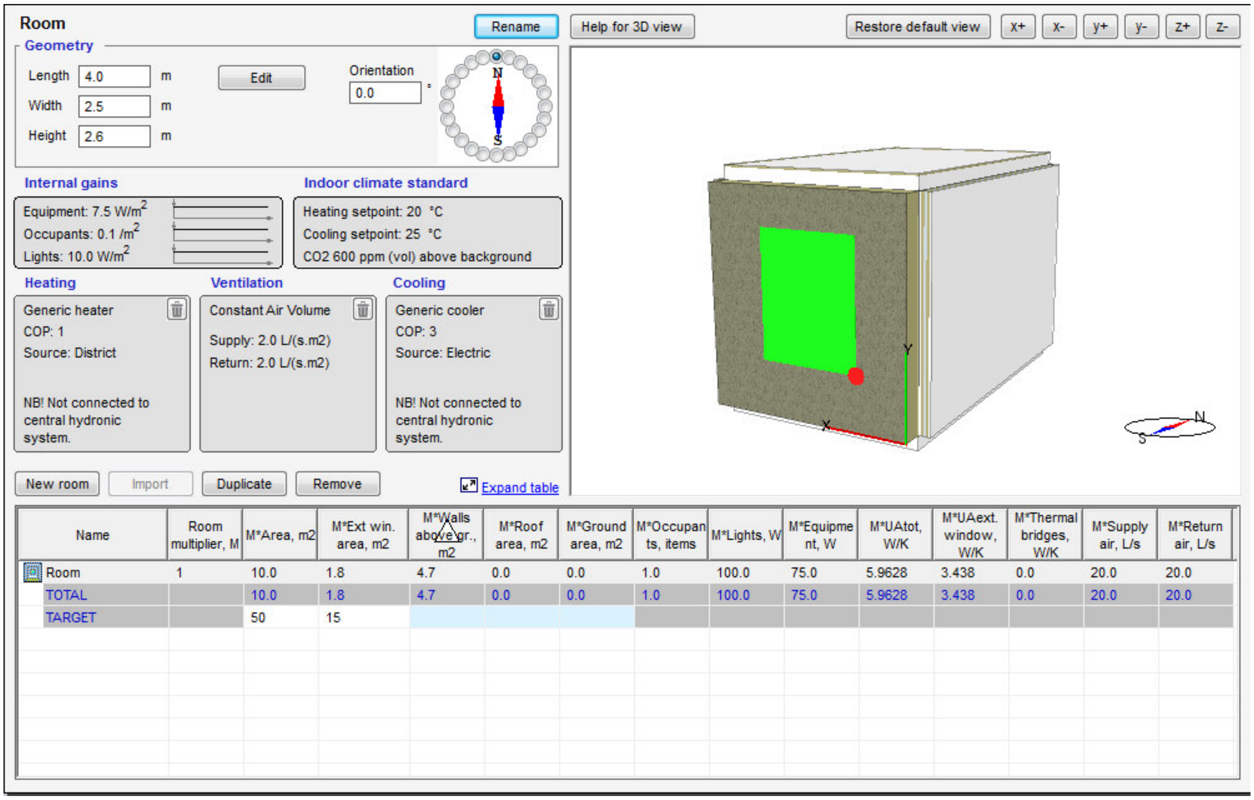
Orientation widget Another way to set room orientation by selecting corresponding radio button.

Rename Change the name of the selected room.

Windows, doors and surface parts

Window

To add a window, drag it with the mouse from the palette to a surface of the room in the 3D view, Figure 2. A selected window can be moved by holding down the Ctrl-key (the window will change from red to green) and dragging the window to a new position, which can be on another wall. Right click and choose Duplicate to insert a copy of the window, slightly shifted from the original position. When a window is added to a surface with internal construction, the surface is assigned the default external construction. Double click to open the window object, Figure 5. To remove the window, right click and choose Delete.



Length 4.0 m
Width 2.5 m
Height 2.6 m
Orientation 0.0 °

Equipment: 7.5 W/m²
Occupants: 0.1 /m²
Lights: 10.0 W/m²

Heating setpoint: 20 °C
Cooling setpoint: 25 °C
CO2 600 ppm (vol) above background

Generic heater
COP: 1
Source: District
NB! Not connected to central hydronic system.

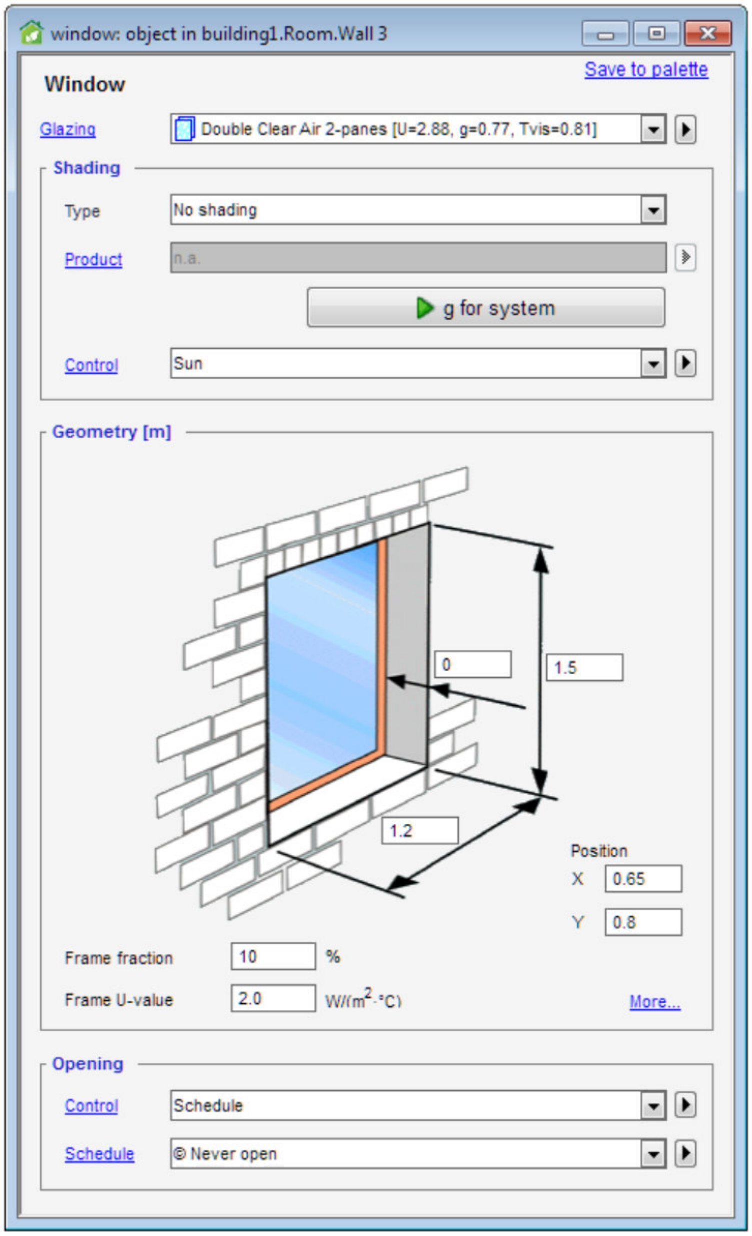
Constant Air Volume
Supply: 2.0 L/(s.m2)
Return: 2.0 L/(s.m2)

Generic cooler
COP: 3
Source: Electric
NB! Not connected to central hydronic system.

Name	Room multiplier, M	M*Area, m2	M*Ext win. area, m2	M*Walls above gr., m2	M*Roof area, m2	M*Ground area, m2	M*Occupants, items	M*Lights, W	M*Equipment, W	M*UAtot, W/K	M*UAext. window, W/K	M*Thermal bridges, W/K	M*Supply air, L/s	M*Return air, L/s
Room	1	10.0	1.8	4.7	0.0	0.0	1.0	100.0	75.0	5.9628	3.438	0.0	20.0	20.0
TOTAL		10.0	1.8	4.7	0.0	0.0	1.0	100.0	75.0	5.9628	3.438	0.0	20.0	20.0
TARGET		50	15											

Figure 4. A window in the 3D view marked and ready to be moved

To edit and set parameters for a window, double click to open the window object or click on the window with the right mouse button and choose “Open”. Both actions will open the window dialog where you for example can edit the geometry and size of the window as well as define shading, shading control etc.



Glazing: Double Clear Air 2-panes [U=2.88, g=0.77, Tvis=0.81]

Type: No shading

Product: n.a.

Control: Sun

0

1.5

1.2

Position X: 0.65

Position Y: 0.8

Frame fraction: 10 %

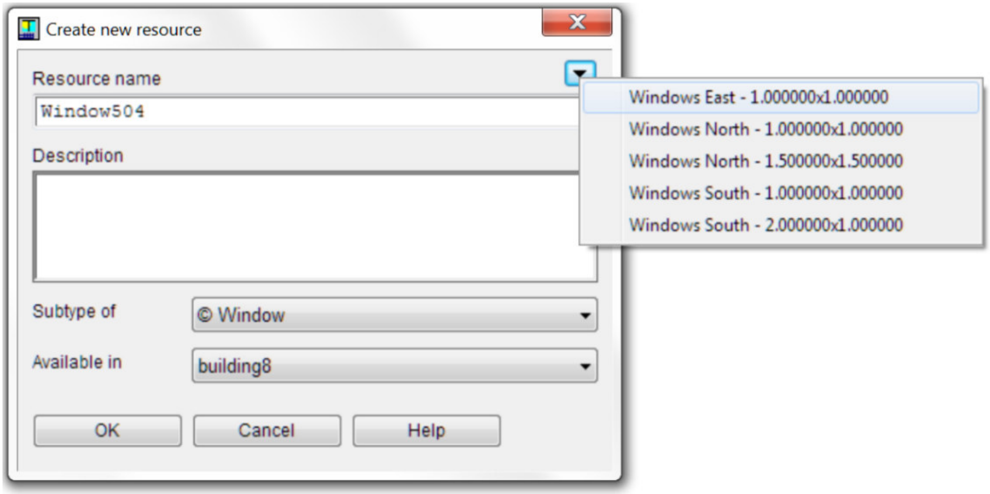
Frame U-value: 2.0 W/(m^2·°C)

Control: Schedule

Schedule: © Never open

Figure 5.

Save to palette A window can be saved as a window type. Click on the link and give your window type a name. If the room you are working with is a room template imported from IFC, see IFC import on page 25, the name can be selected from a list of imported window types shown by clicking on the arrow button, see Figure 6. The saved window types are mapped to the IFC window types when the IFC file is imported as a full building.



Resource name: Window504

Description:

Subtype of: © Window

Available in: building8

Figure 6.

The window type is shown in the palette of the room tab and windows of this type are added by dragging the type to the 3D view of the room tab. Window types can also be assigned in the 3D building and shading view, see Assign property to object on page 54.

Glazing Select the glazing system to be used. Click on link to edit the specific pane and gap combination.

Shading Type Select the type of solar protection to be used.

Shading Product Select the specific shading product. Click on link to change a specific aspect of the product, such as the fabric used. Note that the definition of "Product" here not only entails the material used, but also other things such as measurements of the mounting, durability against wind load etc.

Button: g for system Press this to compute the properties for the combination of shading and glazing at reference conditions according to the standards EN ISO 52022-3, EN 410 and ISO 15099. Only shading and glazing data is used for this calculation.

The boundary conditions are:

Boundary conditions of standard	External air/radiant temp. (°C)	Internal air/radiant temp. (°C)	Ext. conv. heat transf. coefficient (W/m2K)	Int. conv. heat transf. coefficient (W/m2K)	Incident solar rad. (W/m2)
EN ISO 52022-3 summer conditions	25	25	8	2.5	500
EN ISO 52022-3 reference conditions	5	20	18	3.6	300

ISO 15099 summer conditions	30	25	8	2.5	500
ISO 15099 winter conditions	0	20	20	3.6	300

In the glazing report, the total solar energy transmittance is the sum of the direct solar transmittance and the secondary internal heat transfer factor, while the latter is the sum of the convection factor, the thermal radiation factor and the ventilation factor.

Also, the sum of the direct solar transmittance, the solar reflectance outside and the absorptance in all the layers will equal one.

Control Select control scheme for shading operation. The following options are available:

Sun	The shading will be drawn* when the solar irradiance on the unshaded window exceeds 100** W/m2.
Sun + Timer	The shading will be drawn* when the solar irradiance on the unshaded window exceeds 100** W/m2 and also between 22 PM and 7 AM.
Sun + Get heat	The shading will be drawn* when the solar irradiance on the unshaded window exceeds 100** W/m2 during time when people are present in the room. During time of no presence, the shading will be activated when the irradiance is above 100** W/m2 only if the room does not need heating.
Sun + Get heat + Preserve heat	The shading will be drawn* in the same way as for Sun + Get heat, but also during the night time when there is a heating demand and the room has no presence of people.
Always drawn	Shades are permanently in down position (Switchable panes in dark state)
Never drawn	Shades are up (Switchable panes in clear state)
Schedule	Shades are drawn* according to user-specified schedule
Daylight	The shading position (or tint level of switchable glazing) is modulated to maintain a 500** lux daylight lux level in the room (average over floor).
Daylight + Get heat + Minimize cooling	Same as Daylight, but during time of no presence, the shading will be activated to minimize heating and cooling by blocking or admitting solar radiation irrespective of lux level.

*Switchable panes in dark state **Can be selected in Advanced settings in full ESBO

Geometry Here you can edit the geometry:

X Position in x-direction [m].

Y Position in y-direction [m].

Width The window's extension along the x-direction (frame outside measurement) [m].

Height The window's extension along the y-direction (frame outside measurement) [m].

Recess depth The distance between the window outer pane and the façade surface [m].

Frame fraction The frame fraction is the unglazed area of the window divided by the whole window area, defined by the outer frame measures [%].

Frame U-value The frame U-value is the heat transfer coefficient for the unglazed part of the window, including interior and exterior film coefficients. (W/m2°C).

Frame Inner surface The frame inner surface setting is reached by clicking the More… link. It describes the optical properties of the inner surface of the frame.

Frame Outer surface The frame outer surface setting is reached by clicking the More… link. It describes the optical properties of the outer surface of the frame.

Opening control Selection of control strategy for window opening. Supported strategies:

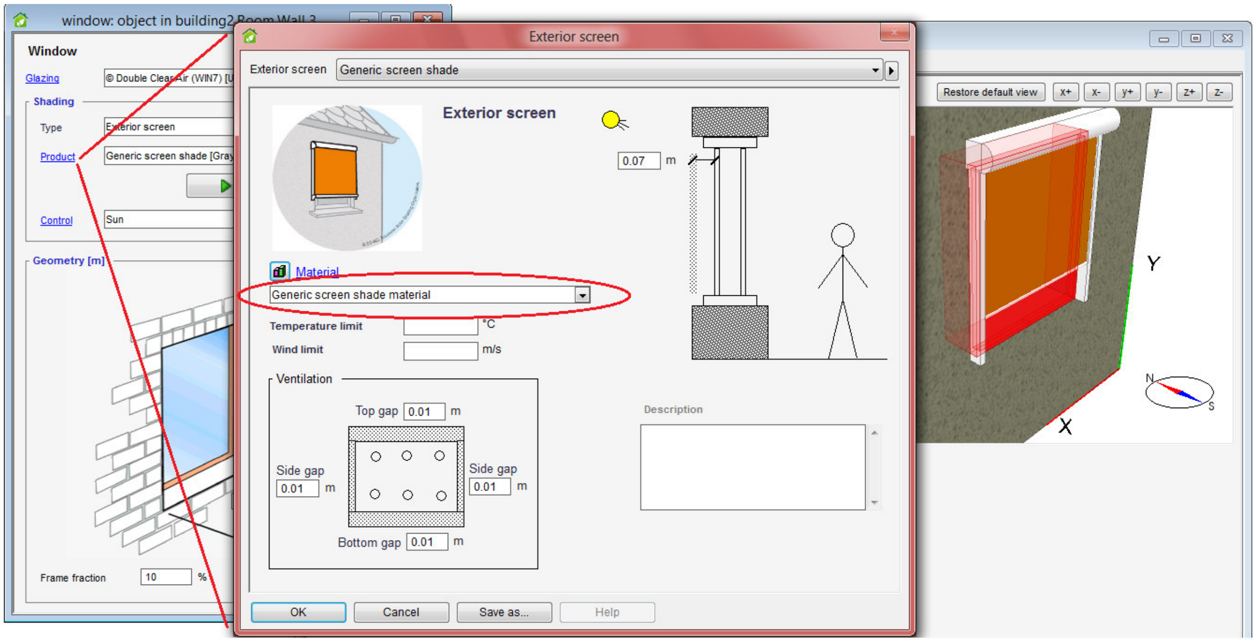
> **Schedule** The opening is controlled by time schedule
>
> **PI temperature control AND schedule** The opening is controlled by air temperatures (both internal and external) in the range from 0 (fully closed) to the value given by the schedule.

Opening schedule Schedule for degree of window opening. 0 = fully closed, 1 = fully open. Schedule smoothing applied by default. This can be changed from Advanced settings on the building tab.

Shading product dialogs

Most of the dialogs for entering product details for different shading types are similar. Here we will describe them together by the example of an Exterior screen. Further down we describe the dialogs for Micro lamellas and Switchable panes which are not similar to Exterior screen.

Below is an example what the dialog looks like when an Exterior screen has been selected in the Type dropdown list. The dialog is opened by clicking the link Product as indicated in Figure 7.


window: object in building2.Room.Wall 3

Window

Glazing: © Double Clear Air (WIN7) [U

Shading

Type: Exterior screen

Product: Generic screen shade [Gray

Control: Sun

Geometry [m]

Frame fraction: 10 %

Exterior screen

Exterior screen: Generic screen shade

Exterior screen

0.07 m

Material: Generic screen shade material

Temperature limit: °C

Wind limit: m/s

Ventilation

Top gap: 0.01 m

Side gap: 0.01 m

Side gap: 0.01 m

Bottom gap: 0.01 m

Description

Figure 7. A shading product dialog (here showing an Exterior screen)

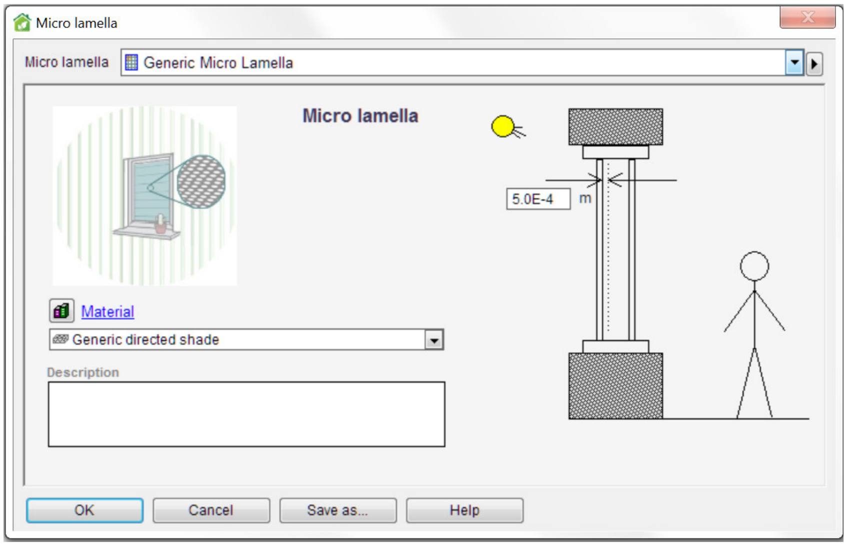
To select a specific fabric for the screen from the database, select Load from database… in the drop down list as indicated in Figure 7. Note that you can sort the elements of the database by any column by clicking on the header. By sorting by the least important property first, e.g. Transmittance, and then by the most important, e.g. Manufacturer, you can get the table in an appropriate order for doing also complex filtering.

In the product dialog, you also select measurements that are specific to the device that you want to describe, for the example of the Exterior screen, the gap between the outer pane and the fabric is given (near the symbol of the sun) and the ventilation gaps around the fabric are given (in the box Ventilation) in order to compute the air thermal air circulation around the fabric.

Inputs for **Temperature limit** and **Wind limit** may also (optionally) be given. If a Temperature limit has been given, the shading will not be drawn when the outdoor air temperature (away from the window) is below this limit. To avoid problems with freezing, you can enter e.g. "-0.5" here. Similarly, Wind limit allows you to prevent lowering the shade when the wind is too high.

In a real live installation of a wind meter, the signal will fluctuate wildly with each individual gust. However, in the simulation weather data file, the wind is averaged over a full hour, so all individual gusts will disappear. Furthermore, models are applied to estimate the actual wind near the window in question and this will further lower the reading in comparison to that given by the weather data file. Altogether, this means that the same numerical value of Wind limit cannot be used for the simulation as is entered in the real shading controller, but a considerably lower value must be used here to get a comparable share of wind limited time over a longer period.

Another shading type is Micro lamella, which is microscopic lamellas placed on the inside of the outer pane of the window. The shading from these is direction dependent, which is described in material files uploaded by the manufacturer of the micro lamella. This direction dependence is also taken into account in the Radiance daylight calculation.



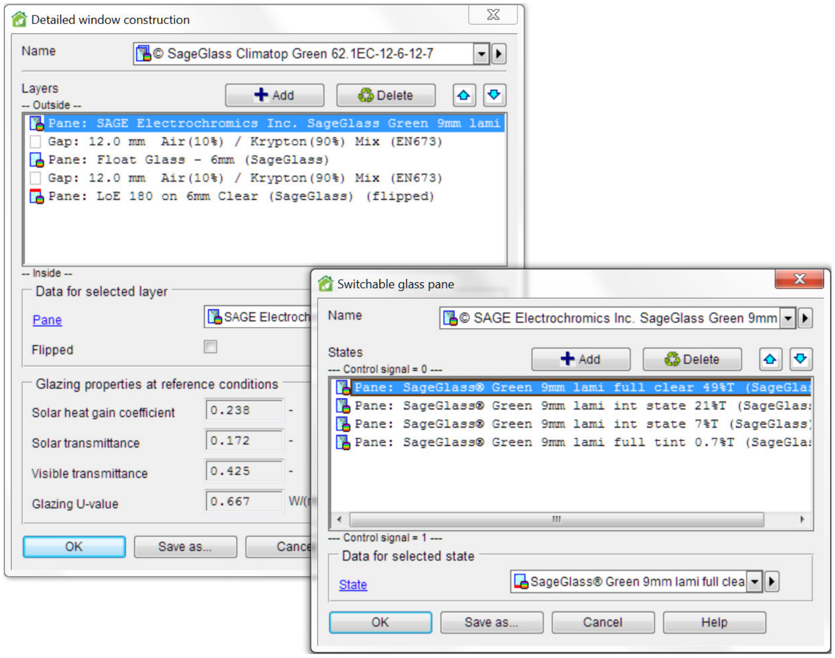
Micro lamella: Generic Micro Lamella

Material: Generic directed shade

5.0E-4 m

Figure 8.

Yet another shading type is Switchable panes, which is a window pane that has different properties based on some control signal. The switchable pane is described in the glazing dialog, Figure 9.



Name: © SageGlass Climatop Green 62.1EC-12-6-12-7

```
Pane: SAGE Electrochromics Inc. SageGlass Green 9mm lami
Gap: 12.0 mm  Air(10%) / Krypton(90%) Mix (EN673)
Pane: Float Glass - 6mm (SageGlass)
Gap: 12.0 mm  Air(10%) / Krypton(90%) Mix (EN673)
Pane: LoE 180 on 6mm Clear (SageGlass) (flipped)
```

Pane: SAGE Electroch

Flipped ☐

Solar heat gain coefficient 0.238 -

Solar transmittance 0.172 -

Visible transmittance 0.425 -

Glazing U-value 0.667 W/(

Name: © SAGE Electrochromics Inc. SageGlass Green 9mm

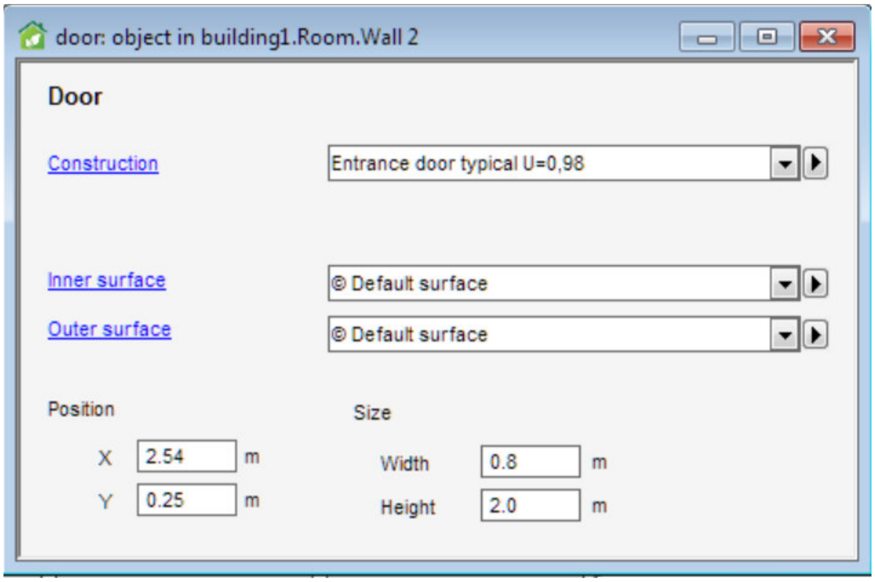
```
Pane: SageGlass® Green 9mm lami full clear 49%T (SageGla
Pane: SageGlass® Green 9mm lami int state 21%T (SageGlas
Pane: SageGlass® Green 9mm lami int state 7%T (SageGlass
Pane: SageGlass® Green 9mm lami full tint 0.7%T (SageGla
```

State: SageGlass® Green 9mm lami full clea

Figure 9.

Door

The purpose of the door object is to describe the main properties of a closed external door. To add a door, drag it with the mouse from the palette to a surface of the room in the 3D view. When a door is added to a surface that is presently internal, the surface is converted to being external and is assigned the default external construction and the color of the wall will change to brown.



door: object in building1.Room.Wall 2

Door

Construction: Entrance door typical U=0,98

Inner surface: © Default surface

Outer surface: © Default surface

Position

X 2.54 m

Y 0.25 m

Size

Width 0.8 m

Height 2.0 m

Figure 10.

Construction To choose door construction, click on the right arrow with the left mouse button and choose “Load from database”. Click the hyperlink to open the construction dialog, Figure 15.

Inner surface The inner surface describes the optical properties of the inner surface of the door.

Outer surface The outer surface describes the optical properties of the outer surface of the door.

X Position in x-direction [m].

Y Position in y-direction [m].

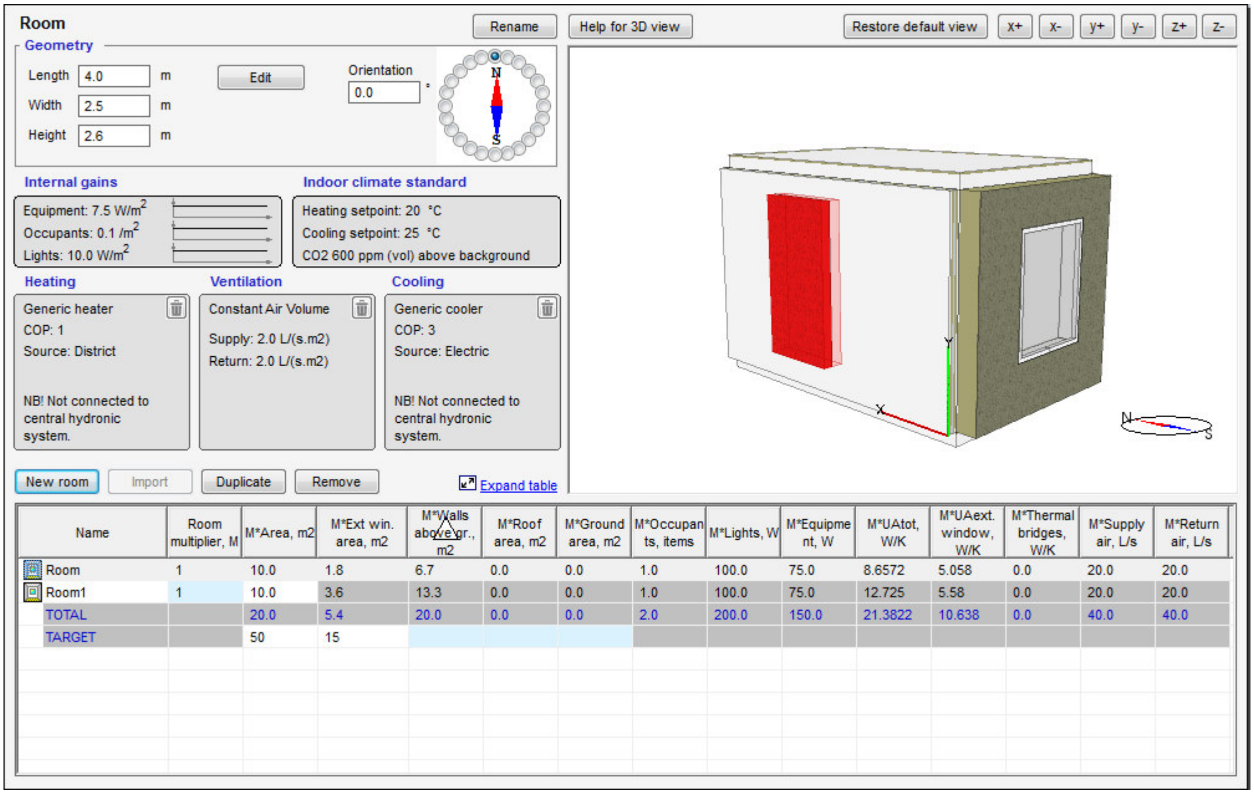
Width The door’s extension along the x-direction [m].

Height The door’s extension along the y-direction [m].

Surface part

A surface part is a part of a surface with different construction and/or boundary conditions. It is primarily used to adjust the total areas of a model that uses zone multipliers, to get the right balance between external and internal area. Let’s say, for example, that you are working on a building with multiple identical floors. You can then describe only one floor and use zone multipliers to get the total floor area right. However, in order to account for the different boundary conditions and constructions in the roof and ground slab, you can add small surface parts with the slab and roof constructions.

Drag a surface part from the palette to a surface of the room in the 3D view. See Figure 11. Double click to open the surface part object and choose construction by loading it from the database, see Figure 12.



Length 4.0 m
Width 2.5 m
Height 2.6 m
Orientation 0.0 °

Equipment: 7.5 W/m^2
Occupants: 0.1 /m^2
Lights: 10.0 W/m^2

Heating setpoint: 20 °C
Cooling setpoint: 25 °C
CO2 600 ppm (vol) above background

Generic heater
COP: 1
Source: District
NB! Not connected to central hydronic system.

Constant Air Volume
Supply: 2.0 L/(s.m2)
Return: 2.0 L/(s.m2)

Generic cooler
COP: 3
Source: Electric
NB! Not connected to central hydronic system.

Name	Room multiplier, M	M*Area, m2	M*Ext win. area, m2	M*Walls above gr., m2	M*Roof area, m2	M*Ground area, m2	M*Occupants, items	M*Lights, W	M*Equipment, W	M*UAtot, W/K	M*UAext. window, W/K	M*Thermal bridges, W/K	M*Supply air, L/s	M*Return air, L/s
Room	1	10.0	1.8	6.7	0.0	0.0	1.0	100.0	75.0	8.6572	5.058	0.0	20.0	20.0
Room1	1	10.0	3.6	13.3	0.0	0.0	1.0	100.0	75.0	12.725	5.58	0.0	20.0	20.0
TOTAL		20.0	5.4	20.0	0.0	0.0	2.0	200.0	150.0	21.3822	10.638	0.0	40.0	40.0
TARGET		50	15											

Figure 11. A room with a surface part added on a wall

Construction To choose surface construction, click on the right arrow with the left mouse button and choose “Load from database”. Click the hyperlink to open the construction dialog, Figure 15.

Inner surface The inner surface describes the optical properties of the inner surface of the surface part.

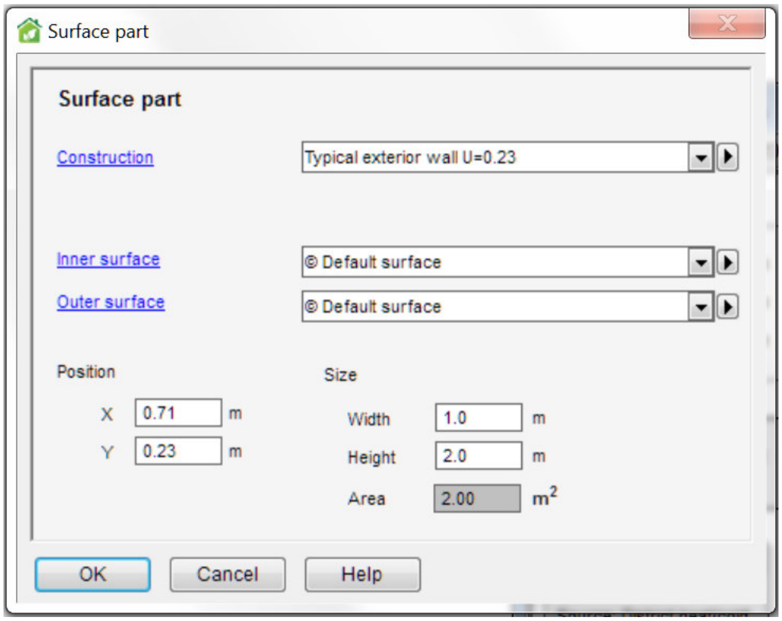
Outer surface The outer surface describes the optical properties of the outer surface of the surface part.

X Position in x-direction [m].

Y Position in y-direction [m].

Width The surface part's extension along the x-direction [m].

Height The surface part's extension along the y-direction [m].


Surface part

Construction: Typical exterior wall U=0.23

Inner surface: © Default surface

Outer surface: © Default surface

Position
X 0.71 m
Y 0.23 m

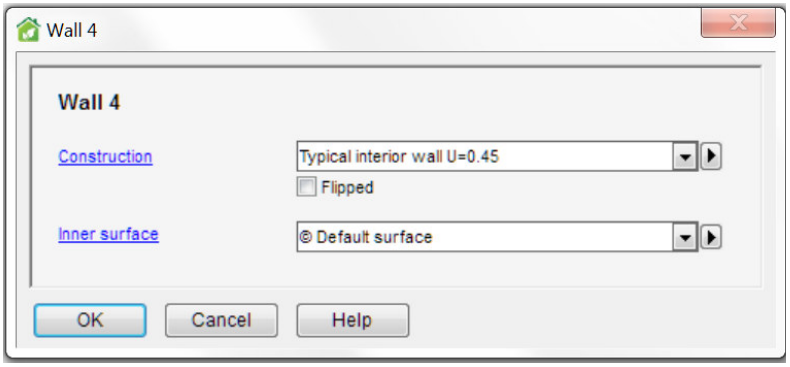
Size
Width 1.0 m
Height 2.0 m
Area 2.00 m^2

Figure 12.

Wall, roof and floor constructions

By default, walls, floor and ceiling have internal constructions.

To reassign a wall, roof or floor, to becoming external, drag a new external construction from the palette to the surface in the 3D view. Double click on the surface in the 3D view to open the wall dialog. Right click and choose Delete to remove the construction assignment.


Wall 4

Construction: Typical interior wall U=0.45

☐ Flipped

Inner surface: © Default surface

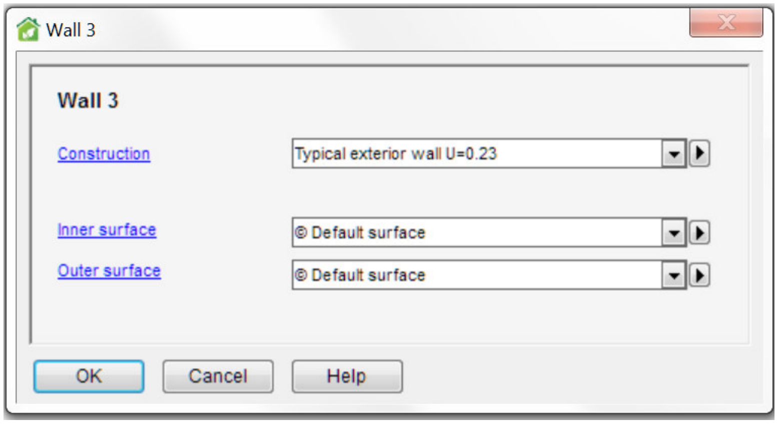
Figure 13. Wall dialog for internal wall, floor and ceiling

Construction To choose wall construction, click on the right arrow with the left mouse button and choose "Load from database". Click the hyperlink to open the construction dialog, Figure 15.

Flipped If checked, the wall layers of the internal wall are counted in the opposite order.

Inner surface The inner surface describes the optical properties of the inner surface of the wall.

Outer surface The outer surface describes the optical properties of the outer surface of the wall.



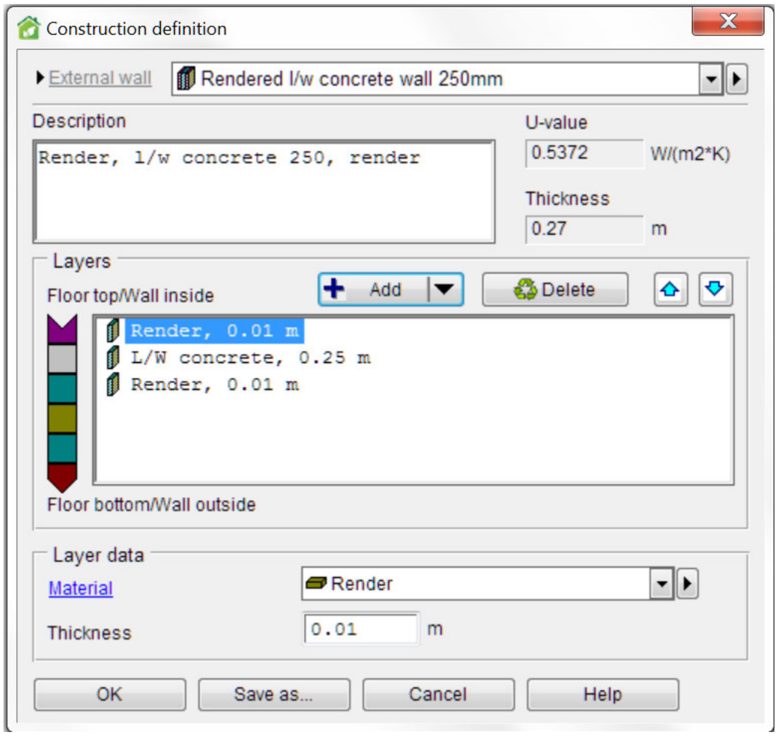
Wall 3

Construction: Typical exterior wall U=0.23

Inner surface: © Default surface

Outer surface: © Default surface

Figure 14. Wall dialog for external wall, floor and roof



External wall: Rendered l/w concrete wall 250mm

Description: Render, l/w concrete 250, render

U-value: 0.5372 W/(m2*K)

Thickness: 0.27 m

Floor top/Wall inside

Render, 0.01 m
L/W concrete, 0.25 m
Render, 0.01 m

Floor bottom/Wall outside

Material: Render

Thickness: 0.01 m

Figure 15. Construction definition dialog

Rooms table

At the bottom of the Room tab there is a **Rooms summary table.** All rooms of the building are shown in the table and key figures of the rooms are displayed. The floor area and the room multiplier can be edited. When either one of these are changed, the other figures of the room are updated. The building totals are shown at the bottom of the table. A target row is displayed at the bottom of the table where the actual building key totals can be entered for easy reference. When a room is selected in the table, its geometry and other properties of the room are displayed.

New room Click here to add a new room.

Import or **Import > Room geometry…** Add a new room by importing an arbitrary polygon-based geometry. The imported geometry will be un-editable.

Import > Room templates from IFC…[4] Add new room templates by importing them from IFC, see IFC import below.

Duplicate To add a copy of a room, select it, and click "Duplicate".

Remove To remove a room, selected it and click "Remove"..

Expand table Click here and the Rooms summary table is opened in a separate resizable window for easy viewing of a larger number of typical rooms.

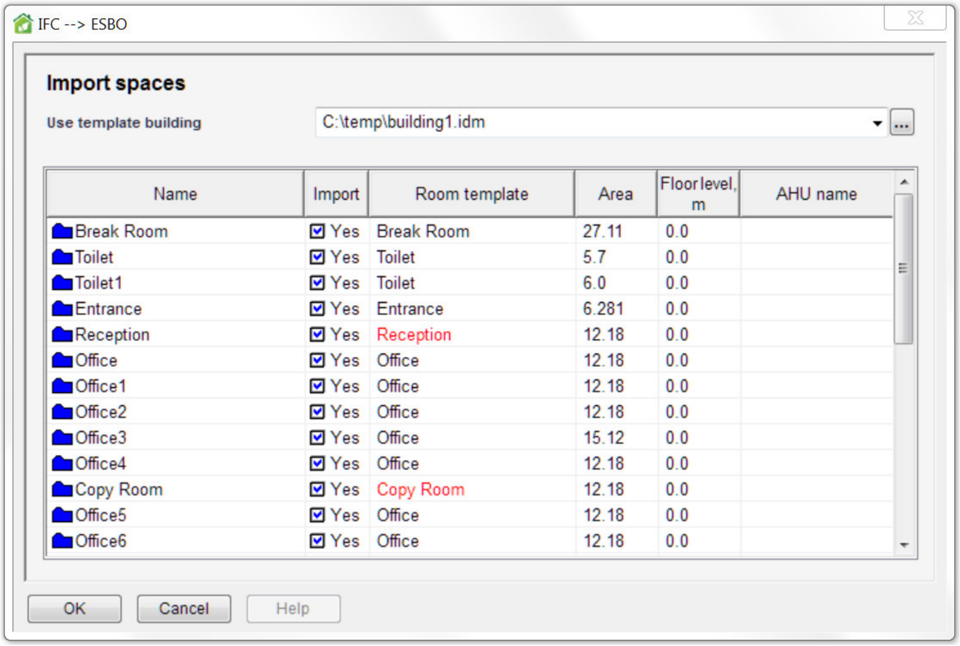
IFC import[4]

With the BIM import extension an entire building can be imported from a Building Information Model (BIM) in the Industry Foundation Classes (IFC) data format. After a simulation, some of the simulation results can be exported to an IFC file, see Export results on page 93.

To import an IFC file select **Import > IFC to ESBO…** in the File menu and select an IFC file which includes ifcSpaces. This will bring up a dialog with a table of the ifcSpaces in the IFC file, Figure 16.

---

[4] Only available with the BIM Import extension.



Import spaces

Use template building C:\temp\building1.idm

Name	Import	Room template	Area	Floor level, m	AHU name
Break Room	☑ Yes	Break Room	27.11	0.0	
Toilet	☑ Yes	Toilet	5.7	0.0	
Toilet1	☑ Yes	Toilet	6.0	0.0	
Entrance	☑ Yes	Entrance	6.281	0.0	
Reception	☑ Yes	Reception	12.18	0.0	
Office	☑ Yes	Office	12.18	0.0	
Office1	☑ Yes	Office	12.18	0.0	
Office2	☑ Yes	Office	12.18	0.0	
Office3	☑ Yes	Office	15.12	0.0	
Office4	☑ Yes	Office	12.18	0.0	
Copy Room	☑ Yes	Copy Room	12.18	0.0	
Office5	☑ Yes	Office	12.18	0.0	
Office6	☑ Yes	Office	12.18	0.0	

Figure 16.

Use template building Select which ESBO building should be used as a template. In this building there should be rooms with the same name as the space types in the IFC file (Room template in the table) and window types, see page 14. A template building can also be created from an IFC file, see below.

Name The name of the ifcSpace. Will be the name of the room if it is imported.

Import Select which ifcSpaces to import.

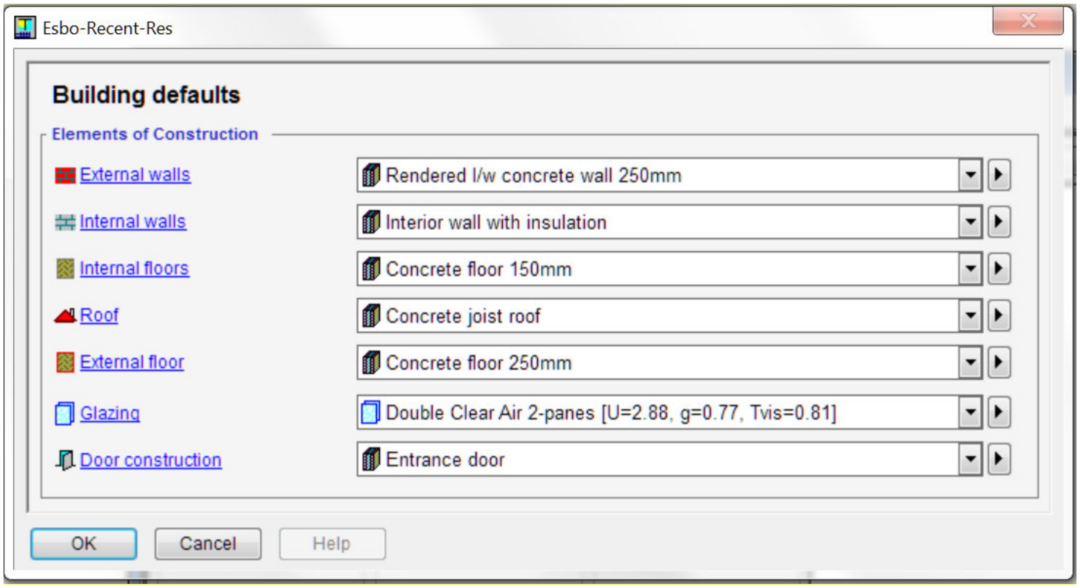
Room template The name of the space type in the IFC file. If a room template of this name does not exist in the template building the name is red. Any room in the template building can be selected from a drop-down menu. When clicking OK the created room will have the same internal gains, indoor climate standard, heating, ventilation, cooling, constructions and window types as the selected room template. The geometry will however be taken from the ifcSpace.

Area Floor area of the ifcSpace.

Floor level Floor level of the ifcSpace.

AHU name Name of the AHU that serves the ifcSpace if this information is included in the IFC file. This is used for information only. A building in ESBO can only have one AHU. If the building in the IFC file has several AHUs it needs to be divided into several ESBO buildings.

To add room templates from an IFC file to a template building select **Import > Room templates from IFC…** on the Room tab. This will bring up a dialog where the default constructions of walls, windows and doors are selected, Figure 17.



Esbo-Recent-Res

Building defaults

Elements of Construction

External walls	Rendered l/w concrete wall 250mm
Internal walls	Interior wall with insulation
Internal floors	Concrete floor 150mm
Roof	Concrete joist roof
External floor	Concrete floor 250mm
Glazing	Double Clear Air 2-panes [U=2.88, g=0.77, Tvis=0.81]
Door construction	Entrance door

Figure 17.

When clicking OK the space types in the IFC file are collected and one room template per space type is created. These room templates can then be attributed in the desired configuration to be used in the IFC import of the entire building, Figure 16.

3D view

In the 3D view you can rotate, pan, zoom and move an object. How to do this is explained below. Pointing with the mouse on the "**Help for 3D view"** will display a text about mouse operations in the 3D view as a tooltip, and in a dialog when the button is clicked:

> To ***Select*** an object: click on the object with the left mouse button. The selected object is shown in red.
>
> To ***Rotate*** the model: press down the left mouse button on the object and move the mouse.
>
> To ***Pan*** the model: use the middle mouse button (or both the left and the right mouse buttons on a two button mouse): Press down and move the mouse left, right, up or down.
>
> To ***Zoom*** the model: press down the right mouse button: Move the mouse upwards to **zoom in** and downwards to **zoom out**.
>
> To zoom out to ***Zoom extents***: click with the right mouse button in the 3D-vew and choose "Zoom extents". This will move the model so that the entire model is visible.

To ***Open the dialog*** for a window, door or a surface part**:** Click with the right mouse button on the object and choose "Open" in the menu.

To ***Set focus*** in the 3D view**:** Click with the right mouse button in the 3D view on the spot where you want the focus to be and choose "Set focus". This sets the point around which the model is rotated and towards which it is zoomed.

To move a room in the z-direction, select the room and press the Ctrl-key and the Shift-key and move the room with the mouse. (Only possible when entering the 3D view via the Building tab).

To ***Drag*** a window, door or a surface: select the object, press the Ctrl-key and move the mouse pointer.

To create a ***Section view*** of a room or a model:

the x+, x-, y+, y-, z+, z- buttons create a section through the room. When section is activated, press Ctrl-key, click within the red frame and move the mouse pointer, to move the section.

x+ Cut the 3D model along the x-axis removing all geometry on the positive side of the cut plane.

x- Cut the 3D model along the x-axis removing all geometry on the negative side of the cut plane.

y+ Cut the 3D model along the y-axis removing all geometry on the positive side of the cut plane.

y- Cut the 3D model along the y-axis removing all geometry on the negative side of the cut plane.

z+ Cut the 3D model along the z-axis removing all geometry on the positive side of the cut plane.

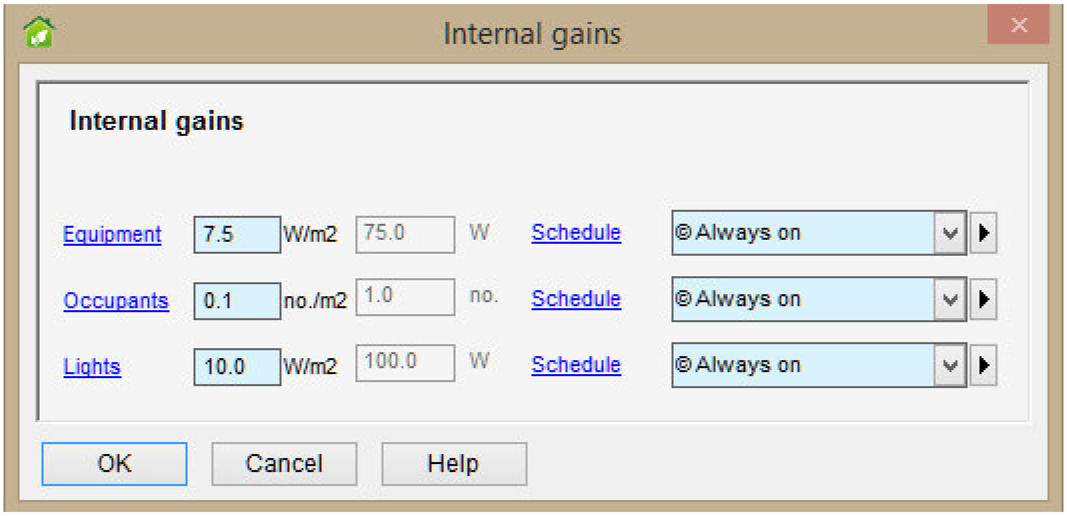
z- Cut the 3D model along the z-axis removing all geometry on the negative side of the cut plane.

Restore default view Clicking here will zoom and pan the model so that the entire model is visible and undo any cut of the model.

Room systems and settings

Internal gains

Internal gains are equipment, occupants and lights in the building. To open the dialog for internal gains, double click in the grey window, see Figure 18.



Internal gains

Equipment 7.5 W/m2 75.0 W Schedule ©Always on

Occupants 0.1 no./m2 1.0 no. Schedule ©Always on

Lights 10.0 W/m2 100.0 W Schedule ©Always on

Figure 18.

Equipment Specific equipment can be chosen by clicking the right arrow and downloading them from the database. The dry convective heating power from appliances in the room is expressed in [W/m^2]. Click the hyperlink to open the dialog for setting other equipment details.

Occupants The number of occupants that load the room (dry and wet) is expressed as the number of occupants/m^2. Click the hyperlink to open the dialog for setting other occupant details.

Lights The rated input power when lights are expressed in [W/m^2]. Click the hyperlink to open the dialog for setting other light details.

Schedules Schedules determine when equipment, occupants and lights are present and active. Click the hyperlink to open the schedule dialog. Specify appropriate hours by drawing a line with the cursor, see Figure 19.

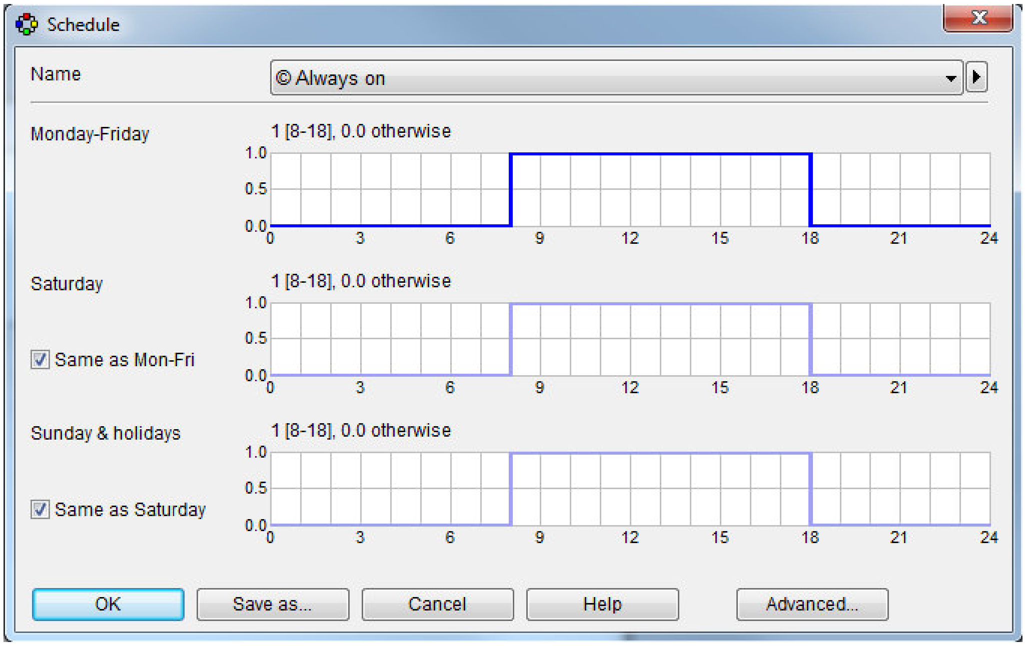
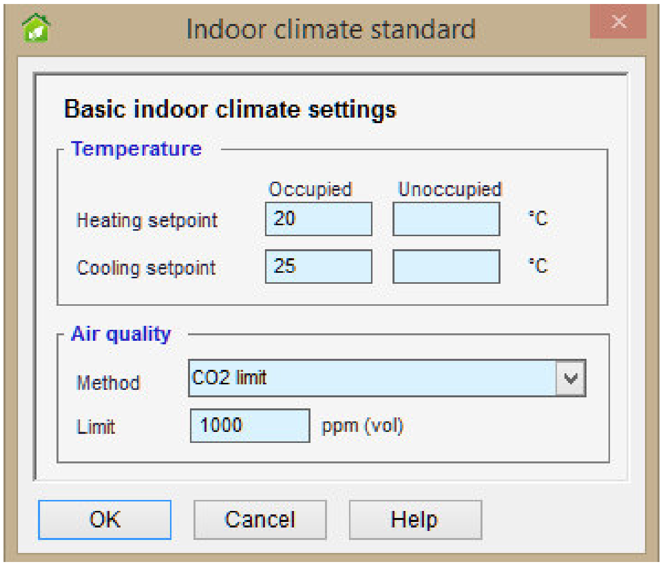


Figure 19.

Indoor climate standard

Double click to open the indoor climate standard object, Figure 20.

In the dialog you can set basic indoor climate settings



	Occupied	Unoccupied	
Heating setpoint	20		°C
Cooling setpoint	25		°C

Method: CO2 limit

Limit: 1000 ppm (vol)

Figure 20.

Heating setpoint The air temperature that heating units attempt to maintain [°C].

Cooling setpoint The air temperature that cooling units attempt to maintain [°C].

Method Type of air quality measure [CO_2 limit].

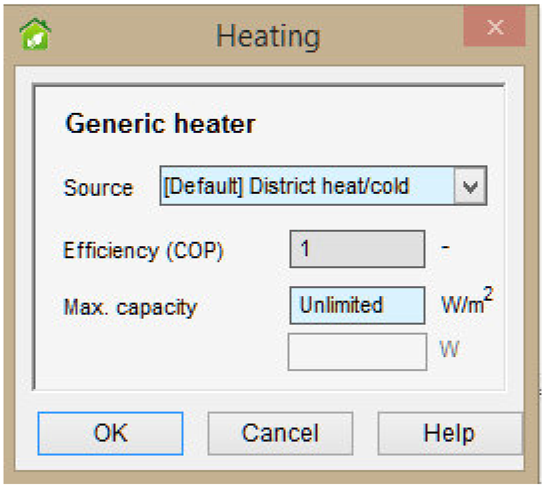
CO_2 limit - maintain CO_2 below the limit.

Limit The air quality setpoint.

Heating

The default heating object is a generic heater. To change the heating object, drag a heating object from the palette to the room tab. Double click to open the heating object, Figure 21. Click the wastebasket to remove the object.

Generic heater



Source: [Default] District heat/cold

Efficiency (COP): 1 -

Max. capacity: Unlimited W/m²

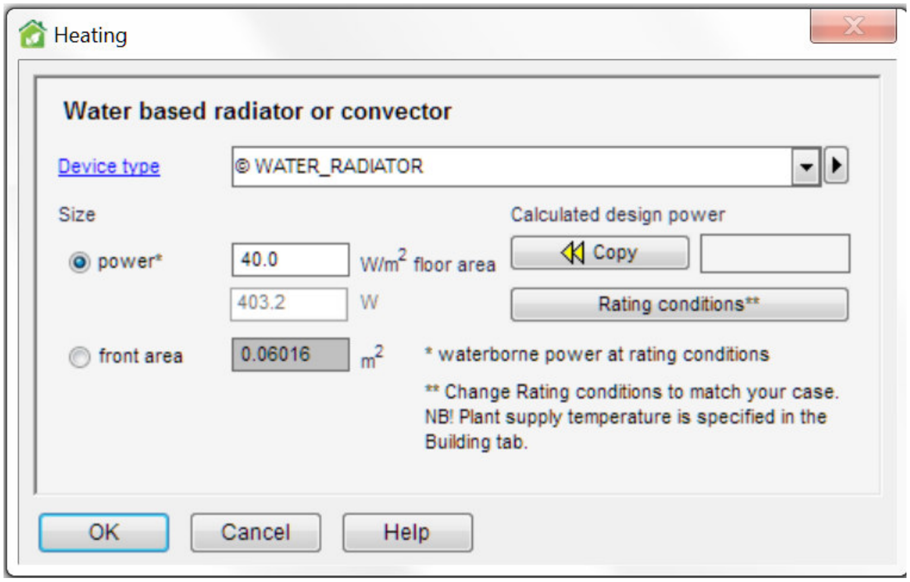
W

Figure 21.

Double click to open the heating object. The generic heater has by default unlimited capacity. It heats the room directly, using the given energy source, i.e. it does not rely on any central systems that have been defined on the Building tab. The generic heater is normally used in the initial stages, to find required system capacity. 40% of the heat is emitted as long wave radiation.

This ratio can be changed in full ESBO under Advanced settings in the Building tab.

Water based radiator or convector



Device type: WATER_RADIATOR

● power*: 40.0 W/m² floor area

403.2 W

○ front area: 0.06016 m²

* waterborne power at rating conditions

** Change Rating conditions to match your case. NB! Plant supply temperature is specified in the Building tab.

Figure 22.

Device type To change the type of radiator or convector, right click on the arrow to the right and choose " Load from database". Click the hyperlink to access radiator parameters that are stored in the database.

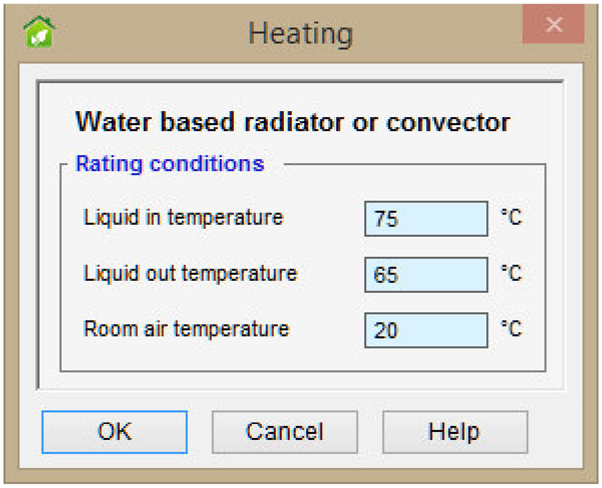
Size The size of the radiator/convector based on [power, front area].

power The emitted power at rating conditions. [W/m²].

Copy Copy data from a previous room unit heating calculation. Design power is shown in the (grey) input field. Corresponding area is shown in the (grey) front area field.

front area The front area of radiator/convector [m²].

Click ***Rating conditions*** to see the room and water temperatures at which the given radiator power will be emitted. Note that actual radiator capacity is strongly dependent on these.



Water based radiator or convector

Rating conditions

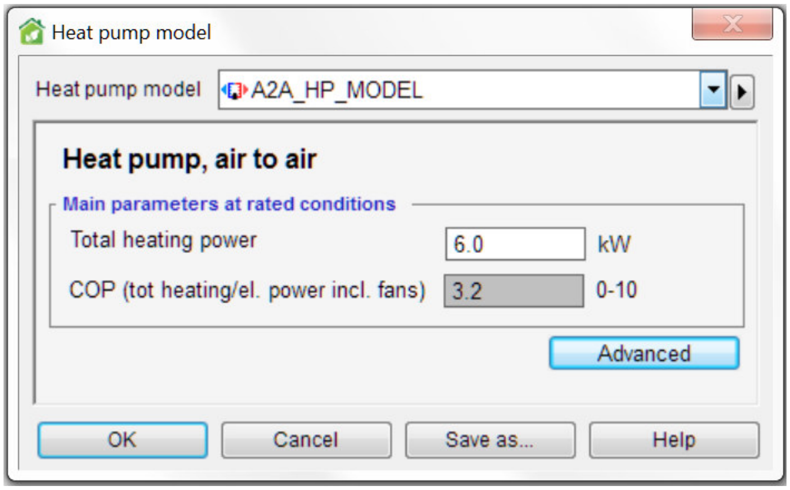
Liquid in temperature 75 °C

Liquid out temperature 65 °C

Room air temperature 20 °C

Figure 23.

Air to air, non-ducted, heat pump



Heat pump model A2A_HP_MODEL

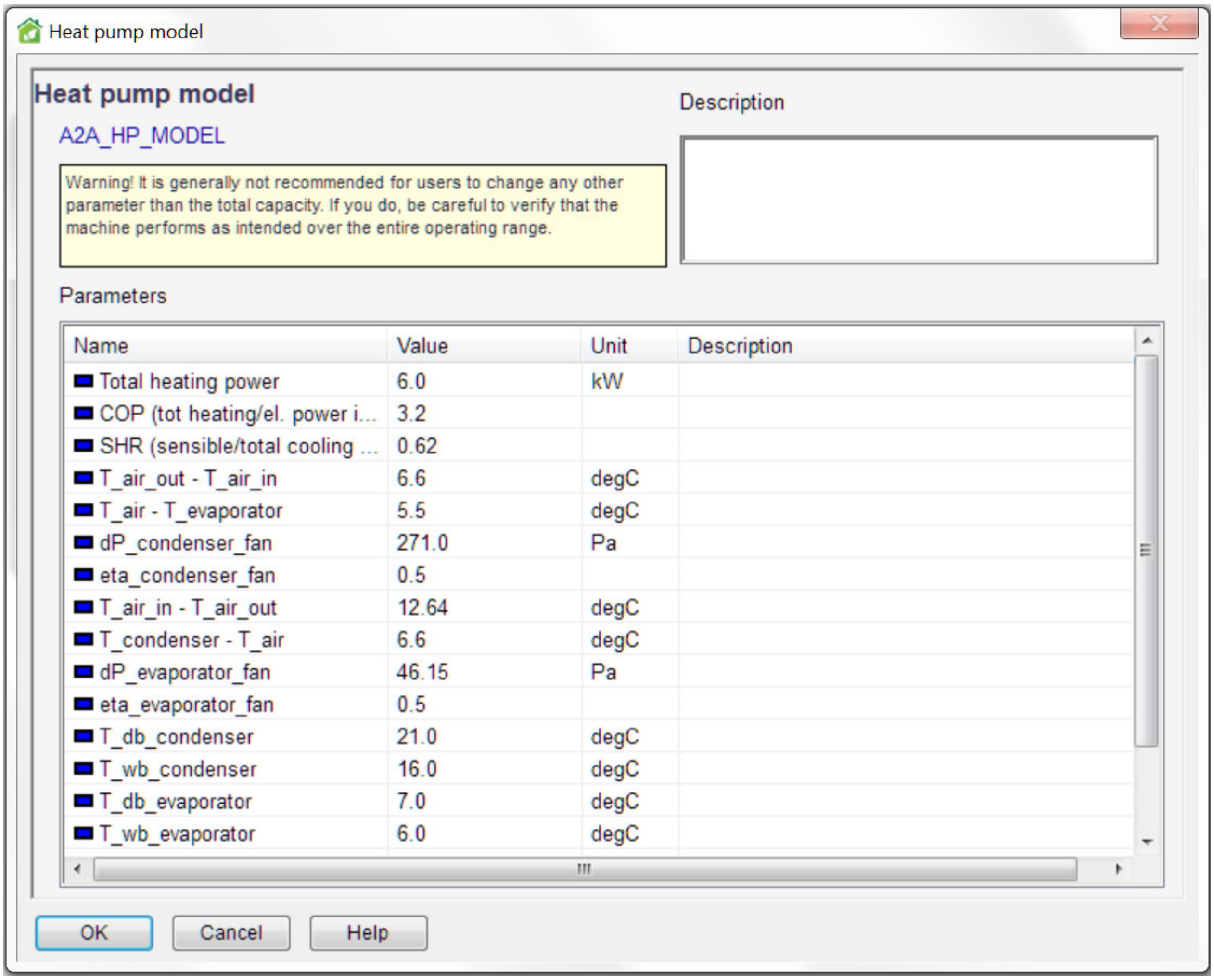
Heat pump, air to air

Main parameters at rated conditions

Total heating power 6.0 kW

COP (tot heating/el. power incl. fans) 3.2 0-10

Figure 24.



Heat pump model

A2A_HP_MODEL

Warning! It is generally not recommended for users to change any other parameter than the total capacity. If you do, be careful to verify that the machine performs as intended over the entire operating range.

Name	Value	Unit	Description
Total heating power	6.0	kW	
COP (tot heating/el. power i...	3.2		
SHR (sensible/total cooling ...	0.62		
T_air_out - T_air_in	6.6	degC	
T_air - T_evaporator	5.5	degC	
dP_condenser_fan	271.0	Pa	
eta_condenser_fan	0.5		
T_air_in - T_air_out	12.64	degC	
T_condenser - T_air	6.6	degC	
dP_evaporator_fan	46.15	Pa	
eta_evaporator_fan	0.5		
T_db_condenser	21.0	degC	
T_wb_condenser	16.0	degC	
T_db_evaporator	7.0	degC	
T_wb_evaporator	6.0	degC	

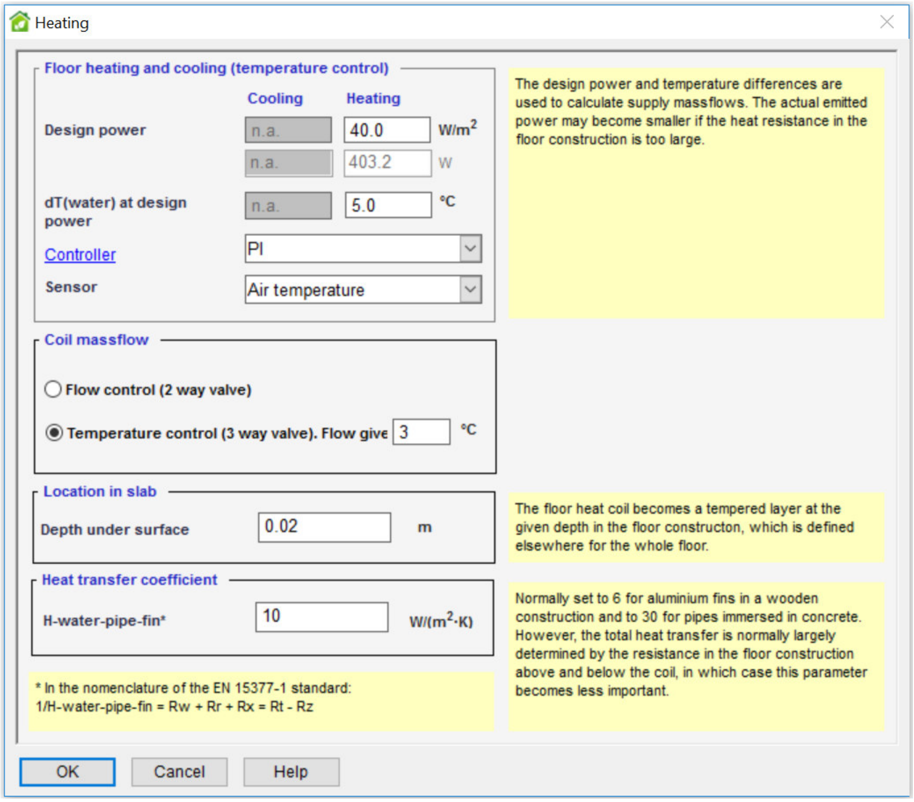
Figure 25.

Model for an air-to-air direct expansion on-off controlled unit for heating of room air. At the given ***rating conditions*** (press button to see), the model will yield given total power and COP, if it is physically possible. If a physically unrealistic COP is given, the model may yield the required performance at the actual rated point, but may render completely erroneous results at other operating points and may also become numerically unstable.

It is generally not recommended for most users to change any other parameter than the total heating power.

Away from the rated point, the performance will be determined by the additionally specified parameters. With the exception of compressor parameters, the input data are measurable quantities but may not always be made available by equipment manufacturers. If parameters have been optimized with respect to measured data from a real device, the model will predict the performance over the whole operating range within the accuracy of a few percent, typically around one.

Floor heating and/or floor cooling



Floor heating and cooling (temperature control)

	Cooling	Heating	
Design power	n.a.	40.0	W/m^2
	n.a.	403.2	W
dT(water) at design power	n.a.	5.0	°C
Controller	PI		
Sensor	Air temperature		

The design power and temperature differences are used to calculate supply massflows. The actual emitted power may become smaller if the heat resistance in the floor construction is too large.

Coil massflow

○ Flow control (2 way valve)

● Temperature control (3 way valve). Flow give 3 °C

Location in slab

Depth under surface 0.02 m

The floor heat coil becomes a tempered layer at the given depth in the floor constructon, which is defined elsewhere for the whole floor.

Heat transfer coefficient

H-water-pipe-fin* 10 W/(m^2·K)

Normally set to 6 for aluminium fins in a wooden construction and to 30 for pipes immersed in concrete. However, the total heat transfer is normally largely determined by the resistance in the floor construction above and below the coil, in which case this parameter becomes less important.

* In the nomenclature of the EN 15377-1 standard:
1/H-water-pipe-fin = Rw + Rr + Rx = Rt - Rz

Figure 26.

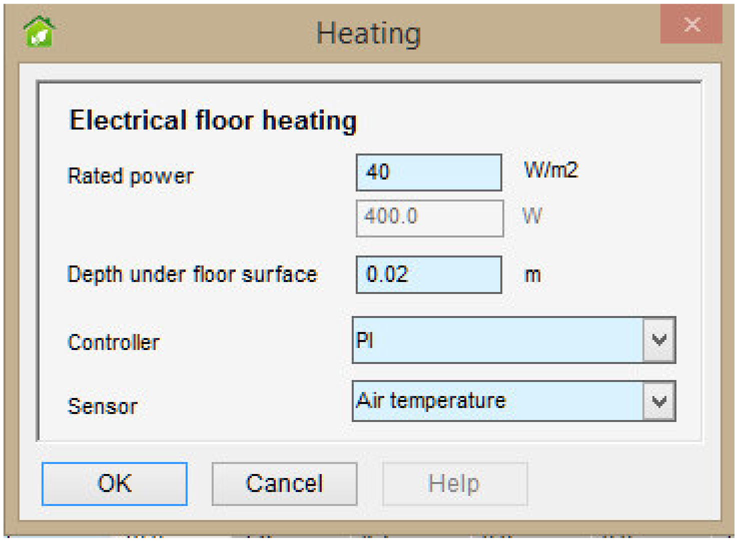
The floor heating circuit is assumed to cover the whole floor of a room. Net design mass flow into the circuit from the hot tank is given in terms of a design power and temperature difference. Note that all of this power may not be accessible to the room, if for example the pipes have been located in the middle of an insulation layer.

If the water temperature from the hot tank (that is specified in the Building tab, Heat Distribution system) is unsuitably high for direct injection into a floor coil circuit, the Temperature control option should be chosen (default).

The coil location in the slab may be critical to the resulting heat emission. Overall heat transfer from the pipes to the surrounding material is governed by the H-water-pipe-fin parameter. Some approximate values are given in the form.

Floor cooling is completely analogous, except in cooling mode, the device if fed from the cooling circuit.

Electrical floor heating



Electrical floor heating

Rated power: 40 W/m2; 400.0 W

Depth under floor surface: 0.02 m

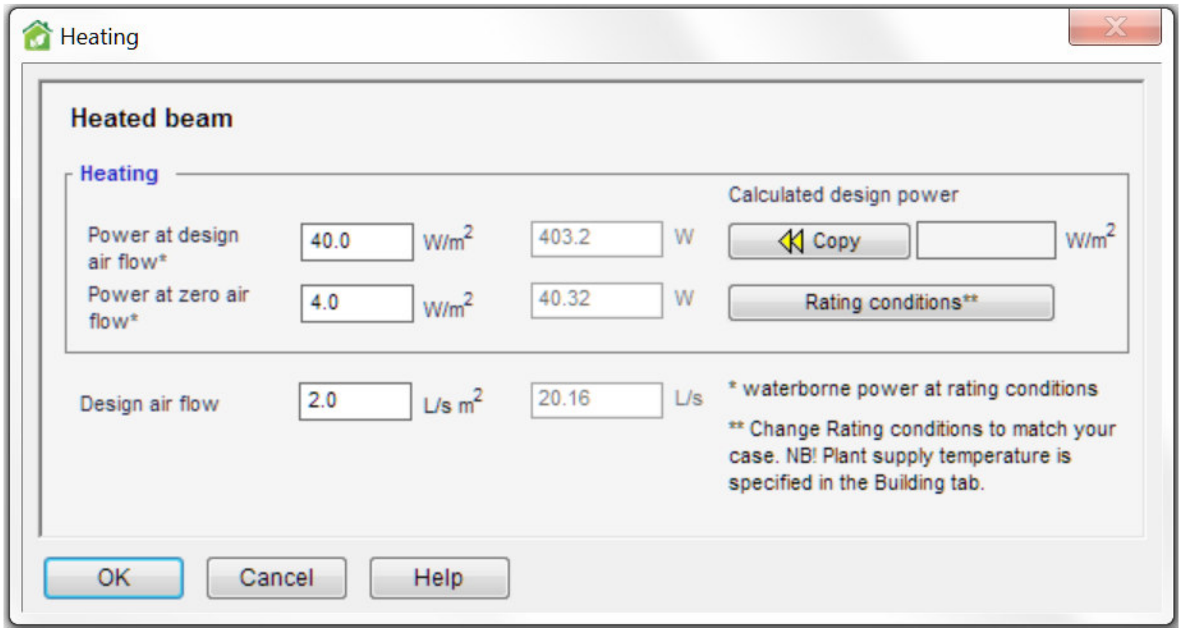
Controller: PI

Sensor: Air temperature

Figure 27.

A controllable electrical heat source will be added at a given depth under the floor surface.

Heated beam



Power at design air flow* 40.0 W/m² — 403.2 W

Power at zero air flow* 4.0 W/m² — 40.32 W

Calculated design power W/m²

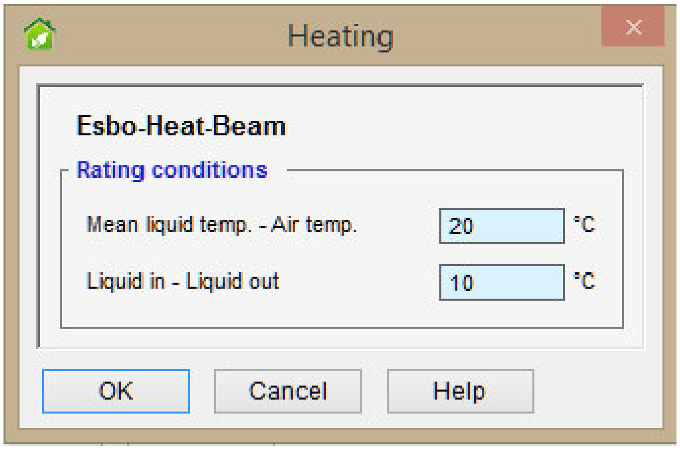
Design air flow 2.0 L/s m² — 20.16 L/s

* waterborne power at rating conditions

** Change Rating conditions to match your case. NB! Plant supply temperature is specified in the Building tab.

Figure 28.

The given power is extracted from the water when temperatures are according to the rating conditions and air flow is at the given design air flow. Some power must also be emitted at zero air flow, otherwise the model may become unstable. If the design air flow is lower than the total supply air flow to the room, the surplus air is injected into the room without passing the beam. Click to open heated beam **rating conditions.**



Mean liquid temp. - Air temp. 20 °C

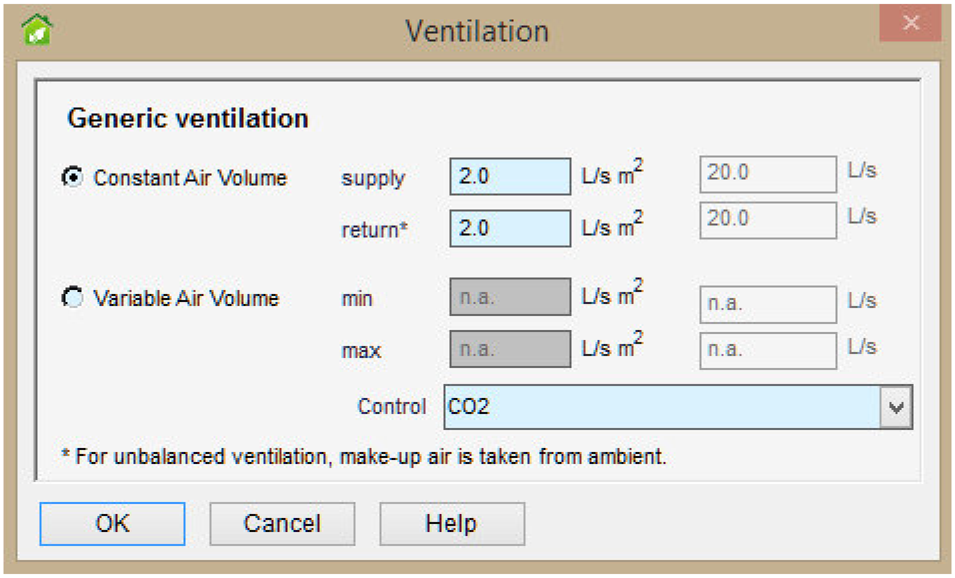
Liquid in - Liquid out 10 °C

Figure 29.

Ventilation

To change ventilation object, drag a new object from the palette to the room tab. Double click to open the ventilation object, Figure 30. Click the wastebasket to remove the object.

Generic ventilation



Generic ventilation

● Constant Air Volume — supply 2.0 L/s m^2 — 20.0 L/s
return* 2.0 L/s m^2 — 20.0 L/s

○ Variable Air Volume — min n.a. L/s m^2 — n.a. L/s
max n.a. L/s m^2 — n.a. L/s

Control: CO2

* For unbalanced ventilation, make-up air is taken from ambient.

Figure 30.

Choose **Type** of ventilation system [Constant Air Volume, Variable Air Volume].

supply The mechanical supply airflow for CAV systems [l/s m^2].

return The mechanical return airflow for CAV systems [l/s m^2].

min The minimum airflow at VAV [l/s m^2].

max The maximum airflow at VAV [l/s m^2].

control Control of VAV system [CO_2, Temperature, Temperature + CO_2].

CO2	The airflow is varied in proportion to the CO2 content of the room air. Minimum requested air flow is kept, when the CO2 level is at or below 500 ppm (vol). (Can be changed under Advanced settings in full ESBO.) Maximum flow corresponds to the PPM level given in the Indoor climate standard object, by default 1000 ppm (vol).

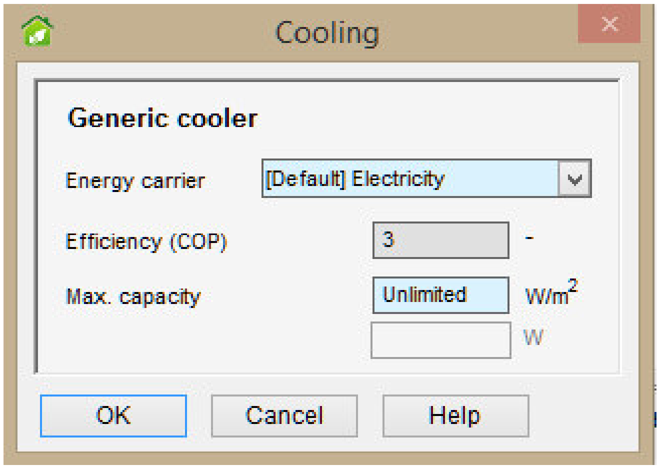
Temperature (cooling only) *	Forcing of the VAV flow begins 1°C below the cooling setpoint and full flow is reached at 1°C above the cooling setpoint. VAV is not used for heating for this option. The throttling range, by default 2°C, can be selected under Advanced settings for full ESBO.
Temperature + CO2*	Both the temperature setpoint (both heating and cooling) and the CO2 setpoint as given in the Indoor climate standard object are kept using PI controllers, i.e. there is no 'throttling range'.

*NB! When any of the temperature controlled VAV schemes are active, the cooling setpoint of any water based unit is displaced by 0.1°C so that air is used before water to reach the given setpoint.

Cooling

The default cooling object is a generic cooler. To change cooling object, drag a cooling object from the palette to the room tab. Double click to open the cooling object. Click the wastebasket to remove the object. Removing this object will avoid local room unit cooling, but the room may still be supplied with mechanically cooled air. To remove all cooling, remove also the Cooling object from the Building tab (but not the Cold storage).

Generic cooler



Generic cooler

Energy carrier: [Default] Electricity

Efficiency (COP): 3 -

Max. capacity: Unlimited W/m²

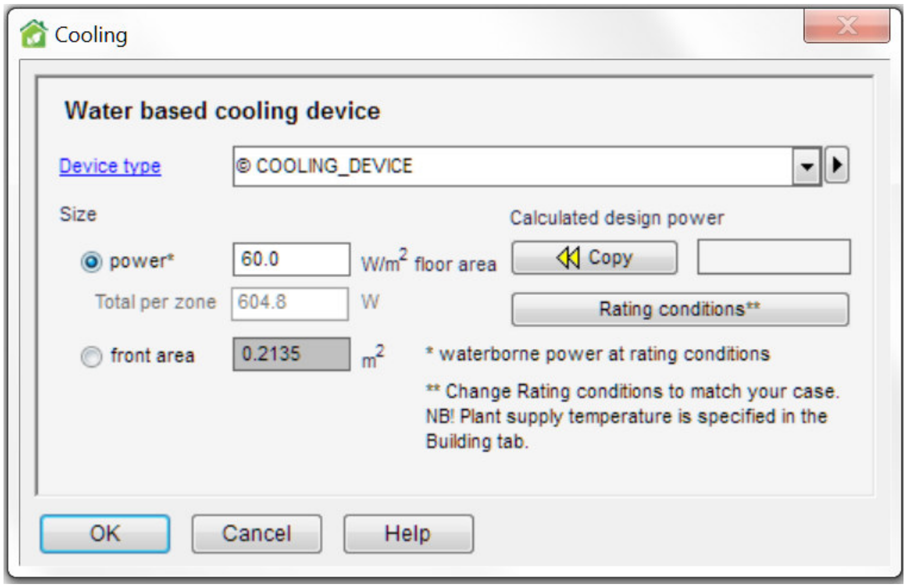
W

Figure 31.

The generic cooler has by default unlimited capacity. It cools the room by convection, using the given energy source, i.e. it does not rely on any central systems that have been defined. The generic cooler is normally used in the initial stages, to find required system capacity. By default, the cooling coil is assumed to hold 15^{0}C and may remove moisture from the air.

This temperature can be changed under Advanced settings.

Water based cooling device



● power* 60.0 W/m² floor area

Total per zone 604.8 W

○ front area 0.2135 m²

* waterborne power at rating conditions

** Change Rating conditions to match your case. NB! Plant supply temperature is specified in the Building tab.

Figure 32.

Device type To change the type of water based cooling device, right click on the arrow to the right and choose "Load from database]. Click the hyperlink to edit basic device parameters.

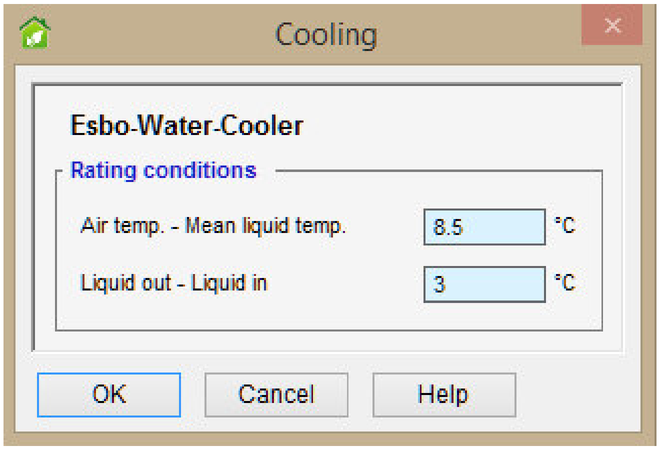
Size The size of the cooling device based on [power, front area].

power The emitted power [W/m²].

Copy Copy data from a previous room unit cooling calculation. Design power is shown in the (grey) input field. Corresponding area is shown in the (grey) front area field.

front area The front area of the cooling device [m²].

Click **Rating conditions** to see temperature conditions at which the device will remove the specified amount of heat.



Esbo-Water-Cooler

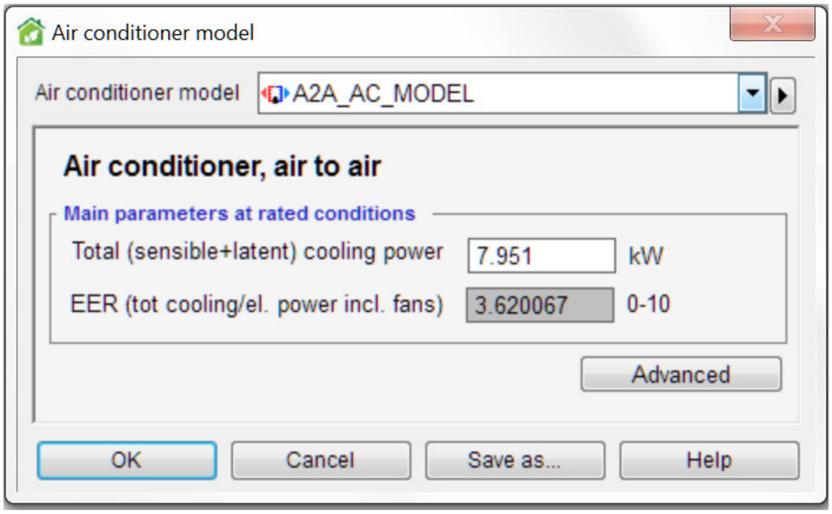
Rating conditions

Air temp. - Mean liquid temp. 8.5 °C

Liquid out - Liquid in 3 °C

Figure 33.

Air conditioner, air to air



Air conditioner model: A2A_AC_MODEL

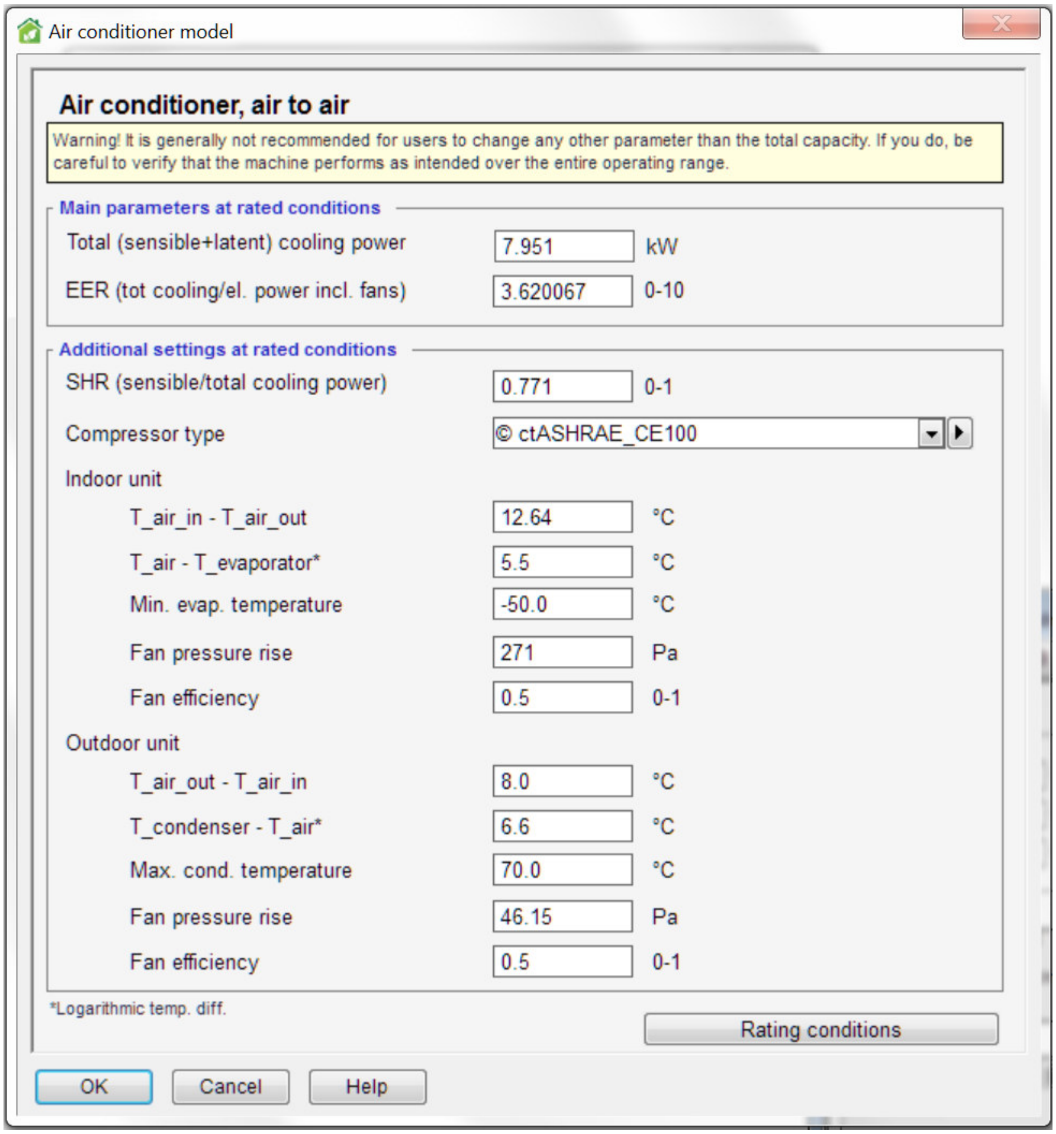
Air conditioner, air to air

Main parameters at rated conditions

Total (sensible+latent) cooling power 7.951 kW

EER (tot cooling/el. power incl. fans) 3.620067 0-10

Figure 34.



Air conditioner, air to air

Warning! It is generally not recommended for users to change any other parameter than the total capacity. If you do, be careful to verify that the machine performs as intended over the entire operating range.

Main parameters at rated conditions

Total (sensible+latent) cooling power: 7.951 kW

EER (tot cooling/el. power incl. fans): 3.620067 0-10

Additional settings at rated conditions

SHR (sensible/total cooling power): 0.771 0-1

Compressor type: © ctASHRAE_CE100

Indoor unit
- T_air_in - T_air_out: 12.64 °C
- T_air - T_evaporator*: 5.5 °C
- Min. evap. temperature: -50.0 °C
- Fan pressure rise: 271 Pa
- Fan efficiency: 0.5 0-1

Outdoor unit
- T_air_out - T_air_in: 8.0 °C
- T_condenser - T_air*: 6.6 °C
- Max. cond. temperature: 70.0 °C
- Fan pressure rise: 46.15 Pa
- Fan efficiency: 0.5 0-1

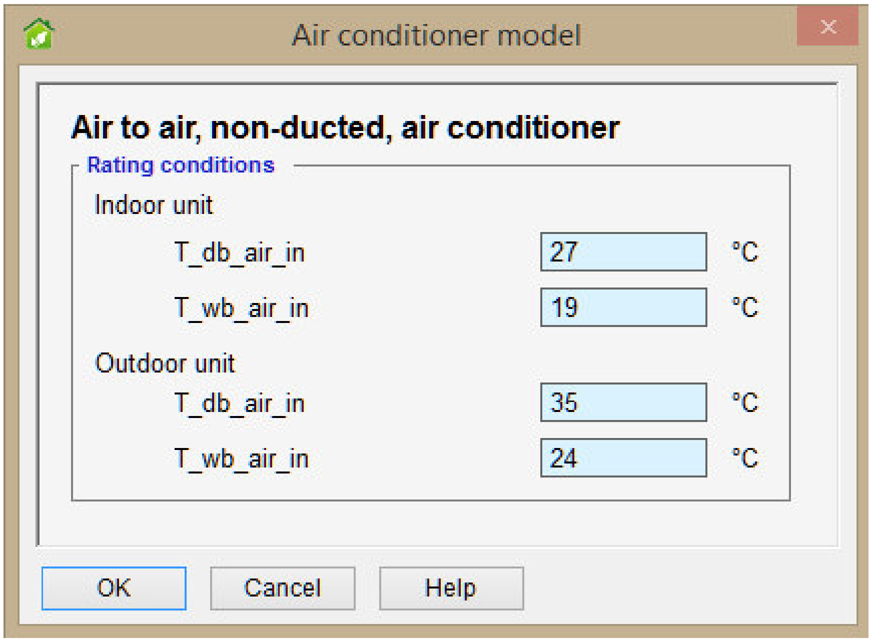
*Logarithmic temp. diff.

Figure 35.

Model for an air-to-air direct expansion on-off controlled unit for cooling and dehumidifying room air. At the given rating condition (press button to see), the model will yield given total power and EER (cooling COP), if it is physically possible. If a physically unrealistic COP is given, the model may yield the required performance at the actual rated point, but may render completely erroneous results at other operating points.

It is generally not recommended for most users to change any other parameter than the total cooling power.

Away from the rated point, the performance will be determined by the additionally specified parameters. With the exception of compressor parameters, the input data are measurable quantities but may not always be made available by equipment manufacturers. If parameters have been identified with respect to measured data from a real device, the model will predict the performance over the whole operating range within the accuracy of a few percent, typically around one. Click to open the rating conditions, by default according to EN14511.



Air to air, non-ducted, air conditioner

Rating conditions

Indoor unit

T_db_air_in 27 °C

T_wb_air_in 19 °C

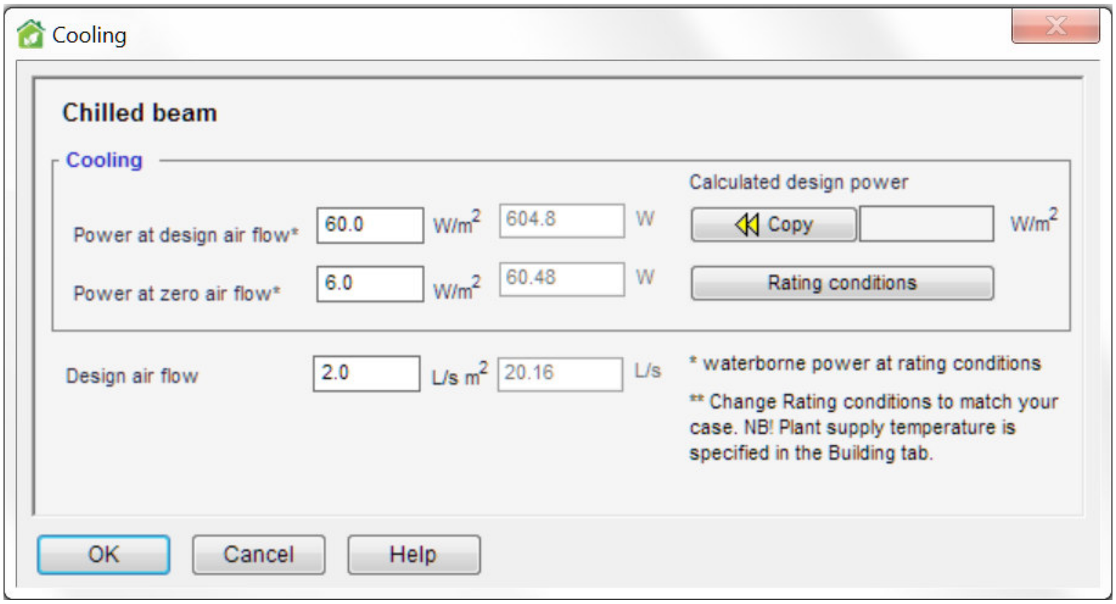
Outdoor unit

T_db_air_in 35 °C

T_wb_air_in 24 °C

Figure 36.

Chilled beam



Power at design air flow* 60.0 W/m2 604.8 W

Power at zero air flow* 6.0 W/m2 60.48 W

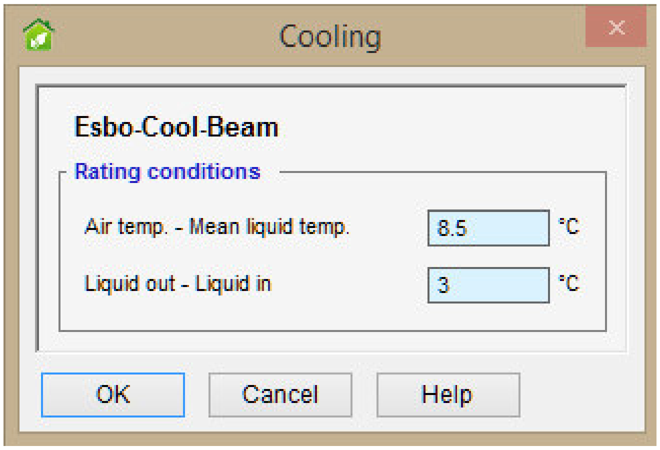
Design air flow 2.0 L/s m2 20.16 L/s

* waterborne power at rating conditions

** Change Rating conditions to match your case. NB! Plant supply temperature is specified in the Building tab.

Figure 37.

Given power is absorbed by the water in the beam when temperatures are according to the rating conditions and air flow is at the given design air flow. Some power must also be absorbed at zero air flow, otherwise the model may become unstable. If the design air flow is lower than the total supply air flow to the room, the surplus air is injected into the room without passing the beam. Click to open the rating conditions dialog.

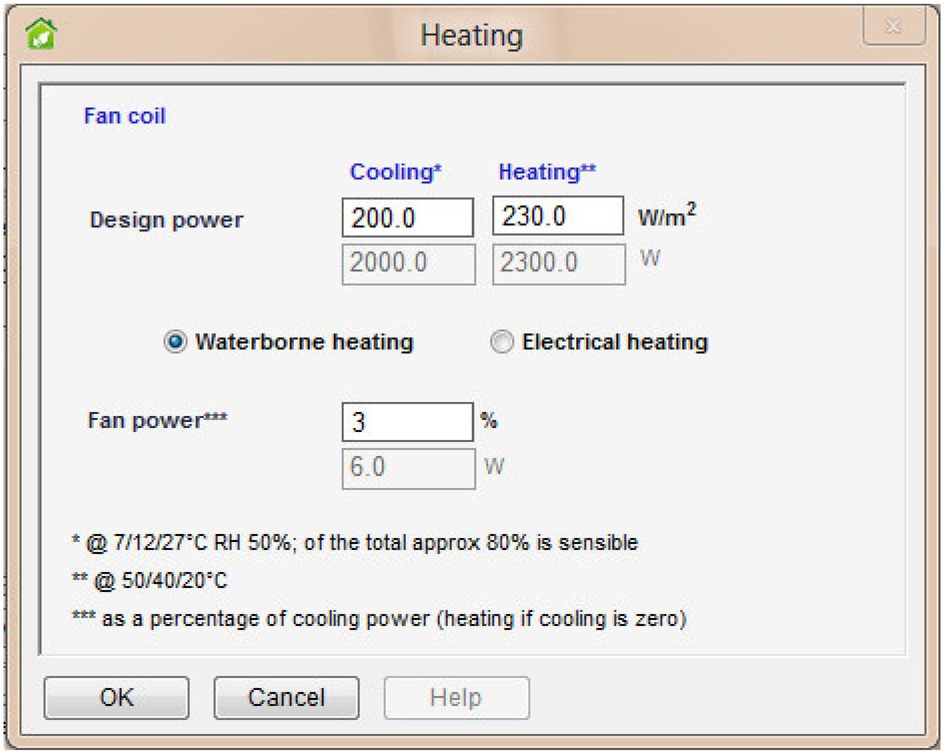


Air temp. - Mean liquid temp. 8.5 °C

Liquid out - Liquid in 3 °C

Figure 38.

Fan coil



Fan coil

	Cooling*	Heating**	
Design power	200.0	230.0	W/m^2
	2000.0	2300.0	W

● Waterborne heating ○ Electrical heating

Fan power*** 3 %

6.0 W

* @ 7/12/27°C RH 50%; of the total approx 80% is sensible

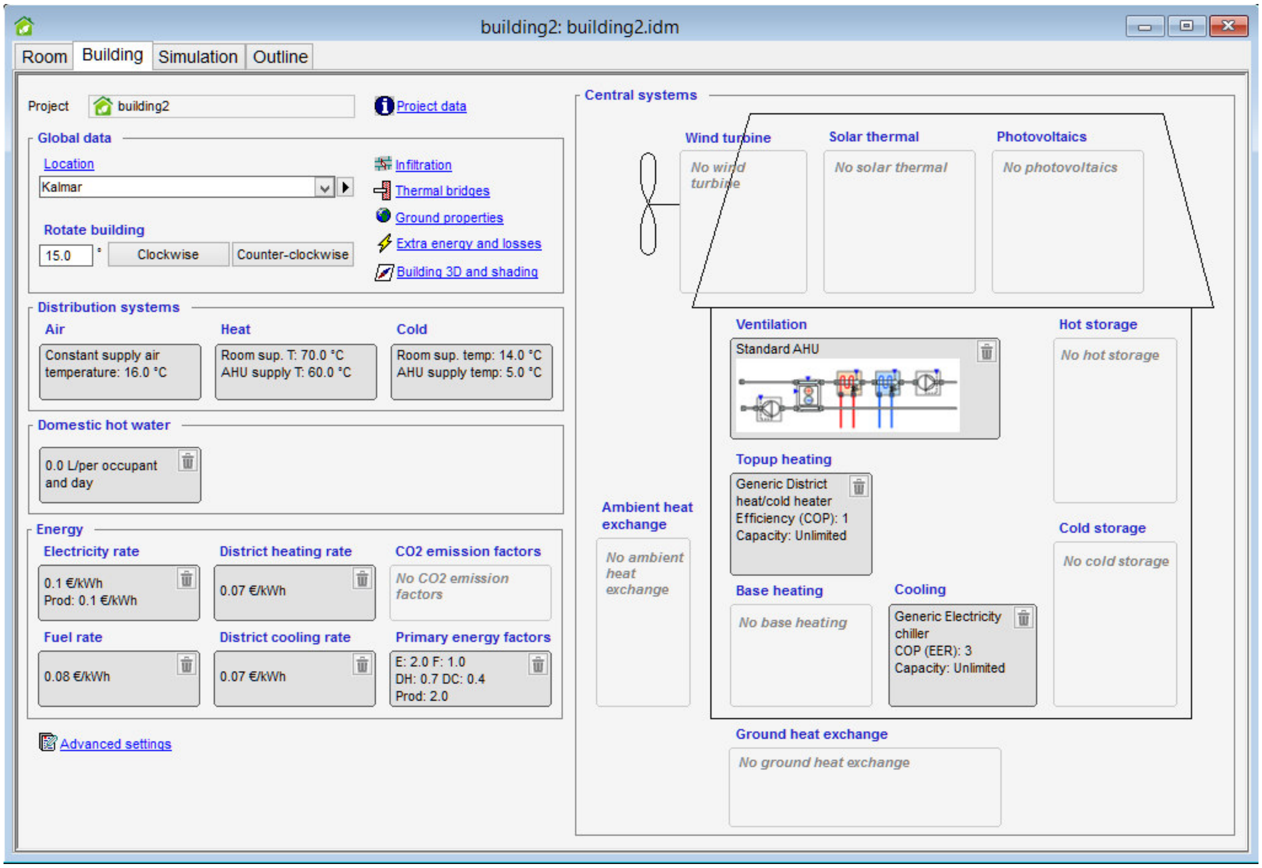
** @ 50/40/20°C

*** as a percentage of cooling power (heating if cooling is zero)

Figure 39.

A fan coil is used for both heating and cooling. For a real device, a fan is used to circulate room air through the device in order to enhance heat transfer. In the simulation model, the fan only serves as a point of electricity consumption and the fan power may be set to zero. In fact, this is the simplest device to use for heating and cooling the room by water from the plant.

Building tab



Project: building2

Location: Kalmar

Rotate building: 15.0 °

Air: Constant supply air temperature: 16.0 °C

Heat: Room sup. T: 70.0 °C AHU supply T: 60.0 °C

Cold: Room sup. temp: 14.0 °C AHU supply temp: 5.0 °C

Domestic hot water: 0.0 L/per occupant and day

Electricity rate: 0.1 €/kWh Prod: 0.1 €/kWh

District heating rate: 0.07 €/kWh

CO2 emission factors: No CO2 emission factors

Fuel rate: 0.08 €/kWh

District cooling rate: 0.07 €/kWh

Primary energy factors: E: 2.0 F: 1.0 DH: 0.7 DC: 0.4 Prod: 2.0

Wind turbine: No wind turbine

Solar thermal: No solar thermal

Photovoltaics: No photovoltaics

Ventilation: Standard AHU

Hot storage: No hot storage

Topup heating: Generic District heat/cold heater Efficiency (COP): 1 Capacity: Unlimited

Ambient heat exchange: No ambient heat exchange

Cold storage: No cold storage

Base heating: No base heating

Cooling: Generic Electricity chiller COP (EER): 3 Capacity: Unlimited

Ground heat exchange: No ground heat exchange

Figure 40.

The building tab is used to specify both general information about the simulation and the HVAC systems that serve the building. Similarly to the Room tab, the default objects for HVAC systems and settings may be replaced by those available on the left hand side bar palette. Most combinations of HVAC system components will automatically be connected into meaningful systems. See the online help topic "Technical description of the generated plant" for further details

Project data

Project data Click to open the project data object, an object for documentation of the simulation case and the current choice of parameters. Project data is written on reports etc.

Global data

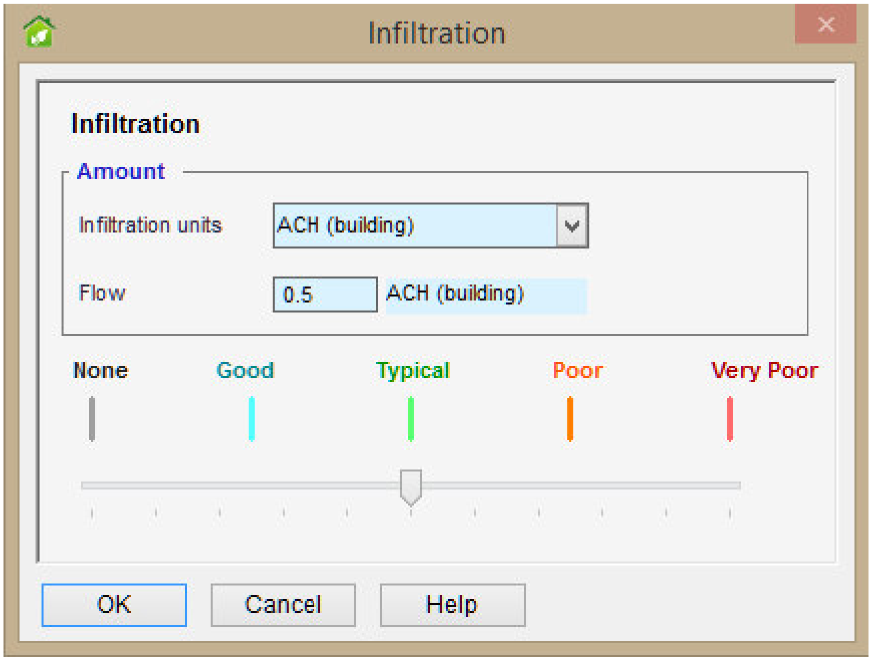
Location Location of the building. The geographical location can be selected from the database or downloaded. The object contains the coordinates of the location, as well as references to design day and hourly climate data. Click hyperlink to see details.

Rotate building Angle to rotate building incrementally [°]. Choose wheather to rotate clockwise or counter-clockwise.

> **Clockwise** Click to rotate the building clockwise by the specified angle around the center of the building.
>
> **Counter-clockwise** Click to rotate the building counter-clockwise by the specified angle around the center of the building.

Infiltration

Infiltration Click to open the infiltration object, which contains parameters for building air leakage, Figure 41.



Infiltration

Amount

Infiltration units: ACH (building)

Flow: 0.5 ACH (building)

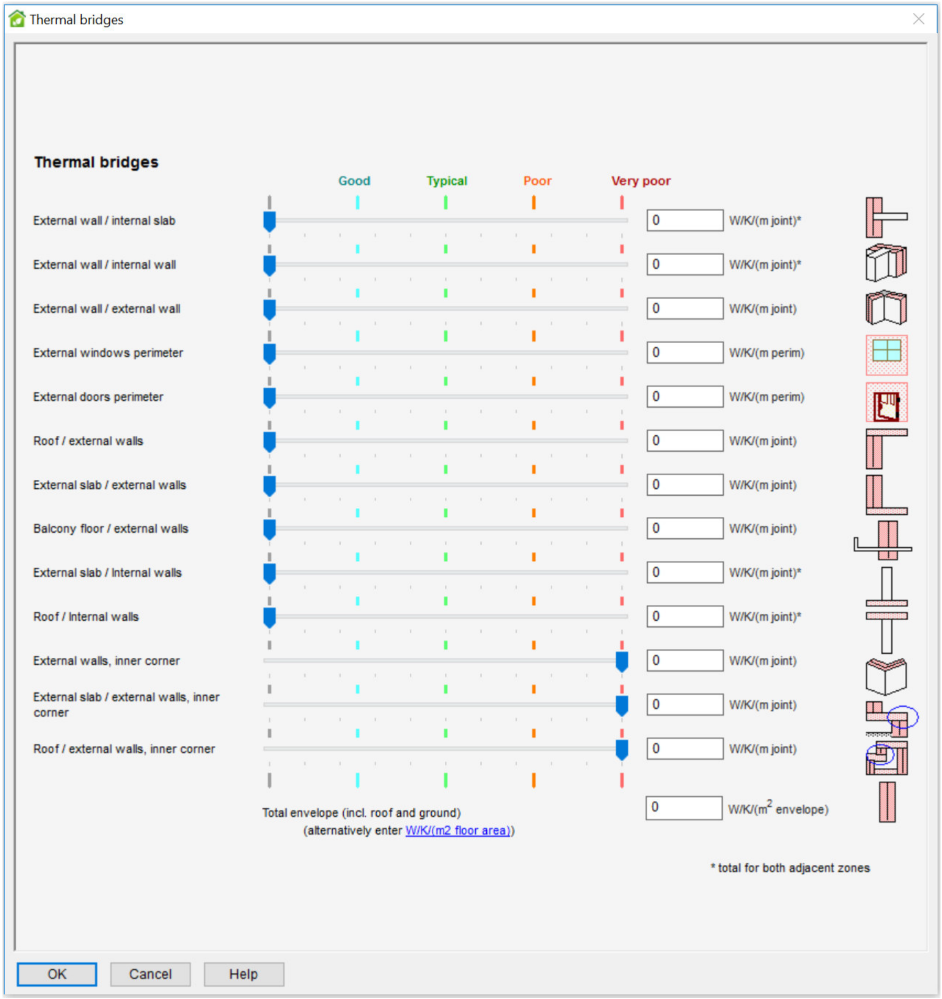
Figure 41.

Data in the infiltration form is used to specify unintentional air flows over the building envelope. Constant envelope air flows to and from each room are introduced.

Please note that the scale of Good, Typical etc. may not be representative in all countries. The statistics have been derived from the ASHRAE Handbook 2015. A reasonably modern building in the Nordic countries would, for example, have only about 4-7% of the “Typical” value.

Thermal bridges

Thermal bridges Click to open thermal bridges object, which contains coefficients for calculation of loss factors for thermal bridges in rooms, Figure 42.



Thermal bridges

External wall / internal slab 0 W/K/(m joint)*
External wall / internal wall 0 W/K/(m joint)*
External wall / external wall 0 W/K/(m joint)
External windows perimeter 0 W/K/(m perim)
External doors perimeter 0 W/K/(m perim)
Roof / external walls 0 W/K/(m joint)
External slab / external walls 0 W/K/(m joint)
Balcony floor / external walls 0 W/K/(m joint)
External slab / Internal walls 0 W/K/(m joint)*
Roof / Internal walls 0 W/K/(m joint)*
External walls, inner corner 0 W/K/(m joint)
External slab / external walls, inner corner 0 W/K/(m joint)
Roof / external walls, inner corner 0 W/K/(m joint)
Total envelope (incl. roof and ground) 0 W/K/(m^2 envelope)
(alternatively enter W/K/(m2 floor area))

* total for both adjacent zones

Figure 42.

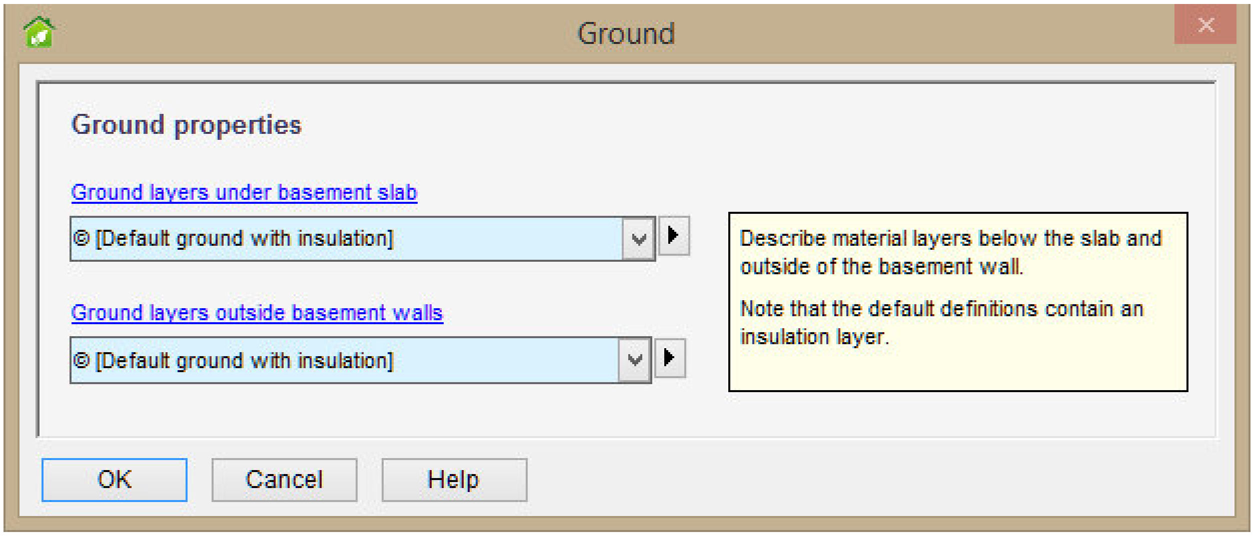
The total loss factor for a room is calculated as the sum of loss factors in bridges created by different construction elements.

The coefficients are given per unit of element size (in most cases per meter). The sizes of elements are calculated from room geometry.

Please note that the scale of Good, Typical etc. may not be representative in all countries.

Ground properties

Ground properties Click to open the ground properties object, which contains parameters for temperature conditions below the building, Figure 43.



Ground

Ground properties

Ground layers under basement slab

© [Default ground with insulation]

Ground layers outside basement walls

© [Default ground with insulation]

Describe material layers below the slab and outside of the basement wall.

Note that the default definitions contain an insulation layer.

Figure 43.

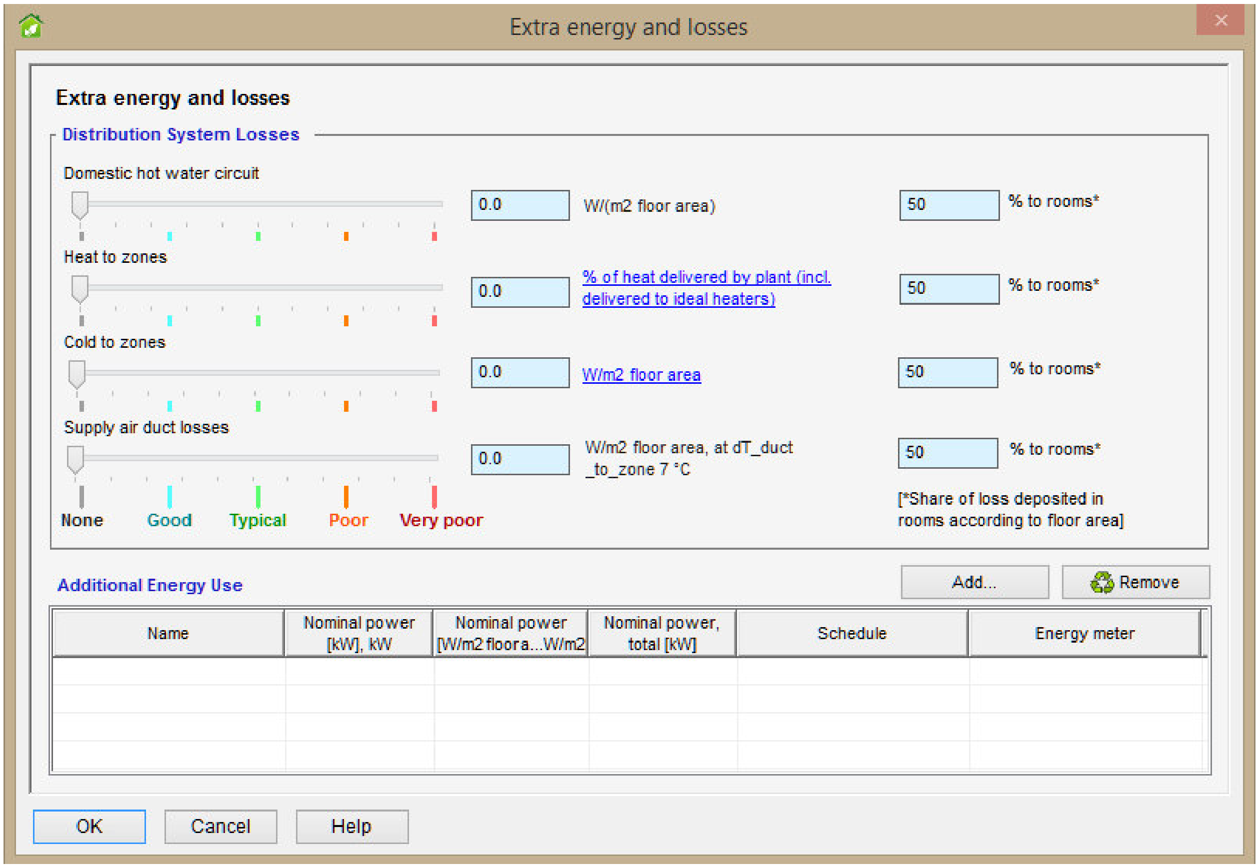
Ground layers under basement slab Ground layers under slab down to constant temperature.

Ground layer outside basement walls Ground layers outside wall to ambient temperature.

The ground layer under the basement floor is connected to a constant temperature, which is computed as the mean air temperature of the selected climate file. The layers around the basement walls are coupled to a facade object for crawl space, which is kept at ground surface temperature. Note that no 2D or 3D effects are modelled for either of these couplings.

Extra energy and losses

Extra energy and losses Click to open extra energy and losses object, which contains information about system losses and extra energy consumers of the building that do not take part in the building heat balance, such as external lighting, Figure 44.



Extra energy and losses

Distribution System Losses

Domestic hot water circuit: 0.0 W/(m2 floor area); 50 % to rooms*

Heat to zones: 0.0 % of heat delivered by plant (incl. delivered to ideal heaters); 50 % to rooms*

Cold to zones: 0.0 W/m2 floor area; 50 % to rooms*

Supply air duct losses: 0.0 W/m2 floor area, at dT_duct_to_zone 7 °C; 50 % to rooms*

[*Share of loss deposited in rooms according to floor area]

Additional Energy Use

Name	Nominal power [kW], kW	Nominal power [W/m2 floora...W/m2	Nominal power, total [kW]	Schedule	Energy meter

Figure 44.

Distribution System Losses are specified to account for leakage from pipes and ducts that pass through the building without having to describe their exact path and insulation properties.

Duct losses include both thermal conduction and air leakage losses, although the actual loss of mass through the duct wall is not modeled. Duct losses take account of actual temperature difference between the duct system and rooms, while water circuit losses are independent of actual temperatures.

Units for heat and cold distribution may be changed for convenience. Click on the hyperlinks to change.

Rough estimates of possible loss levels are provided for convenience via sliders, but these levels vary greatly between countries.

A given percentage of the heat (or cold) from each distribution system is deposited to the room heat balance. Remaining heat is simply lost to ambient.

Any number of **Additional Energy Use** items may be specified (right click to rename them). This is energy which should be accounted for in total supplied energy, but does not enter the building heat balance. Ice melting equipment or external lights are examples.

For each item, both an absolute and a per-floor-area contribution may be given. The total of both is displayed for convenience. Each item must also refer to a schema and an energy meter.

Building 3D and shading

Building 3D and shading Click to open the building 3D and shading window, Figure 45, Figure 46 and Figure 47. For a summary of basic mouse operations, see 3D view on page 27.

Rooms

In the building 3D and shading window, rooms can be given a position in 3D space to form a sensible building. By default all rooms of the building are placed at the origin. Drag rooms from the table in the Room tab to the building 3D and shading window, Figure 45. However, only one item of every type of room can be shown in the 3D view. To reposition a room in the x-y plane: select it, hold down the Ctrl-key (the marking will change from red to green) and drag it. Hold down the Ctrl-key and the Shift-key to move the room in the z-direction.

Windows and solar panels are shaded by the rooms unless all rooms are placed at the default position at the origin and no shading objects have been added.

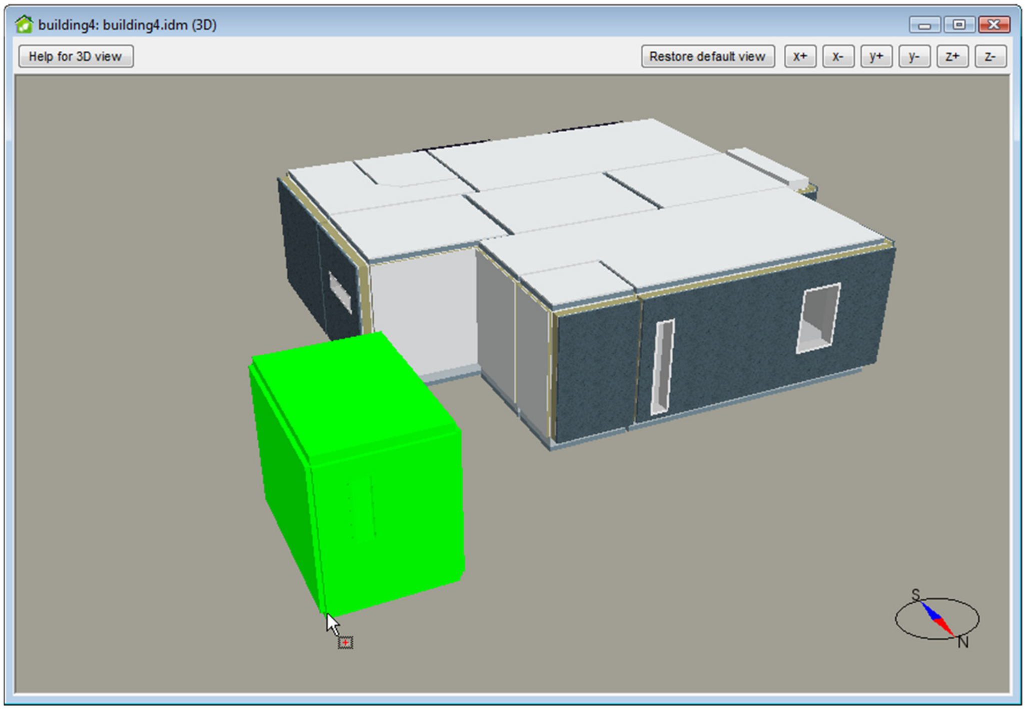


Figure 45. 3D view with several rooms

Shading objects

In the building 3D and shading window, shading objects can be added to produce additional shading of windows and solar panels. Drag shading objects from the palette to the building 3D and shading tab, Figure 46. Right click and choose Delete to remove the shading object. Right click and choose Duplicate to insert a copy of the shading object, slightly shifted from the original position.

A selected shading object can be moved by holding down the Ctrl-key and dragging the shading object to a new position. The shading-object will move in the x-y plane. Hold down the Ctrl-key and the Shift-key to move the shading object in the z-direction.

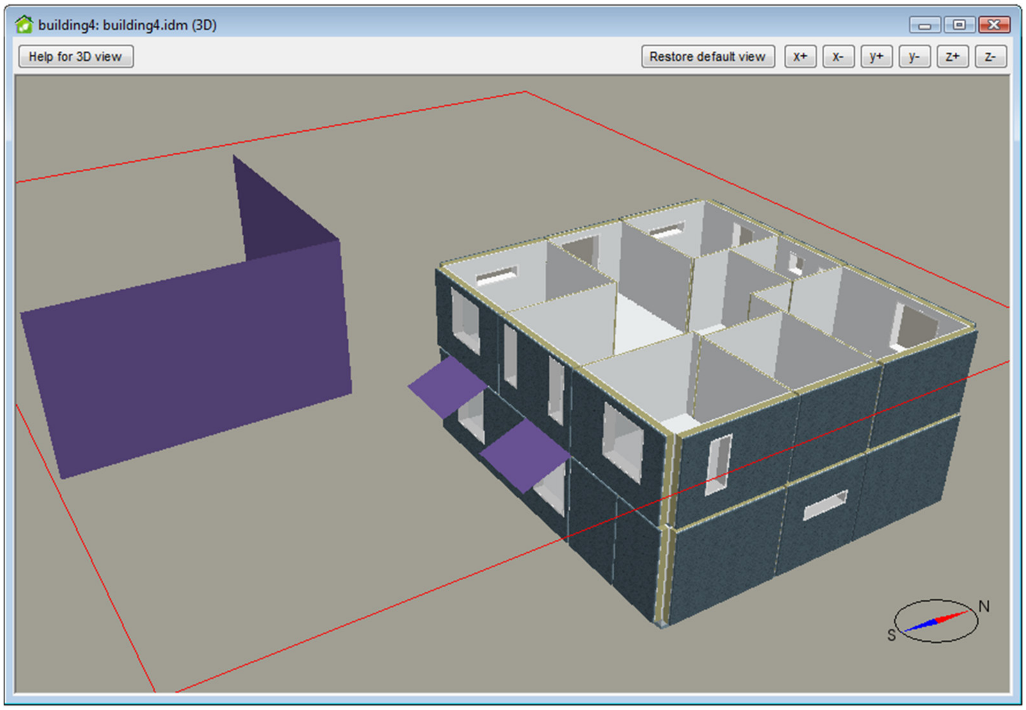


Figure 46. 3D view with shading objects inserted

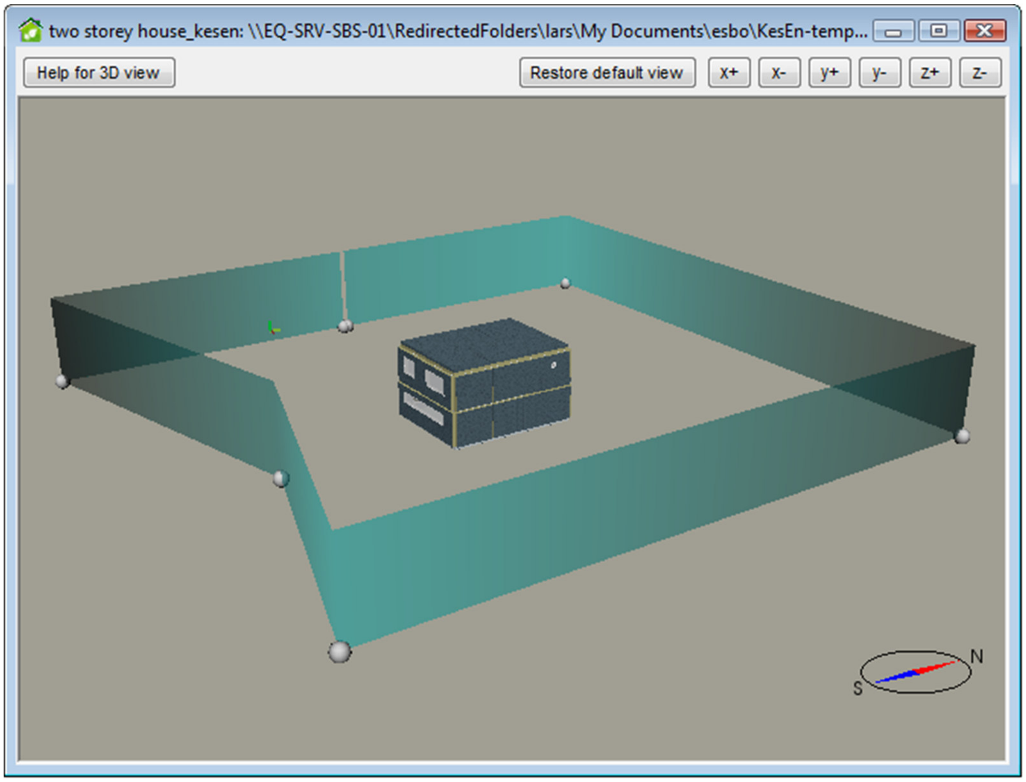


Figure 47. 3D view with shading objects (with handles) surrounding the building

Right click and choose Edit to edit the shape of the shading object, Figure 47.

When in **edit mode**, Figure 47, the shading object can be modified as follows:

- To edit the shape and location of the handle of a shading object, place the cursor over a handle, click the left mouse button, and drag the handle.
- To move the entire shading object, place the cursor over the shading object, in-between two handles, click the left mouse button, and drag the shading object. The shading object follows the cursor while remaining fixed in the z-axis.
- To move the shading object along the z-axis, hold down the shift-key while moving the mouse.
- To rotate the shading object around the z-axis, place the cursor above the shading object, hold down the shift-key and the middle mouse button, and move the mouse.
- To scale the shading object (bring the handles closer/further apart), place the cursor above the shading object, hold down the shift-key and the right mouse button, and move the mouse backward and forward, not sideways.

- To insert a new handle, hold down the Ctrl-key, and click the left mouse button.
- To remove a handle, place the cursor above the handle, hold down the Ctrl-key, and click the right mouse button.

Exit the edit mode by clicking the right mouse button and choosing Done or Cancel from the right mouse button menu.

Assign property to object

The following properties can be assigned to objects in the 3D view:

- constructions of walls, floors, roofs and wall parts
- window types
- surface properties of wall, floors, roofs, wall parts, doors, window frames and shading objects.

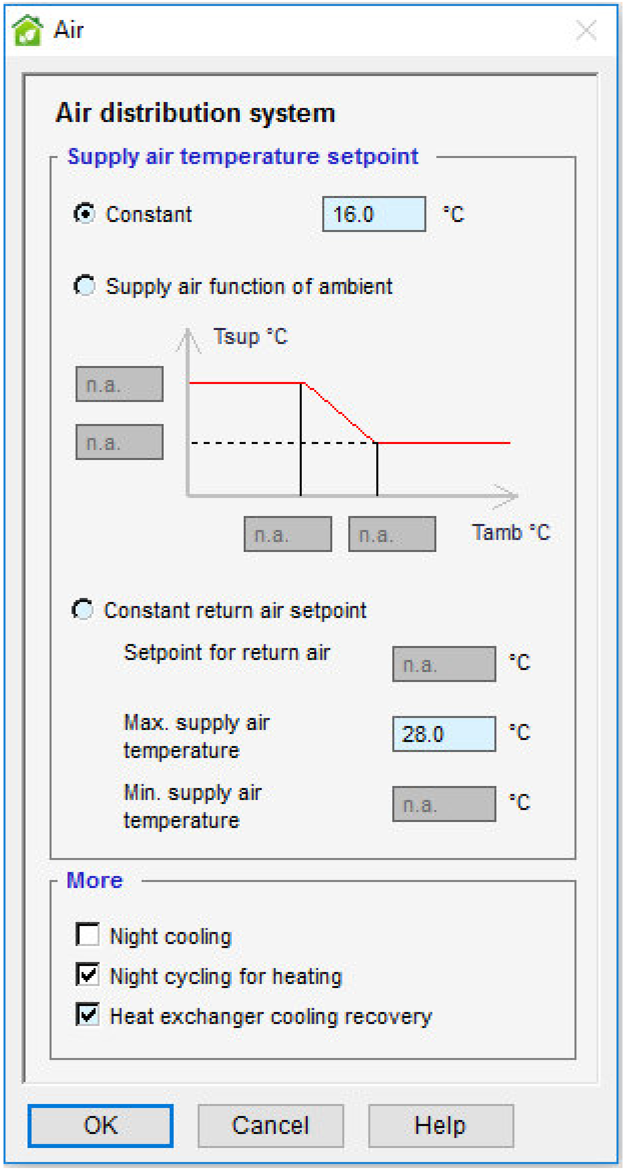
To assign a property to objects: Double-click on the property in the palette on the side bar and select the objects in the 3D view. Click OK to accept.

To add a new property to assign: Click on the database icon on the top of the palette and select a resource from the database.

Distribution systems

Air

The air distribution object contains general settings for the mechanical ventilation system. When applicable, these parameters will be referenced by the selected air handling unit. They may also be used elsewhere.



Air

Air distribution system

Supply air temperature setpoint

● Constant 16.0 °C

○ Supply air function of ambient

○ Constant return air setpoint

Setpoint for return air n.a. °C

Max. supply air temperature 28.0 °C

Min. supply air temperature n.a. °C

More

☐ Night cooling

☑ Night cycling for heating

☑ Heat exchanger cooling recovery

Figure 48.

Three different methods for control of supply air temperature are offered. In the last alternative, closed loop control of the return air is offered. The supply air is varied by a PI controller between the given limits in order to control the return air temperature.

Note that the supply air temperature only will reach its requested setpoint if sufficient heating and cooling is available.

Night cooling When this option is activated, the fans will start at night to cool down the building in order to save cooling during the day. Night (flush) ventilation is automatically made available during Mo-Fri, May 1 through Sept 30. Fans may operate in night vent mode between 22:00 and 07:00.

The night ventilation will be on when the following conditions are all fulfilled:

- Outdoor temperature is above 12°C

- Outdoor air is at least 2°C below return air

- Return air is above 22°C

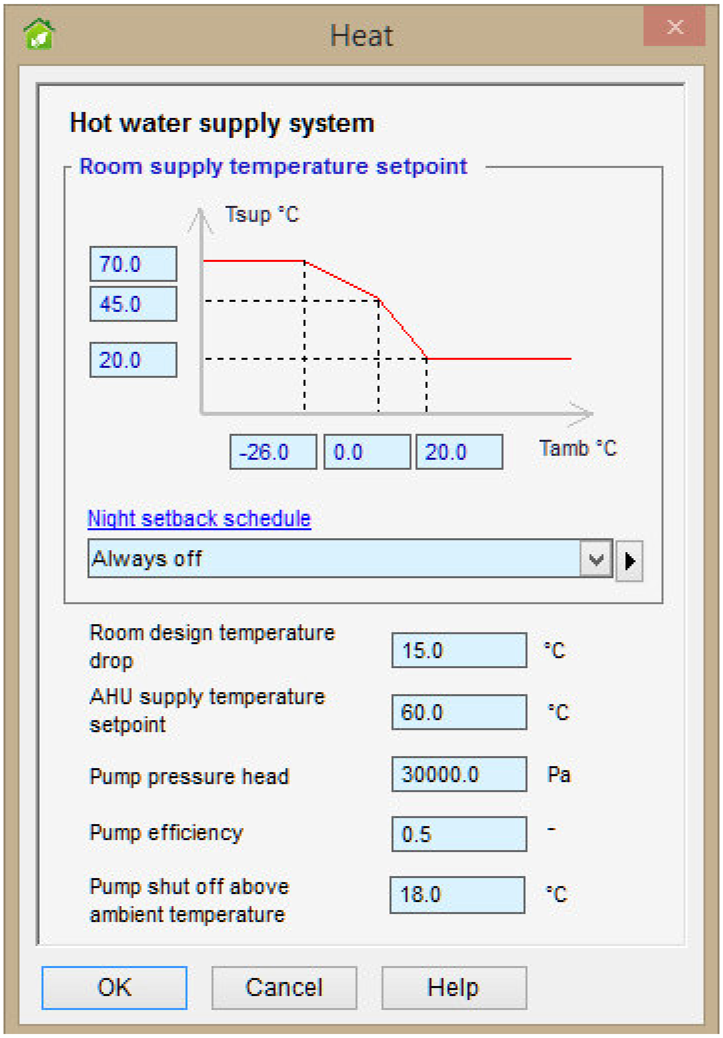
While night flush ventilation is active, the supply air setpoint to the heat exchanger and the heating coil is lowered by 10°C. The setpoint for the cooling coil is increased by 20°C to avoid any mechanical cooling in AHU while night flush ventilation is on. Note, that the cooling setpoints of the spaces must be high enough to be sure that there is no separate room unit based mechanical cooling in spaces.

Night cycling for heating provides the option to heat the building by starting the ventilation system during the night, even if the fan operation schedule is off. The supply air setpoint is set to a higher value (modulated up to the value given by Max supply air temperature) and the fans are started when any room temperature drops below its setpoint.

Heat exchanger cooling recovery enables an air-to-air heat exchanger to precool incoming air whenever possible by using exhaust air.

Heat

The hot water distribution object contains general settings for the water based heating system. All water based heating units in the rooms will be fed with the same water temperature. A separate fixed setpoint is available for hot water to the air handling system.



Tsup °C: 70.0, 45.0, 20.0

Tamb °C: -26.0, 0.0, 20.0

Night setback schedule: Always off

Room design temperature drop: 15.0 °C

AHU supply temperature setpoint: 60.0 °C

Pump pressure head: 30000.0 Pa

Pump efficiency: 0.5 -

Pump shut off above ambient temperature: 18.0 °C

Figure 49.

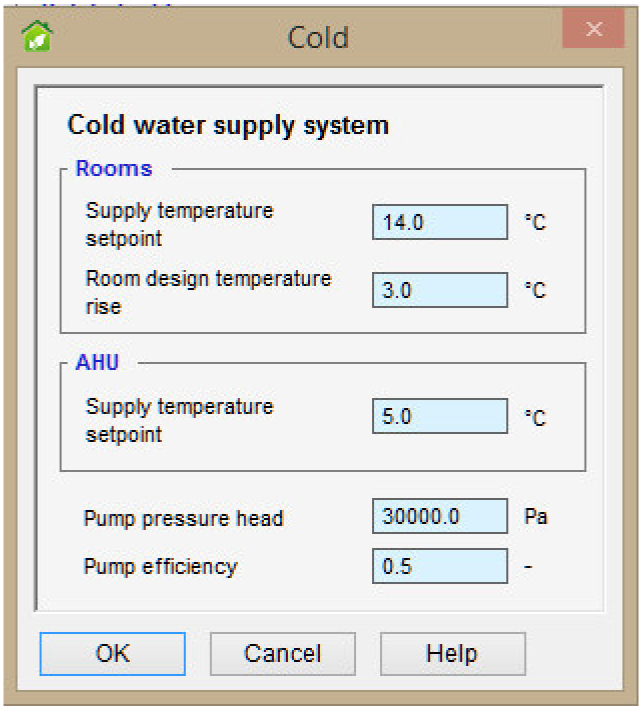
The Room design temperature drop is used by some room units to compute design mass flows and does not affect the control of the hot water system.

An ambient temperature limit is provided, above which the hot water circulation system is shut off. This is the mechanism to use in order to shut off room heating during the summer.

Cold

The cold water distribution object contains general settings for the water based cooling system. All water based cooling units in the rooms will be fed with the same water temperature. A separate setpoint is available for cold water to the air handling system.

The Room design temperature rise is used by some room units to compute design mass flows and does not affect the control of the cold water system.



Cold water supply system

Rooms

Supply temperature setpoint 14.0 °C

Room design temperature rise 3.0 °C

AHU

Supply temperature setpoint 5.0 °C

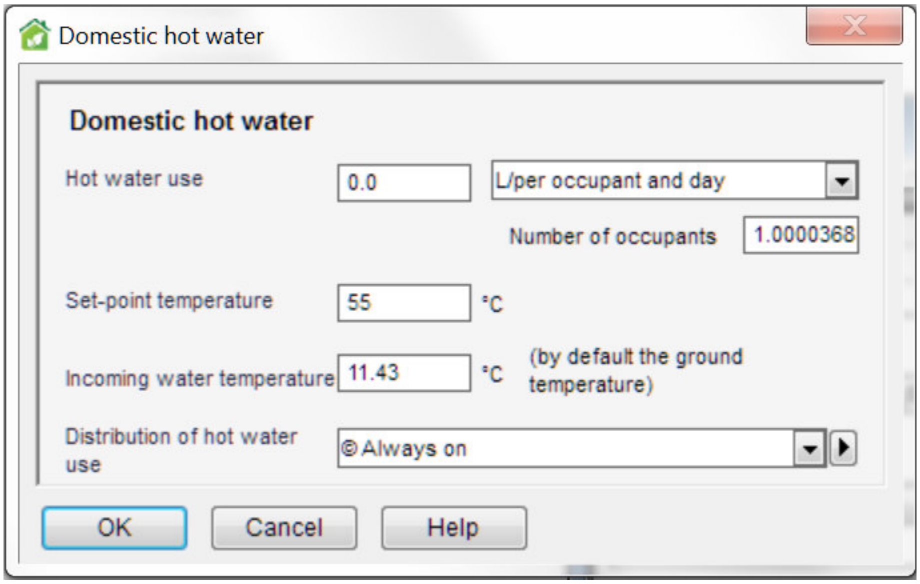
Pump pressure head 30000.0 Pa

Pump efficiency 0.5 -

Figure 50.

Domestic hot water

Drag a domestic hot water object from the palette to the building tab. Double click to open the domestic hot water object, Figure 51. To remove the object, click the wastebasket.



Domestic hot water

Hot water use 0.0 L/per occupant and day

Number of occupants 1.0000368

Set-point temperature 55 °C

Incoming water temperature 11.43 °C (by default the ground temperature)

Distribution of hot water use © Always on

Figure 51.

Domestic Hot Water Use may be specified here using different units. Note that when a unit that includes the number of building occupants is used, the relevant number of occupants should be set here as well.

The temperature of the incoming water may be given, but a default value is computed from the yearly average of the selected climate file.

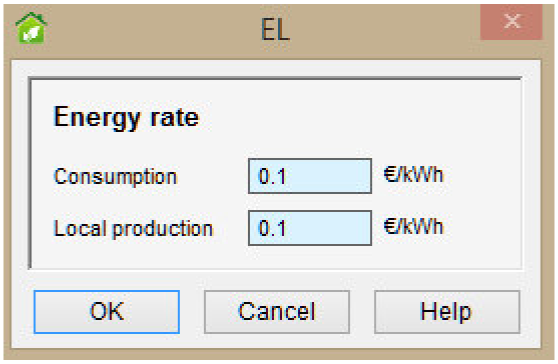
A schedule for the distribution of hot water usage over the day may be given. The total amount of hot water used is automatically calculated to match the requested Hot water use, i.e. the unit of the provided distribution schedule is irrelevant, only the shape is used.

Energy

All energy objects can be dragged from the palette on the left hand side to the building tab. To open the object, double click and choose "Open" in the shortcut menu. To remove the object, click the wastebasket. The following type of objects can be inserted:

The unit for currency can be changed under Advanced settings. Note that given rates have to be manually recalculated when the unit of currency has been changed.

Electricity rate



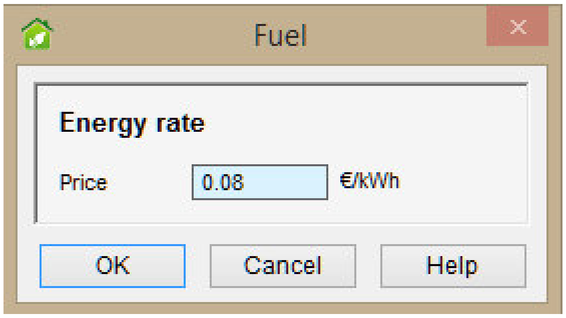
Consumption 0.1 €/kWh

Local production 0.1 €/kWh

Figure 52.

Fuel rate

Note that the pricing is given with respect to fuel heating value, not consumed mass or volume.

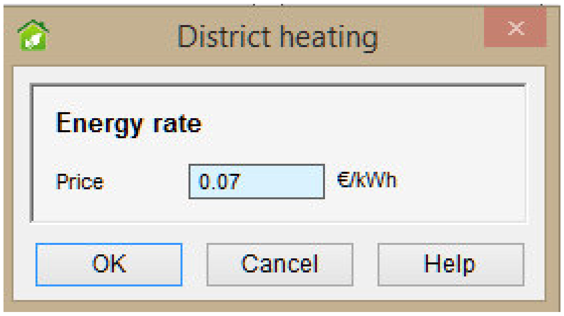


Energy rate

Price 0.08 €/kWh

Figure 53.

District heating rate

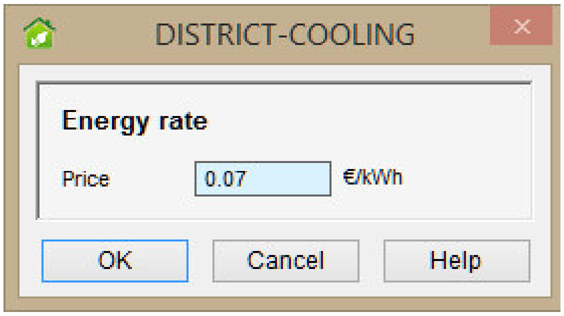


Energy rate

Price 0.07 €/kWh

Figure 54.

District cooling rate



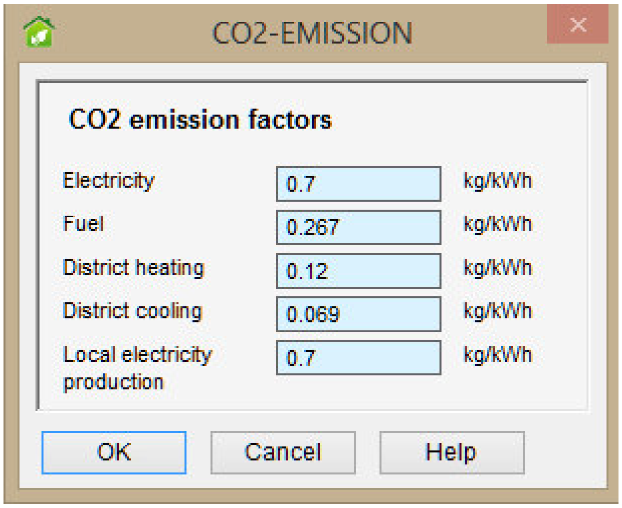
Energy rate

Price 0.07 €/kWh

Figure 55.

CO_2 emission factors

The CO2 emission factors are used to determine the amount of CO2 that will be released into the atmosphere as the energy source is used. For Fuel the reference energy is counted in terms of fuel heating value.



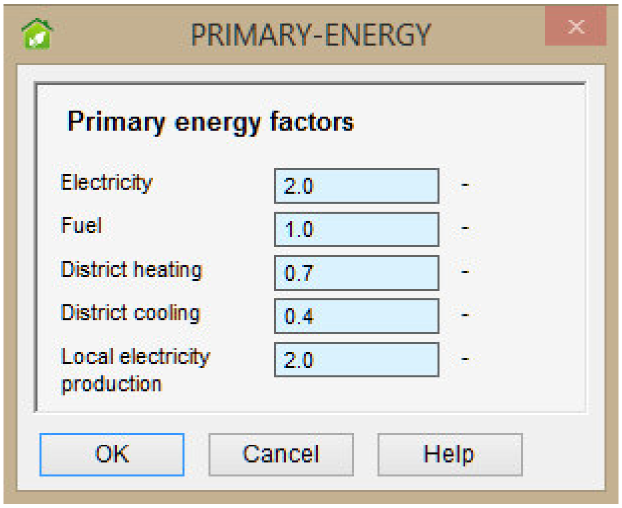
CO2 emission factors

Electricity	0.7	kg/kWh
Fuel	0.267	kg/kWh
District heating	0.12	kg/kWh
District cooling	0.069	kg/kWh
Local electricity production	0.7	kg/kWh

Figure 56.

Primary energy factors

The primary energy factors are used to determine the amount of so called primary energy that will be used for delivery of each unit of each category of energy. Many countries have politically determined primary energy factors that are used to compare the relative environmental impact of different systems.



Primary energy factors

Electricity	2.0	-
Fuel	1.0	-
District heating	0.7	-
District cooling	0.4	-
Local electricity production	2.0	-

Figure 57.

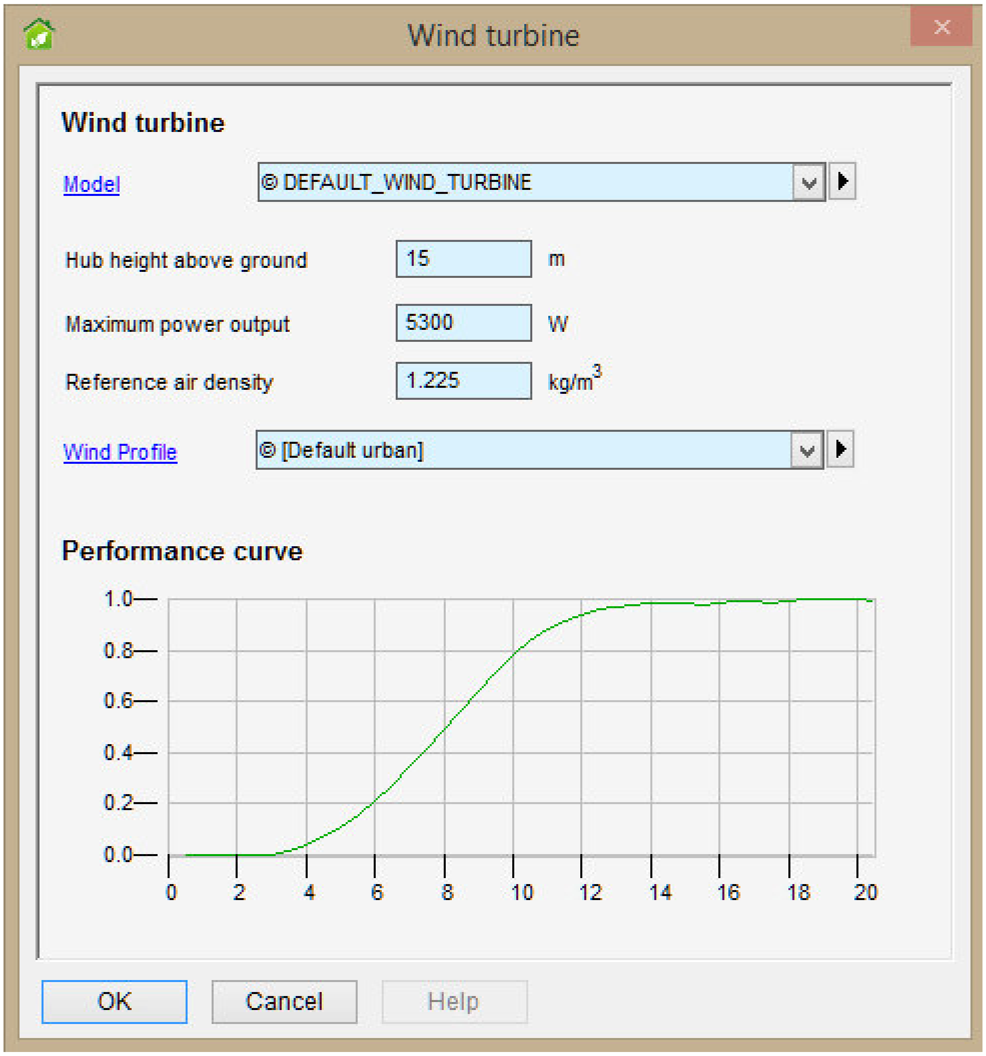
Central systems

All objects can be dragged from the palette on the left hand side to the building tab. To open the object, double click and choose “Open” in the shortcut menu. To remove the object, click the wastebasket. The following type of objects can be inserted:

Wind turbine

A wind generator may be described in terms of a performance curve, which describes generated power as a function of hub level wind velocity.

A Wind profile object must also be selected. This object describes the local vertical wind variation, which depends on the type of terrain.



Wind turbine

Model: © DEFAULT_WIND_TURBINE

Hub height above ground: 15 m

Maximum power output: 5300 W

Reference air density: 1.225 kg/m^3

Wind Profile: © [Default urban]

Performance curve

Figure 58.

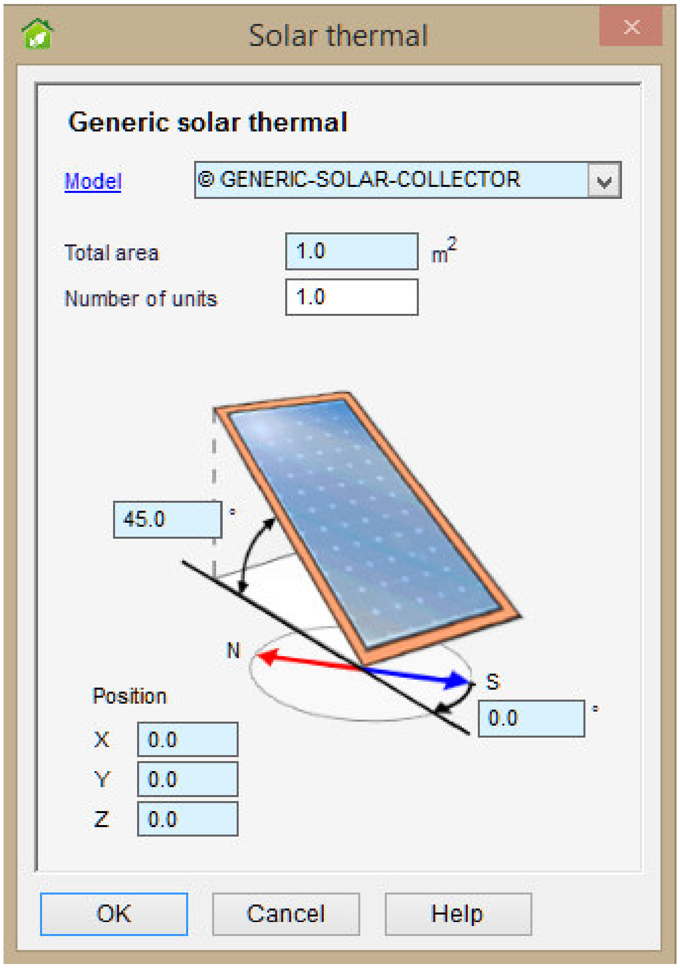
Solar energy

If solar thermal or photovoltaics systems have been added to the building, these will be visible in the building 3D and shading window as solar panels, Figure 61. By default these objects are placed in origo but can be given a more sensible position in 3D space by holding down the Ctrl-key and dragging the panel to a new position. The panel will move in the x-y plane. Hold down the shift-key to move the panel in the z-direction.

Solar panels are shaded by other shading objects. Solar panels themselves shade other solar panels and windows if they have been moved to a sensible position, i.e. if they are left at the origin they will not shade.

Generic solar thermal

Select a solar collector model from the drop down list. Either total area or number of units of the selected type can be specified.



Model © GENERIC-SOLAR-COLLECTOR

Total area 1.0 m^2

Number of units 1.0

45.0 °

0.0 °

X 0.0

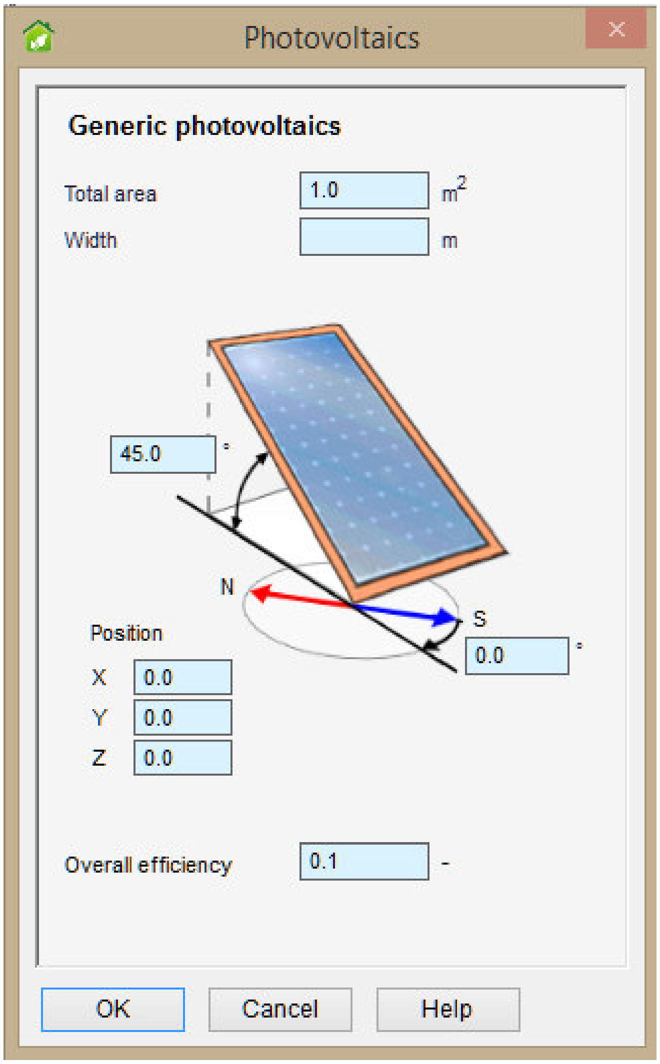
Y 0.0

Z 0.0

Figure 59.

Generic photovoltaics

Photovoltaics can be specified in terms of area and overall efficiency (panel as well as inverter system). All generated electricity shows up as a negative contribution in the delivered energy report.



Photovoltaics

Generic photovoltaics

Total area 1.0 m^2

Width m

45.0 °

0.0 °

Position

X 0.0

Y 0.0

Z 0.0

Overall efficiency 0.1 -

Figure 60.

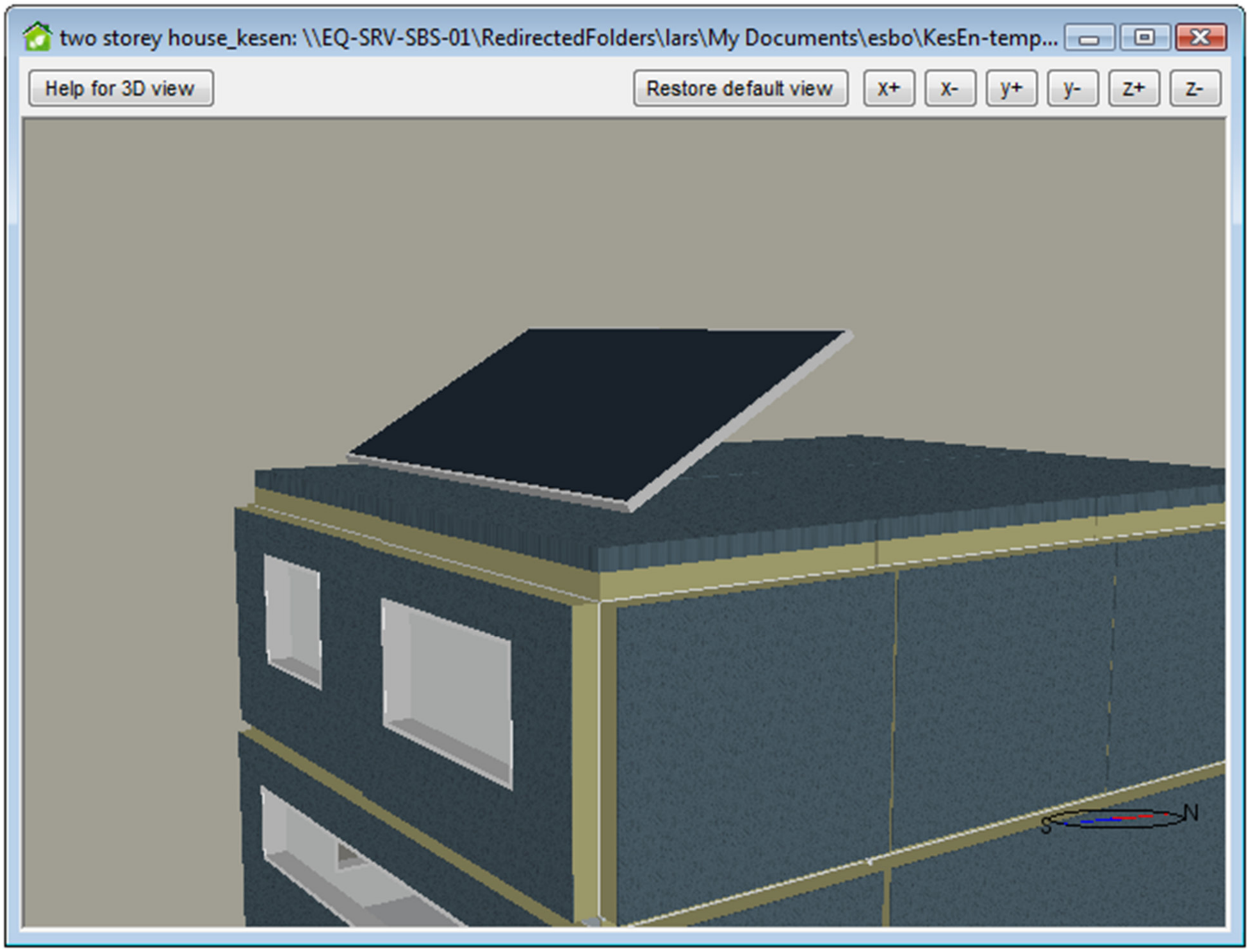


Figure 61. A building with a solar panel/photovoltaics on the roof

Ventilation

All objects can be dragged from the palette on the left hand side to the building tab. To open the object, double click and choose “Open” in the shortcut menu. To remove the object, click the wastebasket. The following type of objects can be inserted:

Standard air handling unit

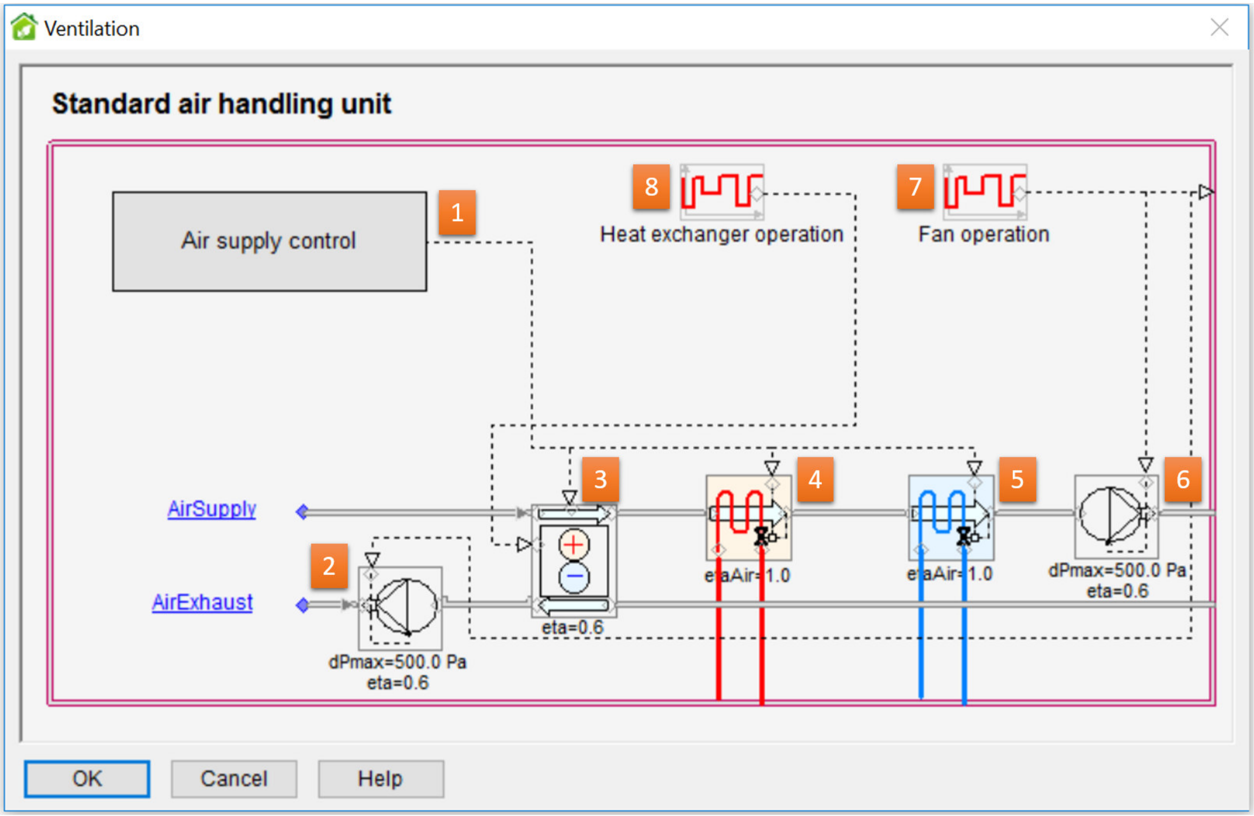


Figure 62.

The standard air handling system consists of the following components Figure 62: supply air temperature setpoint controller (1), exhaust fan (2), heat exchanger (sensible heat exchange only) (3), heating coil (4), cooling coil (5), supply fan (6), schedule (7) for operation of both fans and a schedule for the operation of the heat exchanger (8). The unit provides temperature-controlled air at a given pressure. Some key parameters of individual components are presented in the form; open them to edit. The supply air temperature setpoint is set in the Air distribution system dialog opened by double-clicking on the Air supply control box (1).

Return air only AHU

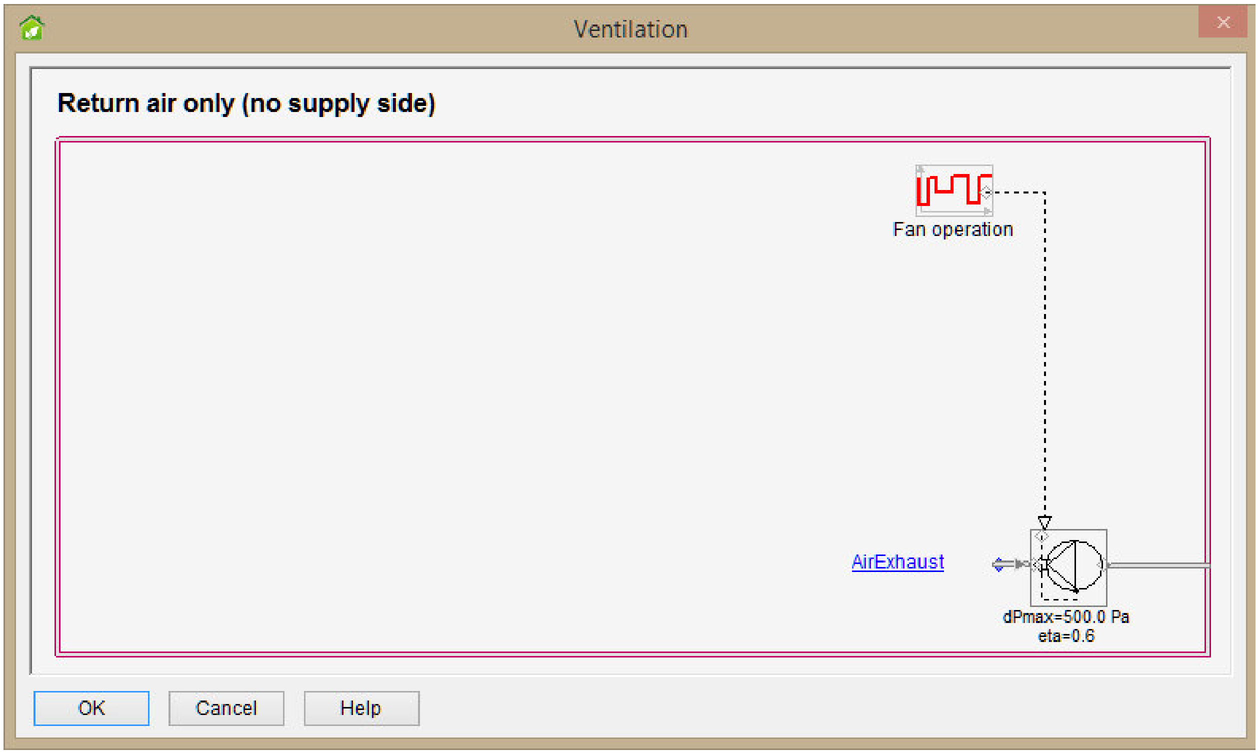


Figure 63.

This AHU should be used for mechanical ventilation systems with exhaust air only. The make-up air in the rooms is ambient air. An error message is issued if a supply air flow is requested by any room.

AHU with electrical heating coil

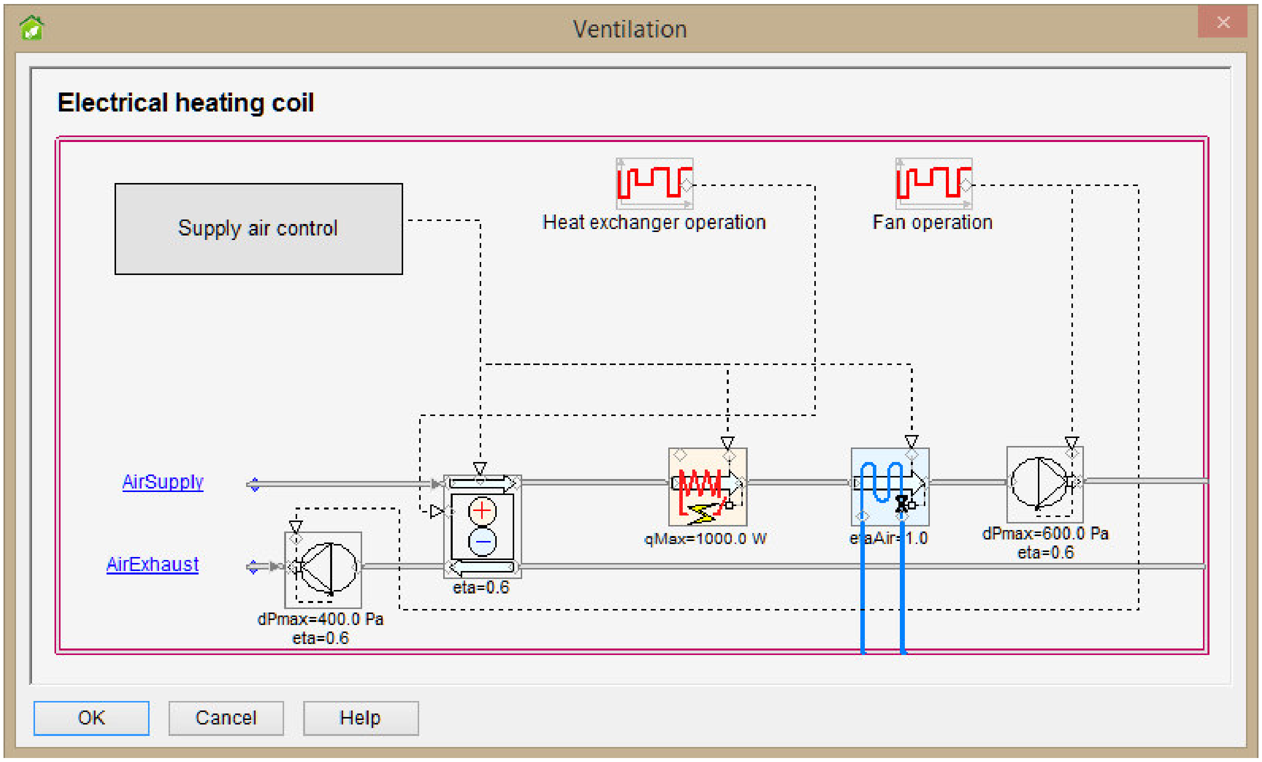


Figure 64.

This AHU is similar to the default AHU, but heating is done by electricity.

AHU with return air and CO_2 control

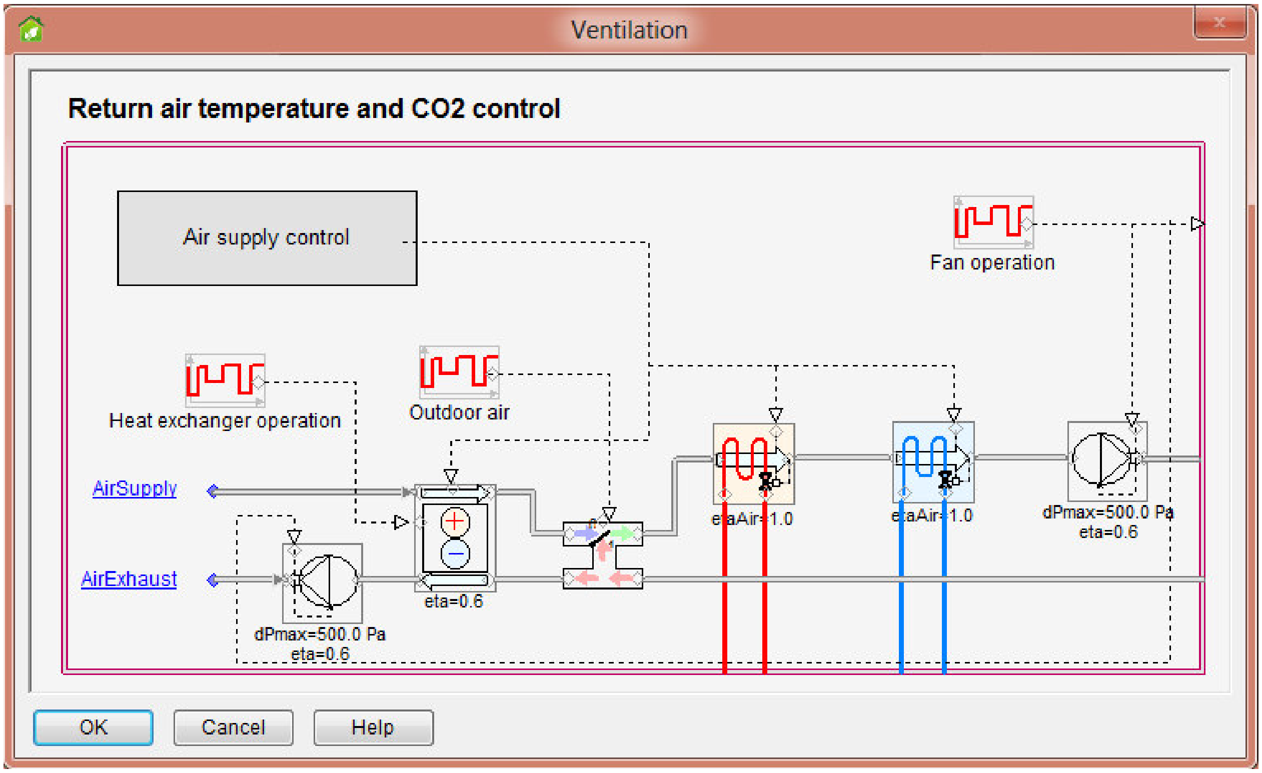
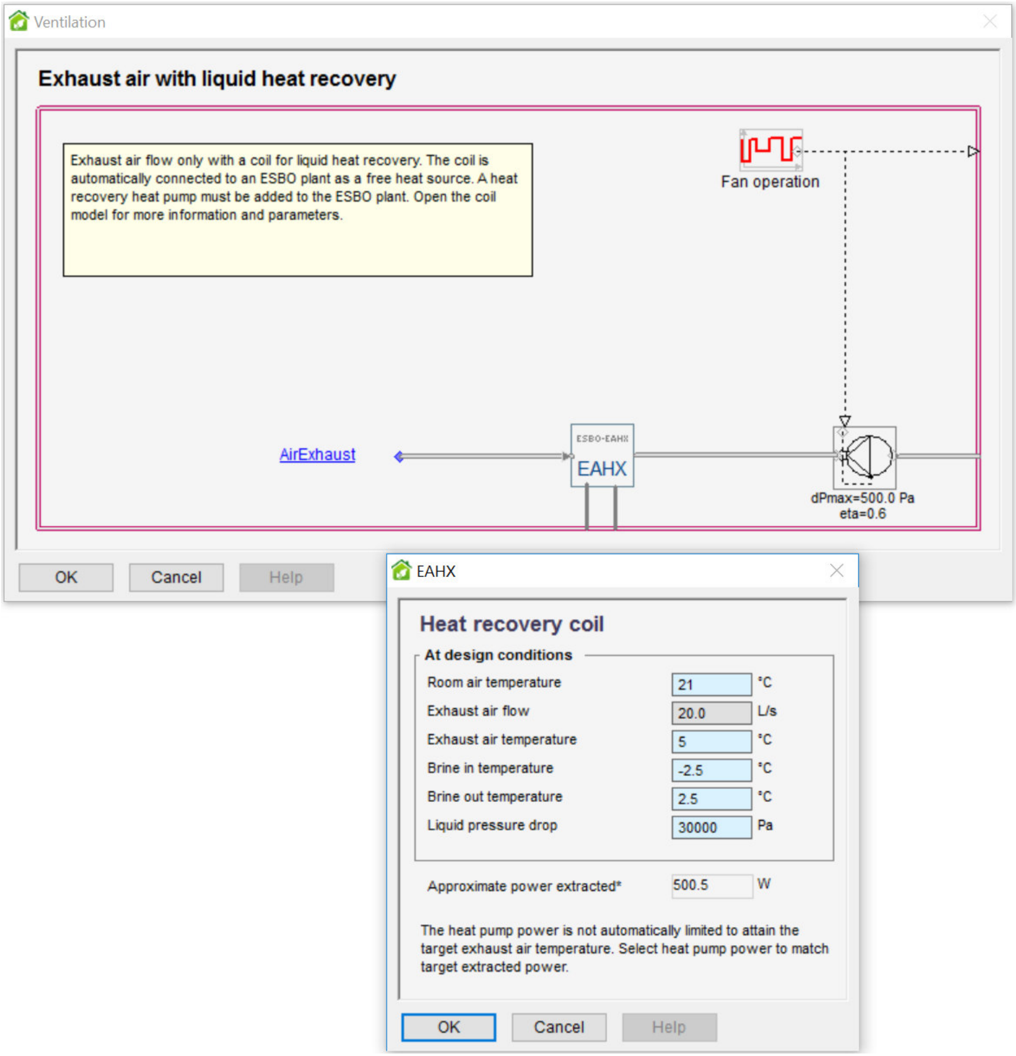


Figure 65.

This air handling unit provides the possibility of recirculating zone air in order to minimize the use of outdoor fresh air. Temperature control of supply air is done with the same options as for the default unit, including night ventilation and cycling. In addition, the CO2 level of the return air is controlled by a proportional controller. When the return air CO2 level is above the setpoint of any zone (by default 1000 ppm (vol)), a maximum amount of fresh air is used. As the measured CO2 level drops, the fresh air fraction is successively reduced down to zero, at 500 ppm (vol) (selectable in Additional settings in full ESBO).

Exhaust air with liquid heat recovery



Exhaust air with liquid heat recovery

Exhaust air flow only with a coil for liquid heat recovery. The coil is automatically connected to an ESBO plant as a free heat source. A heat recovery heat pump must be added to the ESBO plant. Open the coil model for more information and parameters.

Heat recovery coil

At design conditions

Room air temperature	21	°C
Exhaust air flow	20.0	L/s
Exhaust air temperature	5	°C
Brine in temperature	-2.5	°C
Brine out temperature	2.5	°C
Liquid pressure drop	30000	Pa

Approximate power extracted* 500.5 W

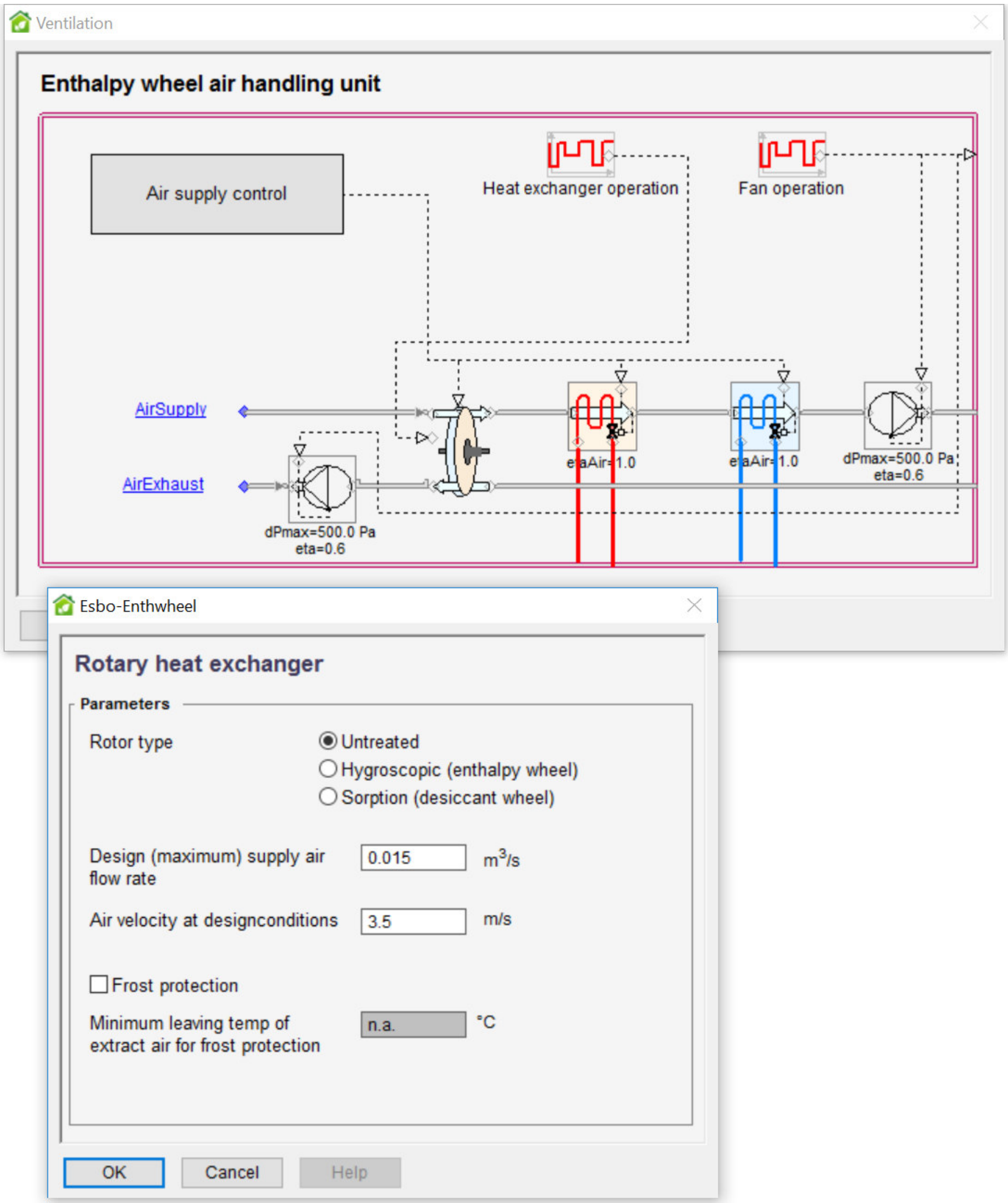
The heat pump power is not automatically limited to attain the target exhaust air temperature. Select heat pump power to match target extracted power.

Figure 66.

This AHU should be used for mechanical ventilation systems with exhaust air only and with an air-to-liquid heat recovery coil. Design parameters for the liquid loop is given in a separate form for the coil. Based on the given parameters, an approximate level of extracted heat is computed.

Normally, a brine to water heat pump or equivalent device should be added to the plant in order to lift the extracted heat to a useful temperature level. The size of the heat pump should be selected to extract approximately the intended amount of heat at design conditions. There is no control loop that maintains the targeted exhaust air temperature. If an oversized heat pump is selected, the air will be cooled too low. No warning is issued for this condition during simulation.

Enthalpy wheel air handling unit



Rotary heat exchanger

Parameters

Rotor type
● Untreated
○ Hygroscopic (enthalpy wheel)
○ Sorption (desiccant wheel)

Design (maximum) supply air flow rate: 0.015 m^3/s

Air velocity at designconditions: 3.5 m/s

☐ Frost protection

Minimum leaving temp of extract air for frost protection: n.a. °C

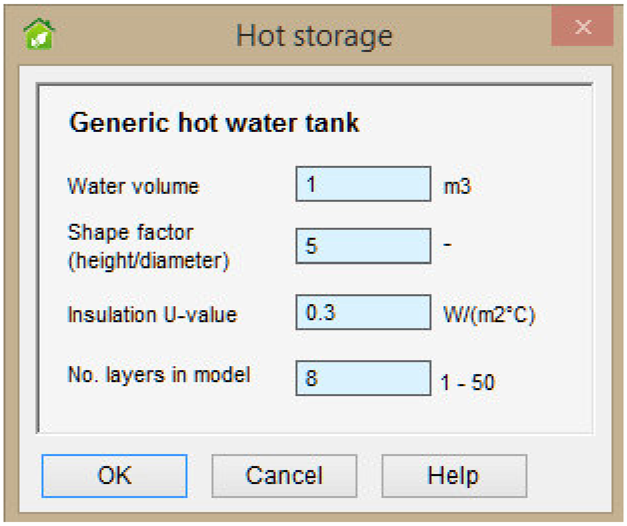
Figure 67.

This air handling unit is the same as the Standard Air Handling unit except for the heat exchanger, which here models the behaviour of a thermal wheel with possible moisture exchange (according to prEN 16798-5-1.) An untreated wheel will only transfer moisture via condensation. The hygroscopic wheel is treated with a special desiccant material which enables moisture transfer. Sorption wheels have even higher sorptive capacity.

If Frost protection is enabled, the speed of the wheel is adapted to avoid frost formation. The user must then provide a minimum temperature level for the exhaust air. For dwellings 1 °C is recommended, while for other applications the risk of frost build-up is lower and lower temperatures can be selected.

Hot storage

Generic hot water tank



Hot storage

Generic hot water tank

Water volume: 1 m3

Shape factor (height/diameter): 5 -

Insulation U-value: 0.3 W/(m2°C)

No. layers in model: 8 1 - 50

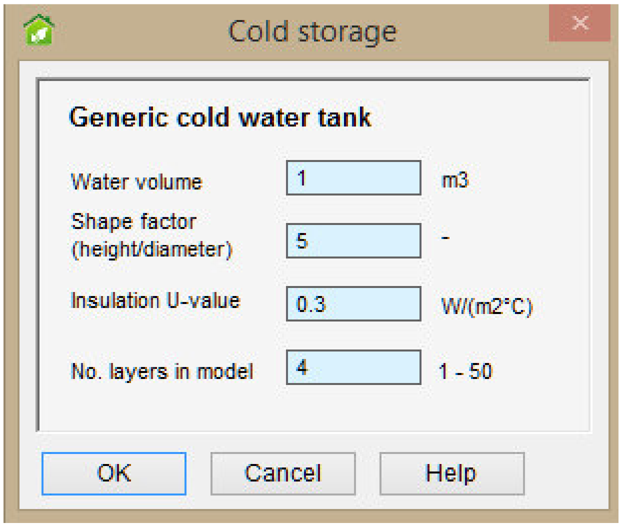
Figure 68.

A hot water storage tank may be defined to store heat from, e.g. a solar collector. See the online help topic "Technical description of the generated plant" for further details

In full ESBO, the temperatures of the different tank layers may be studied by selecting Plant details for Requested output on the Simulation tab.

Cold storage

Generic cold water tank



Generic cold water tank

Water volume: 1 m3

Shape factor (height/diameter): 5 -

Insulation U-value: 0.3 W/(m2°C)

No. layers in model: 4 1 - 50

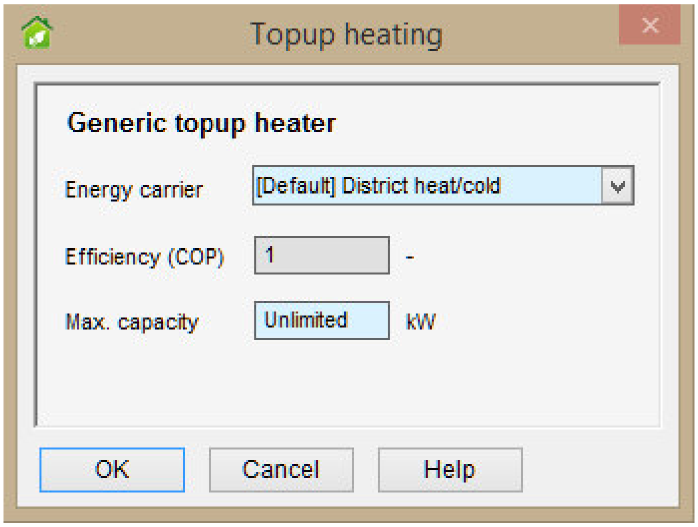
Figure 69.

A cold water storage tank may be defined to store cold from, e.g., the evaporator circuit of a heat pump. See the online help topic "Technical description of the generated plant" for further details.

In full ESBO, the temperatures of the different tank layers may be studied by selecting Plant details for Requested output on the Simulation tab.

Topup heating

Generic topup heater



Energy carrier: [Default] District heat/cold

Efficiency (COP): 1 -

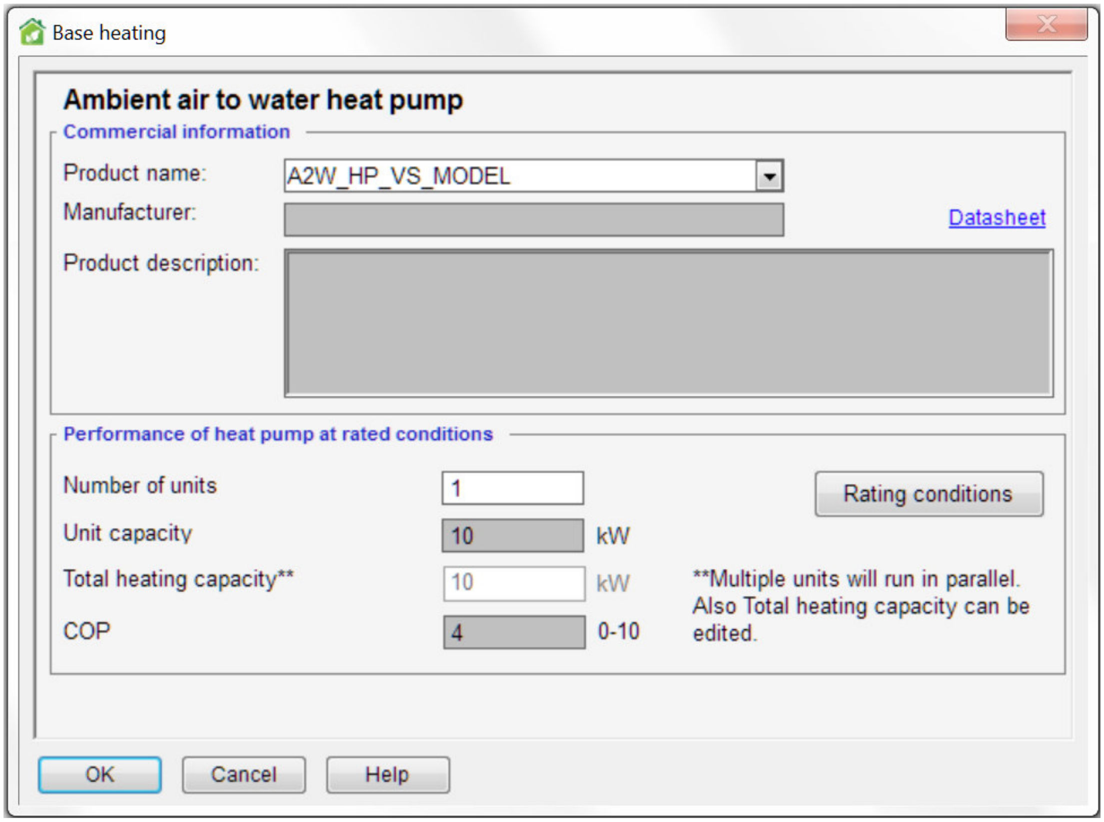
Max. capacity: Unlimited kW

Figure 70.

The top-up heater is employed when the available water temperature drops more than 2^{0}C below the highest requested temperature. Energy source as well as a constant production efficiency (or COP) can be selected. The total capacity can optionally be limited.

Base heating

Ambient air to water heat pump



Ambient air to water heat pump

Commercial information

Product name: A2W_HP_VS_MODEL

Manufacturer:

Product description:

Performance of heat pump at rated conditions

Number of units: 1

Unit capacity: 10 kW

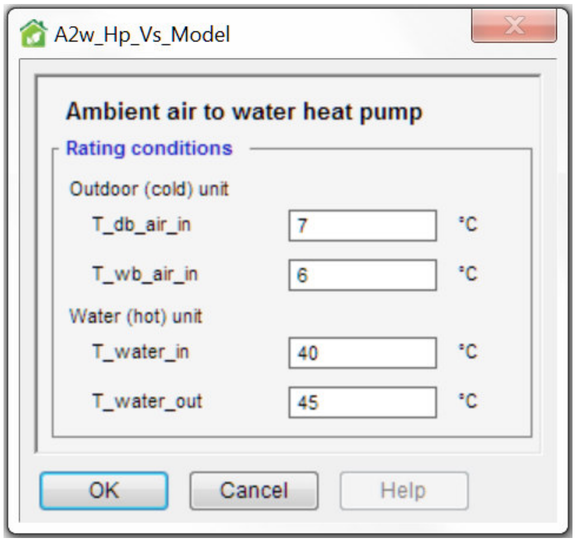
Total heating capacity**: 10 kW

COP: 4 0-10

**Multiple units will run in parallel. Also Total heating capacity can be edited.

Figure 71.

Figure 71 shows the dialog for a model with an air-to-water heat pump unit for water heating. At the given rating condition (press button to see dialog below), the model will yield given total power and COP. Note that this unit has its own ambient air heat exchanger, i.e. there is no need to add a separate such device to the model.



Ambient air to water heat pump

Rating conditions

Outdoor (cold) unit

T_db_air_in 7 °C

T_wb_air_in 6 °C

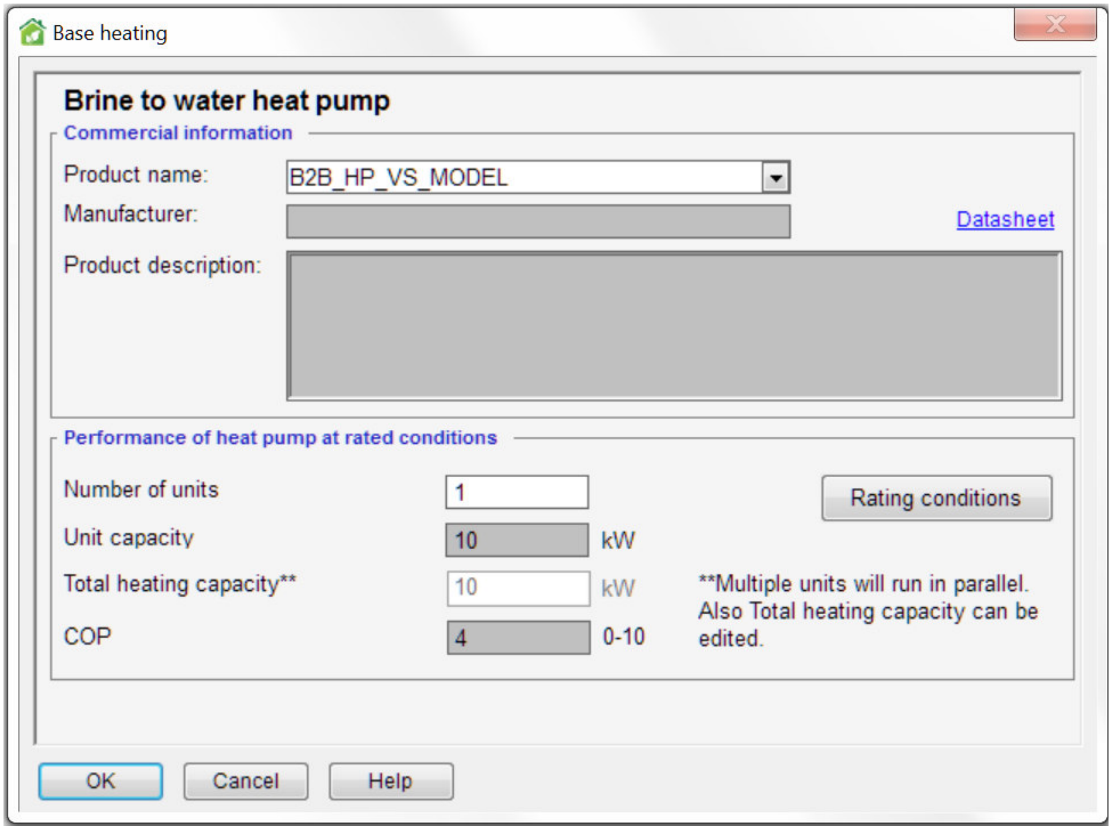
Water (hot) unit

T_water_in 40 °C

T_water_out 45 °C

Figure 72.

Brine to water heat pump



Brine to water heat pump

Commercial information

Product name: B2B_HP_VS_MODEL

Manufacturer:

Product description:

Performance of heat pump at rated conditions

Number of units 1

Unit capacity 10 kW

Total heating capacity** 10 kW

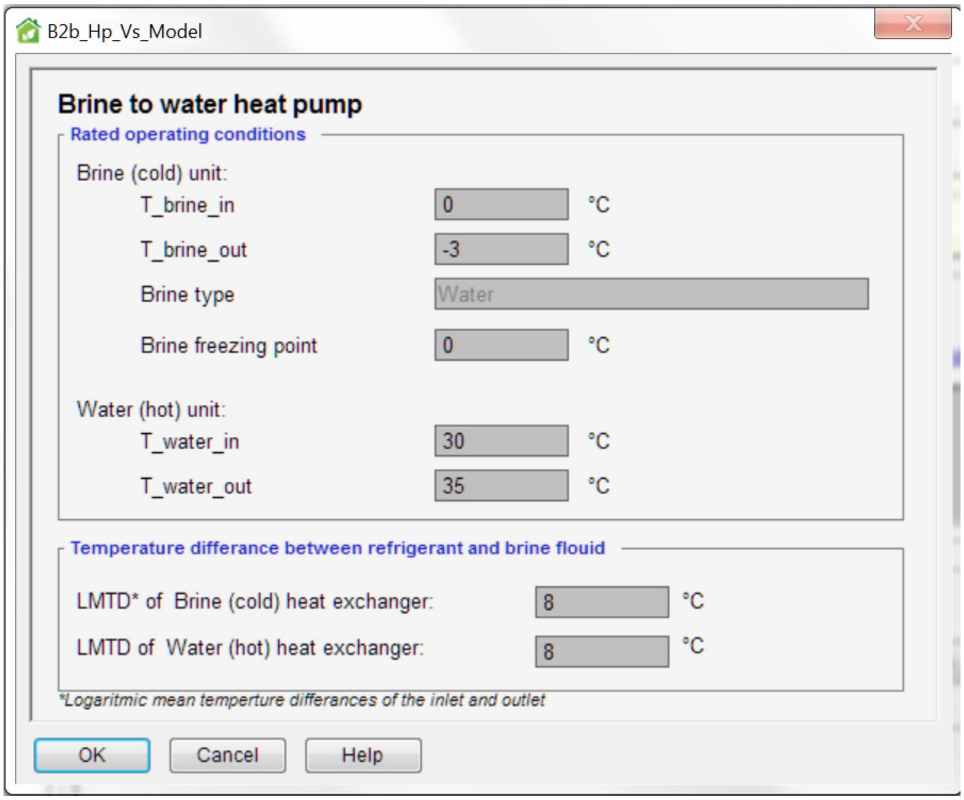
COP 4 0-10

**Multiple units will run in parallel. Also Total heating capacity can be edited.

Figure 73.

Figure 73 shows the dialog for a model with a brine to water heat pump unit for hot water heating. At the given rating condition (press button to see), the model will yield given total power and COP.

The cold (evaporator) side of the Brine to water heat pump, will automatically be connected to the brine circuit. In most situations, some ambient or ground heat exchanger must also be added by the user to the brine loop in order to collect heat for the heat pump. This is done by simply dragging such a component into the form. The cold side of the heat pump will always be connected to a heat exchanger in the cold tank and thus provide “free” cooling to the building whenever this is possible. Click to open the dialog for **rating conditions**



B2b_Hp_Vs_Model

Brine to water heat pump

Rated operating conditions

Brine (cold) unit:

T_brine_in 0 °C

T_brine_out -3 °C

Brine type Water

Brine freezing point 0 °C

Water (hot) unit:

T_water_in 30 °C

T_water_out 35 °C

Temperature differance between refrigerant and brine flouid

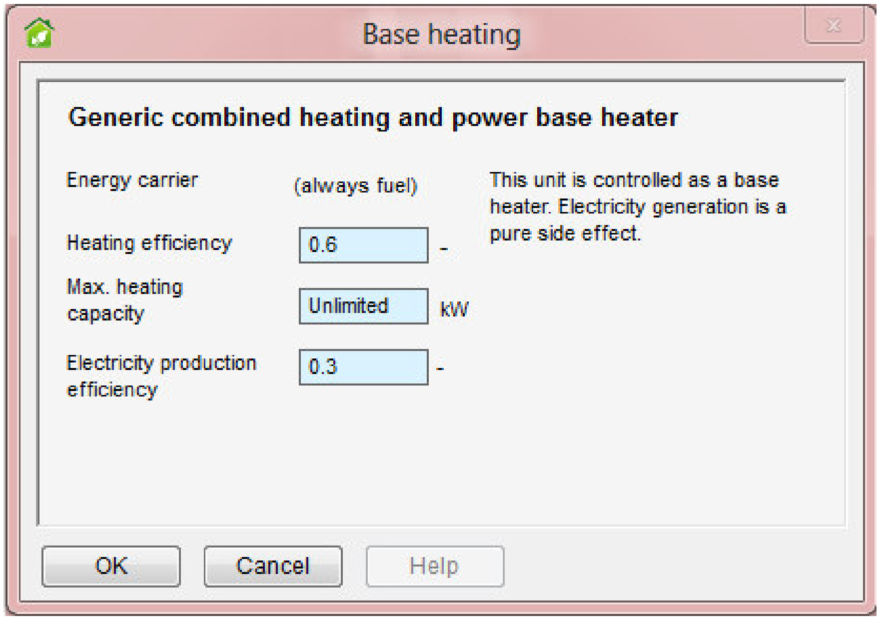
LMTD* of Brine (cold) heat exchanger: 8 °C

LMTD of Water (hot) heat exchanger: 8 °C

*Logaritmic mean temperture differances of the inlet and outlet

Figure 74.

Generic combined heating and power base heater



Generic combined heating and power base heater

Energy carrier (always fuel)

Heating efficiency 0.6 -

Max. heating capacity Unlimited kW

Electricity production efficiency 0.3 -

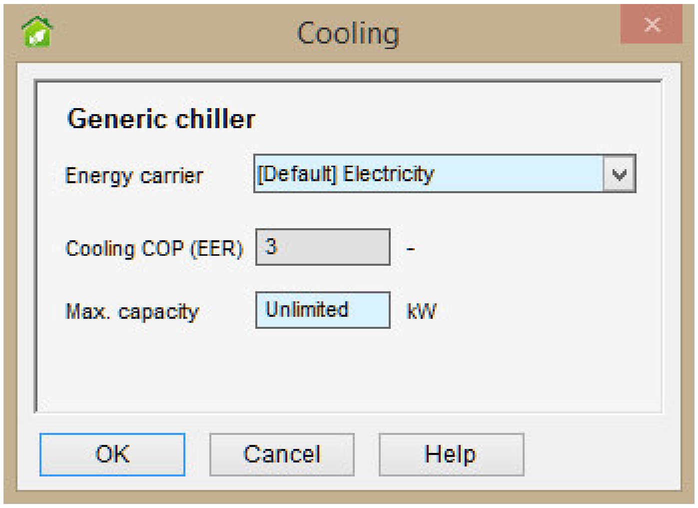
This unit is controlled as a base heater. Electricity generation is a pure side effect.

Figure 75.

A simple, fixed efficiency, CHP model is available.

Cooling

Generic chiller



Generic chiller

Energy carrier [Default] Electricity

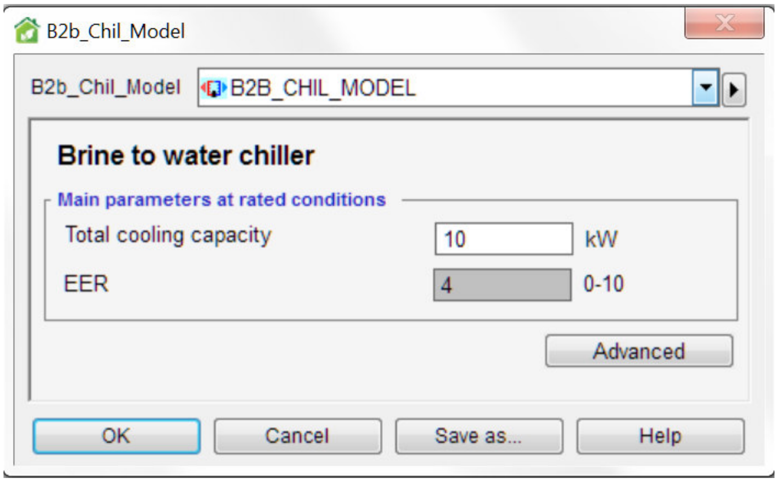
Cooling COP (EER) 3 -

Max. capacity Unlimited kW

Figure 76.

The energy source as well as a constant production efficiency (or cooling COP) can be selected. The total capacity can optionally be limited.

Brine to water chiller



B2b_Chil_Model: B2B_CHIL_MODEL

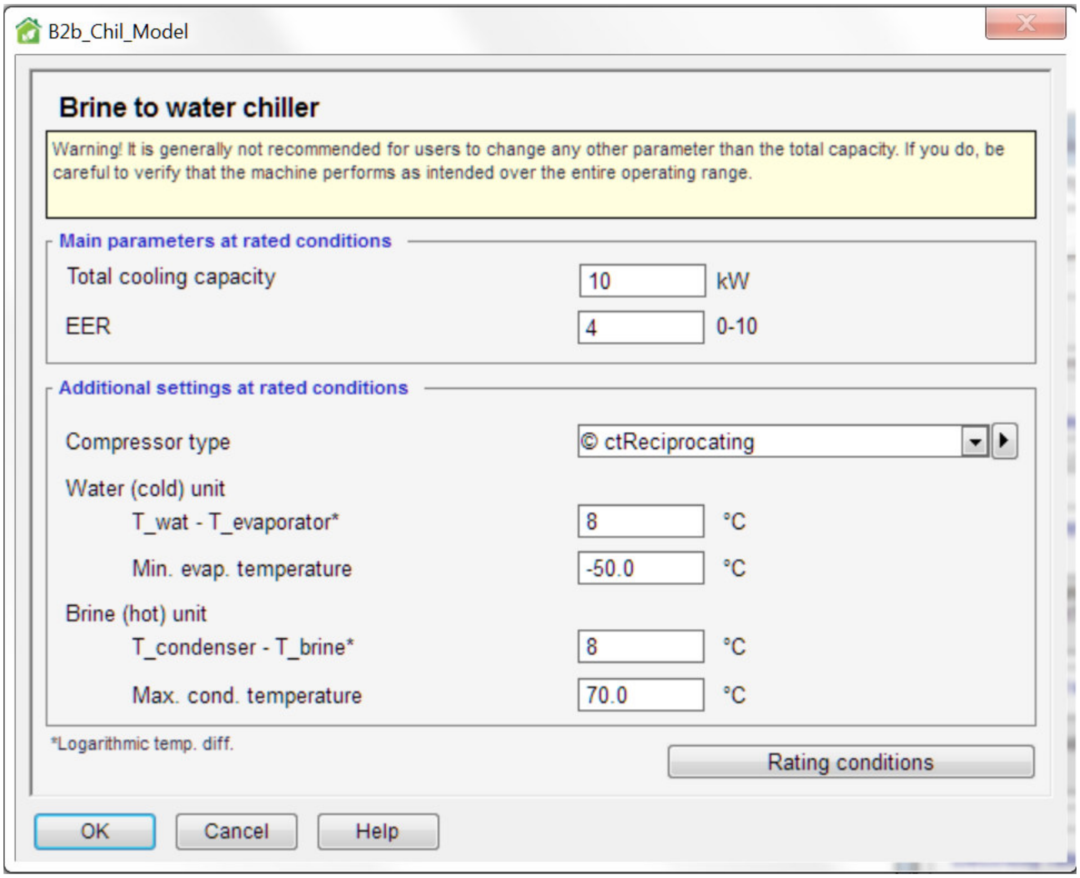
Brine to water chiller

Main parameters at rated conditions

Total cooling capacity: 10 kW

EER: 4 (0-10)

Figure 77.



Brine to water chiller

Warning! It is generally not recommended for users to change any other parameter than the total capacity. If you do, be careful to verify that the machine performs as intended over the entire operating range.

Main parameters at rated conditions

Total cooling capacity 10 kW

EER 4 0-10

Additional settings at rated conditions

Compressor type © ctReciprocating

Water (cold) unit

T_wat - T_evaporator* 8 °C

Min. evap. temperature -50.0 °C

Brine (hot) unit

T_condenser - T_brine* 8 °C

Max. cond. temperature 70.0 °C

*Logarithmic temp. diff.

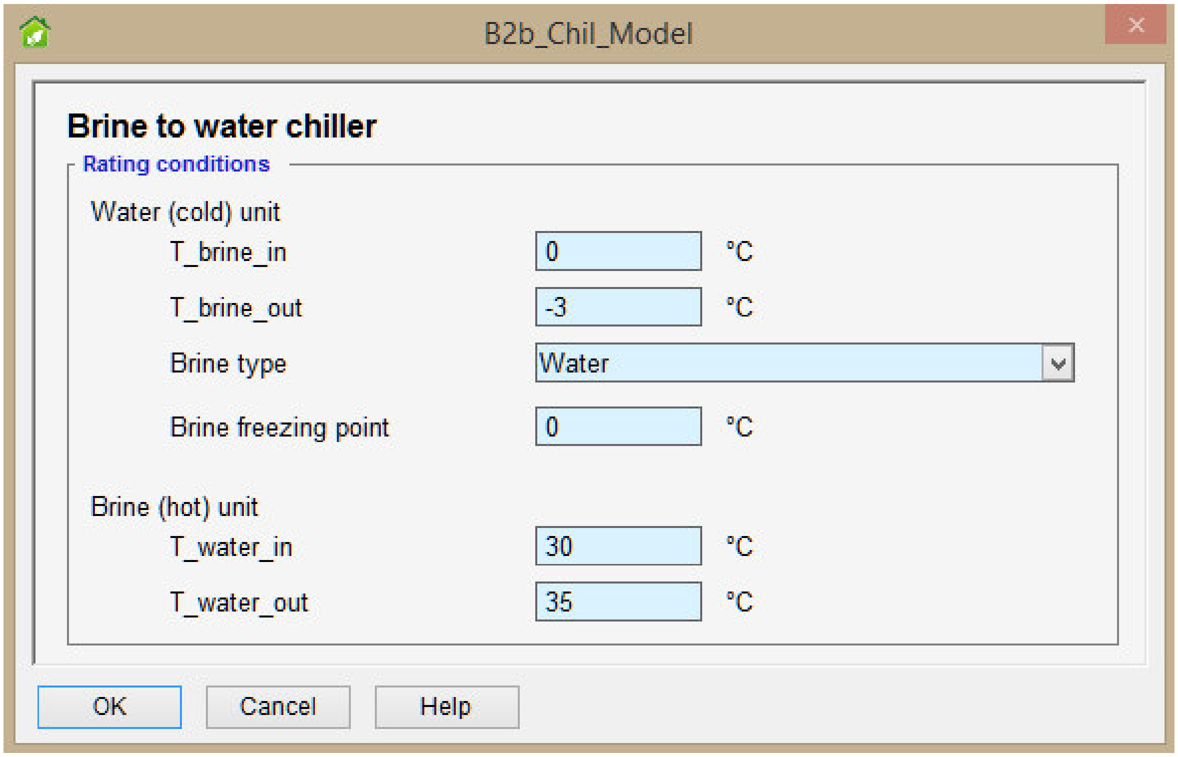
Figure 78.

Figure 78 shows the dialog for a model with a brine to water on-off controlled unit for water cooling. At the given rating condition (press button to see), the model will yield given total power and EER (cooling COP).

It is generally not recommended for most users to change any other parameter than the total cooling capacity.

Away from the rated point, the performance will be determined by the additionally specified parameters. These are measurable quantities but may not always be made available by equipment manufacturers. If parameters have been identified with respect to measured data from a real device, the model will predict the performance over the whole operating range within the accuracy of a few percent, typically around one.

The hot (condenser) side of the Brine to water chiller, will automatically be connected to the brine circuit. In most situations, some ambient or ground heat exchanger will must also be connected to the brine loop in order to dispose of the waste heat. This is done by simply dragging such a component into the form. The hot side of the chiller will always be connected to a heat exchanger in the hot tank and thus provide “free” heating to the building when possible. Click to open the dialog for **rating conditions.**



Brine to water chiller

Rating conditions

Water (cold) unit

T_brine_in 0 °C

T_brine_out -3 °C

Brine type Water

Brine freezing point 0 °C

Brine (hot) unit

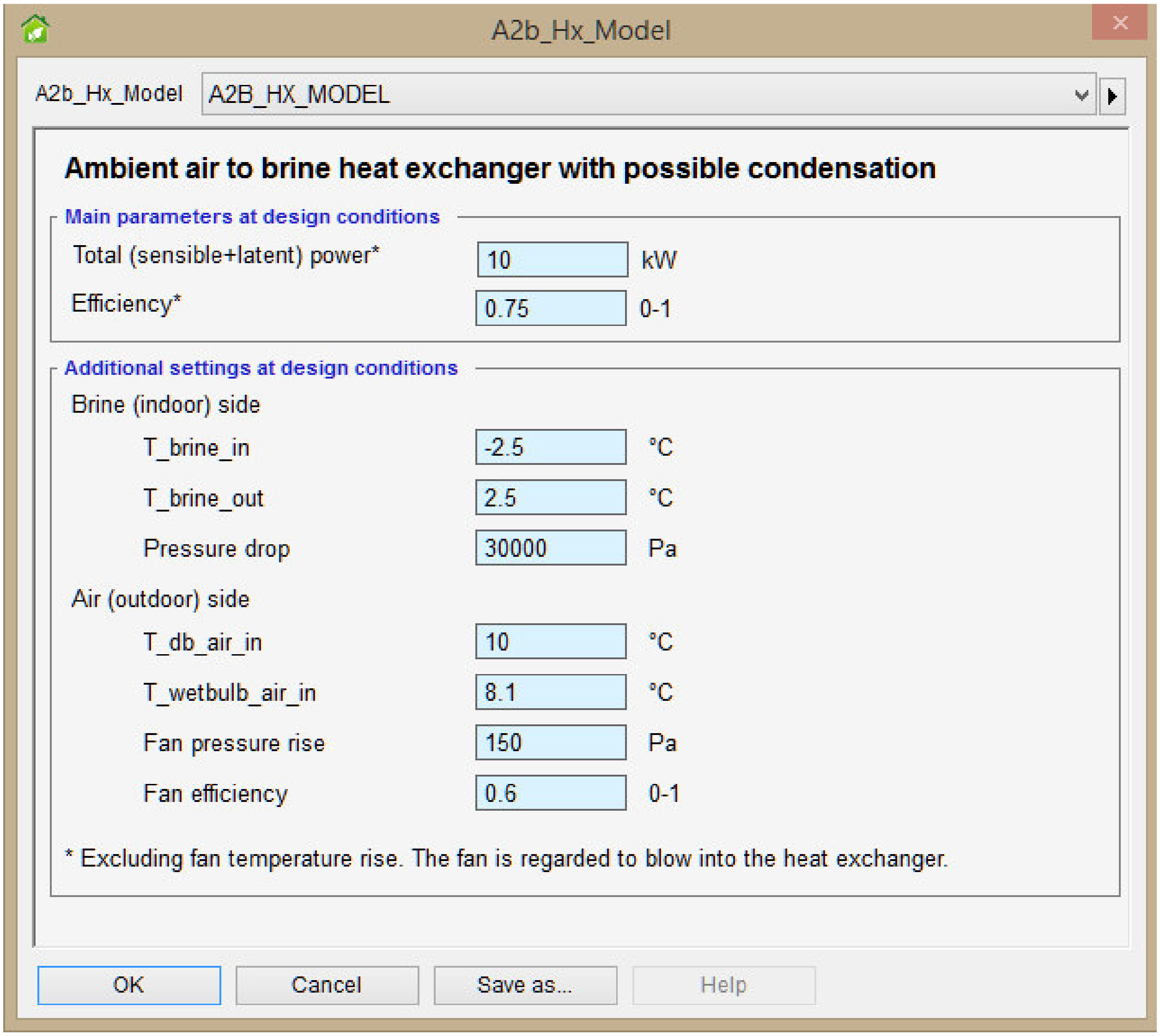
T_water_in 30 °C

T_water_out 35 °C

Figure 79.

Ambient heat exchange

Ambient air to brine heat exchanger with possible condensation



A2b_Hx_Model: A2B_HX_MODEL

Ambient air to brine heat exchanger with possible condensation

Main parameters at design conditions

Total (sensible+latent) power*: 10 kW

Efficiency*: 0.75 0-1

Additional settings at design conditions

Brine (indoor) side

T_brine_in: -2.5 °C

T_brine_out: 2.5 °C

Pressure drop: 30000 Pa

Air (outdoor) side

T_db_air_in: 10 °C

T_wetbulb_air_in: 8.1 °C

Fan pressure rise: 150 Pa

Fan efficiency: 0.6 0-1

* Excluding fan temperature rise. The fan is regarded to blow into the heat exchanger.

Figure 80.

Figure 80 shows the dialog for a model with a fan assisted ambient heat exchanger. In heat production mode, condensation may occur and therefore a wet coil rating point is required. The efficiency is defined with respect to an apparatus dew point which is the average of entering and leaving brine temperature. Wet coil leaving air conditions will lie on a straight line between entering conditions in the psychometric chart and the apparatus dew point. The dimensionless distance along this line is defined as the efficiency.

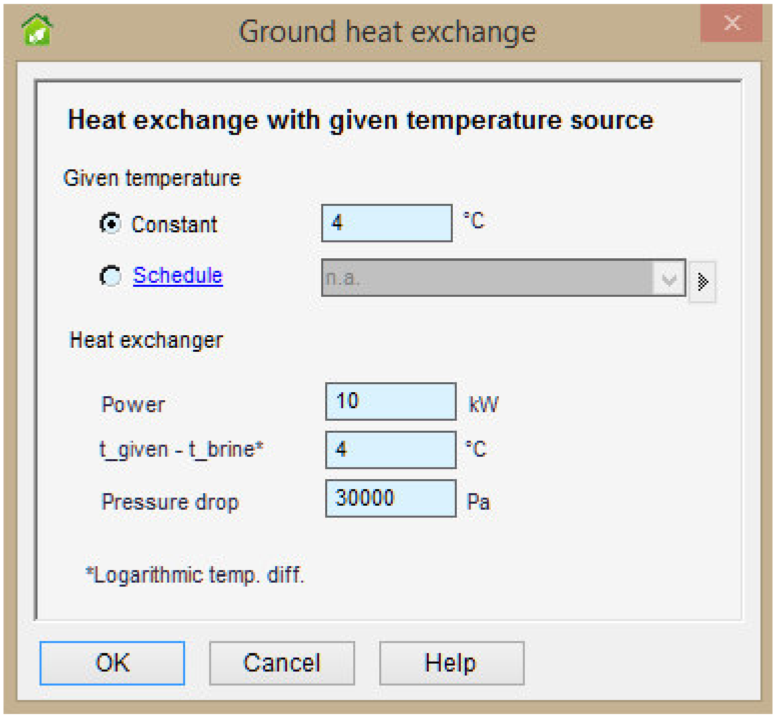
Ground heat exchange

All ambient or ground heat exchangers are connected to a brine loop. The brine loop will always be connected to heat exchangers in the hot and cold supply systems. This way, a ground heat exchanger can directly cool the building without the assistance of a chiller. However, should a Brine to water chiller be dragged in, its condenser will also be cooled by the brine loop (and the resulting hot brine may even be warm enough to be utilized directly for heating).

When two or more central system boxes are graphically connected the added system covers the function of both boxes.

Select Plant details under Requested output in the Simulation tab in order to see the time-evolution of key Central system variables.

Heat exchange with given temperature source


Ground heat exchange

Heat exchange with given temperature source

Given temperature

● Constant 4 °C

○ Schedule n.a.

Heat exchanger

Power 10 kW

t_given - t_brine* 4 °C

Pressure drop 30000 Pa

*Logarithmic temp. diff.

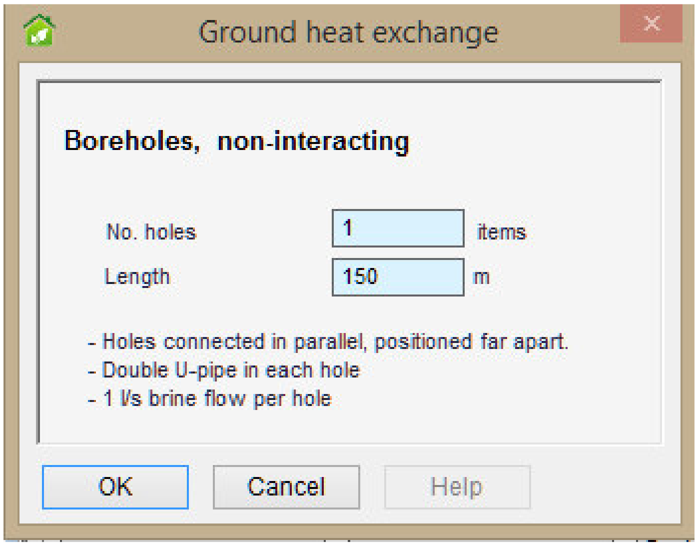
Figure 81.

The model is used to specify the option of heat exchange with a temperature source with a practically infinite capacity, such as sea water or in some approximations the ground. In place of the default constant temperature, a schedule that prescribes the temperature variation as a function of time can be given. To do this, click the hyperlink.

The given power, temperature difference and pressure loss are used to determine sizes of the heat exchanger and associated pumps and pipes. Pumps are regarded to be capacity controllable down to zero flow with given constant efficiency.

Ground source borehole loop

A detailed model for a borehole system is provided. ESBO supports a series of identical boreholes that are positioned far apart from each other and that are connected in parallel. (A separate module is available for IDA ICE to study interacting boreholes.)



Boreholes, non-interacting

No. holes 1 items

Length 150 m

- Holes connected in parallel, positioned far apart.
- Double U-pipe in each hole
- 1 l/s brine flow per hole

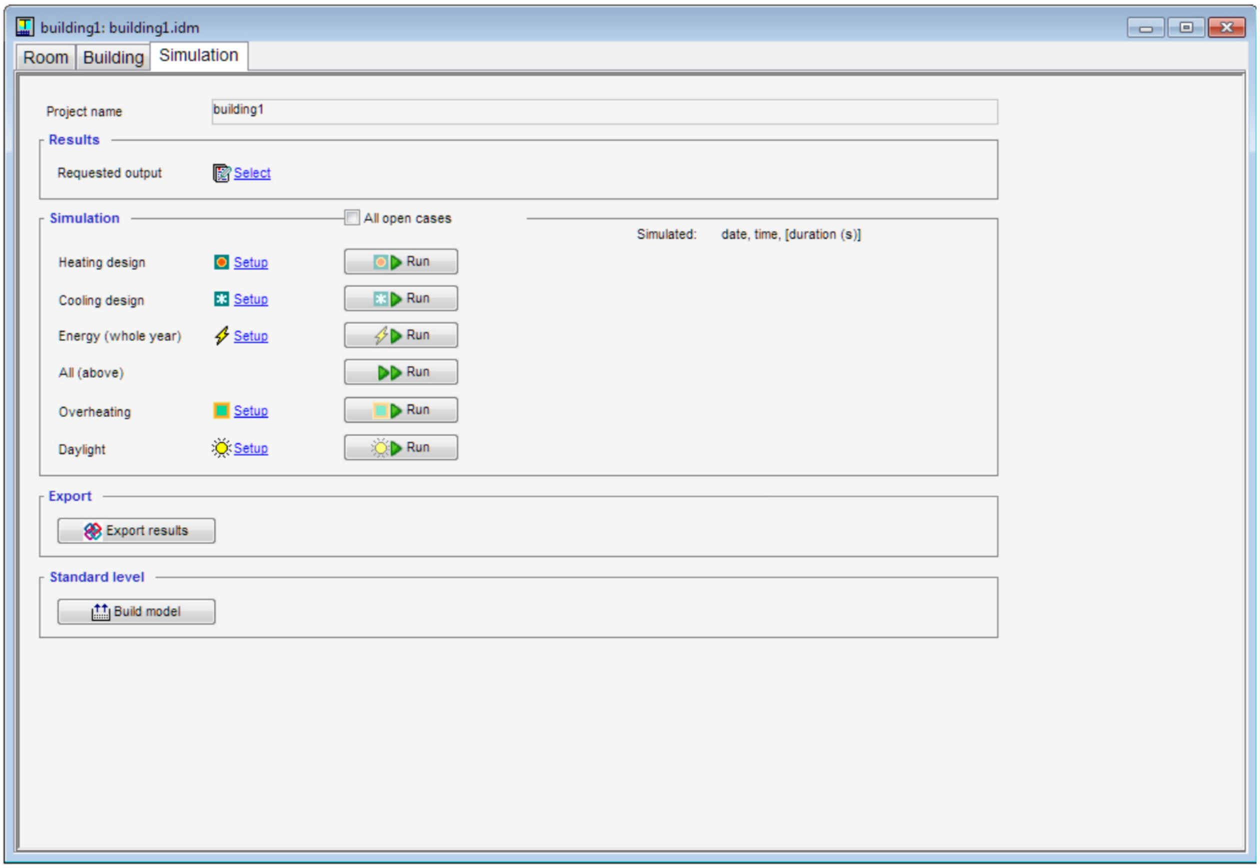
Figure 82.

The present version of ESBO only supports the study of a borehole system during the first year of operation. The ground temperature is started at the yearly average temperature of the climate file.

The default control options will try to use borehole heat (or cold) whenever it is needed and available. No long term strategies of storing heat for future use are employed.

Simulation tab

On this tab, the actual simulations are carried out. Five types of simulations are available: **Heating design**, **Cooling design**, **Energy, Overheating** and **Daylight**.



Project name: building1

Figure 83.

When an Energy simulation is carried out, the whole year is simulated, and internal gains (lights, equipment and occupancy) are cut to 60% (user selectable in full ESBO) of given values. This is because buildings only rarely are used to their full capacity.

For Cooling design and Overheating simulations, a statistically selected[5] clear and hot day is simulated over and over until the building has completely adapted, corresponding to a very long[6] spell of identical hot days. Full internal gains according to their schedules as provided by the user are applied. The process is repeated for each month of the year[7]. Results from several of these

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[5] Design day weather data is according to ASHRAE Fundamentals 2013, the 0.4% cumulative frequency level for cooling design and the 99.6% level for heating.

[6] Maximized to 14 days in ESBO. This is sufficient for most buildings to adapt.

[7] Process is terminated in fall/spring if heat load is decreasing from month to month.

monthly hot days are kept, corresponding to the peaks of individual rooms, air handling units and the central plant. Note that when results are presented, cooling peaks for different systems will often occur during unexpected months. While air handling units normally peak during the summer as expected, individual rooms may often peak during winter months when the sun stands low.

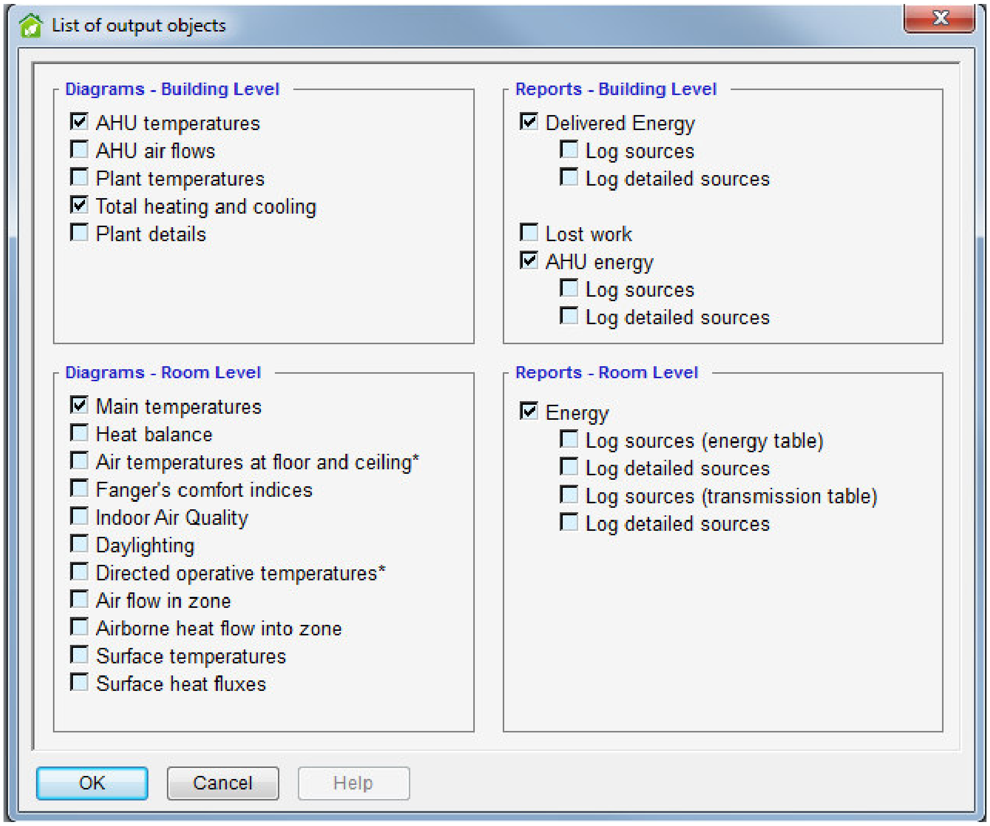
An Overheating study is very similar to a cooling design study, but instead of looking for peaks in cooling power, it finds the days when room air temperatures are the highest. Overheating simulations are normally used to study buildings with no or limited installed cooling capacity. Note that mechanical cooling equipment is *not* automatically removed for an overheating study. This must be done manually by the user.

A Heating design study is similar to Cooling design, but a bit simpler. Only a single cold spell is studied, and for this coldest month, a statistically selected cold day is repeated until the building has adapted. Internal gains are assumed to be zero, and no solar radiation is allowed to enter the building. Full ESBO allows some more user configuration of the design conditions.

A Daylight calculation is an advanced ray tracing calculation executed in the Radiance™ lighting simulation tool.

Results

Requested output Click the hyperlink **Select** to open dialog to specify what diagrams and reports that will be created during the simulation. Note in particular the Plant details option that will provide the time-evolution of key central system variables.



Diagrams - Building Level

☑ AHU temperatures
☐ AHU air flows
☐ Plant temperatures
☑ Total heating and cooling
☐ Plant details

Reports - Building Level

☑ Delivered Energy
  ☐ Log sources
  ☐ Log detailed sources

☐ Lost work
☑ AHU energy
  ☐ Log sources
  ☐ Log detailed sources

Diagrams - Room Level

☑ Main temperatures
☐ Heat balance
☐ Air temperatures at floor and ceiling*
☐ Fanger's comfort indices
☐ Indoor Air Quality
☐ Daylighting
☐ Directed operative temperatures*
☐ Air flow in zone
☐ Airborne heat flow into zone
☐ Surface temperatures
☐ Surface heat fluxes

Reports - Room Level

☑ Energy
  ☐ Log sources (energy table)
  ☐ Log detailed sources
  ☐ Log sources (transmission table)
  ☐ Log detailed sources

Figure 84.

Simulation

Click on the appropriate **Run** button, to carry out the desired simulation. Click the one next to **All** to run all simulations (will run Cooling design, not Overheating). Once a simulation is finished, the (provider specific) standard report is automatically opened. Click on the **Report** link to reopen this report if it has been closed.

The **Report** link next to the button for performing **All** simulations, will open the (provider specific) combination report, where all simulations are presented together.

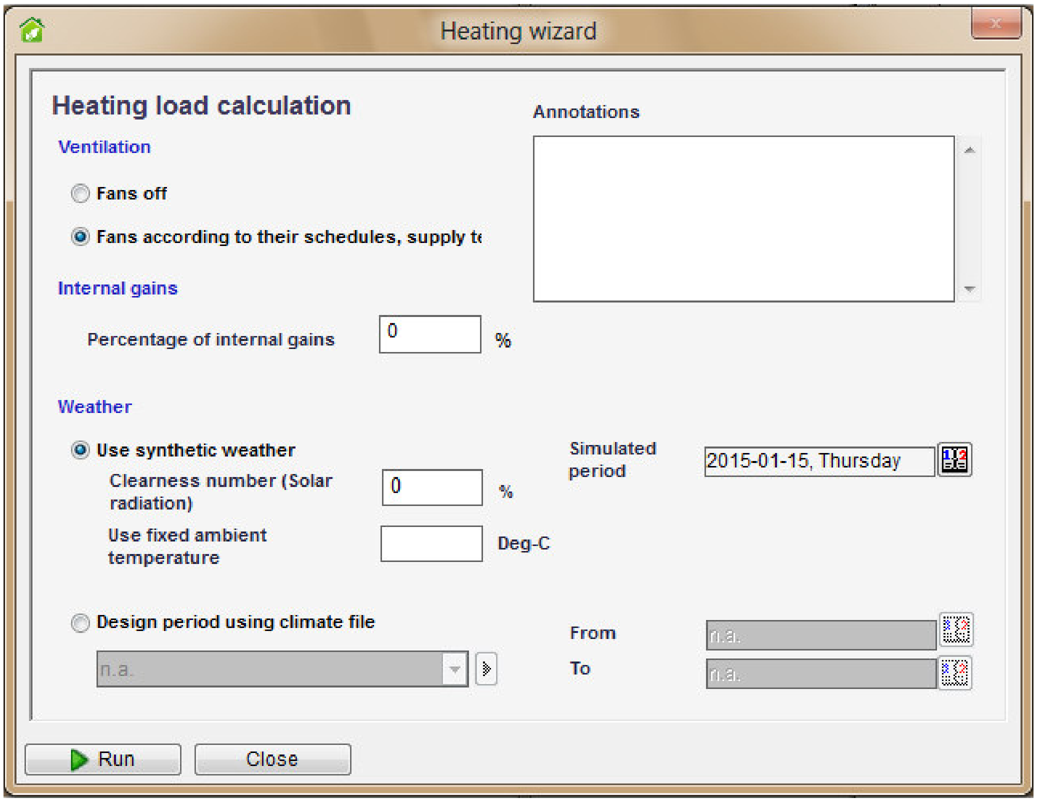
The **Details** link will provide access to further (provider independent) reports that may be of interest. In full ESBO, the additional results that have been selected under Results are presented here.

Simulated The time when the latest simulation was run and how many seconds it took.

Clicking **Summary**, will open an overview screen on a separate tab, which provides overview of the key results of the simulation.

Clicking "**Setup**" allows you to define key parameters to be applied in the calculation.

Heating design - Setup



Ventilation

○ Fans off

● Fans according to their schedules, supply te

Internal gains

Percentage of internal gains: 0 %

Weather

● Use synthetic weather

Clearness number (Solar radiation): 0 %

Use fixed ambient temperature: Deg-C

Simulated period: 2015-01-15, Thursday

○ Design period using climate file: n.a.

From: n.a.

To: n.a.

Figure 85.

Ventilation The fans can be turned off to consider the heating load without any AHU.

Internal gains The percentage of internal gains determines the percentage of all internal gains as defined in the rooms that should be applied (normally zero. It is customary to size heating without the added benefit of internal gains.)

Weather

Use synthetic weather With synthetic weather, the date of the simulation as well as the Clearness number influences solar radiation. If Clearness number is set to 0 %, the calculation is done without any solar radiation, while 100 % means clear sky conditions.

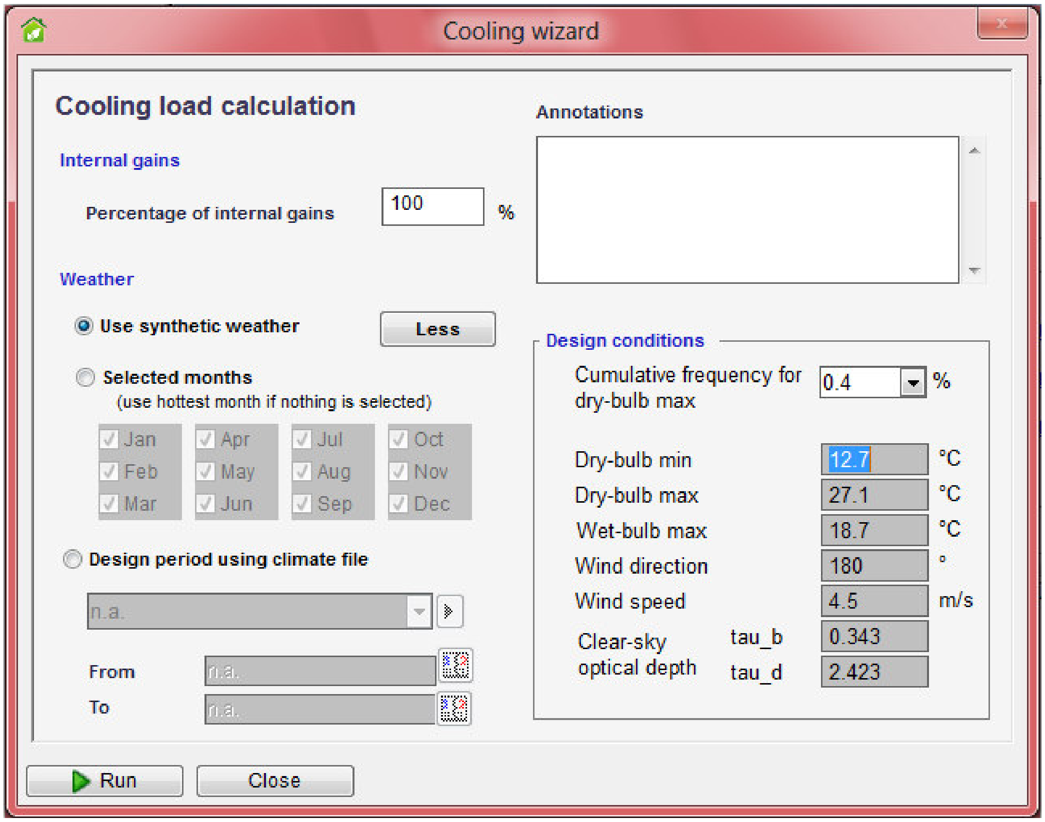
If a ***fixed ambient temperature*** is specified, maximum and minimum dry bulb temperatures within the location are no longer used.

Design period using climate file is used to size the heating wrt. a selected cold period from a climate file. This option may not be fully supported by the standard reports of all providers.

Simulated period Specify the date to be simulated

Click “Run” to start the simulation

Cooling design - Setup



Cooling load calculation

Internal gains

Percentage of internal gains 100 %

Weather

● Use synthetic weather

○ Selected months
(use hottest month if nothing is selected)

☑ Jan ☑ Apr ☑ Jul ☑ Oct
☑ Feb ☑ May ☑ Aug ☑ Nov
☑ Mar ☑ Jun ☑ Sep ☑ Dec

○ Design period using climate file

n.a.

From n.a.

To n.a.

Annotations

Design conditions

Cumulative frequency for dry-bulb max		0.4	%
Dry-bulb min		12.7	°C
Dry-bulb max		27.1	°C
Wet-bulb max		18.7	°C
Wind direction		180	°
Wind speed		4.5	m/s
Clear-sky optical depth	tau_b	0.343	
	tau_d	2.423	

Figure 86.

Internal gains The percentage of internal gains determines the percentage of all internal gains as defined in the rooms that should be applied (normally 100 %).

Weather

Use synthetic weather With synthetic weather, simulations for a hot day of all months are carried out by default, but results are kept only for months where some system or room has a cooling load peak.

Under **Cumulative frequency…** the user may select the degree of severity of the applied climate data.

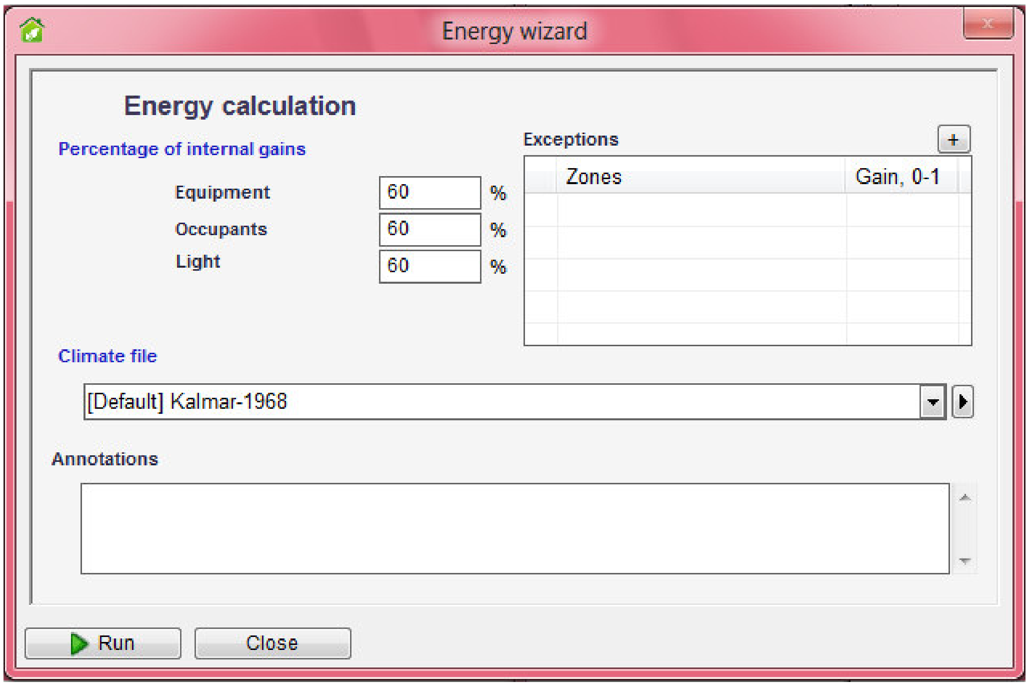
If **Selected months** is selected, and then some specific months are filled in, simulations will only be performed for the selected months. Simulation results (to be viewed under Details) will be saved for all simulated months, not only for the months that show a peak.

Design period using climate file is used to size cooling wrt. a selected hot period from a climate file. This option may not be fully supported by the standard reports of all providers.

Simulated period Specify the date to be simulated

Click “Run” to start the simulation

Energy - Setup



Percentage of internal gains

Equipment 60 %

Occupants 60 %

Light 60 %

Climate file: [Default] Kalmar-1968

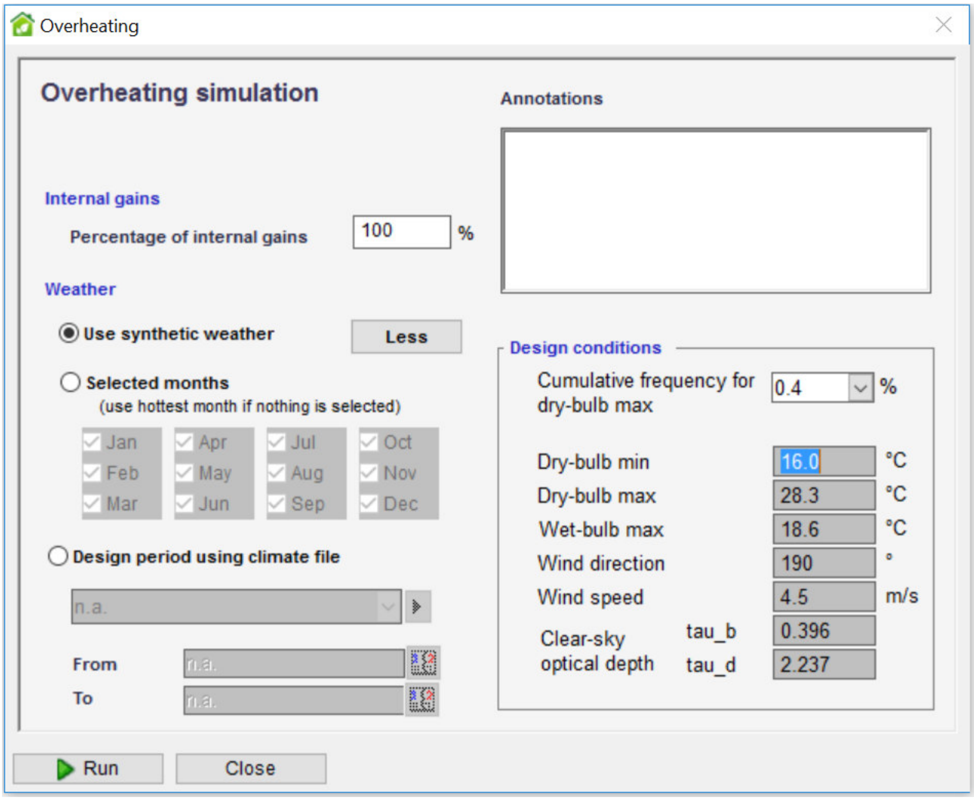
Figure 87

Percentage of internal gains Define percentage of internal gains that should be active for the energy calculation. These factors are applied to account for the fact that buildings only rarely are used to their design capacity.

Climate file allows you to run the simulation with a different climate file.

Click “Run” to start the simulation

Overheating - Setup



Overheating simulation

Internal gains

Percentage of internal gains: 100 %

Weather

● Use synthetic weather

○ Selected months (use hottest month if nothing is selected)

☑ Jan ☑ Feb ☑ Mar ☑ Apr ☑ May ☑ Jun ☑ Jul ☑ Aug ☑ Sep ☑ Oct ☑ Nov ☑ Dec

○ Design period using climate file: n.a.

From: n.a.

To: n.a.

Design conditions

Cumulative frequency for dry-bulb max	0.4	%
Dry-bulb min	16.0	°C
Dry-bulb max	28.3	°C
Wet-bulb max	18.6	°C
Wind direction	190	°
Wind speed	4.5	m/s
Clear-sky optical depth tau_b	0.396	
Clear-sky optical depth tau_d	2.237	

Figure 88

Internal gains The percentage of internal gains determines the percentage of all internal gains as defined in the rooms that should be applied (normally 100 %).

Weather

Use synthetic weather With synthetic weather, simulations for a hot day of all months are carried out by default, but results are kept only for months where some room has a temperature peak.

Under **Cumulative frequency…** the user may select the degree of severity of the applied climate data.

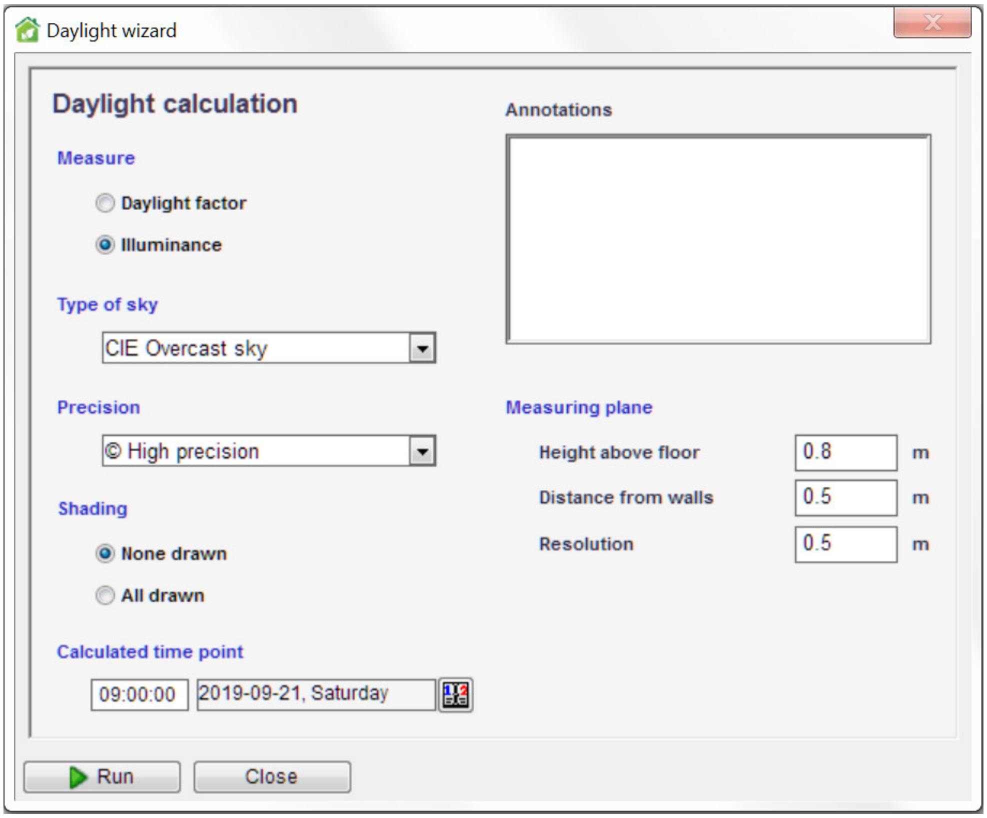
If **Selected months** is selected, and then some specific months are filled in, simulations will only be performed for the selected months. Simulation results (to be viewed under Details) will be saved for all simulated months, not only for the months that show a peak.

Design period using climate file is used to size cooling wrt. a selected hot period from a climate file. This option may not be fully supported by the standard reports of all providers.

Simulated period Specify the date to be simulated

Click “Run” to start the simulation

Daylight - Setup[8]



Daylight calculation

Measure

○ Daylight factor

● Illuminance

Type of sky: CIE Overcast sky

Precision: © High precision

Shading

● None drawn

○ All drawn

Calculated time point: 09:00:00 2019-09-21, Saturday

Annotations

Measuring plane

Height above floor 0.8 m

Distance from walls 0.5 m

Resolution 0.5 m

Figure 89.

Measure Select which measure to calculate, either daylight factor or illuminance.

Type of sky Select one of 4 standard sky models or a climate based sky. If climate based sky is selected, irradiance values are taken from the climate file at the specified time point.

Precision Detail level of Radiance calculation. Right-click and choose Open to see the specific Radiance settings and to create new sets of settings. For details about the specific Radiance settings, see the Radiance documentation.

Shading Select if controllable shades should be up or drawn.

Calculated time point Time point is only used with illuminance calculation.

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[8] Only available with the Daylight extension.

Measuring plane Daylight is calculated on measuring planes. For each room a measuring plane is created at the specified height above the floor, with the specified distance to walls and with the specified distance between measuring points.

Click “Run” to start the daylight calculation.

Export results[9]

Results from heating and cooling load simulations in ESBO can be exported to an IFC file. This is done by choosing Export results. The exported file will not contain a full Building Information Model (BIM), but only simulation results for each ifcSpace.

Standard level

Available only if the full IDA ICE application is accessible.

Build model Click to build and open an IDA ICE model of the system.

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[9] Only available with the BIM Import extension.