Software for Architecture,
Engineering and Construction

CYPETHERM **EPlus**

User's manual

Modelling and simulation of buildings with EnergyPlus™ version 23.1.

Contents

1 Introduction

CYPETHERM EPlus is an application for the modelling and simulation of buildings with EnergyPlus™. It is integrated into the Open BIM workflow via the IFC standard.

CYPETHERM EPlus includes some of the following features:

- Importing the geometric model of the building from IFC files generated by CAD/BIM programs such as IFC Builder (free CYPE application), Allplan®, Archicad® or Revit®.
- Importing the building's air conditioning installation defined with manufacturers' systems from IFC files, generated by the Open BIM DAIKIN, Open BIM FUJITSU and Open BIM VAILLANT programs.
- Simulating the most widespread air conditioning systems in buildings, including manufacturers' predefined equipment.
- Integrating international codes and approved manuals for the definition of the thermal characteristics of the building.
- Checking for surface and interstitial condensation.
- Automatically defining the building's thermal bridges from the edges of the BIM model.
- Reports on the results of the energy simulation of the building: energy demand, energy consumption, indoor comfort.
- Exporting analysis results to CYPETHERM Improvements Plus for the energy analyses and economic analyses of different building proposals.

1.1 System requirements

In order to be able to run the program, a computer with the following characteristics is required:

Windows 7, 8 or 10 operating system (64-bit versions).

1.2 Scope

The simulation limitations of CYPETHERM EPlus match those of the implemented EnergyPlus™ version 23.1 features, which are described in the EnergyPlus 23.1 *Input Output Reference* manual. In some cases, the limitations of the engine have been overcome by means of equivalences and analysis approximations.

The elements that CYPETHERM EPlus can simulate are listed below, along with their known limitations.

Geometry. In terms of the geometric description of the building, there are no known limitations on the number of elements (zones, external walls, openings, etc.), dimensions or shape.

Elements and construction systems. The description of the construction systems is different for opaque walls and openings. In each of these categories, the program allows the following elements to be simulated:

- Opaque building envelopes:

  Walls: façades, party walls, partitions, underground walls (basement walls).

  Slabs: Slab-on-ground floors (screeds) with optional edge insulation, floor slabs, overhangs and roofs.

  The composition of opaque building envelopes is defined by layers. Each layer can be a solid material, an air cavity (even a ventilated cavity wall) or a vapour barrier. There are no limits for the number of layers, as CYPETHERM EPlus automatically groups the defined layers to fit the maximum limit of 10 layers per element permitted by EnergyPlus 23.1.

  Alternatively, the simplified description of the enclosures is permitted with an indication of the thermal characteristics of the assembly.

  Therefore, all construction systems matching these definitions can be simulated.

  One single value can be defined for the air permeability of all façades in the building, and a different one for the roofs.

- Openings: opaque (doors), glazed (windows, skylights, glazed doors, curtain walls) as well as unglazed and doorless units.

The definition of the materials used in the openings is limited to the definition of their overall thermal properties, distinguishing between glazed and opaque fractions in the case of glazed openings.

In windows and skylights, sun protection accessories (blinds and curtains) and their control systems, shading elements (overhangs and lateral protections) and various window elements (lintel, blind box, etc.) that produce flat thermal bridges can be defined.

One value for the air permeability of each glazed opening can be defined. A single value for the air permeability of all doors in the building can be defined, as well as a different value for the openings.

Linear thermal bridges. The effect of the linear thermal bridges produced by the meeting of the different building elements with each other and with the ground is simulated.

Loads and thermal inertias. In each space of the building, the sensible and latent thermal loads due to occupancy (if the space is occupied), lighting, ventilation and internal equipment are considered. The corresponding values can be edited, and hourly usage profiles can be defined.

Air infiltrations are defined at thermal zone level. Their operational conditions can be defined on an hourly basis.

Operational and indoor comfort conditions. The setpoint temperatures of each thermal zone can be edited with hourly resolution, distinguishing between cooling and heating setpoints.

Ventilation systems. In each habitable thermal zone, users can choose between the following options:

- Mechanical ventilation: allows the characteristics of the specific fan(s) for the ventilation feature to be defined.
- Ventilation via the air conditioning system
- Natural ventilation: the area does not have a ventilation system. This option is only allowed in existing buildings.

Air conditioning systems: The program allows the following air conditioning systems to be simulated:

- Constant performance equipment.

- Electric heating transmitters (Joule heating).
- Sensible heat recovery and heat recovery wheel, single zone system.
- Water HVAC systems**:**
  - Heating by radiators and radiant floor heating.
  - Fan-coils.

  Can be connected to the following types of hydraulic circuits:
  - Hot-water systems by condensing or non-condensing boilers and by air-to-water heat pumps.
  - Air-source heat pump systems (optional domestic air-to-water heat pump for heating and cooling).
- Direct expansion HVAC systems:
  - Split air conditioning (split 1x1)
  - Packaged air conditioning units with electric, gas or water heating (PTAC).
  - Air-to-air heat pumps (PTHP).
  - Multisplit system.
  - Variable refrigerant flow system (VRF), heat pump and 3 pipe heat recovery. The external unit can have an air-cooled chiller, water-cooled chiller, or evaporative-cooled chiller.
  - Water to air heat pump.

- All-air HVAC systems:
  - Constant all-air volume systems, single-zone (rooftop units) and multi-zone (with terminal reheating).
  - Variable all-air volume systems (VAV), with variable flow boxes with and without series and parallel fan.
  - Dual duct systems, constant all-air volume and variable air volume, with a single fan or with a fan per duct.
  - Centralised ventilation systems (only processing the ventilation air flow):
    - Sensible heat recovery and heat recovery wheel.
    - Dedicated outdoor air system (DOAS).

The air handling units (AHUs) associated with these air conditioning systems are configurable. The characteristics of the following elements can be defined:

- Cooling coil:
  - Water coil, connected to a water-air conditioning system using chillers.
  - Direct expansion, available in single-zone constant all-air volume systems, in simple duct variable flow systems and in the dedicated outdoor air systems (DOAS).
- Heating coil:
  - Water coil, connected to a hot-water system using boilers and/or air-to-water heat pumps.
  - Electric.
  - Gas.
  - Direct expansion, available in single-zone constant air volume systems and in the dedicated outdoor air systems (DOAS).
- Supply fan.
- Humidity control: dehumidification and humidifier.
- Outdoor air intake, with the following features:
  - Free cooling.
  - Sensible and enthalpy heat recovery systems.
  - Return fan.

The heat recovery unit has a bypass damper that allows outdoor air to pass through when it is beneficial to reduce cooling needs. If the heat recovery unit is integrated in equipment with cooling and heating coils, the bypass damper will act in accordance with the operation of the coils.

The characteristics of the heat recovery units are taken into account for the calculation of the energy demand of the building.

- Water-cooled system:
  - System for chillers, by cooling towers of 1 or 2 speeds.

- System for reversible heat pumps, using cooling towers and boilers.
- Water-cooled system at a defined temperature (constant or scheduled).

The following limitations apply to the simulation of air conditioning systems:

Availability and activation schedules of the air conditioning systems cannot be defined, expect in *Constant performance equipment*. In general, the air conditioning systems are activated automatically to maintain the set point temperatures defined in the thermal spaces. Air HVAC systems, if they have an external air intake, can follow the use profile defined for the ventilation of the spaces in the areas they serve. Otherwise, they continuously drive air.

The performance curves of the boilers and the chillers can be edited. The rest of the generic systems are simulated with the default performance curves of the EnergyPlus 23.1 template objects. Commercial equipment is simulated with the manufacturers' performance curves.

Only one *Constant performance equipment* can be defined per zone. Likewise, each zone can be served by only one *Air-air conditioning system*. Both types of equipment can be defined with any other terminal unit in the same zone. All other air conditioning systems can be repeated and combined with no restrictions.

Finally, only one terminal unit with ventilation function can be defined in the zone. All ventilation airflow assigned to the spaces in the zone will enter through that terminal unit.

DHW systems. A DHW system is made up of a group of production sets and storage tanks that meet a DHW demand. The program does not perform the dynamic simulation of the DHW production. The energy consumption for this item is calculated from the DHW demand, including heat losses from storage tanks, distribution and recirculation losses, and the average seasonal coefficient of performance of the production sets.

Energy production in the building. Primary systems can be defined for the on-site production of the following:

- Thermal energy for heating and DHW from renewable sources. Thermal energy production is defined on the basis of the building's requirements.
- Electrical energy from renewable sources. The amount of energy produced can be defined as monthly values or as the total electrical energy consumed on site.

Maximum and minimum values. The following limits are known in the values of some properties, imposed by the EnergyPlus 23.1 models that are used in CYPETHERM EPlus:

Specific heat of solid materials. The minimum value is 100 J $kg^{-1}K^{-1}$. If a lower value is defined, the program will automatically assume the minimum value.

Global heat transfer coefficient (U) of glazed openings or their glazed fraction. The maximum allowed value is 7 W $m^{-2}K^{-1}$.

Overall heat transmission coefficient (U) of the opaque fraction of glazed openings. The maximum permissible value is 5.80 W $m^{-2}K^{-1}$.

1.3 Regulatory framework

CYPETHERM EPlus includes the following codes:

Building materials

EN ISO 10456. Building materials and products. Hygrothermal properties. Tabulated design values and procedures for determining declared and design thermal values.

Thermal resistance and thermal transmittance coefficient of building elements

EN ISO 6946. Building components and building elements. Thermal resistance and thermal transmittance. Calculation methods.

EN ISO 13370. Thermal performance of buildings. Heat transfer via the ground. Calculation methods.

EN ISO 10077-1. Thermal performance of windows, doors and shutters. Calculation of thermal transmittance. Simplified method.

EN ISO 13789:2017. Thermal performance of buildings. Transmission and ventilation heat transfer coefficients. Calculation method.

Linear thermal bridges

EN ISO 14683. Thermal bridges in building construction. Linear thermal transmittance. Simplified methods and default values.

EN ISO 10211. Thermal bridges in building construction. Heat flows and surface temperatures. Detailed calculations.

2 Getting started

This section describes the structure of the program and the basic controls that are common to CYPE software.

2.1 Start screen

Launching the program displays the start screen, which is divided into the following sections:

File. Allows users to create a new file, open an existing file or open one of the files offered as an example.

Recent files. Quickly accesses the most recently opened files in the program.

Help. Accesses program documents. Clicking **About...** displays the license number**.**

BIMserver.center. From the top bar of the screen, users can log in to BIMserver.center with their user account and password.

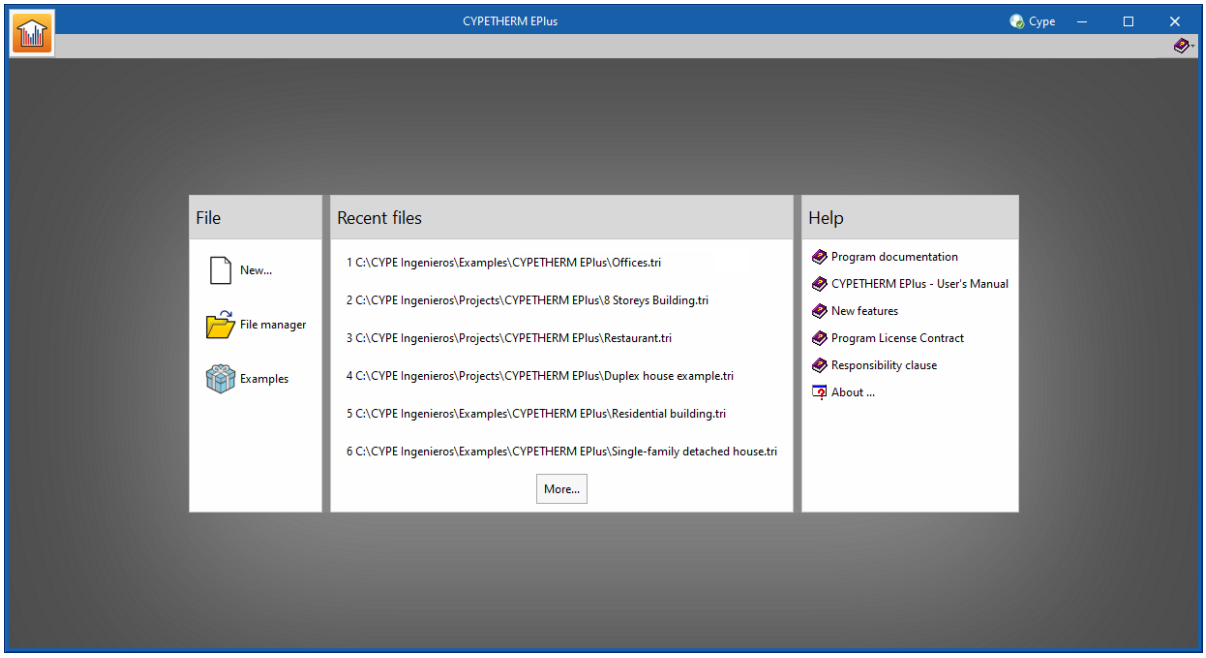


Fig. 1. Start screen

To continue reading this manual, please log in to your BIMserver.center account and open the *Offices* example job by clicking on the **Examples** option in this start screen.

To start creating a new file, go to the *Working method: Open BIM workflow* section.

2.2 Interface structure

The program interface is divided into three tabs: *Building*, *Floor Plans* and *Analysis*. Each of these tabs is split into four sections.

Toolbar. Contains the program's main features.

Building components tree. Contains the elements that make up the analysis model.

Main window. Allows the position of the selected element in the tree or in the main window to be displayed in the 3D model.

3D model viewer. Allows users to edit the properties or view the results of the selected element in the project tree.

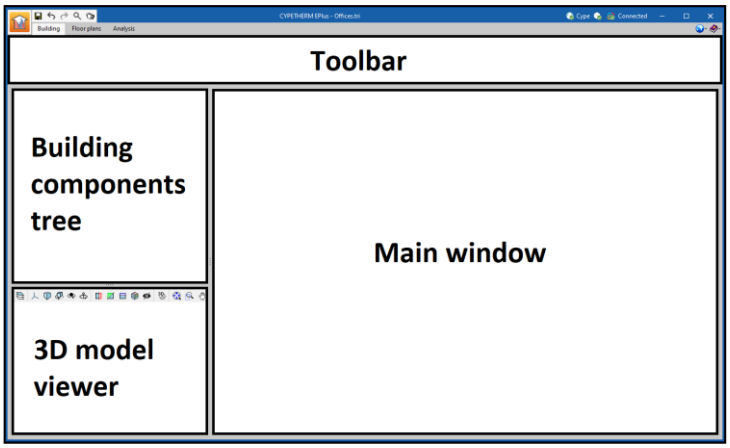


Fig. 2. Interface structure

2.3 Tools

This section describes the program's basic controls. These features and their symbols are common to CYPE software.

2.3.1 *Main menu*

This menu can be accessed from the main option bearing the program icon, located in the top left-hand corner of the screen. The menu contains the basic controls.

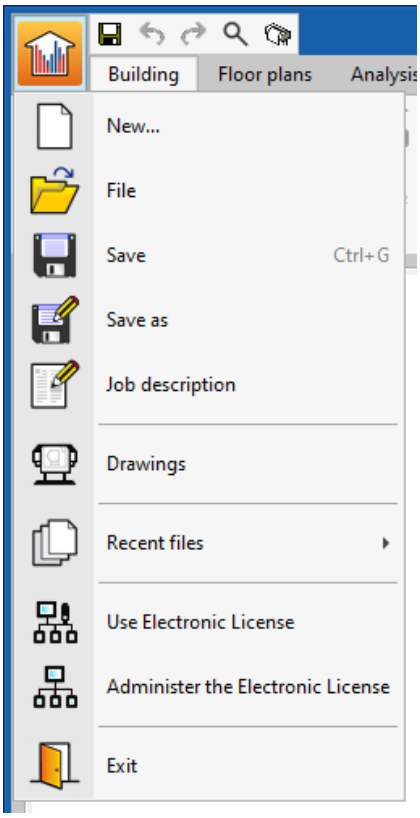


Fig. 3. Main menu

New. Creates a new file.

File. Opens the *File management* window, which presents the tools listed below, that can be used to run CYPETHERM EPlus files (.tri files)

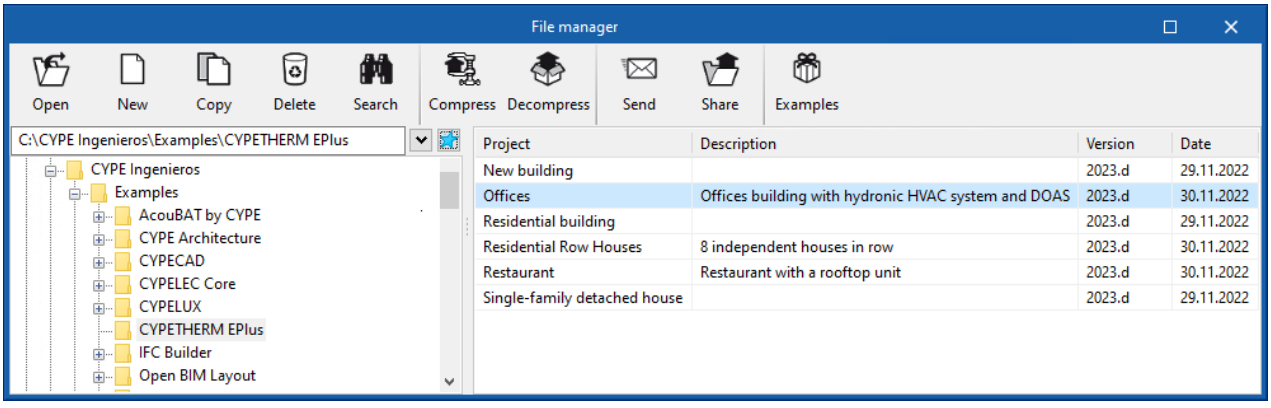


Fig. 4. Managing files

Open. Opens the selected file.

New. Creates a new file.

Copy. Copies the selected file.

Delete. Deletes the selected file.

Search. Searches for files by keyword.

Compress. Compresses the selected file in .cyp format.

Decompress. Decompresses a file in .cyp format. The decompressed file will only be visible in the file management window if it is a CYPETHERM EPlus file (.tri file).

Send. Compresses and sends the selected file to CYPE technical support by e-mail.

Share. Shares the selected file over the internet. The file will be stored on a server in .cyp format and an address for accessing it will be generated. The file can only be accessed by people who have this address.

Examples. Allows users to restore and access the example jobs in the program.

Save. Saves the changes made to the file. The program automatically saves the changes when switching to the *Analysis* tab.

Save as. Saves the file under a different name or in a different location.

Job description. Allows the description of the job entered to be modified when creating a new file.

Drawings. Opens the wizard for printing drawings, in order to obtain the drawings contained in the *Floor plans* tab.

Recent files. Allows users to access the most recently opened files in the program directly.

Exit. Closes the program.

2.3.2 *General settings*

This menu can be accessed from the option with the globe icon, located in the top right-hand corner of the screen. Here, several general program features can be configured, such as the units of measurement.

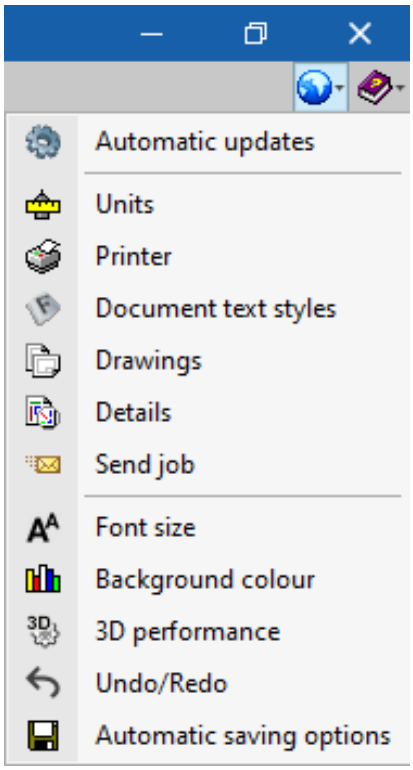


Fig. 5. General settings menu

2.3.3 *Help*

This menu can be accessed from the option with the book icon, located in the top right-hand corner of the screen. It contains the program's documents, including the user manual, and user license information.

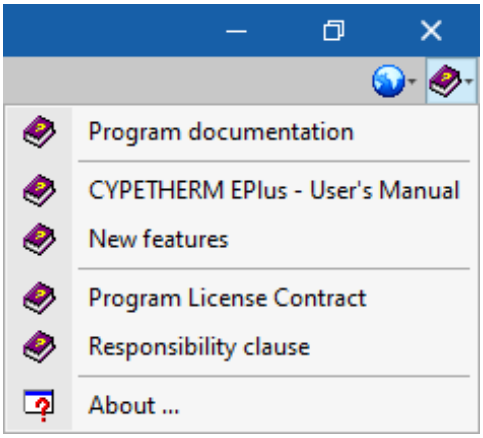


Fig. 6. Help menu

Integrated help messages are also provided in the program's panels:

Displays a specific help message about the option in the window.

2.3.4 *Managing elements in lists*

In several program windows, the elements in the job are organised into lists. The following controls are provided to manage and edit the elements:

Adds a new element to the list.

Deletes the selected item from the list.

Duplicates the selected item, adding a copy to the list.

Accesses the editing panel of the selected item.

Slides the selected element through the list, to arrange its order.

Assigns the characteristics of the selected element to other elements in the list.

Displays the list of available elements.

2.3.5 *Using libraries*

Using libraries allows elements to be defined in the current job and saved on hard drives to be used in other projects.

When importing or updating the BIM model, a directory can be defined to search for types. If this directory contains CYPETHERM EPlus elements whose references coincide with those of the elements in the current job, the program will automatically import their properties.

Imports the elements saved on the hard drive into the job. If this control is applied to an element defined in the job, only the properties of the saved element will be imported, without altering the reference of the element defined in the current job.

Updates the elements defined in the job, with the properties of the elements saved on the hard drive with the same reference.

Exports the selected item to a file, so that it can be imported at a later stage.

Selects a list of saved elements to be loaded into the library when creating a new file.

2.3.6 *Property definition wizards*

Wizards are provided for most of the elements in the job in order to define their properties, with values from reference sources such as the EN and ISO Standards or ASHRAE (American Society of Heating, Refrigerating and Air-Conditioning Engineers) manuals.

Open the element definition wizard. For air conditioning systems, this option restores the default properties.

2.3.7 *Generating drawings*

A tool for generating and printing drawings is included in the **Drawings** option in the *Main Menu* and using the quick access option located above the tabs. In CYPETHERM EPlus, this wizard works on the drawings and templates defined in the *Floor Plans* tab.

In the window that opens when clicking on these two options, the desired drawings (floor plans) can be added to the plan and the printing peripheral can be chosen, including printing in PDF format.

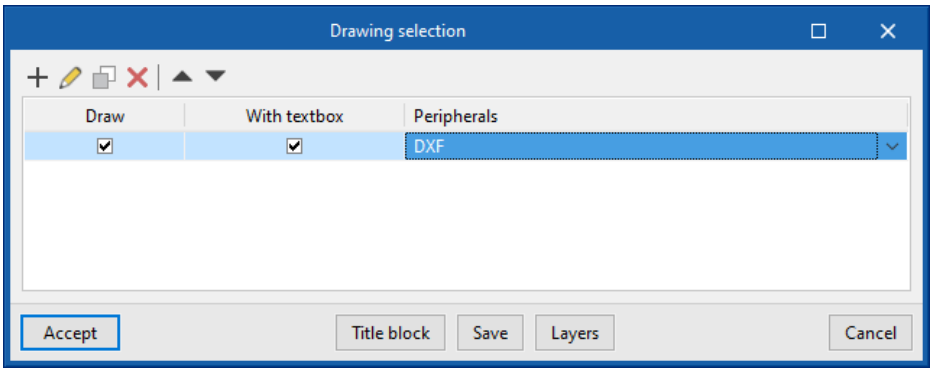


Fig. 7. Graphics to be added to the drawing

When clicking on **Accept**, the **Drawing layouts** tool opens in a new window, where the different graphics selected in the project's drawing can be arranged.

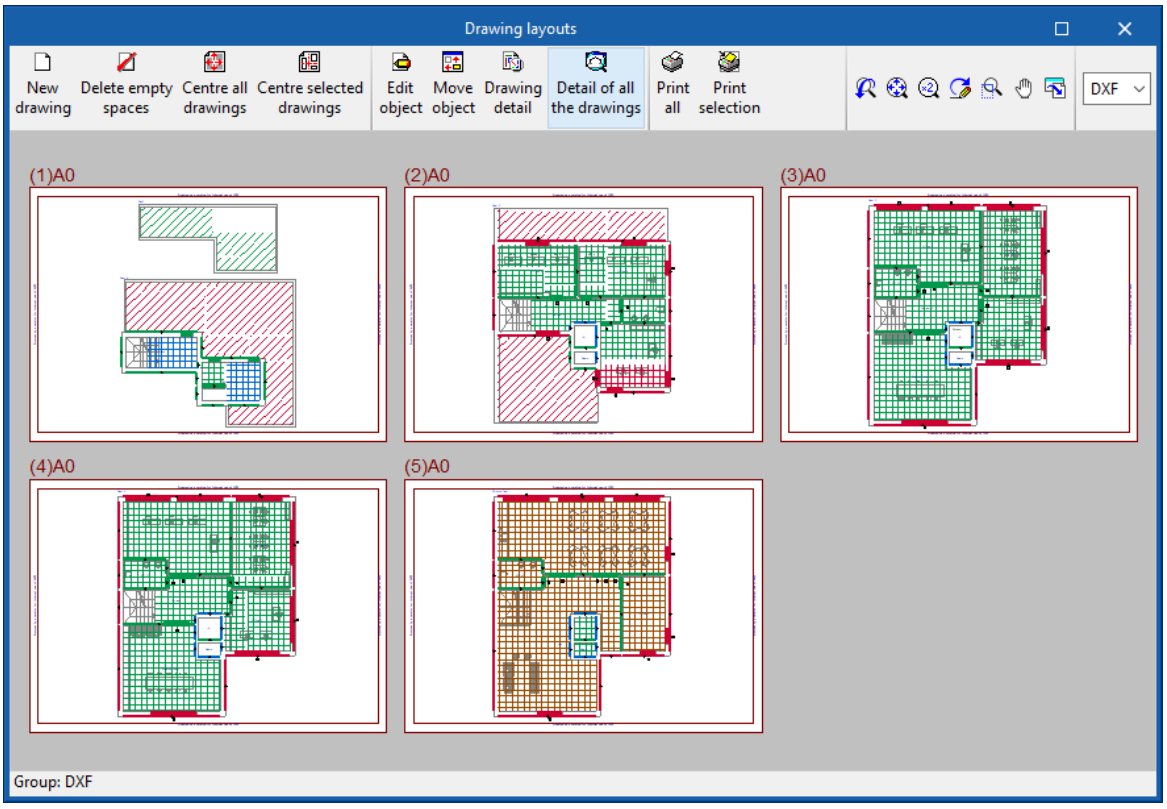


Fig. 8. Tool for generating and printing drawings

3 Building

The *Building* tab defines the general parameters, the location data and the building model. The building model is contained in a tree diagram consisting of the following branches:

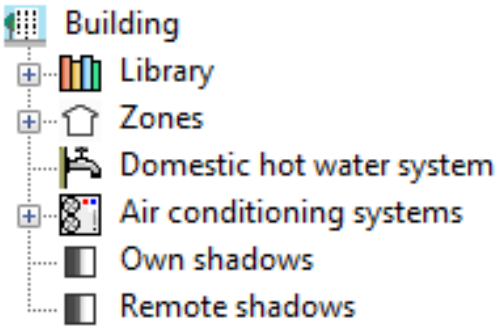


Fig. 9. Components tree of the building model

Library. The different space types and building elements in the job (external walls, partition walls, glazed openings, doors and linear thermal bridges) are entered in the library.

Zones. In each zone, the spaces within it are entered by defining the walls (façades, party walls, partition walls and basement walls), slabs (screeds, floor slabs, overhangs and roofs) and linear thermal bridges. Terminal units of the air conditioning system(s) covering the spaces in the zone are also entered.

DHW systems. Building systems for producing domestic hot water (DHW) are defined.

Air conditioning systems. Subsystems for producing and distributing the heating and/or cooling system(s) of the job are defined.

Own shadows. Building surfaces that do not belong to the spaces but that can cast shadows on facades and roofs, such as balcony slabs or railings, are defined.

Remote shadows. Surfaces of remote obstacles that could cast shadows on the building are defined.

3.1 General parameters

In the *General parameters* panel, the following general data for the building is defined:

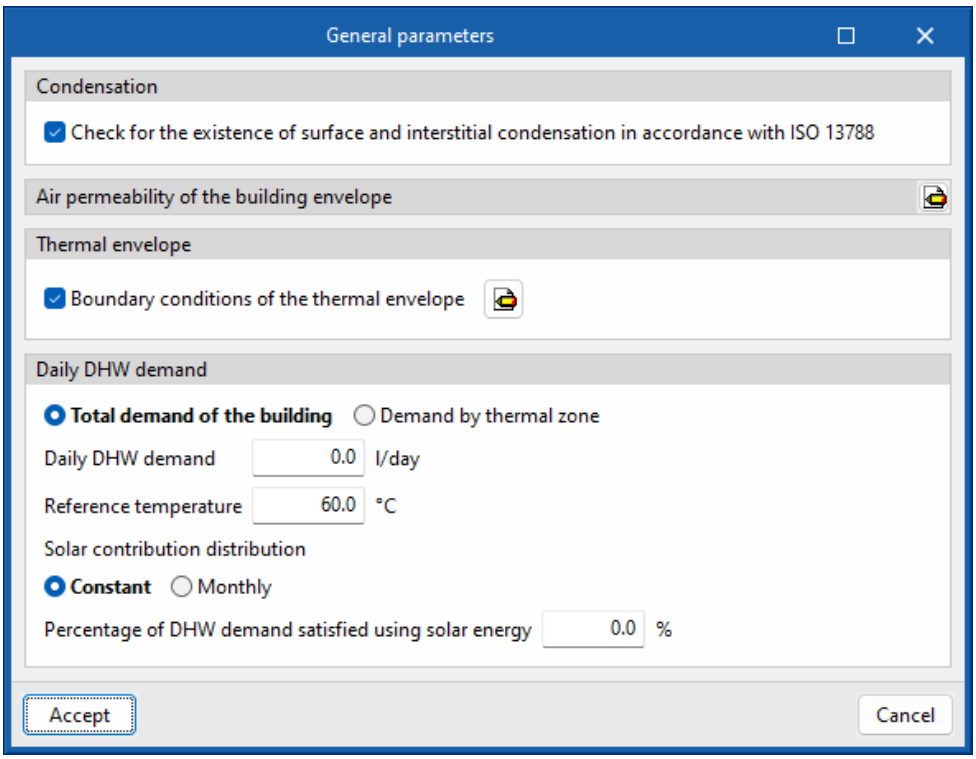


Fig. 10. General parameters

3.1.1 *Condensation*

The program optionally includes the checking of the existence of surface and interstitial condensation according to the EN ISO 13788 standard, offering results for each construction system. If this option is activated, the energy simulation is not allowed to be carried out if the condensation checks are not met.

3.1.2 *Air permeability of the building envelope*

Air permeability values are defined for the different types of opaque elements and openings that make up the building envelope. A limit value of the air change ratio with a differential pressure of 50 Pa (n50) can be defined, which will be compared with the value calculated for the building in the *Thermal envelope* report.

3.1.3 *Thermal envelope*

Optionally, the program includes the verification of thermal transmittance (U) limit values for the different types of building elements. Users can define these values in this section. If any of the components in the building's thermal envelope exceeds the established limit value, a warning will appear when the *Check the model* option is selected.

3.1.4 *Daily DHW demand*

The Domestic Hot Water (DHW) demand can be defined as a single value for the whole building, or a value can be defined for each thermal zone. The parameters related to DHW are described in the *Thermal zones of the building* section.

3.2 Location data

In the *Location data* window, the climatic data of the location where the building is situated is described. The energy simulation shall be performed with the climate data file indicated in the *Climate data file* section, located in the top left-hand corner of this panel. The wizard allows users to fill in the data in the panel with the information contained in the file. The outdoor temperature, wind distribution and solar irradiation graphs shown in this panel reflect the data from the selected climate data file.

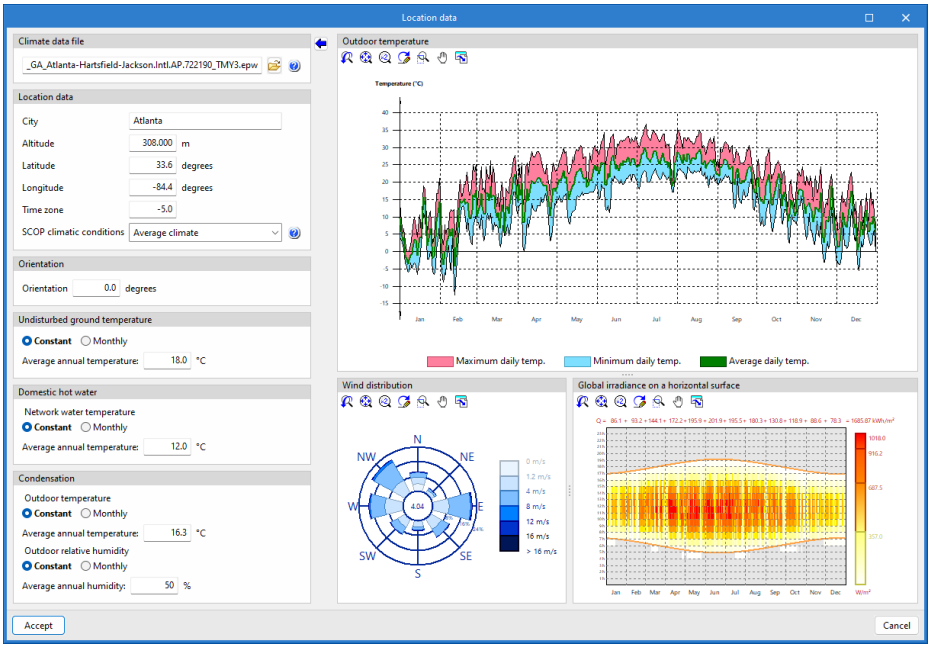


Fig. 11. Location data

The location-related parameters used in the program's calculations are defined as follows:

3.2.1 Location data

3.2.1.1 City, Altitude, Latitude, Longitude, Time zone

This data is informative and is involved in the drafting of the results reports. In the energy simulation, these parameters are automatically read from the .epw climate data file.

3.2.1.2 SPF climatic conditions

Select the appropriate climate zone for the location of the building. This selection is used to determine the average seasonal coefficient of performance for DHW production ($SCOP_{DHW}$) of the heat pump systems.

3.2.2 Orientation

Allows users to rotate the building. The orientation of the building is displayed in the *Floor Plans* tab, using the arrow in the bottom left corner of the plan view.

3.2.3 Undisturbed ground temperature

The ground temperature (unaffected by ambient conditions) is defined as a constant value for the whole year or per month. These values are used in the calculation of heat losses to the ground.

3.2.4 Domestic hot water

The temperature of the mains water is defined, with a constant value for the whole year or per month. These values are used in the calculation of the energy required for producing domestic hot water (DHW).

3.2.5 *Condensation*

The outdoor temperature and humidity values to be used to check for condensation are defined. Constant values can be defined for the whole year or per month.

3.2.6 *Climate data file*

Enter the location of the climate data file in .epw format for the building location. More than 2100 climate .epw data files for locations all over the world are available free of charge on the official EnergyPlus website (energyplus.net/weather).

3.3 Energy sources

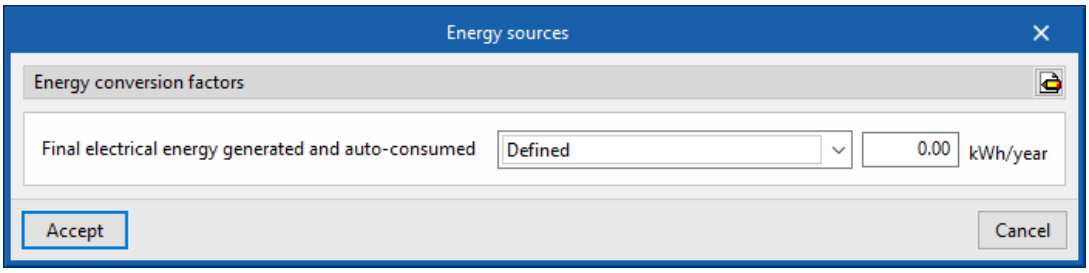


Fig. 12. Energy sources

3.3.1 *Energy conversion factors*

Pitch factors from final energy to primary energy, non-renewable primary energy and CO_2 emissions are defined for the different types of energy vectors available in the program.

3.3.2 *Generated and self-consumed final electrical energy*

The annual amount of electrical energy generated and consumed by the building itself, usually due to the use of on-site renewable sources (PV solar systems, small wind turbines, mini-hydros, etc.), is defined. The indicated value shall be subtracted from the annual final electrical energy consumption to determine the share of electrical energy consumption from the grid.

3.4 Library

The library contains the types of elements used in the job. The elements in each of the library sections are created and managed via the controls for list management and the use of libraries, described in the *General Tools* section.

The elements that make up the building model are classified into the following types.

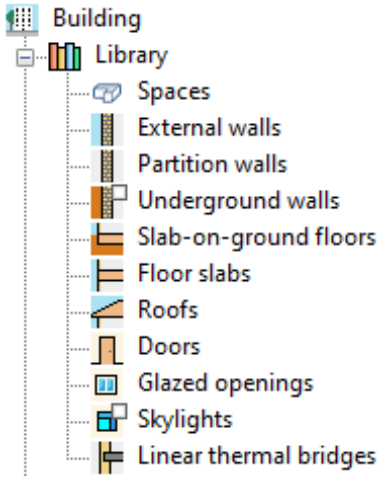


Fig. 13. Library of building element types

3.4.1 *Spaces*

The concepts defined for each type of space are those related to internal heat gains. Depending on the type of internal gains present, two types of spaces can be distinguished:

Occupied. Indoor space intended to be used by people. In these spaces, the ventilation flow rate, the installed power of lighting, the occupancy and activity level and the installed power of the internal equipment can be defined.

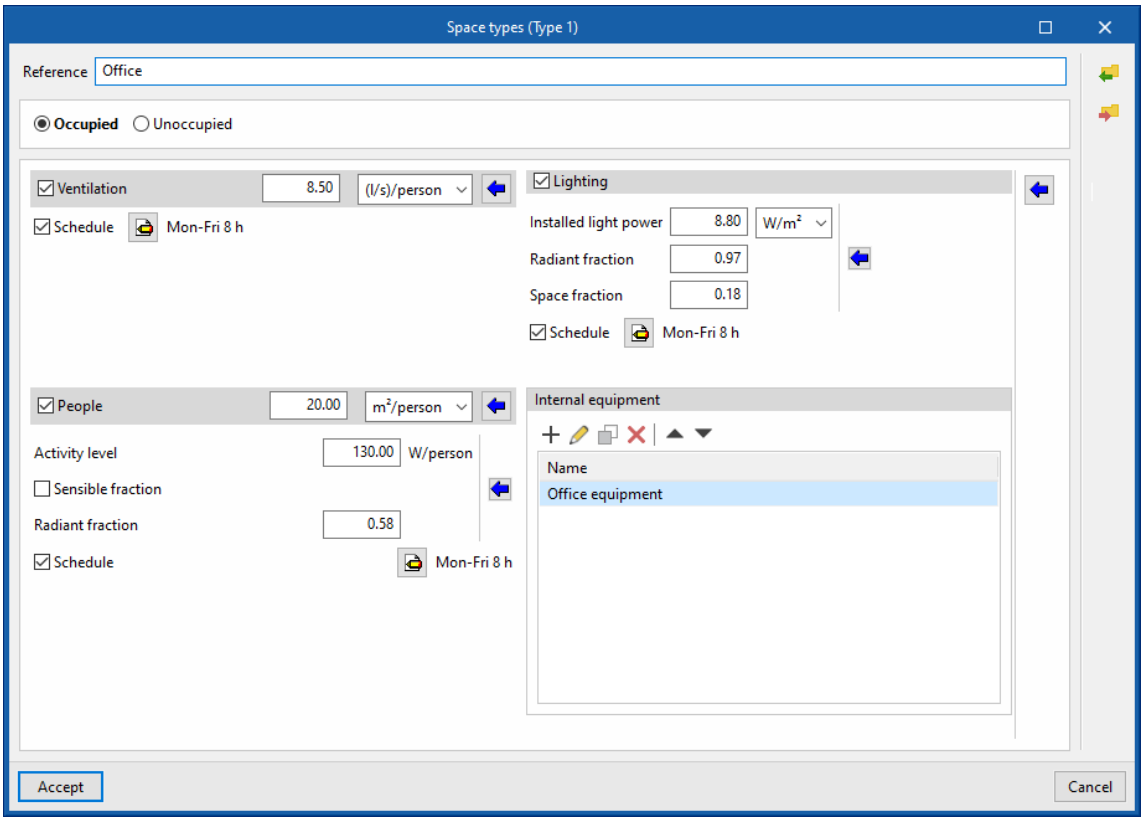


Fig. 14. Occupied space

Each of these concepts is defined by a nominal value and a schedule, which modifies this nominal value during the year by applying a percentage. If no schedule is defined, the nominal value is considered constant throughout the year.

To the right of each of these concepts is a wizard that provides nominal values according to the use of the space. To the right of the panel, the wizard option that encompasses all four concepts offers values for the entire space.

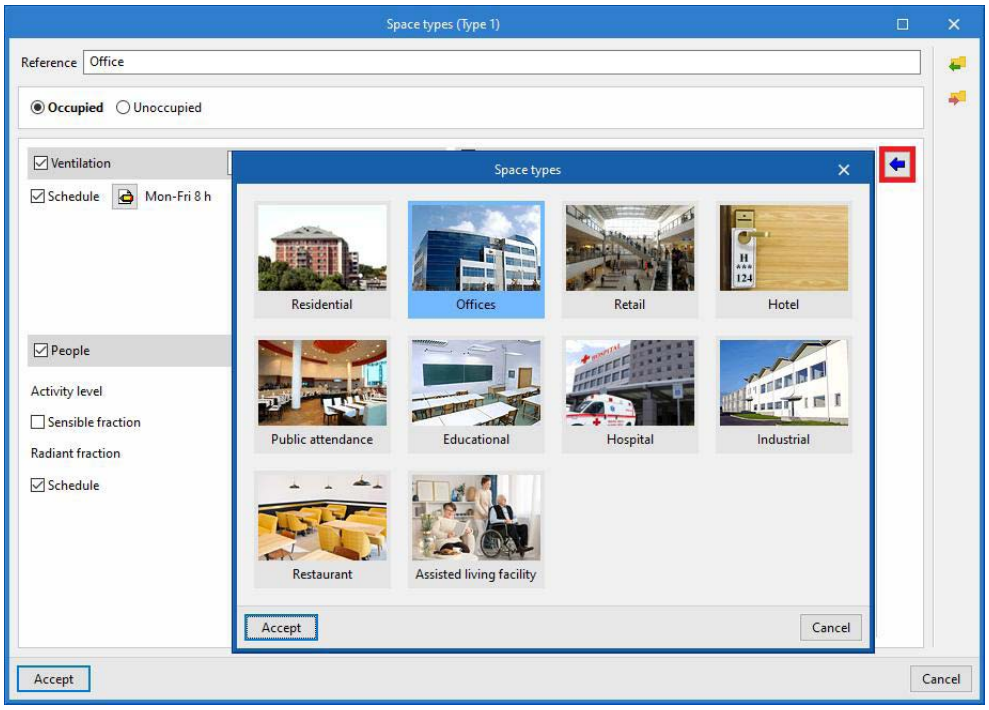


Fig. 15. Space type definition wizard

Unoccupied. Indoor space that is not intended for permanent use by people, i.e. a room without air conditioning requirements (e.g. garage, storage room or technical room). In these spaces, users can define the ventilation flow rate (which shall be permanent), the installed lighting power and the installed power of the internal equipment.

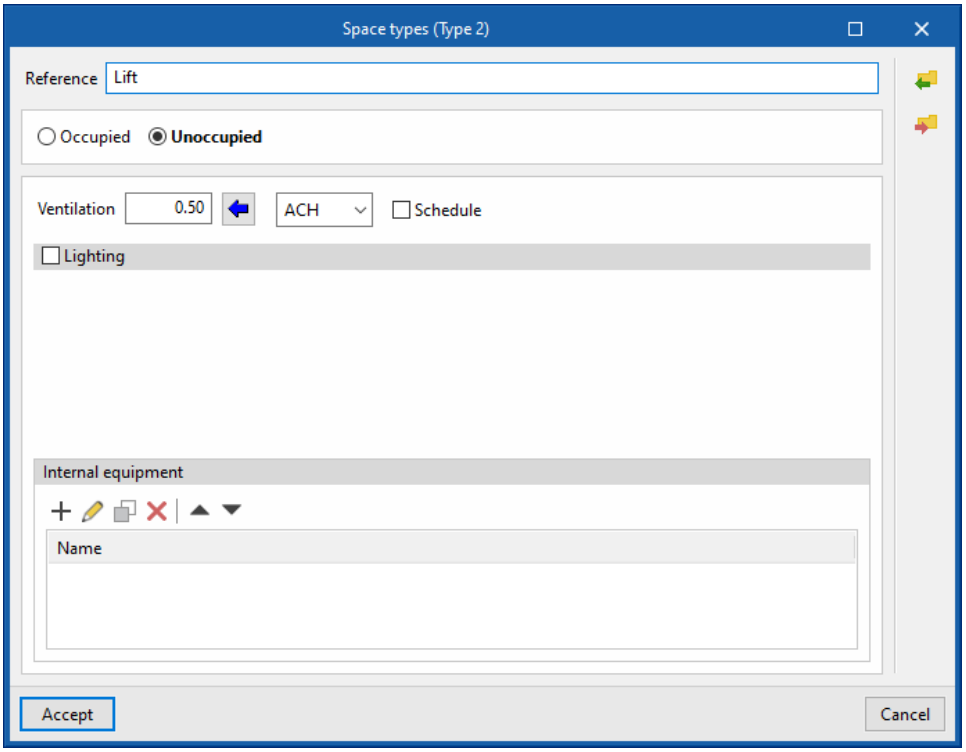


Fig. 16. Unoccupied space

3.4.2 *Opaque building elements*

Opaque building elements are classified into the following categories within the library:

External walls. Vertical enclosures in contact with the exterior environment (façades) or in contact with the spaces of another building (party walls). When defining an external wall, users must specify whether it is a party wall and whether it is adiabatic.

Partition walls. Internal partition walls are fitted to separate the building's interior into different rooms.

Underground walls. These underground vertical external walls are used to build floors below ground level (basements).

Slab-on-ground floors. Horizontal enclosures (screeds, raised floor slabs) in floors that are in direct contact with the ground.

Floor slabs. Floor slabs are the horizontal or slightly inclined lower enclosures between one floor and another, i.e. the flooring of each intermediate floor of the building. This category also includes overhangs, i.e. enclosures in contact with the exterior environment from the lower side.

Roofs. Superior enclosures in contact with the external environment.

There are two ways to define the opaque building elements:

3.4.2.1 *Defining by layers*

The layers of materials that make up the enclosure are defined in order, from the outside to the inside in the case of vertical enclosures (walls), and from the top to the bottom in the case of horizontal enclosures (floors).

The materials used in opaque enclosures are classified into solid materials, air gaps (including ventilated façades) and vapour barriers. The thermal properties of each of the materials must be defined according to their Layer type. To the right of the Layer panel, multiple material libraries from various countries' standards are provided.

A single value of the absorption coefficient of the building element is indicated, which must correspond to the external layer (that receives solar radiation).

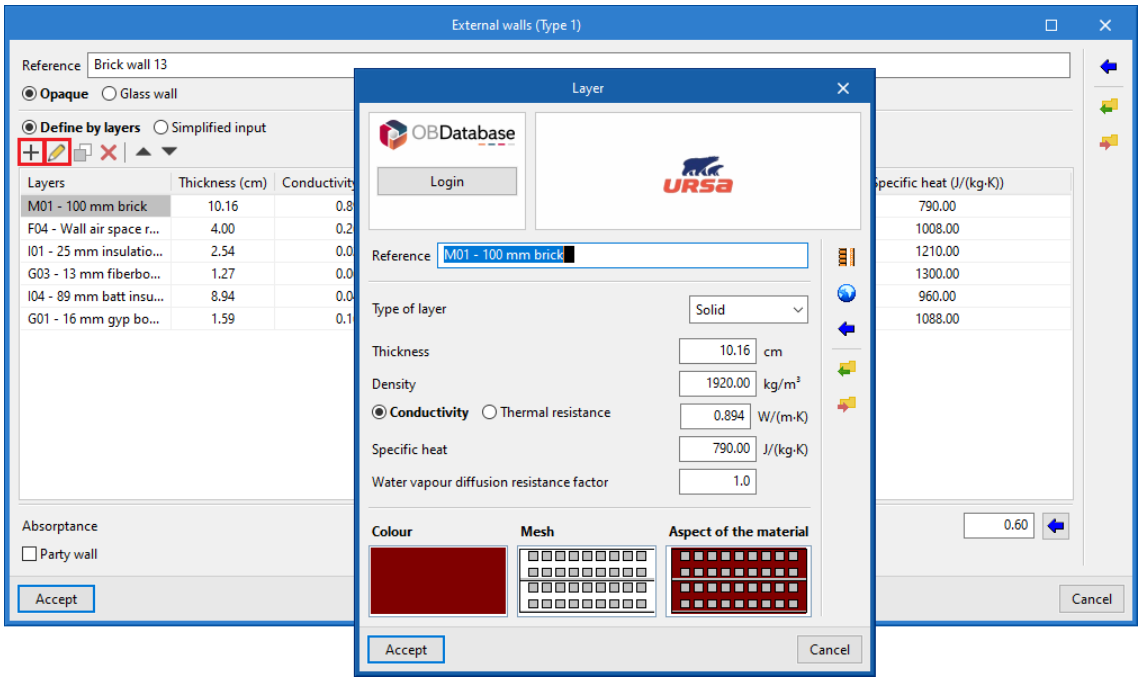


Fig. 17. Definition of opaque building elements by layers

3.4.2.2 *Simplified definition*

The global thermal properties of the enclosure are defined. The *Heat capacity by surface unit* is not used in the simulation; it is only used in the drafting of the results reports.

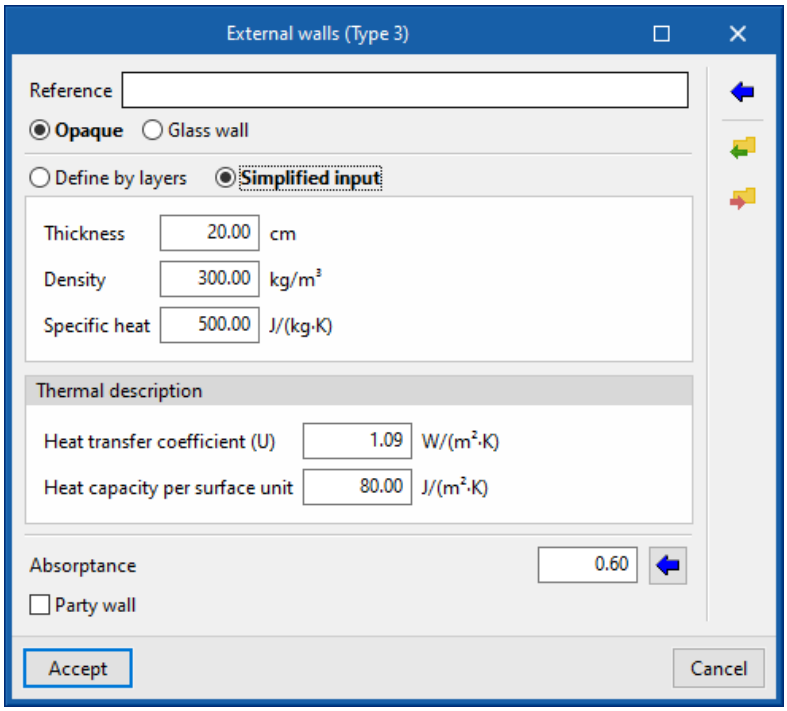


Fig. 18. Simple definition of opaque building elements

3.4.3 *Building openings*

Building openings are classified into the following categories within the library:

Doors. Opaque openings. Defined by their heat transfer coefficient (U-value) and their absorption coefficient.

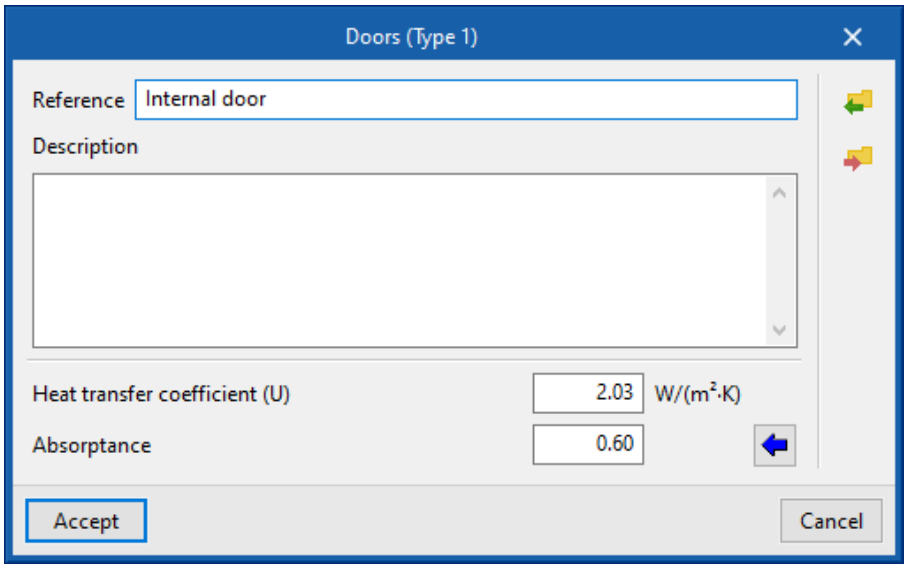


Fig. 19. Defining doors

External walls. Glazed option. Vertical translucent enclosures in contact with the external environment (curtain wall systems).

Glazed openings. Translucent openings in vertical enclosures (windows and glazed doors).

Skylights. Translucent openings in horizontal enclosures.

When defining glazed openings and skylights, the following characteristics are permitted:

Air leakage rate for a reference pressure of 100 Pa. This value depends on the type of fittings, available via the wizard.

Glazed fraction. The heat transfer coefficient (U-value) and the solar heat gain coefficient of the opening must be specified. If the *Opaque fraction* option is selected, the values indicated in this panel will only be applied to the glazed fraction of the opening.

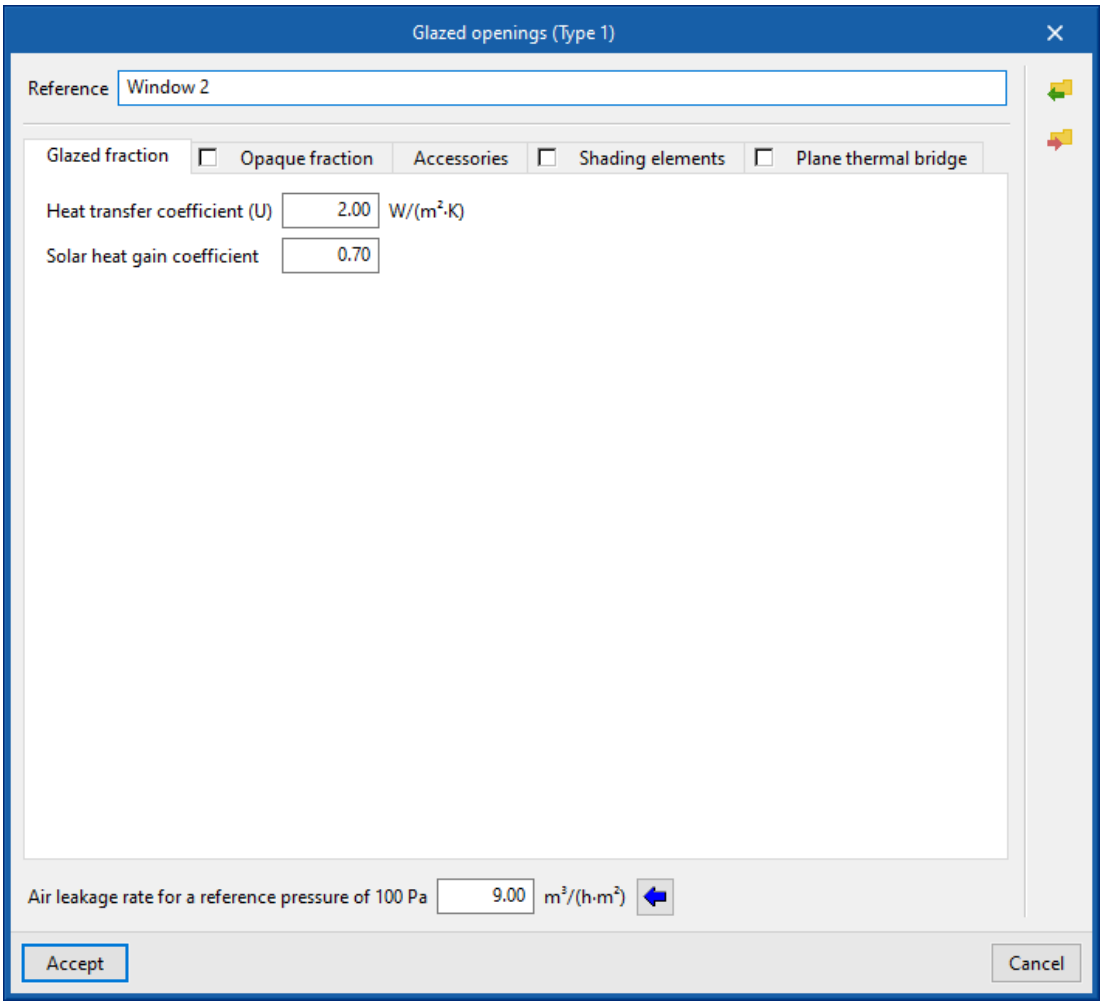


Fig. 20. Defining glazed openings and skylights. Glazed fraction

Opaque fraction. The opening frame fraction and its thermal properties can be specified, as well as the existence of thermal bridges due to the coupling between the different parts that make up the opening, which are defined by both their length and linear thermal transmittance. A wizard is provided to determine the latter parameter with values from EN ISO 10077-1.

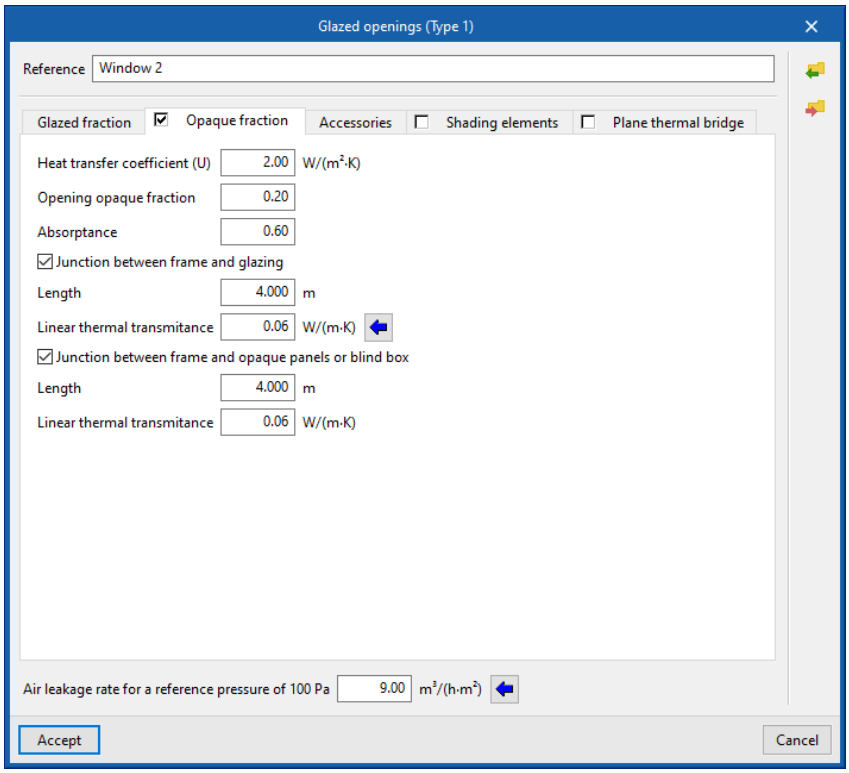


Fig. 21. Defining glazed openings and skylights. Opaque fraction

Accessories. Accessories for external solar protection (blinds) or interior solar protection (curtains) can be added and activated.

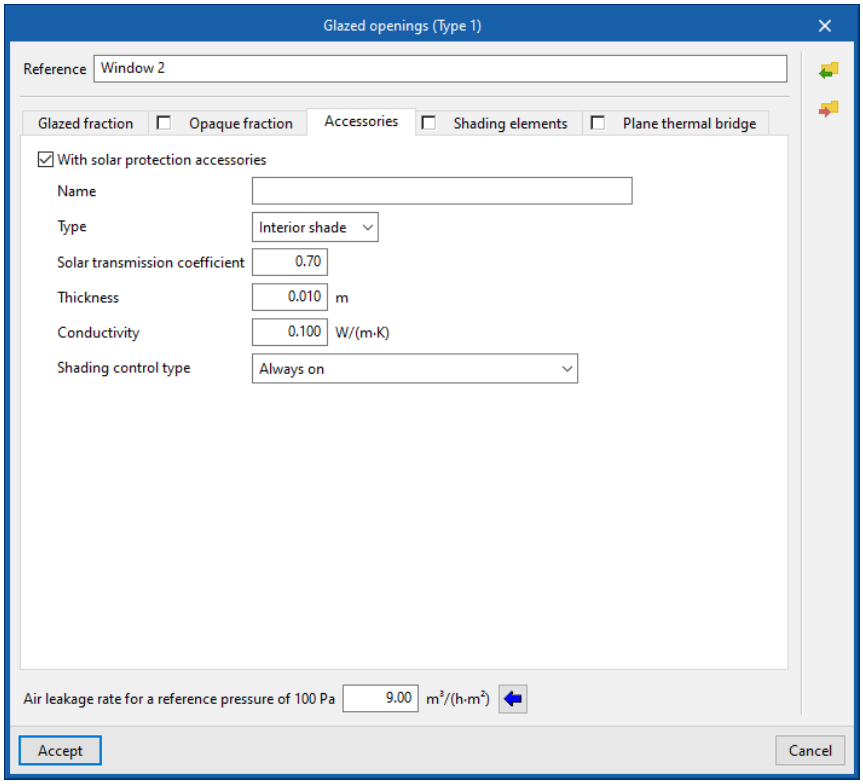


Fig. 22. Defining glazed openings and skylights. Solar protection accessories

Shading elements. Overhangs on the façade that cast shadows on the opening can be defined.

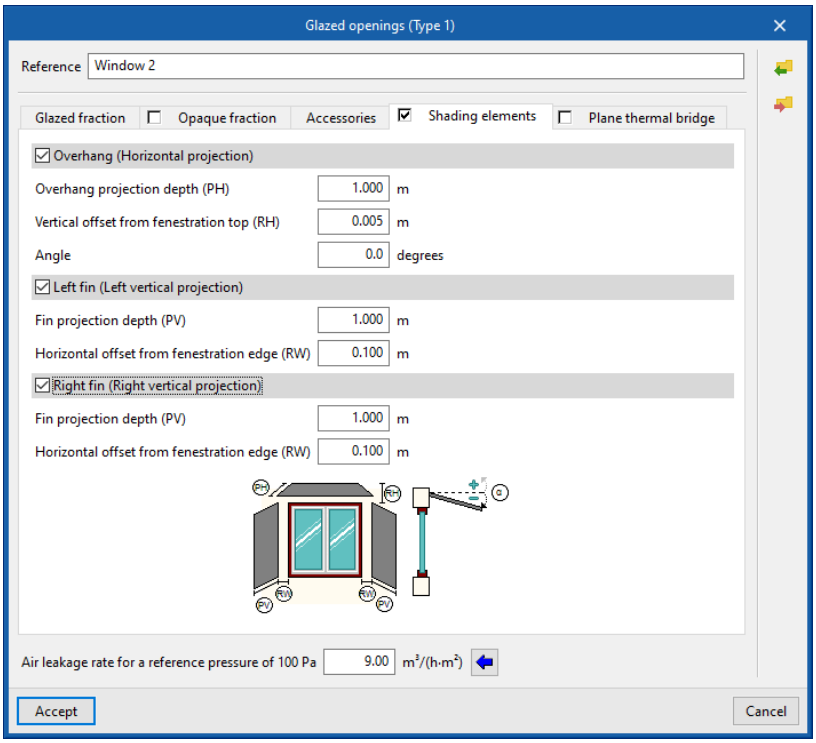


Fig. 23. Defining glazed openings and skylights: Fixed shading elements

Plane thermal bridges. Building elements surrounding the opening can be defined by layers of materials or by their overall thermal properties, in order to consider the heat transfer through them.

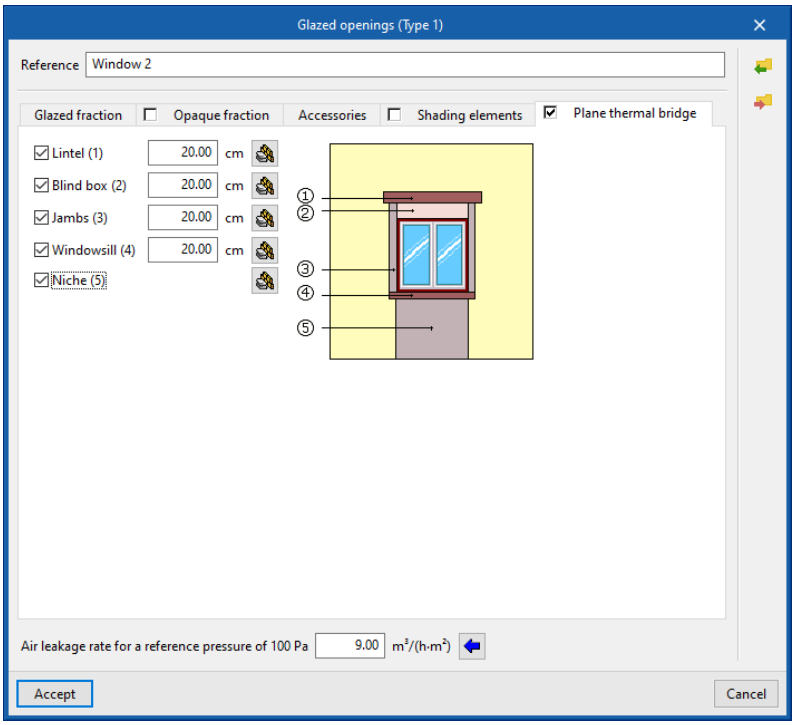


Fig. 24. Defining glazed openings and skylights. Plane thermal bridges

3.4.4 *Linear thermal bridges*

Linear thermal bridges are produced when different building elements come into contact with each other and with the ground.

In order to define a type of thermal bridge, its *Psi* linear thermal transmittance and the origin of this value must be specified (*Value* drop-down menu). Thermal bridges marked with the **Undefined** option will not intervene in the energy simulation.

A number of wizards are provided based on different codes in order to determine the value of the linear thermal transmittance depending on the type of intersection and the characteristics of the building elements involved.

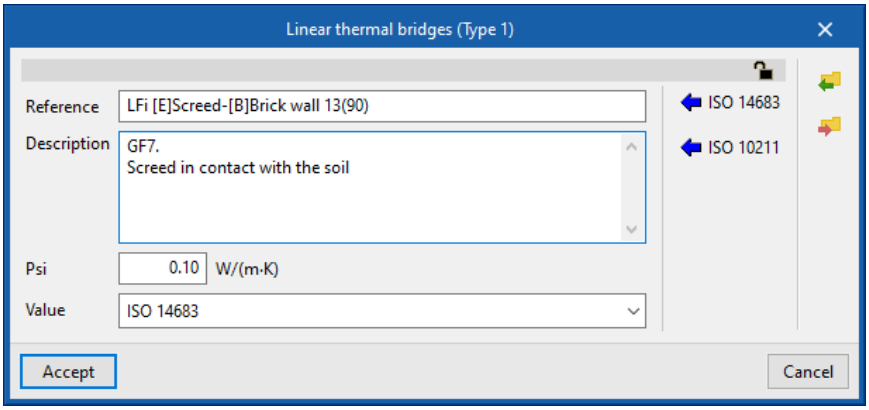


Fig. 25. Defining linear thermal bridges

There is a tool for automatically defining linear thermal bridges, via the **Edges** option in the toolbar (see *Edges* section).

3.5 Zones

The building model is defined in *Zones*. A building can be divided into one or more thermal zones, which contain the building spaces. A thermal zone consists of a group of spaces that share operational temperature conditions.

Within each thermal zone, the building components tree defines the spaces it contains and the terminal units of the air conditioning system used for these spaces.

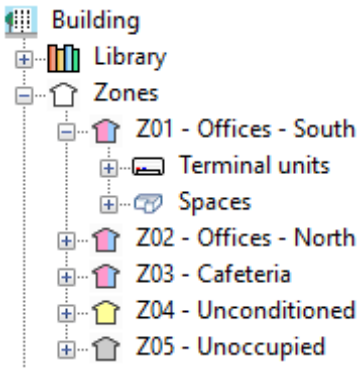


Fig. 26. Building zones

The characteristics of the zones and spaces are described in this section. The characteristics of the terminal units are described in the *Air conditioning systems* section.

3.5.1 *Thermal zones of the building*

When a thermal zone is selected in the tree diagram, it is highlighted in the 3D model viewer and the Zone panel is displayed in the main window, where the following properties are defined:

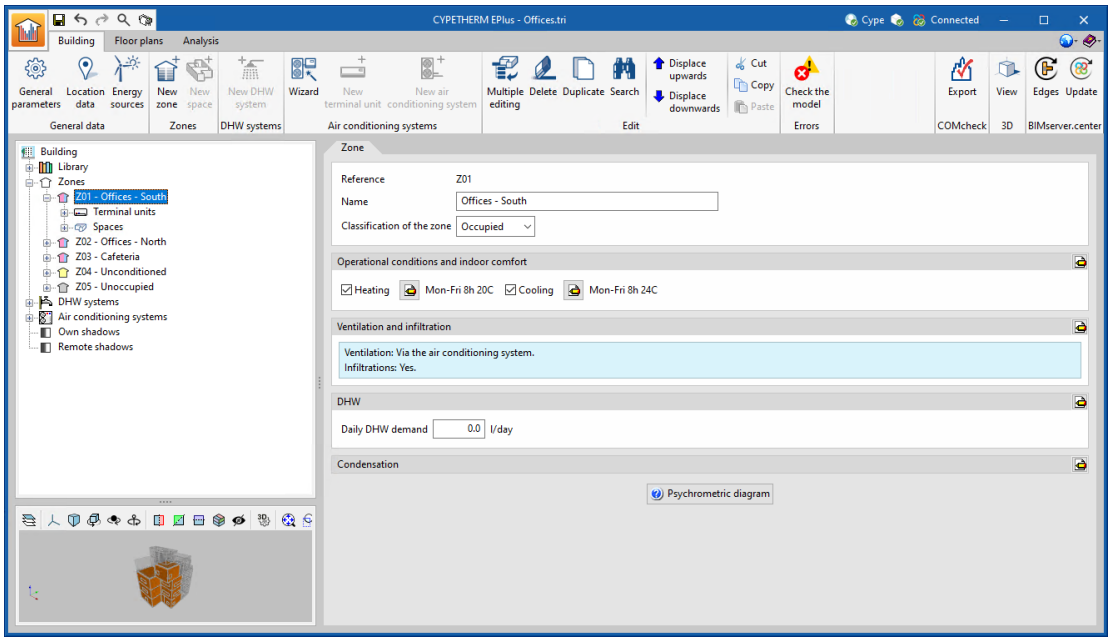


Fig. 27. Thermal zone properties

3.5.1.1 *Classifying the zone*

Occupied or *Unoccupied.* All spaces in the zone must match the type chosen in this drop-down menu.

In the tree diagram, a Zone classified as *Unoccupied* or *Not defined* will be shown in grey. A Zone classified as *Occupied* will be coloured according to its operating conditions.

3.5.1.2 *Operational conditions and indoor comfort*

Heating. The heating setpoint temperature is defined by means of an hourly profile.

Cooling. The cooling setpoint temperature is defined by means of an hourly profile.

In the tree diagram, an unconditioned occupied zone (with undefined setpoint temperatures) will be shown in yellow. If *Heating* is selected, it will be shown in red, and if *Cooling* is selected, it will be shown in blue.

In this section, the **Edit advanced properties** option allows users to define a minimum and maximum internal comfort temperature. These temperature values are used in the *Internal comfort* report in order to be compared with the internal temperature of the zone. These comfort temperatures are not used in the EnergyPlus simulation.

3.5.1.3 *Ventilation and infiltration*

Ventilation. The type of ventilation must be defined for all spaces in the zone, including:

- **Natural.** The ventilation flow defined in the spaces of the zone enters directly.
- **Mechanical.** The characteristics of the fan(s) (double flow option) driving the defined ventilation flow in the spaces of the zone are defined.
- **Via the air conditioning system.** The defined ventilation flow in the spaces of the zone will enter through the defined air conditioning system, which must be compatible with this feature.

Infiltrations. The existence of infiltrations in each zone can be defined, i.e. an unwanted flow of air from the outside into the group of spaces. Different possibilities of defining this flow are offered, via two calculation methods and different schedules.

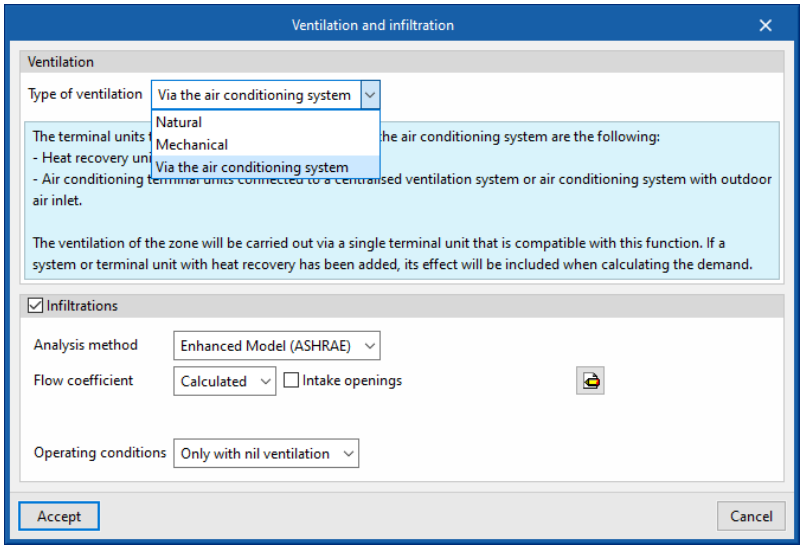


Fig. 28. Ventilation and infiltration, within the Zone

3.5.1.4 *DHW*

This section will appear in each thermal zone if users select the **Demand by thermal zone** option in *General parameters* under **Daily DHW demand**.

The following parameters are defined for the domestic hot water demand in each zone of the building. When the **Total building demand** option is chosen, these definitions must be made for the total building, in the *General parameters* window.

Daily DHW demand. DHW (domestic hot water) volume consumed each day.

Reference temperature. Production temperature of the DHW volume defined in daily DHW demand.

Solar contribution distribution. The percentage of the energy demand for DHW production covered by the building's solar thermal installation is defined. A constant value or a monthly value can be defined. If the building does not have a solar thermal installation, a value of 0% must be indicated.

3.5.1.5 *Condensation*

This section defines the indoor environment parameters for checking for surface and interstitial condensation, if this option has been activated in *General parameters*.

The **Psychrometric diagram** option displays the internal air temperature and humidity points (in red) defined in this section, and the outdoor air defined in the *Location data* window.

3.5.2 *Spaces*

For each zone, the spaces within it are defined. The building spaces and their building elements are imported from the BIM model, so the definitions developed throughout this section will be obtained automatically (*Working method: Open BIM workflow* section).

When a space is selected in the components tree diagram, it is highlighted in the 3D model viewer and the *Space* panel is displayed in the main window. A space is defined by its type within the library and by its general geometrical characteristics (area and volume).

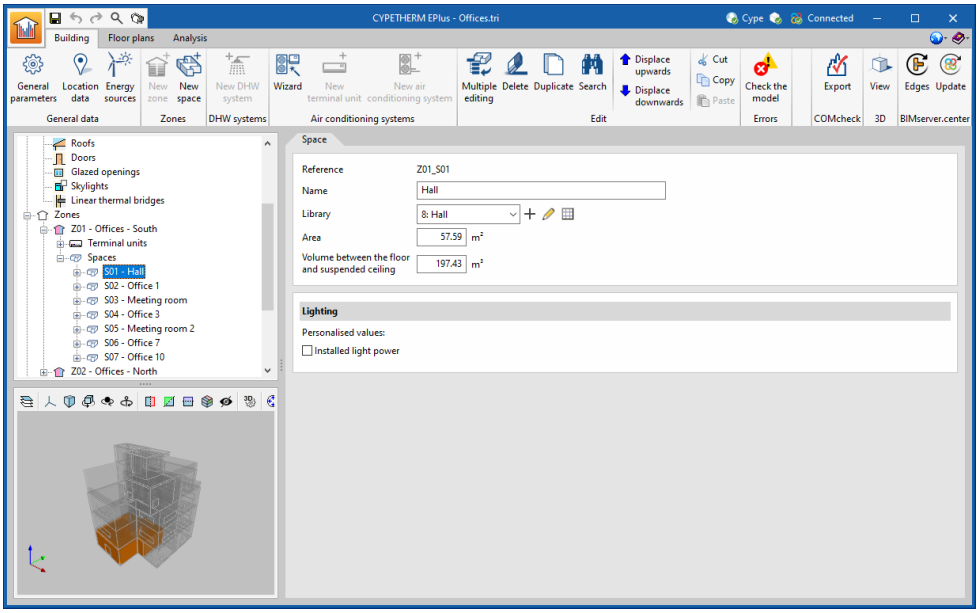


Fig. 29. Properties of a building space

The *Area* value defined in the spaces is used for the calculation of the simulation results per surface area. Spaces with no floor slab area (*Area* = 0) can be defined, provided that at least one space in the same thermal zone has an *Area* value greater than 0.

An individual value of installed lighting power can be defined for each space. If this option is checked, the defined value will replace the one for the corresponding library type. This option will only be available if the type of space chosen in *Library* has a defined lighting load (*Lighting* checkbox activated).

Within each space, the building components tree displays and defines the building elements within it and the thermal bridges associated with the space.

3.5.2.1 *Building components of the space*

The building elements of the space are divided into walls (vertical enclosures) and floors (horizontal enclosures). Each of these groups contains the list of specific elements that make up the space, in the first tab of the panel that opens in the main window, and the adjoining elements, in the second tab. When an element is selected from the list, it is highlighted in the 3D model viewer.

Elements that belong to two spaces at the same time, such as interior partitions, should not be defined twice. They will only be defined in one of the spaces, indicating that they are adjacent to the other. In the Adjacent tab, the properties of these elements can be displayed and the space to which they have been assigned can be checked.

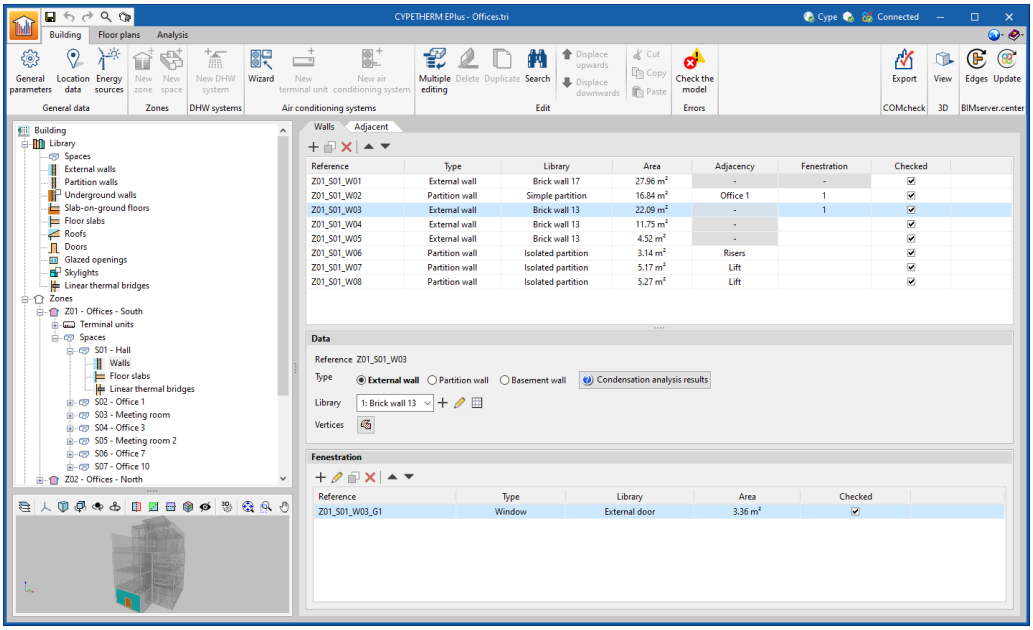


Fig. 30. Building elements of the space

Each opaque building element in the space (walls and floor slabs) is defined by the following characteristics:

Type. Sets the conditions on the other side of the element (outline conditions).

External wall / Roof / Overhang. The conditions of the external environment are considered.

External wall defined as a Party wall. The temperature conditions of the external environment, with no exposure to sun or wind (limit zone in the external wall) are considered.

External wall defined as an Adiabatic party wall. Adiabatic conditions are considered, i.e. there is no heat transfer through this element.

Basement wall / Screed. Ground conditions are considered.

Partition wall / Floor slab. The Adjacent space must be defined, in accordance with the options offered in the drop-down menu:

- Adiabatic element: element between spaces with the same temperature conditions, therefore there is no heat transfer through it.
- Another space: allows you to select the adjacent space from the spaces defined in the job.
- Unknown space: the adjacent space is not defined in the job. The temperature conditions of this unknown space are assumed to be those of the external air.

Condensation analysis results. The results of the condensation check of the element can be displayed, according to the *Type* chosen.

Library. The element type is selected from those available in the library, according to the Type chosen.

Vertices. The coordinate points that determine the position and surface area of the element can be defined.

In the list that appears at the bottom of the panel, openings can be defined for opaque elements in contact with the exterior (external walls, roofs, overhangs) and interior partitions (partition walls, floor slabs).

Openings are associated with the opaque elements that contain them, and are defined by the following characteristics:

Type:

- **Openings in *Walls* (external wall, partition wall).** A choice can be made between *Door*, *Window* or *Opening*.
- **Openings in *Floor slabs* (roof, overhang, floor slab).** A choice can be made between *Skylight* or *Opening*.

Library. The type of element is selected from those available in the library, according to the *Type* chosen.

Vertices. Allows users to display and define the coordinate points that determine the position and surface of the opening.

Linear thermal bridges. Linear thermal bridges associated with the intersection of the opening with the enclosure containing it may be assigned.

3.5.2.2 *Linear thermal bridges of the space*

When selecting the *Linear thermal bridges* section within a given space, the linear thermal bridges associated with the space will be displayed in the main window.

Each specific thermal bridge is defined by the environment surrounding it, its library type and its length.

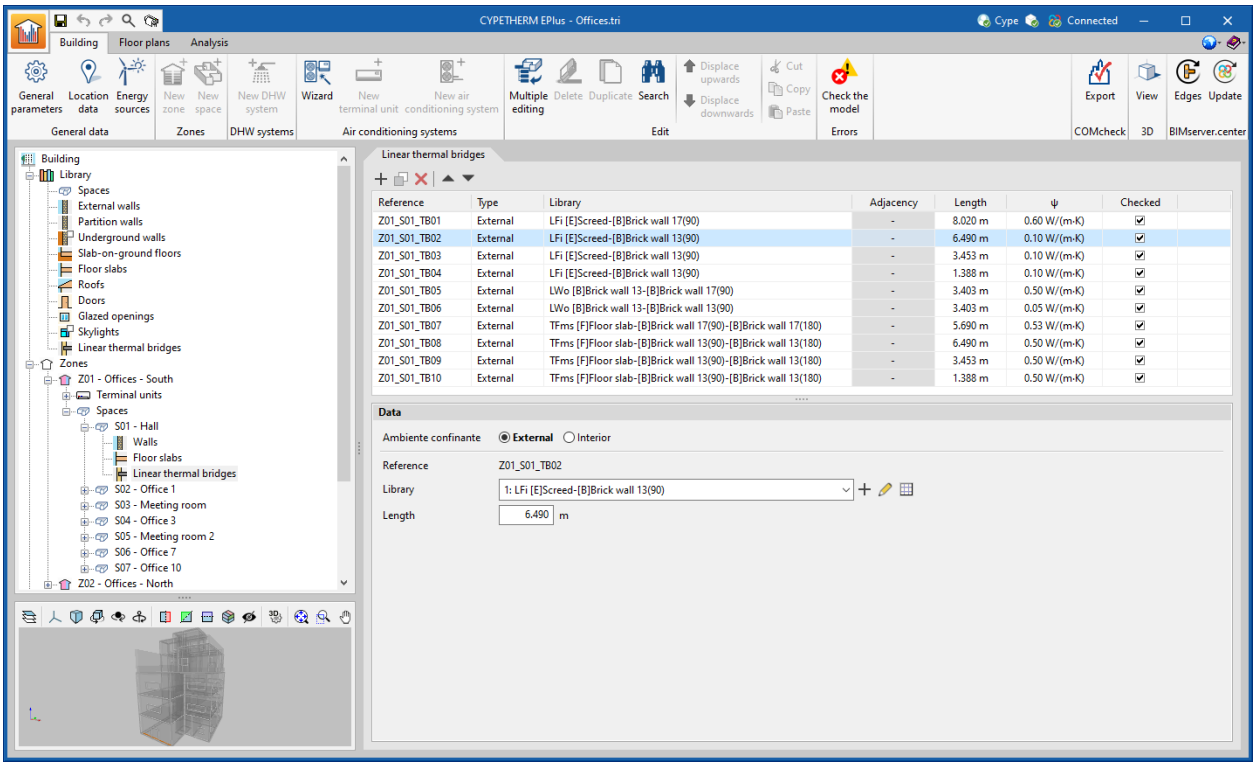


Fig. 31. Linear thermal bridges of the space

3.5.3 *Creating and organising zones and spaces*

To add a new thermal zone, select an existing zone in the building components tree and click on the **New zone** toolbar option. A pop-up window will appear with the zone editing panel. After clicking **Accept**, the new empty zone will appear in the building components tree.

Since the building spaces and their building elements are imported from the BIM model, new spaces will not usually need to be created, although the program has a feature for this purpose. To add a new space to the zone, select the Space section within the zone in the building components tree and click on the **New Space** toolbar option. A pop-up window will appear with the zone editing panel. After clicking **Accept**, the new empty zone will appear in the building components tree.

To organise the existing building enclosures into different zones, *Editing tools* are provided in the toolbar. The **Displace upwards** and **Displace downwards** options allow you to reorder the elements of the diagram. The **Multiple editing** option provides a wizard to edit the properties of the different types of building elements simultaneously. More specifically, it allows users to move Spaces between the different Zones as well as to modify their Library Type and, in projects such as a Block of houses, their Use unit.

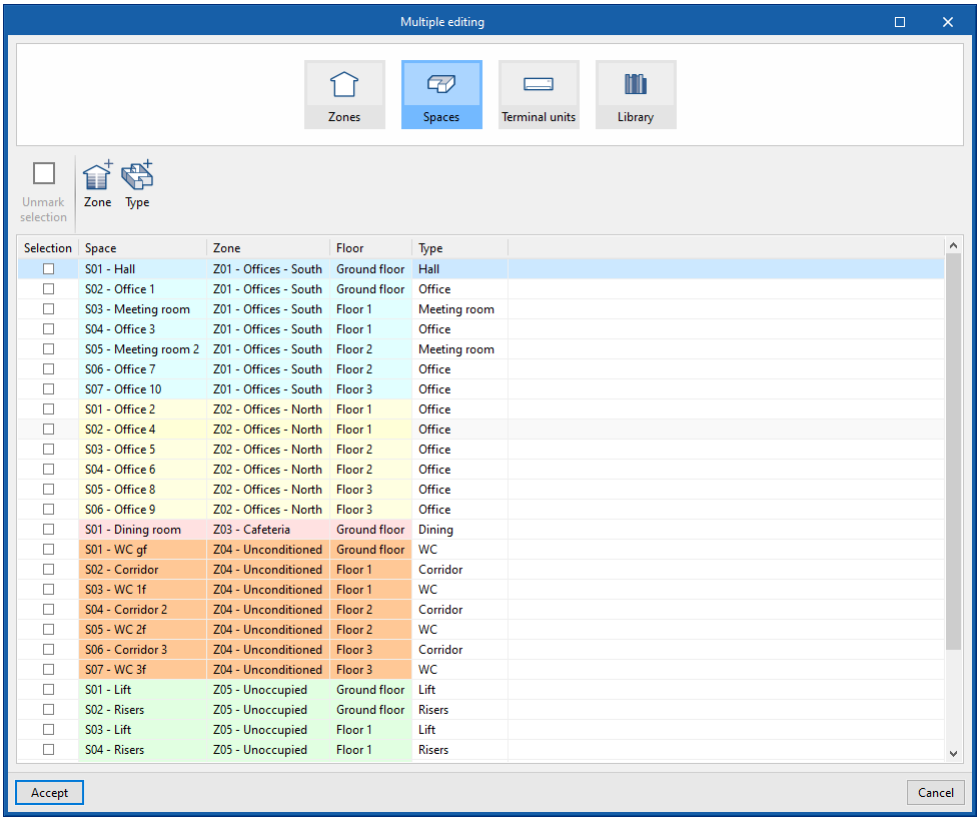


Fig. 32. Multiple editing of spaces

3.6 DHW systems

This section of the building components tree defines the systems responsible for producing domestic hot water (DHW). A DHW system consists of a set of DHW production sets and, optionally, a set of storage tanks.

The definition of DHW systems depends on the option chosen in DHW daily demand under *General parameters*  .

If *Total demand of the building* has been chosen, a single DHW system can be defined to meet this demand. In order to define the DHW system, select *DHW systems* in the building components tree and add the production sets and storage tanks in the *System* panel that appears in the Main window.

If *Demand by thermal* zone has been chosen, more than one system can be defined and the zones covered by each system can be selected. A zone can only be covered by one DHW system. To add a new DHW system, select *DHW systems* in the building components tree and click on the **New DHW system** option in the toolbar.

3.6.1 *Production sets*

The *Production sets* list contains the definition of the sets that supply the DHW demand allocated to the system. The part of this demand covered by each piece of equipment must be specified. The group of production sets defined in the system must cover the entire DHW demand, i.e. the sum of the percentages must be 100%.

The following types of DHW production sets are available:

Generic equipment

Allows the simulation of any DHW production set based on the energy vector used as well as its average seasonal coefficient of performance. A wizard is provided to calculate the average seasonal coefficient of performance of combustion boilers, according to the EN 15378 standard.

The *Rated capacity* data does not play a role in the energy simulation; it is only used for drawing up the results reports.

Optionally, the characteristics of a storage tank integrated in or associated with the production set can be defined. Losses associated with storage will be assigned to this

equipment (and not to all the equipment in the system). This option allows equipment such as electric boilers to be defined.

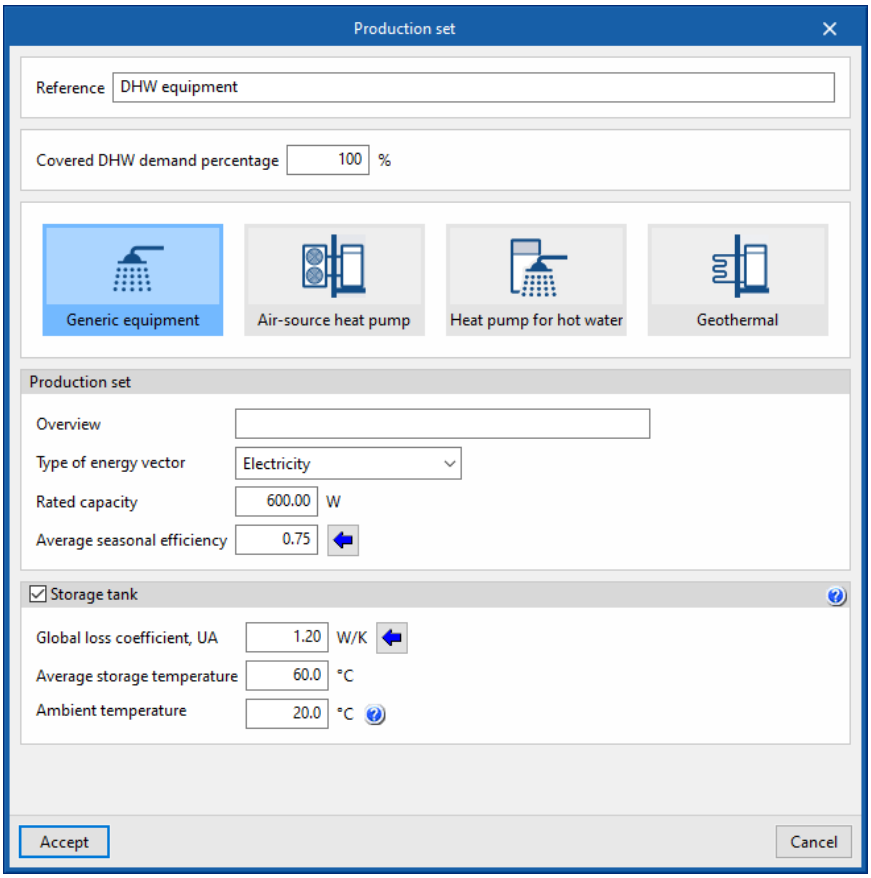


Fig. 33. Generic DHW production set

Manufacturer's equipment: air-source heat pump, heat pump for hot water, geothermal

In *Air-source heat pump*, *Heat pump for hot water* and *Geothermal*, under the logos of different manufacturers, some categories allow users to select equipment from their commercial catalogues. The characteristics of this equipment are fully defined within the program on the basis of the data provided by the manufacturers.

3.6.2 *Storage tanks*

The *Storage tanks* list contains the definition of the DHW tanks or storage tanks associated with the system, in order to account for their heat losses in the calculation of the DHW energy demand. These heat losses will be compensated by the group of production sets defined within the DHW system.

To define a DHW storage tank, its overall loss coefficient (UA value), the average temperature of the stored water and the ambient temperature of the room where the tank is installed must be indicated. A wizard is provided to calculate the UA value of the storage tank based on the characteristics of its insulation, according to the *Technical Guide to designing and analysing the thermal insulation of pipes, appliances and equipment* drafted by the Spanish agency for ecological transition *IDAE.*

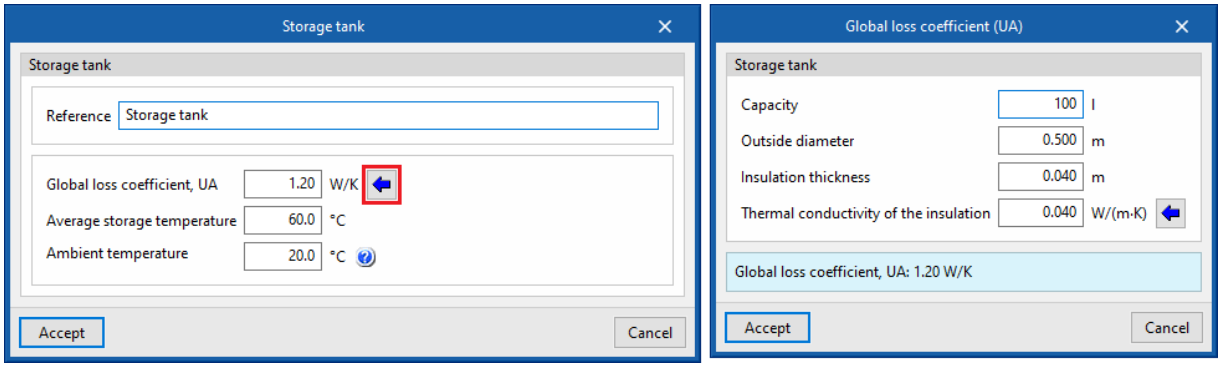


Fig. 34. DHW storage tank

3.6.3 *Distribution network*

The *Distribution network* section allows users to define the distribution and recirculation losses associated with the DHW system, in order to account for them in the calculation of the energy demand for DHW.

These losses can be defined as a constant value in W, or as a percentage of the DHW energy demand of the zones covered by the DHW system.

3.7 Air conditioning systems

The air conditioning systems of the building are defined in two sections of the components tree:

- **Terminal units (within each Zone):** the equipment in the spaces that come into contact with the air in each space.
- **Air conditioning systems:** the centralised production equipment and air conditioning units supplying the terminal units or other air conditioning systems. Together with the centralised equipment, the relevant features of the workflow distribution network are also defined.

Generally, a complete air conditioning system consists of one or more terminal units connected to a centralised system, which in turn may require other production systems. For example, in an all-air conditioning system, the supply air terminals are the terminal units and the air handling unit (AHU) is the centralised system. If the AHU contains a chilled water coil, an additional production system will need to be defined to generate the chilled water.

There may also be air conditioning systems composed only of terminal units: this is the case of electric radiators or 1x1 split type equipment.

In the program, air conditioning systems and their terminal units are classified according to the type of fluid that acting on the load of the space. Thus, a distinction is made between water-air conditioning systems, direct expansion (refrigerant) systems and air-air conditioning systems and terminal units. Furthermore, the program includes the definition of other stand-alone terminal units and water-cooled systems for chillers and reversible heat pumps.

This includes the possibility of defining any type of air conditioning system, based on its average seasonal coefficient of performance in terms of cooling and/or heating production and the type of energy it uses, through the terminal unit of the *Constant performance equipment* type.

A wizard is provided for the guided definition of the building's air conditioning systems. Depending on the type of system chosen, the wizard will successively display the definition panels corresponding to the different air conditioning system equipment.

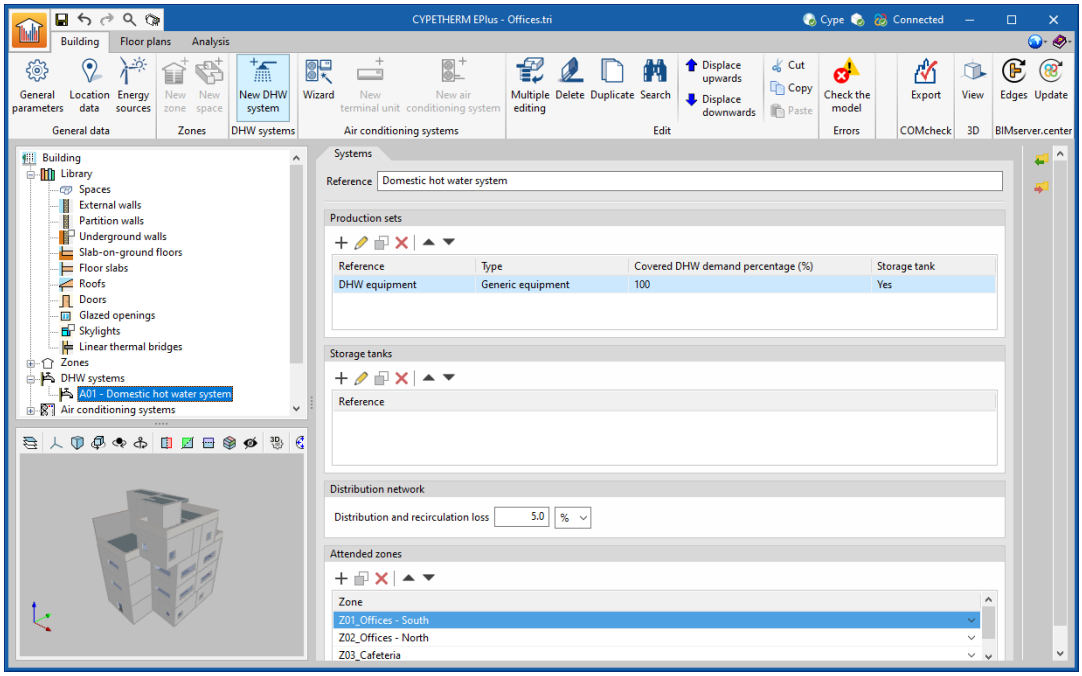


Fig. 35. DHW systems

3.7.1 *Centralised HVAC systems*

To add a new centralised HVAC system, select *Air conditioning systems* in the building components tree and click on the **New air conditioning system** option in the toolbar. A pop-up window appears in which the type of production system can be selected from water-based, direct expansion (refrigerant), air-air conditioning systems or water-cooled air systems.

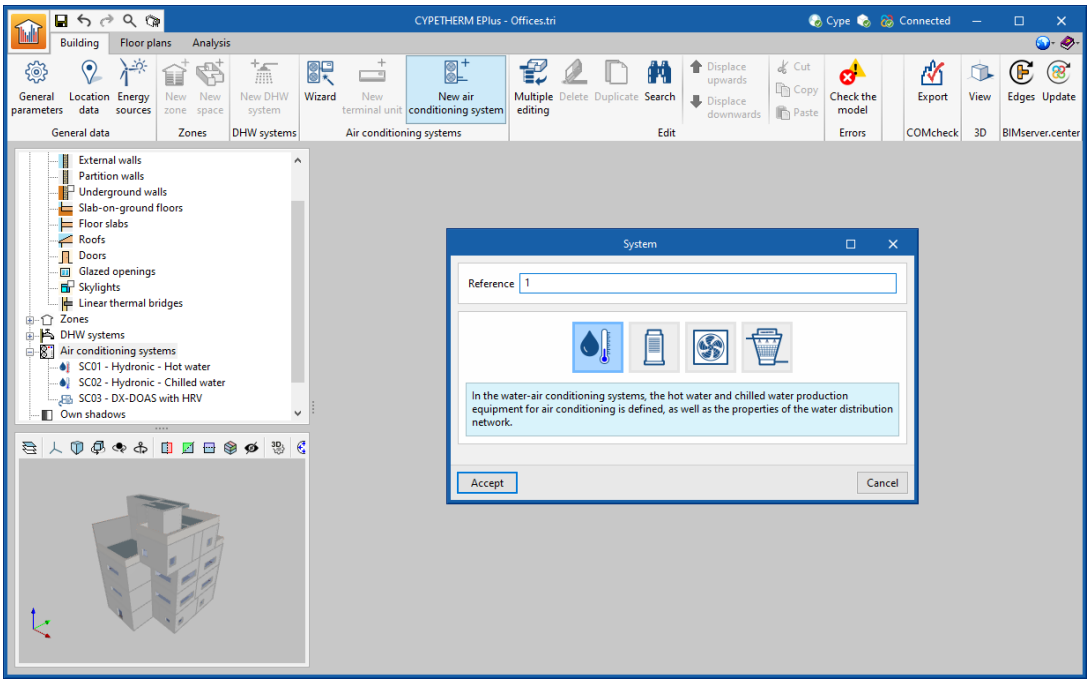
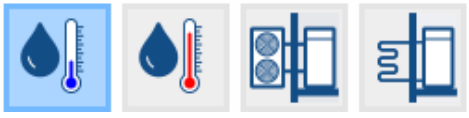


Fig. 36. New centralised supply system

When a general type is chosen, a new window opens in which the specific type of system is selected and its characteristics are defined. The systems included in the program for each type are listed below, from left to right, according to the icons representing them:

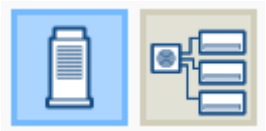
Water-air conditioning systems:

- Chilled-water production with chillers both air-cooled and water-cooled.
- Hot water production with boilers and air-water heat pumps.
- Air-source heat pump (reversible air-water heat pump).
- Geometric heat pump (reversible geothermal water-water heat pump).



Direct expansion systems:

- External unit of variable refrigerant flow systems (VRF) both air-cooled and water-cooled.
- External unit of multisplit systems.



Air-air conditioning systems:

- Central ventilation system:
  - Heat recovery unit, sensible heat recovery and heat recovery wheel
  - Dedicated outdoor air system (DOAS)
- Constant all-air volume system
- Variable all-air volume (VAV) system
- Constant all-air volume system, with double duct
- Variable all-air volume system (VAV) with double duct

Centralised ventilation systems (heat recovery and dedicated outdoor air system (DOAS)) only supply and temper the ventilation or primary air flow. In other words, **they do not have the ability to control the thermostat** and overcome the thermal load of the zones. In order to supply primary air and also air-condition the spaces with the same system, one of the available air-conditioning units (all-air systems) must be defined.

Water-cooled systems:

- For reversible heat pumps, with cooling towers and boilers.
- For chiller, with cooling towers.
- At defined temperature (constant temperature or an hourly profile).

When selecting the type of equipment, the editing panel is updated to show its characteristics. Under the logos of different manufacturers, some categories allow users to select equipment from their commercial catalogues. The characteristics of this equipment are completely defined within the program, so that users only have to indicate the characteristics related to their installation. In the generic equipment editing panels, in addition to list and library management, the following general features are offered:

- Display and edit advanced system features.
- Restore the default values offered by the program.

If a value is not specified for certain equipment characteristics, e.g. the rated power of production equipment or the flow rate of a fan, the EnergyPlus autosize feature is used. This feature calculates the non-user-defined values from the requirements of the connected terminal units and the design characteristics of the equipment.

When the creation of a new centralised HVAC system is completed, it will appear as an element in the *Air conditioning systems* section of the components tree. Clicking on it will open its editing panel in the main window.

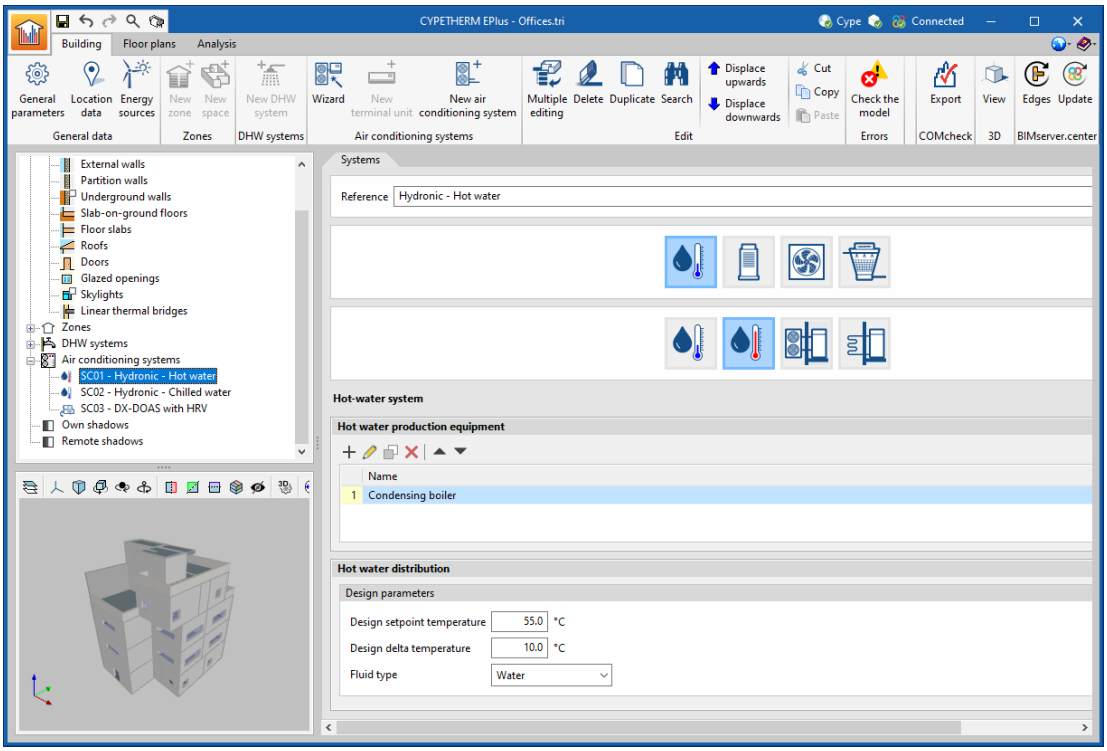


Fig. 37. Editing a centralised HVAC system

Defining fans and circulating pumps

Within the centralised HVAC systems, the relevant characteristics of the working fluid distribution network are also defined, which includes the fluid transport equipment, i.e. fans and circulating pumps.

Terminal units that supply air, such as fan coils, direct expansion (refrigerant) indoor units and heat recovery units, also contain fans.

The power consumption of this auxiliary equipment is included in the consumption of heating and cooling services, except for the consumption of fans for centralised HVAC systems, which is charged to the ventilation service.

Fans are defined in a similar way for all equipment in the program:

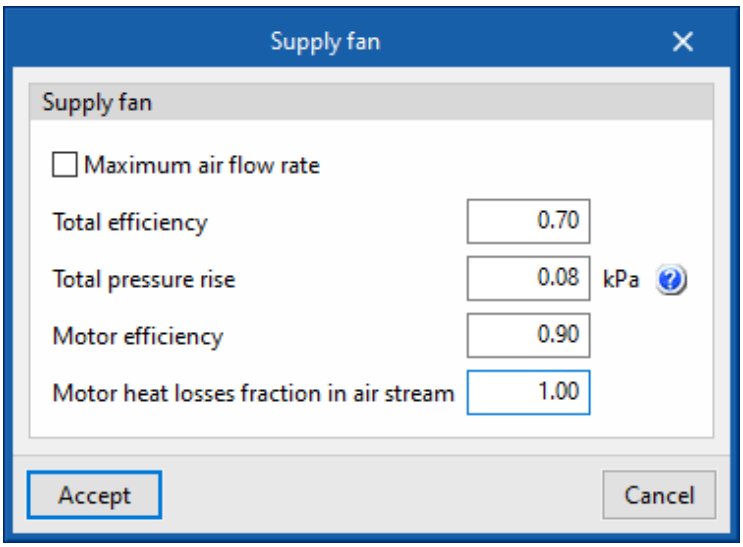


Fig. 38. Fan

- **Maximum air flow rate / Air flow.** Air flow that passes through the fan. If "maximum flow rate" is indicated on the panel, the air flow rate may vary during the simulation up to the value set in this box. If the air flow rate is not specified, the program will calculate the required air flow rate.
- **Specific power**. Power consumption of the fan per m3/s of air flow that it moves.

If the performance value of the air conditioning system includes the fan consumption, you can fill in the value of the specific power with 0 in order not to double count the fan consumption.

- **Motor efficiency**. This is considered in the calculation of the heat losses of the fan's electric motor, which will affect the supply air temperature as defined in the following variable.
- **Motor heat losses fraction in air stream**. If the supply air flows through the fan motor, the heat losses of the motor will cause an increase in the air temperature. If, on the other hand, the fan motor is outside the air flow, its heat losses will not affect the air flow, so this should be indicated with a value of 0. This box can be filled in with any value in between, if desired.

*The **ventilation equipment** (heat recovery and primary air conditioning) contains two identical fans, one for intake and one for exhaust. Users should only define the characteristics of one of the fans.*
These units always drive the total ventilation airflow defined in the spaces of the zones to which they are connected. The electrical power of their fans is proportional to the ventilation flow rate.

Circulating pumps are also defined similarly in the different types of hydraulic circuits:

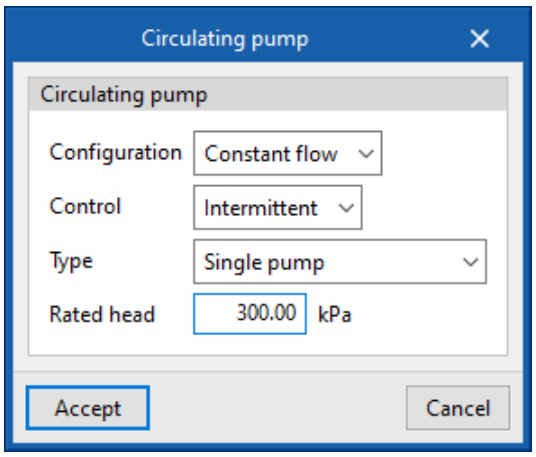


Fig. 39. Circulating pump

- **Control.** *Intermittent* means that the circulating pump is switched on and off at the same time as the air conditioning system. Continuous means that the circulating pump is always on.

The selection of *Continuous* control means that when the air conditioning system is off for long periods of time with no demand, heat losses from the pump accumulate in the fluid, which can cause a significant rise in the fluid temperature.

- **Configuration.** *Constant flow* and *Variable flow* represent a fixed or variable speed pump, respectively.
- **Type.** Allows the number of identical pumps contained in the hydraulic circuit and their position to be selected.
- **Rated head.** The pump head is used in the calculation of the power consumption.

The water flow rate in the circuit is determined automatically by the calculation engine, based on the heating or cooling demand of the day of design and the *Design temperature difference* (TD) indicated by the user in the hydraulic circuit.

The electrical power of the circulation pump (P) is obtained from the water flow rate ($\dot{V}$) and the rated head (H). The motor considers a fixed pump efficiency value equal to 0.78.

$$P\ [\mathrm{W}] = \frac{\dot{V}\ [m^3/s] \cdot\ H\ [\mathrm{Pa}]}{0.78}$$

3.7.2 Terminal units

3.7.2.1 Defining terminal units

Defining the terminal units of air conditioning systems is similar to that of centralised systems. To add a new terminal unit, select the *Terminal units* section of the building components tree in the Zone where you a new terminal unit is to be added. When clicking on the **New terminal unit** option in the toolbar, a pop-up window will appear where the type of terminal unit can be selected from among constant performance equipment, water terminal units, direct expansion terminal units, air terminal units, electric heaters and heat recovery units.

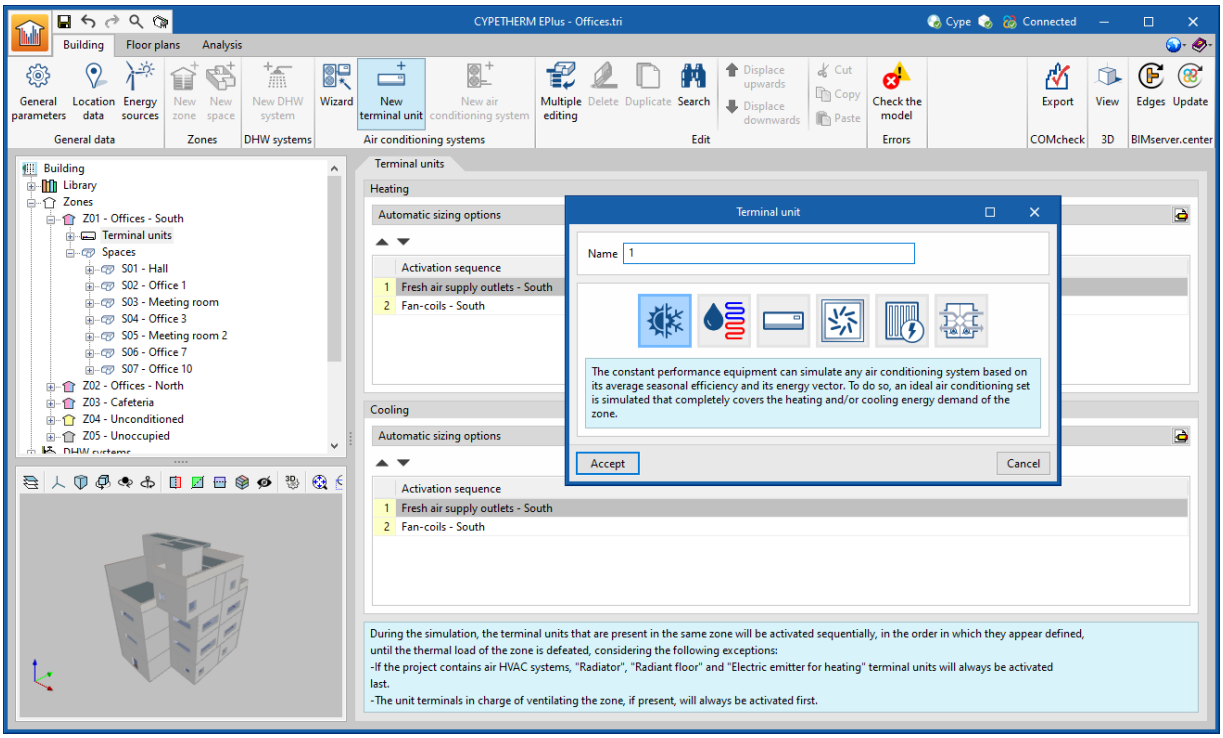


Fig. 40. New terminal unit

Choosing a general type will open a new window in which the type of terminal unit is selected and its characteristics are defined. The systems included in the program within each type are listed below from left to right, according to the icons representing them:

Constant performance equipment. This equipment can be used to represent any air conditioning system according to its power, its average seasonal coefficient of performance in terms of cooling and/or heating production and the type of energy it uses (energy vector). If its power is not specified, it will act as an ideal unit capable of instantly overcoming the thermal loads of the area where it is located (infinite power unit). Only one constant performance equipment can be defined per zone. Three types of constant performance equipment are available:

- Just heating.
- Just cooling.
- Heating and cooling.

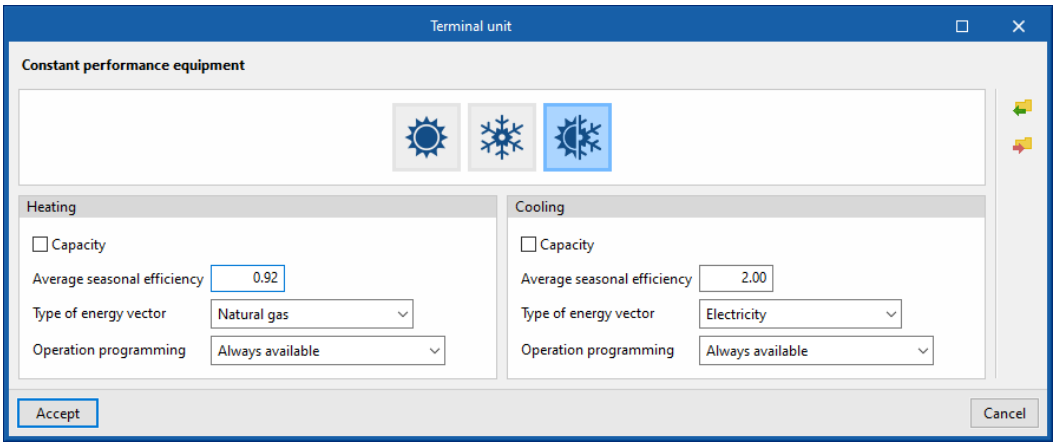


Fig. 41. Constant performance equipment

Water terminal units. These must be connected to a water-air conditioning system.

- Radiator.
- Radiant floor for heating.
- Fan coil for heating and cooling.

Direct expansion terminal units:

- Split 1x1. It is a stand-alone terminal unit, i.e. it does not need to be connected to a system.
- Internal unit of a multisplit system. It must be connected to a direct expansion system of the same type (external unit).
- Internal unit of a variable refrigerant flow (VRF) system. Must be connected to a direct expansion system of the same type (external unit).
- Compact window unit. It is a self-contained terminal unit. If heating water coils are defined, it must be connected to a hot-water system.
    - Compact air conditioning equipment (gas, water, electric heating).
    - Compact heat pump unit (direct expansion heating).
- Water to air heat pump. Must be connected to a water-cooled system for a reversible heat pump.

Air conditioning terminal units. These represent the supply air terminals (diffusers, grilles, nozzles, etc.) into which the ducts of all-air systems lead. In the program, they must be connected to an air conditioning system (i.e. an air conditioning unit), depending on their type:

- Supply air terminal. Must be connected to an all-air constant or centralised ventilation system, depending on the option chosen
- Dual duct, all-air supply outlet. Must be connected to an all-air dual duct constant volume system.
- Variable air volume (VAV) box. Must be connected to a variable all-air system.
- Dual duct variable air volume (VAV) box. Must be connected to an all-air dual duct variable volume system.

If the air terminal unit is connected to an air system with external air intake or to a centralised ventilation system, the **Ventilation** option **Via the air conditioning system** must be activated in the zone window**.**

Electric emitter for heating. This represents electric heating equipment (electric radiator, fan heater, etc.). It is a stand-alone terminal unit, i.e. it does not need to be connected to a system.

Heat recovery unit. This is a stand-alone terminal unit, i.e. it does not need to be connected to a system. To use this terminal unit, the **Ventilation** option **Via the air conditioning system** option must be activated in the zone window.

As with the centralised part of the air conditioning systems, selecting the type of terminal unit updates the editing panel to show its characteristics. Under the logos of different manufacturers, some categories allow users to select equipment from their commercial catalogues. The characteristics of this equipment are completely defined within the program, so that users only have to indicate the characteristics related to their installation. In the generic equipment editing panels, the following features are offered:

Display and edit advanced characteristics of the equipment.
Restore the default values proposed by the program.

If a value is not specified for certain equipment characteristics, e.g. its rated capacity or fan flow rate, the EnergyPlus autosize feature is used. This feature calculates the non-user-defined values from the thermal loads and the automatic sizing options of the Zone.

System. This section appears on the panels of the non-autonomous terminal units. The centralised system to which the equipment is connected must be selected. The drop-down menu will only offer the systems compatible with the terminal unit defined in the job. The list management options on the right-hand side of the drop-down menu allow users to carry out the following:

Define a new centralised production system of any type.

Edit and select a centralised production system defined in the job.

Indicates that the selection made in the drop-down menu is either empty or incorrect.

When the creation of a new terminal unit is completed, it will appear as an element in the *Terminal units* section of the components tree, within each Zone. By clicking on the element, its editing panel will appear in the main window.

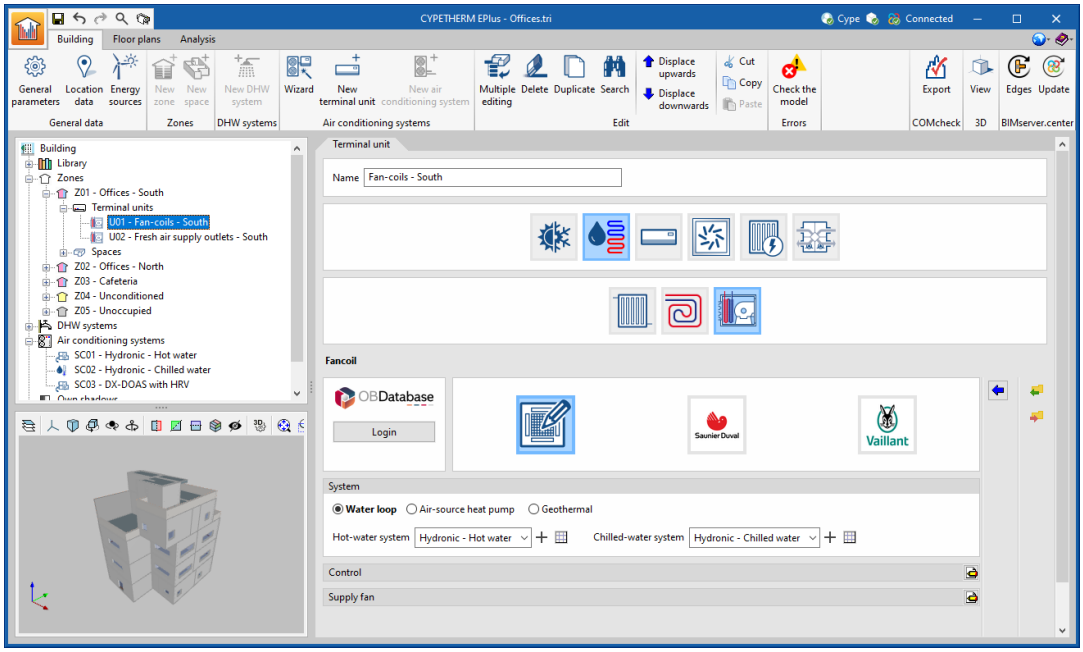


Fig. 42. Editing a terminal unit

3.7.2.2 *Terminal unit management and automatic design options*

The *Terminal units* panel allows users to manage the operation of the terminal units defined in each zone and to define the EnergyPlus automatic design options.

During the simulation, the terminal units within the zone shall be activated sequentially until the thermal load of the zone is overcome, according to the order defined in the *Activation sequence* sections, distinguishing between heating and cooling.

The terminal unit responsible for ventilating the zone, if present, will always be activated first.

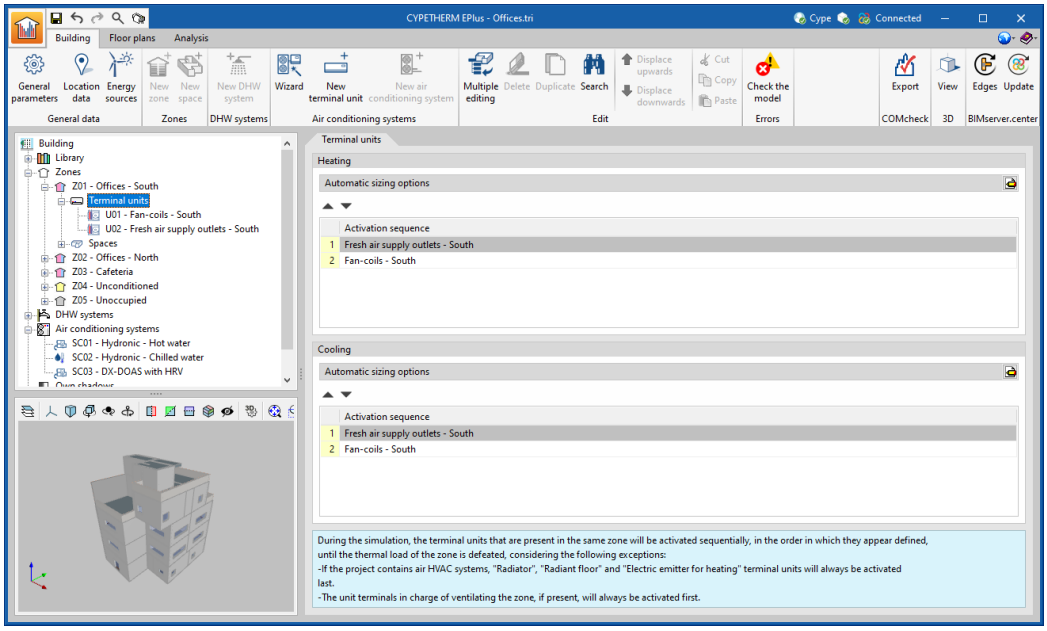


Fig. 43. Terminal unit management

The automatic heating/cooling design options are advanced features that allow users to edit the parameters used by EnergyPlus to determine the characteristics of the HVAC equipment that have not been specified by the user (autosize feature):

Zone heating/cooling sizing factor. Scaling factor on the calculated thermal load in the zone. The capacity of the air conditioning equipment shall be determined from the heat load of the zone multiplied by this factor.

Supply air temperature input method for the heated/cooled zone. The air flows to be supplied by the equipment to overcome the heat load are calculated based on a user-defined design supply air temperature. Three options are available:

- Supply air temperature: the design supply air temperature for heating/cooling must be defined.
- Temperature difference: the temperature difference between the supply air and the zone temperature must be defined.
- System supply air temperature: only valid if the zone is connected to an all-air system. "System supply air temperature" will be defined as the cooling/heating design supply temperature in the air handling unit window of the all-air system.

3.7.3 *Defining air conditioning systems using a wizard*

In the *Air conditioning systems* section of the toolbar, the **Wizard** option guides users through the process of defining a complete air conditioning system, including mixed systems for air conditioning and DHW, or to add terminal units to systems that have already been defined.

In the first window of the *Wizard*, the new system must be named and its type must be chosen between water-air conditioning system, direct expansion system, air-air conditioning system and constant air volume system.

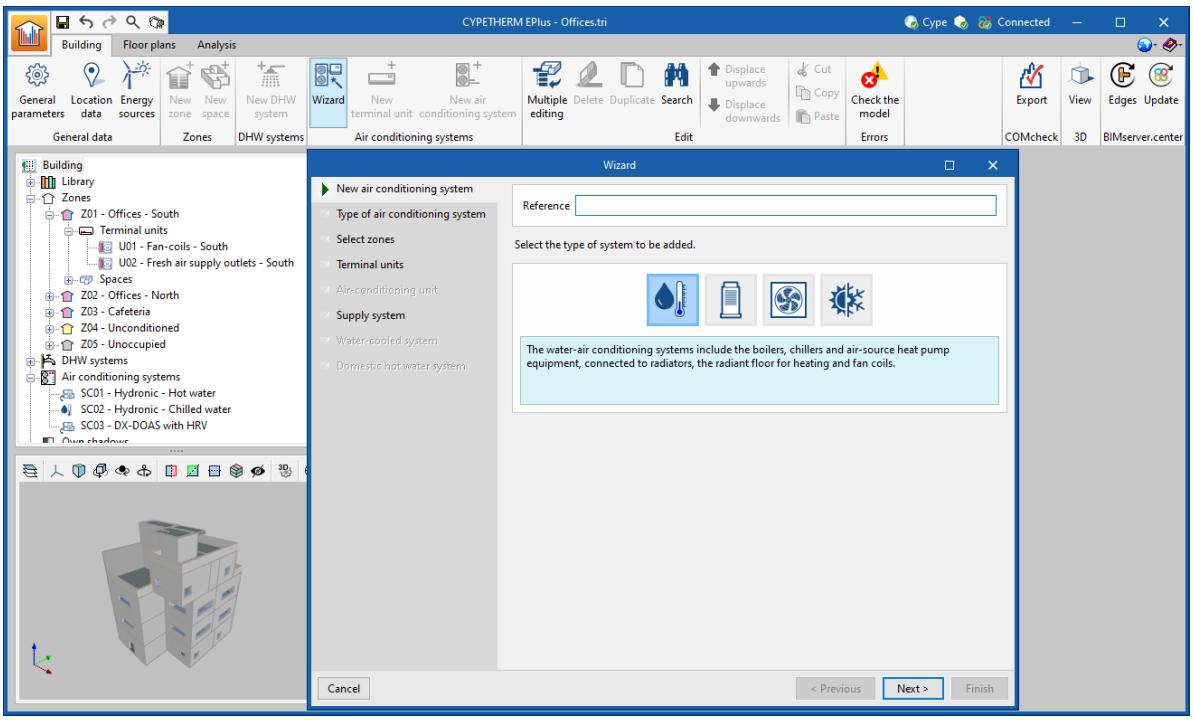


Fig. 44. Wizard for defining air conditioning systems

The wizard's steps for defining the air conditioning system are displayed on the left-hand side of the window. The different sections are highlighted in black if they need to be defined according to the chosen options. The options in the bottom bar allow users to navigate through the wizard.

In the second step of the wizard, users must choose the type of air conditioning system according to the previously chosen category.

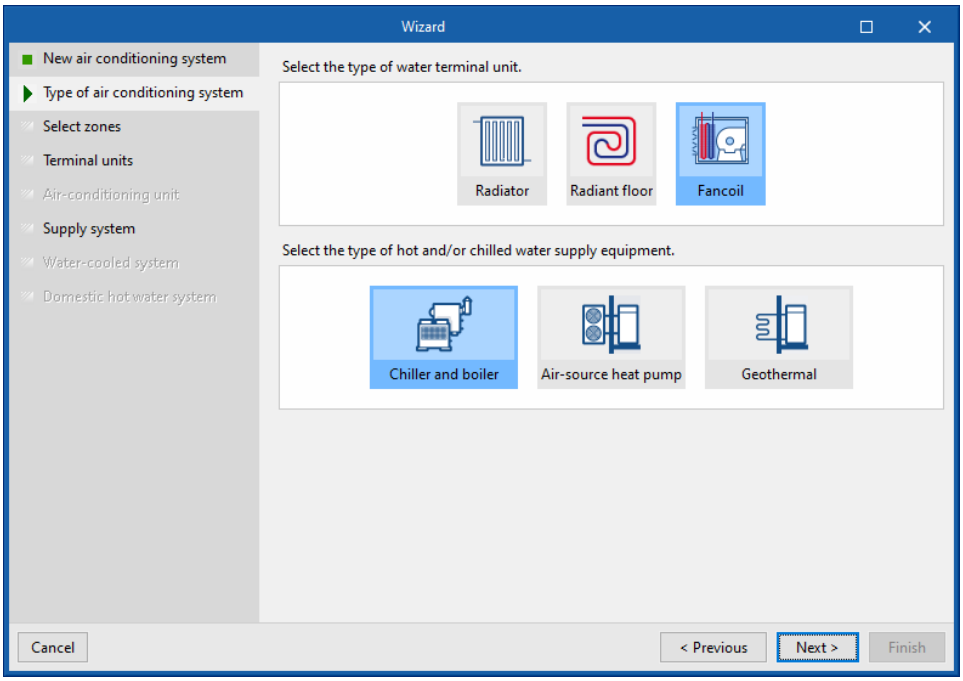


Fig. 45. Wizard for defining air conditioning systems: selecting the type of system

In the third step, users must select the zones in their building that will be associated with the air conditioning system. The wizard will automatically create the defined system terminal units in each of the selected zones and connect them to a centralised production system if necessary. The following options are available:

- **Replace the systems introduced previously.** If this option is selected, terminal units that already exist in the selected zones will be deleted. When deleting terminal units, terminal units may no longer be connected to any air conditioning systems in the job. In this case, after completing the wizard, the user will be asked if they want to delete the unused systems.
- **Add an air conditioning unit per zone.** This option will appear if an air conditioning system has been chosen. If this option is selected, then the same number of air conditioning units will be added as the number of zones selected, each of them connected to the terminal units defined in each zone.
- **Add a supply system per zone.** If this option is selected, the same number of production units will be added as the number of zones selected, each one connected to the units defined in each zone. Depending on the type of system chosen, this equipment can be either directly the terminal units or air conditioning units with water coils.

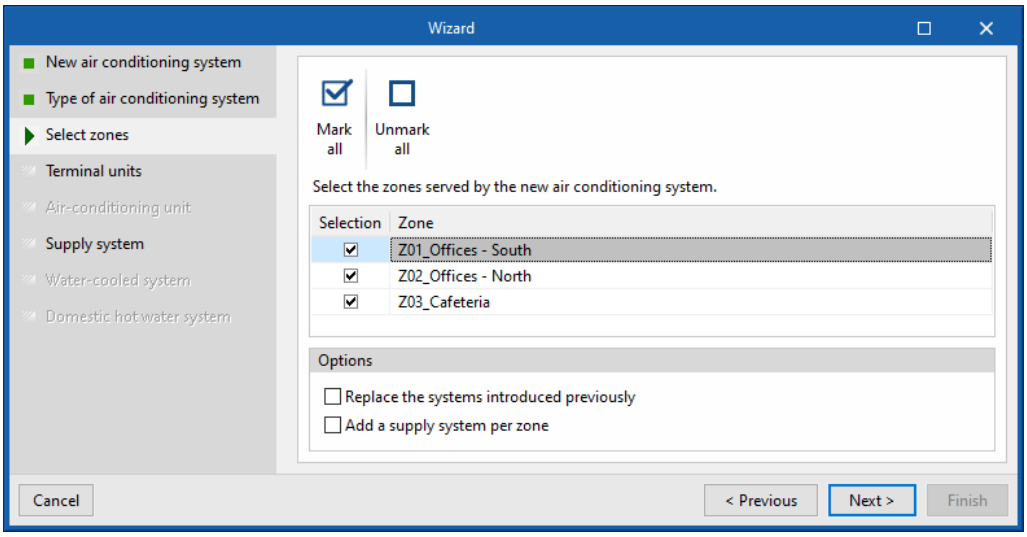


Fig. 46. Wizard for defining air conditioning systems: selecting zones

The following steps of the wizard go through the different elements that make up the chosen type of air conditioning system, so that users can define its characteristics. In general, the definition panels corresponding to the terminal units and air conditioning systems available in the program will be displayed as required.

To describe the other options available in the wizard, the definition of an air conditioning system with options connected to a water-cooled chiller and a mixed boiler for heating and DHW is displayed.

In the definition of this system, the next step offered by the wizard is the definition of fan coil type terminal units. The terminal units defined in this step will be added to all the zones selected in the previous step. More than one terminal unit of the same type can be created in the zone using the list in the panel (according to the combination possibilities of air conditioning systems offered by the program).

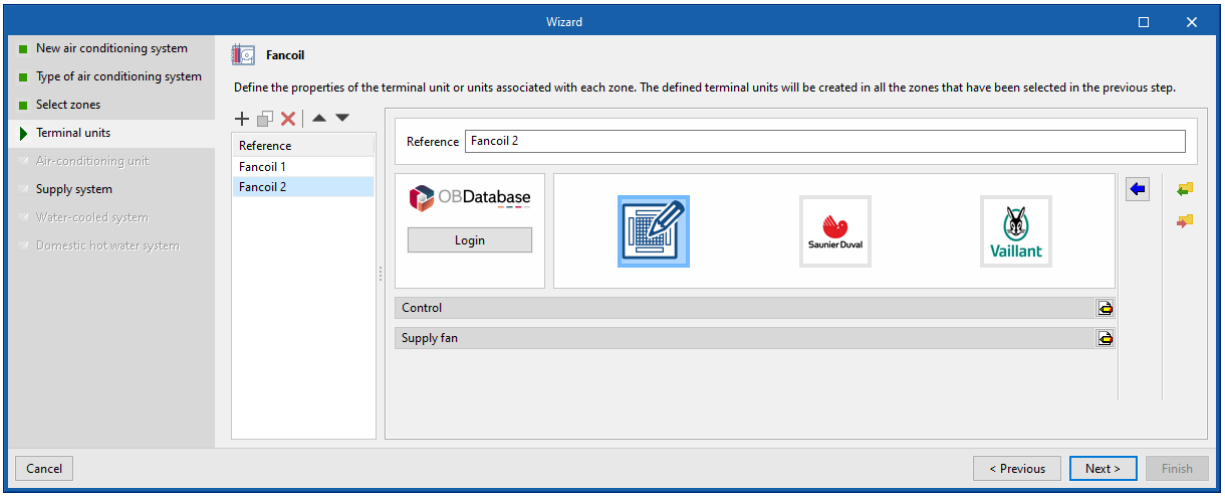


Fig. 47. Wizard for defining air conditioning systems: terminal units

The next step is to define the centralised production equipment (or the air conditioning units in the case of air systems) to which the terminal units will be connected. In this example, the wizard shows the hot-water systems and chilled-water systems.

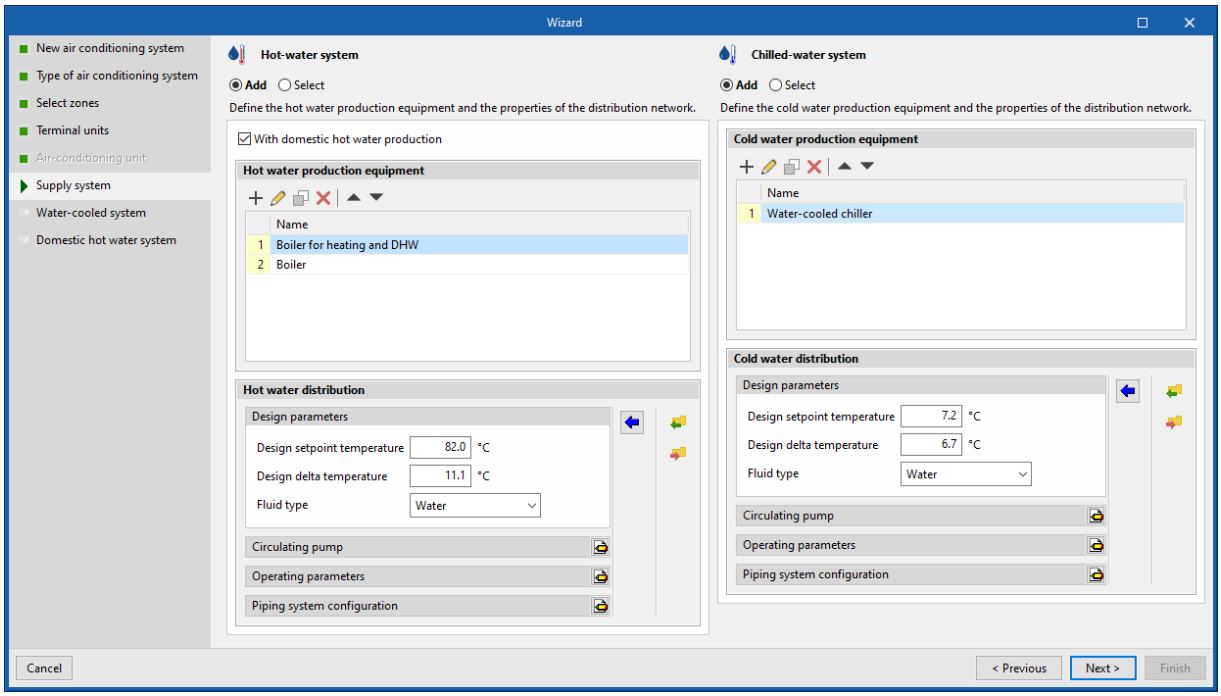


Fig. 48. Wizard for defining air conditioning systems: centralised production system

The following options are available for each system:

- **Add.** Allows a new air conditioning system to be defined.
- **Select.** Allows an air conditioning system of the corresponding type to be selected from among those defined in the job. If the **Add a supply system/air conditioning unit per zone** option was selected in the third step of the wizard, a system must be selected for each selected zone.
- **With DHW production.** With DHW production. This option is exclusive to hot water production systems (hot-water system and air-source heat pumps). It allows a mixed air conditioning and DHW system to be defined.

In this example, a new hot-water system has been defined with the **With domestic hot water production** option, and a new chilled-water system containing a water-cooled chiller. The wizard detects the needs of the selected equipment, and in the next step proposes the definition of the condensing system for the chiller.

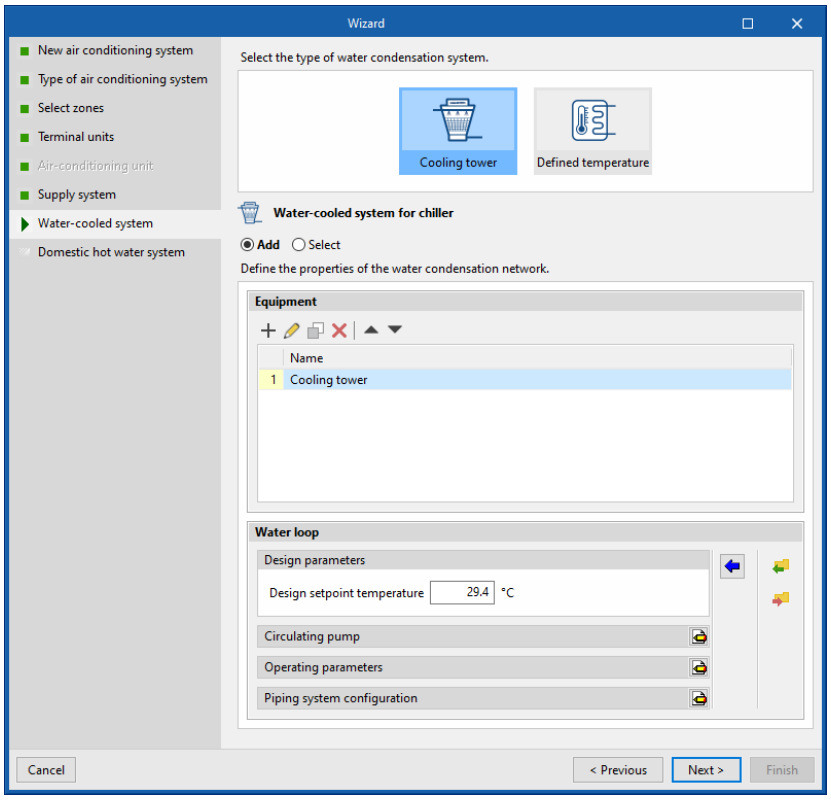


Fig. 49. Wizard for defining air conditioning systems: auxiliary systems

Finally, the wizard displays the definition of the DHW system to be added, based on the characteristics of the hot water production system equipment that has been previously defined. If several boilers have been defined, the boiler that produces DHW must be specified in order to calculate its characteristics. The user can either accept the wizard's proposal or edit it.

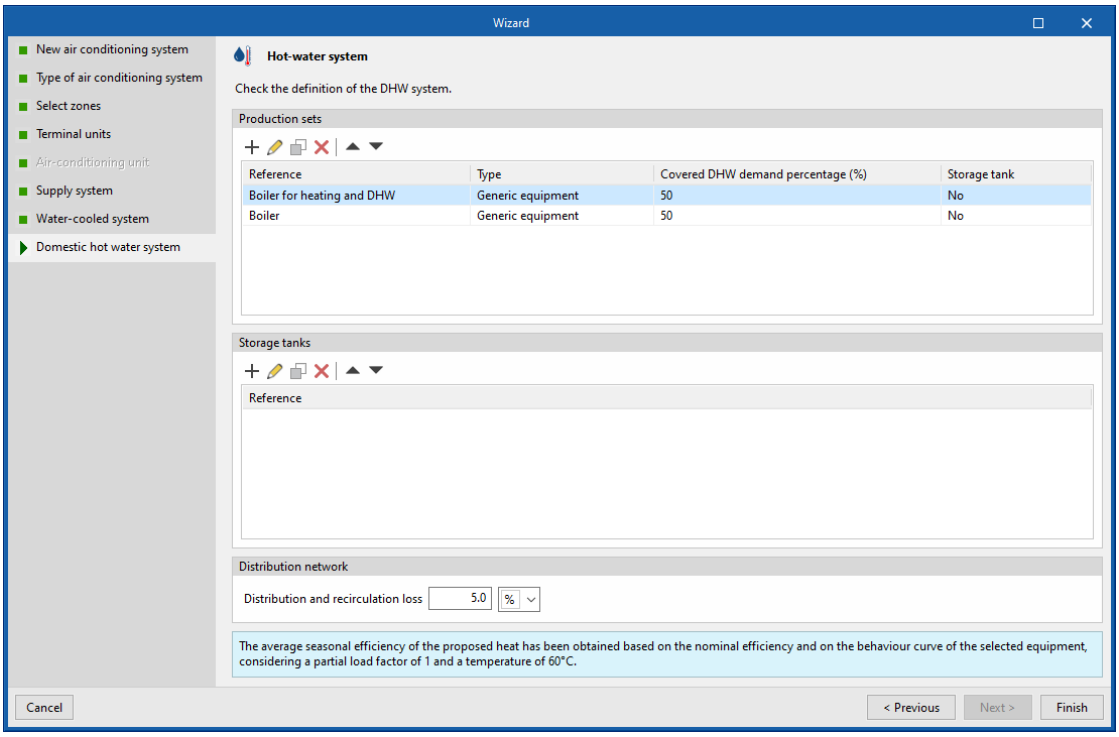


Fig. 50. Assistant for defining air conditioning systems: Mixed heating and DHW system

At the end of the wizard, the different elements of the defined system are added to the components tree of the job and the necessary ventilation options are chosen at zone level. In case a DHW system has been added with the wizard, the definition depends on the selection previously made in *General parameters* for the Daily DHW demand. If the *Total demand of the building* was defined, the wizard will create a single DHW system for the building. If the *Demand by thermal zone* was defined, the wizard will create by default a single DHW system that serves the zones selected in step 3 of the wizard. In the latter case, if **Add a supply system per zone** was selected in the wizard, a DHW system will be created for each zone.

3.8 Shadows

Shadows due to the building's own elements (own shadows) and shadows due to nearby obstacles (remote shadows) are imported from the BIM model. In these sections of the components tree, these drawings that cast shadows on the building can be visualised and edited.

In the list of elements that appears in the main window when selecting these sections of the tree, the unchecked elements will not intervene in the energy simulation. Each shadow is defined only by the vertices of a polygon.

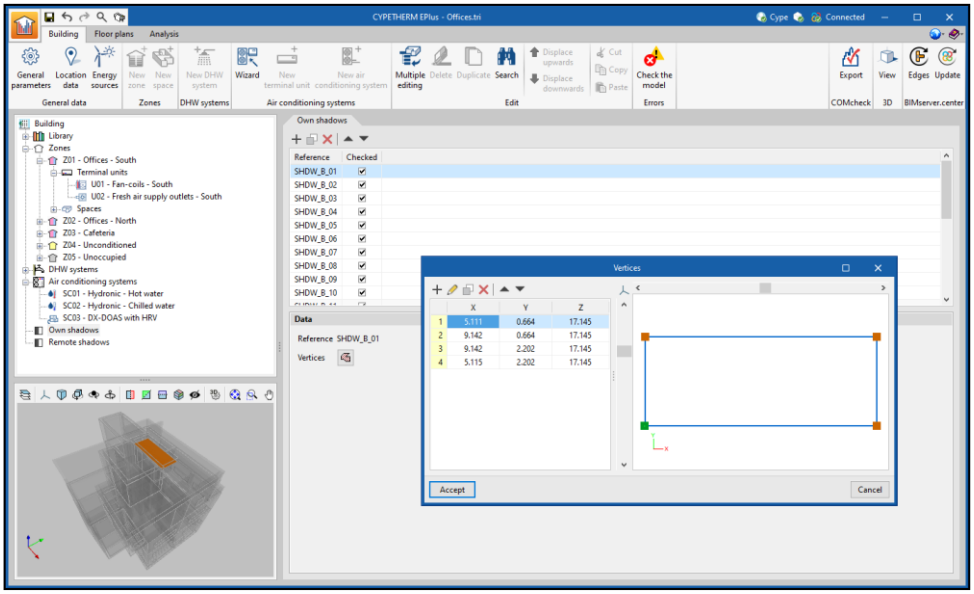
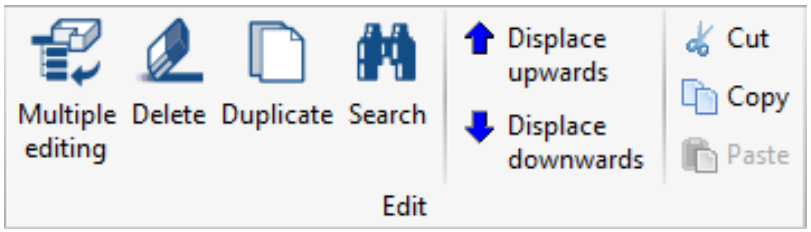


Fig. 51. Shadows

3.9 Editing tools



The options in the *Edit* section of the toolbar allow users to adjust the elements of the building components tree.

The **Multiple editing** option offers a wizard to edit the properties of the different types of building elements at once. It allows users to delete and modify the properties of the Thermal Zones, move the Spaces and edit their type, move the Terminal units and modify the properties of some of the elements in the Library. The wizard will act only on the elements of each type selected on the left side of the window.

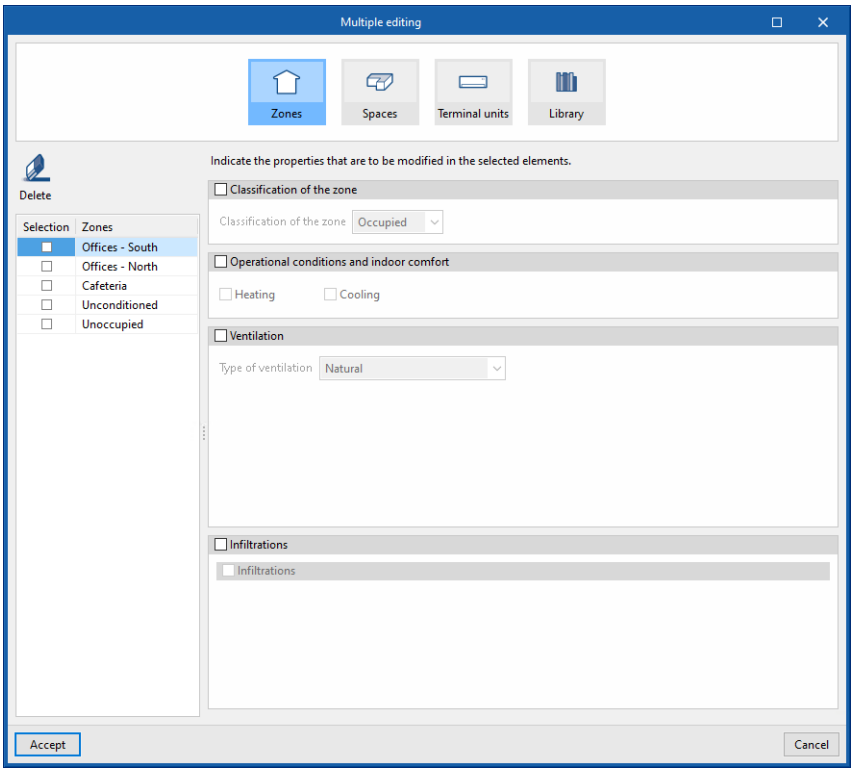


Fig. 52. Wizard for multiple editing of building elements

3.10 Checking the model

The **Check the model** option in the toolbar analyses the definitions made in the job and displays errors at the bottom of the screen if there are incorrect or incompatible definitions. A warning will be displayed if the definitions are potentially incorrect but do not cause errors in the calculations.

3.11 Exporting to COMcheck

The **COMcheck Export** option in the toolbar automatically generates a COMcheck file including the zoning and thermal envelope characteristics of the building entered in the program.

The COMcheck suite of programs, offered by the US Department of Energy (DOE), is used to verify the compliance with the "International Energy Conservation CODE (IECC)" of ASHRAE Standard 90.1, as well as with various state regulations.

3.12 3D View

The **3D View** option in the toolbar opens the 3D model viewer in a pop-up window.

3.13 Edges

The IFC4 standard does not include the concept of linear thermal bridges. CYPE has therefore created an entity so that when an IFC4 file generated by IFC Builder is imported, the intersections of the building elements (edges) can be reflected and processed at a later stage in CYPETHERM EPlus.

When the job has been created from a BIM model generated in IFC Builder, the thermal bridges library contains all the edges of the building (geometric entities obtained from the intersection between the different building elements). Some of the edges may give rise to linear thermal bridges. Once the building has been defined without errors, the edge processing tool, available in the **Edges** option of the toolbar, can be used to automatically obtain the linear thermal bridges present in the building.

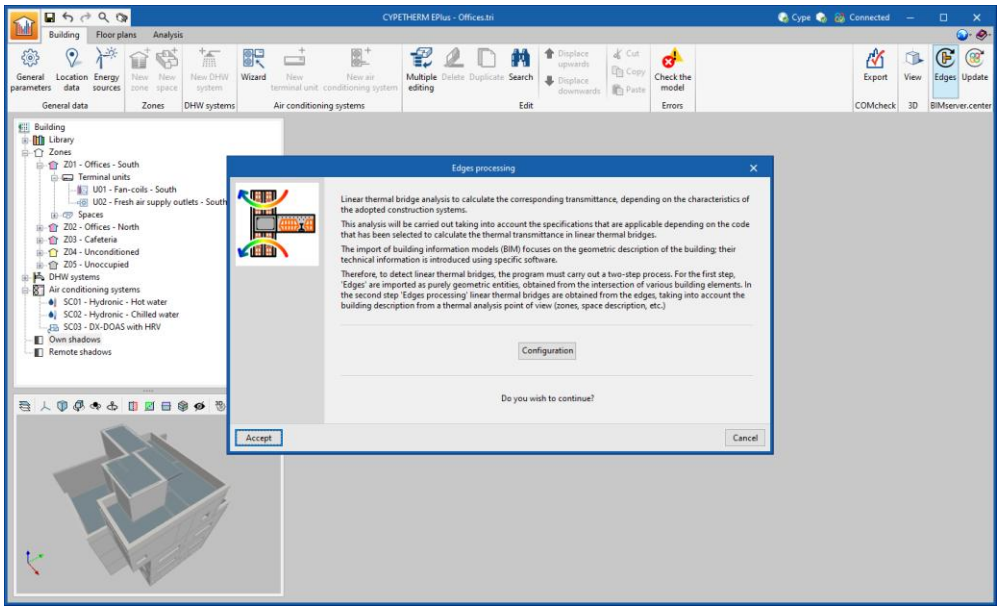


Fig. 53. BIM model edge processing

The program analyses the building by detecting the geometric edges that lie between an occupied space and the outside, and an occupied space and an unoccupied space. Using the **Configuration** option, the characteristics of the main construction systems are selected so that the corresponding thermal transmittances are calculated. Various codes are provided for this calculation.

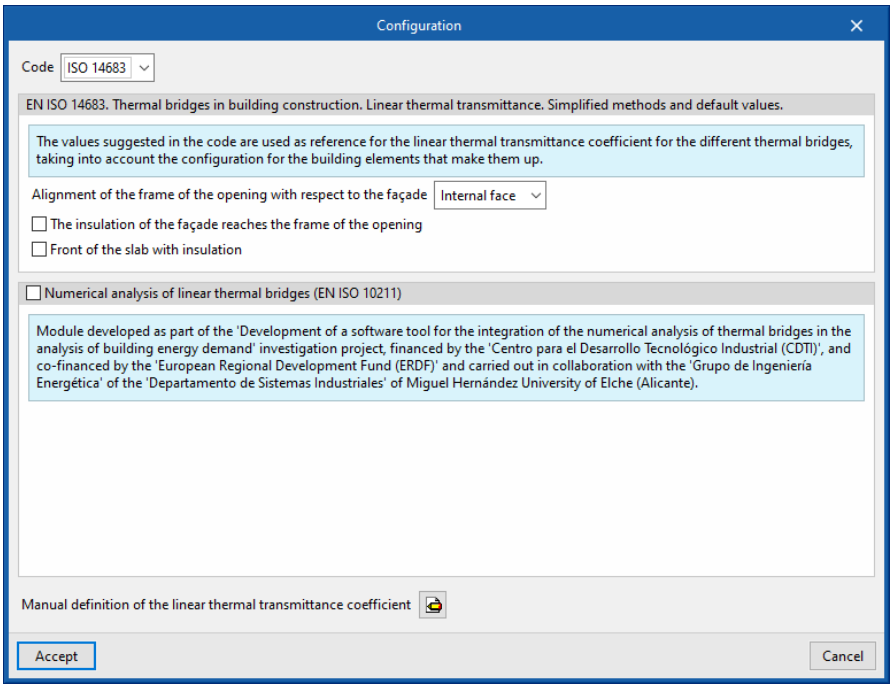


Fig. 54. Configuration of BIM model edge processing

3.14 Update

The **Update** option allows users to synchronise changes made to the IFC files of the linked BIM model. This option flashes if changes have been made to the BIM model. This feature related to the Open BIM workflow is described in the *Updating the analysis model* section.

4 Floor plans

The *Floor plans* tab contains the floor plans of each floor in the building, where the building elements are represented. From this view, users can view and edit the characteristics of the building's building elements by first selecting the corresponding option on the toolbar and then selecting the specific element on the floor plan in the main window. When an element is selected in the component's tree, it will be highlighted in the 3D viewer and in the floor plan.

Floor plans are automatically generated from the BIM model. Templates in *DXF/DWG* format can also be imported from the BIM model using the **DXF-DWG** options in the top left-hand toolbar.

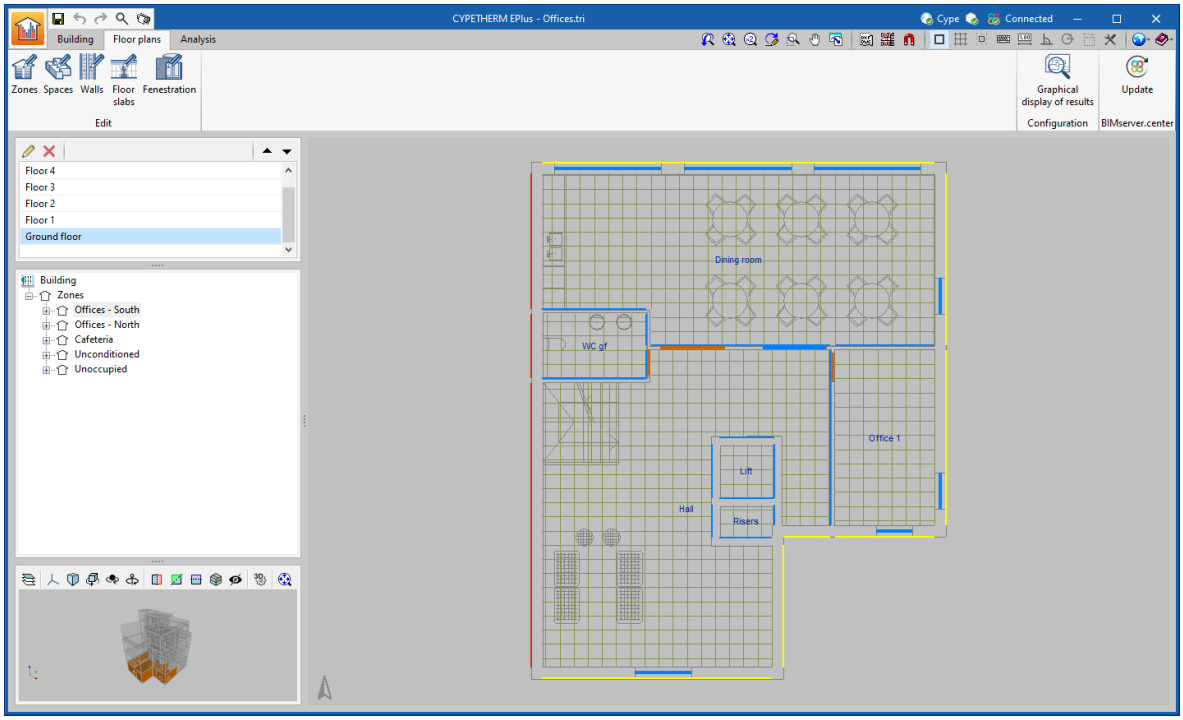


Fig. 55. Floor plans

5 Analysis

The *Analysis* tab runs the simulation and displays the results via the options on the toolbar.

If the job has not been analysed, a warning will be displayed on the screen. Once the job has been analysed, the results of the analysis will be displayed in the main window and the options that allow the reports to be obtained will be highlighted.

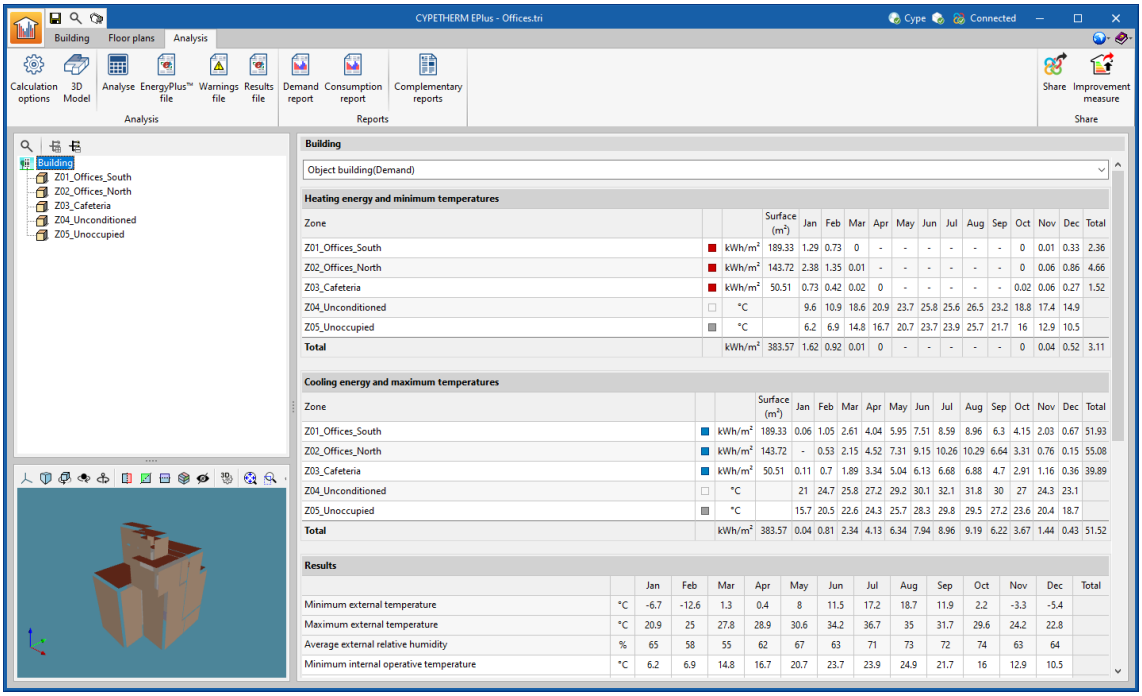


Fig. 56. Simulation results

The building components tree contains the thermal zones. In the main window, the results of the selected section of the components tree (whole building or thermal zone) will be displayed.

In this tab, the 3D model viewer shows the model of the building sent to the calculation engine, available in the *3D model* option.

Monthly simulation results are displayed in the main window based on the selections made in the components tree. The top drop-down menu allows users to view the results of the different simulations that have been carried out (Demand and Consumption).

5.1 Calculation options

The following options are defined to configure the simulation:

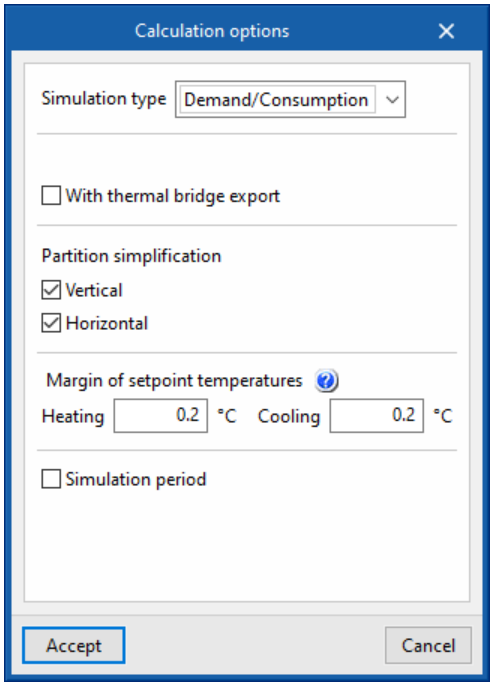


Fig. 57. Calculation options

Simulation type

- **Demand:** simulates the building without the air conditioning systems.
- **Demand/Consumption:** carries out two simulations of the building, with and without the air conditioning systems

With analysis by space. This option appears when *Demand* is selected as the simulation type. The simulation of the building is carried out by considering the spaces individually, instead of grouping them in the defined thermal zones.

Partition simplification. These options simplify the analysis model of the building, which enables a considerable reduction of the simulation time while maintaining the accuracy of the results. This simplification involves the reduction of the number of surfaces that make up the model. The **Vertical** option eliminates vertical interior partitions within the same zone, replacing them with their thermal inertia. The **Horizontal** option, in a second step, reunifies the floor slabs.

With thermal bridge export. Check this option to include thermal bridges in the simulation.

Margin of setpoint temperatures. Any hours during which the air temperature in the building spaces is outside the range of the heating or cooling setpoint temperatures by more than the indicated values shall be counted as off-setpoint hours.

Simulation period. By default, the building will be simulated for a full year. Check this option to define a different simulation period.

5.2 3D model

Displays the elements of the building energy model. This BEM (Building Energy Model) is the one used in the simulation with the calculation engine, and is created from the definitions in the Building tab, which were imported from the BIM model.

The characteristics of each of the model's elements can be consulted in the information speech bubble icon on the right.

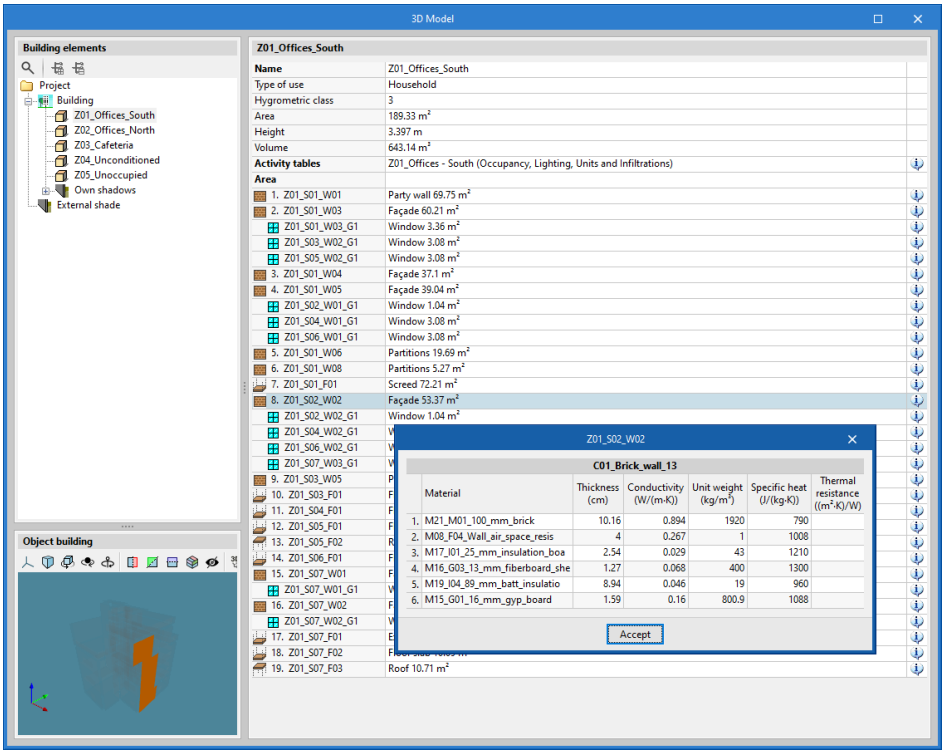


Fig. 58. 3D analysis model

5.3 Analysis

The **Analysis** option launches the energy simulation and regenerates the reports, allowing the *Calculation options* to be modified beforehand.

Each time the tab is changed, the **Analysis** option must be selected in order to regenerate the reports. The simulation will only be launched if the *Building* tab definitions have resulted in changes to the input data file to the calculation engine.

5.4 EnergyPlus files

5.4.1 *EnergyPlus™ file*

Displays the input files with an **.idf** extension to the EnergyPlus calculation engine. The header of the viewer displays the location of each file. The Project_dem.idf file contains the Demand simulation data. The Project_cons.idf file contains the *Consumption* simulation data.

5.4.2 *Warnings file*

Displays the error and warning **.err** files caused by the EnergyPlus calculation engine. If the simulation has been interrupted due to an error caused by the calculation engine, this file will be displayed on the screen.

5.4.3 *Results file*

Opens the result files generated by the EnergyPlus calculation engine in **HTML** format for each simulation (demand and consumption).

5.5 Reports

The calculation results and definitions are included in several reports. By clicking on the option that opens the desired report, this report will be displayed in the document viewer included in the program, and will offer the following tools:

Share. Allows the selected document to be shared over the internet. The document will be stored on a server in PDF format and an address will be generated to access it. The file can only be accessed by those who have this address.

Export. Allows the document to be saved in several formats, including PDF, DOCX and HMTL.

Print. Sends the document to the printer, with the page settings selected on the wheel option  .

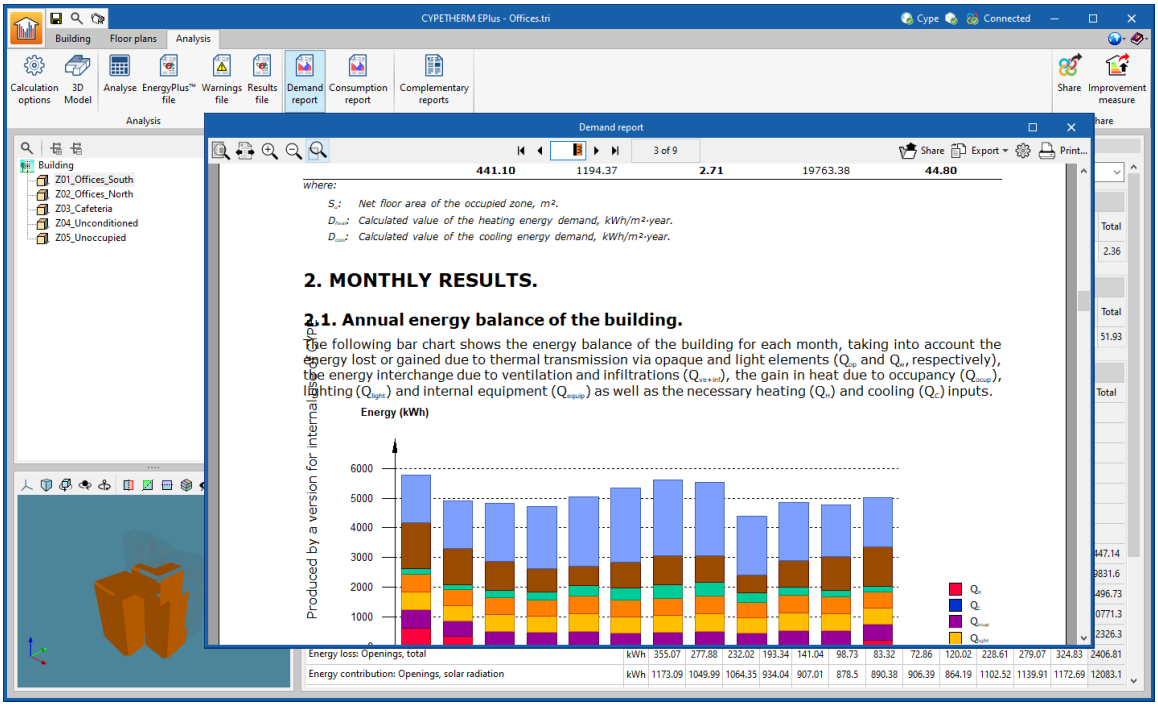


Fig. 59. Document viewer

5.5.1 *Demand report*

Provides the *Demand* simulation results. The results of the energy demand for heating and cooling of the building and per heating zone are provided. The results of the energy balance in the building and the annual energy and power demand of the building are included as graphs.

5.5.2 Consumption report

Provides the *Consumption* simulation results. The results of the building's energy consumption for heating, cooling and domestic hot water are given, and are classified according to the type of final energy consumed.

5.5.3 Building envelope

This contains the results of the Transmission heat transfer coefficient calculated according to EN ISO 13789:2017 and the air permeability of the thermal envelope. A breakdown by elements is carried out and the value of the thermal transmittance (U) of each element is compared with the limit value set by the user.

5.5.4 Complementary reports

5.5.4.1 Description of materials and building elements

The different elements present in the job are displayed together with their materials, quantities, transmission coefficients, etc. The building envelope (external envelopes, floors, roofs and openings), the partitioning system (vertical partitions and floor slabs) are specified.

5.5.4.2 Condensation

This report is available if the **Check for the existence of condensation** option has been selected under *General parameters*. The results of the check for the existence of surface and interstitial condensation according to the EN ISO 13788 standard are displayed.

5.5.4.3 Linear thermal bridges

The thermal bridges defined in each zone are listed along with their characteristics.

5.5.4.4 Internal comfort

By means of graphs and tables, the report allows users to view the evolution of the indoor temperature of the zones, comparing it with the outdoor temperature. Both the number of hours that exceed the indoor comfort temperature defined in each zone and the number of hours outside the setpoint are recorded. The hourly indoor temperature results of the zones are exported to a .csv file available in the _dat directory associated to the program file.

5.5.4.5 *Calculation of the reduction factor*

This contains the methodology and detailed results of the calculation of the heat transfer to the unconditioned spaces of the building according to EN ISO 13789:2017. These results are used in the calculation of the Transmission heat transfer coefficient of the Building envelope report.

5.6 Export

The **Export** and **Improvement measure** options allow the energy simulation results to be exported to the linked BIM project. These features related to the Open BIM workflow are described in the *Exporting results to the BIM project* section.

6 Working method: Open BIM workflow

CYPETHERM EPlus is an application integrated in the Open BIM workflow via the IFC standard. For this reason, and to take advantage of all the benefits offered by this workflow, the application must be connected to BIMserver.center, a service managed by CYPE for managing, sharing and updating projects in the cloud. To do this, users must connect to the service with their user account, which can be created free of charge via the BIMserver.center link, where they will also have information on the service and the Open BIM workflow.

The Open BIM workflow allows many of the necessary definitions required for the energy simulation, which have already been made in previous stages of the building project, to be automatically entered into the CYPETHERM EPlus program. This technology significantly simplifies and accelerates the energy simulation of the building by automatically converting the BIM model (building information model) into a BEM model (building energy simulation model).

6.1 Entering the analysis model

To create a new CYPETHERM EPlus file, click on the **New...** option. A pop-up window will appear where users can assign a name and location to the new file as well as an optional description.

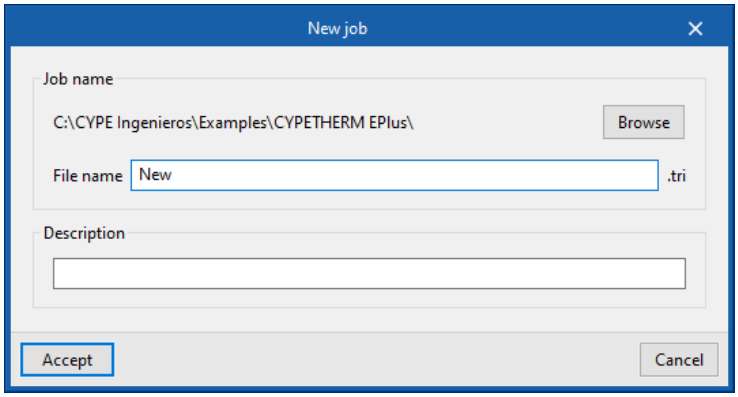


Fig. 60. New file

When clicking on **Accept**, the BIMserver.center window will appear where users can *Log in* and *Select a project* containing a geometrical model of the building in IFC format (BIM project initiator file).

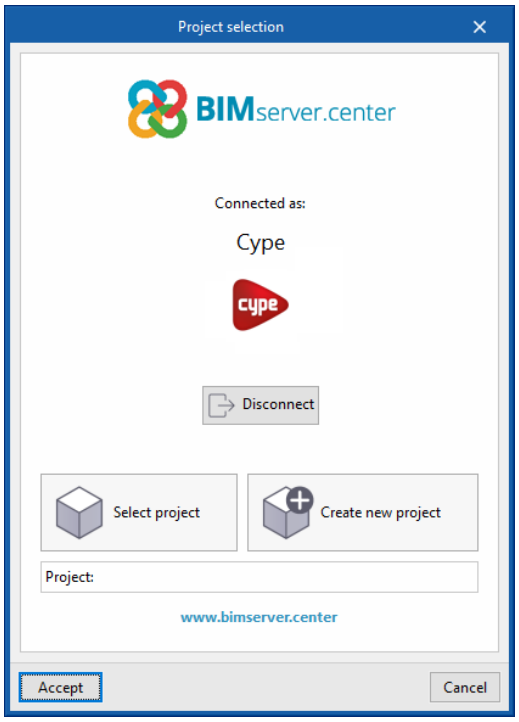


Fig. 61. Select BIM project hosted on BIMserver.center

The program supports geometric models created with any 3D modelling program that can export its files in IFC4 format. One of them is the free IFC Builder application, available in the BIMserver.center Store.

CYPETHERM EPlus also supports information from other IFC files added to the project, as described in the following section*: Importing complementary BIM information*.

Thanks to Open BIM technology, CYPETHERM EPlus will automatically import the information contained in the IFC files. In this initial import process, a calculation model linked to the building information model (BIM) is created. This allows the analysis model to be synchronised with the changes in the BIM model.

The link between the analysis model and the BIM model is established on the basis of the references of the elements that make up the BIM model. In order to update the BIM model correctly, the references of the elements must be kept within CYPETHERM EPlus.

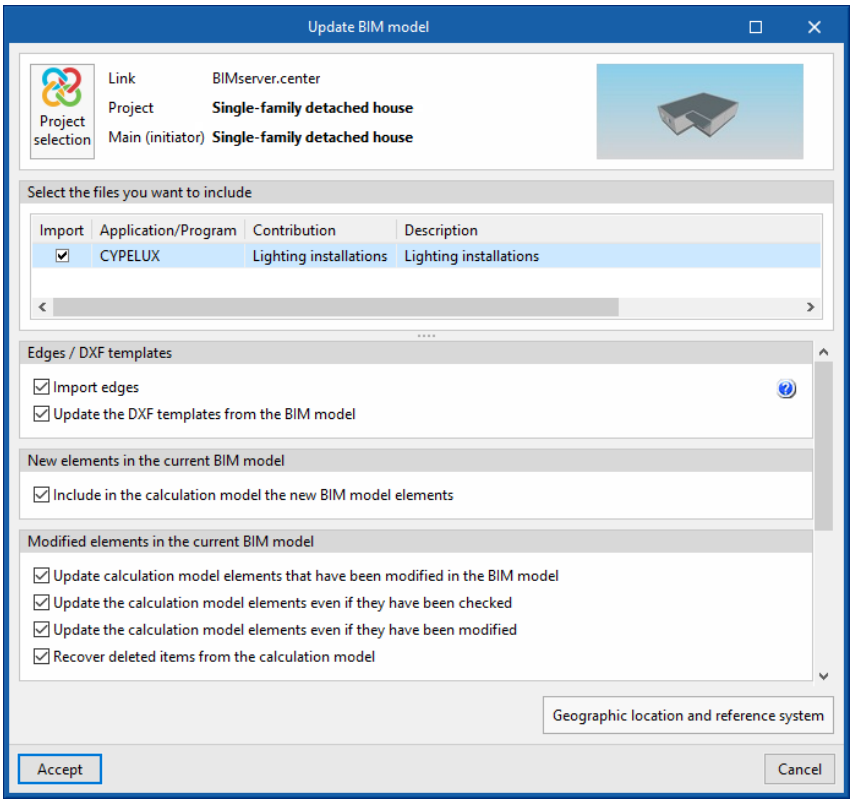


Fig. 62. Initial import of the BIM model

Should users have library files for the elements of the CYPETHERM programs, they can be assigned to the types of the new project at this time during the initial import. To do this, check the **Directory for searching typologies** option and select the directory containing the files with the library elements (.bib files). By doing this, the program will automatically assign the properties of the compatible elements found in the directory whose references coincide with those of the elements of the BIM model (*Using libraries* section).

The **Import edges** option allows the edges of the BIM model generated with the IFC Builder program to be included in the analysis model. The BIM model must contain edges in order to be able to use the automatic building thermal bridging tool (*Edges* section).

After clicking on **Accept** in this initial import wizard, the program interface will appear with the imported BIM model. In the building components tree, within the Zones section, the building geometry (Spaces, Walls, Slabs and their Openings) is fully defined. Furthermore, if groups of spaces were defined in IFC Builder, they will have been imported into CYPETHERM EPlus as Thermal Zones.

To take advantage of the full potential of the Open BIM workflow, we recommend making changes to the model elements in the originating programs. To synchronise the model correctly, imported BIM model elements must keep their reference (their name).

Only the characteristics of the building that are specific to the needs of the energy simulation are yet to be defined. In the tree diagram, the categories of the library that are not yet defined are shown with an orange marking. If these elements are part of the spaces, the orange marking will be displayed on all levels of the components tree to which the elements are associated.

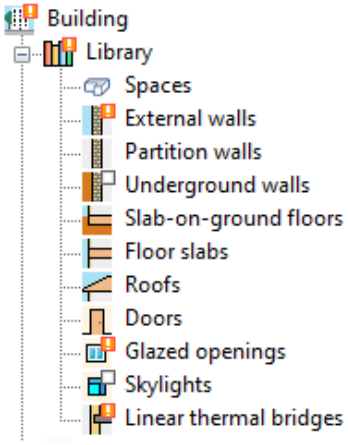


Fig. 63. Building components tree with undefined library elements (orange marking) and categories without elements (white marking)

The climate data file to be used in the simulation (*Location data* section) and the characteristics of the thermal zones must also be defined.

If the edges of the BIM model have been imported, the thermal bridges category of the library will always appear as undefined. In order to manage thermal bridges automatically, the rest of the model must be defined and error-free. At this point, the **Edges** option can be used to automatically define the linear thermal bridges.

6.2 Importing complementary BIM information

CYPETHERM EPlus can import BIM files with the following information:

Air conditioning installations in the building. The air conditioning systems and equipment defined in the Open BIM DAIKIN, Open BIM FUJITSU and Open BIM VAILLANT programs, available on BIMserver.center, are imported.

Installed lighting power. The installed lighting power defined in the building spaces is imported from the CYPELUX, CYPELUX CTE (Spain) and CYPELUX RECS (Portugal) programs, available on BIMserver.center.

6.3 Updating the analysis model

The **Update** option in the Building tab toolbar allows users to synchronise changes made to the BIM model. If changes have been made to the linked BIM model, this **Update** option will flash with a warning signal. Clicking on it will bring up the *Update BIM model* window, which offers several options to manage the import of the changes made to the model.

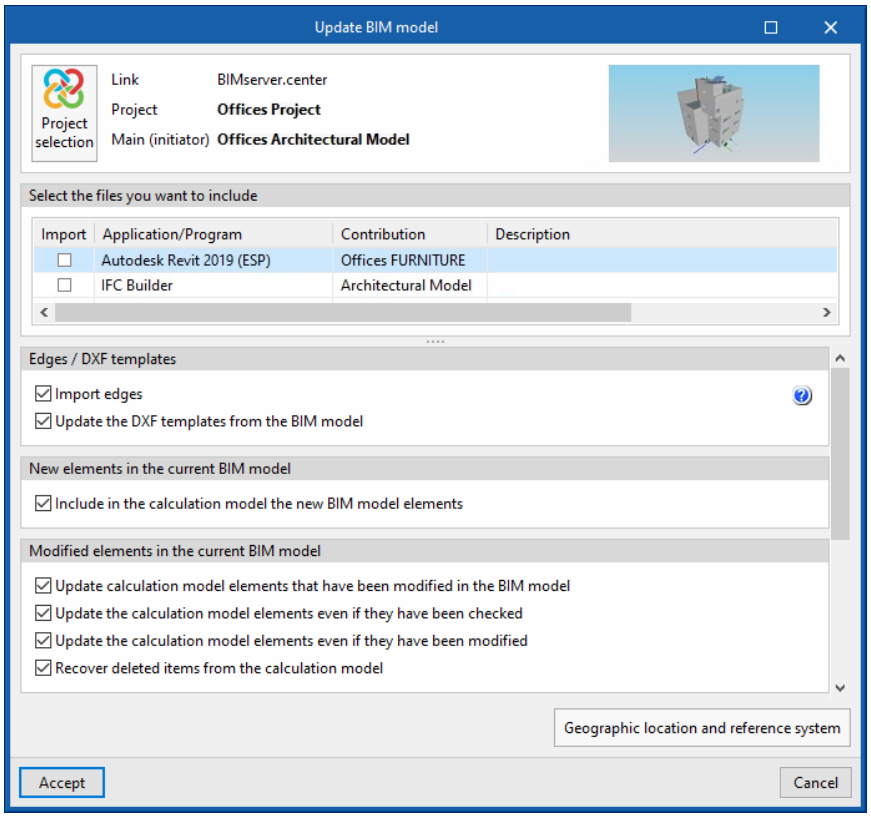


Fig. 64. BIM model update options

6.4 Exporting results to the BIM project

Once the energy simulation has been carried out, the simulation results can be exported to the linked BIM project. This action allows users to consolidate the building project, by adding information to it.

To share the CYPETHERM EPlus results and include them together with the linked BIM model, use the **Share** and **Improvement measure** options in the *Analysis* tab toolbar.

6.4.1 *Share*

Exports the demand and consumption reports to the linked BIMserver.center project, in an IFC format file containing the reports in PDF format.

6.4.2 *Improvement measures*

Exports CYPETHERM EPlus results to an IFC file that can be imported by CYPETHERM Improvements Plus, a program designed for the energy and economic analysis of different alternatives or improvement measures proposed for the building.

In order to compare different scenarios for the same building, the building must first be simulated in its initial state. The results of the analysis will be exported to CYPETHERM Improvements Plus from the wizard either as an *Initial situation* (without associated costs) or as *Improvement measures*, if costs are to be associated with this analysis scenario.

The changes must then be made to the building and the simulation should be re-launched. The new analysis results will be exported to CYPETHERM Improvements Plus from the wizard as *Improvement Measures*. The costs associated with the Improvement Measures can be filled in from the export wizard, or completed later in CYPETHERM Improvements Plus.

When simulating different alternatives on the same building, users are recommended to work on a new file, in order to maintain the data of the initial simulation. In any case, each time a job is exported from *Improvement Measures*, a backup copy of the file is created in the local directory associated with the BIM project, with a .tri_back extension.