User's Manual

Contents

1. Introduction

CYPETHERM FUJITSU is a program for the energy simulation and analysis of buildings featuring Fujitsu HVAC systems. The energy simulations are performed with the U.S. DOE's calculation engine EnergyPlus™ version 9.0.

1.1 Minimum software requirements

The program is compatible with Microsoft OS Windows 7, 8 and 10 (64-bit versions).

Additional software requirements:

- A minimum of 1 GB of available space on the hard disk.

1.2 Capacities

In this section the elements that CYPETHERM Fujitsu is capable of simulating and its known limitations are detailed.

In general, the simulation limitations of CYPETHERM Fujitsu correspond to the EnergyPlus™ functionalities (version 9.0) that have been implemented and are described in the EnergyPlus™ 9.0 Input Output Reference manual. In some cases the limitations of the calculation engine have been overcome by means of equivalences and approximations of calculation.

Geometry

As for the geometric description of the building, there are no known limitations in the number of elements (zones, walls, openings, etc.), dimensions or shape.

Elements and constructive solutions

The description of the constructive solutions is different for the opaque part of the building envelope and the fenestration. In each of these categories, the program allows you to simulate the following elements:

Opaque envelopes:

- Walls: facades, dividing walls, partitions, underground walls.
- Slabs: floors in contact with the ground with optional peripheral insulation, floors between levels, overhangs and roofs.

The composition of the opaque envelopes is defined by layers. Each layer can be a solid material, an air gap (even ventilated) or a vapour barrier. There are no limitations in the number of layers, since CYPETHERM FUJITSU automatically groups the layers defined to adapt to the maximum limit of 10 layers per element that is allowed by EnergyPlus™ 9.0.

Alternatively, a simplified description of the envelopes is allowed indicating the thermal properties of the set.

Therefore, it is possible to simulate all constructive solutions that can be assimilated to these definitions.

It is possible to define a single value for the air permeability of all the facades of the building, and a different one for the roofs.

Fenestration:

- Opaque: doors
- Glazed: windows and glazed doors, skylights
- Openings

The definition of the fenestration materials is limited to the definition of their global thermal properties, distinguishing between glass and opaque fraction in the case of glazed openings.

In the glazed openings, the definition of sun protection accessories (interior and exterior blinds) and their control, of shadow elements (cantilevers and side protections), and of the different elements of the windows (lintel, blind box, etc.) that produce plane thermal bridges are allowed.

It is allowed to define a value for the air permeability of each glazed opening. It is allowed to define a single value for the air permeability of all the doors of the building, and a different one for the openings.

Linear thermal bridges

The effect of the linear thermal bridges produced by the meeting of the different construction elements and the ground can be 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. It is possible to edit the corresponding values and define usage profiles hour by hour.

Air infiltrations are defined at the thermal zone level. The value of the air flow rate can also be defined hour by hour.

Operational conditions and interior comfort

It is allowed to edit the set point temperatures of each thermal zone with hourly resolution, distinguishing between cooling and heating set points.

Air conditioning systems

The program enables the simulation of the following HVAC systems:

Stand-alone terminal units:

- Constant performance systems
- Electric heating transmitters (Joule heating)
- Heat and Energy Recovery Ventilators (HRV/ERV), single zone

Water HVAC systems:

- Heating by radiators and underfloor heating
- Fan-coils

  That can be connected to the following types of hydraulic loops:

  - Hot-water systems, including conventional or condensing boilers
  - Chilled-water systems, including chillers with air, water or evaporative condenser

Direct expansion HVAC systems:

- Fujitsu's Airstage variable refrigerant flow (VRF) systems
- Packaged air-to-air heat pump (PTHP) equipment. For simulation purposes this is equivalent to split equipment, not inverter.
- Packaged air conditioning units with electric, gas or water heating (PTAC).
- Water-loop heat pump systems (water-to-air heat pump).

Air HVAC systems:

- Constant air volume systems, single zone (rooftop units) and multizone (with terminal reheating).
- Variable air volume systems (VAV), with variable flow boxes with optional auxiliary fan.
- Dual-duct systems, constant air volume and variable air volume, with a single fan or with a fan per duct.
- Centralized ventilation systems (only handle the ventilation air flow):
    - Heat and Energy Recovery Ventilator (HRV/ERV)
    - Dedicated outdoor air system (DOAS)

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

    - **Cooling coil:**
        - Water, connected to a chilled-water system using chillers.
        - Direct expansion, available in single-zone constant air volume systems, in variable flow systems with rooftop units and in the DOAS.
    - **Heating coil:**
        - Water, connected to a hot-water system using boilers.
        - Electric
        - Gas
        - Direct expansion, available in single-zone constant air volume systems and in the DOAS.
    - Supply fan
    - Return fan
    - Humidity control: dehumidification and humidifier
    - Outdoor air intake, with the following functions:
        - Free cooling
        - Heat and energy recovery

Condenser water systems:

- For chillers, by cooling towers of 1 or 2 speeds.
- For reversible heat pumps, using cooling towers and boilers.

There are the following limitations regarding the simulation of HVAC systems:

- It is not allowed to define availability and activation schedules of the HVAC systems. In general, the HVAC systems are activated automatically to maintain the set point temperatures defined in the thermal zones. Air HVAC systems continuously drive air, except for centralized ventilation systems, which follow the defined use profile for the ventilation of the spaces of the thermal zones it serves.

- It is allowed to edit the performance curves of the boilers and the chillers. The rest of the generic systems are simulated with the default performance curves of the EnergyPlus™ v9.0 template objects.

There are the following limitations regarding the number and type of HVAC systems that can be simulated in the same building:

- You can define any number of air and direct expansion HVAC systems.
- If only water, direct expansion or centralized ventilation systems have been defined in the building, it is possible to simulate any number of systems of these types. However, if any other type of HVAC system has been defined (other air HVAC systems or any condenser water system), only one hot-water and one chilled-water system can be defined in the building.
- Only one condenser water system of each type can be defined (for chiller and for reversible heat pump).
- If only water, direct expansion or centralized ventilation systems have been defined in the building, it is possible to define any number and type of terminal units in the same thermal zone. However, if any other type of HVAC system has been defined, in each thermal zone it is only possible to define a single terminal unit of the following types: air terminal units (ATU), water terminal units and the water-to-air heat pump (WAHP). These terminal units cannot be defined together with other types of units in the same thermal zone, with the exception of an electric emitter for heating, or a radiator or a radiant floor.
- If the building contains air HVAC systems (except centralized ventilation systems) or condenser water systems, it is possible to define several VRF terminal units (indoor units) in the same thermal zone, but they cannot be defined together with other types of terminal units with the exception of an electric emitter for heating, or a radiator or a radiant floor.
- Only one constant performance equipment per thermal zone can be defined. In this zone no other type of terminal unit can be defined.
- Only a terminal unit with ventilation function can be defined per thermal zone. All the ventilation air flow assigned to the spaces in the zone will enter through that terminal unit.
- It is allowed to define a maximum of 10 production devices within the same water system or condenser water system.

Domestic hot water (DHW) systems

The program does not perform the dynamic simulation of the DHW production. The energy consumption for this concept is calculated through the DHW demand and the average seasonal performance of the system that supplies it.

Maximum and minimum values

The following limits are known in the values of some properties, imposed by the EnergyPlus™ v9.0 models that are used in CYPETHERM FUJITSU:

- 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. The maximum allowed value is 7 W $m^{-2}K^{-1}$

2. Getting Started

2.1 Initial window

When opening CYPETHERM FUJITSU the initial window will appear. This window is broken into 4 sections:

1. **File:** The file section allows users to create a new file, open existing files with the file manager, or access the preloaded example files.
2. **Recent files:** The recent files section displays the most recently opened files
3. **Help:** The helps section provides the user with access to program documentation and licensing information. Clicking "About…" will display the users current license code.
4. **BIMserver.center:** This section displays the status of the user's connection to the BIMserver.center and provides a direct link to the website.

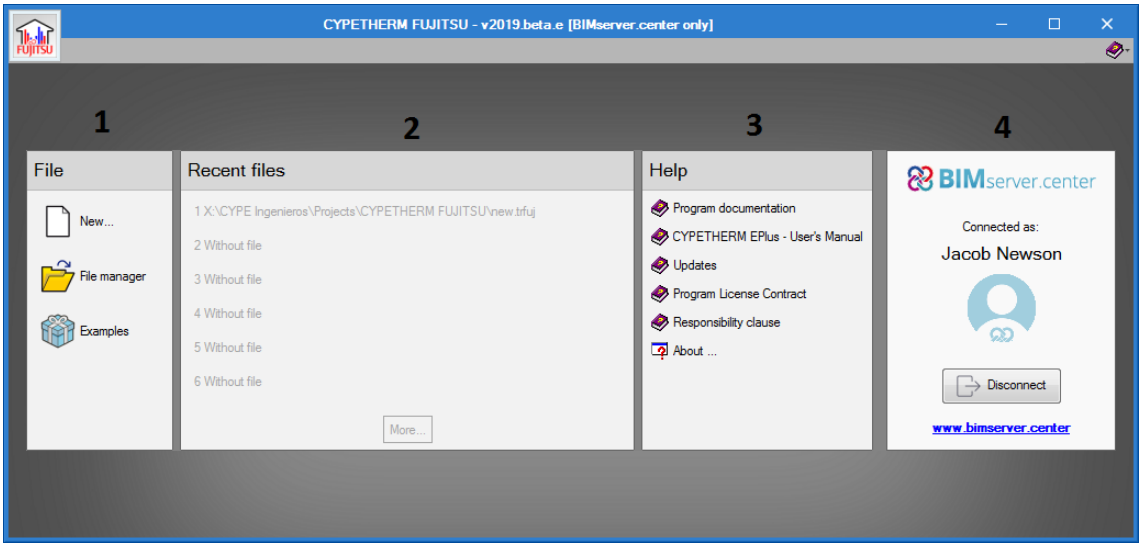


Figure 1: Opening window interface

2.2 Starting a new project

To start a new Project, click "New…" in the File section of the initial window. A prompt will open allowing users to designate a file name and an optional description.

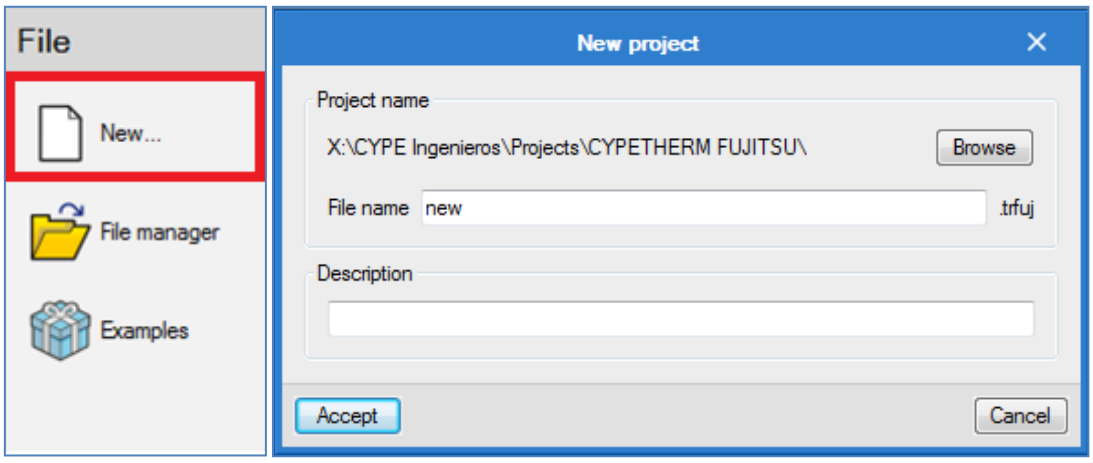


Figure 2: New file option

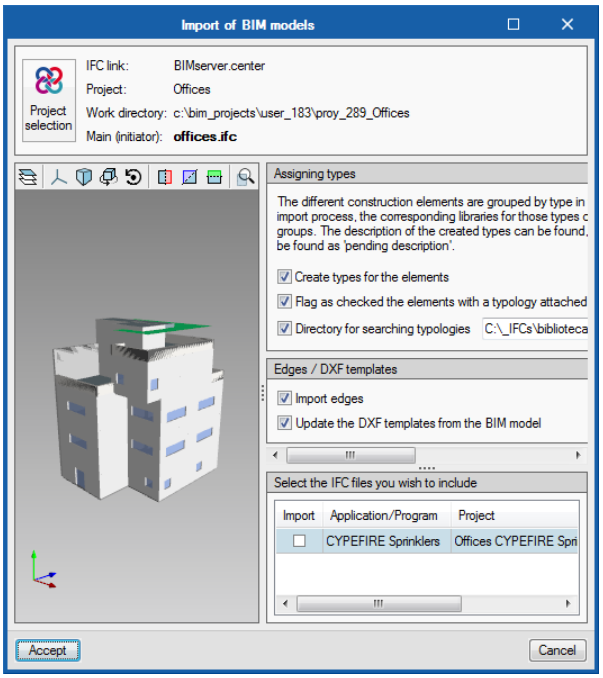


Figure 3: Importing BIM model

Opening an existing BIM project

To open an existing BIM project simply select the project in the window and the model will be loaded. Make sure to check that the BIMserver Synchronizer is activated and up-to-date. The BIM model will be imported and the configuration can be altered prior to starting the project. Clicking *Accept* will open the open the model in the software and commence the project.

After inputting the necessary details, clicking accept will open the next window.

With the window in Figure 4 users have the option to open an existing BIM project with its associated 3D model or to instead use the 3D model wizard to generate a 3D model separate from the BIMserver.

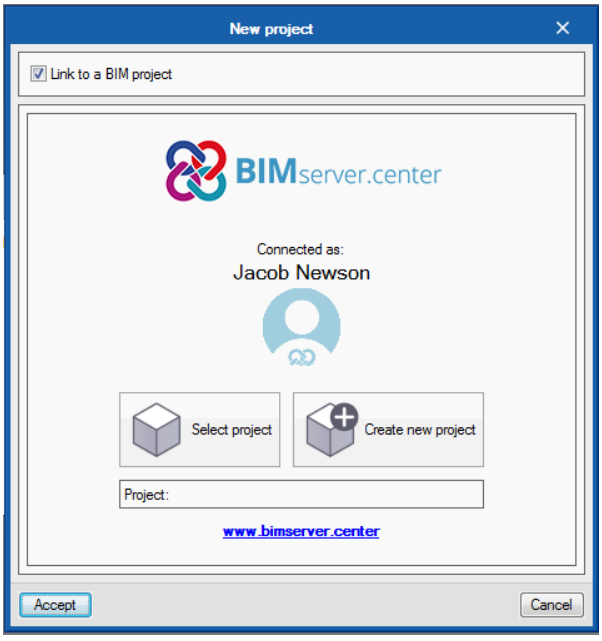


Figure 4: New project window

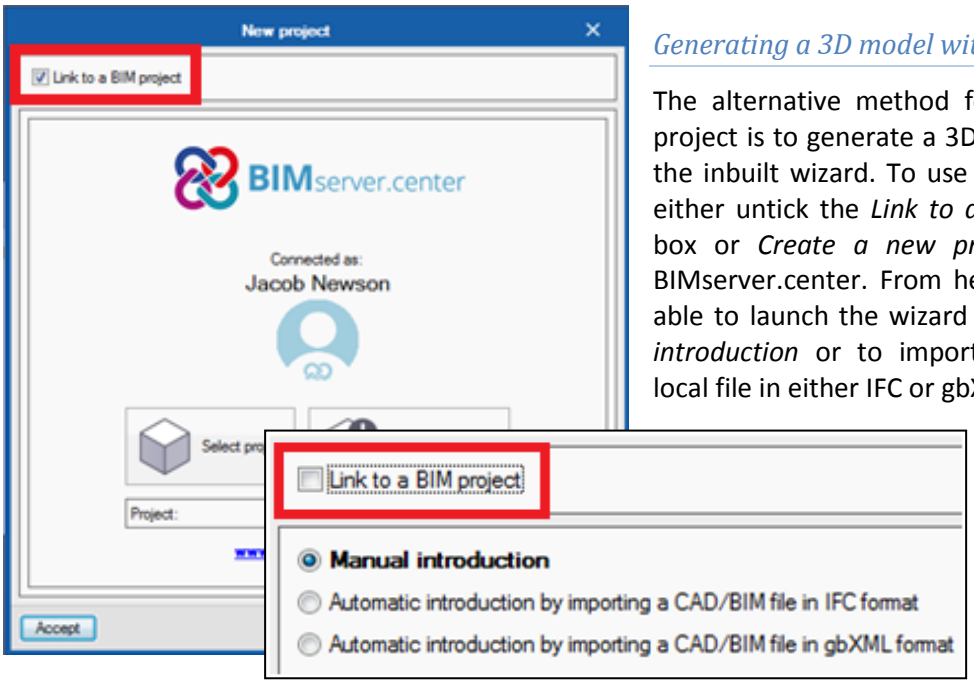


Figure 5: Linking to a BIM project

Generating a 3D model with the wizard

The alternative method for starting a project is to generate a 3D model using the inbuilt wizard. To use this method, either untick the *Link to a BIM project* box or *Create a new project* in the BIMserver.center. From here users are able to launch the wizard with *Manual introduction* or to import an existing local file in either IFC or gbXML format.

Automatic introduction from BIM files in gbXML format

The gbXML format (Green Building XML) has been developed to facilitate interoperability between design and development programs used in the building industry. Thanks to the gbXML format it is possible to exchange data between applications avoiding manual input and the possible errors that this entails.

The program facilitates the introduction of a building thanks to the import of all the information contained in a BIM file in gbXML format with all the constructive elements, the premises and the zones.

Automatic introduction from BIM files in IFC format

The IFC (Industry Foundation Classes) format is a 3D architectural file format used by the building industry to exchange and share information between programs.

The program facilitates the introduction of a building thanks to the import of all the information contained in a BIM file in IFC format with all the constructive elements, the premises and the zones.

This .ifc file can be generated by IFC Builder or by another BIM program capable of creating files in IFC4 format.

Units

After selecting *Manual introduction* or creating a new BIM project and *Accept*, the following prompt will appear allowing users to determine the system of units to be used for the project. This can be altered afterwards using the *General options* button.

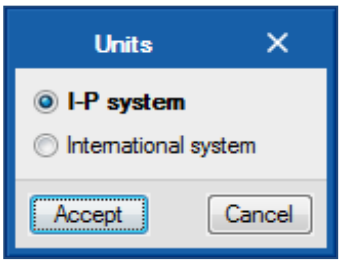


Figure 6: Units systems

3D model wizard

The 3D model wizard will be launched once the units system has been selected. From here the user must complete 6 steps to generate a 3D model (Type, Location, Floors, Geometry, VRF system, and Ventilation).

Type of project

The first window of the definition wizard allows you to choose the type of building project. Depending on the chosen type, the default library typologies will be loaded to define the internal heat gains and the constructive solutions.

Figure 7: Type of project, 3D model wizard

Location

The following window allows you to choose the location of the project and its corresponding climatic data. Select a state first to see the locations whose climatic data are available in the program. For the state of California, the official climate data of the California Climate Zones, which are owned by the California Energy Commission, are provided.

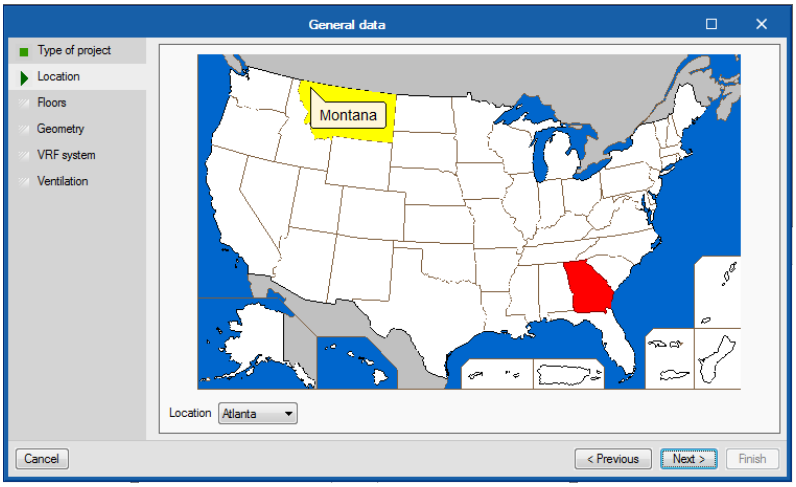


Figure 8: Location, 3D model wizard

The climatic data of the rest of localities are property of the National Renewable Energy Laboratory (NREL), and correspond with the TMY3 files recommended for energy simulation. If you cannot find the desired location, you can upload your own climatic data file .epw in the general interface of the program. Meteorological data of over 2100 world locations can be found on the EnergyPlus website (energyplus.net/weather).

Floors

Determine the number of floors of the building and its height, distinguishing between floors below ground (basements) and above ground. When adding a new floor, the option *number of floors in the group* allows the creation of several equal floors at the same time.

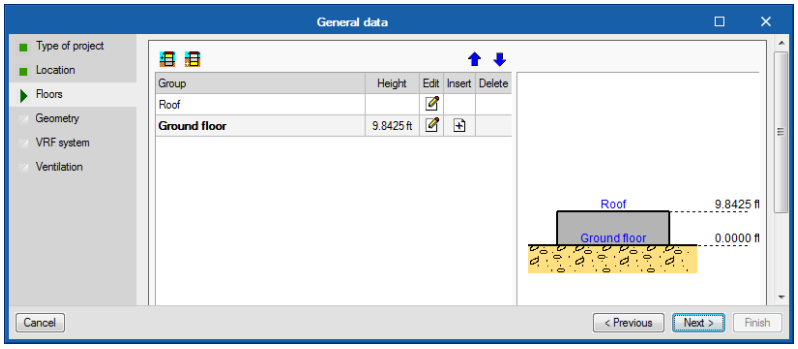


Figure 9: Floors selection, 3D model wizard

Geometry

Chose the geometry of the building among the proposed forms. The dimensions, the orientation of the building and the total area of windows must be defined. The assistant will create the 3D model of the building for the simulation with the form and number of defined floors. A single space will be created per floor, which will correspond to a thermal zone.

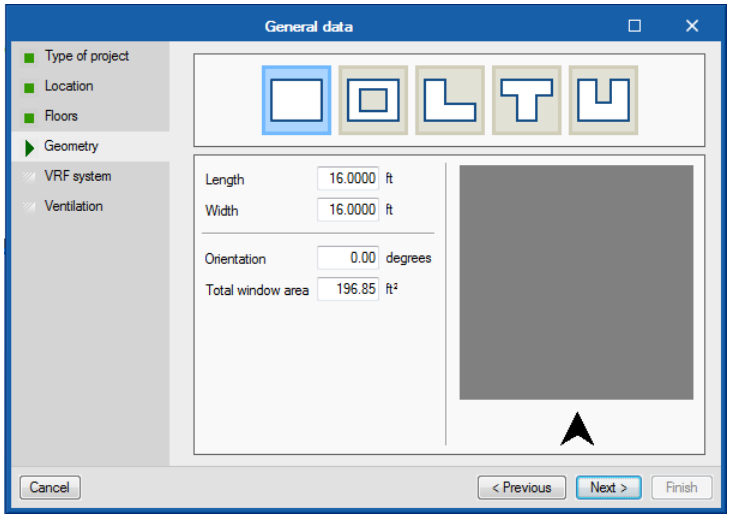


Figure 10: Geometry, 3D model wizard

VRF system

Once the building has been defined, the wizard can add a Fujitsu Airstage variable refrigerant flow (VRF) air conditioning system. In the Indoor units section, you must define the indoor VRF units that you want to install on a building floor. These indoor units will be copied on all floors of the building. In the Outdoor unit section, you must select the outdoor unit VRF to which the defined indoor units will be connected. The Single OU option will create a single outdoor unit (OU) to which all the building's indoor units will be connected. The One OU per floor option will create as many outdoor units (OU) as the building's floors. The indoor units of a floor will be connected to each OU.

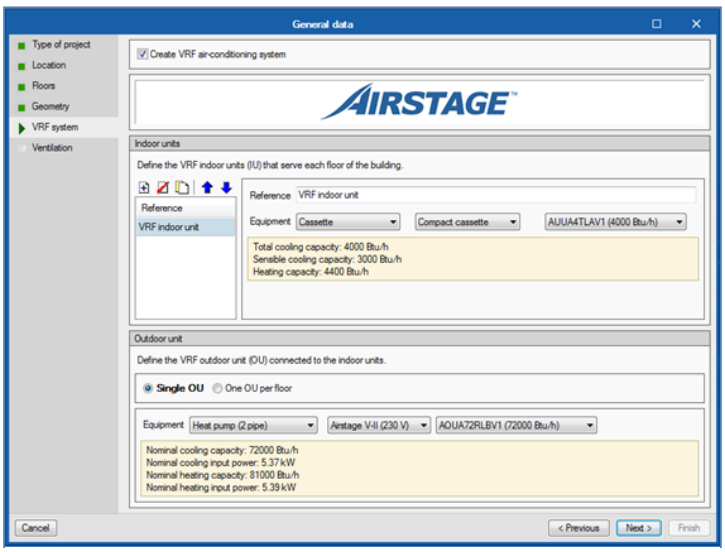


Figure 11: VRF system, 3D model wizard

Ventilation

Finally, the option of creating a ventilation system for the building is offered. The equipment that will allow the entrance of the air to the building can be a heat / energy recovery ventilator (HRV / ERV) or a direct-expansion dedicated outdoor air system (DX-DOAS). In this window, you must define the characteristics of the chosen equipment. The blue arrow button restores the default values. The *Single unit* option will create a centralized system that will serve all the floors of the building. The *One unit per floor* option will create a ventilation system for each floor of the building.

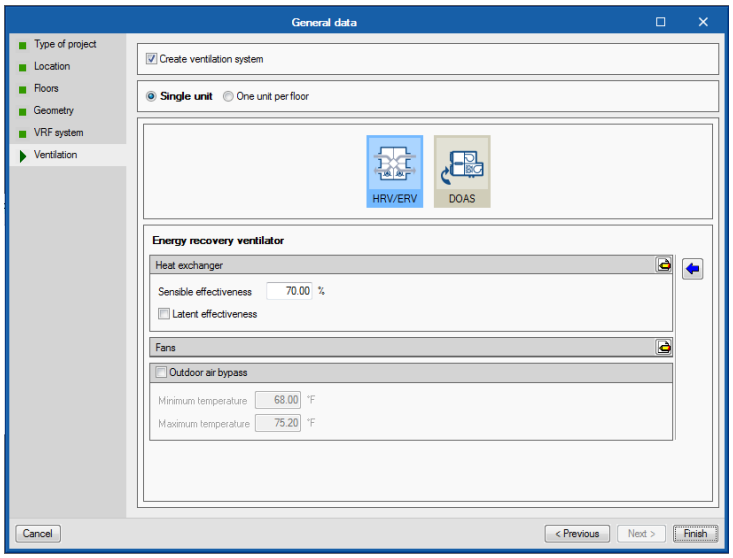


Figure 12: Ventilation, 3D model wizard

Once the wizard is finished, the 3D thermal model of the building appears in the main window of the program.

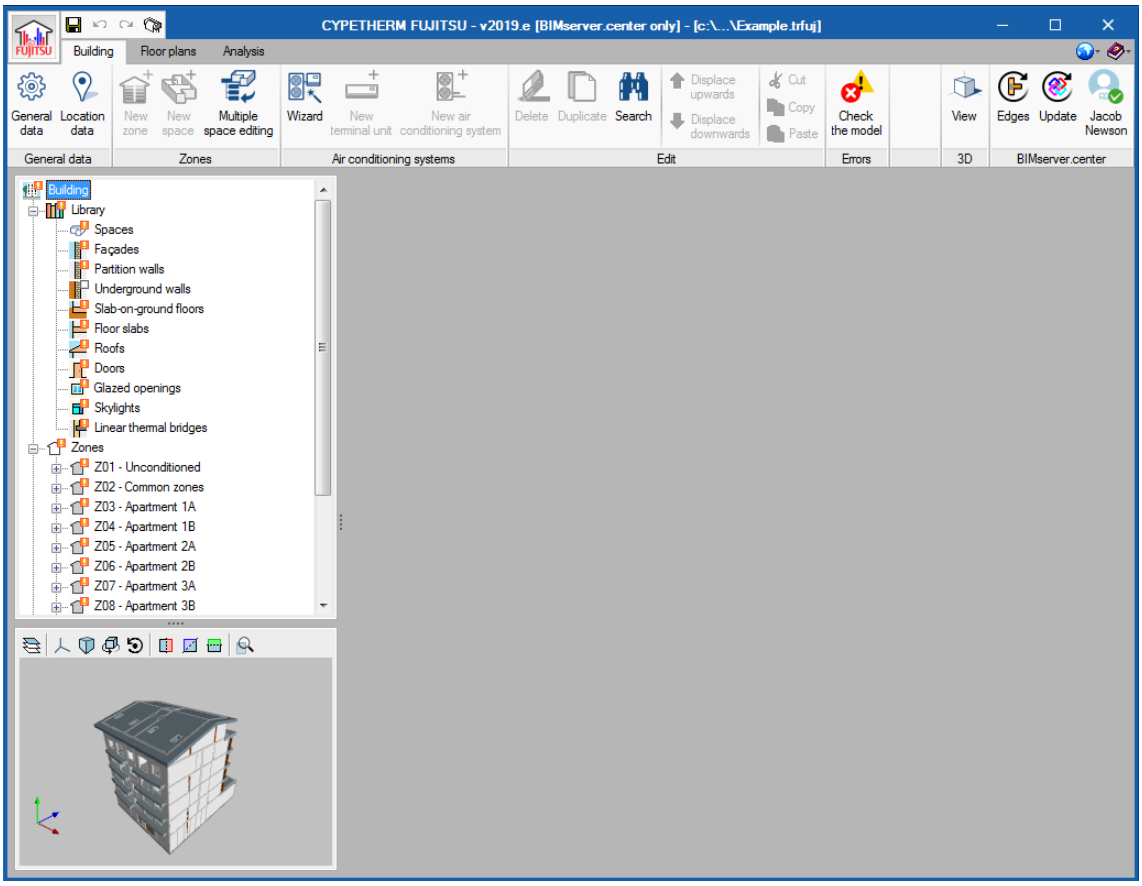


Figure 13: Main window, CYPETHERM FUJITSU

2.3 Interface

The interface of the main window of the program is broken into three tabs: Building, Floor plans, and Analysis. The three tabs are structured in the same format and can each be broken into four sections.

Primary toolbar: Consists of the primary tools used to interact with the project.

Project tree: A library of all elements and operations within the project.

3D model viewer: The standard 3D model viewer contained within all CYPE software. The window's dimensions can be adjusted and also contains a tool bar for useful functions such as viewing properties, layers and rotation of the model.

Configuration window: The main window of the interface is reserved for adjusting settings of any selected components in the project tree.

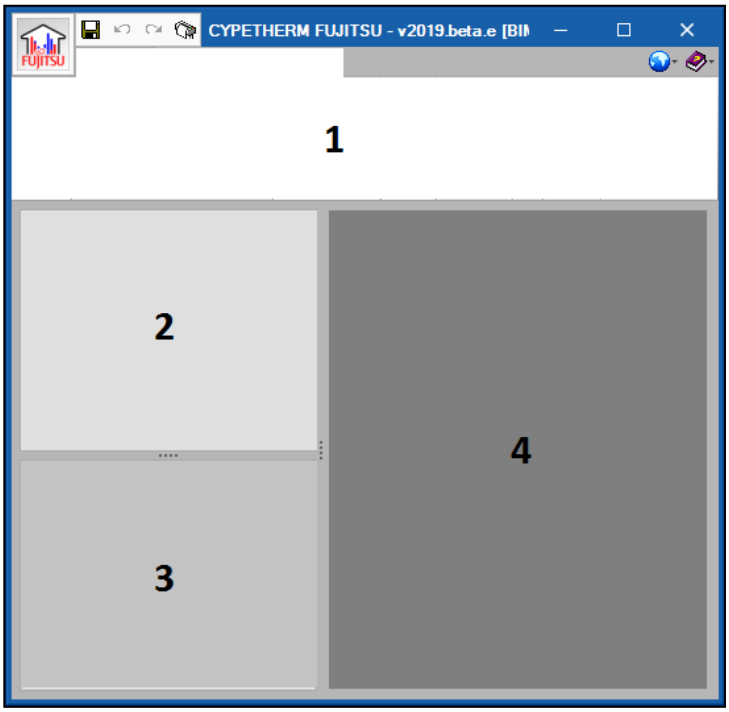


Figure 14: Interface structure

2.3.1 Auxiliary tools

The auxiliary toolbars located within the interface are very similar to those found in all CYPE software and serve to complete and configure the basic commands of the program.

File button

In the top left corner of the window is the File button used to access the most basic commands alongside four shortcuts (Save, undo, redo, and drawings). Clicking the button opens a drop down menu containing the following options:

- New file
- Open file
- Save
- Save as
- Alter job description
- Produce drawings
- Recent files
- Exit

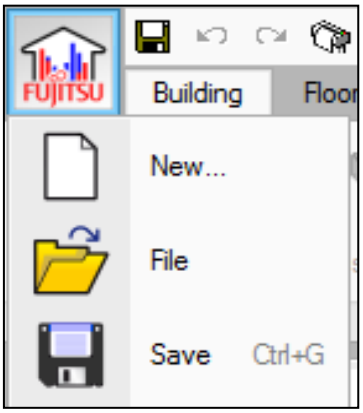


Figure 15: File button drop-down menu

General configuration

In the top right hand corner of the screen the user has access to two buttons: configuration, and help.

Figure 16: General configuration buttons

Configuration: The configuration tool is used to change a number of basic settings for the program, such as the unit system, drawing settings, and background colour.

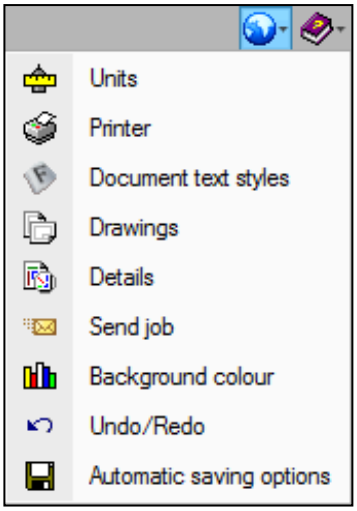


Figure 17: Configuration drop-down menu

Help: The help tool is used to access the program documentation, user manuals, and licensing information.

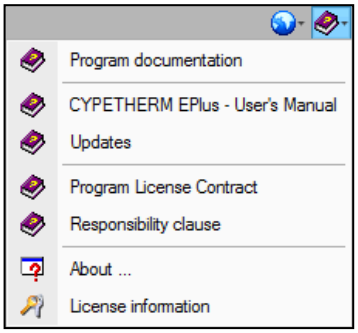


Figure 18: Help drop-down menu

General toolbar

The general toolbar is found in every configuration window. The tools on the left are used to add, delete, copy, and edit items listed. The tools on the right are used to import and export the elements of the list as library files, for use with other projects.

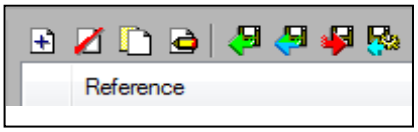


Figure 19: General toolbar

3. Building tab

The general data, the building location data and the thermal model of the building are defined in the Building tab.

The thermal model of the building is organized in a tree scheme with four main branches:

- **Library**
  In the library the user can define the types of spaces and elements (walls, floors, windows…) that make up the building.
- **Zones**
  Each thermal zone will include several spaces of the building, which will be made of different elements (walls, floor, windows…), and also the terminal units of the HVAC system. The operational conditions of the HVAC system are defined at the zone level.
- **Air conditioning systems**
  This section is used to define the supply side (central plant) of the HVAC systems of the building. These will serve the terminal units defined in the zones.
- **DHW systems**
  This section is used to define the domestic hot water systems of the building.

3.1 General data

The first section of the Building tab is the General data section. From here the user has access to two tools used to assign the general parameters of the project: General data, and Location data.

Figure 20: General data

3.1.1 General data

The General data window is broken into 4 sections:

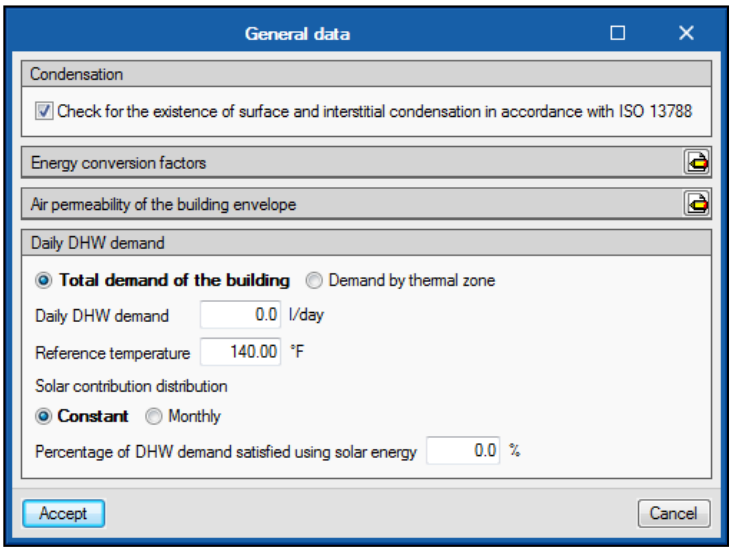


Figure 21: General data window

Condensation: The program includes the option for verification of the existence of surface and interstitial condensations according to the UNE-EN ISO 13788 standard, offering results for each constructive solution.

Daily DHW demand:

The parameters to calculate the energy consumption associated with domestic hot water (DHW) production can be defined for each thermal zone, in the Zone panel, or for the entire building, in this panel.

The daily DHW demand in litres/day must be defined and the temperature at which that amount of water is produced (reference temperature).

To consider solar thermal installations for DHW, you can define the percentage of DHW demand satisfied using solar energy, as a total annual value or month by month. This value is subtracted from the energy expenditure for the production of DHW.

Energy conversion factors:

The user defines the energy conversion factors from different sources. These factors take into account the origin of the energy consumed in the building.

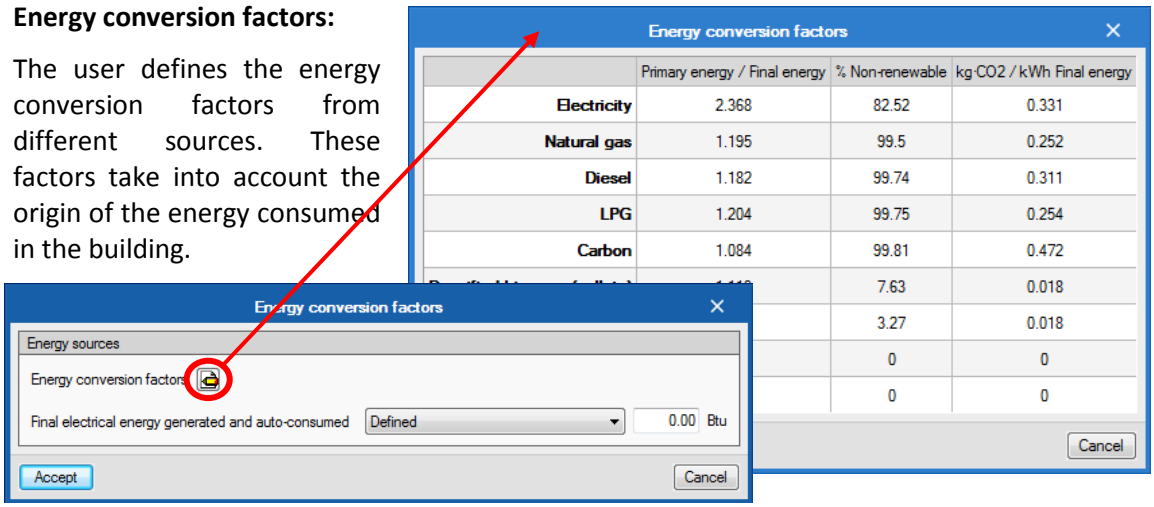


Figure 22: Energy conversion factors windows

There is the option for including any electrical energy that is generated (such as by solar panels) and subtracting that value from the energy expenditure.

Air permeability:

The air permeability of the different envelopes of the building can be configured using the following window.

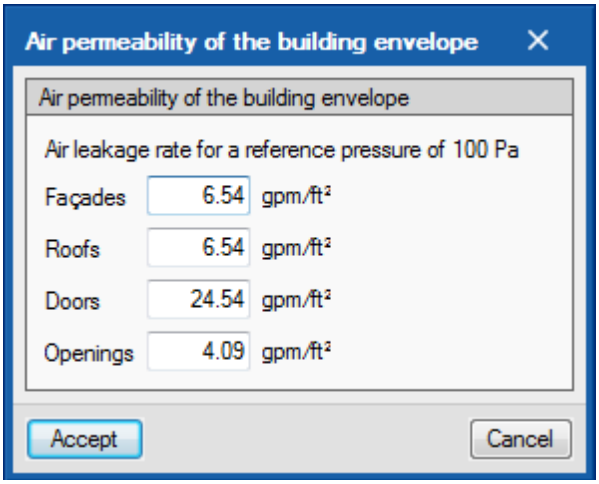


Figure 23: Permeability of the air

3.1.2 Location data

The icon “Location Data” opens the window for defining the weather data. The program runs the energy simulation using the data in the Weather Data File loaded (epw format).

The blue arrow icon opens the US map for location selection. Accepting this pop-up window will load the corresponding Climate data file and update the Location Data. The charts in the right hand side show the data of outdoor temperatures, wind speed and direction and solar irradiation contained in the .epw file loaded.

If you cannot find the desired location, you can upload the corresponding weather data file in epw format in the section Climate data file. Meteorological data of over 2100 world locations can be found on the EnergyPlus website (energyplus.net/weather).

The data in the sections Orientation, Undisturbed temperature of the soil, Solar contribution of domestic hot water and Condensation must be specified by the user.

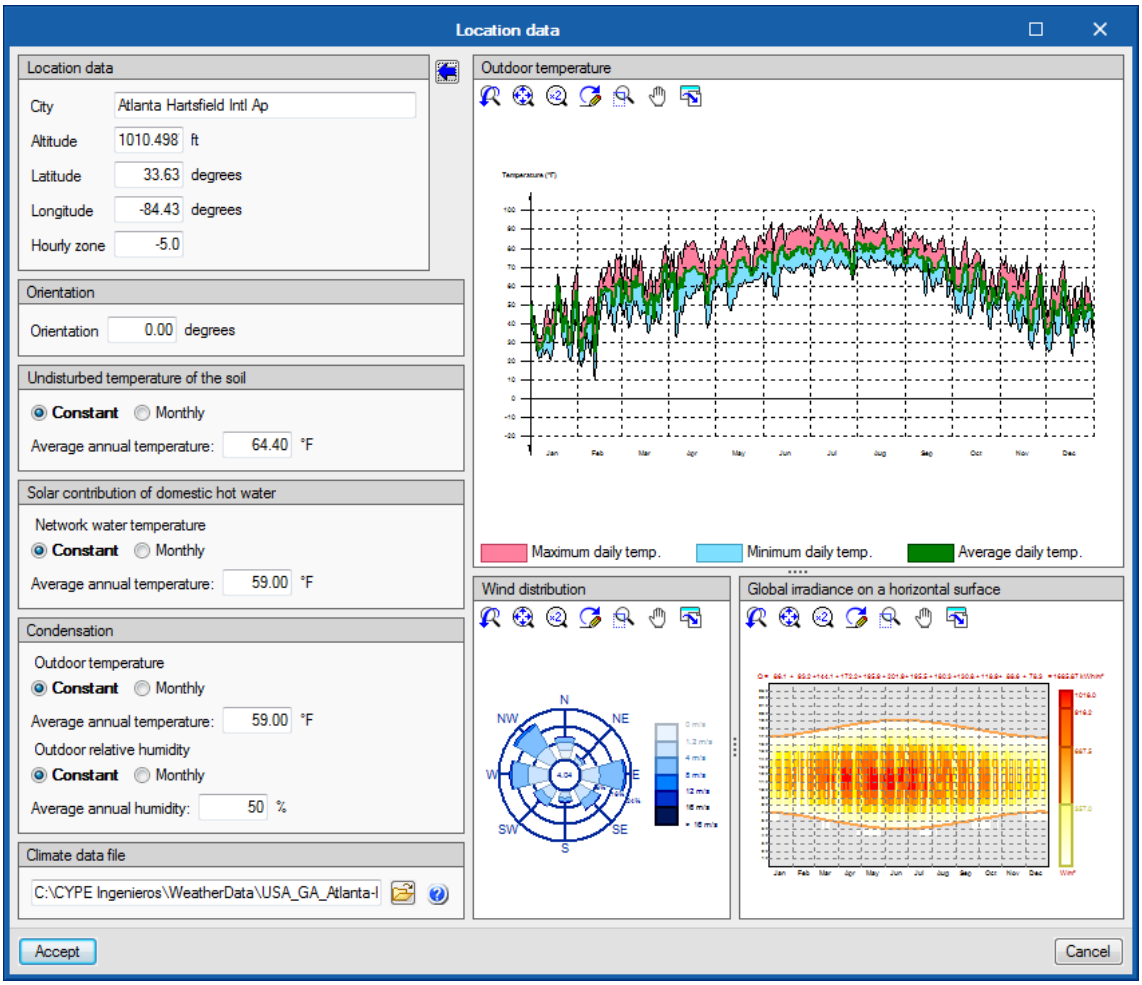


Figure 24: Location data window with visualization of climate data

3.2 Library

Once the work has been created and the general data and the location have been defined, the types of enclosure and constructive elements present in the building must be defined.

If the work has been created from BIM files and the directory for the typology search has been indicated, the elements that appear in the library will be already defined. The elements present in the model that are not in the library will be pending to be defined.

The way to create and manage each element of the library is identical in all cases:

- **Manual introduction:** Creation of a new element.
- **Import of the library:** Import of elements saved in a database previously defined by the user.

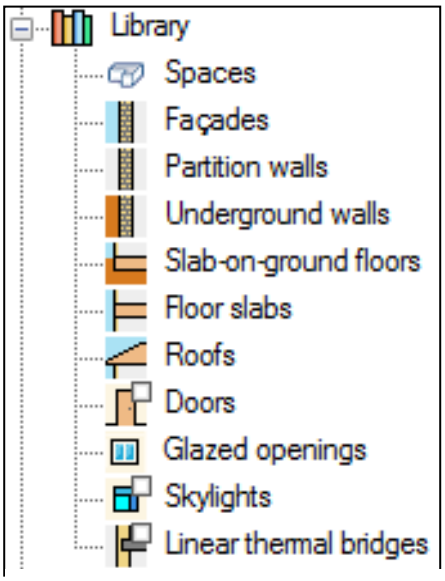


Figure 25: Library section of the project tree

Spaces

- **Occupied**: Indoor enclosure intended for the use of people. The data of the heat gains corresponding to ventilation, lighting, occupancy and internal equipment are customizable. For each type of heat gain, the blue arrow icons allow to import values from ASHRAE standards and manuals. The right-hand side blue arrow icon fills in all the heat gains at a time, depending on the type of space selected.
- **Not occupied**: Interior enclosure not intended for the permanent use of people, and hence without cooling or heating needs. The user can define internal gains due to ventilation, lighting and internal equipment.

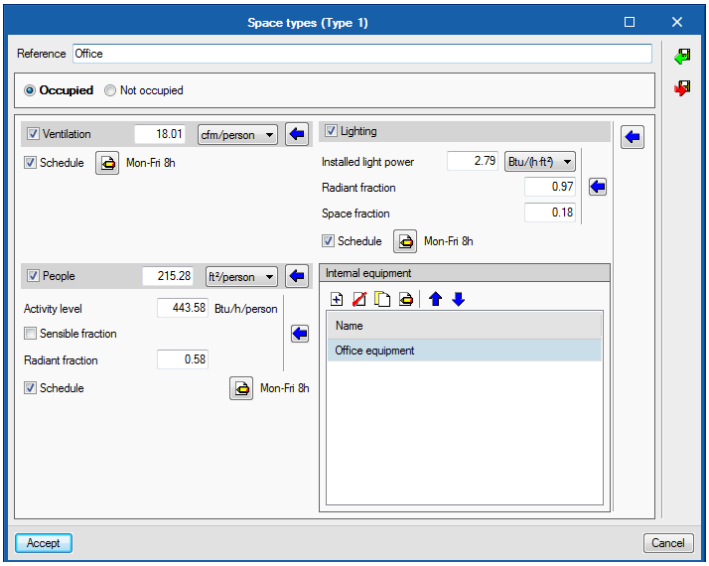


Figure 26: Space types window

Construction elements

The introduction of the construction elements comprises the definition of the opaque building envelopes (walls, partitions and slabs) and the fenestration (windows, skylights and opaque doors).

Walls and partitions

- **Facades:** Vertical enclosures in contact with the external environment or in contact with another building (dividing wall).
- **Partitions:** The partitions are arranged to separate the interior of the building in different enclosures.
- **Underground walls:** These vertical enclosures in contact with the ground are used to build floors below ground.

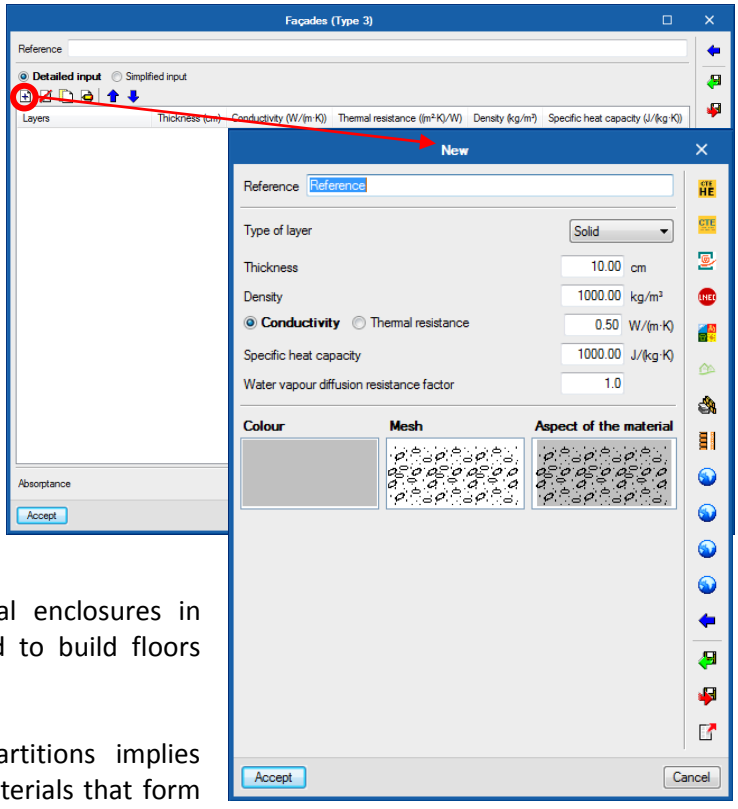


Figure 27: Creating a new facade

The detailed input of walls and partitions implies specifying each of their layers. The materials that form the walls can be defined by the designer or imported from different libraries of materials. Alternatively, the simplified input allows for defining a wall with its total thickness and its average relevant properties. In this option, the properties labeled as “thermal description” are just information and do not take part in the energy simulation.

Slabs

Once the walls and partitions are defined, the slabs are defined, which are classified as:

- **Roofs:** Superior enclosures in contact with the external environment.
- **Floor slabs:** The floors connecting levels. Horizontal or slightly inclined lower enclosures existing between one floor and another.
- **Slab-on-ground floors:** The enclosures that are in contact with the ground.

As in the definition of walls and partitions, slabs can also be introduced as generic walls or by defining their layers.

Doors, windows and skylights

The fenestration makes an important contribution to the thermal load of an enclosure. That is why the definition of doors, windows and skylights must be adjusted enough to allow the introduction of both predefined parameters and values provided by manufacturers (in accordance with the applicable regulations).

In the windows and skylights the following elements can be detailed:

- Glazed fraction
- Opaque fraction
- Accessories
- Shadow elements
- Plane thermal bridges

In the case of doors, the definition does not need to be so exhaustive and, therefore, only the thermal transmittance and the absorption coefficient are indicated.

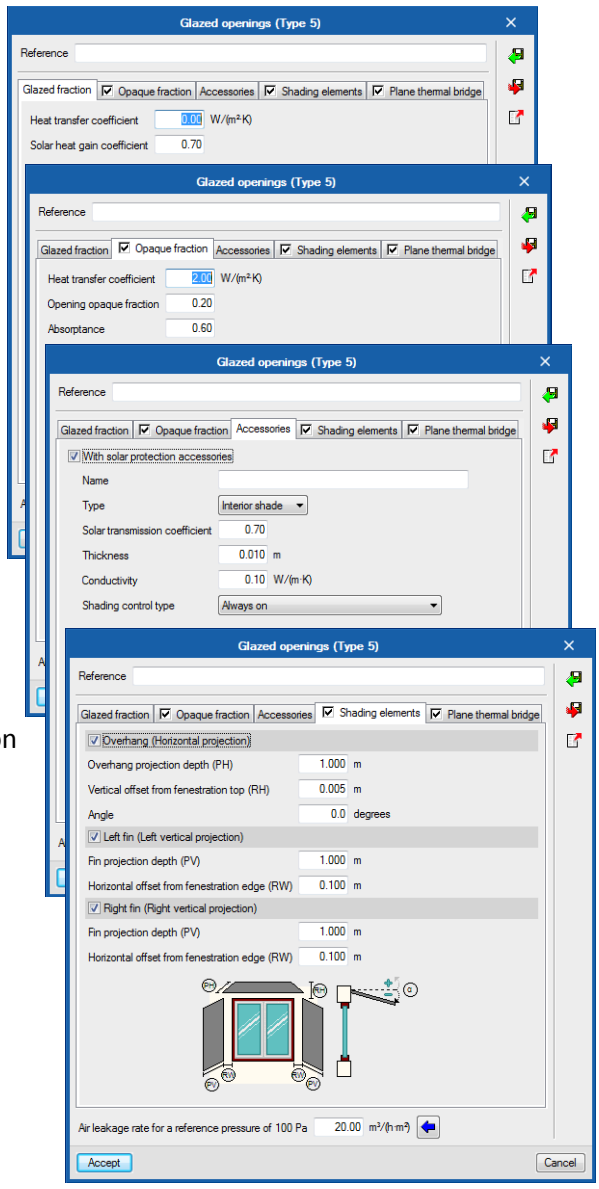


Figure 28: Definition of the glazed openings

Linear thermal bridges

The loss of heat through thermal bridges has a considerable impact on the results of energy demand. For this reason, the correct definition of the characteristics of the thermal bridges is essential for an accurate calculation of the building's energy consumption.

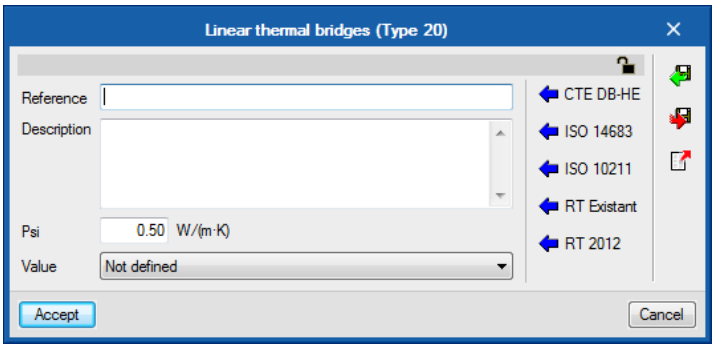


Figure 29: Definition of linear thermal bridges

The data that defines a thermal bridge:

- Linear thermal transmittance (psi)
- Value
- Type of meeting

This data can be customized or can be imported from three assistants implemented in the program:

- CTE DB-HE (thermal bridge Atlas of supporting document DA DB-HE / 3)
- ISO 14683
- ISO 10211

When the work has been created from a BIM model generated in IFC Builder, the library of thermal bridges contains all the edges of the building (purely geometric entities obtained from the intersection between the different construction elements) although part of these edges does not intervene in the calculation.

For the detection of linear thermal bridges it is recommended that the building be completely defined (zoning, description of the spaces, etc.) and the option Edge Processing (see section Edge Processing) be used for the program to show only the types of thermal bridges used in the work. In this way it is much easier to modify, if necessary, the values of the types of thermal bridges proposed by the program.

BIM Model

In the case where the model was imported from a BIM model there will be the following error messages in the library to signal that the elements have not been defined.

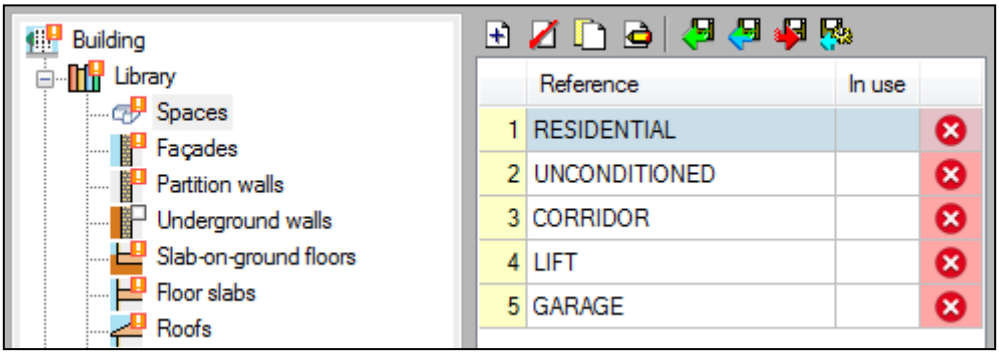


Figure 30: BIM model definition error

All of these elements/operations must be defined for the analysis to be completed successfully.

3.3 Zones

The thermal zones group the spaces of the building, which are defined each by a space type and the corresponding construction elements from the library. By clicking in each of these elements, the user can see and change the definition of the element by selecting an existing type from the library. Element types can also be created and edited from these windows with the buttons close to the option Library.

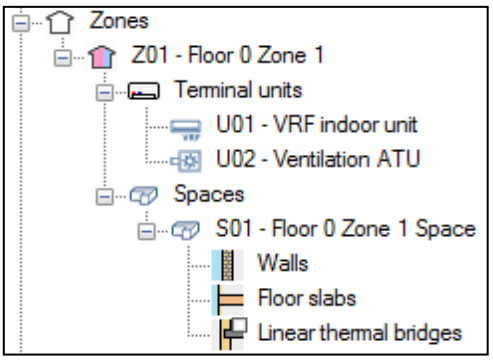


Figure 31: Zones, Project tree

Each of this group of spaces will be served by one or more HVAC terminal units, which are specified as well inside the thermal zones.

Each zone contains the definition of the following parameters:

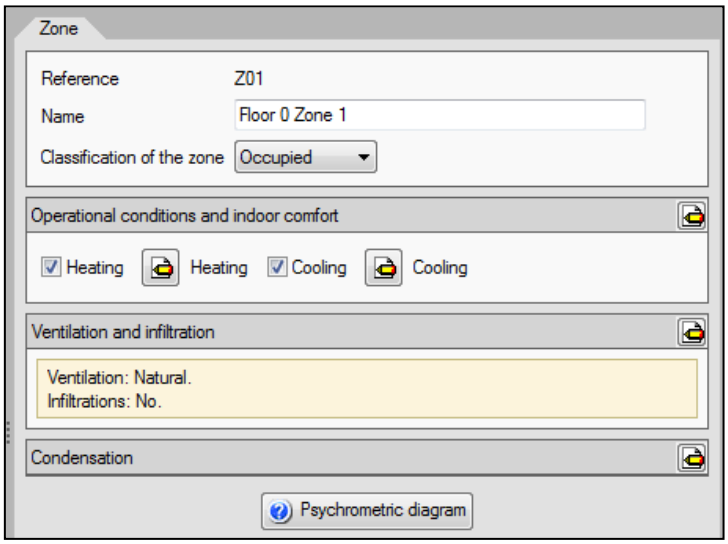


Figure 32: Window for the definition of Zones

Classification of the zone: Occupied or Not occupied. All the spaces inside the zone must have this same classification.

Operating conditions and indoor comfort: set point temperatures for the air inside the zone for cooling and heating, defined for the whole year in an hourly basis.

Ventilation and infiltration: the ventilation needs of the zone are automatically calculated from the specifications made in the Spaces. In this menu, the user must choose whether the ventilation air flow will be enter the zone as Natural ventilation, Mechanical ventilation (allows for defining fan consumption) or Via the air-conditioning system (e.g. by means of a DOAS or an ERV). Optionally, the user can activate the calculation of the air infiltration.

Condensation: parameters for performing calculations of condensation in the constructive elements.

Once the zones of the building have been defined, the spaces are introduced, indicating the geometrical characteristics and subsequently the constructive elements.

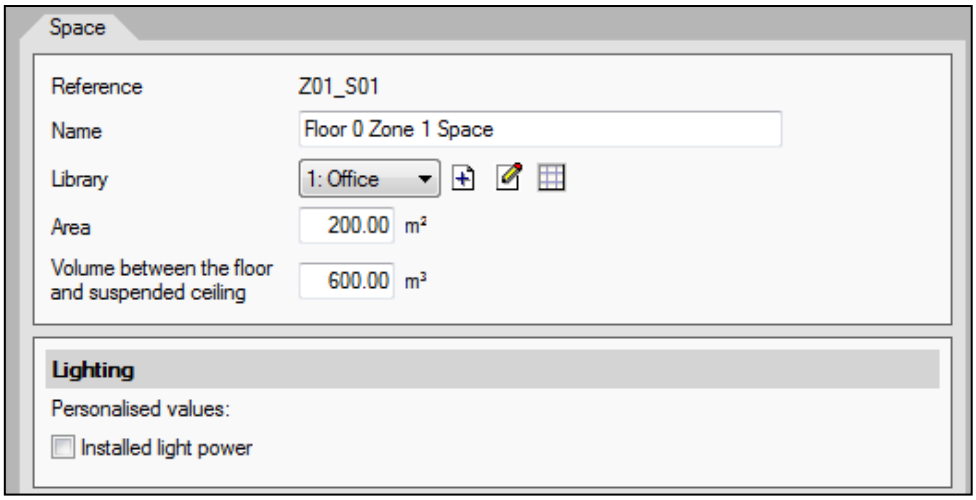


Figure 33: Window for the definition of Spaces, Zones

Each space in the building is defined by its typology within the library, its geometric characteristics and its constructive elements. The user can define the specific lighting power value of the space. If defined, this value will override the value defined in the corresponding space typology from the library.

Enclosure elements

In each space the user can visualize and manage the enclosure elements that make it up and the associated thermal bridges. The user can access the openings and associate linear thermal bridges by clicking on the walls in which they are embedded.

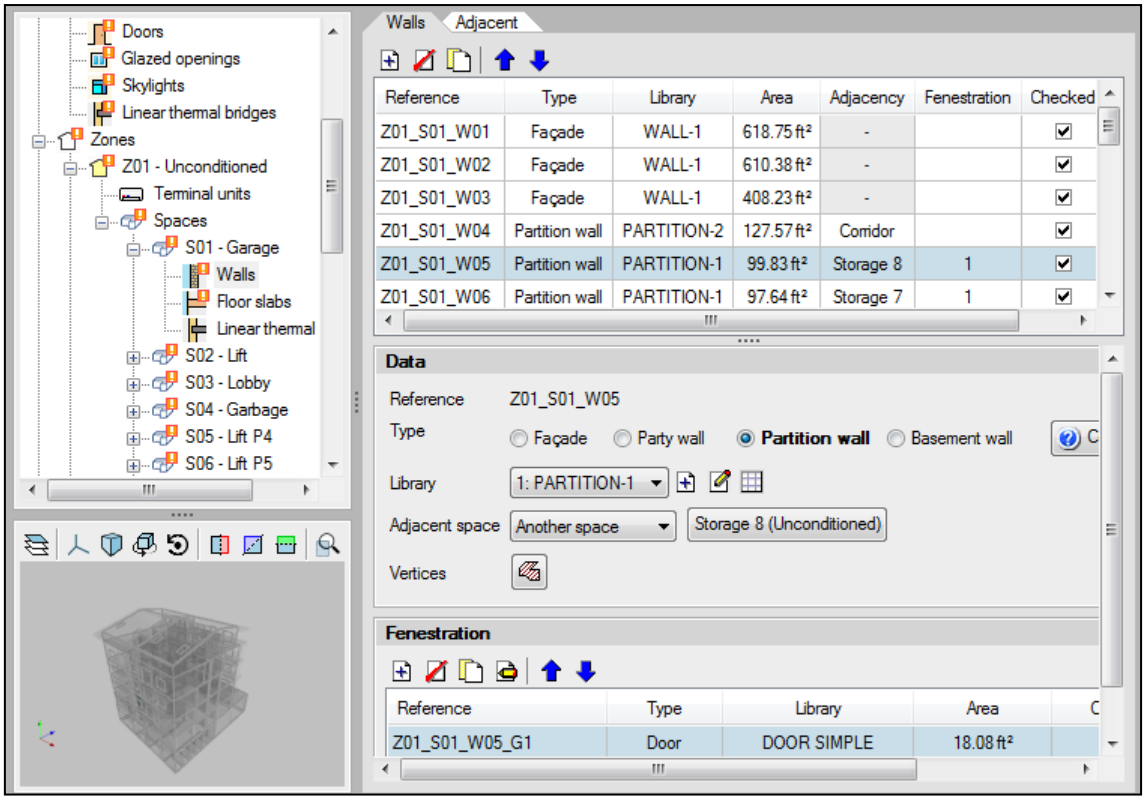


Figure 34: Enclosure elements, Zones

3.4 Domestic Hot Water (DHW) systems

In this section, the systems in charge of producing the domestic hot water (DHW) of the building are defined. The definition of the DHW systems depends on the option chosen in Daily Demand of DHW within General Parameters. If you have chosen 'Total building demand', you can define a single DHW system that meets this demand. If 'Demand by thermal zone' has been chosen, it is allowed to define more than one system and select the zones served by each one. A zone can only be served by one DHW system.

To define a generic DHW system, the user must indicate the type of production equipment, the energy vector it uses, its seasonal energy performance and its nominal power. The nominal power does not affect the DHW calculations, it is only used for reporting purposes. The blue arrow icon opens a window to calculate the seasonal performance of combustion boilers, according to the EN 15378 standard.

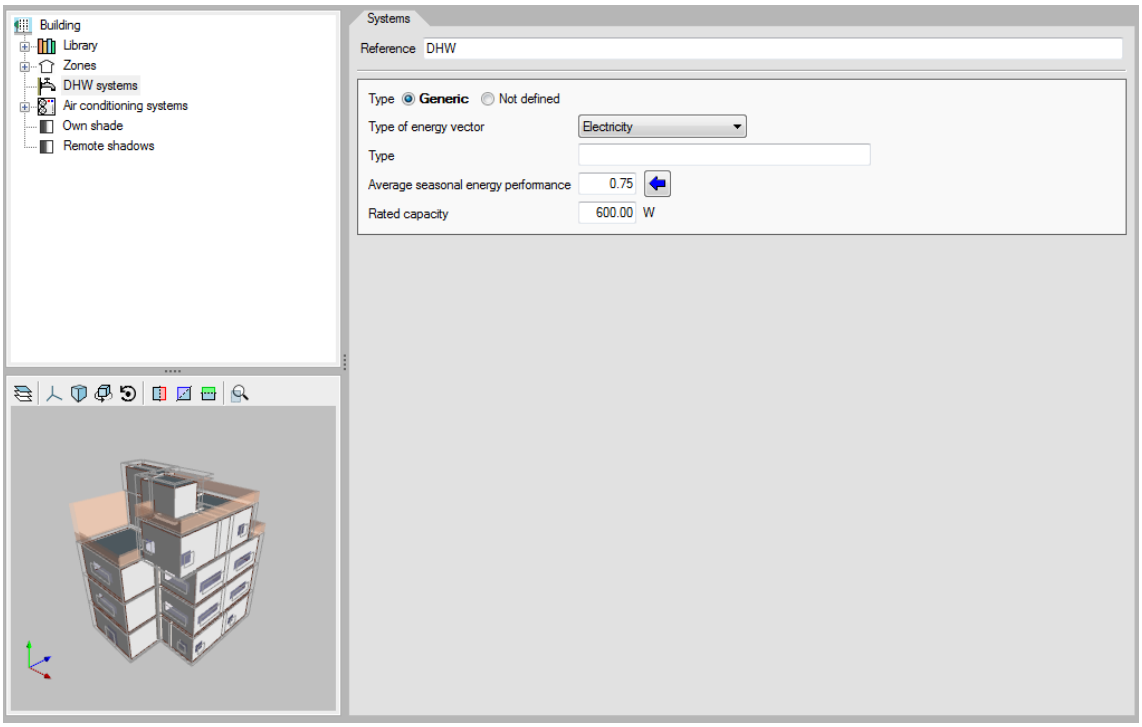


Figure 35: DHW systems

3.5 HVAC systems

The HVAC systems of the building are defined in two sections of the scheme:

- **Terminal units (within each Zone):** these are the equipment found in the enclosures that come into contact with their air.
- **Air conditioning systems:** they are the centralized production equipment and air conditioning units that serve terminal units or other air conditioning systems. Together with the centralized equipment, the relevant characteristics of the distribution network of the working fluid are also defined.

Generally, a complete HVAC system consists of one or more terminal units connected to a centralized system, which in turn may need other production systems. For example, in an all-air system, the air terminal units (ATU) are the terminal units and the air handling unit (AHU) is the centralized system. If the AHU contains a chilled water coil, it will be necessary to define an additional production system that generates the chilled water.

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

In the program, the air conditioning systems and their terminal units have been classified according to the type of fluid that combats the thermal load of the enclosure. Thus, it distinguishes between and water, direct expansion and air terminal units and air conditioning systems. In addition, the program includes the definition of other autonomous terminal units and condenser water systems for chillers and reversible heat pumps.

The program includes the possibility of defining any type of HVAC system, knowing its average seasonal performance of production of cold and / or heat and the type of energy it consumes, through the terminal unit *Constant performance equipment*.

The user can define the building's HVAC systems using the inbuilt wizard. Depending on the type of system chosen, the wizard successively displays the definition panels corresponding to the different equipment of the HVAC system.

3.5.1 Centralized production systems

To add a new centralized production system you must select the branch of the HVAC Systems tree and press the button *New air conditioning system* on the primary toolbar. A pop-up window will appear in which to select the type of production system. The user can choose between the water, direct expansion and air HVAC systems or the condenser water system.

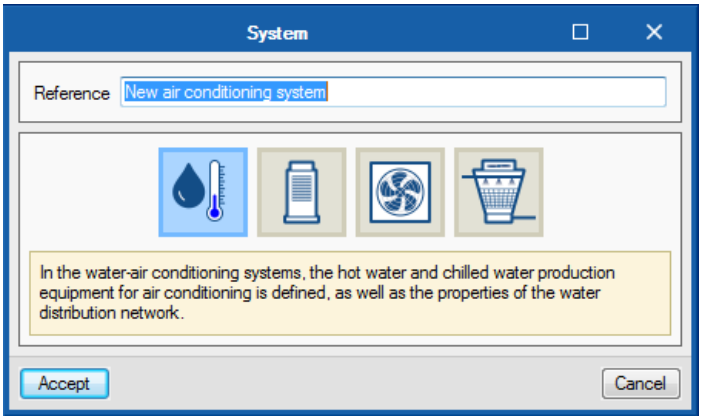


Figure 36: Centralized production systems

When choosing a general typology, a new window will open in which the specific system type is selected and its characteristics are defined. The systems included in the program within each typology are listed below according to the icons that represent them, from left to right:

Water HVAC systems:

- Chilled-water systems, with chillers.
- Hot-water systems, with boilers.

Direct expansion systems:

- Outdoor unit of variable refrigerant flow systems (VRF) Airstage by Fujitsu

Air HVAC systems:

- Centralized ventilation system:
  - Centralized heat/energy recovery ventilator (HRV/ERV).
  - Dedicated Outdoor Air System (DOAS).

- Constant air volume system
    - Rooftop unit (DX coils).
    - Air-handling unit (water coils).
    - Air-handling unit, single zone system, configurable.
- Variable air volume system (VAV)
    - Rooftop unit (DX cooling coils.
    - Air-handling unit (water coils).
- Constant air volume system, dual duct
- Variable air volume system (VAV), dual duct

Condenser water systems:

- For reversible heat pump, with cooling towers and boilers.
- For chiller, with cooling towers.

When selecting the type of equipment, the editing panel is updated to show its characteristics.

The characteristics of the Fujitsu's Airstage equipment are completely defined within the program, so that the user should only indicate the characteristics related to their installation.

In the generic HVAC equipment edition panels, in addition to the list and library management tools, the following general utilities are offered:

-  Show and edit advanced system features.
-  Restore the default values proposed by the program.

If a value is not specified for certain equipment characteristics, such as its rated capacity or the air flow of a fan, the *autosize* function of EnergyPlus™ is used. This function calculates the values not defined by the user from the thermal loads of the associated zones and the design characteristics of the equipment.

3.5.2 Terminal units

The addition of the terminal units of the HVAC systems is analogous to that of the centralized production equipment. To add a new terminal unit you must select the branch of the tree *Terminal units* within the *Zone* where you want to add a new terminal unit. When clicking on the primary toolbar button *New terminal unit*, a pop-up window will appear in which to select the type of terminal unit, between constant performance equipment, water terminal units, direct expansion terminal units, air terminal units, electric emitter for heating and energy recovery ventilator (HRV/ERV).

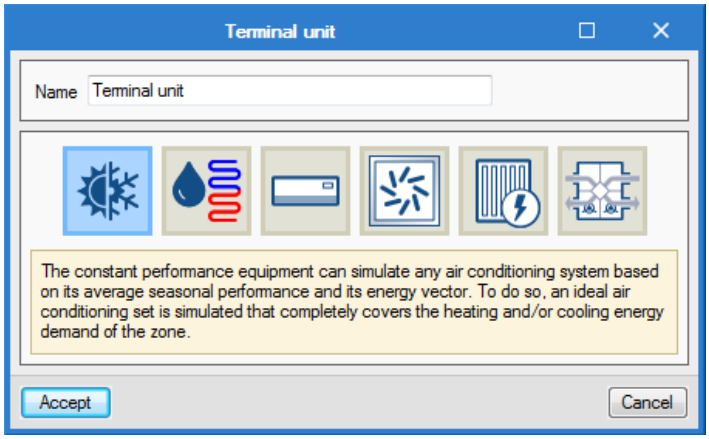


Figure 37: Terminal unit window

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

Constant performance equipment

It is an ideal piece of equipment capable of instantly overcoming the thermal loads of the area where it is located (infinite power equipment). For this reason, it is not allowed to define this type of terminal unit together with any other unit in the same zone. In practice, this equipment can be used to represent any HVAC system based on its heating and/or cooling seasonal performance and the type of energy it consumes (energy vector). It is allowed to define the function of heat recovery, for which the user must activate in the panel of the Zone the option *Ventilation via the air conditioning system*. Three types of constant performance equipment are offered:

- Heating only
- Cooling only
- Heating and cooling

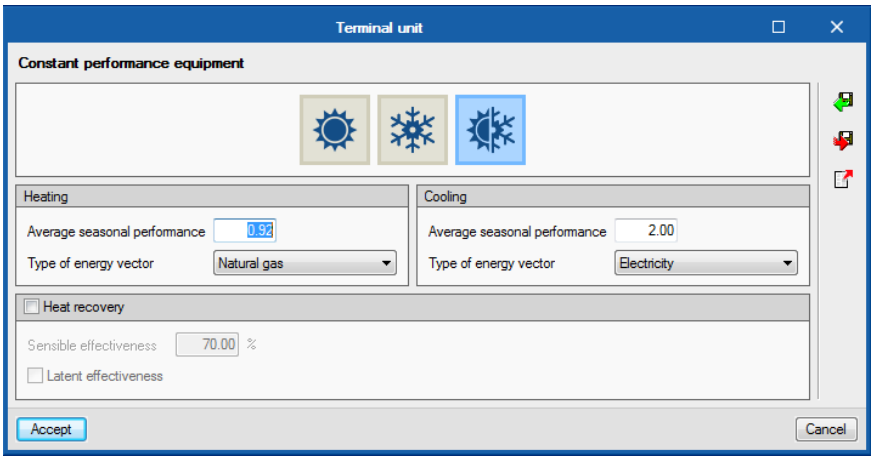


Figure 38: Terminal unit window, Constant performance equipment

Water terminal units

They must be connected to a water system.

- Radiator
- Radiant floor, for heating only
- Fancoil, for heating and cooling

Direct expansion terminal units

- Indoor unit of variable refrigerant flow system (VRF) Airstage by Fujitsu. It must be connected to a direct expansion system of the same type (outdoor unit).
- Packaged terminal unit. It is an autonomous terminal unit. If you define a water heater, you must connect it to a water heating system.
    - PTAC: Packaged terminal air conditioner with gas, water or electric heating.
    - PTHP: Packaged terminal heat pump (direct expansion heating). For simulation purposes, it is equivalent to the split-system equipment.
- Water-to-air heat pump (WAHP). It must be connected to a condenser water system for a reversible heat pump.

Air terminal units (ATUs)

They represent the supply outlets (diffusers, nozzles, registers) and boxes into which the ducts of the all-air systems open. In the program, they must be connected to an HVAC system (that is, to an air handling unit), depending on their type:

- Air supply outlet. It must be connected to a system of constant air flow or centralized ventilation, according to the chosen option:
  - For rooftop equipment or single-zone AHU.
  - For AHU with water coils. The difference with the previous type is that it allows the option of terminal reheating.
  - For centralized ventilation system. The difference with the previous types is that it does not allow the flow of supply air to be defined, since this will come automatically determined by the needs of ventilation defined in the spaces of the zone.
- Air supply outlet, dual duct. It must be connected to a dual duct, constant air volume system.
- Variable air volume (VAV) box. It must be connected to a VAV system.
- Variable air volume (VAV) box, dual duct. It must be connected to a dual duct VAV system.

If the air terminal unit is connected to an air system with an outside air intake or to a centralized ventilation system, the option of Ventilation through the air conditioning system must be activated in the zone panel.

Electric emitter for heating

This element represents electric heating equipment (electric radiator, fan heater, etc.). It is an autonomous terminal unit, that is, it does not need a connection with any system.

Heat/Energy recovery ventilator (HRV/ERV)

It is an autonomous terminal unit, that is, it does not need a connection with any system. To use this terminal unit, the option of *Ventilation via the air conditioning system* must be activated in the zone panel.

As with the centralized part of the climate control systems, when selecting the type of terminal unit, the editing panel is updated to show its characteristics. For the indoor units of VRF systems, the user can select the units in the Airstage by Fujitsu commercial catalog. The characteristics of the Airstage indoor units are completely defined within the program, so that the user should only indicate the outdoor VRF unit they are connected to. In the generic equipment edition panels, the following utilities are offered:

-  Show and edit advanced features of the equipment.
-  Restore the default values proposed by the program.

If a value is not specified for certain equipment characteristics, such as its nominal power or the flow rate of a fan, the *autosize* function of EnergyPlus™ is used. This function calculates the values not defined by the user from the thermal loads of the associated zones and the automatic sizing options.

- **System**

  This section appears on the panels of the non-autonomous terminal units. The centralized system to which the equipment is connected must be selected. The drop-down will only offer the systems compatible with the terminal unit defined in the work. The list management buttons to the right of the drop down allow:

- Define a new centralized production system, of any type.
- Edit and select a centralized production system defined in the building.
- Indicates that the selection made in the drop-down is empty or is incorrect.

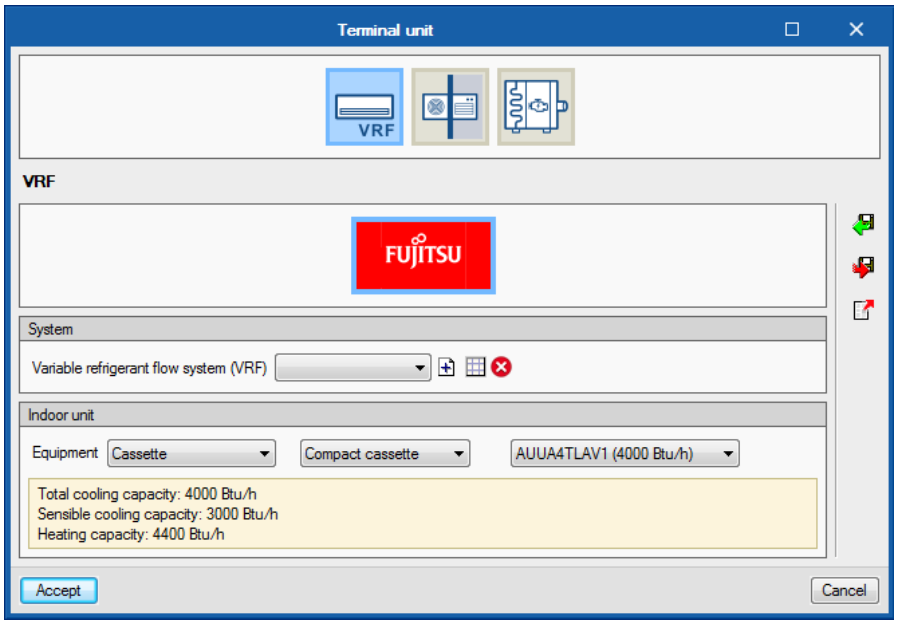


Figure 39: Terminal unit window, direct expansion terminal unit

At the end of the creation of a new terminal unit, it will appear as an element in the section *Terminal Units* of the scheme, within each *Zone*. When clicking on the element, its editing panel appears on the screen.

Management of terminal units and automatic sizing options

The *Terminal units* panel allows managing the operation of the terminal units defined in each zone and defining the EnergyPlus™ automatic sizing options.

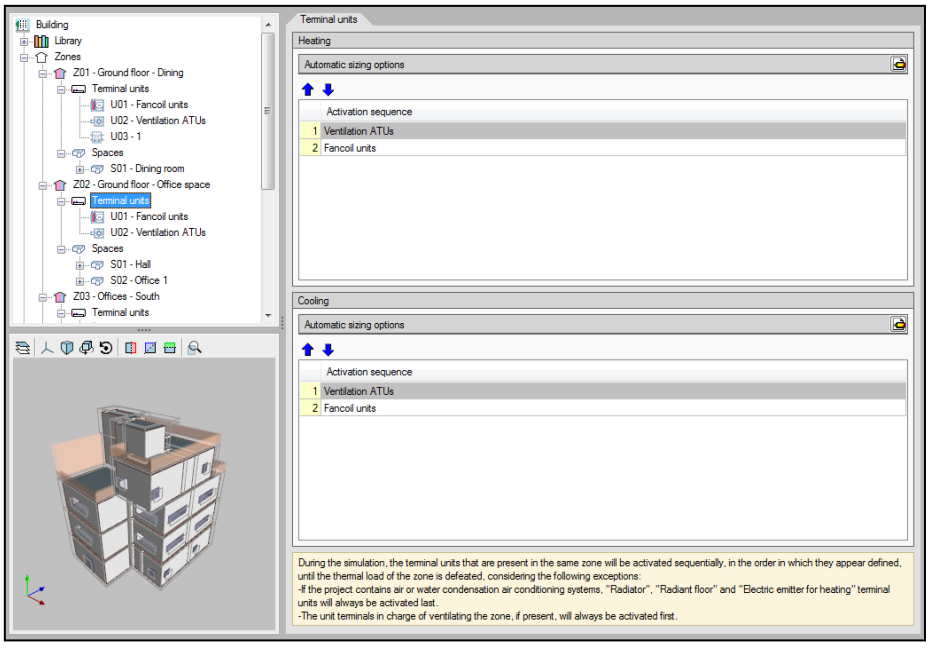


Figure 40: Terminal units panel

During the simulation, the terminal units present in the zone will be activated sequentially until the thermal load of the zone is overcome, according to the order defined in the sections *Activation sequence*, distinguishing between heating and cooling. The following exceptions are considered:

- If the building contains air HVAC systems or condenser water systems, the Radiator, Radiant Floor and Electric Emitter for heating terminal units will always be activated last.
- The terminal unit responsible for ventilation of the zone, if any, will always be activated first.

The automatic heating / cooling sizing options are advanced functions that allow editing the parameters that EnergyPlus™ uses to determine the characteristics of the HVAC equipment that the user has not specified (autosize function):

- Zone heating / cooling sizing factor: scaling factor on the thermal load calculated in the zone. The capacity of the HVAC equipment will be determined from the thermal load of the area multiplied by this factor.
- Zone cooling/heating design supply air temperature input method: the air flow rates that must be driven by the equipment to overcome the thermal load are calculated according to a design supply temperature defined by the user. Three options are offered:
    - Supply air temperature: the design air flow temperature for heating / cooling must be defined.
    - Temperature difference: the temperature difference between the supply air and the temperature of the zone must be defined.
    - System supply air temperature: only valid for air HVAC systems. The cooling/heating design set point defined in the panel of the air HVAC system will be taken as "supply air temperature".

3.5.3 HVAC systems wizard

In the HVAC systems section, the Wizard button allows you to define in a guided way a complete HVAC system, including systems for both HVAC and DHW, or add terminal units to already defined systems.

In the first window of the Wizard, the new system should be named and its typology should be chosen between water HVAC systems, direct expansion systems, air HVAC systems or constant performance equipment.

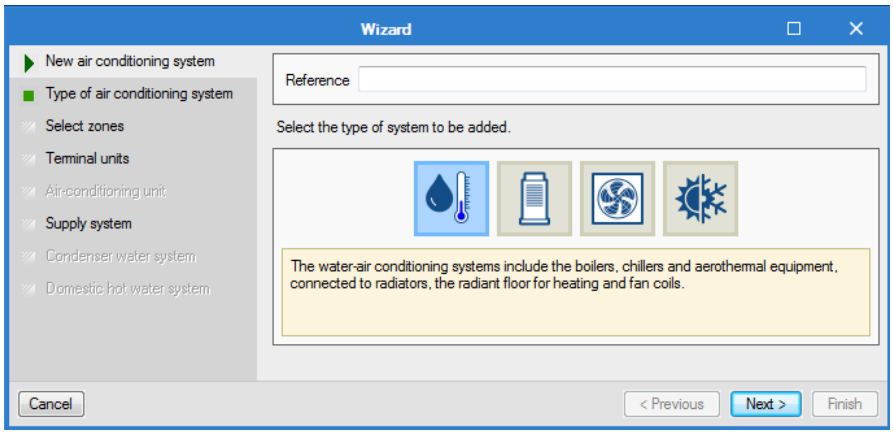


Figure 41: HVAC systems wizard

On the left side of the window are the steps by which the wizard will guide the user to complete the definition of the HVAC system. The different sections light up in black if it is necessary to define them according to the chosen options. The buttons on the lower bar allow you to navigate in the wizard.

In the second step of the wizard, the user must choose the type of HVAC system according to the category chosen above.

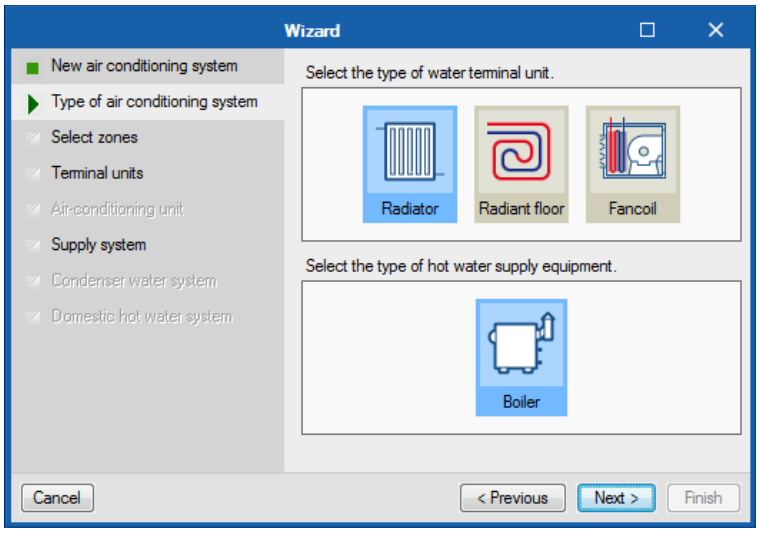


Figure 42: Type of air-conditioning system, HVAC wizard

In the third step, the user must select the zones of the building that will be associated with the HVAC system. The wizard will automatically create the terminal units of the system defined in each of the selected zones and connect them to a centralized production system if necessary. The following options are offered:

- **Replace the previously introduced systems**
  If this option is selected, the terminal units that already exist in the selected zones will be eliminated. When erasing terminal units it is possible that the air conditioning systems of the building are no longer connected to any terminal unit. In this case, at the end of the wizard, you will be asked if you want to delete the unused systems.
- **Add one air handling unit per zone**
  If this option is selected, as many AHUs as selected zones will be added, each one connected to the air terminal units defined in each zone.
- **Add a supply system per zone**
  If this option is selected, as many supply systems as selected zones will be added, each one connected to the equipment defined in each zone. Depending on the type of system chosen, such equipment can be directly the zone terminal units or AHUs with water coils.

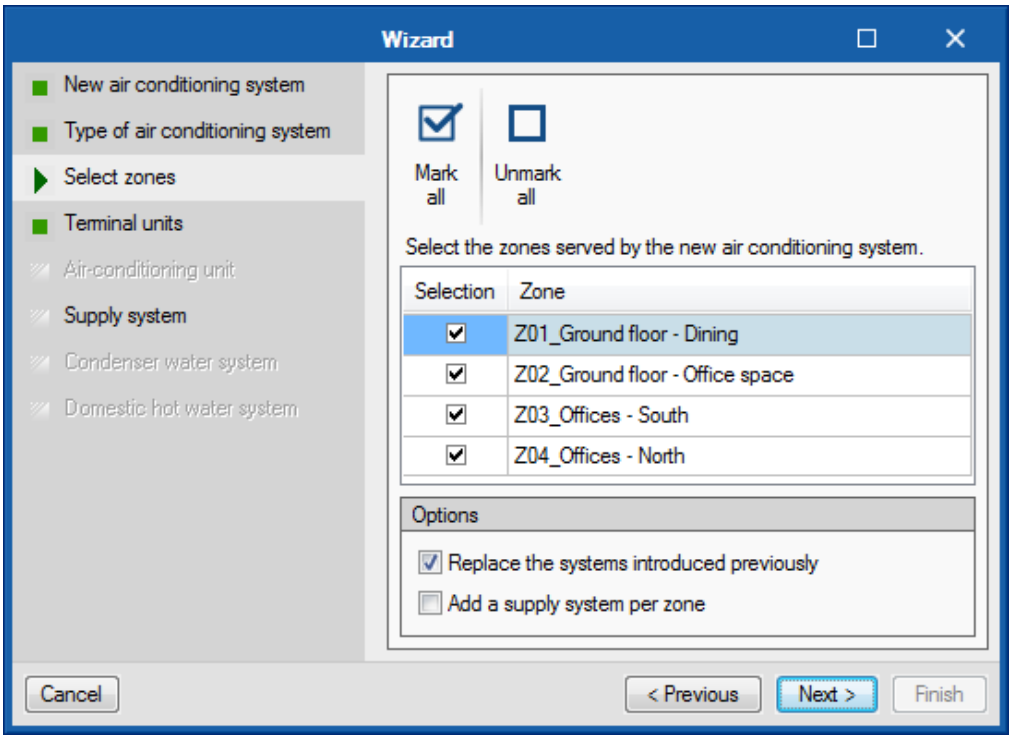


Figure 43: Selecting the zones, HVAC wizard

The following steps of the wizard run through the different elements that make up the type of HVAC system chosen, so that the user can define their characteristics. In general, the definition panels corresponding to the terminal units and to the HVAC systems available in the program will be shown as necessary.

To describe the rest of the options available in the wizard, the next figures show the definition of an HVAC system that consists of fan-coils connected to a water-condensed chiller and a boiler for heating and DHW.

Then, the next step offered by the wizard is the definition of the terminal units, fan-coil type. The terminal units defined in this step will be added to all the zones selected in the previous step. It is allowed to create more than one terminal unit of the same type in the zone by means of the panel list (according to the limitations of the systems detailed in the Capabilities section).

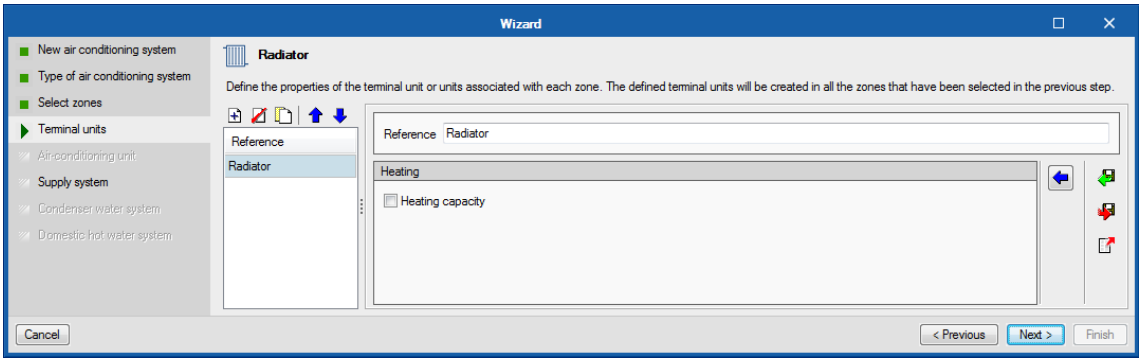


Figure 44: Defining the terminal units, HVAC wizard

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

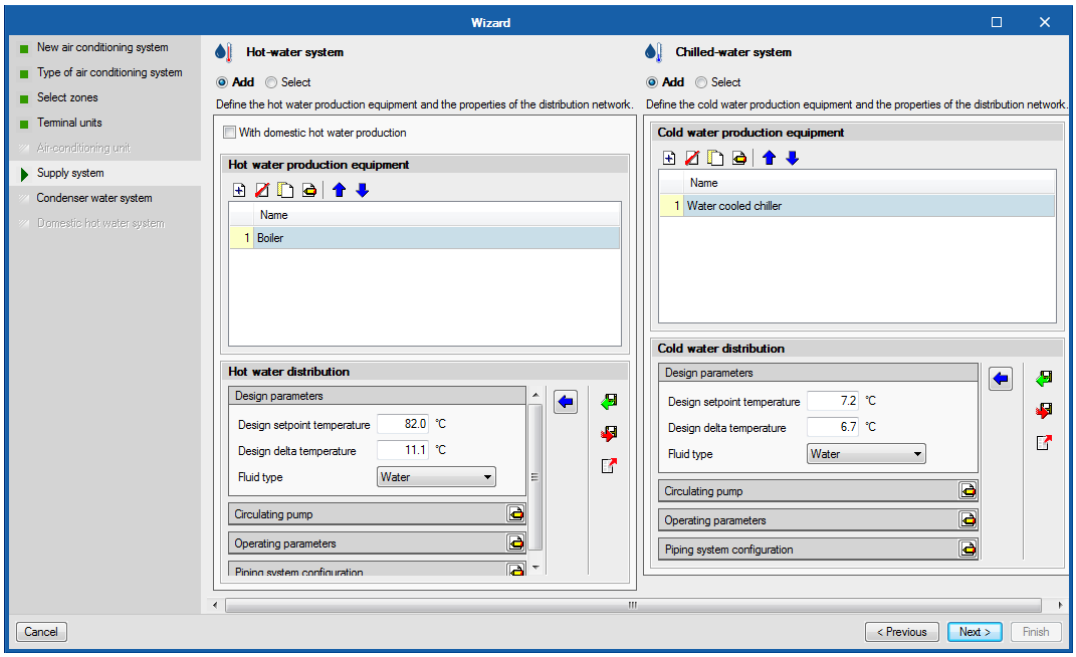


Figure 45: Defining the supply systems, HVAC wizard

For each system the following options are offered:

- *Add*: allows you to define a new HVAC system.
- *Select*: allows you to select a HVAC system of the corresponding type, among those defined in the building. If in the third step of the wizard the option Add a production system / climate unit per zone was selected, a system must be selected for each selected zone.
- *With DHW production*: This option is exclusive to hot-water systems. It allows the definition of a hot-water system for heating and DHW.

In this example, a new hot-water system has been defined with the option With DHW production, 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 condenser water system for the chiller.

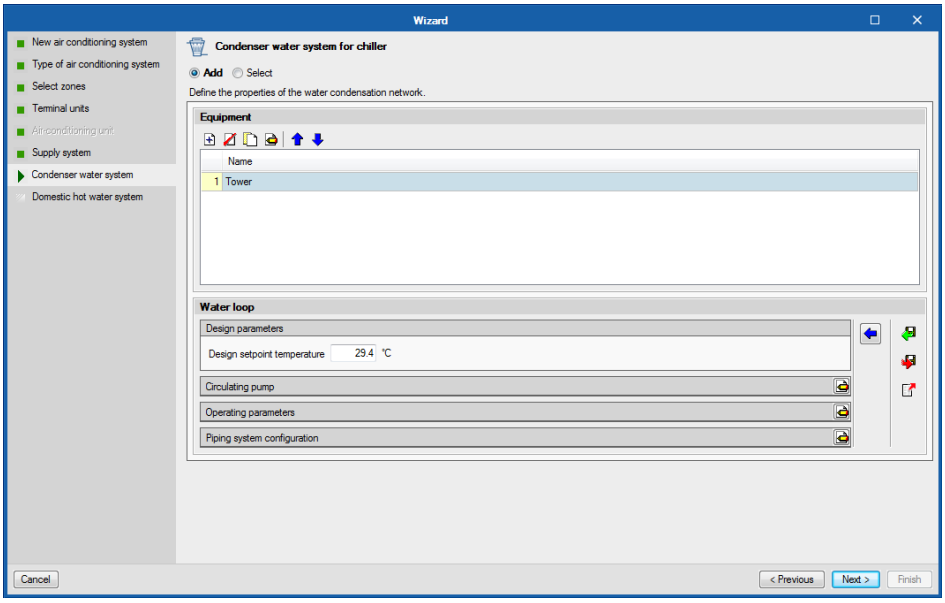


Figure 46: Condenser water system, HVAC wizard

Finally, the wizard shows the definition of the DHW system to be added, based on the characteristics of the previously defined hot-water system supply equipment. In the case of having defined several boilers, it must be specified which one produces DHW in order to calculate its characteristics. The user can accept the proposal of the wizard or edit it.

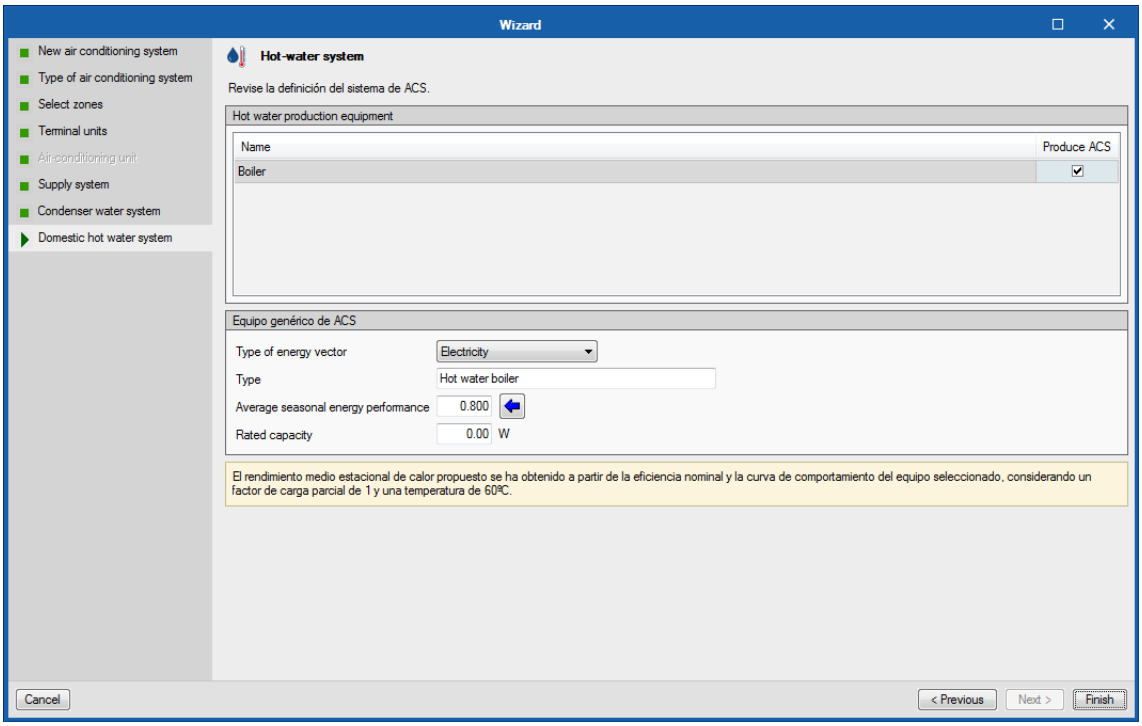


Figure 47: Defining the hot water system, HVAC wizard

At the end of the wizard, the different elements of the defined system are added to the scheme of the building and the necessary ventilation options at the zone level are chosen. If you have added a DHW system with the wizard, its definition depends on the selection previously made in General Parameters for the Daily Demand of DHW. If the total Building Demand was defined, the wizard will create a single DHW system for the building. If the Demand was defined by thermal zone, 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 the option “Add a supply system by zone” has been selected in the wizard, a DHW system will be created for each zone.

3.6 Shadows

This section is used to configure the shadows cast onto the building by both the buildings own features (such as balconies) and the features of nearby buildings (remote shadows).

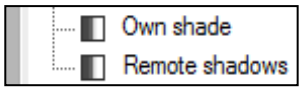


Figure 48: Shadows, Project tree

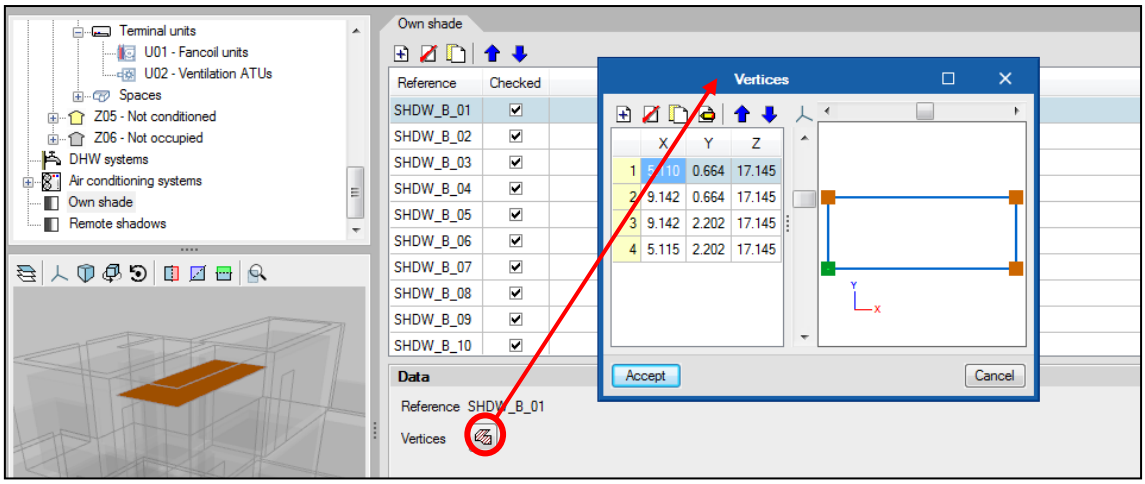
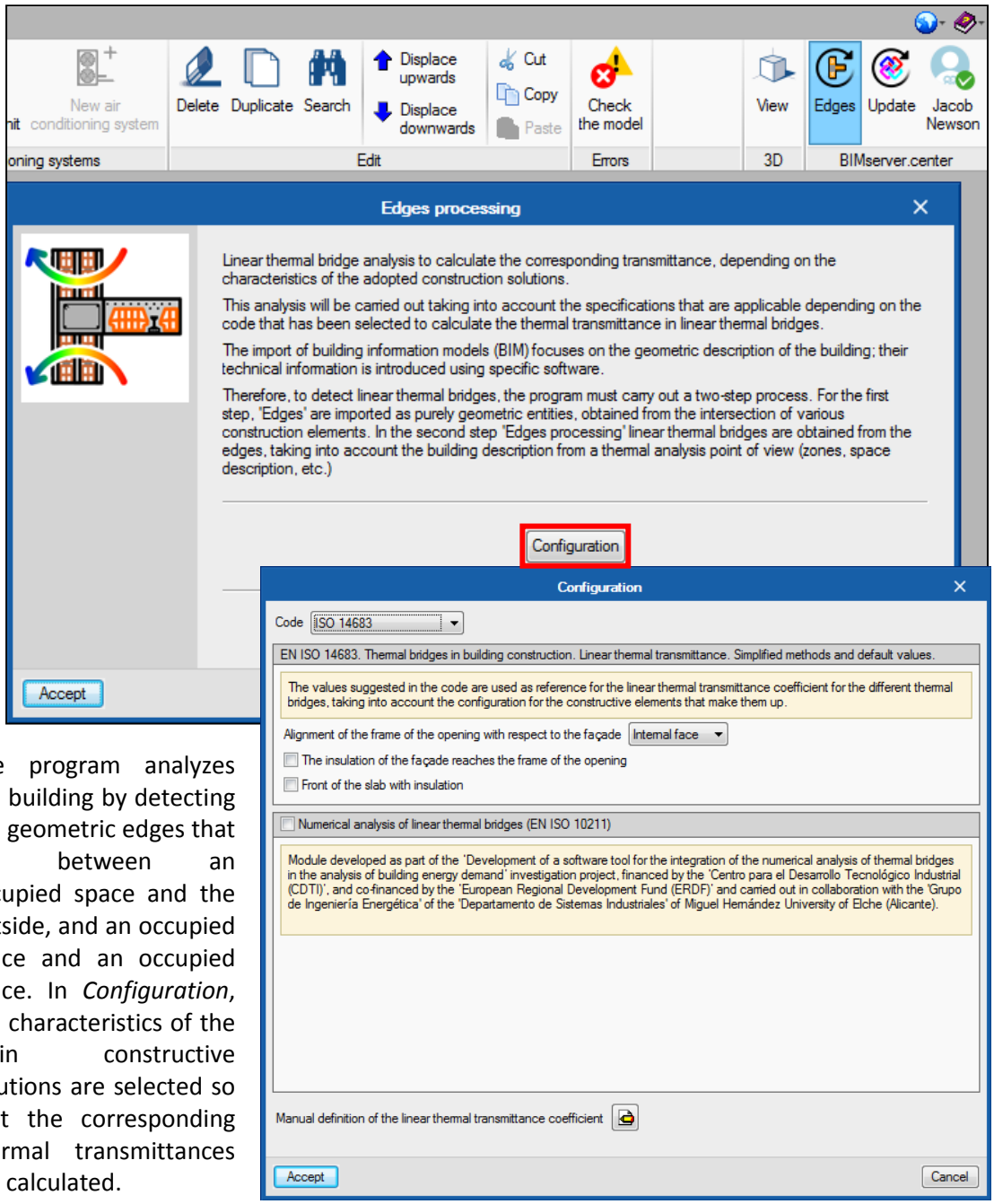


Figure 49: Configuration of the shadow cast by the buildings own feature

3.7 Edge processing

The IFC4 standard does not include the concept of linear thermal bridges, therefore CYPE has created an entity so that when an IFC4 file generated by IFC Builder is imported, the intersections of the constructive elements (edges) can be reflected for further treatment in CYPETHERM FUJITSU.

As mentioned in the section Thermal bridges, when the work has been created from a BIM model generated in IFC Builder, the library of thermal bridges contains all the edges of the building (purely geometric entities obtained from the intersection between the different constructive elements), although part of these edges does not intervene in the calculation. Once the building has been defined without errors, this tool can be used to obtain the linear thermal bridges present in the work through the *Edges* button on the ribbon.



The program analyzes the building by detecting the geometric edges that are between an occupied space and the outside, and an occupied space and an occupied space. In *Configuration*, the characteristics of the main constructive solutions are selected so that the corresponding thermal transmittances are calculated.

Figure 50: Edge processing tool and configuration window

3.8 BIM model

If there have been any changes to the linked BIM model, the *Update* button on the Primary toolbar will flash and display a warning signal. When clicking on it, the panel *Update the BIM model* appears. Here various options are offered to manage the importation of the changes introduced in the model.

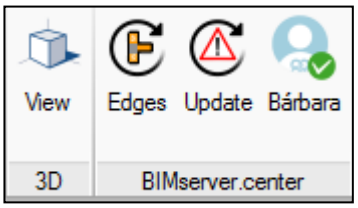


Figure 51: BIMserver.center section, Primary toolbar

3.9 Check the model

The *Check the model* button is available on the ribbon. This button analyzes the definitions made in the building and shows error messages in the lower part of the screen if there are incorrect or incompatible definitions. If there are potentially incorrect definitions that do not produce errors in the calculations, a warning message will be displayed.

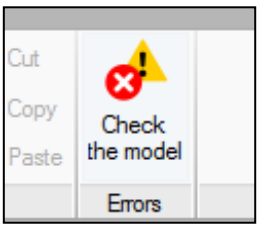


Figure 52: Check the model button, Errors section

As explained in section 4.2. Library, subsection BIM model, each icon that appears in the tree allows, through a small mark, the detection of the absence or non-definition of a typology.

4. Floor plans tab

This section contains the plans of every floor with the corresponding construction elements. From here it is also possible to edit the characteristics of the construction elements.

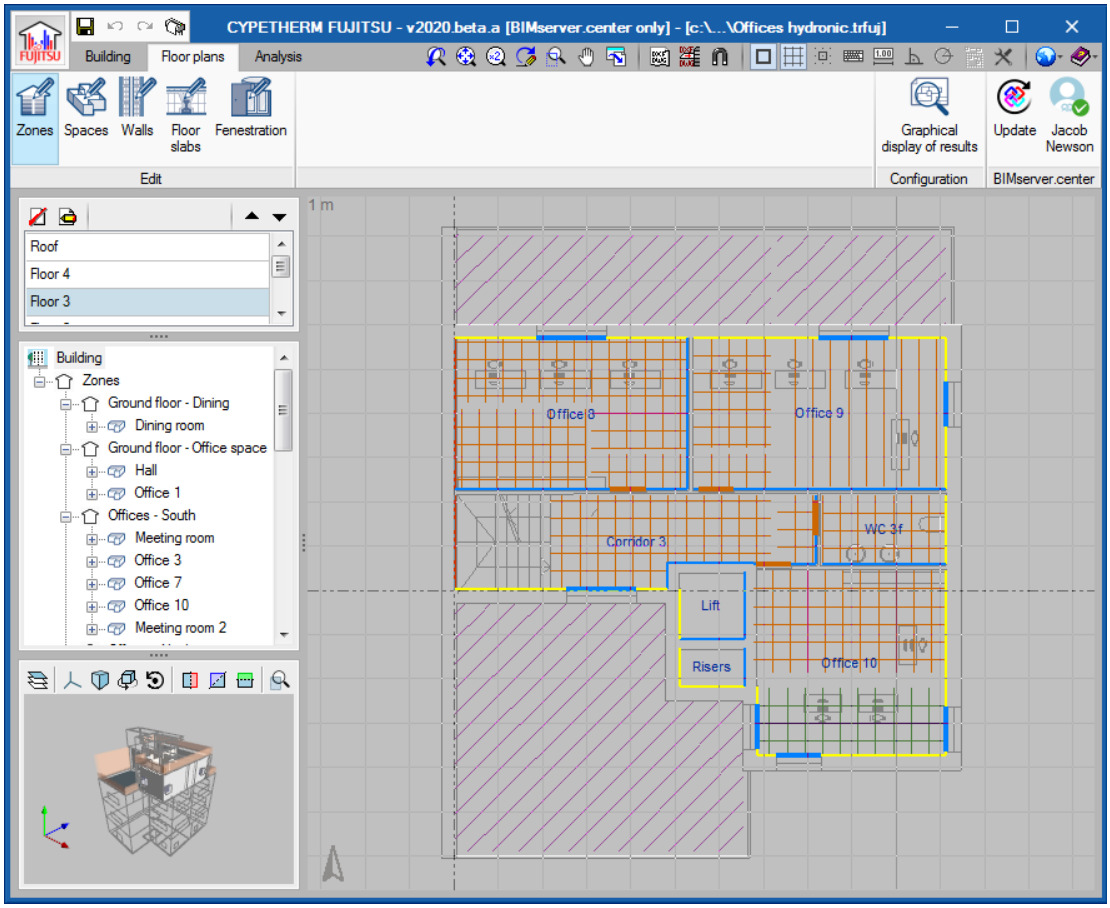


Figure 53: Floor plans tab

4.1 Without BIM model

Without a BIM model, you will be able to import plans with the buttons with 'DXF / DWG', or you will be able to create a new plan by placing yourself on previously entered objects.

4.2 With BIM model

If you created your project from the IFC file import, the plans, containing the construction elements and their typologies, will be imported directly into the 'Floor plans' tab. You can edit them by selecting corresponding tool in the primary toolbar and then selecting them in the window. Selecting elements in the Project tree will highlight them in the window.

4.3 Generation of plans

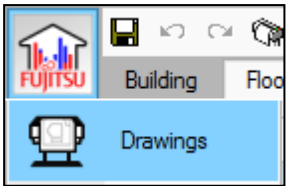
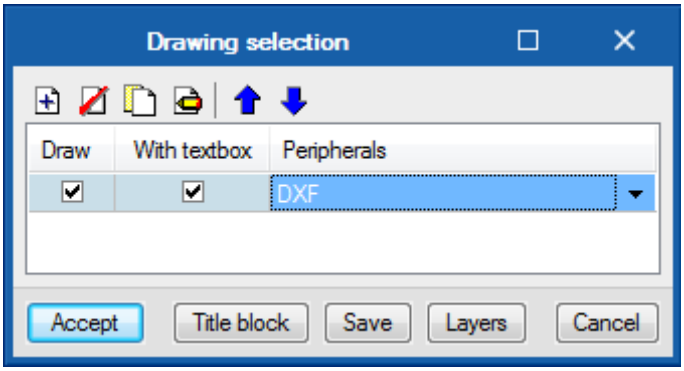


Figure 54: Drawings button, File

The printing of the plans is available via the menu 'File'> 'Drawings'.

In the drawing selection prompt, click new and add the desired floors to the drawing. Choose a PDF generator in 'Peripherals' used to import PDF. Click accept and the software will generate the drawings.



You must click on 'Detail of all drawings' to display your plans.

Figure 55: Drawing selection prompt

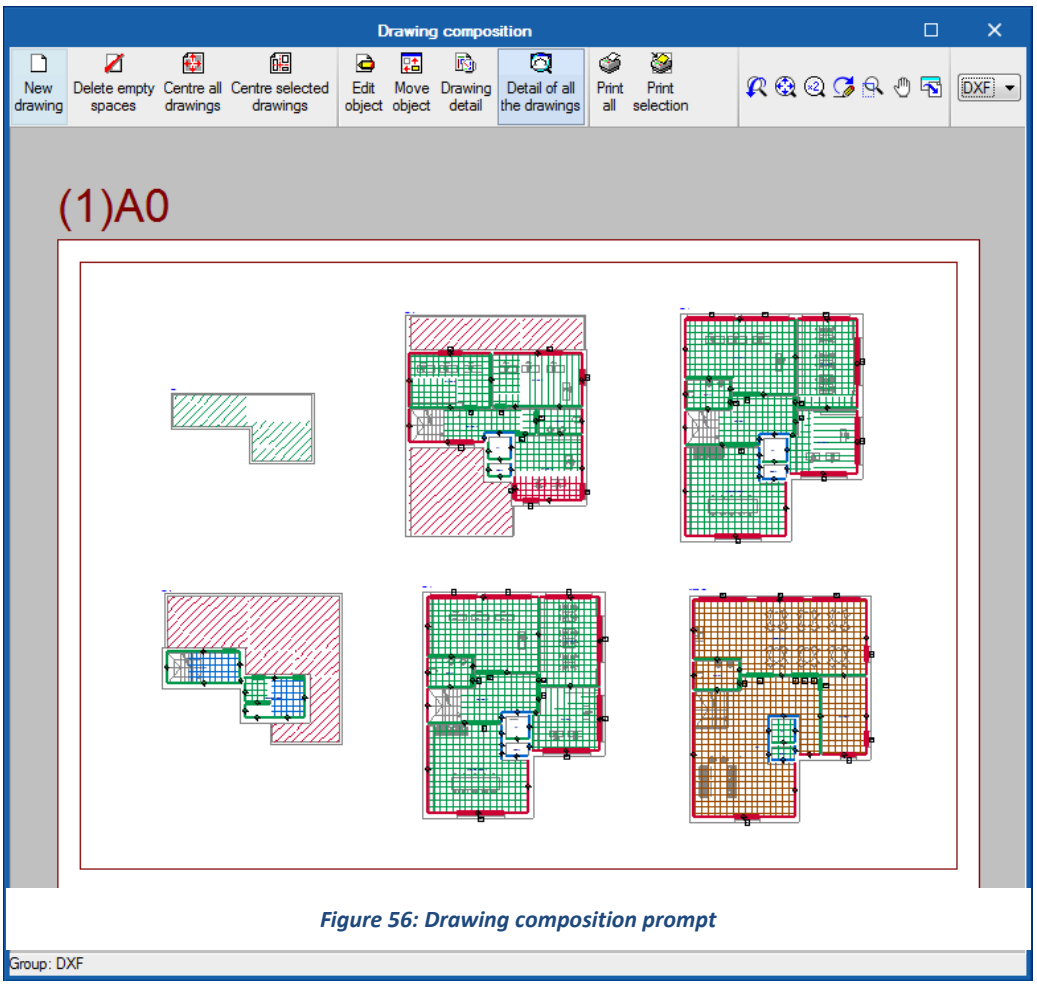


Figure 56: Drawing composition prompt

5. Analysis tab

In this section the user can run the energy simulation and view the results.

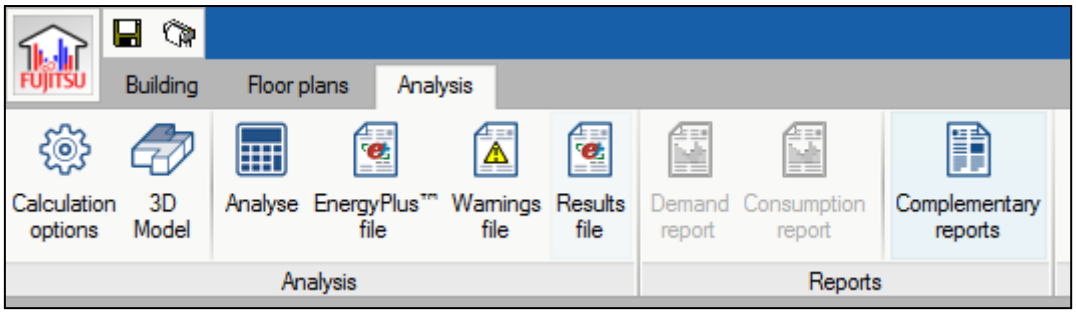


Figure 57: Analysis tab, Primary toolbar

5.1 Analysis

Calculation options

In Calculation options, you can choose the simulation you want to run:

- **Demand**
  Simulation of the building only (without the HVAC systems). Allows analyzing the thermal demand of each building zone separately.
- **Demand/Consumption**
  Simulation of the building with and without the HVAC systems. For the consumption simulation, an ideal HVAC system will be automatically added to the zones with a cooling or heating temperature set point that do not contain any HVAC system, in order to keep the zone air at the defined temperature set points. This ideal system does not consume any energy.

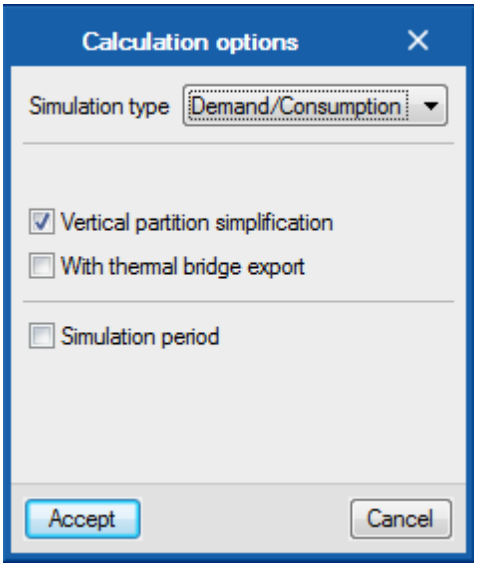


Figure 58: Calculation options prompt

In large works, where calculation times can be very high, it is convenient to activate the option "Vertical partition simplification". The activation of this option consists in the calculation of a simplified option of the 3D calculation model where the vertical partitions, instead of sending them to EnergyPlus™ separately, are grouped by "characteristics" and simulated as the internal mass of each zone. This option is advisable, above all, in large works, since it greatly reduces the complexity of the model and, consequently, the calculation times, offering results with hardly any differences with respect to those of the complete model.

The option "With thermal bridge export" includes the thermal bridges of the building in the simulation.

There is also the possibility to simulate a period of time instead of the full year, to check the validity of the calculation model or visualize the behavior of the building for a few specific days.

3D model

The 3D Model button shows all the elements of the calculation model of the building that will be used in the simulation with the calculation engine.

You can consult all the characteristics of each element in the information balloon that appears on the right.

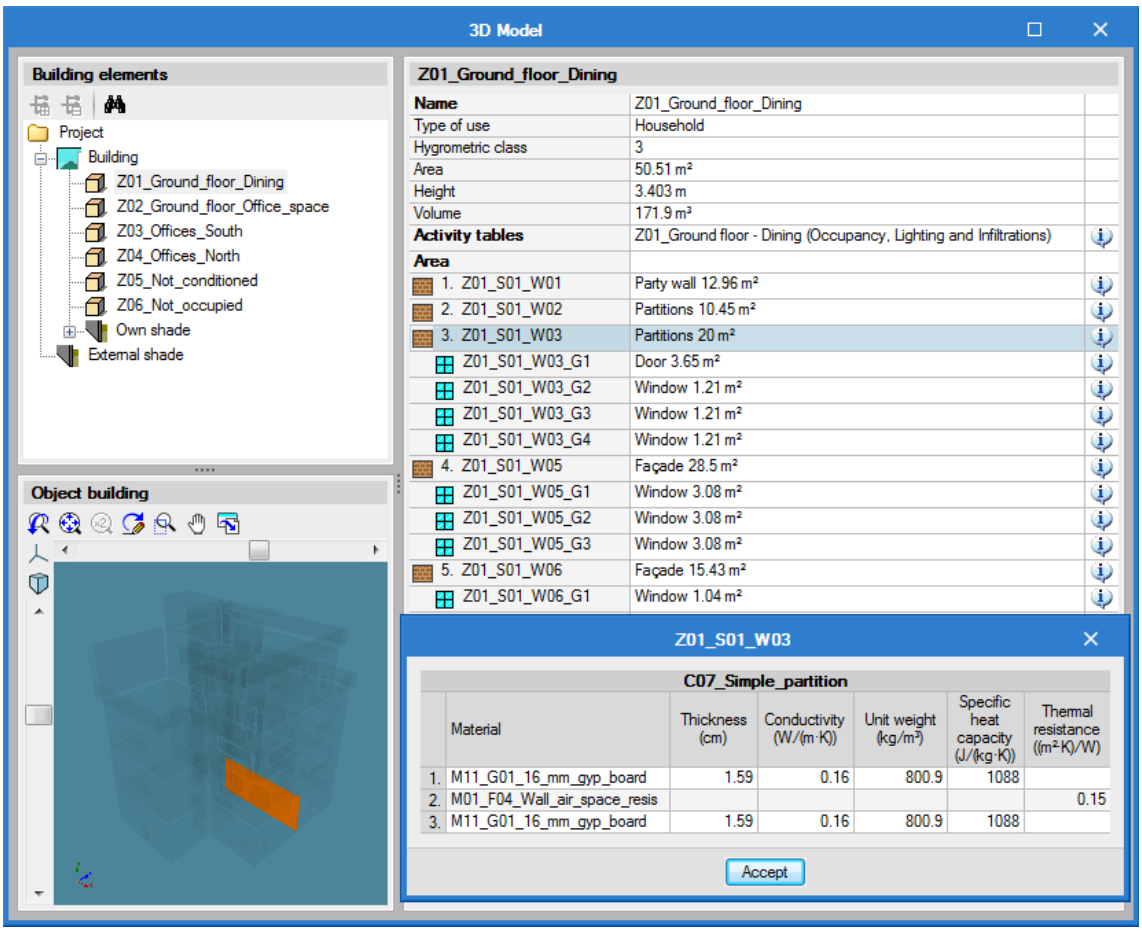


Figure 59: 3D model prompt, Analysis tab

Analyse

Run the simulation and/or update the reports, being able to modify the options defined in "Calculation options".

EnergyPlus™ file

Using this option, the software generates the .idf file of the building data. This is the file which is used as the input data for EnergyPlus™.

Warnings file

Through this option you can consult the .err file with warnings and errors returned by EnergyPlus™.

Results file

Through this option you can consult the .html file with a summary of the output of results generated by EnergyPlus™.

5.2 Results

In this section the calculation options are defined, the simulation is launched and the results are viewed.

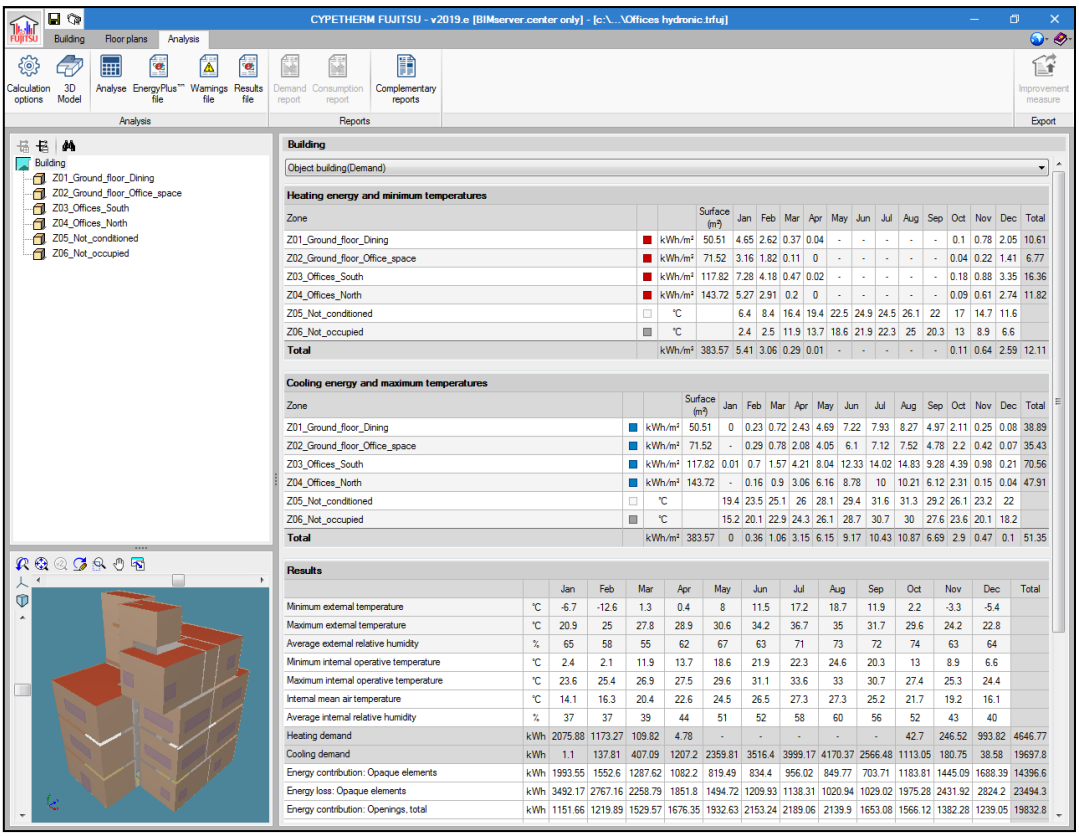


Figure 60: Analysis tab window

Throughout the work process, it is only necessary to re-launch the simulation if the definitions made in the Building and Floor plans tabs have altered the EnergyPlus™ input data files with respect to the last calculated simulation. In this case, the work not calculated notice will appear on the screen. If the EnergyPlus™ input data has not been altered, the calculation results will be displayed directly. In any case, it is necessary to click on the *Analyse* button to generate the reports.

5.2.1 Reports

Demand report

In this report the results of the calculation of the energy demand of the building are detailed.

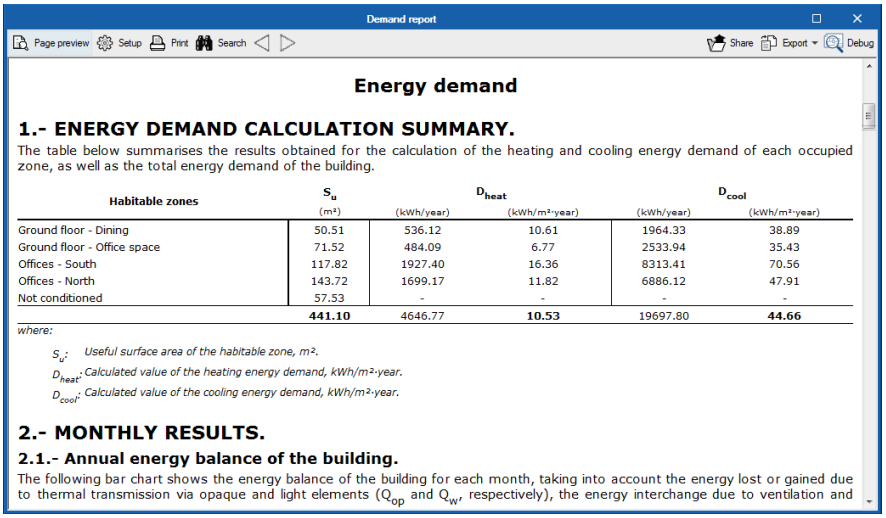


Figure 61: Demand report

Consumption report

In this report are detailed the results of the calculation of the energy consumption of the building HVAC and DHW systems.

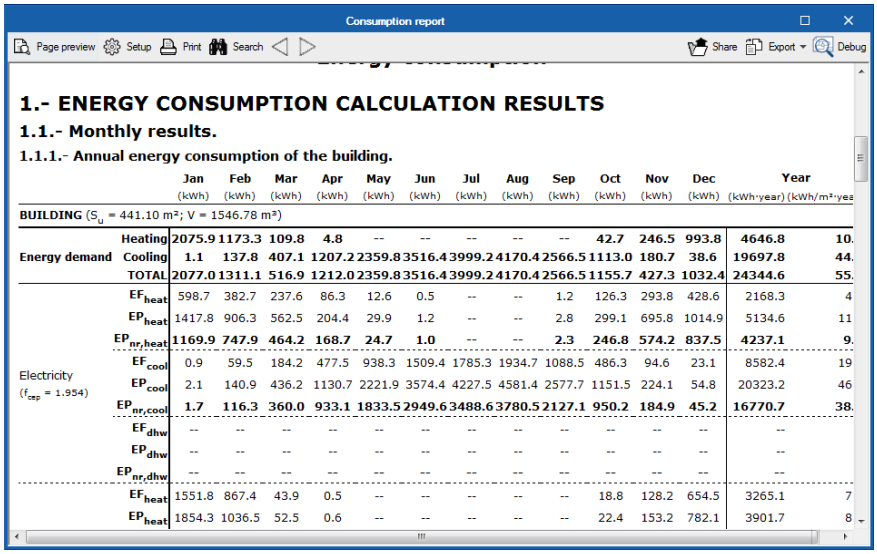


Figure 62: Consumption report

Complementary reports

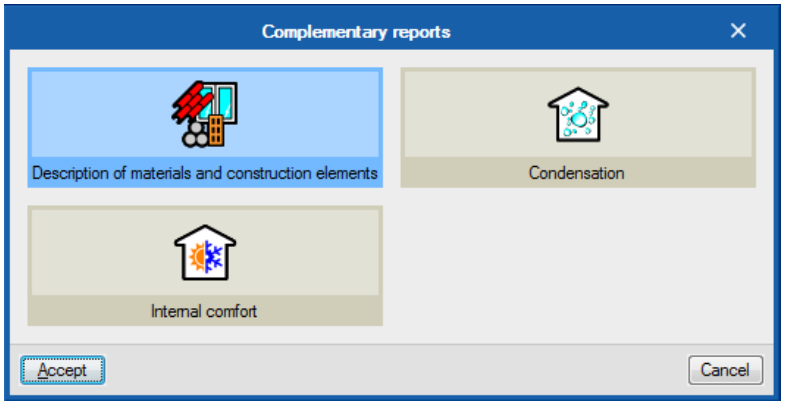


Figure 63: Complementary reports

Description of materials and construction elements

This report shows the different elements present in the work together with their materials, quantities, transmission coefficients, etc.

Condensation

This report is available if the option Condensation has been selected in the General data window. The report shows the justification of the calculations carried out by the program following the guidelines of the ISO 13788 standard.

Internal comfort

This list allows the visualization, through graphs and tables, of the evolution of the indoor air temperature of the zones, comparing it with the outdoor air temperature and counting the number of hours that the comfort temperature defined in each zone is exceeded.

5.2.2 Export results

The *Improvement measure* button will export the results from CYPETHERM FUJITSU to CYPETHERM Improvements Plus, a program designed for the energy and economic analysis of the building.

First, the simulation of the building in its current state must be run with CYPETHERM FUJITSU. This case will be defined as the initial solution for the Improvement measure exportation.

Subsequently, the desired modifications of the building will be made in the Building tab. It is recommended to save the work in a different file so as not to lose the definition of the initial situation. The modified building will be simulated and, in the improvement measure wizard, this case will be defined as an Improvement Measure, specifying its associated costs.

Figure 64: Improvement measure export tool