TIMEPAC

Towards Innovative Methods
for Energy Performance Assessment
and Certification of Buildings

TIMEPAC
GUIDELINE

Enhancing Energy Performance Certification:

Guidelines for the generation of EPCs from BIM models

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TIMEPAC aims to modernize building certification practices according to the latest Energy Performance of Buildings Directive (EPBD) review. The guidelines series provides recommendations for stakeholders involved in building certification to improve their working procedures to meet the objectives of the Directive.

The guidelines aim to standardize the integration of Building Information Modeling (BIM) with Energy Performance Certificate (EPC) generation. They provide a framework for extracting data from BIM models to improve EPC quality, promote energy efficiency certification, and support building data reuse throughout its life cycle. The focus is on ensuring interoperability between modeling tools, using Industry Foundation Classes (IFC) as the data exchange standard. The guidelines cover creating new BIM models for EPC and evaluating existing models for EPC suitability.

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grand agreement Nº 101033819.

TIMEPAC “Guidelines for the generation of EPCs from BIM models”

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30 October 2024

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The integration of Building Information Modelling (BIM) and Energy Performance Certification (EPC) represents a long-term objective, not only for elevating the quality of EPC but also for fostering the unified reuse of existing building data throughout various stages of the building life cycle, including renovations. This ambitious endeavour encounters challenges, with interoperability between different modelling and simulation tools standing out as a major hurdle.

In response to these challenges, we present a comprehensive set of guidelines aimed at calculating EPCs from BIM models using existing technologies. These guidelines are a step forward in promoting the development of reliable protocols for leveraging BIM in energy efficiency certification across the European Union.

1.1 The BIM-to-EPC guidelines

1.1.1 Purpose

The primary purpose of these guidelines is to establish a standardized and efficient process for integrating BIM with EPC generation. By providing a structured framework, the guidelines aim to facilitate the extraction of relevant data from BIM models and its transformation into inputs for EPC calculation tools. The overarching goal is to enhance the quality of EPCs, promote energy efficiency certification, and support the unified reuse of building data in various stages of the building life cycle, including renovations.

1.1.2 Scope

These guidelines address the challenges and opportunities associated with the integration of BIM and EPC, focusing on the interoperability between different modelling and simulation tools. The scope encompasses the extraction of comprehensive information from BIM models, covering building geometry, materials, systems, and performance characteristics.

The guidelines consider two distinct scenarios within the EPC generation process: creating a new BIM model for EPC generation and assessing the suitability of an existing BIM for EPC generation. The guidelines emphasize the use of Industry Foundation Classes (IFC) as the standard for data exchange to ensure interoperability across diverse BIM software and certification tools.

1.1.3 Audience

These guidelines are tailored for a diverse audience involved in the building industry, including but not limited to architects, designers, engineers, energy assessors, facility managers, and other stakeholders engaged in the BIM and EPC processes. The content is designed to be accessible to both beginners seeking a foundational understanding and experienced professionals aiming to enhance their knowledge and skills in leveraging BIM for energy efficiency certification. The guidelines serve as a valuable resource for anyone involved in the generation of EPCs through the utilization of BIM models, contributing to the broader goal of sustainable and energy-efficient building practices.

1.1.4 Scenarios

These guidelines comprehensively consider two primary scenarios within the EPC generation process:

- **Creating a new BIM model for EPC generation**: This scenario guides users through the steps involved in initiating a BIM model explicitly designed for the purpose of generating Energy Performance Certificates.
- **Assessing the suitability of and BIM for EPC generation**: Users facing an existing BIM model can refer to this scenario, which outlines how to assess and adapt an already-established model for efficient EPC generation.

1.1.5 Project phases

These guidelines consider specific project phases associated with EPC generation:

- **Design Phase**: Insights for creating a new BIM model tailored for EPC generation. Architects and engineers involved in the design process can follow the outlined steps to ensure the inclusion of relevant data for energy efficiency assessment.
- **Completion Phase**: Scenarios where an existing BIM model is assessed for its suitability in EPC generation upon project completion. This involves adapting and validating an established model for seamless integration with EPC tools.
- **Renovation Phase**: Professionals engaged in building renovations who need to assess and update BIM models, ensuring accurate and up-to-date data for EPC generation post-renovation.

1.1.6 Building types

These guidelines are applicable across a range of building types. Whether you are dealing with small residential structures or with tertiary buildings, the principles outlined in these guidelines remain relevant. The scalable nature of the guidelines ensures their applicability to a diverse array of building types and sizes, offering flexibility and usability in various architectural and engineering contexts.

1.2 Document structure

The document is organized into several sections, each addressing specific aspects related to the integration of BIM and EPC:

1. **Introduction to the guidelines** outlines the scope and target audience, while delving into the key concepts such as EPCs, BIM, information exchange, and the role of IFC.
2. **BIM data for EPC assessment** explores the benefits of utilizing BIM data and provides insights into available software solutions, architectural modelling, analytical spaces modelling, and Mechanical, Electrical and Plumbing (MEP) modelling.
3. **Information Exchange for EPC Assessment** guides users on data exchange and validation processes, specifically focusing on IFC exportation and importation into various EPC tools.
4. **In-Depth Study** addresses challenges associated with complex design models and their IFC importation.
5. **Annexes** provide detailed information requirements for architectural and analytical models.

These guidelines have been structured in such a way that they can be read from start to finish or go to specific sections to understand the processes that are particularly relevant to their function within a BIM workflow for EPC generation.

1.3 Key concepts

1.3.1 Energy Performance Certificates

This section provides answers to frequently asked questions about energy performance certification.

What is an Energy Performance Certificate (EPC)?

According to the European Building Performance Directive (EPBD), an EPC "means a certificate recognised by a Member State or by a legal person designated by it, which indicates the energy performance of a building or building unit", and it should include "the energy performance of a building expressed by a numeric indicator of primary energy use in kWh/(m2.y), and reference values such as minimum energy performance requirements, minimum energy performance standards, nearly zero-energy building requirements and zero-emission building requirements, in order to make it possible for owners or tenants of the building or building unit to compare and assess its energy performance".

The EPC is calculated by an authorized technical expert in accordance with an international defined methodology set by the European Union but adapted to the circumstances of each country.

The EPC should also "contain recommendations for the improvement of the energy performance of the building", which could be implemented stepwise through a roadmap included in the building renovation passport.

What are the outputs of an EPC calculation?

The EPC assesses a building's energy efficiency, utilizing an energy simulation that aligns with the legislation of each country. EPC results are categorized alphabetically from A to G, facilitating straightforward comparison with other buildings.

The grading is determined by factors such as the building's primary energy consumption, encompassing heating, cooling, and hot water systems, as well as its CO_2 emissions.

EPC calculations provide insights into energy consumption and CO_2 emissions, taking into account the building's systems, energy demand, renewable energy usage, building element definitions, and potential retrofit enhancements.

Which elements should the EPC evaluate?

To assess the energy efficiency of a building, it is necessary to consider the following factors in the calculation:

- Climatological conditions and orientation of the building.
- Use of the building and operational conditions.
- Geometrical and thermal technical characteristics of the building's construction elements. These elements include internal and external walls, internal and external floors, ground floors, roofs, windows, and doors. These aspects are evaluated independently (thermal characteristics of the element) and in conjunction (airtightness, thermal bridges, etc.).
- Solar protections incorporated into the building.
- Natural ventilation strategies implemented within the building.
- Technical specifications of HVAC (Heating, Ventilation, Air Conditioning), hot water systems, lighting, and urban systems if applicable, considering their energy efficiency.

- Technical requirements and contribution of renewable energy systems.

Who verifies an EPC?

The authorities are responsible for verifying the EPCs, but they can delegate this task to third-party verifiers. This obligation entails randomly assigning a percentage of issued EPCs for verification.

NOTE: The presence of misinformation within the EPC could result in monetary penalties. Therefore, the information contained in the EPC should reflect the actual characteristics of the building or the building unit, in accordance with an energy audit conducted by a competent technician.

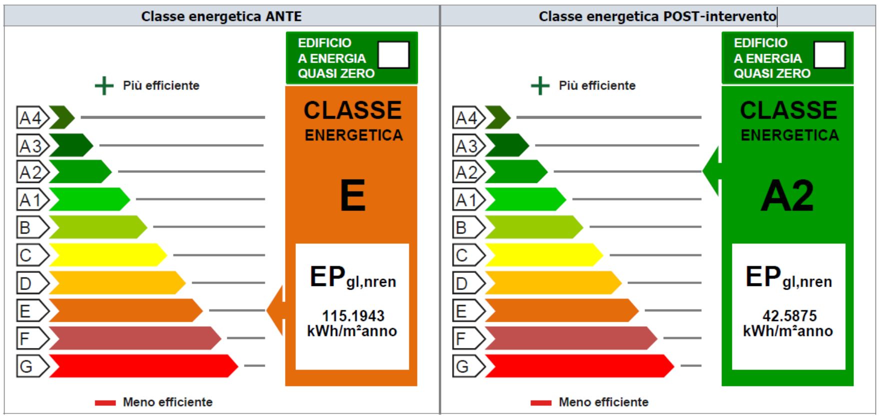


Figure 1. Example of EU energy label for EPC before and after renovation

1.3.2 Building Information Modelling (BIM)

This section provides answers to frequently asked questions about Building Information.

What does BIM mean?

The acronym BIM has a dual meaning, as it can refer to both the Building Information Model, understood as an object, and Building Information Modelling, as a workflow.

- **Building Information Model:** A BIM is a 3D virtual representation of a building that includes not only its geometry and spatial relationships between its parts but also contains information characterizing all its elements.
- **Building Information Modelling:** It refers to the methodology used to create a virtual representation of a building. It enables collaboration among various stakeholders involved in the design, construction, maintenance, and demolition processes.

What are the benefits of using BIM?

A BIM model serves as an abstract representation of the physical world, capturing both the geometric and non-geometric properties of building components, as well as their interconnections. For example, a wall within a BIM object corresponds to a real wall constructed with specific materials, potentially incorporating other elements such as windows and doors.

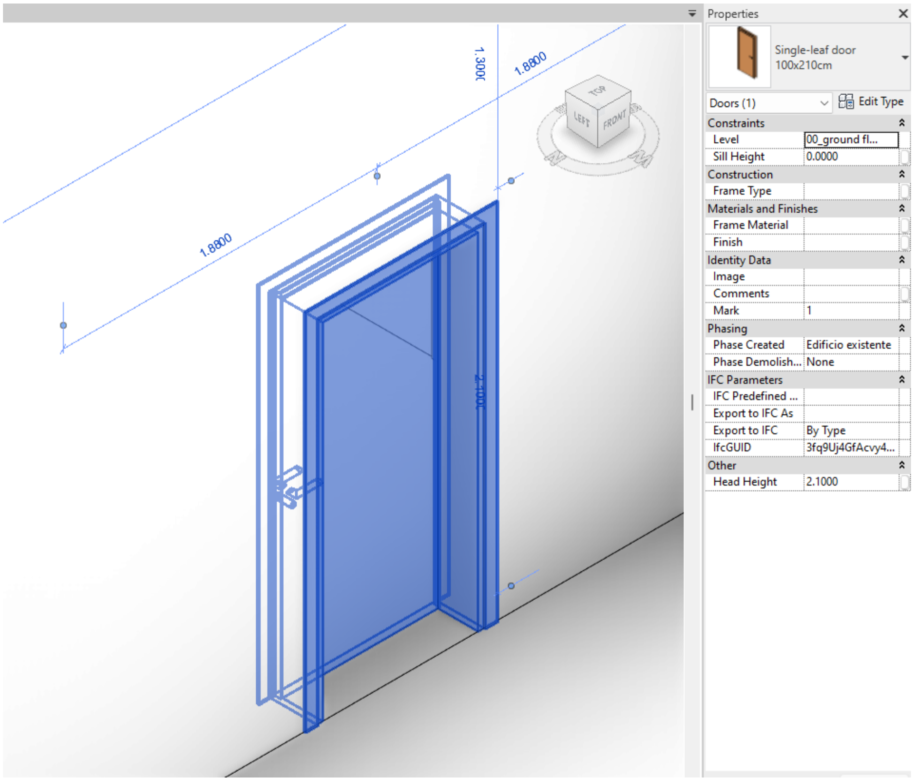


Figure 2. Virtual representation of a door inserted in a wall in a BIM model

NOTE: A BIM should not be viewed solely as a set of software tools for model production, but rather as an integral part of a collaborative working process which leads to more efficient, cost-effective, and high-quality construction projects

1.3.3 Information exchange

This section provides answers to frequently asked questions about information exchange in the context of BIM and EPC tools.

What does information exchange mean?

At the core of the BIM methodology lies its capability for seamless information exchange with other applications utilized in the Architecture, Engineering, and Construction (AEC) industry. These interoperability capacities are essential for facilitating smooth data exchange among diverse technicians, software platforms within the sector, and the various stakeholders involved in a project.

What are the benefits of information exchange?

By utilizing information exchange, BIM can cultivate a culture of teamwork and transparent cooperation aimed at enhancing the quality of buildings, including their energy efficiency.

1.3.4 Industry Foundation Classes

This section provides answers to frequently asked questions about the IFC data model.

What is an IFC, and what is it for?

IFC is an open international interoperability standard. It facilitates the exchange of data models among different technicians, software applications, and stakeholders throughout the lifecycle of buildings. It serves as a common language for information exchange within project teams and across various software platforms during different phases of design, construction, maintenance, and commissioning.

The current IFC model definitions were developed by BuildingSMART, an international association dedicated to promoting efficiency in the AEC sector through Open BIM standards.

How is IFC used in the AEC sector?

IFC is also employed for sharing information between parties involved in a particular building project. For example, an architect may provide the owner with a model of a new facility design. Subsequently, the owner may share this building model with a contractor to obtain a quote. Upon completion, the contractor may deliver an as-built model to the owner, containing information on installed equipment and manufacturers.

Moreover, IFC can serve as a platform for archiving project data. This can occur progressively throughout the design, acquisition, and building stages, or it can act as a repository for long-term preservation and operations.

How does IFC work?

IFC operates as a data schema that assigns names and describes relationships between objects. This enables the objects to be easily interpreted and exchanged by different software platforms. As a result, the IFC format has gained significant popularity among software vendors offering BIM tools, including model authoring, design, simulation and analysis, and viewing tools. This popularity stems from its ability to provide interfaces for exporting, importing, and transmitting data seamlessly.

What data exchange formats are currently in use?

The IFC standard has undergone several versions since its conception, starting from IFC1 up to the current IFC4 version, which includes the ifcXML and IFCzip variants. IFC4, released officially in March 2013, represents the latest iteration. However, it took several years before this version was widely adopted and implemented in industry software.

How is an IFC organized?

Like all BIM formats, the IFC format comprises geometric elements accompanied by associated information presented in the form of parameters. Consequently, the standardized schema of IFC encompasses entities (classes), their attributes (properties and P-sets), and their relationships, which can extend to objects, concepts, processes, or individuals.

IFC classes represent building elements along with their properties and relationships. These classes can further be categorized into types, each with its specific properties and relationships. For instance, the CLASS IfcWindow encompasses various window TYPES, such as WINDOW, SKYLIGHT, LIGHTDOME, etc., while the CLASS IfcDoor includes DOOR, GATE, TRAPDOOR, etc. These types, in turn, consist of instances representing individual elements and their respective properties.

The standardized language provided by IFC is crucial for ensuring interoperability across different software applications. For example, an energy simulation tool seeks out a predefined set of classes and types (e.g., IfcWindow and IfcDoor) to access the necessary data. Additionally, each class is assigned a default and standardized set of parameters known as P_SET. For instance, the CLASS IfcWall is associated with a P_SET containing parameters such as U-value, Load-bearing capacity, Sound insulation class, Fire behaviour, etc. These data sets relevant to each CLASS can be recorded in viewers and manipulated in programs that import IFC.

What is a Model View Definitions (MVD)?

BuildingSMART defines Model View Definitions (MVDs) as subsets of the IFC schema that describe data interchange for specific usages or workflows. MVDs essentially serve as filtered views that enable users to export different packages of model data tailored to their specific needs. By utilizing these filtered IFC views, users can simplify the data exchange process while adhering to defined protocols, thus avoiding unnecessary or duplicate information exchange.

Currently, there is no dedicated MVD specifically designed for energy analyses. Therefore, it is crucial to define information requirements to ensure efficient and accurate energy analyses can be performed using BIM data.

2. BIM DATA FOR EPC ASSESSMENT

This chapter provides an overview of the minimum requirements for BIM data necessary for an Energy Performance Certificate (EPC) assessment. It covers the benefits of using BIM data for EPC assessments, explores different software solutions available, and outlines specific requirements for architectural modelling, including detailed information on:

- Minimum required categories and properties for building elements (walls, floors, roofs, ceilings, internal walls, internal floors, windows, and doors)
- Accuracy requirements for information
- General suggestions for creating the architectural model
- Recommendations for ensuring the correct modelling of building elements

Additionally, references to Annex I are provided, containing tables outlining the minimum parameters and recommendations for modelling walls, floors, roofs, ceilings, internal walls, internal floors, windows, and doors using both REVIT and CYPE software.

2.1 Frequently answered questions

What are the benefits of an EPC assessment using BIM data?

BIM enables the compilation of all building data within an intelligent representation of the building and its components. This representation is defined through various relations and interactions between complex parametric geometry and the known real data of the building during its life cycle phases. Such an approach offers several advantages in the generation of EPC.

- **BIM provides more efficient data input**. With BIM, all the necessary building data is stored in a single digital model, allowing for quick and easily extraction and use in energy analysis software. This reduces the time and effort required for manual data input.
- **BIM enables more reuse of existing data**. Building designs and data can be reused across different projects, leading to the development of more accurate energy models over time. This also helps to reduce the time and effort required for future projects.
- **BIM facilitates dynamic energy simulation**. Instead of static methods, BIM supports the use of dynamic energy simulation, incorporating factors like building occupancy patterns for a more accurate representation of energy consumption.
- **BIM enables whole-building spatial simulation.** Unlike the zone-based approach, BIM allows for a more precise understanding of how different building systems and components interact, enhancing overall energy performance analysis.
- **BIM supports continuous verification.** Throughout the building's lifecycle, BIM enables continuous monitoring and tracking of energy performance. This facilitates ongoing improvements and optimizations to enhance building performance over time.

Given these considerations, conducting an energy performance assessment based on BIM data serves as a powerful tool for guiding designers toward sustainable design projects in a more systematic, transparent, and efficient manner compared to traditional methods.

What software solutions are on the market?

Users have a wide array of software solutions to choose from when creating BIM models. On the other hand, BuildingSMART has actively promoted open BIM adoption through standards, such as IFC. Open standards facilitate compatibility among software solutions developed by different providers, each striving to establish its market presence and gain a competitive edge while ensuring interoperability with the IFC standard. Therefore, the user should select the software according to their needs, but always ensuring interoperability options are available for the chosen software.

What software should I use?

It is important to emphasize that it is not possible to definitively determine the best software for EPC calculation, as different software options have varying characteristics and capabilities across the different domains of architectural design, structures, building equipment systems, and facility management. Additionally, not all tools can effectively evaluate and represent the activities and data related to the entire lifecycle of buildings. However, the wide array of options available allows users to choose the software that best fits their specific needs and budget constraints.

Autodesk's REVIT software stands out as the most widely used among users. With its various capabilities, the tool was specifically designed to facilitate the inclusion and evaluation of building model data to meet sustainable aspects and EPC data requirements. For these reasons, REVIT has been used as the reference BIM software in this guideline.

Additionally, there are other BIM tools with different approaches. The incorporation of the Open BIM workflow in CYPE tools now places all of the company's software within the realm of collaborative, multidisciplinary, and multiuser BIM workflows.

In the context of EPC development using modelling tools, there are two main approaches:

1. Adopting the CYPE Open BIM workflow, which encompasses a sequence of tools (such as CYPE Architecture, OpenBIM Construction Systems, CYPE Analytical, etc.). The final model comprises a combination of different models with various packages of information generated using these tools. The interconnection of these models relies on a combination of the IFC model and additional data structured files to complement this model.
2. CYPE has also developed plugins to facilitate information exchange with third-parties. These plugins allow for the export of a BIM model created with other software and its import into the CYPE Open BIM workflow. Thus, the CYPE Open BIM workflow can be followed even if the model did not originate from a CYPE tool.

To provide further insight into these methods, this document will include guidelines on using the CYPE Open BIM workflow with CYPE tools.

NOTE: The methods of exporting and importing information will be explored in more detail in the chapter titled “Information Exchange for EPC Assessment”.

2.2 Architectural modelling

The architectural model encompasses all architectural elements and systems of the building, including walls, floors, roofs, windows, stairs, and other features, along with their related information. Both the geometry and the information contained in the architectural model are essential for ensuring the proper construction or evaluation of the building envelope.

It is important to note that while structures, such as beams and columns, are part of the building envelope, they must be considered separately from the architectural model for energy evaluation purposes. However, it is crucial to evaluate the relationships between the envelope and the structure, including factors like thermal bridges, as these insights are integral to energy evaluation

2.2.1 How to create an architectural model for EPC purposes

2.2.1.1 Elements of the architectural model

When considering a building for evaluating its energy efficiency, it can be viewed as a system comprising two distinct subsystems: passive and active. The passive subsystem is primarily responsible for demand control, while the active subsystem focuses on consumption efficiency.

During the creation of an architectural model, the emphasis is placed on the passive subsystem and its characteristics. This includes considerations such as site conditions (orientation), building form, building envelope, materials, and solar protections. Developing an adequate architectural model requires attention to all building elements within these categories to facilitate the creation of an EPC.

2.2.1.2 General recommendations

When assessing the energy efficiency of a building, the manner in which the model is created can significantly impact its compatibility with EPC software. Therefore, it is crucial to follow some basic recommendations to ensure the creation of a successful architectural model.

In terms of general aspects of the model, it is essential to verify the units used to ensure accurate information exchange and analysis. To achieve this, it is recommended that the modelling scale be set to 1:1, ensuring that the model accurately represents reality and facilitates meaningful analysis.

2.2.1.3 Model location

It is crucial to position the model as close as possible to the internal origin of the software. Failure to do so may result in issues with the correct functioning of the software.

In the case of REVIT, the model must be positioned appropriately relative to the base point (within a distance of less than 16 km from the base point). Additionally, it should be accurately located based on the agreed survey point, which is geo-referenced to the actual site of the building using the coordinate system. This ensures that the building is correctly placed within its designated geolocation.

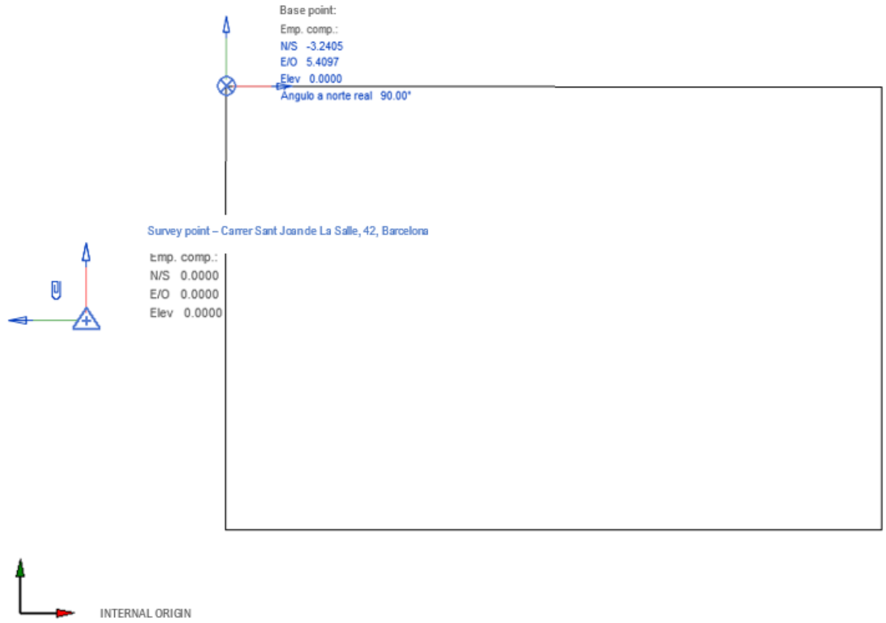


Figure 3. Internal Origin, Survey point, and Base point in REVIT.

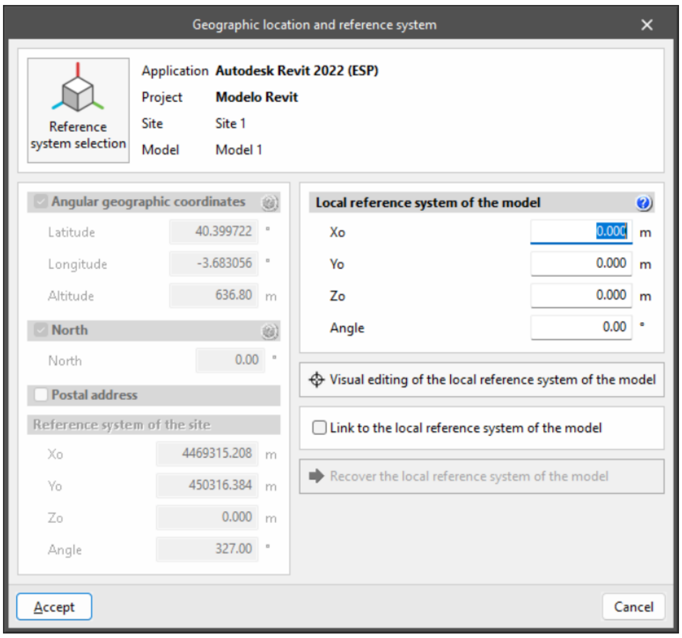


Figure 4. Coordinates point and origin in CYPE Architecture.

2.2.1.4 Model orientation

The building should also be correctly oriented, as orientation plays a crucial role in energy analysis by determining factors such as solar gains and wind effects. The orientation selected by the modeller will be imported into the EPC software.

In the case of REVIT, users usually work with non-real orientation to simplify the modelling process. However, this approach remains compatible with placing the building on its real-world coordinates. To properly place the building, it is essential to align it with true north by navigating to "position" within the "Manage" tab. Once the true north is established, the user can navigate from Revit's orientation to real-world orientation using the properties toolbar if necessary.

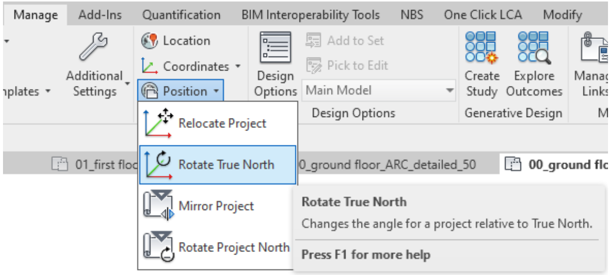


Figure 5. True North configuration in REVIT.

In the case of CYPE Architecture, it is necessary to configure the correct rotation introducing the coordinates and the angle.

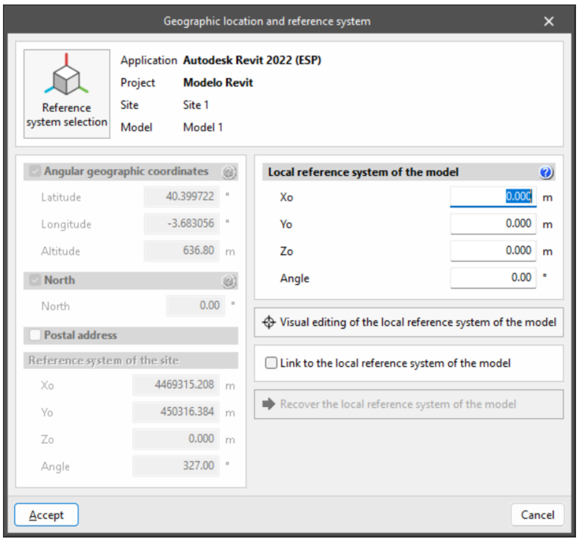


Figure 6. Orientation in CYPE Architecture.

2.2.1.5 Model division in levels

Concerning the building geometry, it is recommended to divide the model by levels (floors) and ensure all elements are correctly assigned to their respective levels. This is important because energy analyses typically operate on a per-level basis, construction projects are often managed by floors, and building, services, and property management rely on level division.

It is preferable to name the levels with a numerical prefix, using two digits in the case of more than nine levels. This facilitates quick visual identification and ensures alphabetical ordering. Alternatively, '+' or '-' signs can be used to indicate whether a level is above or below ground, respectively. Additionally, indicating the height of each level can help avoid complexity and provide further clarity.

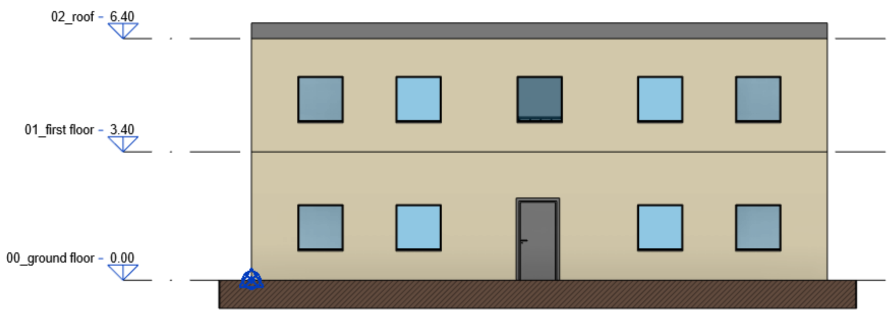


Figure 7. Example of division into levels (floors) in REVIT

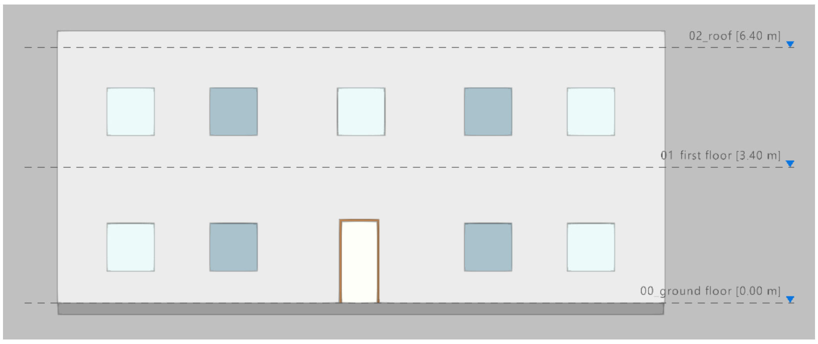


Figure 8. Example of division into levels (floors) in CYPE

2.2.1.6 Building element modelling

All elements within the architectural model should be recognizable by the software, distinct from other objects or generic ones/B-rep. To prevent interoperability failures, it is crucial to model elements using their associated modelling options. Using alternative modelling methods increases the likelihood of incorrect interpretation by the EPC tool. Therefore, walls should be created using the wall tool within the software, roofs with the roof tool, and so forth.

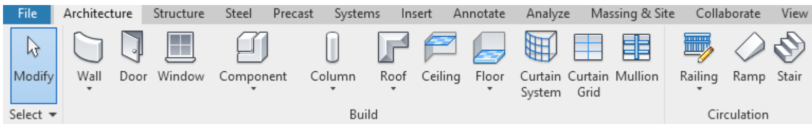


Figure 9. Example of architectural elements modelling options in REVIT.

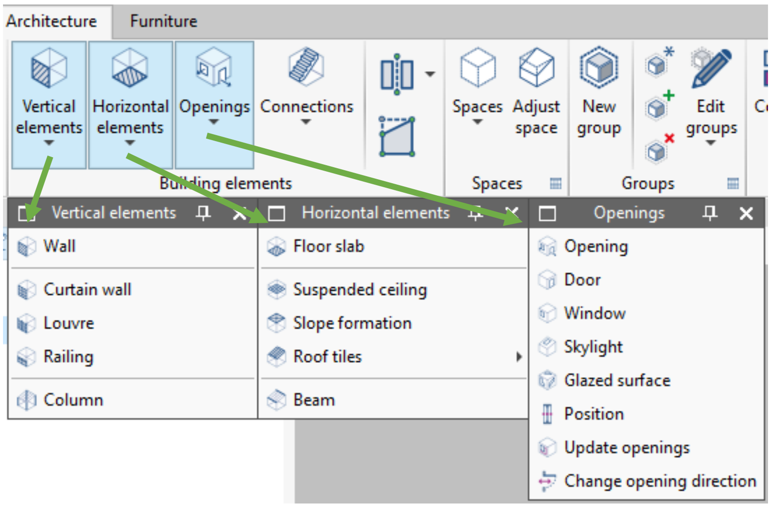


Figure 10. Example of architectural elements modelling options in CYPE Architecture.

This recommendation also applies to loadable families. A family is a group of elements with common properties (parameters) and related graphic representations. They are created in an external file and can be added to the project file.

Another type of family is the system family. System families are predefined families within the software. While these families can be duplicated and parametrically modified, they cannot be externally created and imported into the project.

A window or a door is a loadable family while a wall is a system family.

There are also in situ families which are created within the software by the user. However, they are only created when a specific component is needed in a project.

It is important to ensure that when modelling a window or a door as families, the software recognizes them as such. Therefore, it is essential to use the correct tools for modelling families.

When using BIM tools based on families such as REVIT and creating loadable families (e.g., windows and doors), it is important that the chosen family template belongs to the correct category (Figure 11).

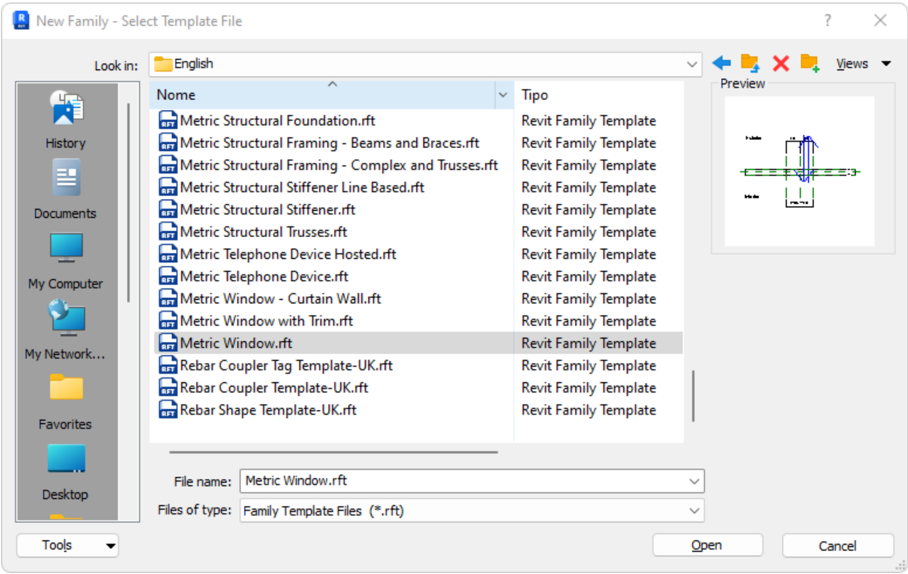


Figure 11. Example of window family creation from a window family template in REVIT.

In the case of CYPE Architecture, this recommendation does not apply, as the families are exclusively system families referred to as typologies (Figure 12).

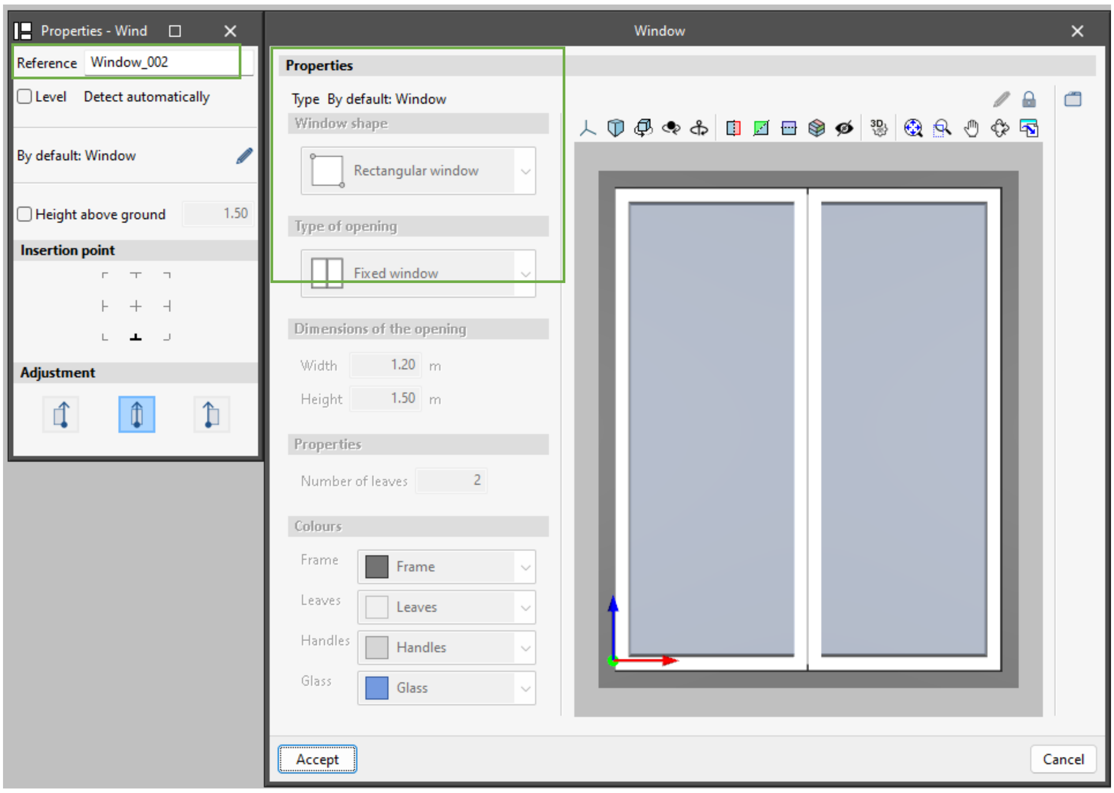


Figure 12. Example of window family creation in CYPE Architecture.

2.2.1.7 Multi-layered elements modelling

Another important issue is the correct arrangement of multi-layered elements. Each layer of a building component possesses distinct characteristics and serves a different function within the element itself (such as preventing condensation, providing inertia, insulating, etc.). During modelling, an element can be placed facing the outside or inside of the building, depending on the direction of the drawing line. To prevent inaccuracies in the model, it is recommended to verify the orientation of construction elements.

In the case of REVIT, it is important to ensure the correct orientation of windows and walls. Otherwise, using the flip control can alter the elements within the drawing area ( ). The order of material layers holds significance for energy purposes; hence, it should accurately represent the real building.

In the case of CYPE, this recommendation does not apply because material placement is handled by different software. However, when utilizing Open BIM Construction Systems software to arrange the layers of elements, it is essential to follow the correct order.

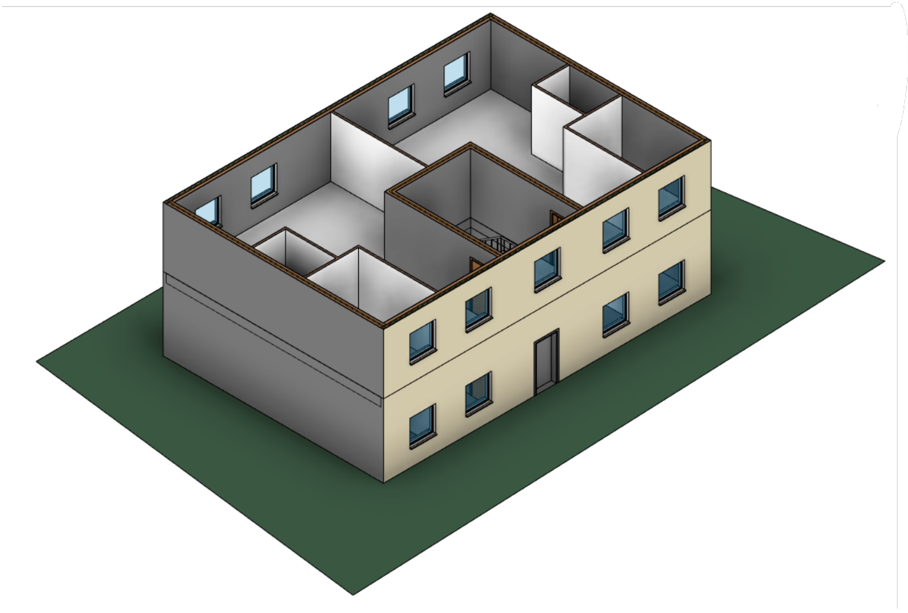


Figure 13. Example BIM architectural model for energy purposes in REVIT

2.2.2 The minimum requirements for the information exchange

Considering some of the previous basic recommendations, an architectural model tailored for energy analysis can be created. This section will outline the essential elements needed to create a suitable architectural model for energy-related purposes.

A BIM model for energy analysis encompasses both geometric and non-geometric information:

- Geometric information relates to the form of the building and the correct positioning of its elements.
- Non-geometric information encompasses all construction characteristics of the building model components that can influence the building's energy demand.

Depending on the BIM software, both types of information may be evaluated together or separately, with the latter often facilitated by compatible information exchange files. The recommendations outlined in the following sections apply universally to both geometric and non-geometric information, regardless of the BIM software employed.

Architectural model minimum required categories, elements, and information accuracy		
Minimum required categories	Minimum required elements	Information accuracy
Building envelope	• Exterior walls, floor in contact with the ground (ground slabs), roof • Ceilings, interior floors, interior walls • Windows, doors	High - Including detailed and accurate geometry, and detailed information about physical and thermal characteristics
Materials	• Material layers of each part of the building envelope	High - Including detailed and accurate information of physical and thermal characteristics

Solar protections	• Overhangs • Slats • Other exterior solar protection	Low - Including general geometry and some physical information

2.2.2.1 Exterior walls, external floors, and roofs

Walls, floors, and roofs, among other elements, constitute the building envelope. Exterior walls, floors, and roofs define the passive system of the building, shielding occupants from external conditions. Additionally, interior walls and floors serve to delineate spaces with varying comfort requirements. An effective passive system ensures protection from exterior conditions, while partitions contribute to interior comfort. When modelling the building envelope, it is crucial to ensure that the representation matches the reality of the construction. Otherwise, the results obtained from the EPC may not accurately reflect the actual conditions within the building.

However, for energy analysis purposes, wall models should not contain excessive information, as this can be impractical. EPC software is designed to consider those characteristics of construction elements relevant for simulation purposes. Extraneous information that does not apply to the simulation is typically ignored and not processed by the software.

To streamline the modelling process and ensure compatibility with EPC software, it is essential for the envelope to include specific minimum information. This facilitates energy analysis within the EPC software. Typically, this information is represented as parameters for elements such as walls, floors, and roofs, but it can also be derived from the modelling process itself.

- The following list highlights the minimum information requirements for exterior walls, exterior floors, and roofs to ensure that all necessary information for EPC development is included in the model. **Specification of the environment the element is separating**. Most software categorize elements as either exterior or interior. Ensuring this distinction enables modelling software to communicate with simulation software to delineate interior boundaries effectively.
- **Incorporating thermal and physical properties of elements**. It is unnecessary to include all properties in the energy model; only those required for EPC development are required. The data included depends on the specific data needs of the EPC software and its capability to automatically introduce information into the model. If automated, the physical and thermal data must align with the EPC software's requirements. However, if manual input is necessary, the data requirements remain the same as in the automated process, but the architectural model's information should be manually input within the EPC softwar using the IFC model as database. Minimum properties typically required for walls, floors, and roofs include thickness, density/mass, thermal transmittance, heat capacity per unit area, specific heat, and absorption coefficient.
- **Including thermal and physical properties of each layer in multi-layered elements**. Similar to element properties, the data included depends on the EPC software's capabilities or the EPC developer's need for manual input. Typically, minimum physical and thermal properties required for each layer of walls, floors, and roofs by most software include the type of layer (e.g., air chamber, water barrier, structure), thickness, density/mass, specific heat, conductivity/thermal resistance, vapor resistance, and absorption coefficient.
- **Ensuring continuity and accurately representing joints** are vital aspects of designing the building envelope. Continuity is essential to enclose inner spaces accurately, as in a real construction. Gaps in the modelled envelope can lead to issues with simulation software and

inaccurate EPC results. Additionally, different encounters between elements must be resolved to reflect actual construction, as they give rise to thermal bridges. Although EPC software typically cannot interpret the exact composition and layer order of joints, it can recognize potential thermal bridges at specific points. Therefore, the BIM modeler must ensure that the joining elements are correctly aligned: (1) to ensure the EPC software identifies the joint as a thermal bridge, and (2) to provide the EPC developer with the composition and characteristics of the joint, enabling them to accurately input its length and Psi value (linear thermal transmittance) into the EPC software.

If the BIM model includes all these data, the EPC developer, aided by the EPC software, can assess the building envelope and its internal condition requirements in accordance with the regulations of the country in which the building is located.

General recommendations for modelling of building elements:

- Double-check the element specifications and ensure that the correct parameter (interior, exterior, party wall) is defined for each element. Otherwise, the EPC software may misinterpret the wall requirements, leading to errors. This is typically straightforward to verify, as most BIM software provide user-defined parameters for establishing element specifications.
- Some BIM software currently lack the capability to define categories for floors or walls in contact with the ground. It is advisable to introduce a new user-defined parameter to ensure the accurate exportation of ground floors (e.g., IFCExportAs in REVIT).
- Ensure that both material layers and elements' minimum required conditions are visible in the model. If the software lacks the minimum parameter by default, create a parameter to define them and associate it with the material layer or element. The correct association is crucial to assist the EPC developer in locating the parameter. Additionally, in cases where the EPC software can automatically read the parameter, this ensures it is accessible. A user-defined parameter can be exported from the BIM model by following the options for exporting non-default IFC parameters, as explained in the exportation chapter.
- If the BIM software permits, it is preferable to define the parameters of elements by accurately specifying the parameters of its layers. This ensures that the element parameters align with those of the layers, avoiding discrepancies within the EPC software. Additionally, this approach proves beneficial in cases where the EPC software relies solely on the layers of the elements to define them.
- Avoid using generic elements and manually introduce user-defined parameters to incorporate their characteristics. Reserve the use of user-defined parameters for special cases only. This practice can lead to issues with the EPC software recognizing these parameters and reading the layers of the elements, particularly if the software defines elements based on their layers.
- Ensure the shape and thickness of each element layer are accurate by utilizing the tools provided by the BIM software. The thermal behaviour of each element directly depends on the thickness of each layer. Therefore, it is crucial to model each layer correctly. For instance, a sloped roof defined by variable thickness in its mortar layer exhibits different thermal behaviour compared to a sloped roof where the mortar layer has consistent thickness throughout, and the slope is defined by the structure supporting the roof. However, some EPC software may not interpret layers with increasing thickness accurately. In such cases, the BIM modeler must approximate the variable thickness of the layer to a continuous thickness layer that is equivalent.
- Ensure continuity throughout the entire building envelope and accurately define the various encounters between elements. This can be achieved by meticulously defining the category of each element layer (structure, insulation, finishing, etc.) and the location line of walls, floors, and roofs.

While most BIM software may not offer detailed joint representation, the modeler should strive for the most realistic approximation while minimizing the modelling process time.

Annex I. The architectural model, contains Table 1.1.1. which outlines all the minimum parameters and their recommendations for ensuring compliance during the modelling of walls, floors, and roofs using REVIT software.

Annex I. The architectural model, contains Table 1.2.1. which provides the minimum parameters and recommendations necessary for ensuring compliance during the modelling of walls, floors, and roofs using CYPE software (including CYPE Architecture and Open BIM Construction systems).

2.2.2.2 Ceilings, internal walls, and internal floors

Ceilings, internal walls, and internal floors, while not as crucial as the exterior envelope, are integral components of the inner envelope, defining the distribution and configuration of rooms. Consequently, they also play a significant role in simulation processes. Interior floors and walls delimit inner spaces with varying conditioning and/or scheduling requirements, whereas ceilings segregate spaces into conditioned or non-conditioned areas and non-conditioned installation plenums, each with distinct thermal loads and noise requirements.

Given that various environments can influence heat flow transmission, accurately defining the internal elements of the envelope is crucial for the energy model. Nevertheless, to streamline the modelling process and avoid excessive time consumption, it is necessary to ensure that these elements contain the minimum required information as specified by the EPC software.

Typically, this information is modelled through parameters for various elements such as walls, floors, and ceilings, along with the outcomes of the modelling process. Like those previously defined for exterior elements, these parameters include accurate definition, specification of material layers, determination of thermal and physical properties of elements, ensuring element continuity, and establishing proper interfaces between different elements.

However, making sure encounters are correct doesn't always mean dealing with thermal bridges. This is because the difference in environmental conditions between inner spaces is usually not significant enough to cause considerable thermal flows through junctions, leading them to be often overlooked. These junctions primarily affect the continuity of elements, particularly between ceilings and other components, or between elements separating conditioned and non-conditioned spaces. The objective is to properly enclose spaces away from plenums and non-conditioned areas, thereby mitigating direct thermal losses or addressing potential thermal bridges between these spaces.

The general recommendations for adequately modelling interior building elements are similar to those recommended for exterior elements.

Annex I. The architectural model, contains Table 1.1.1. which outlines all the minimum parameters and their recommendations for ensuring compliance during the modelling of interior walls, interior floors, and ceilings using REVIT software.

Annex I. The architectural model, contains Table 1.2.1. which provides the minimum parameters and recommendations necessary for ensuring compliance during the modelling of interior walls, interior floors, and ceilings using CYPE software (including CYPE Architecture and Open BIM Construction systems).

2.2.2.3 Windows and doors

Windows and doors are integral components of the building envelope and significantly influence heating and cooling gains and losses in interior spaces. Therefore, similar to other construction elements, they must be accurately modelled to develop the energy model required for the EPC. Additionally, they must include information about their properties necessary for the simulation processes, which ultimately impact the EPC results.

The minimum information required for modelling windows and doors include:

- **Specification of the environments being separated by the elements,** allowing the EPC software to recognize the exterior elements within the model. This primarily concerns doors, as interior windows are uncommon.
- **Definition of window and door dimensions**, encompassing length, height, frame dimensions, glass dimensions, and dimensions of other elements (e.g., opaque panels). It is crucial to specify accurate dimensions of windows or doors and their components in the model. Usually, this is accomplished during the modelling of window or door families. If enabled by the EPC software, it can automatically differentiate between the transparent and opaque areas of the components, addressing a potential weak point within the building envelope. Otherwise, the EPC developer will have access to accurate data.
- **Including thermal and physical properties of windows or doors** depends entirely on the EPC software being used. The software might automatically include this information within the EPC model, or the EPC developer may need to input the data manually. Typically, the minimum required physical and thermal properties for windows include thermal transmittance, visual light transmittance, and solar factor.
- **Incorporating thermal and physical properties** of each element of the window and door also varies based on the information required by the EPC software. Usually, the minimum required information includes glass thermal transmittance, glass solar factor, glass visual light transmittance, frame thermal transmittance, and frame absorptivity.
- **Properly placing windows and doors** in their actual positions, respecting the layers of the wall, to accurately define thermal bridges. This will determine whether the insulation of the wall is continuous with the insulation of the frame or if a thermal bridge exists.

If the BIM model includes all this information, the EPC software can evaluate these envelope elements and their contribution to meeting the internal condition requirements of the building.

The general recommendations to ensure the adequate modelling of the windows and doors are:

- Double-check the element specifications and ensure that the correct parameters (interior or exterior) are defined for each element. Otherwise, the EPC software may consider incorrect properties for the windows, leading to errors. Typically, this is easy to verify since most BIM software have a user-defined parameter to establish the element specifications.
- If the BIM software being used permits, ensure that the minimum required properties of windows or doors and their sub-components (frame, glazing panes, etc.) are included in the model. If the software lacks the necessary parameters required by the EPC software, create a parameter to define them by modifying the window or door family. When saving a copy of the family, these parameters will be automatically stored.
- Ensure that windows and doors are correctly positioned relative to the wall. If applicable, confirm that the wall insulation is continuous with the window or door. Typically, these options are available when

creating or modifying the window or door family by specifying the placement of the window planes or by including connections within the window or door family model. For instance, if the wall does not allow for direct integration of insulation wrappings, one possible approach is to incorporate these connections within the window or door family by including insulation layers surrounding the window as extruded parametric elements. By doing this, the EPC developer can accurately determine in the model the properties of the encounter and the value of the thermal bridge. Alternatively, if the EPC software supports this functionality, the detection of thermal bridges can be automated.

Annex I. The architectural model, contains Table 1.1.1. which outlines all the minimum parameters and their recommendations for ensuring compliance during the modelling of windows and doors using REVIT software.

Annex I. The architectural model, contains Table 1.2.1. which provides the minimum parameters and recommendations necessary for ensuring compliance during the modelling of windows and doors using CYPE software (including CYPE Architecture and Open BIM Construction systems).

2.2.2.4 Materials

Understanding the properties of materials is essential for defining the layers of each building element. The physical and thermal properties, coupled with the thickness of the material layer forming the element, determine its thermal behaviour.

BIM software typically offer material libraries, providing various options for the modeller to choose from. However, these options are often customizable to better reflect real-world conditions.

For accurate EPC development, the BIM modeller must ensure that all material information is present and visible in the model after export. Generally, the minimum required information about materials aligns closely with the requirements for the layers of the element.

Incorporating the thermal and physical properties of each material composing each layer of every building element is crucial. The inclusion of such data depends entirely on the capabilities of the EPC software being used. It may automatically integrate the information into the EPC model, or the EPC developer may need to input the data manually.

In general, the minimum physical and thermal properties for materials include the type of material, density and/or mass, specific heat, conductivity, permeability, and absorptivity or emissivity.

The general recommendations to ensure adequate modelling of the materials are:

- Use the most similar materials from the material library if the specifications of the material used in the building element are unknown. In some cases, the material libraries offer BIM modeller complete construction systems that can also be used to approximate BIM construction to reality.
- If the material is familiar to the BIM modeller, use the most similar material available within the library to craft a personalized material based on the general parameters of the library material. This ensures the creation of an appropriate and accurate material representation.
- When material documentation is provided by the product manufacturer, it can be uploaded to the library material of the BIM software. This functionality is available only in BIM software that supports loadable building products. Ensure that all the necessary physical or thermal parameters are included. If any parameters are missing, they should be added using the options provided by the software.
- Some BIM software may still be unable to export material properties to IFC format which can be used by certain EPC software to compile and transform IFC building elements into their internal counterparts. In such cases, two recommendations can be followed to inform the EPC developer of the

material characteristics, although they won't be automatically exported to the EPC software. By following these recommendations, the EPC developer will need to define material characteristics manually within the EPC software by following the IFC model.

- Create text parameters linked to the building elements containing the essential information required for the material. The method for doing this varies based on the BIM software utilized. For detailed instructions on how to execute this with REVIT exportation, please consult the IFC exportation chapter.
- Change the reference name of the material to incorporate essential information about the material or to enable the EPC developer to select from the existing materials library in the EPC software. The reference name of the material is always exported, making it a useful reference for the EPC developer to choose the appropriate material in the EPC software. An example of a potential material name structure is as follows:

ID_Material category_Material Type_Description

MT_Insulation_EPS_d23,λ0.035,c1740

d: Density: 23 kg/m^2

λ: Thermal conductivity: 0.035 [W/mK]
c: Specific heat: 1740 [J/kgºC]

Annex I. The architectural model contains Table 1.1.2. which outlines all the minimum parameters and their recommendations for ensuring compliance during the modelling of materials and constructive systems using REVIT software.

Annex I. The architectural model contains Table 1.2.2. which provides the minimum parameters and recommendations necessary for ensuring compliance during the modelling of materials and constructive systems using CYPE software (including CYPE Architecture and Open BIM Construction systems).

2.2.2.5 Solar protections

Solar protections are important for mitigating the greenhouse effect within buildings that have a large number of glazed surfaces. They also aid in diminishing radiation incident on non-glazed surfaces, thereby enhancing their performance during the summer months. For energy simulation purposes, solar protections can be classified into three distinct categories:

- **Structural solar protections.** These are non-mobile overhangs integrated into the building structure, often in the form of balconies providing shade for surfaces below. Their inclusion in modelling is crucial for accurately assessing the thermal behaviour of the building envelope, including thermal bridges. Typically, they are modelled using BIM software tools designed for floors or roofs.
- **Non-structural fixed solar protections**. These are solar protections affixed to the building structure but are not removable, such as slats. Some BIM software offer specialized tools for modelling these solar protections, while others may require them to be modelled as a distinct family.
- **Mobile solar protections**. They are either attached to the building structure or integrated into windows, featuring mechanisms for deployment as needed, such as blinds or mobile

canopies. Modelling these solar protections usually involves creating a family or incorporating them into an existing family structure.

Modelling solar protections enables EPC software to account for irradiation obstacles. Along with their basic formal properties (such as thickness, shape, and dimensions), EPC software often necessitate additional parameters. The specific minimum required parameters vary depending on the EPC software and are determined by each country's regulations. However, some common parameters include the absorption coefficient, thermal transmission coefficient, and solar coefficient for non-structural fixed solar protections and mobile solar protections.

The general recommendations to ensure adequate modelling of the solar protections are as follows:

- It is advisable to model structural solar protections in a manner that accurately reflects the construction reality. Similar recommendations applicable to floors and roofs should also be applied here, particularly those concerning joints and encounters to define thermal bridges.
- It is recommended to model non-structural fixed solar protections to ensure that the correct shadowing patterns are accounted for by the EPC software. Utilize the appropriate modelling tools available in the selected BIM software. If the BIM software lacks a specific tool for modelling solar protections, utilize the appropriate family categories for modelling. If there is no specific family category for solar protections, use nested families based on the generic metric family template, and select the building element (e.g., walls or windows) as the host. If the solar protections can adjust to changes in irradiation over time (e.g., adjustable slats), creating scheduling and positioning parameters is advisable to inform the EPC developer about the behaviour of the solar protections. Typically, EPC software cannot automatically read these parameters.
- Modelling mobile solar protections can be complex. Additionally, since their effectiveness often relies on human behaviour, evaluating them can be challenging and may be limited to specific periods when heat gains cause discomfort for occupants. Therefore, it is recommended to model them only if necessary. If they are not modelled, it is advisable to include certain parameters to ensure that the EPC developer is aware of their presence and can incorporating them into the EPC software. For example, parameters for blinds could include indication of the presence of blinds within the window family, whether they are external or internal, whether insulation is present in the roller shutter box, the thermal transmittance correction factor of the blind, the solar transmission correction factor when the blind is in use, and the colour of the blind.

Annex I. The architectural model contains Table 1.1.3. which outlines all the minimum parameters and their recommendations for ensuring compliance during the modelling of solar protections using REVIT software.

Annex I. The architectural model contains Table 1.2.3. which provides the minimum parameters and recommendations necessary for ensuring compliance during the modelling of solar protections using CYPE software (including CYPE Architecture and Open BIM Construction systems).

2.3 Analytical spaces modelling

An analytical model is a simplified digital representation of a building along with its physical and functional attributes. This model can serve various purposes, including the analysis of the building's energy performance. This analysis may involve determining the energy consumption of HVAC systems or assessing the amount of natural light entering a space. To achieve this, the model must encompass essential building information, including components, systems, parameters, and relationships that influence heat transfer processes throughout the entirety of the building.

The analytical model provides input to the simulation engine, which reproduces the performance of the building. This simulation can be utilized to estimate the building's energy consumption, identify potential energy efficiency enhancements, or evaluate various design alternatives.

To create an analytical model, the simulation software needs to abstract the BIM model into a format compatible with the simulation engine. This process is automated within the EPC software if the BIM software can export the information needed by the simulation applications. Therefore, an accurate BIM model with sufficient information is essential to generate an effective analytical model.

2.3.1 How to create an analytical model for EPC purposes

To develop an analytical model for EPC purposes, various methods are available. For instance, an analytical model can be manually crafted from scratch by directly modelling it within the simulation software.

Some BIM software, like Revit, feature integration with simulation software such as Green Building Studio or Insight. This integration enables the creation and visualisation of the analytical model within the BIM software, aiding the modeler in identifying errors and adding additional information directly within the BIM environment before transferring it to the simulation software.

Cype software has separated the generation of the analytical model from the EPC application to provide users with greater flexibility in managing information and errors. The BIM model can be automatically converted into an analytical model using the *Open BIM Analytical Model* software, but users still have the option to edit or create the analytical model from scratch as needed.

Basic suggestions to create a BIM model that allows the generation of an analytical model by the EPC software

The analytical model is used to perform the energy analysis of the building. It is generated by transforming all the elements within a BIM model into a set of components capable of representing the thermal behaviour of the building. These components typically include surfaces representing the building elements along with their associated information, spaces representing the internal environments and their data, and adjacencies that depict the relationships between spaces and surfaces. However, depending on the applicable legislation, it may also be necessary to include connections between surfaces, representing the weakest points of thermal flows in the building. This requirement is common in EPCs.

The architectural model comprises the building elements along with their thermal information, as well as their adjacency with other elements both within the inner and outer envelope of the building. Additionally, it includes the connections between these building elements, forming a comprehensive representation of the building's structure and thermal characteristics. These building elements and their associated data are converted into surfaces containing specific information. These surfaces represent the routes through which thermal flows occur during heat transfer processes, occurring either between inner spaces or between internal and external spaces. The edges of these surfaces represent the connections between them.

If the architectural BIM model includes rooms, it may contain certain information about the interior environment, such as the name, reference, volume, or area of each room. However, this information alone may not be sufficient for the energy simulation software. Additional data such as schedules, inner setpoint temperatures, equipment, and other parameters related to the interior environment may be necessary to accurately assess the energy performance of the building.

When considering analytical spaces, we are referring to air volumes with distinct environmental conditions. These spaces experience heat gains or losses due to various loads, such as occupancy, lighting, HVAC systems, etc. Additionally, they are influenced by differences with adjacent spaces, along with the specific conditions of the elements separating them.

While the term "analytical spaces" may be specific to Revit software, the underlying concept can be applied across different software tools. To create such spaces, users can define boundaries for each area and assign specific properties such as space type, function, and occupancy. This functionality is available in software like Revit and CYPE, allowing users to designate and characterize spaces for analysis purposes.

It is important to differentiate between the concepts of "room" and "space". In REVIT, a room belongs to the architectural model, serving purposes related to architectural design and documentation. Conversely, a space is a component of the analytical model, specifically intended for analysis purposes such as energy analysis. This differentiation highlights the specialized role of each component and how they are utilized within the building design workflow.

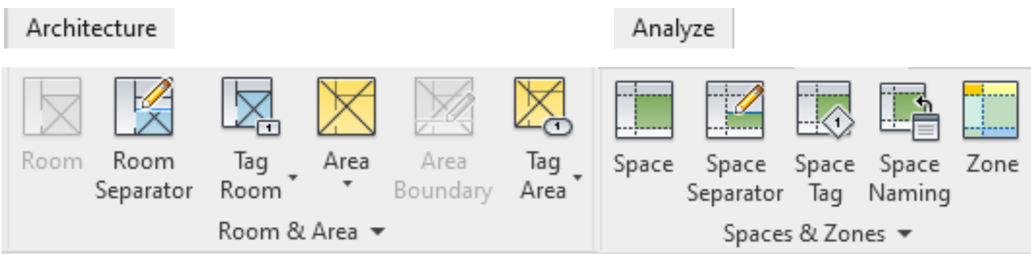


Figure 14. Room, Space and Zone configuration in REVIT

In CYPE, it is also possible to create, edit, and assign spaces within the model. Unlike in some other software like REVIT, there is no distinction between rooms and spaces.

Spaces can be designated using the CYPE IFC Builder, starting from an IFC file generated by any BIM software. Alternatively, within the CYPE workflow, spaces can be assigned either through Cype Architecture software when initiating modelling form scratch or through Open BIM Analytical Model, using an uploaded IFC file in the CYPE BIMserver.center platform. This flexibility enables users to smoothly incorporate analytical spaces into their building models, regardless of the BIM software initially used.

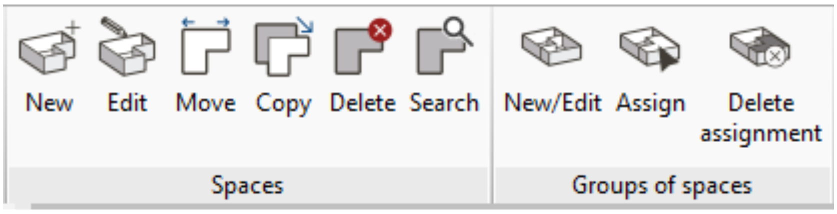


Figure 15. Spaces and Group of spaces configuration in IFC Builder

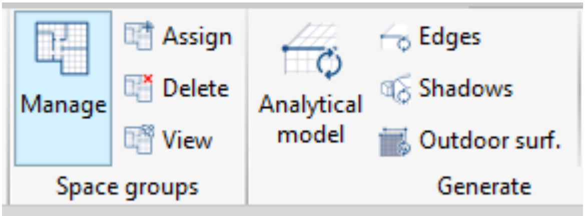


Figure 16. Space groups configuration in Open BIM Analytical Model

Thermal zones are groups of spaces with similar environmental characteristics, distinct from other zones, often managed as a single entity, particularly in relation to HVAC systems. For instance, in an apartment where various spaces like the living room, bathroom, and kitchen are all conditioned by the same system (e.g., a hydronic system), these spaces should be grouped into a single thermal zone. Conversely, unconditioned spaces like a stairwell should be assigned to a distinct unconditioned thermal zone. This ensures accurate representation of the building's energy performance characteristics during analysis.

To facilitate the creation of an analytical model by the simulation software, it is crucial to integrate the assignment of analytical spaces and, highly recommended, the assignment of zones, within the BIM architectural model.

BIM software facilitates the grouping of spaces into thermal zones, enabling users to manage and analyse groups of spaces with similar environmental requirements. Once included, users can graphically inspect spaces and zones.

For example, in REVIT, users can visualize the function of spaces and their grouping into zones using colour schemes.

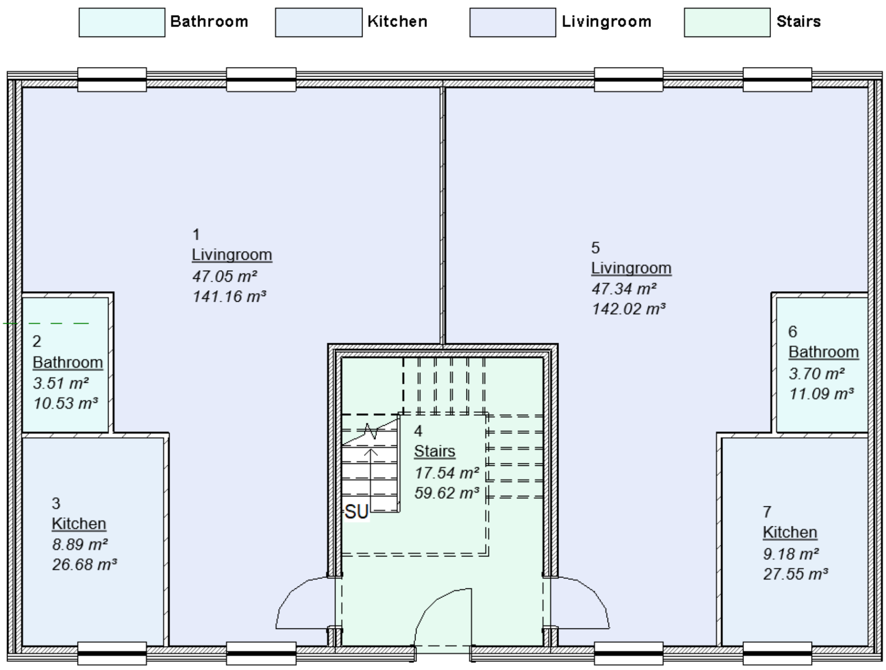


Figure 17. View with spaces' colour schemes in REVIT

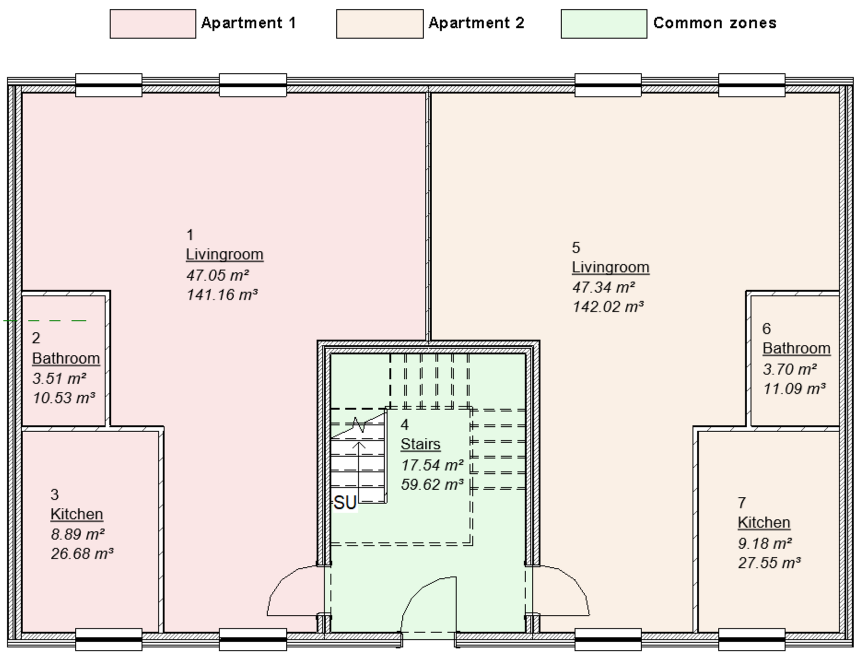
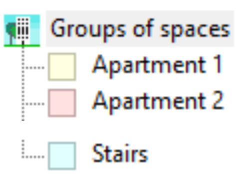


Figure 18. View with zones' colour schemes in REVIT

In CYPE, zones and spaces are also visualized using colour schemes.



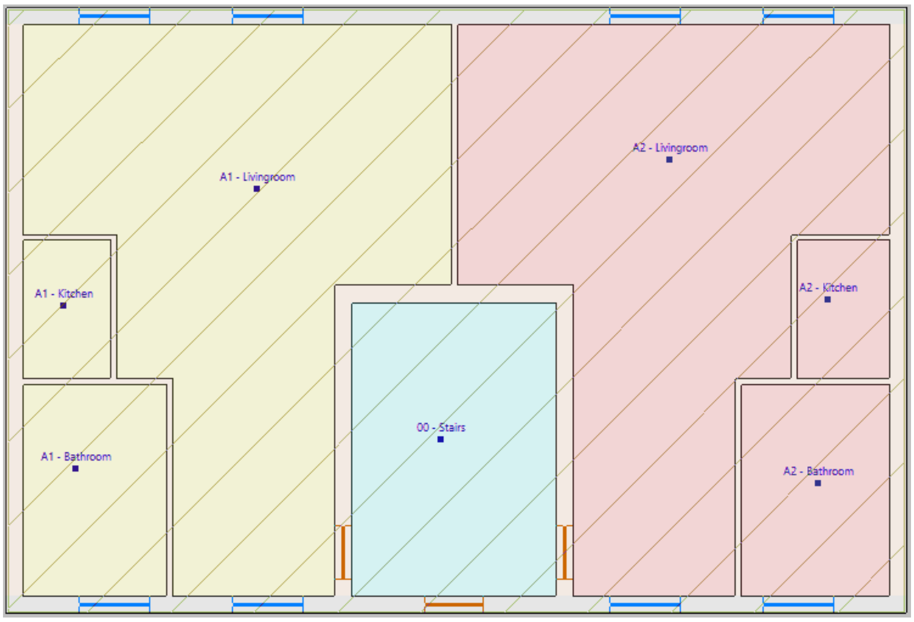


Figure 19. View with zones' colour schemes in CYPE

Alongside visual representations of space and zone subdivisions, generating tables containing information about the entities within the model can aid in verifying the accuracy of space and zoning parameters. These tables also serve to identify any unassigned spaces in the model, allowing for their proper assignment or removal.

<0_Space Schedule>

A	B	C	D	E	F
Level	Zone	Number	Name	Area	Volume
00_ground floor	Apartment 1	A1-LVN	Livingroom	47.05 m^2	141.16 m^3
00_ground floor	Apartment 1	A1-BTH	Bathroom	3.51 m^2	10.53 m^3
00_ground floor	Apartment 1	A1-KTC	Kitchen	8.89 m^2	26.68 m^3
Apartment 1: 3				59.46 m^2	178.37 m^3
00_ground floor	Apartment 2	A2-LVN	Livingroom	47.34 m^2	142.02 m^3
00_ground floor	Apartment 2	A2-BTH	Bathroom	3.70 m^2	11.09 m^3
00_ground floor	Apartment 2	A2-KTC	Kitchen	9.18 m^2	27.55 m^3
Apartment 2: 3				60.22 m^2	180.66 m^3
01_first floor	Apartment 3	A3-LVN	Livingroom	47.08 m^2	141.24 m^3
01_first floor	Apartment 3	A3-BTH	Bathroom	3.51 m^2	10.53 m^3
01_first floor	Apartment 3	A3-KTC	Kitchen	8.89 m^2	26.68 m^3
Apartment 3: 3				59.48 m^2	178.45 m^3
01_first floor	Apartment 4	A4-LVN	Livingroom	47.37 m^2	142.10 m^3
01_first floor	Apartment 4	A4-BTH	Bathroom	3.70 m^2	11.09 m^3
01_first floor	Apartment 4	A4-KTC	Kitchen	9.18 m^2	27.55 m^3
Apartment 4: 3				60.25 m^2	180.74 m^3
00_ground floor	Common zones	S0-STR	Stairs	17.54 m^2	59.62 m^3
01_first floor	Common zones	S1-STR	Stairs	17.48 m^2	52.45 m^3
Common zones: 2				35.02 m^2	112.07 m^3

Figure 20. Space schedule in REVIT

Following these basic recommendations, you can develop the model for your building and verify it to ensure a smooth EPC certification process.

2.3.2 The minimum requirements for information exchange

As previously stated, the key elements for generating an analytical model include spaces and their organization into zones, along with comprehensive information about building elements and their interconnections.

By defining and incorporating spaces and zones, the simulation software can seamlessly generate the analytical model, which serves as input to the simulation engine for estimating the energy demand and consumption of each space and zone within the building. This data is subsequently utilized to calculate the energy efficiency of the building and generate the EPC rating.

2.3.2.1 Minimum requirements for analytical spaces

While these requirements may vary depending on the software and workflow used, minimum requirements for analytical spaces models typically include:

- Reference and space type
- Constraints like space level, size, shape, and orientation
- Dimensions: surfaces, perimeter (edges, linear thermal bridges), area, volume
- External/internal characteristics
- Loads and thermal inertias
- Occupancy, activity level, illumination

General recommendations to ensure the adequate modelling of the spaces are:

- Define spaces with accurate constraints to represent their real shape and boundaries.
- Properly name spaces for correct identification and association with the appropriate function and EPC parameters.
- Classify spaces as external or internal based on their location in the building.
- Ensure correct definition of edges between different surfaces of spaces to prevent deviations.
- Associate each space with its intended function or activity, which is crucial for determining energy demand and consumption.
- Specify internal inputs on energy consumption, such as electronic equipment or domestic devices, within each space.
- Define space utilization profiles based on factors like occupancy, activity level, and lighting.

Annex II. The analytical model contains Table 2.1.1. which outlines all the minimum parameters and their recommendations for ensuring compliance during the modelling of spaces using REVIT software.

Annex II. The analytical model contains Table 2.2.1. which provides the minimum parameters and recommendations necessary for ensuring compliance during the modelling of spaces using CYPE software (including CYPE Architecture, Open BIM Analytical Model, and CYPE IFC Builder).

2.3.2.2 Minimum requirements for zones

The minimum required properties for zones include:

- Reference and zone type
- Dimensions such as surfaces, perimeter, area, volume
- Service type (habitable, or non-habitable)
- Cooling and heating information, including unconditioned areas
- Outdoor air information

- Setpoint temperatures
- Ventilation type: central, independent, natural
- Infiltration
- Domestic hot water (DHW) and reference temperature
- Contribution of renewable thermal energy produced on-site
- Considerations for condensation

General recommendations to ensure the adequate modelling of the zones are:

- Clearly define the reference and zone type for each zone based on occupancy, type, or use.
- Accurately define the dimensions of each space and group them into zones for heat gain and loss calculations.
- Specify if the zone is habitable or non-habitable to estimate cooling and heating needs.
- Define cooling and heating information and load requirements for each zone.
- Determine outdoor air information, including temperature, wind speed, and humidity, for each zone.
- Define setpoint temperatures for occupant comfort and energy efficiency.
- Select the appropriate ventilation system type (natural or mechanical) and define it accurately.
- Determine the infiltration rate for each zone to calculate energy requirements.
- Analyse the potential for condensation in each zone and implement appropriate prevention measures.

Annex II. The analytical model, contains Table 2.1.2. which outlines all the minimum parameters and their recommendations for ensuring compliance during the modelling of zones using REVIT software.

Annex II. The analytical model, contains Table 2.2.2. which provides the minimum parameters and recommendations necessary for ensuring compliance during the modelling of zones using CYPE software (including Open BIM Analytical Model, CYPETherm HE Plus, and CYPE IFC Builder).

2.3.2.3 Creation of the analytical model for EPC purposes

In the process of creating an EPC from a BIM model, it is essential to note that users typically do not generate the analytical model manually. Instead, the software automatically or partially generates it from the BIM model. Most EPC software imports the IFC model, which includes both the analytical spaces and architectural model, and then transforms it into the required analytical model for simulation engines.

Once the analytical space model is linked to the architectural model, the resulting model is ready for export in IFC format to proceed with generating an EPC.

When working in Revit, users have the option to create the analytical model directly within the software. This functionality is facilitated by Revit's integration with energy analysis software such as Green Building Studio or Insight. The resulting model is a blend of the analytical surface model derived from the architectural model, analytical spaces model, and zones.

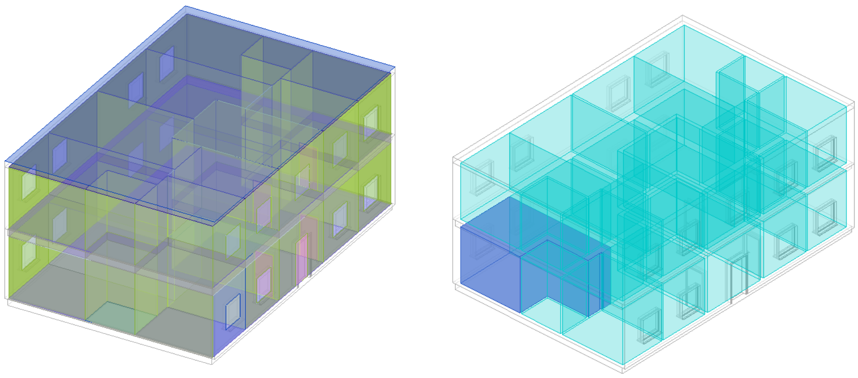


Figure 21. Revit analytical surfaces and analytical spaces views.

While Revit's integration with Green Building Studio or Insight allows for the creation of an analytical model, it is important to note that the requirements for this model differ from those needed by EPC software. Additionally, only the gbXML export format is available for interoperability purposes.

Therefore, while the analytical model created semi-automatically by Revit and Green Building Studio or Insight can be valuable for validating analytical space modelling and its inputs, it cannot be exported as an IFC model or substitute those generated by EPC tools.

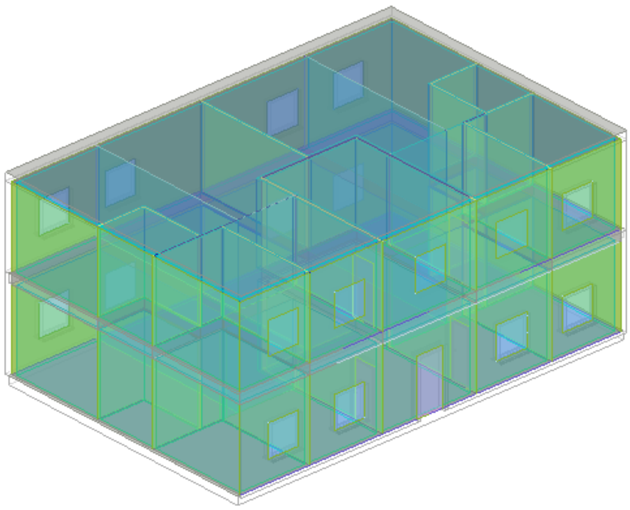


Figure 22. REVIT BIM analytical model

When using the CYPE workflow, architectural modelling and room allocation are handled within the software, but parameters for analytical space modelling must be managed in the Open BIM Analytical Model tool. This software allows users to input all necessary parameters related to the internal environment and heat transfer processes, resulting in a complete analytical model suitable for simulation engines.

The generated model, consisting of surfaces, analytical spaces, and zones, contains all essential inputs for simulation and simplifies the process for users. Additionally, it highlights connections between surfaces through edges, which are crucial for identifying thermal bridges within the building envelope.

As this tool complements the analytical modelling capabilities of CYPETHERM HE PLUS , it should be utilized in conjunction with Revit (or other BIM modelling tools) and CYPETHERM workflows.

Similar recommendations for analytical space modelling in Revit also apply in this case. Alternatively, users can leverage the IFC Builder for similar purposes.

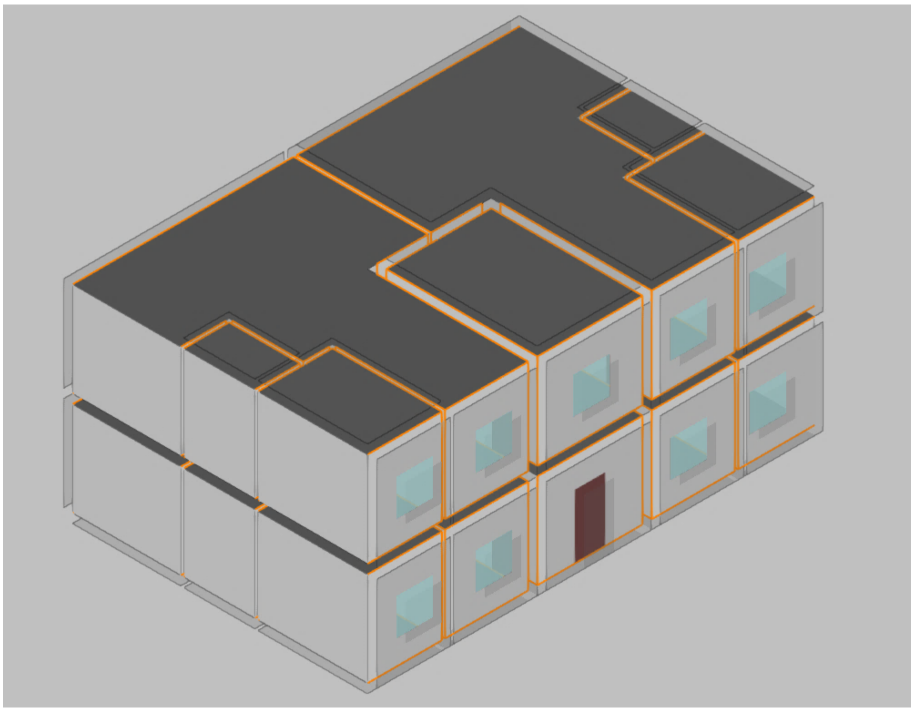


Figure 23. CYPE's analytical model

2.4 MEP modelling

A Mechanical, Electrical, and Plumbing (MEP) model is a digital representation of the building's mechanical, electrical, and plumbing systems.

These systems include mechanical components like HVAC (heating, ventilation, and air conditioning), elevators, and escalators. Electrical systems cover lighting, power distribution, and fire protection. Plumbing installations consist of water supply, drainage, and waste management.

BIM MEP models are developed using specialized software, enabling architects, engineers, and contractors to collaborate in a virtual environment. These models serve various purposes such as clash detection, energy analysis, and simulation, enhancing building efficiency and sustainability. Moreover, they are valuable for facility management and maintenance post-construction.

In BIM, a MEP element refers to an object representing an installation system element –any HVAC, mechanical, plumbing, electrical or lighting system, such as, ventilation equipment, boilers, air conditioning systems – equipped with one or more connectors –for example, electrical, ducts, pipes, cable trays – to link with corresponding systems. These connectors serve to create facility networks from the MEP elements.

As with construction elements, MEP elements need to be associated with their corresponding families depending on the software used. Additionally, they must be modelled as installation system objects that each software is capable of interpreting.

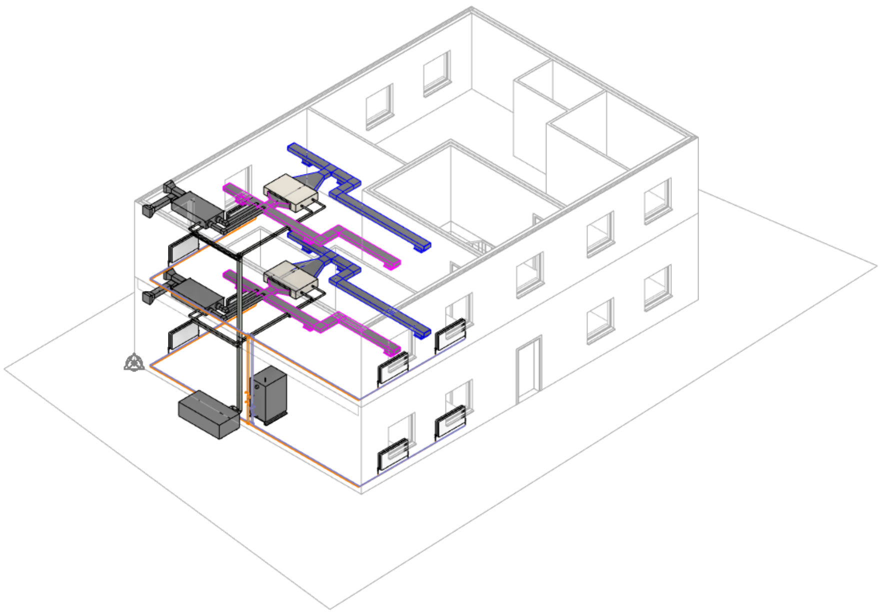


Figure 24. View of a BIM MEP model

2.4.1 The minimum requirements for information exchange

Exporting the information contained in a BIM MEP model for EPC generation can be challenging as simulation programs may not yet support its import. Instead, EPC generation typically involves configuring parameters like heat generators, system networks, and terminals for each space and zone within the simulation software.

EPC generation applications typically do not directly import MEP model information, so there are no strict minimum requirements for a MEP model when generating an EPC. However, MEP models can still be valuable for EPC purposes. For example, data from the MEP model, like boiler power ratings or heat recovery unit efficiency, can inform the configuration of EPC software parameters.

3. Information exchange for EPC assessment

The exchange of information between different software can occur in two ways, which can also be partially combined:

- **Method 1**: Exporting/importing the information using specific formats.
- **Method 2**: Exporting/importing the information using BIM open standard formats.

Method 1 involves the use of specific formats, which entails employing an exchange file specifically designed to transfer a particular set of information between BIM authoring tools and a simulation tool. This ensures the presence of all necessary data for conducting simulations, without including extraneous information that would not serve this purpose.

Method 2 utilizes an "open" exchange format capable of facilitating a lossless flow of information between any BIM authoring tool and any simulation tool, following the principles of OpenBIM logic.

3.1 Benefits of using open formats

While proprietary formats guarantee compatibility in data transfer, streamline operability, and mitigate the need for file conversions, they also restrict data accessibility in an industry increasingly reliant on digital cooperation, collaboration, and communication technologies.

In contrast, open formats not only ensure accessibility but also promote compatibility, usability, transparency, management, and sustainability of BIM digital data. This is achieved through various mechanisms and principles inherent to open formats, among them:

- **Accessibility and compatibility** lay the foundations of open formats interoperability by enabling the diverse stakeholders participating in the processes to take part regardless of the BIM tool they are using. Therefore, collaboration is enhanced.
- The open and neutral formats establish a common language and define workflows that facilitate **usability** for the stakeholders. These also contribute to an easier integration of the data, which results in opportunities for development and automatization.
- Since the exchange of information depends on independent quality benchmarks, it gives stakeholders better confidence in data, fomenting greater access to data and **transparency**.
- Open formats also improve data management by connecting all a priori disconnected workflows. Improved data **management** ensures data quality, increases data reuse, and prevents duplicate inputs of identical data.
- Warranting long-term standardization protection results in ensuring the **sustainability** of open formats.

Open BIM standards such as gbXML or IFC are utilized for data exchange between BIM authoring tools and EPC generation tools. In some cases, the use of these formats is the only viable option.

3.2 IFC exportation and exchange

3.2.1 How to export data from REVIT to IFC

The first step for exporting is to review the IFC mapping table to ensure that all the required entities are defined according to the IFC schema. To do this, navigate to the REVIT main menu > Export >

Options > IFC Options (Fig 26). A mapping table window will appear, where you need to assess export options and names based on the IFC schema. IFC class name options labelled "non-exported" will not appear in the IFC.

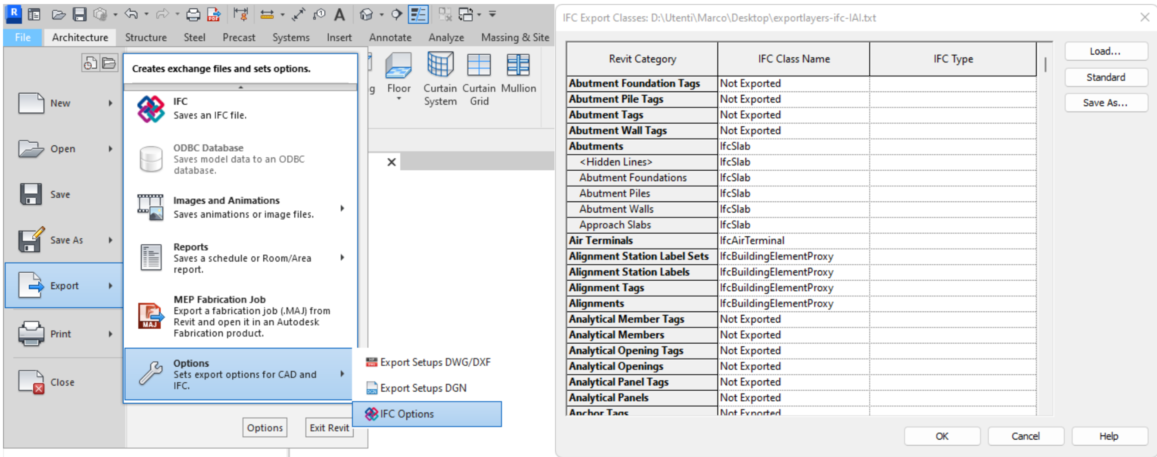


Figure 25. IFC export option and mapping table window in REVIT.

Once the mapping table has been checked and corrected, if necessary, the export configuration must be chosen. To do this, navigate to the REVIT main menu > Export > IFC (Figure 27).

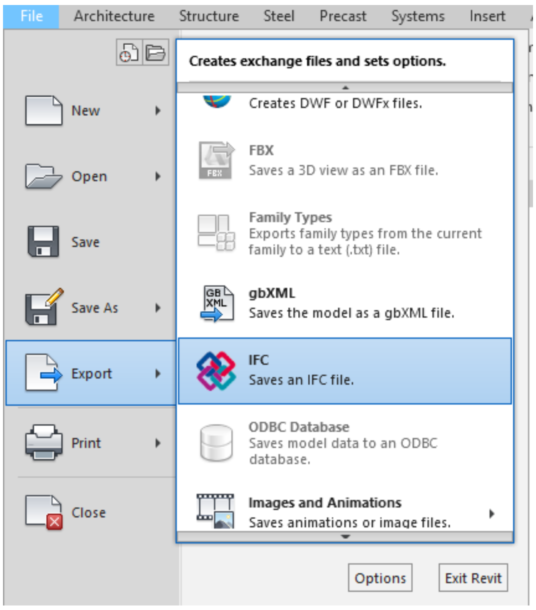


Figure 26. IFC export in REVIT

A new window will open, prompting the modeler to name the file and adjust the configuration (Figure 28).

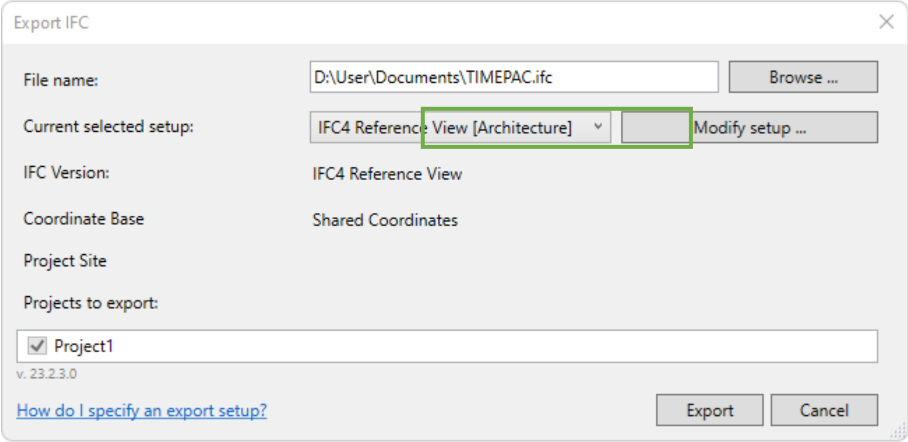


Figure 27. Export IFC configuration in REVIT

In the next window, several configuration options will appear within different tabs. The modeller should start by the "General" tab:

- IFC Version: The modeller can select from different versions of IFC. Generally, it's advisable to opt for IFC4, the latest version developed by BuildingSmart. However, it's crucial to verify the version and Model View Definition supported by the simulation software to ensure optimal export. For instance, some software may perform better with IFC 2x3 Coordination View 2.0.
- File Type: Various file types are available for selection. For the purposes of these guidelines, the IFC option is recommended.
- Exporting Phase: Multiple exporting phases can be created, and this option will display all of them to the modeller. However, as detailed in the modelling requirements tables (Annex I), all elements should belong to the same phase for energy evaluation within each model (architectural, analytical, and MEP). This ensures that all elements comprising the energy active and passive systems of the building are accounted for. Moreover, linking all models into one ensures the complete representation of the building's system. Therefore, all elements within all models should be developed in the same phase, corresponding to the phase in which these elements are placed.
- Space Boundary Conditions: Space boundaries are virtual objects used to calculate various quantities for analysing spaces or rooms within buildings. There are two distinct levels:
  - Level 1: Boundaries of a space defined by surfaces of building elements enclosing the space or virtual surfaces provided by an adjacent space without a dividing wall. These boundaries do not account for material changes within building elements or differences in spaces/zones.
  - Level 2: Similar to Level 1 boundaries but more detailed, subdivided when there are material differences and/or variations in spaces or zones on the other side of the building element. These boundaries represent both sides of a heat transfer surface, with the thickness of the building element acting as a separator. It is recommended to choose Level 2 boundary conditions.
- Base Coordinates: Different options are available based on the coordinate system. Since it is recommended for all linked elements to share coordinates with each other and with reality, selecting shared coordinates as base coordinates is advisable.

In the additional "Content" tab, the modeller should primarily consider checking the "Export linked files as independent IFC" option based on the importation capabilities of the EPC software. This decision depends on whether the software can only import one file or multiple files.

The "Property sets" tab determines which property sets the modeller intends to export. It is essential for the modeller to ensure that all minimum required parameters are included in the IFC file. Therefore, it is recommended to select the "Exporting IFC common property sets" option.

If any parameter within a property set does not appear by default, it is recommended to follow the guide in the *What to do if the parameter I need to develop the EPC is not a default REVIT Parameter?* sub-chapter.

For certain elements' geometry, it is advisable to set the detail level to low or extra low in the "Level of Detail" tab. This helps prevent the generation of models with overly detailed elements that may not be significant for the EPC software.

Ultimately, the selections within the "Advance properties" tab depend on the modeller's specific needs. However, considering the requirements of the model, it is advisable not to check any of the options.

After filling out all these tabs, click on "Ok" and the window will close (Figure 29). Next, select the projects that need to be exported, and confirm to initiate the exportation of the model (Figure 30). Once the exportation is finished, proceed with the validation phase.

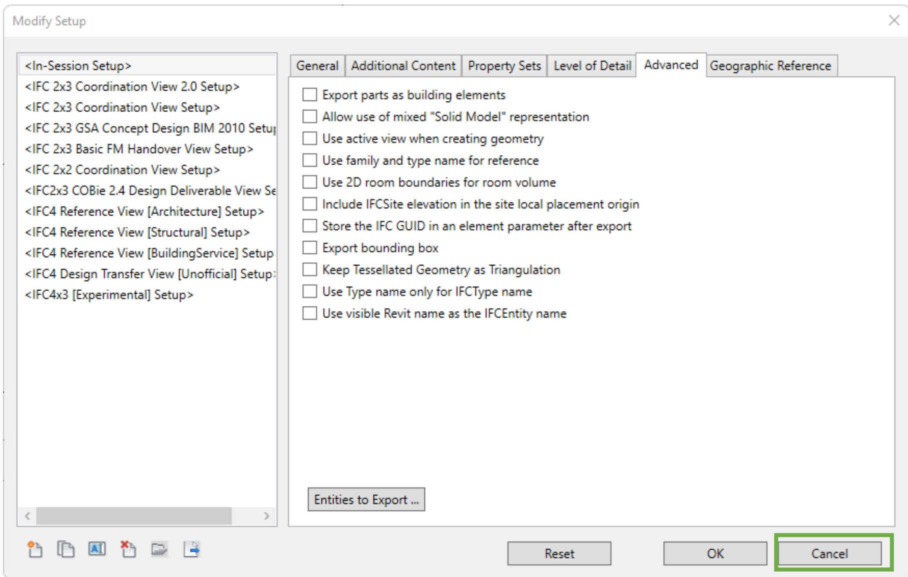


Figure 28. Exportation configuration window in REVIT

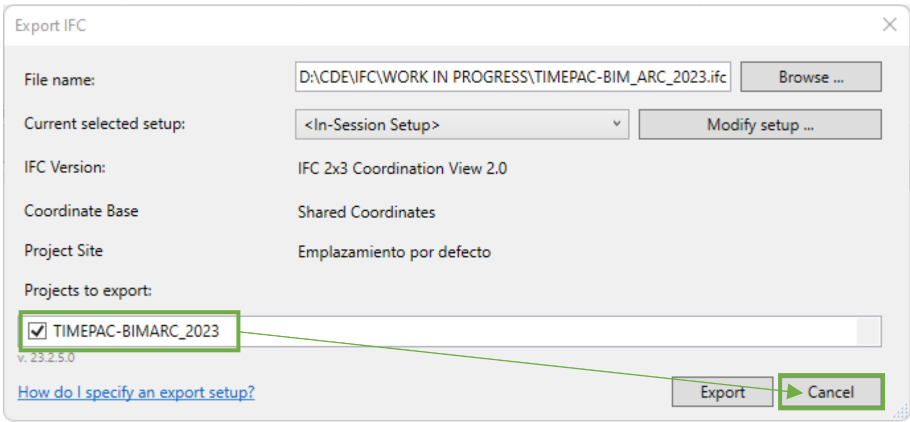


Figure 29. IFC exportation in REVIT

3.2.2 What to do if the EPC parameter is not a default REVIT Parameter

There are three different methods to include the necessary parameters for exporting them in IFC format.

1. Exporting REVIT property sets.
2. Exporting schedules as property sets.
3. Exporting user defined property sets.

Method 1: Exporting REVIT property sets

The steps to develop the model are:

1. Utilize REVIT tools to define the model, prioritizing simplicity over complex forms, and ensure the model's level of detail meets the requirements of the EPC software.
2. Create any undefined parameters as shared parameters, associating each parameter with the relevant entity and organizing them into the appropriate REVIT property sets. Whenever possible, use equivalent IFC parameters (as outlined in step 3), though it's not mandatory in this scenario.
3. If IFC parameters are not pre-existing in REVIT, generate REVIT project parameters using the IFC shared parameters file located in (C:) > Program Files > Autodesk > REVIT 20XX > IFC Shared Parameters.txt.
4. Integrate these shared parameters as project parameters within the REVIT project.
5. Adhere to the exportation steps outlined in the "How to Export from REVIT to IFC" sub-chapter. During exportation, ensure to check the "Export REVIT Property Sets" option in the Property Sets tab (Figure 31). Finally, proceed with exporting the IFC file.

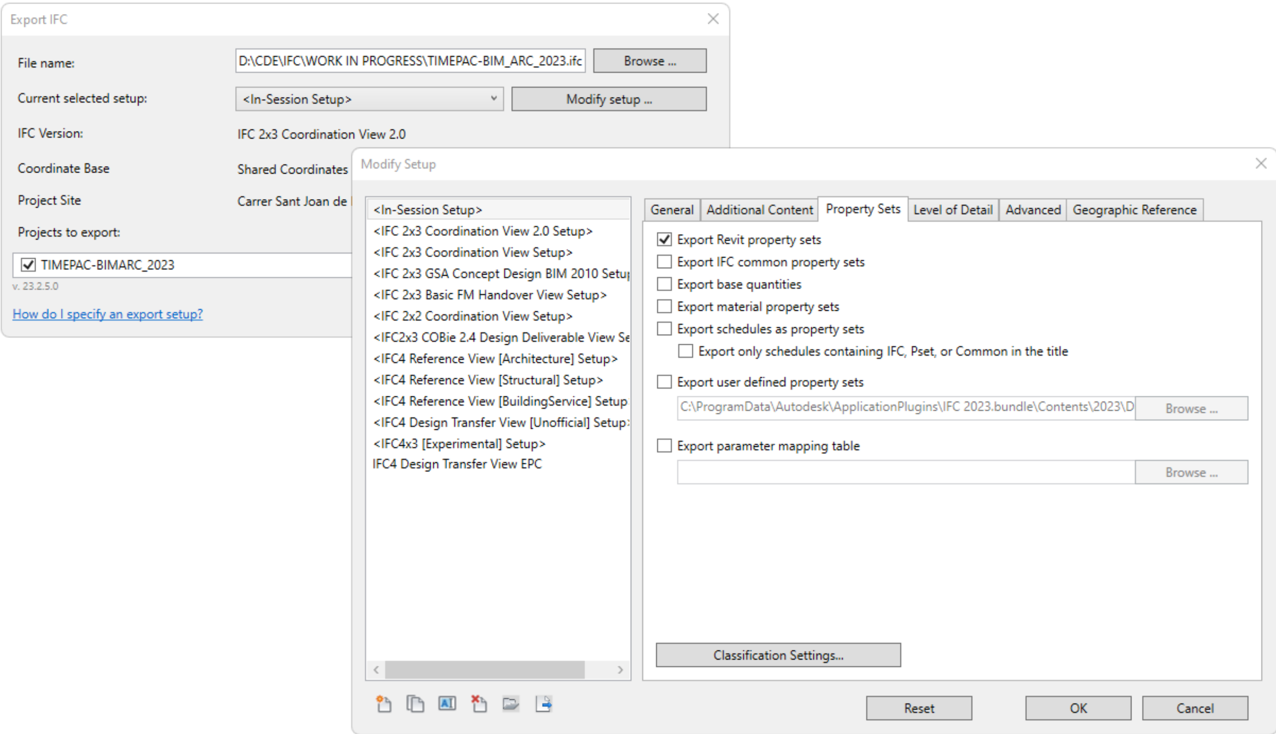


Figure 30. Example of how to export all REVIT property sets

Disadvantages of this method:

- All REVIT parameters are included in the IFC, named and treated as in the modelling tool.
- Most of the parameters included are not filtered, hence unnecessary for the model.
- It is a basic way to proceed that results in a non-standardized IFC model.

Advantages of this method:

- It is easy to develop and does not require a lot of time.

Method 2: Exporting schedules as property sets

The steps to develop the model are:

1. Utilize REVIT tools to define the model, prioritizing simplicity over complex forms, and ensure the model's level of detail meets the requirements of the EPC software.
2. Create shared parameters based on the list of undefined parameters. Associate each parameter with the corresponding entity and organize them into the appropriate REVIT property sets. Utilize equivalent IFC parameters whenever feasible (as outlined in step 3).
3. If IFC parameters are not available by default in REVIT, generate REVIT project parameters using the IFC shared parameters file located in (C:) > Program Files > Autodesk > REVIT 20XX > IFC Shared Parameters.txt.
4. Integrate these shared parameters into the project as project parameters.

5. If necessary parameters are already defined by IFC-shared parameters but assigned to a different entity, they can also be utilized provided they are grouped and associated with the intended entity by the modeller.
6. After creating the parameters, proceed to create various schedules (such as planning, quantities, material take-off, etc.) utilizing the evaluated parameters. Ensure that the titles of these schedules include "Pset," "IFC," or "Common" to denote their association (Figure 32). Each of these schedules will be exported as a property set in the IFC model.

<Pset_IFCWall aditional properties>

A	B	C	D	E
Familia y tipo	Coeficiente de tran	Densidad	Calor específico	Permeabilidad al air
Muro básico: Muro	0.6319 W/(m²·K)	1550.00 kg/m³	840.0000 J/(kg·°C)	29
Muro básico: Muro	0.6319 W/(m²·K)	1550.00 kg/m³	840.0000 J/(kg·°C)	29
Muro básico: Fach	0.2670 W/(m²·K)	1600.00 kg/m³	840.0000 J/(kg·°C)	29
Muro básico: Fach	0.2670 W/(m²·K)	1600.00 kg/m³	840.0000 J/(kg·°C)	29

Figure 31. Example of REVIT schedule to be exported as Property set

7. Then, proceed with exportation steps defined in the *How to export from REVIT to IFC?* sub-chapter. In the “Property sets” tab, ensure to check the following options: “Export IFC common Property Sets”, “Export schedules as property sets”, and “Export only schedules containing IFC, Pset, or Common in the title options” (Figure 33). Finally, export the IFC file.

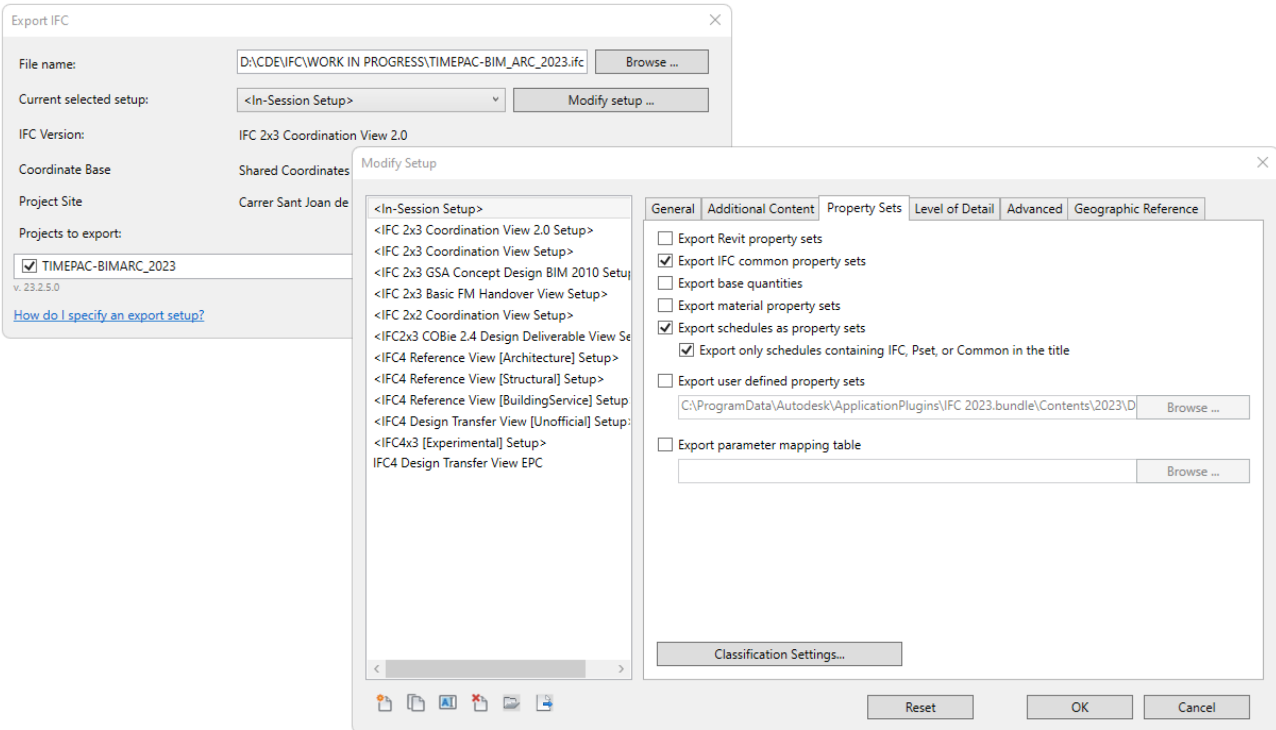


Figure 32. Example of how to export IFC and user defined property sets in REVIT

Disadvantages of this method:

- Transferring schedules between projects is limited.

- It involves a manual process to create all necessary schedules.
- There is a higher likelihood of errors due to the manual nature of the method.
- The functionalities of the schedules are restricted.
- It may not be applicable to all categories of the model, particularly those involving analytical models, which can present challenges.

Advantages of this method:

- The outcome is an improved and more organized IFC model, encompassing all standardized IFC parameters along with separately defined user parameters.
- It simplifies the workflow and should be easily implementable by all modelers.

Method 3: Exporting user defined property sets

The steps to develop the model are:

1. Develop the model using REVIT tools. Aim to minimize the use of complex forms and ensure that the level of detail aligns with the requirements of the EPC software.
2. Instead of creating parameters directly within the software, utilize a text file as input. This file will define the property sets of the modeller and introduce REVIT parameters. Ensure that the file adheres to a specific configuration (Figure 34).

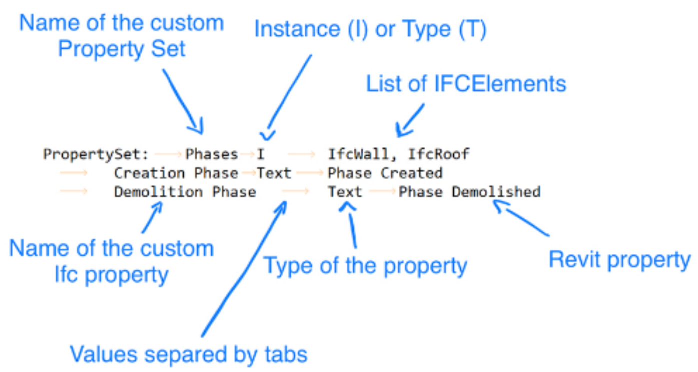


Figure 33. Example of an exportation text file configuration.

3. If IFC parameters do not appear by default in REVIT, include them in the file.
4. Then, follow the exportation steps defined in the *How to export from REVIT to IFC?* sub-chapter. However, In the “Property sets” tab, the modeller should check the “Export user-defined property sets” and select the .txt file that was previously created.

Disadvantages of this method:

- Requires expertise from users who must be familiar with every parameter to be exported.
- Generating the mapping .txt file can be time-consuming and challenging.

Advantages of this method:

- The user will have complete control over all parameters and information exported.

- The level of standardization for IFC is the highest possible.

For the purposes of the energy model, if additional information is required in the future for developing the EPC, the recommended method is the second one. This allows the modeller to easily control the parameters and property sets to be exported, in contrast with the first method. Notably, a high level of expertise, such as that needed to develop the mapping text, is not required.

3.2.3 REVIT exportation: Unsolved problems

Unsolved problems related to the architectural model

Currently, it is not possible to export the architecture envelope layers properties in IFC. The only properties exported are:

- Number of layers.
- Name of the layers.
- Material of the layers.
- Thickness.

However, the EPC software requires specific properties of each material layer that cannot be exported by REVIT. These properties include:

- Material Density.
- Material specific heat.
- Material vapor resistance.
- Material thermal conductivity.

Even though all this information can be added during import phase, it is important that it appears within the IFC to be delivered to the EPC developer. This ensures that the developer has insight into the composition of the materials. One possibility to export these material characteristics is by following the second method. This involves developing a Material Take-off schedule of the building's envelope, including all necessary parameters. However, as a preliminary step, it's necessary to utilize the "Parts" tool in REVIT on the envelope entities.

While it is possible to obtain the construction layers' parameters in the IFC model, a problem arises during the import process into the EPC software. This occurs because the EPC software interprets those "Parts" of the model as independent entities rather than components of a larger entity, such as a wall. Consequently, it reads them as the wall itself.

Hence, the only remaining option is to manually input the necessary data within a schedule and export it as property sets using the second method. However, this approach merely serves as a patch for the problem, and it is advisable to utilize this method solely for visualizing all the building properties to proceed with the next step of the guide, which is validation. Nonetheless, achieving successful importation may still be challenging.

Unsolved problems relating the analytical model

REVIT does not automatically export zones to IFC, thus requiring manual configuration for all REVIT zones through the command "Export to IFC as" (Figure 35).

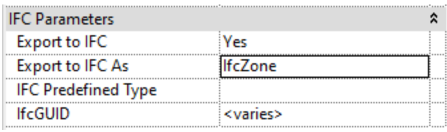


Figure 34. REVIT IFC Parameters for the zone properties

To accomplish this, select the zone you intend to export and configure the IFC Schema version and the IfcZone field in the properties panel. To expedite the process, you can use the corresponding command to select all zones in REVIT simultaneously or generate a table listing all zones with a column labelled "Export to IFC As" to associate them to the IFC parameter. This will ensure the correct association of the IFC class with the zones.

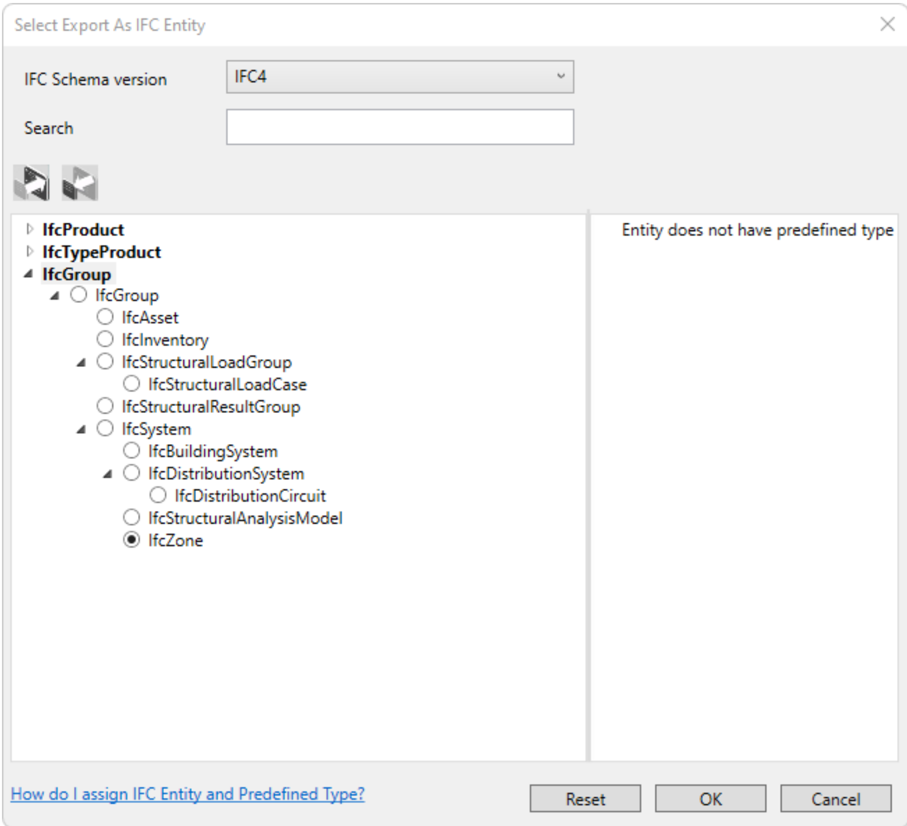


Figure 35. REVIT Manual selection window for the IFC Entity

3.2.4 How to exchange IFC using CYPE

CYPE software workflow

All CYPE software operates with an internal workflow that relies on IFC exchange combined with other information formats such as Json, xml, glTF, PDF, DXF, and FBX. These formats, generated by each respective software, converge within the same visualization platform known as BIMserver.center.

One possibility to follow CYPE's internal workflow is to use each CYPE software for architectural, analytical and MEP modelling, with BIMserver.center serving as the storage of exportation/importation. Subsequently, the final exportation can be directed to CYPETherm HE Plus for EPC generation (Figure 37).

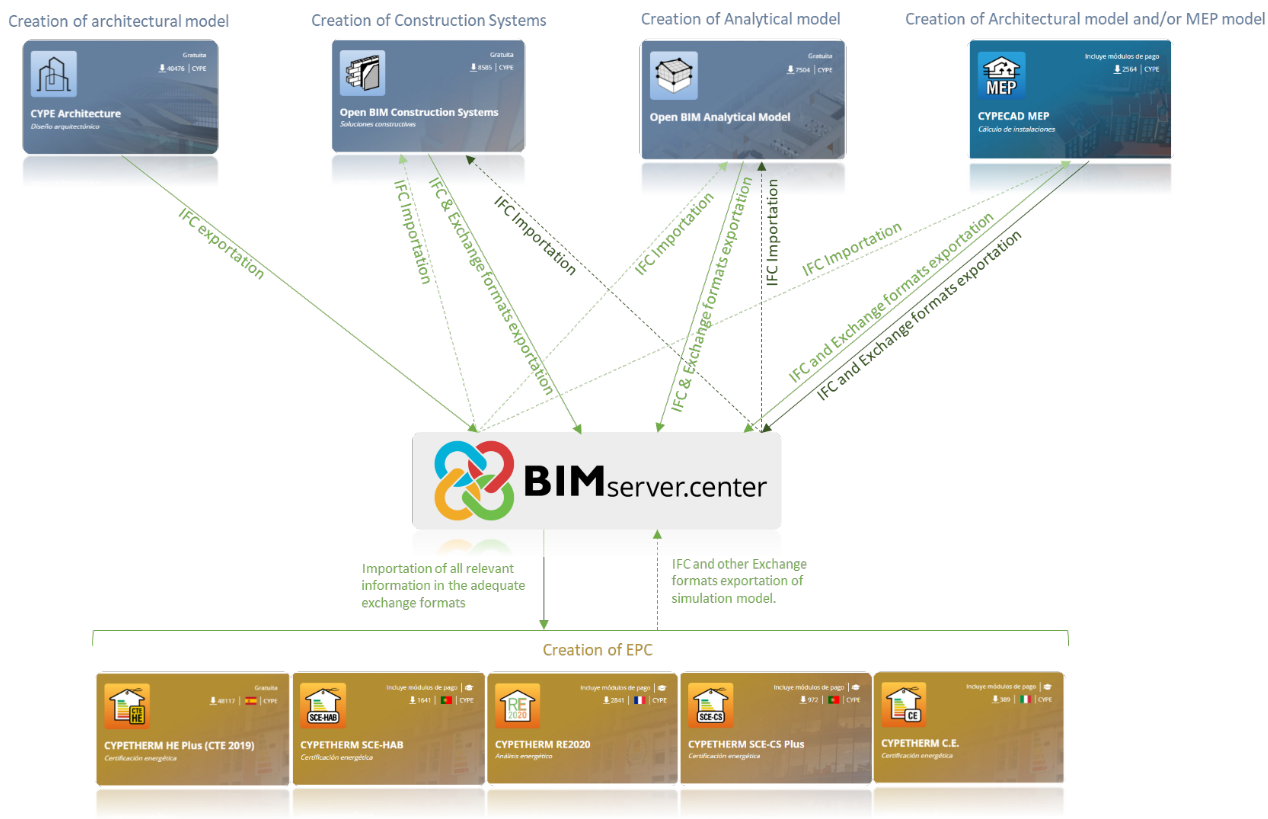


Figure 36. CYPE Workflows

IFC exchange using CYPE Architecture

Beginning with CYPE Architecture, the architectural model is developed. Using the exportation button within the selected software (Figure 38), the IFC model is automatically uploaded to the BIMserver.center.

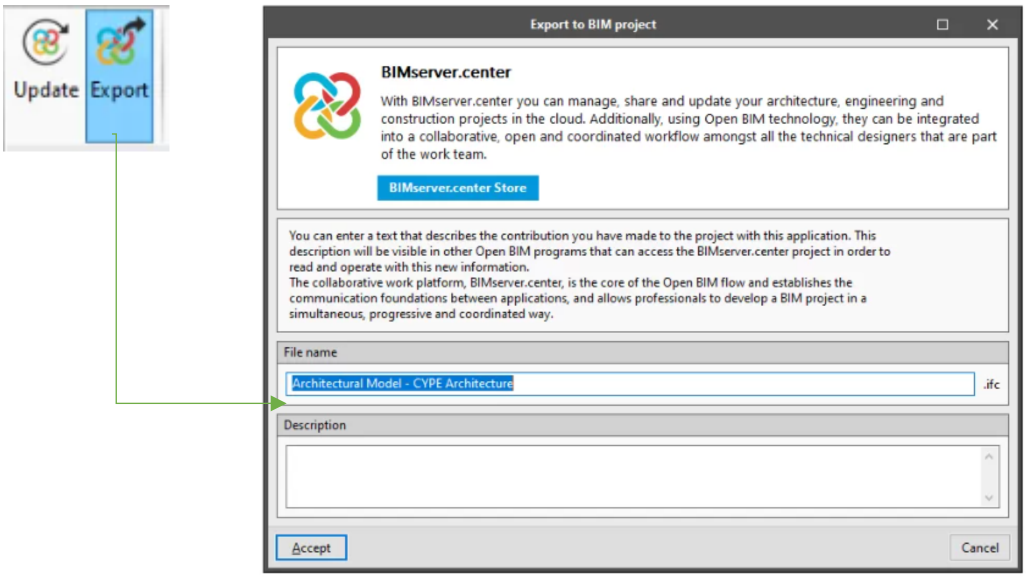


Figure 37. Exportation in CYPE Architecture

For the construction systems, analytical model, and MEP model (only when the architectural model was developed using CYPE Architecture), the exported IFC from the previous software should be imported into each specific software (such as Open BIM Construction Systems, Open BIM Analytical Model). This importation process occurs automatically when initiating the use of the software and creating a new model (Figure 40).

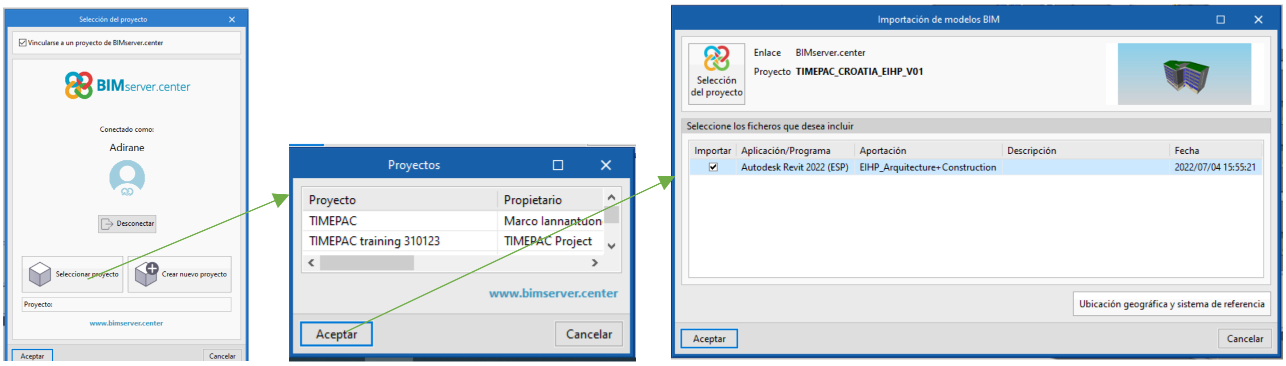


Figure 38. BIMserver.center importation workflow

Multiple experts can simultaneously work with different tools, and all their work will be synchronized with the BIMserver.center using the exportation button. At any point of the project, if one of the experts needs to download modifications made in any other model from the same project, they can update the model using the "Actualize" importation button (Figure 41).

Figure 39. Importation/Exportation buttons in CYPE software

Ultimately, all the information will be stored together within the BIMserver.center (Figure 42). This consolidated data from different models can be imported at any time into any CYPE tool.

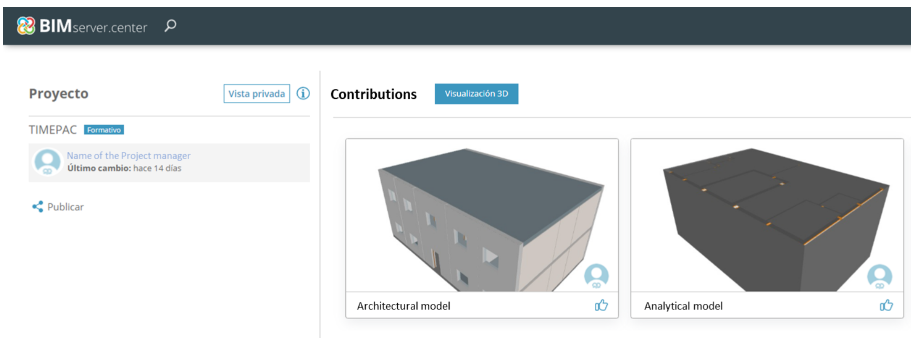


Figure 40. BIMserver.center cloud storage of different models of the same project

IFC exchange using IFC Builder and CYPECAD MEP

IFC Builder is a free application developed by CYPE for creating and maintaining IFC models of buildings. It allows the introduction of construction and structural elements of the building, depending on the type of calculation to be performed. Modelling is conducted via plans in a 2D working environment, utilizing parametric 3D elements.

When generating a new project, it is possible to import a BIM model in IFC format generated by other programmes such as REVIT (using IFC format for importing Revit model). This feature enables access to data from applications using BIM technology within IFC Builder, allowing for the automatic introduction of construction elements of the building.

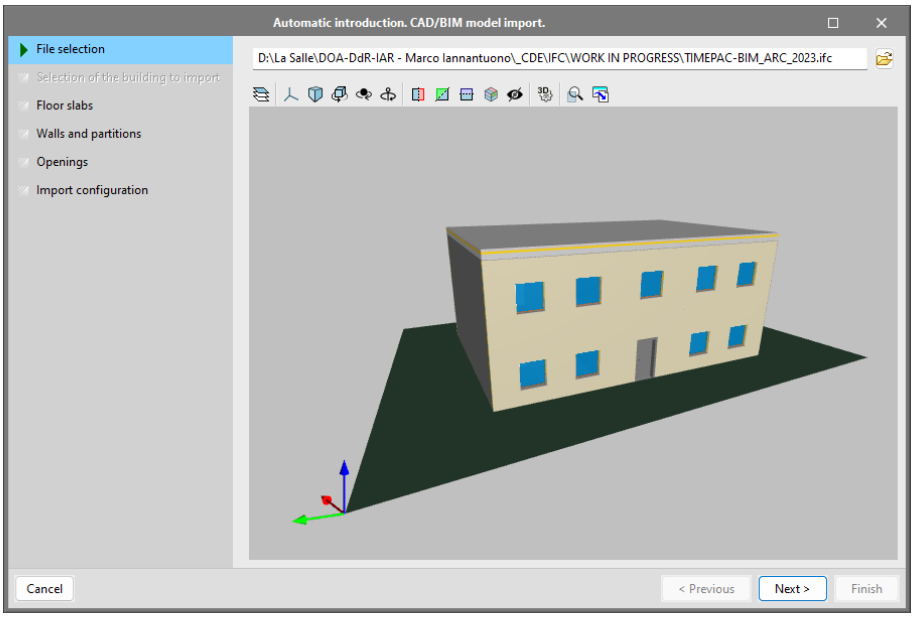


Figure 41. IFC automatic introduction in IFC Builder

The first step is to verify and associate the correct type and function of the construction elements, correcting any errors as necessary. For instance, when importing an IFC model generated by REVIT into IFC Builder, a foundation slab in contact with the ground may be mistakenly recognized as an internal floor slab. In such cases, using IFC Builder allows for the association of the correct function of the element, such as "screed".

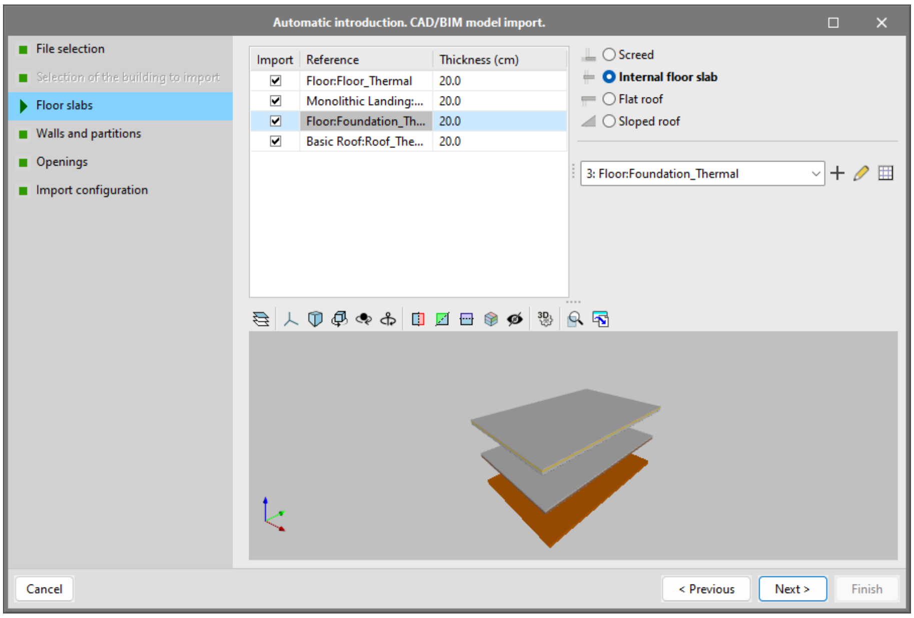


Figure 42. Definition of the construction elements in IFC Builder

The building elements used to model the building in IFC Builder are:

Horizontal elements (Floor slabs)	• Screed • Internal floor slab • Flat roof • Sloped roof
Vertical elements (Walls and partitions)	• External wall • Partitions • Basement wall • Virtual partition • Defences
Openings	• Door • Window or glazed opening

The next step is to generate the building floors, upon which building elements will be modelled or adjusted, and spaces and climate zones assigned. Users have the option to utilize the assigned levels from the original IFC file or modify them according to their preferences.

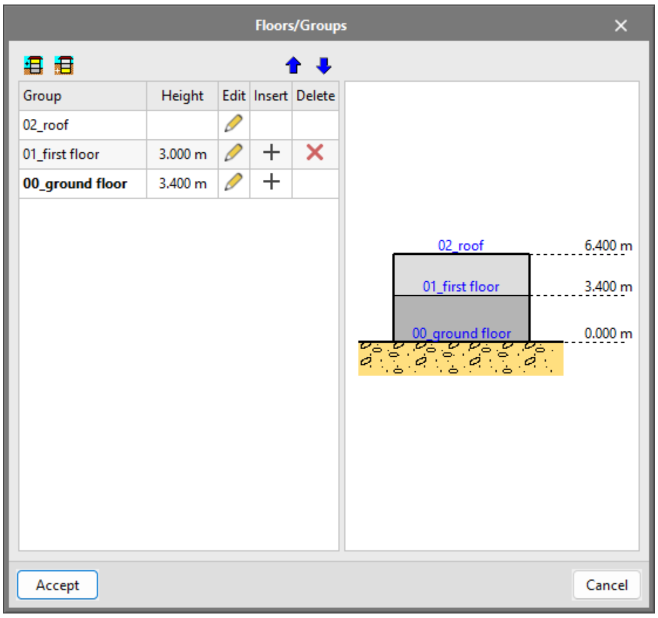


Figure 43. Definition of floors in IFC Builder

After making necessary modifications to the original IFC model and verifying the correct function of the model, the definition of spaces can start. A space represents the subdivision of an area based on construction elements such as walls, floors, roofs, and ceilings—whether physical or virtual. This initial grouping, organized by type, allows for the unified definition of air conditioning and lighting characteristics for all spaces belonging to the same type within simulation tools.

Once the definition of building spaces is completed, the division into thermal zones is established. Thermal zones represent a grouping of spaces based on the system and setpoints that characterize them, as explained in the analytical model chapter.

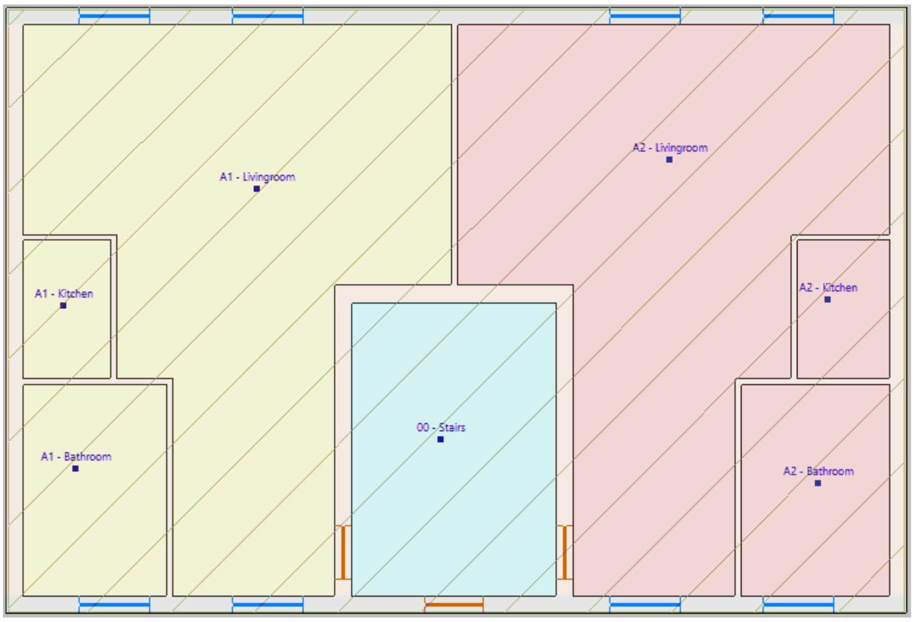


Figure 44. Definition of spaces and zones in IFC Builder

At this stage, the validated IFC model in IFC builder is ready to be uploaded to BIMserver.center, following the instructions outlined in the previous chapter. This enables interoperability with other CYPE simulation tools.

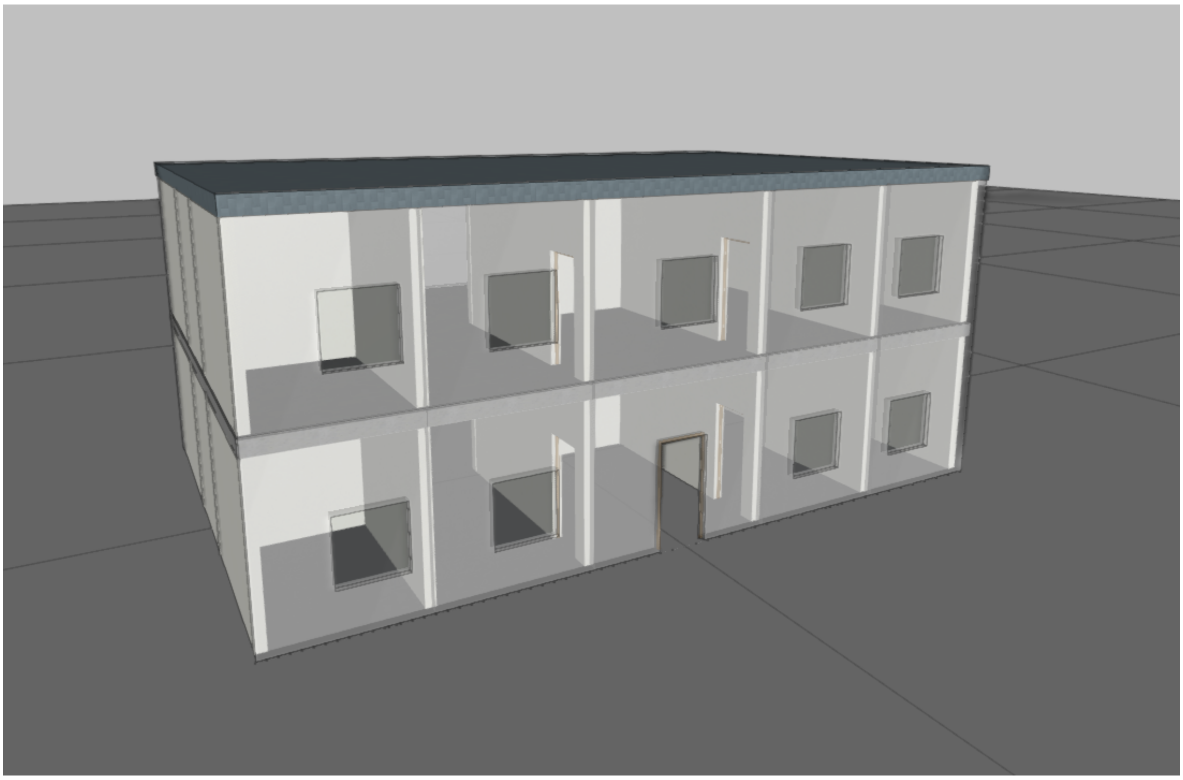


Figure 45. IFC model in IFC Builder

3.3 IFC Validation

Validating an IFC file exported from REVIT or other BIM authoring tools can be a complex process. Different methods of exporting and exchanging IFC files exist, and each software may vary in how it maps the data. Therefore, it is essential to validate this data before proceeding with the import into a simulation tool.

Here are general steps that can be followed to validate the IFC file using an IFC viewer:

Select an IFC viewer:

Choose a suitable IFC viewer that supports the latest version of IFC and can correctly read all the classes, types, and Model View Definitions (MVDs). There are various IFC viewers available, ranging from free, open-source software to more advanced, commercial applications. Examples include Autodesk Navisworks, Solibri Model Checker, BIM Vision, Tekla BIMsight, and usBIM.viewer from ACCA.

Open the IFC file:

Open the IFC file exported from REVIT or another BIM authoring tool in the IFC viewer. Ensure that the file includes all the required disciplines and is saved in the correct format.

For complex models, disciplines may be divided into multiple files such as Architectural, Structural, MEP, etc. In such cases, there will be separate IFC models for each AEC domain.

As a minimum requirement for the use of IFC for energy simulations, the model must include all architectural elements with descriptions of materials, as well as spaces and zones.

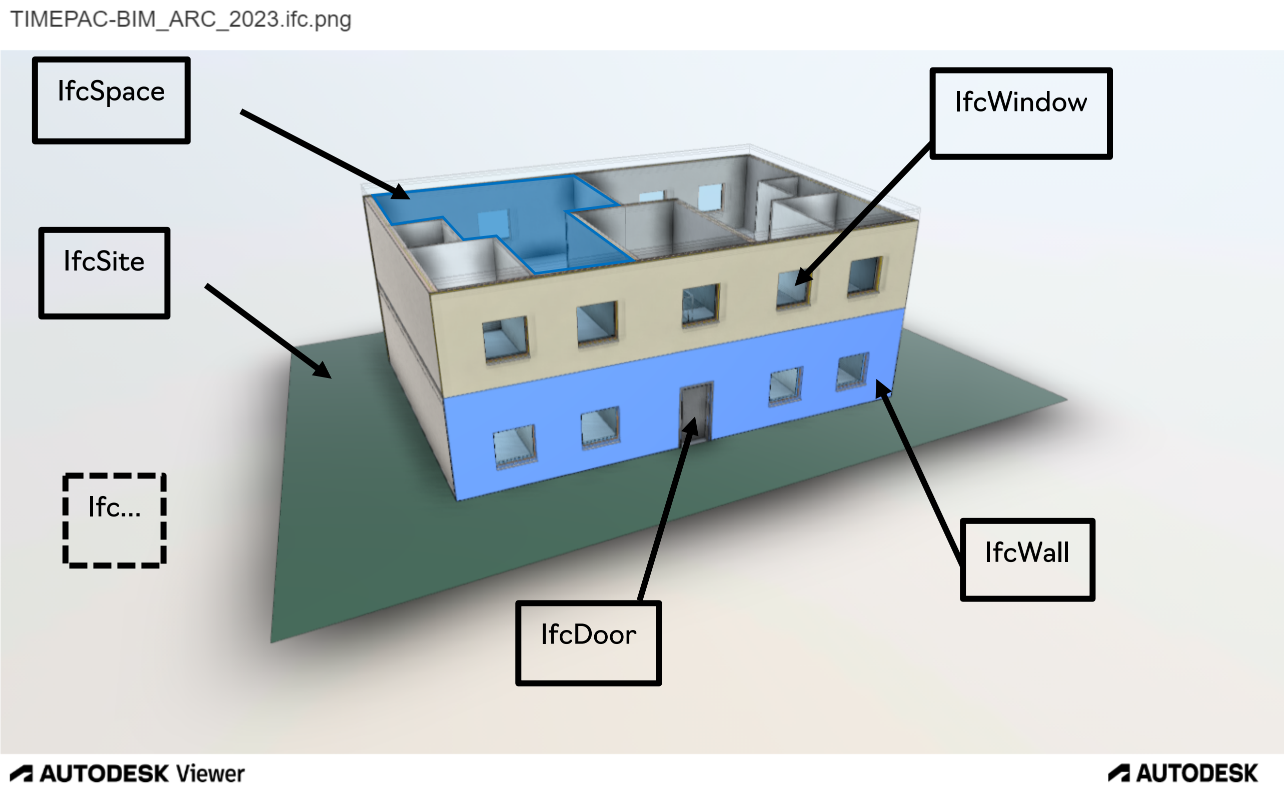


Figure 46. View of the IFC Architectural model with AUTODESK Viewer

TIMEPAC-BIM_MEP_2023.ifc.png

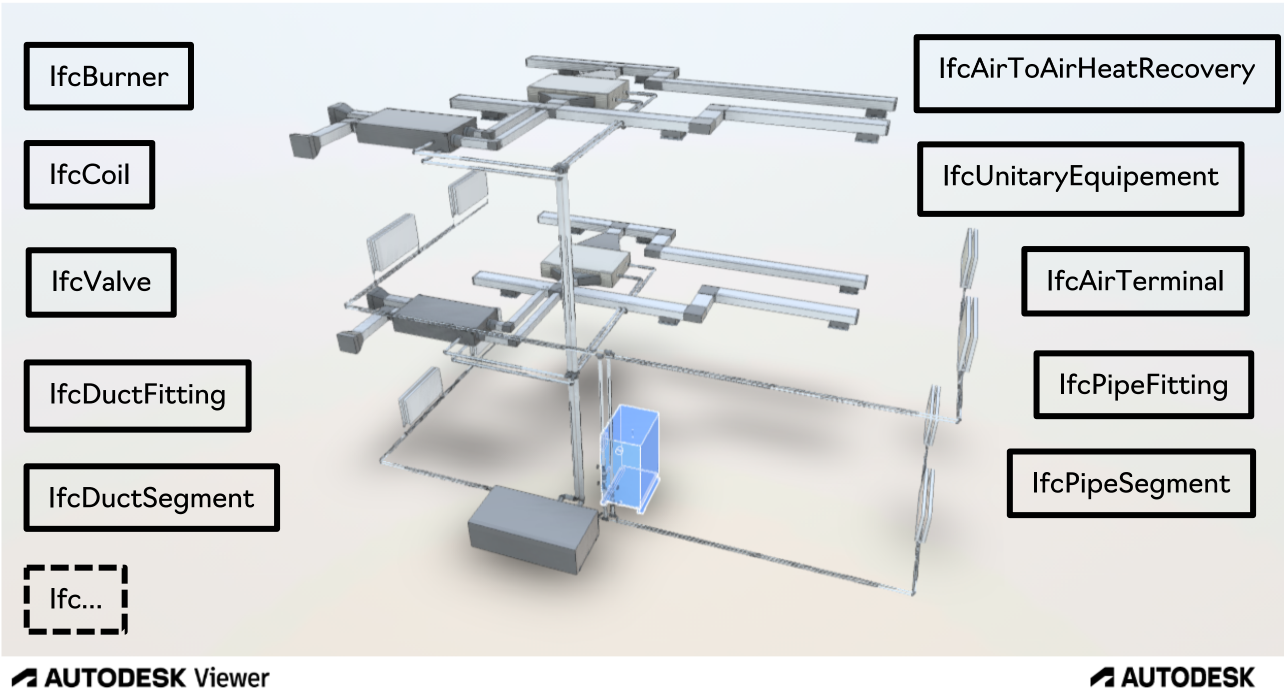


Figure 47. View of the IFC MEP model with AUTODESK Viewer

When we open an IFC file in a viewer, it becomes apparent that the data is organized in a hierarchical structure. This hierarchy encompasses five levels:

- **Project Level**: At the top of the hierarchy is the project level. Here, information regarding the overarching project, including its name, description, and location, is stored. Additionally, details about key stakeholders involved in the project, such as the owner, architect, and contractor, are included.
- **Site Level:** Following the project level is the site level, representing the designated area of land for project construction. This level encompasses various construction activities, such as building erection, retrofitting, or demolition. It may also include precise geographic coordinates using the World Geodetic System (WGS), specifying longitude, latitude, and elevation.
- **Building Level:** Moving down the hierarchy, we encounter the building level. This tier encompasses comprehensive data about the entire building structure, including its dimensions, shape, and geographical position. Furthermore, it encompasses information regarding structural elements like walls, floors, and roofs.
- **Storey Level:** Progressing further, we reach the storey level, which pertains to individual floors or storeys within the building. Here, details such as storey height, elevation, and positioning are recorded. Additionally, structural components specific to each storey, such as columns, beams, and slabs, are documented.
- **Space Level:** Finally, at the lowest level of the hierarchy lies the space level. This tier encompasses information about individual spaces or rooms within the building, including their dimensions, intended functions, and occupancy details. Moreover, it includes data about interior components like doors, windows, and furniture.

At each level of the hierarchy, there exist relationships known as "aggregation" and "composition" that connect it to the levels above and below. For instance, a building aggregates its storeys, while a storey composes its spaces. This hierarchical structure facilitates the organization and accessibility of data within an IFC file in a logical and efficient manner.

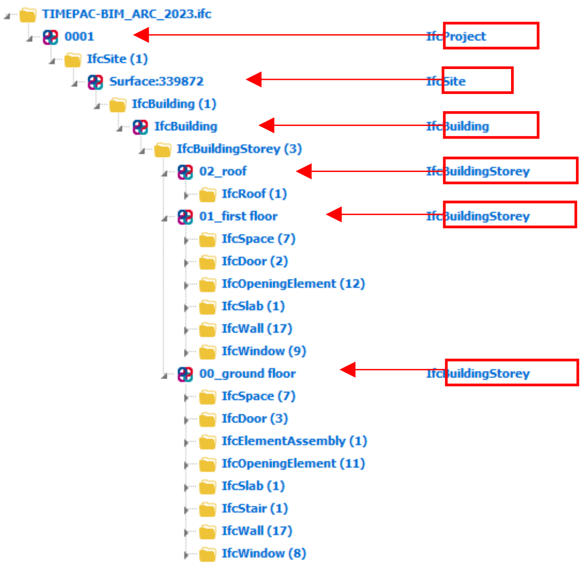


Figure 48. IFC hierarchy of the IFC Architectural model

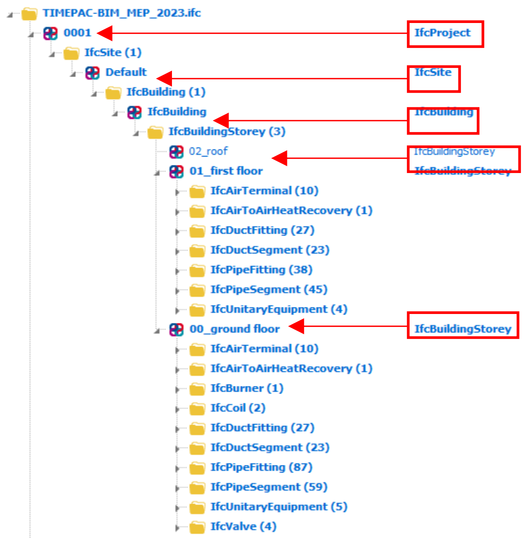


Figure 49. IFC hierarchy of the IFC MEP model

Check for errors:

The IFC viewer can identify errors present in the IFC file, including missing data, incorrect formatting, or conflicts between disciplines. If any errors are detected, it is advisable to rectify them in the REVIT model and re-export the IFC file. Alternatively, adjustments can be made directly within the IFC file, although this approach may introduce additional errors.

Check for data completeness:

Ensure that all required data is included in the IFC file. This encompasses essential information such as building geometry, analytical models, MEP systems, and other relevant data.

You can reference the minimum information requirements for each discipline in the corresponding chapters of the guidelines.

Check for accuracy:

Validate the accuracy of the IFC file by conducting a thorough comparison between the building geometry, analytical models, and MEP systems within the IFC file and those present in the original REVIT model or any other BIM authoring tool. Ensure that all elements are correctly aligned and that the dimensions correspond accurately to the design specifications.

Verify that the IFC file can be used for EPC assessment:

Confirm that the IFC file is suitable for its intended purpose by verifying the inclusion of all required disciplines and ensuring that the data contained within is both complete and accurate.

Save the validated IFC file:

Save the validated IFC file with a new name or version number to preserve the original IFC file in its unaltered state.

3.4 IFC Importation in EPC Tools

Importing IFC files into EPC tools facilitates the transfer of BIM data from the design and construction phases to the energy analysis phase, enabling accurate modelling and simulation of the building's energy performance. Here are key considerations to bear in mind during this process:

- **Compatibility**: Ensure the EPC tool supports IFC importation and verify compatibility between the IFC file's version and the software tool.
- **Data Validation:** Utilize the EPC tool's validation step, if available, to compare imported IFC data against predefined rules, ensuring consistency and accuracy.
- **IFC Mapping:** Employ an IFC mapping process within the EPC tool to translate objects from different BIM authoring tools to their internal representation, accounting for varied naming conventions.
- **IFC Model Viewing:** Utilize the EPC tool's model viewing feature post-importation, if available, to inspect the IFC model and its elements. Verify completeness and accuracy and identify any necessary additional data.

3.4.1 CYPETHERM HE Plus

CYPETHERM HE Plus is specialized software designed for generating energy performance certifications for buildings in compliance with Spanish regulations, specifically CTE DB HE 0, HE 1, and HE 4. It accomplishes this through energy simulations conducted with EnergyPlus. Additionally, there exist versions of CYPETHERM tailored for developing Energy Performance Certificates (EPCs) for France, Portugal, and Morocco.

This application seamlessly integrates into the CYPE software workflow using the IFC standard. It relies on connectivity with BIMserver.center to facilitate project management, sharing, and updates in the cloud. For detailed guidance on information exchange utilizing BIMserver.center, refer to the "IFC exchange using CYPE software workflow" chapter.

This workflow streamlines the exchange of essential 3D model data necessary for energy simulation and EPC generation. It includes crucial elements such as envelope geometry, spaces, and zones. By exchanging information already developed in earlier stages of the building project and leveraging various software tools, this workflow enhances efficiency and accuracy in energy performance assessment and certification processes.

New project creation and IFC import:

To initiate a new project in CYPETHERM HE Plus, ensure you are connected to BIMserver.center. Click on the "New project" button, prompting a pop-up window to appear. Within this window, you can designate a name and location for the new file, along with an optional description (Figure 52).

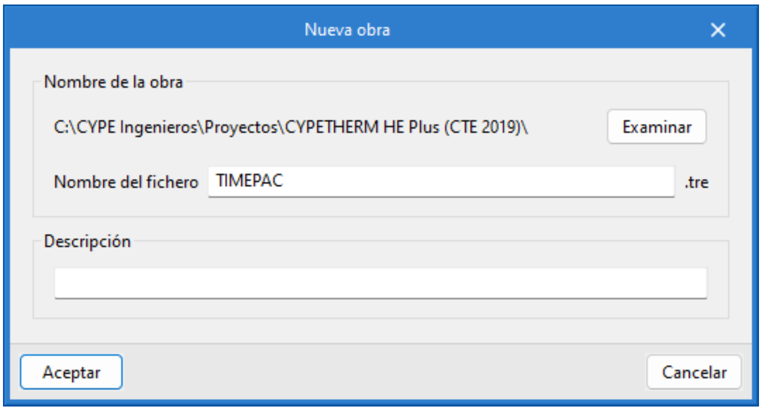


Figure 50. New project creation in CYPETHERM HE

Following the setup of the project in CYPETHERM HE Plus, the BIMserver.center window will open (Figure 53). Here, you can select the project containing the 3D geometric model of the building.

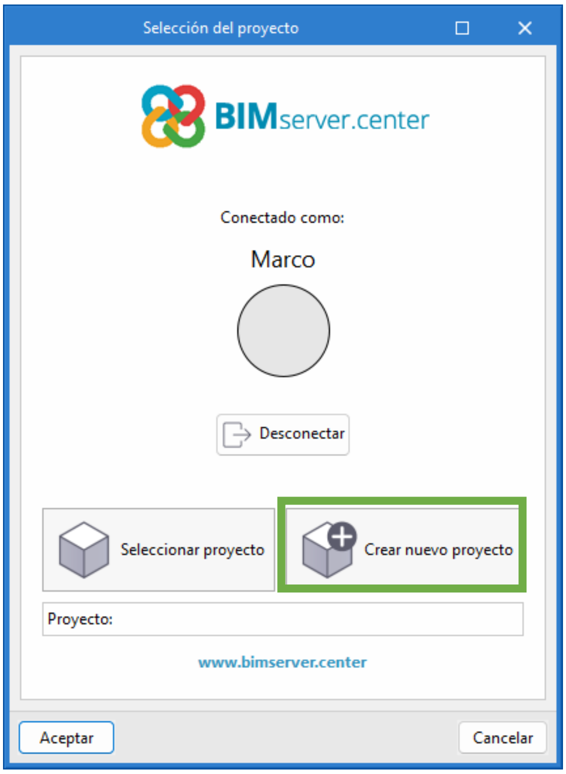


Figure 51. Project selection in BIMserver.center

CYPETHERM HE can import geometric models created with various 3D modelling software capable of exporting IFC4 files. One such software is CYPE IFC Builder, which is detailed in the sub-chapter "IFC exchange using IFC Builder". Additionally, files from CYPECAD MEP can be imported, containing not only the geometric model of the building but also definitions of construction elements, the building envelope, and HVAC systems.

For cases where the analytical model is not included, it's necessary to develop it beforehand using Open BIM Analytical Model software. This ensures the accurate representation of the building's energy performance characteristics.

After selecting the project in the BIMserver.center window, you will encounter the BIM model import panel (Figure 54).

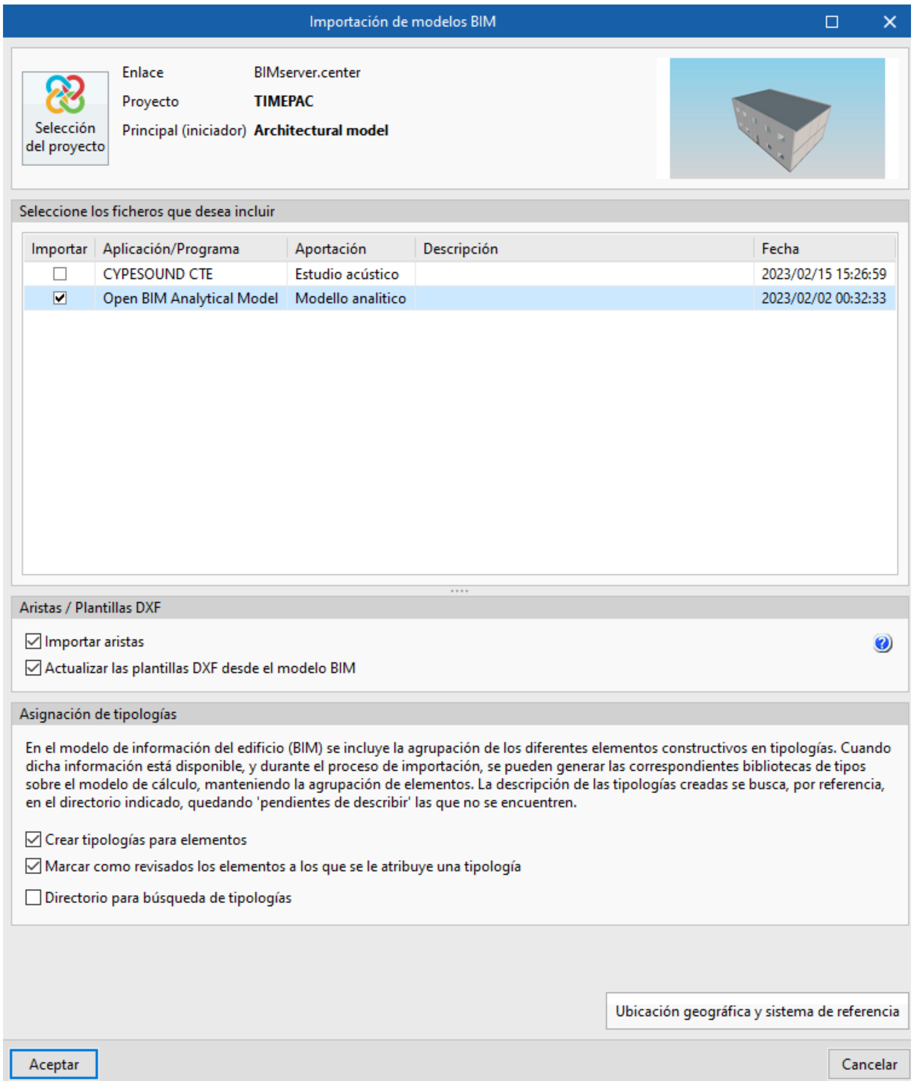


Figure 52. Model import from BIMserver.center to CYPETHERM HE PLus

Through this process, an energy model linked to the 3D model is imported into CYPETHERM HE. This enables synchronization of the calculation model with any changes made to the 3D model on BIMserver.center. Upon completion, a message indicating "Import completed" will appear upon accepting the previous window (Figure 55).

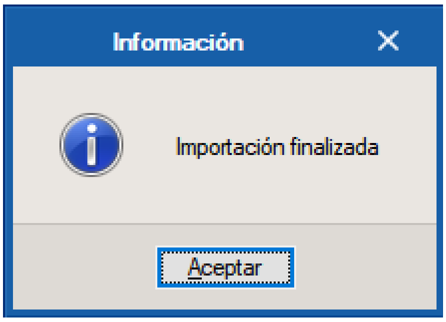


Figure 53. Import complete from BIMserver.center

Finally, you will reach the main interface of the application (Figure 56), where you will introduce all the necessary definitions for environmental conditions, geolocation, building elements, zones, and systems.

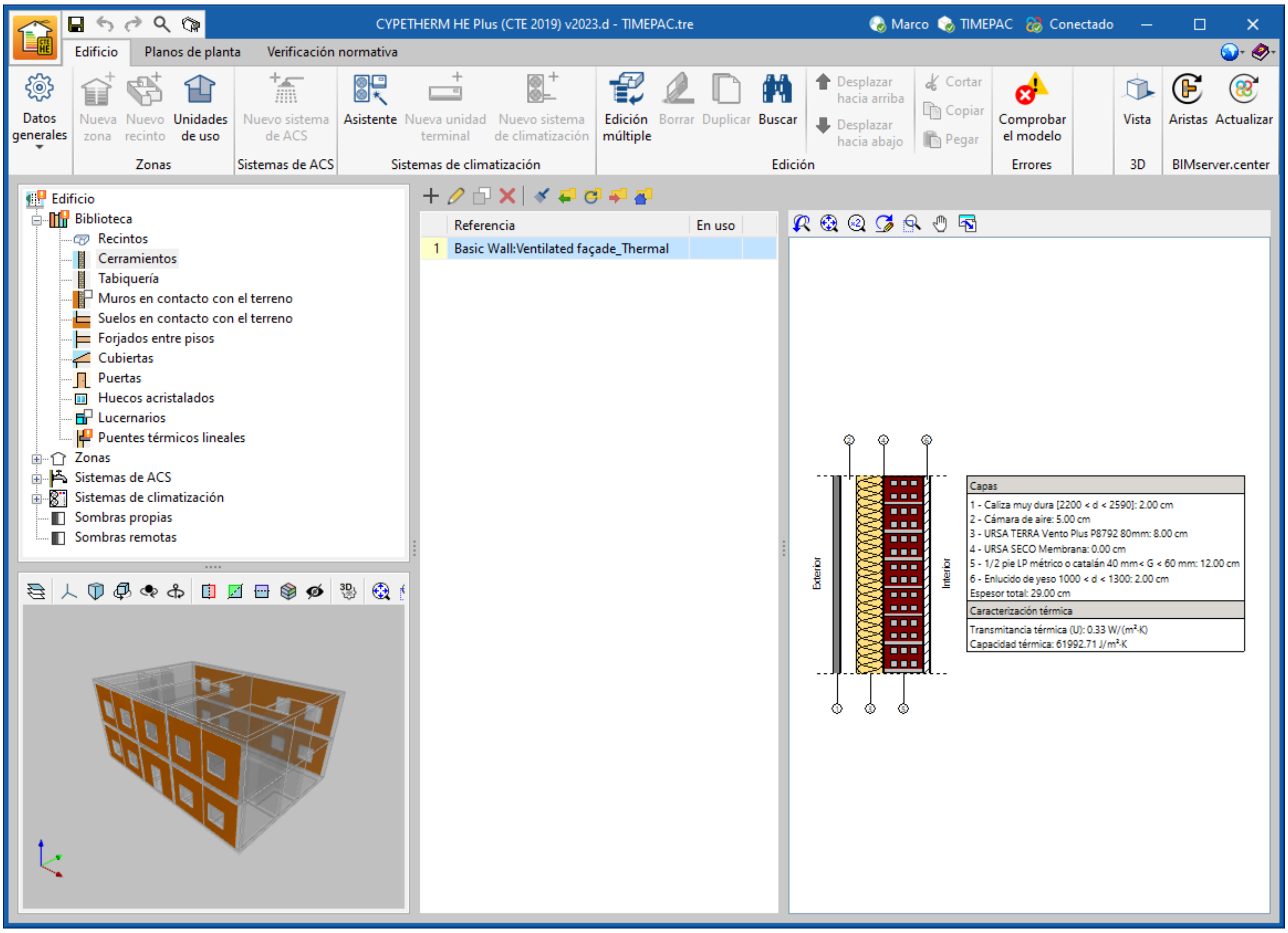


Figure 54. CYPETHER HE Plus user interface

To initiate the simulation and EPC generation from the BIM data, you can proceed with defining the general data, constructive elements, envelope, and thermal bridges within the project's library. Follow all necessary steps to complete the energy model of the building, which has been imported from the BIM model.

3.4.2 EC700 (EDILCLIMA)

EC700, the foundational software module of EDILCIMA, calculates buildings' energy efficiency in accordance with the UNI/TS 11300 technical specification (issued by UNI, the Italian National Unification). It considers all services outlined in the UNI/TS 11300-5 technical specification, including heating, cooling, domestic hot water, ventilation, energy requirements for escalators and elevators, and lighting.

In particular, it facilitates the following calculations:

- Dynamic hourly assessment of building energy performance in accordance with the European standard UNI EN ISO 52016-1.

- Determination of heat load for sizing heating systems (following EN 12831), as well as assessment of heating and cooling requirements to evaluate the energy efficiency of the building envelope (in compliance with UNI/TS 11300-1), and primary energy for cooling (as per UNI/TS 11300-3).
- Incorporation of contributions from renewable sources (such as thermal solar, photovoltaic, biomass) as outlined in UNI/TS 11300-4.
- Estimation of the level of automation of building control systems (Building Automation and Control Systems - BACS) for each energy service, following the calculation method specified in UNI EN 15232. This includes the capability to determine the achieved primary energy savings after implementing improvements.

The software enables experts to work within the BIM environment by importing IFC files.

Project configuration:

To configure the project in EC700 the steps to follow, before importing the IFC file, are:

1. **General project data**, including the building's name and address, as well as the calculation method used for energy simulations (Figure 57) and the description of the type of the building (Figure 58).

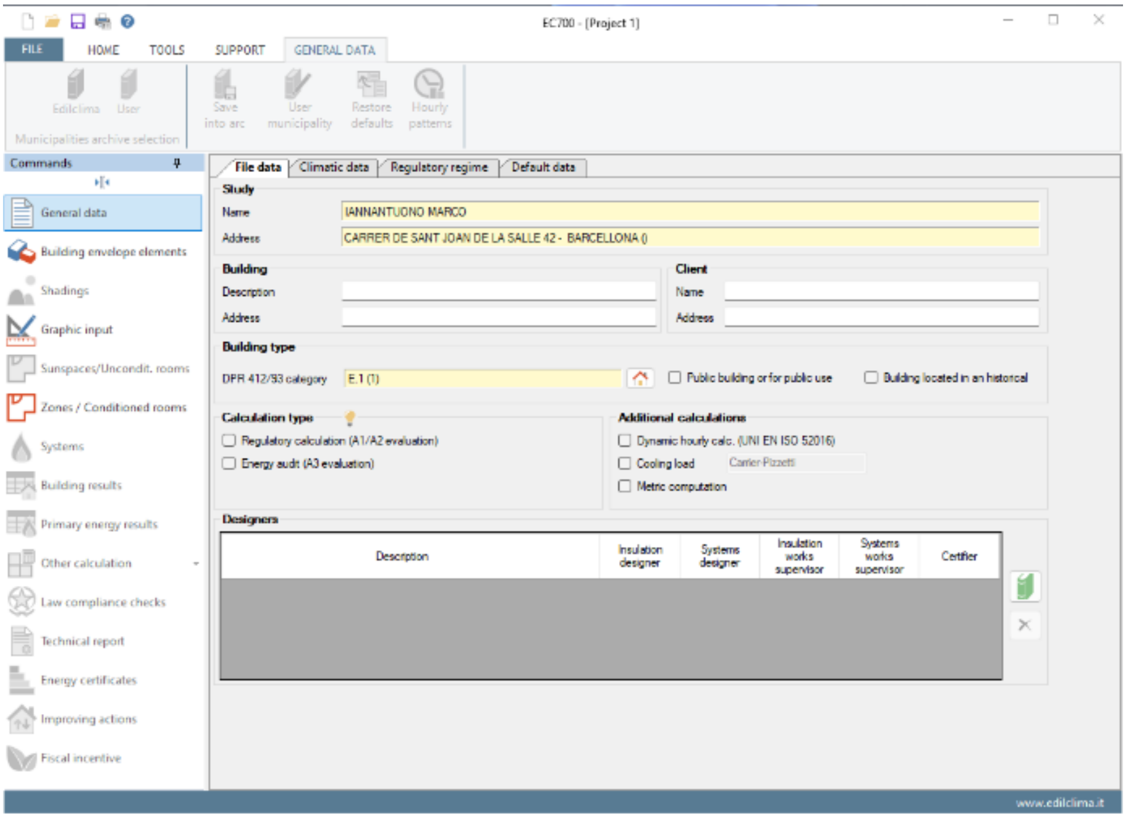


Figure 55. General project data configuration in EC700

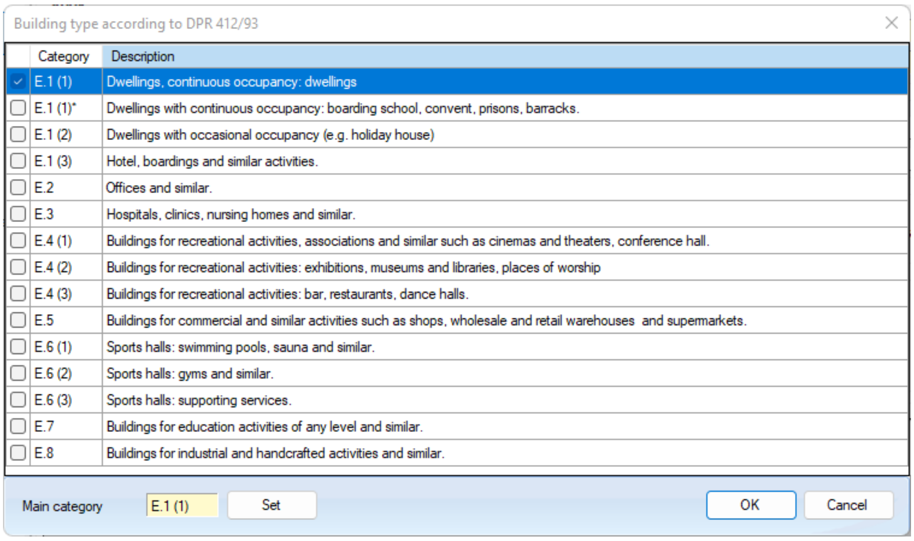


Figure 56. Building type configuration in EC700

2. **Geographical data**, including Municipality, Italian Province, coordinates and orientation (Figure 59). Upon entering this data is entered, the programme automatically sets the climatic data for the selected zone, including hourly data and external temperature, etc. (Figure 60).

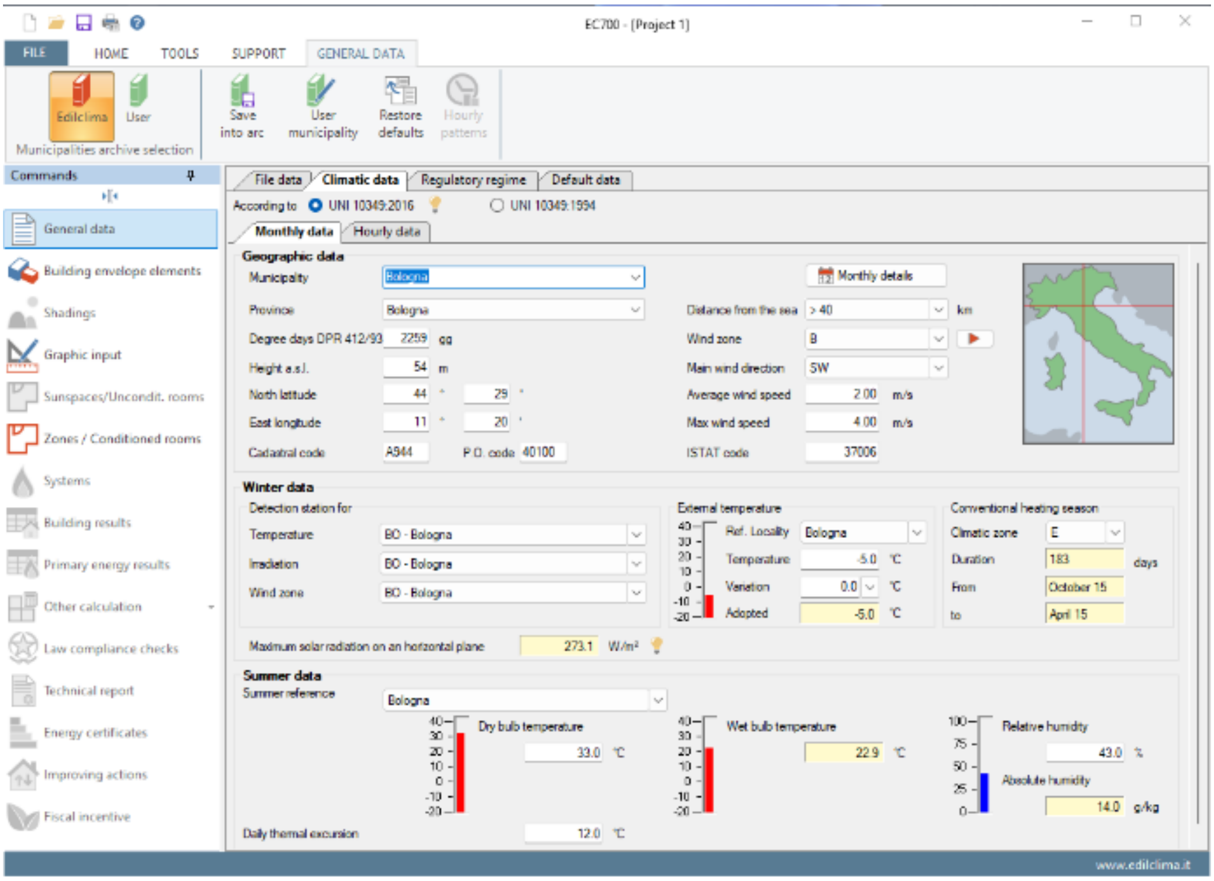


Figure 57. Geographical data configuration in EC700

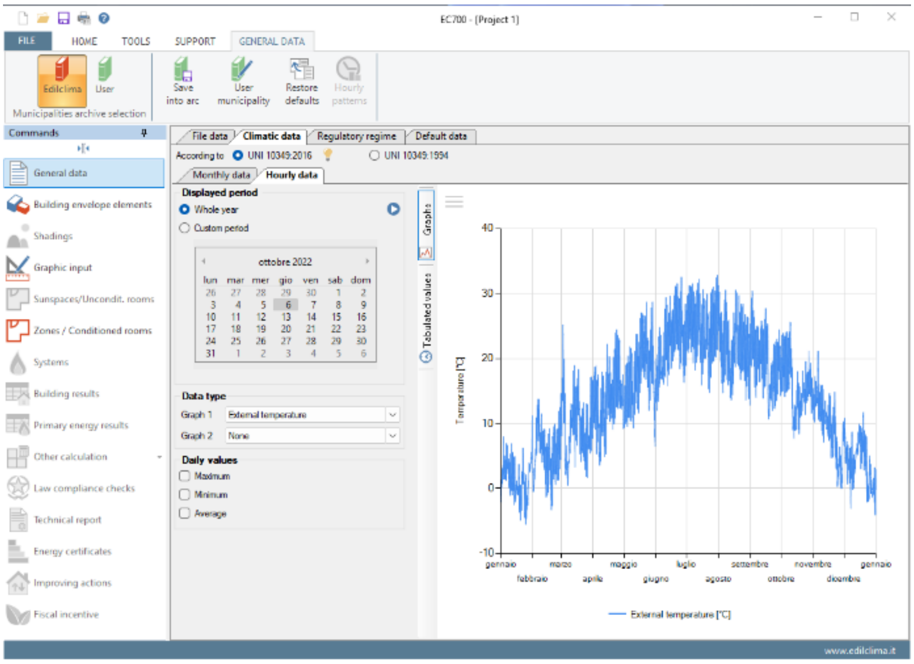


Figure 58. Example of hourly data graph in EC700

This data cannot be directly imported into the software via an IFC file. However, with an IFC file containing the general project and geographical data, it is possible to use an IFC visualization software to obtain the necessary information and then enter it into the software.

After completing these two mandatory steps, it becomes possible to:

- Configure information related to the “regulatory regime”, including details on “law compliance checks and technical reports”, and information regarding “energy certificates regulation”.
- Configure and modify “default data”, such as internal temperatures, air exchange factors, etc.

IFC import:

To ensure a correct import into EC700 of the IFC file, a model containing all the dispersing structures of the building with their characterized stratigraphy must be generated from the BIM software. Thermal spaces should be inserted to allow EDILCIMA to accurately identify all zones and the structures delineating them.

The import of the IFC file into EC700 occurs following the configuration of the general project data. During this step, it is possible to configure the building envelope and to specify the spaces and zones.

Within the home section, there is the “Load IFC” tab, which facilitates the selection of the .ifc format for importation into EC700.

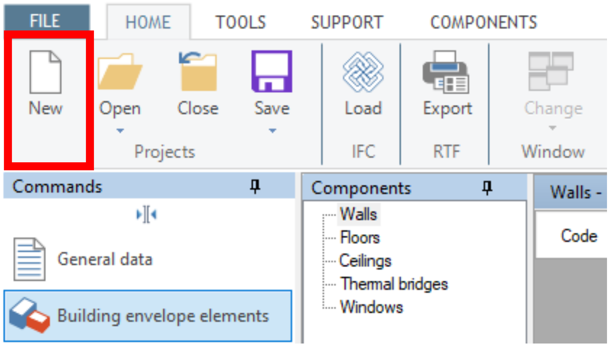


Figure 59. IFC Load in EC700

Once the file is selected and the import is complete, a configuration wizard will open, guiding the user through linking the materials and layers of the IFC file with materials in the EDILCIMA database. This process involves associating the IFC layers (IfcMaterialLayer) with the materials in the EDILCIMA library, along with their thermal characteristics such as conductivity, specific heat, density, etc. (Figure 62).

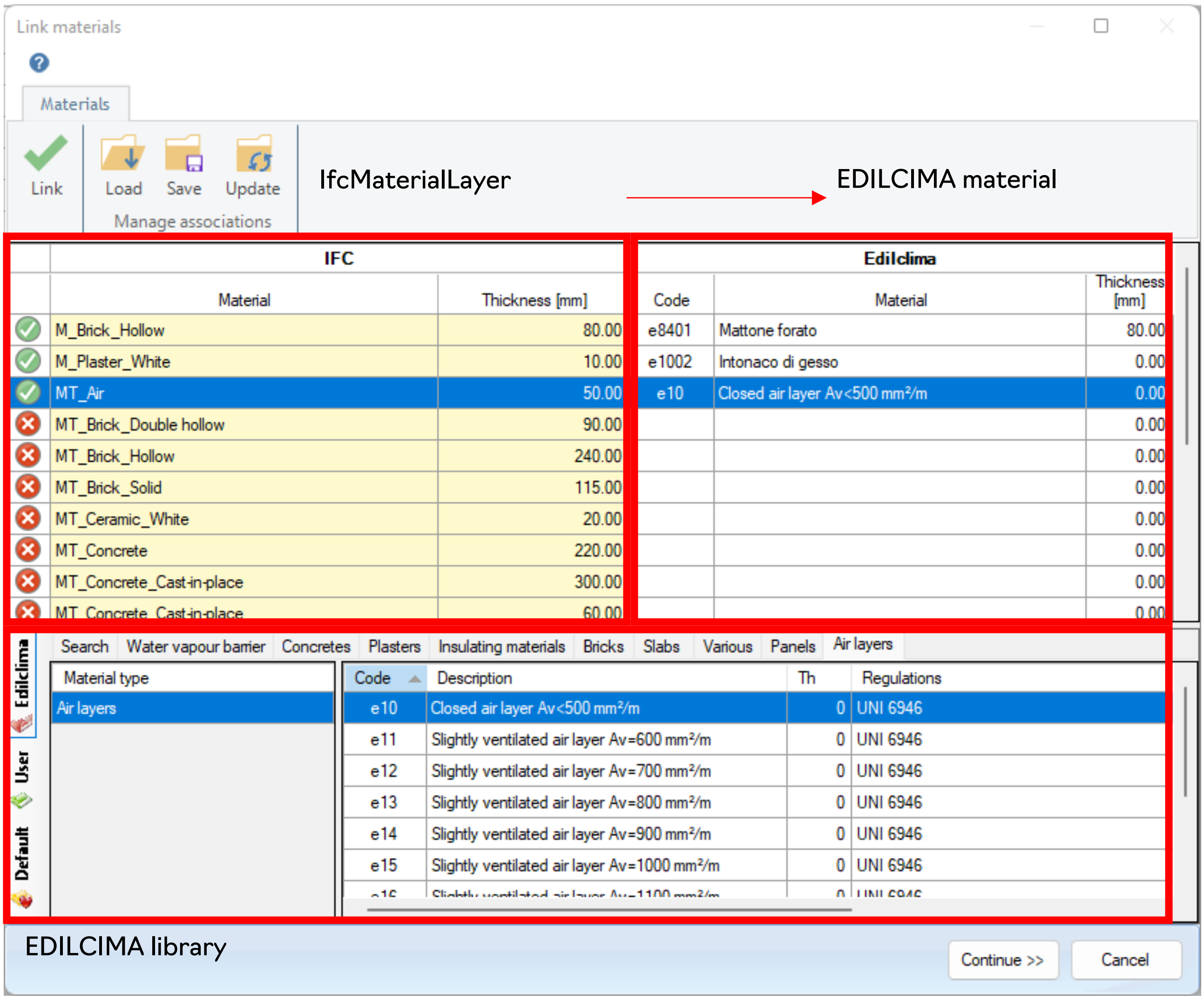


Figure 60. Linking materials between IFC and EDILCIMA

It is crucial to ensure that the names of materials are correctly configured, initially in REVIT and then in the IFC file, to enable accurate identification for association with EDILCIMA. The software does not categorize materials by construction element, underscoring the importance of distinguishing materials belonging to different elements by their names. For instance, a material labelled "Insulation" might pertain to either wall or roof insulation, each having distinct physical and thermal characteristics. Therefore, it is advisable to name the layers descriptively, such as "wall_insulation" and "roof_insulation"

If the thickness of the selected layer from the EDILCIMA library differs from the thickness of the material contained in the IFC file, a warning is displayed, indicating that the thickness used for the calculation will be the one described in the IFC file (Figure 63).

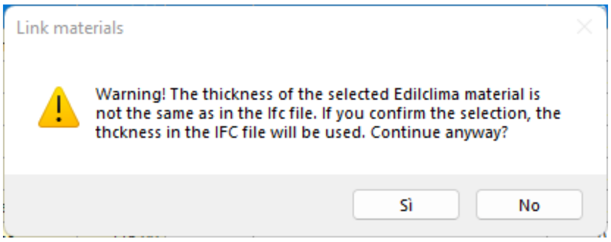


Figure 61. Warning during linking materials in EC700

To finalize the import process of the IFC, it is necessary to configure the linked spaces and zones. The characteristics of the room, such as the type (conditioned, unconditioned, sunspace), will be defined, and the thermal zones to which the rooms will be associated will be organized (Figure 64).

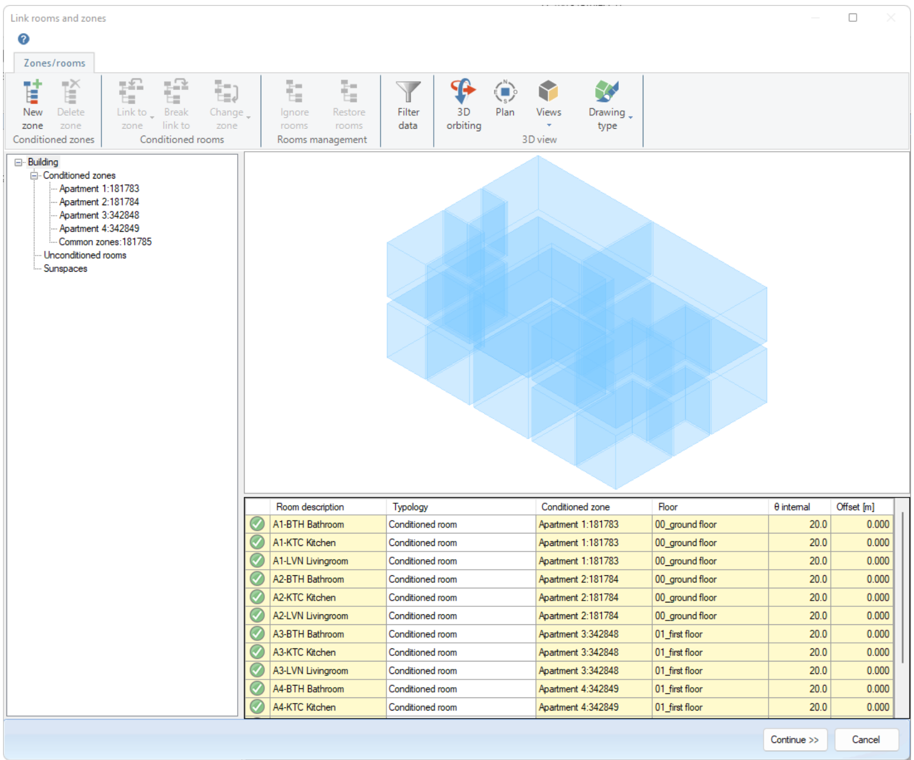


Figure 62. Linking rooms and zones in EC700

Through the guided wizard, users can view and, if necessary, modify the definition of spaces and their grouping into zones that have been previously configured in REVIT. For further details regarding the proper export of zones, readers can refer to the chapter about exportation.

Once the IFC model has been imported into EC700, it can be viewed using the "Graphic Input" function (Figure 65).

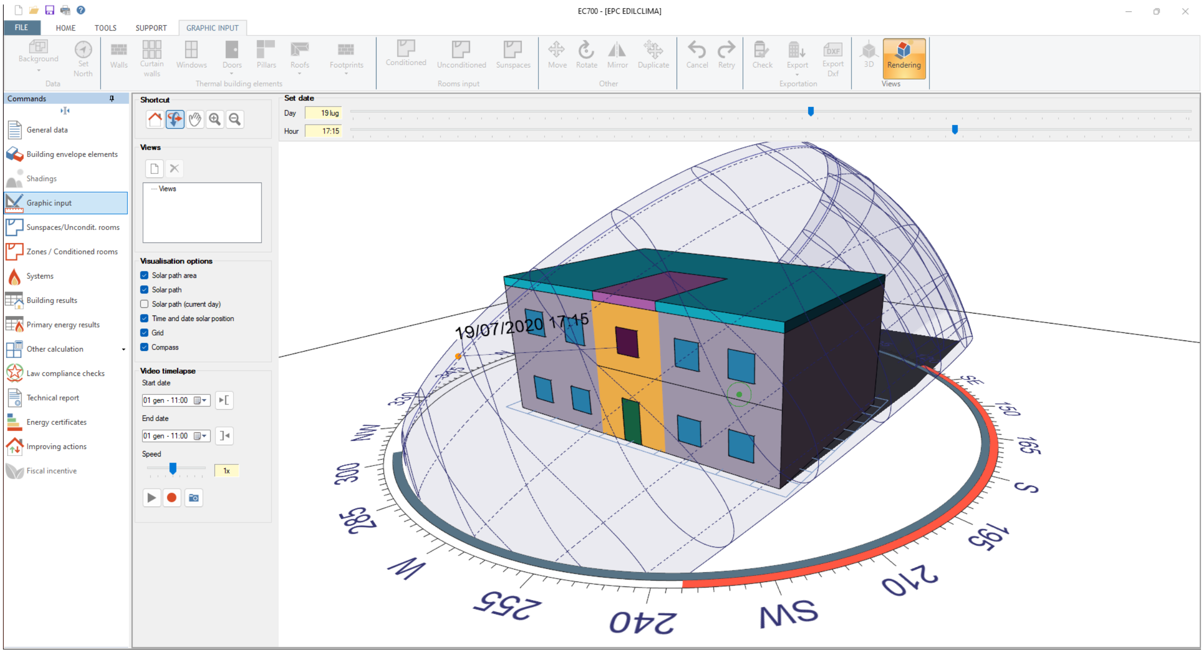


Figure 63. Graphic input in EC700

An additional step is required to transfer space and zone data into EC700: adding information about ventilation, lighting, and temperatures for each space. To accomplish this, select a space and open its data using the dedicated command (Figure 66).

Figure 64. Space data

As described, the IFC model has been imported into EC700, and it is possible to view it in the Graphic Input. From this interface, the Export command is displayed, enabling users to perform a complete export or select specific zones to import into the program (Figure 67).

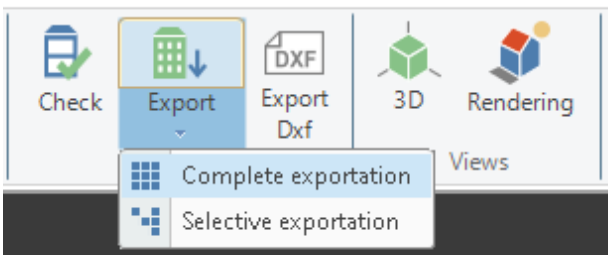


Figure 65. Zone exportation via Graphic Input in EC700

Finally, in the Zones/Conditioned rooms command, users can observe the organization of the zones (Figure 68). In the adjacent window, the zone summary is displayed, providing the definition of the corresponding surfaces and volumes of each zone (Figure 69).

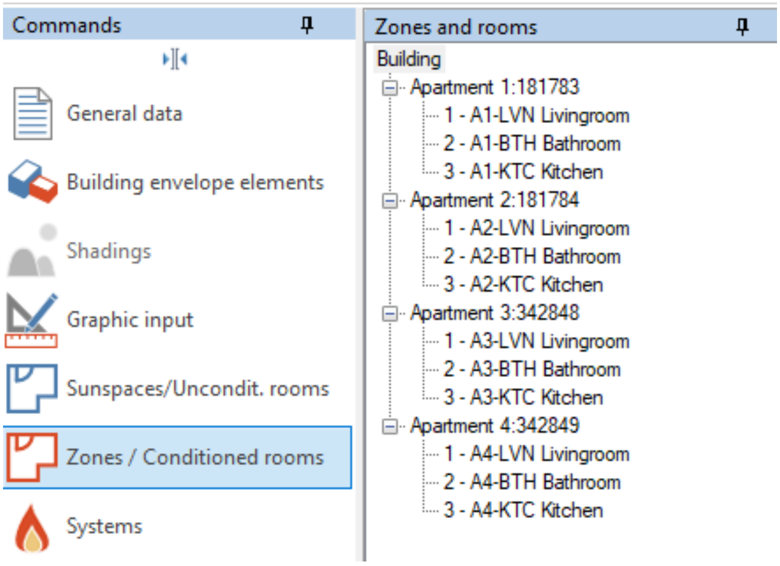
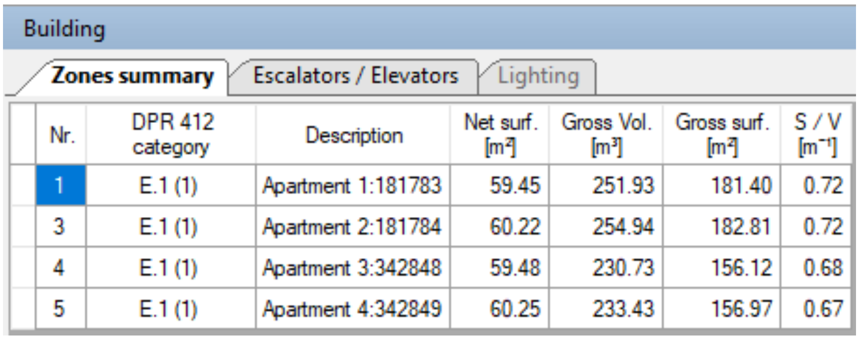


Figure 66. Imported zone data from the IFC in EC700


Building

Zones summary | Escalators / Elevators | Lighting

Nr.	DPR 412 category	Description	Net surf. [m²]	Gross Vol. [m³]	Gross surf. [m²]	S / V [m⁻¹]
1	E.1 (1)	Apartment 1:181783	59.45	251.93	181.40	0.72
3	E.1 (1)	Apartment 2:181784	60.22	254.94	182.81	0.72
4	E.1 (1)	Apartment 3:342848	59.48	230.73	156.12	0.68
5	E.1 (1)	Apartment 4:342849	60.25	233.43	156.97	0.67

Figure 67. Imported zones summary in EC700

Once the process of importing the IFC model and thermal zone data has been completed, it is possible to proceed with defining the other parameters and configuring the systems for the generation of the EPC.

3.4.3 ETU-SOFTWARE

The ETU-Software[1] serves as the EPC generation tool chosen for the Austrian case study of TIMEPAC. Its data model facilitates data exchange with BIM databases via IFC. Drawings from diverse 3D architectural CAD systems are compatible with the ETU geometry model.

HottCAD, an integral component of all ETU 3D software products, is a comprehensive yet user-friendly drawing tool. It allows users to swiftly create a three-dimensional virtual model of their building, enabling precise calculations and simulations using various ETU software tools. The HottCAD

[1] ETU Software GmbH: https://www.etu-software.com/index.html

drawing environment offers numerous drawing wizards and import utilities to incorporate existing drawings, including those in IFC format.

The BIM models intended for import into the ETU software must meet certain additional information requirements to ensure correct importation by the EPC software. **IFC version and MVD**

Due to the complexity of the IFC standard and the multifaceted possibilities of data transfer in this format, specific requirements must be met by an IFC file for correct import and calculation in HottCAD.

The most commonly used IFC standard is version 3, officially designated as "IFC 2x3". IFC files exported to newer specifications can also be imported into HottCAD. However, the possibility of errors cannot be entirely ruled out. Conversely, IFC4 expands the previous standard with new object types, especially in the MEP area, and is equivalent to IFC2x3 for the current status of the import interface.

To ensure correct import into HottCAD, IFC files must always adhere to the "Coordination View 2.0" Model View Definition. This ensures that the components are in a format compatible with HottCAD's requirements for further processing.

Floors/levels

Buildings with a traditional floor structure (basement floor, ground floor, upper floors, roof) are commonly supported. A key requirement for accurate transfer is specifying the height level of each respective storey. Additional information, such as the actual height, can then be derived from the configurations.

Walls

Currently, curved walls or walls with non-parallel side surfaces can only be visually displayed and not calculated within HottCAD. However, potential solutions can be implemented by manually setting multiple corners to approximate the desired shape.

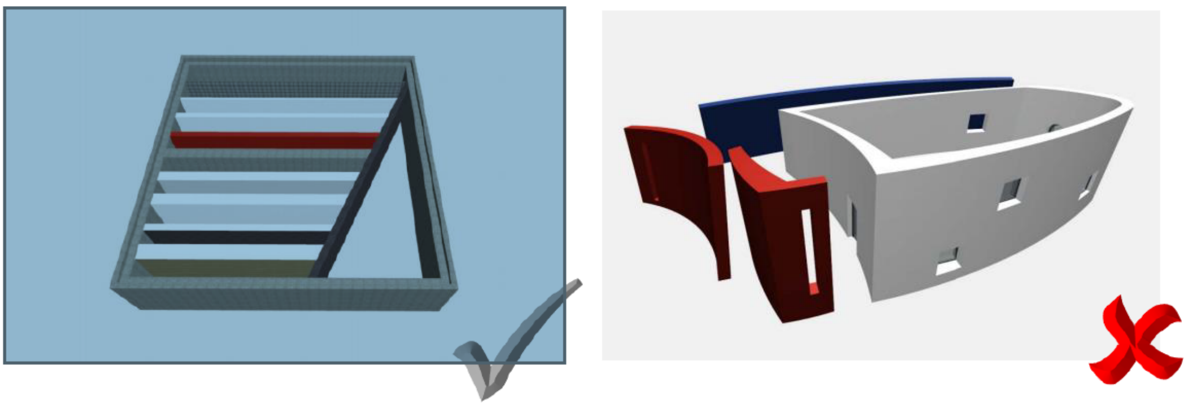


Figure 68. ETU-Software ©

In certain cases, it is possible that after import, the main side of the wall is incorrectly determined (Figure 71). The main side is indicated with a thick black line (1). However, after the IFC import, functions within the Walls workspace are available to correctly align the main face of the wall. Additionally, these functions allow for converting exterior walls to interior walls and vice versa (2).

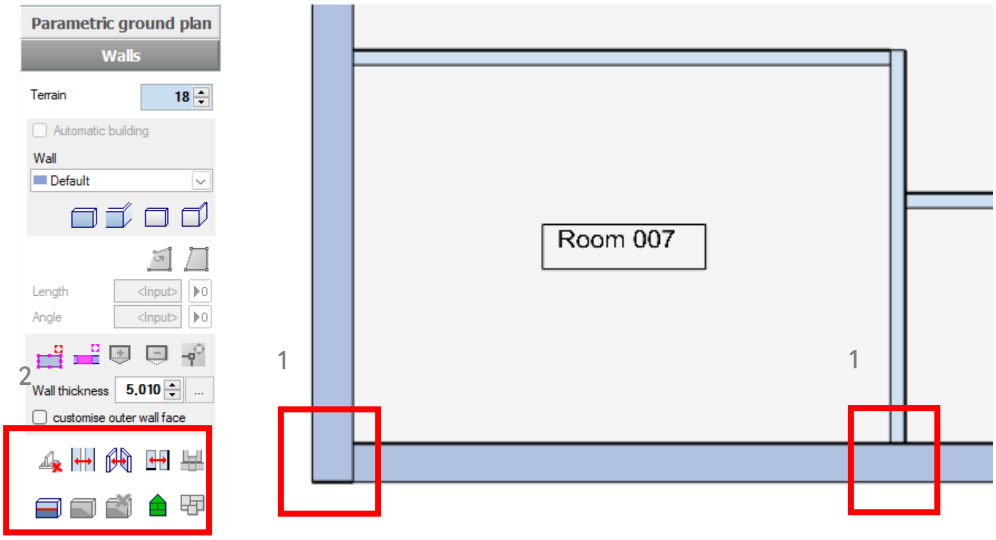


Figure 69. Walls correction in HottCAD

Ceilings and floors:

When adopting storey and intermediate ceilings, as well as floor slabs, it is essential to ensure that both the basic plane (the area visible in 2D) and the thickness of the component are stored as values. The ceiling must always be represented as a straight prism.

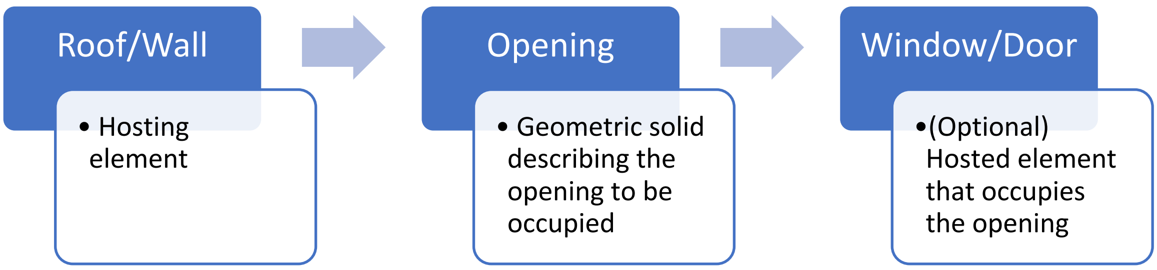
Rooms:

For rooms, the same geometric specifications must be adhered to as for ceilings and floors.

Openings:

In principle, windows and doors can be fully modelled. However, the description of the wall or ceiling opening containing the window is crucial for the correct transfer of the components.

The "object chain" explained in the following diagram must be considered for optimal transfer. Many CAD systems, including ArchiCAD, REVIT, and Allplan, already map the IFC export in this form. From a geometric standpoint, the opening must be in the form of a prismatic solid.



Roofs:

There are no special geometric requirements for roofs. Roofs can be described using both simple and complex prismatic geometries.

No-geometric information exchange:

In addition to the geometrical import of the components, other component properties can be exchanged for the corresponding elements. The decisive factor for energy analysis is primarily the U-value, which can be exchanged for the following component types:

- Walls/Columns
- Roofs
- Floors
- Windows/Doors

No-calculation-relevant component exchange:

Objects that are not relevant to calculation can be exchanged to HottCAD as pure three-dimensional elements. However, it must be noted that importing these components can significantly increase the import time.

The following IFC classes are not currently supported for calculations:

- Stairs and ramps
- Elements of furniture
- Railing
- Transport elements (e.g., bicycles, cars, elevators)
- End devices of electrical, water, ventilation, and heating networks

Project configuration:

To configure the project in ETU-Software before importing the IFC file, follow these steps:

1. Configuration of the **general project data**, to be manually introduced (Figure 72).

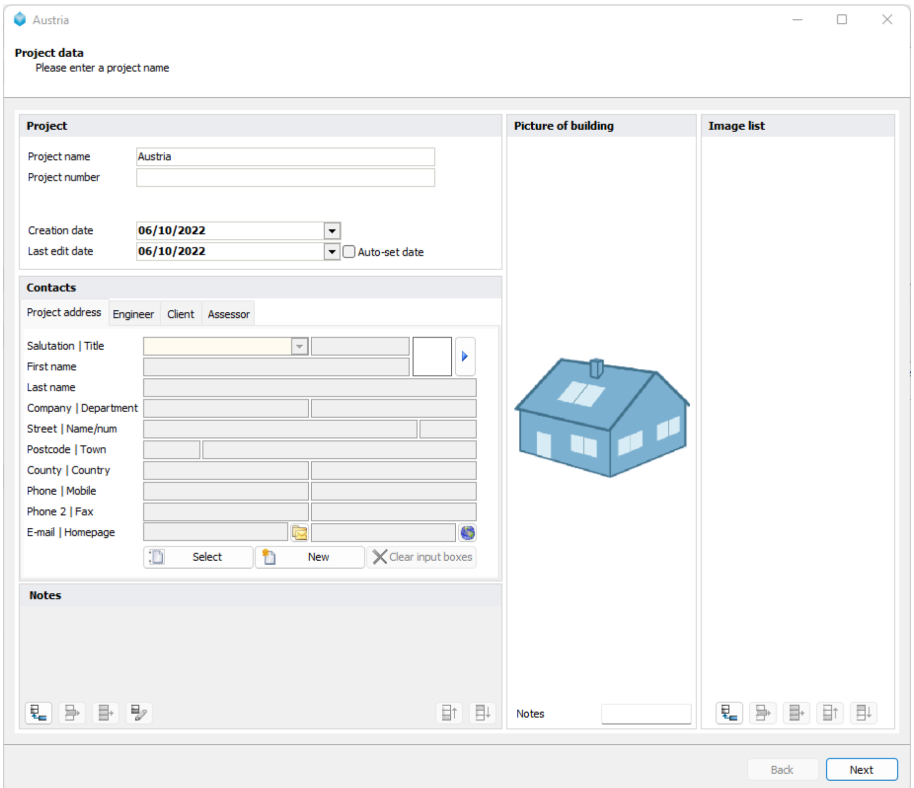


Figure 70. Project data configuration in ETU-Planer

2. **Project location** configuration, in Austrian federal states, also introduced manually (Figure 73).

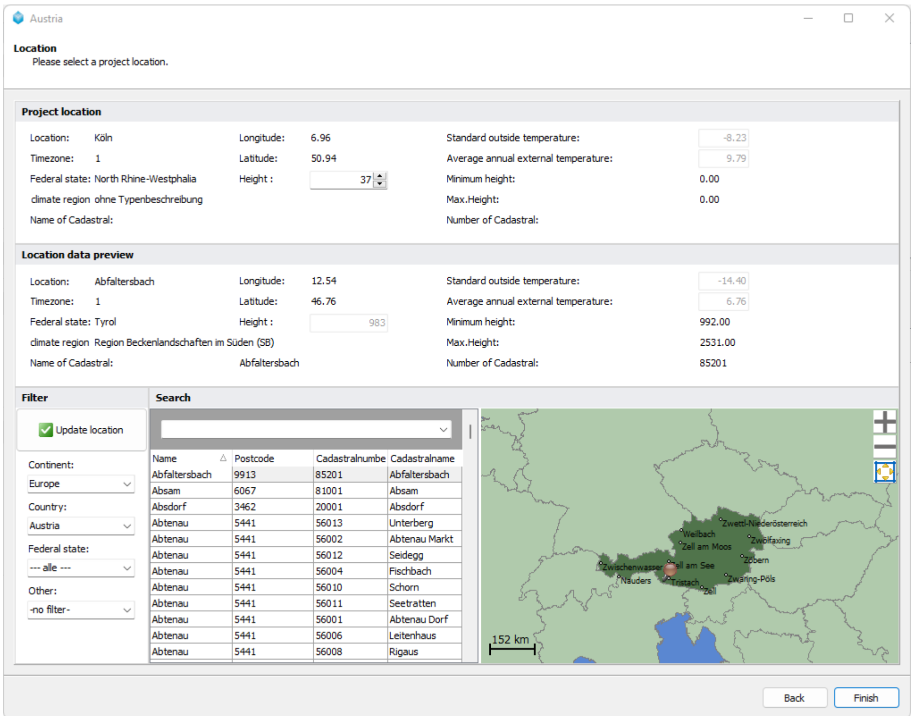


Figure 71. Project location configuration in ETU-Planer

IFC import:

After configuring the general project data and the project location, the software prompts the user to select the project creation mode in HottCAD. To utilize the IFC import function, select the "Graphical creation" command (Figure 74).

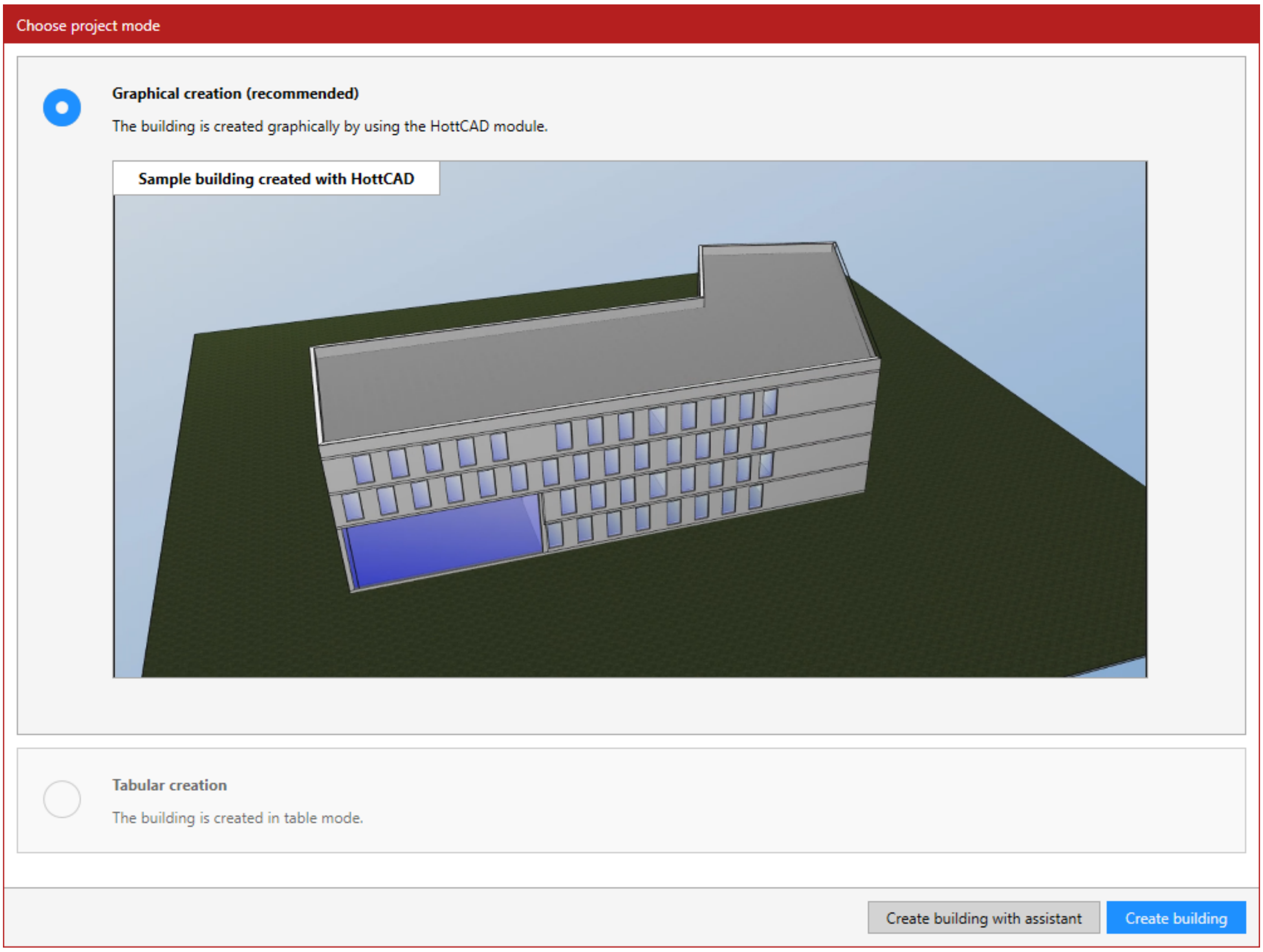


Figure 72. Choose project mode in HottCAD

ETU-Planer is now configured to receive the IFC file import. Within the main screen, an import button is available along with various options that allow the IFC file to be imported either completely or in a reduced form (Figure 75).

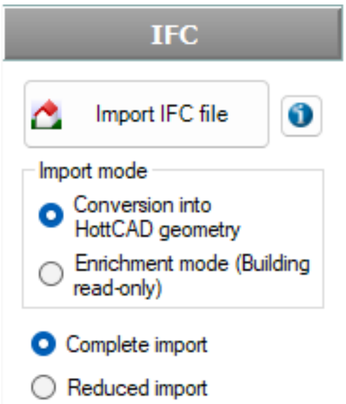


Figure 73. Import IFC file in HottCAD

It is also possible to decide whether to convert IFC elements into HottCAD geometry or to use the read-only function. In this last case, it will be necessary to model the elements manually. However, the conversion option allows for the full use of the IFC import functionality, meeting the information requirements listed above.

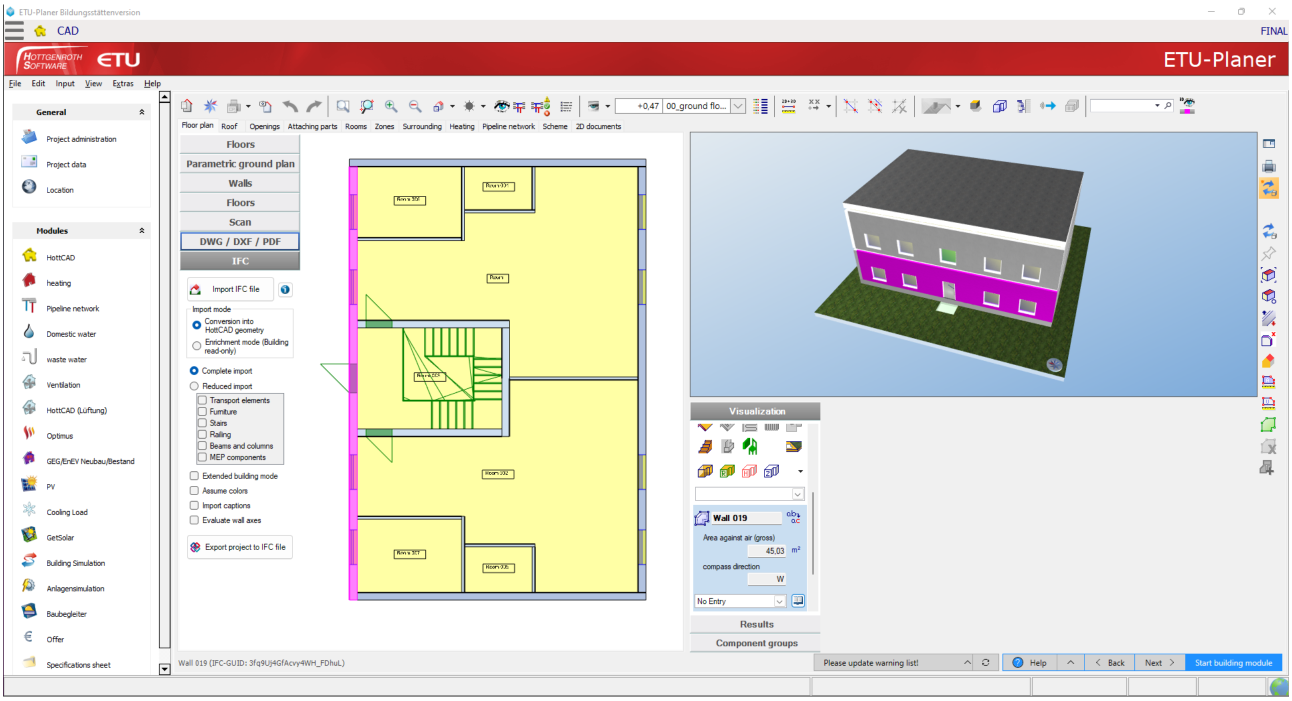


Figure 74. ETU-Planer interface and HottCAD 3D model visualization

Once the import process is complete in the HottCAD main screen, users can view the imported model and select the elements converted from the IFC model to make any changes.

The next step is to configure the building envelope. While the transmittance U-value is recognized automatically, users can still select building elements from the ETU component library to provide a detailed definition of the element stratigraphy (Figure 77).

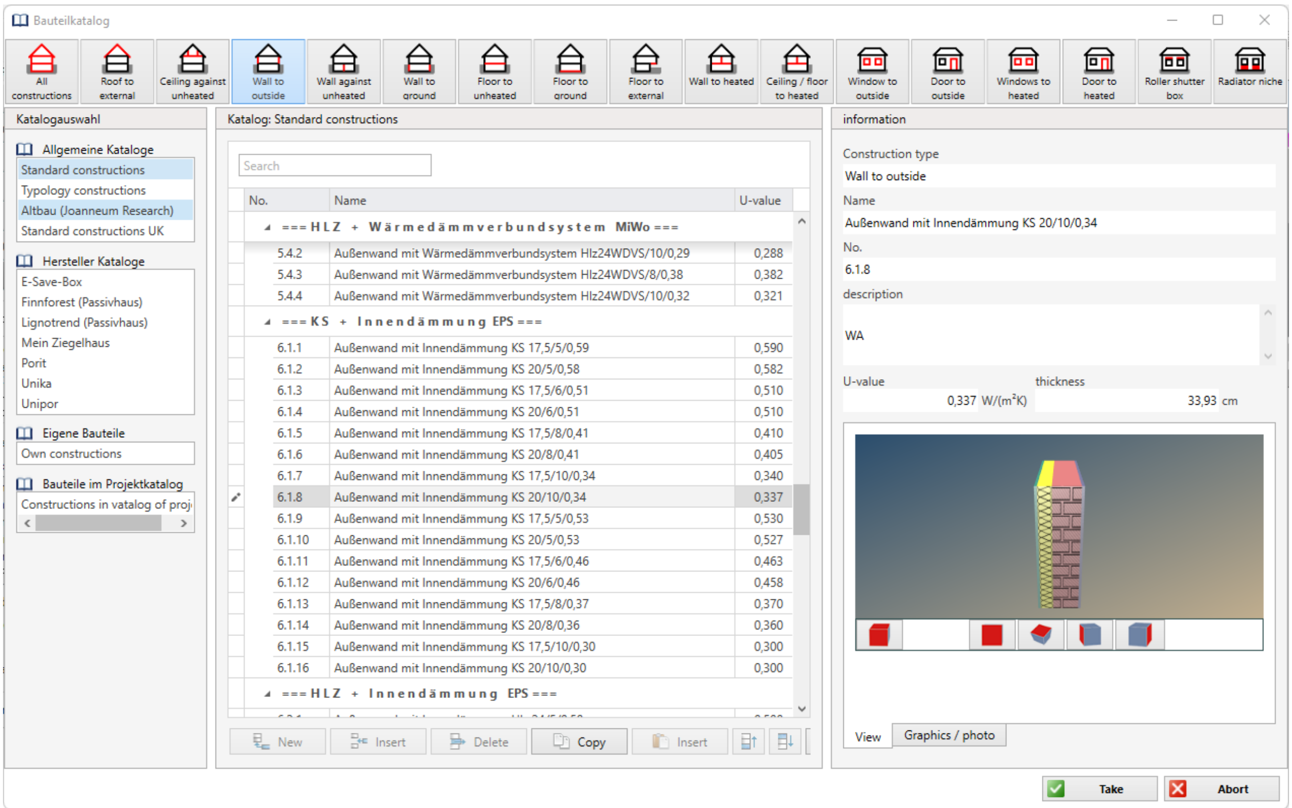


Figure 75. ETU-Planer construction elements library

The materials and stratigraphy of the elements are not imported into the software. Only the total thickness and the name of the elements are imported, without any layers.

Once the import process in HottCAD is complete, users can configure the parameters for EPC generation using the various modules available in ETU-Planer.

4. In depth study

4.1 What happens if I import complex design models?

Advancements in BIM software development are enabling more detailed modelling of buildings, capturing a greater portion of their complexities. These software tools offer a range of functionalities that allow to create complex design models, from the simplest aspect such as different skylights to complete buildings organic design.

As the complexity of building designs increases and BIM software capabilities grow, the IFC exchange format also needed adaptation to facilitate interoperability between BIM software, streamlining BIM workflows. The IFC standard is evolving to accommodate these complexities through new versions. Currently, IFC can capture many of the intricacies of BIM models, utilizing parameterized objects or boundary representations (B-Rep). However, when evaluating energy efficiency, the ability to import and interpret data from IFC formats is contingent upon the capabilities and data requirements of existing EPC tools. Complex objects may pose challenges for current importation processes within these tools. Therefore, it is often preferable to utilize simple extrusions instead of B-Rep elements, as elements created through swept solids typically import without issue.

This necessity arises due to challenges in information exchange between BIM and EPC software. It is observed that complex elements within IFC models are generally not interpreted correctly. For instance, intricate organic elements like curved walls or specialized family types such as curtain walls with nested elements may fail to import accurately into EPC software. While each software may attempt to address these importation challenges differently, inaccuracies in interpretation may still occur, despite adequate characterization. .

Common scenarios that may pose challenges when developing a model for energy analysis include curtain walls, curved walls, discontinuities in the envelope due to structure elements, the presence of skylights, windows between two different levels, and complex space configurations.

To exemplify these cases in the present guidelines, an adaptation of the example model has been made, which will be used to test the importation into the EPC software (Figures 78-82). This adaptation embraces some of the most common cases of what are considered special or complex forms in architectural modelling.

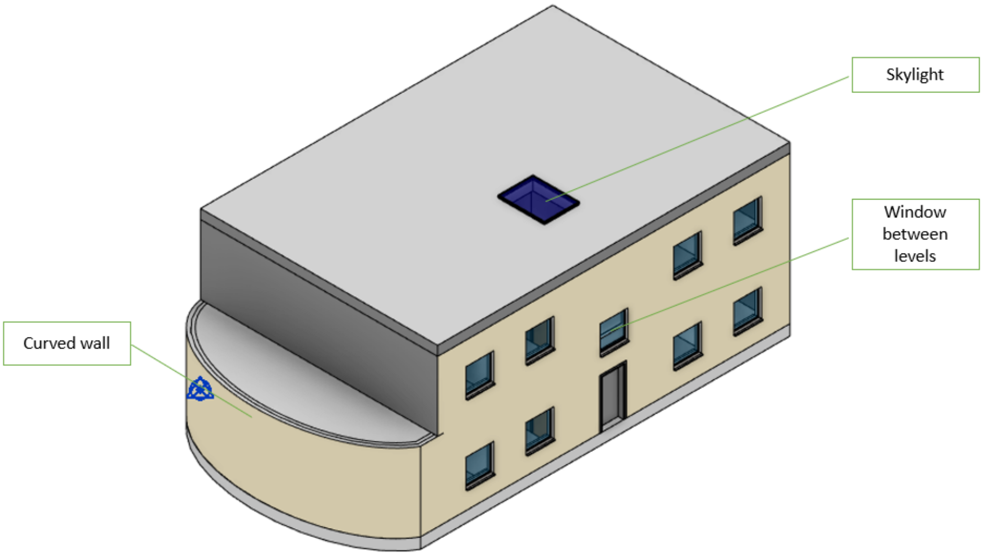


Figure 76. Architectural model changes: Skylight, window between levels, and curve wall.

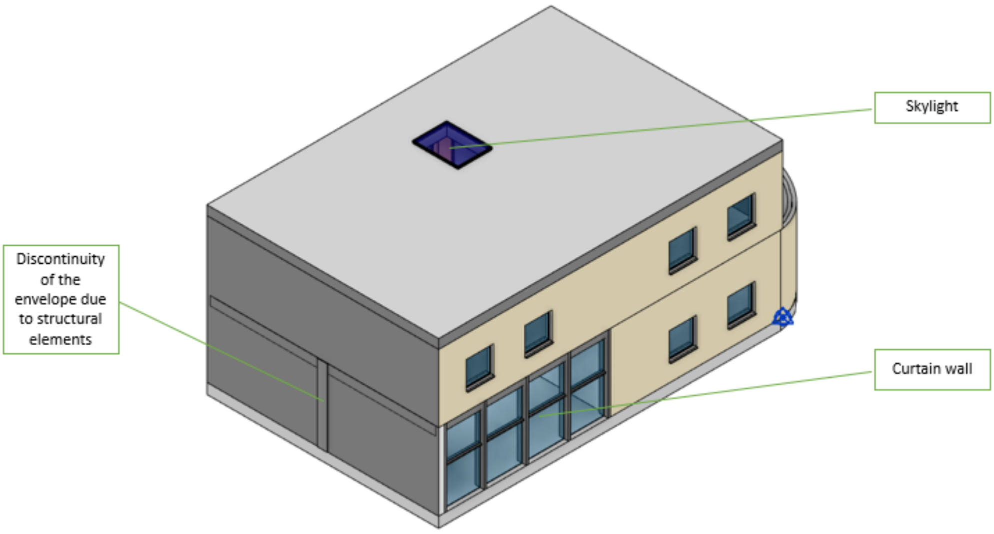


Figure 77. Architectural model changes: Skylight, curtain wall, and envelope discontinuity.

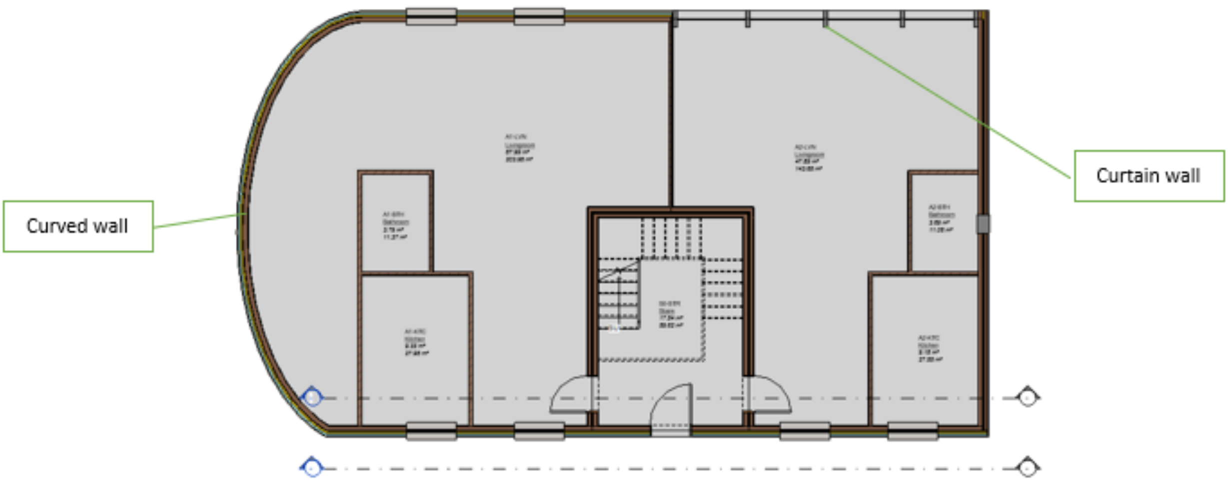


Figure 78. Architectural model changes: curved wall and curtain wall.

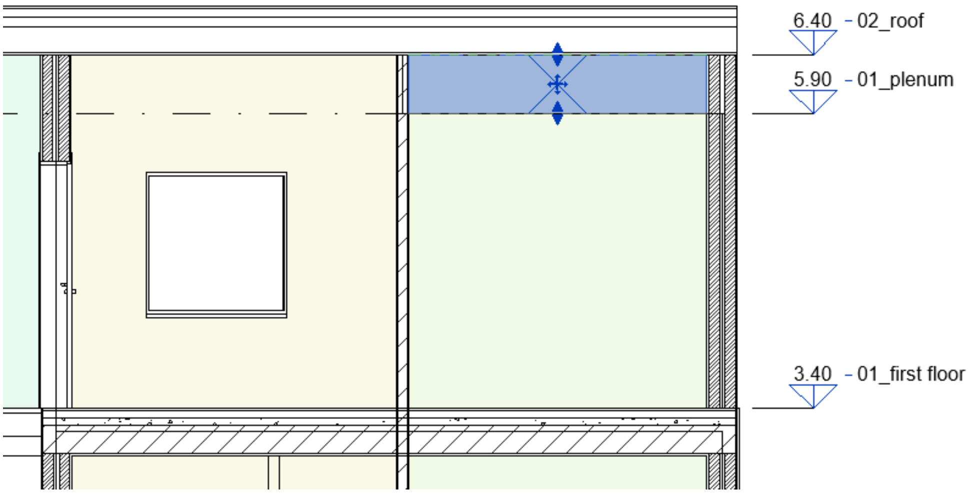


Figure 79. Analytical model changes: plenum space

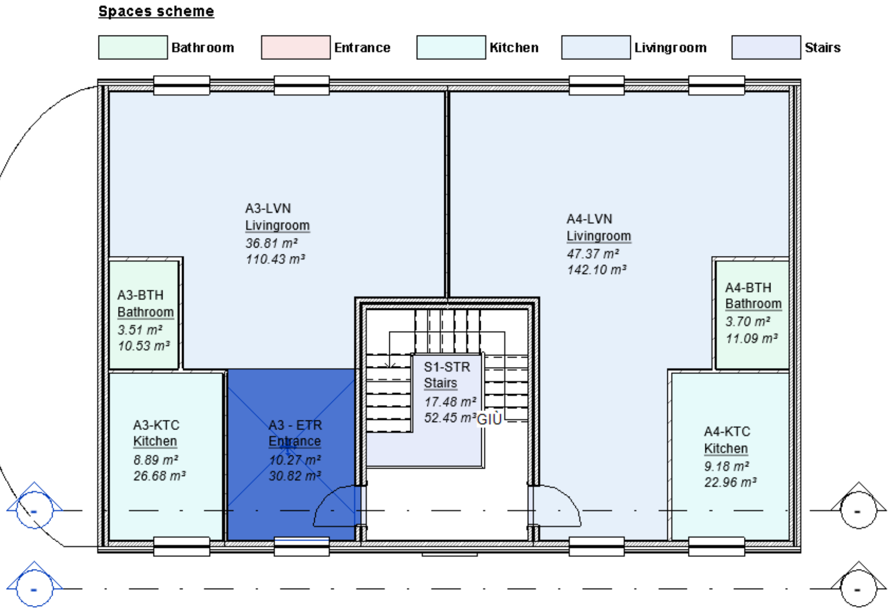


Figure 80. Analytical model changes: virtual partition

4.2 IFC importation of the complex forms

4.2.1 CYPE IFC Builder

The following table evaluates elements of the adapted model that cannot be imported (elements the EPC software can read) or converted (elements the EPC software cannot translate into its counterpart needed for analysis) within the CYPE IFC Builder software for evaluation. For each element, modelling solutions are provided as temporary fixes until the EPC software is adapted.

	Imported	Converted	Solutions
Architectural model			
Curved wall	✓	✗	• model the curved wall as segments in Revit and export the IFC file

			• model the curved wall as segments directly in IFC Builder • model the curved wall as segments in CYPE Architecture
Curtain wall	✗	✗	• model the curtain wall as windows in Revit and export the IFC file • model the curtain wall as windows directly in IFC Builder • model the curtain wall in CYPE Architecture
Skylight window	✓	✓	
Windows between levels	✓	✗	• move the window to the upper or lower level • divide the window into two corresponding windows for each level
Discontinuity (column)	✓	✗	• the column can be modelled as a thermal bridge in Open BIM Analytical Model

	Imported	Converted	Solutions
Analytical model			
Plenum space	✗	✗	• use Open BIM Analytical Model to model the plenum space
Virtual space partition	✗	✗	• use Open BIM Analytical Model to model the virtual space partition

These issues arise primarily when using BIM software outside of the Cype workflow, such as when importing an IFC file generated with Revit into IFC Builder. Conversely, when following the Cype workflow, these problems are typically minimized or avoided altogether.

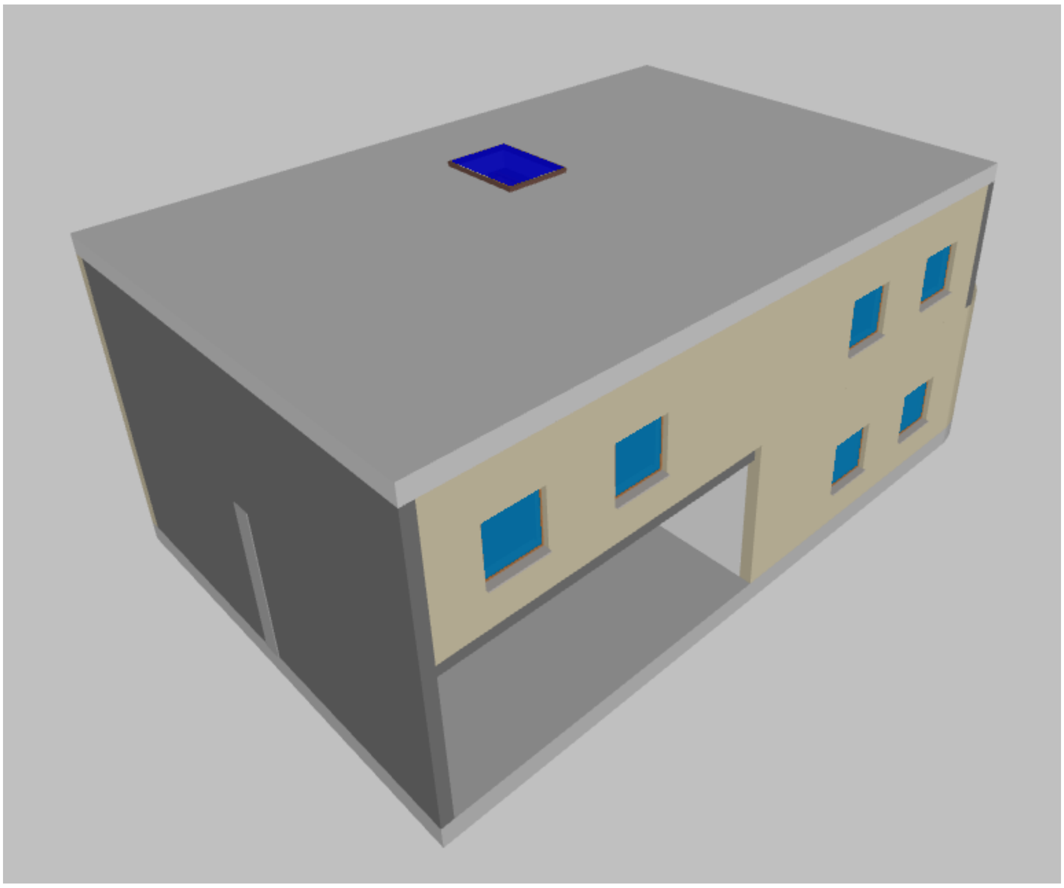


Figure 81. 3D view of the imported model in IFC Builder: the column is present, while the curtain wall is not

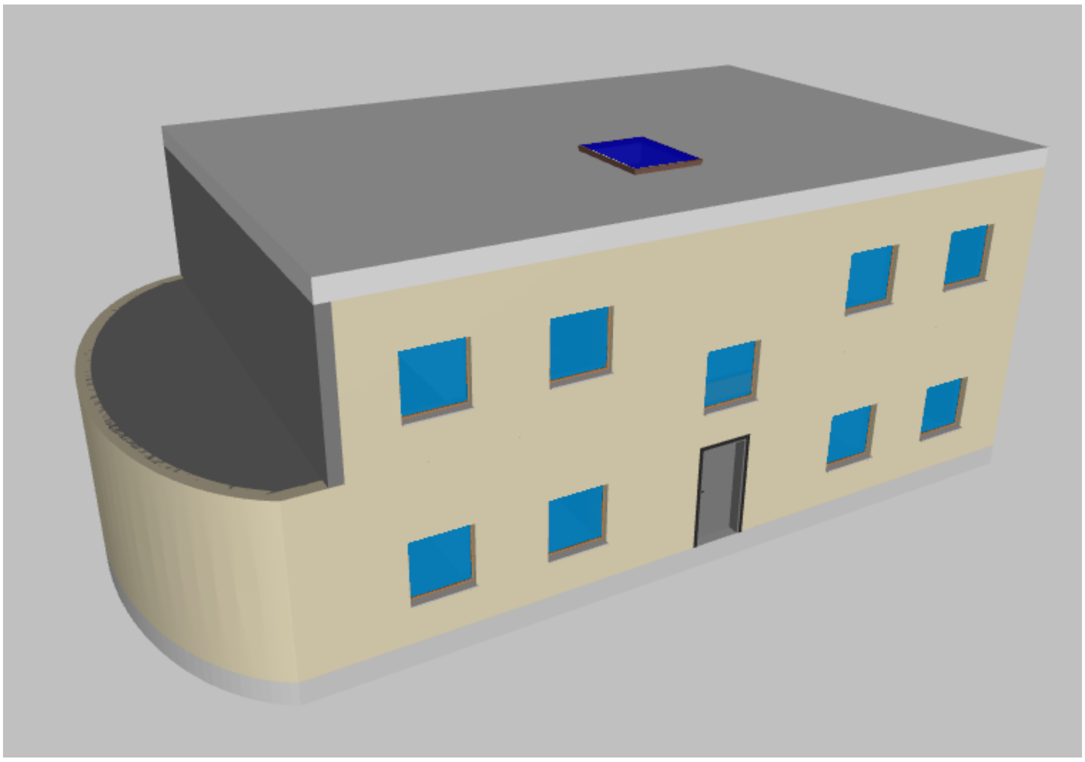


Figure 82. 3D view of the imported model in IFC Builder: the window, skylight and curved wall are imported.

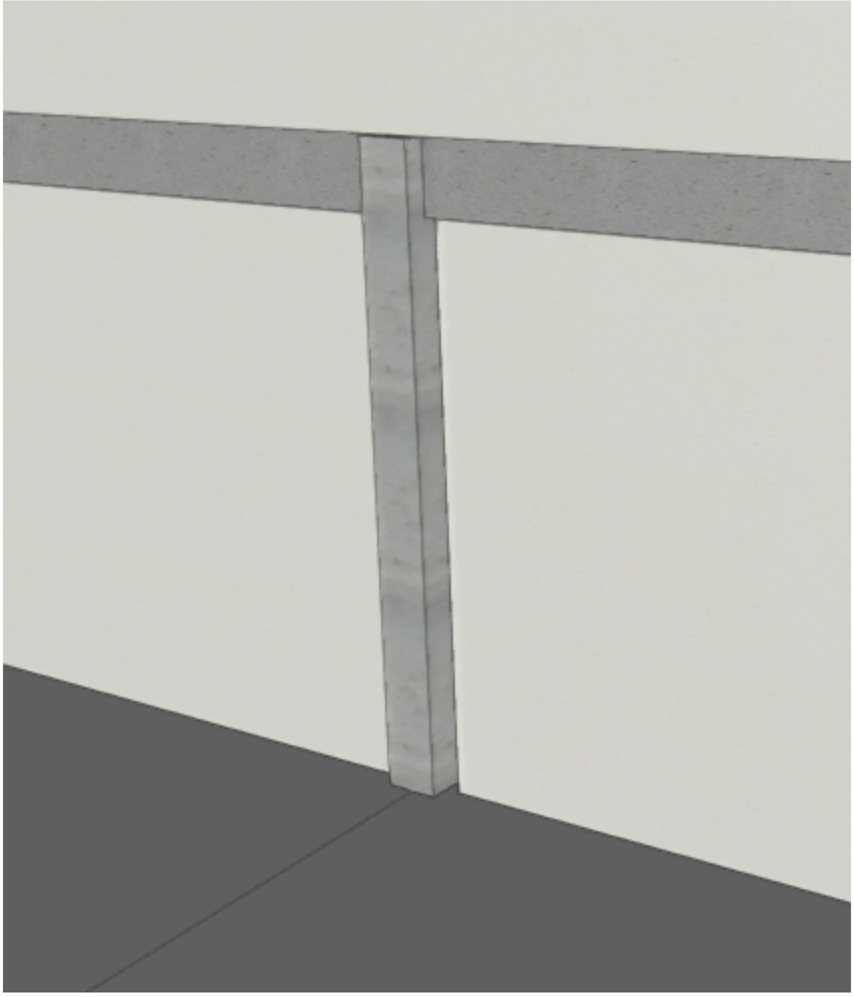


Figure 83. 3D view of the imported column in IFC Builder: the column is imported

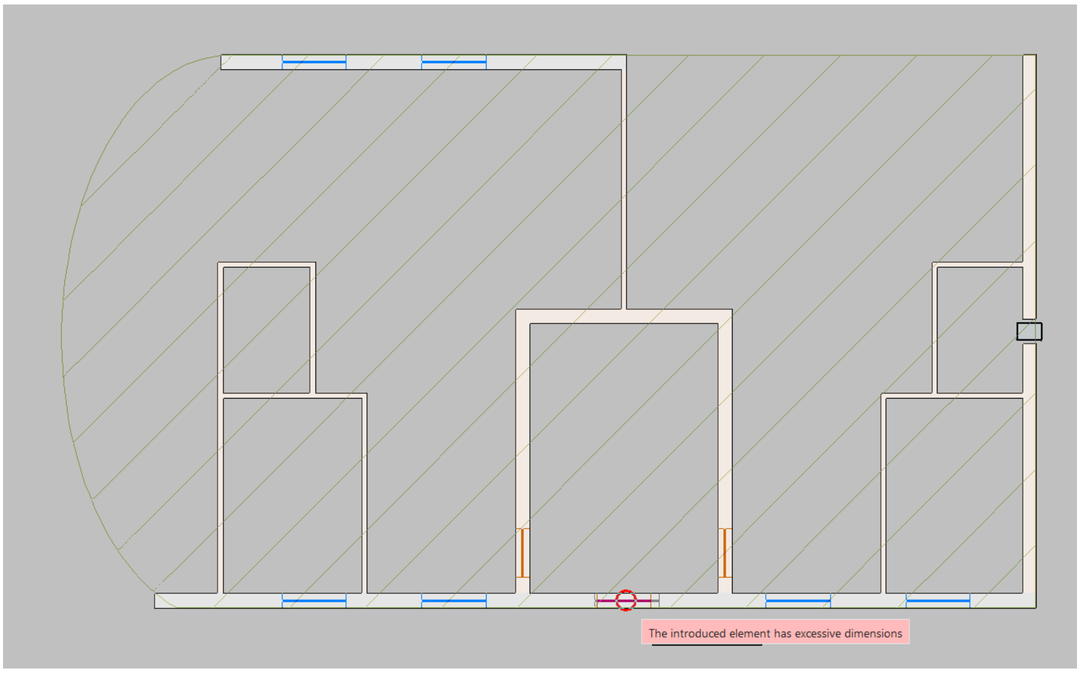


Figure 84. Plan view of the model converted in IFC Builder: The curtain wall, curved wall, and column have not been converted; the window is converted but it results in an error within the software, rendering it unusable.

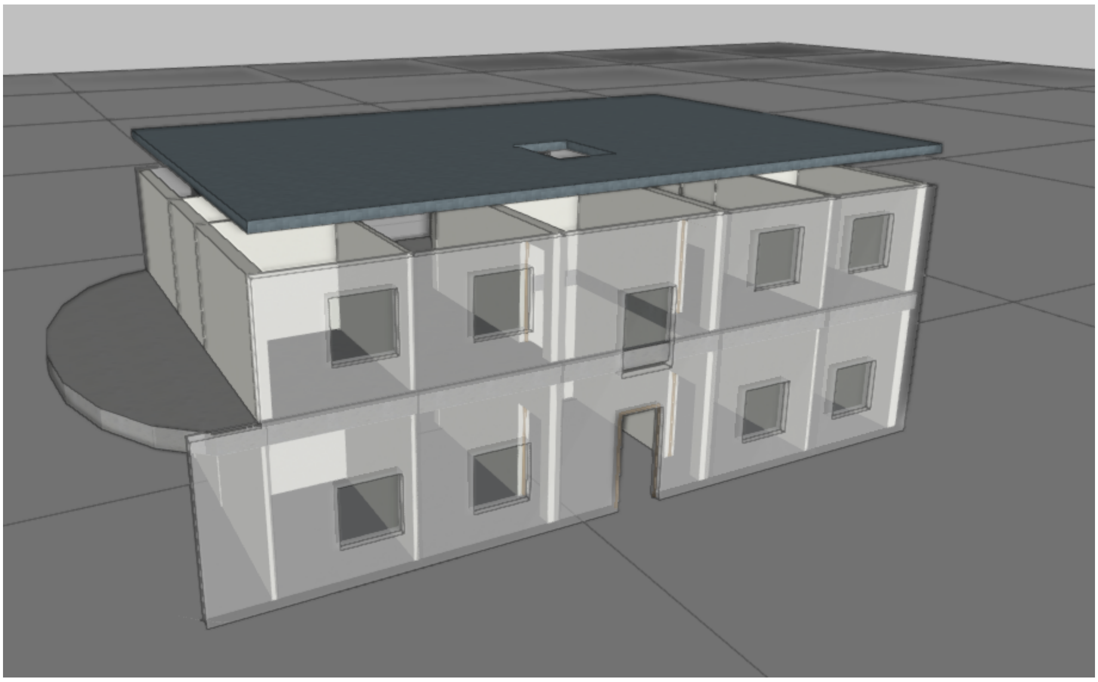


Figure 85. 3D view of the model converted in IFC Builder: The curved wall is not present.

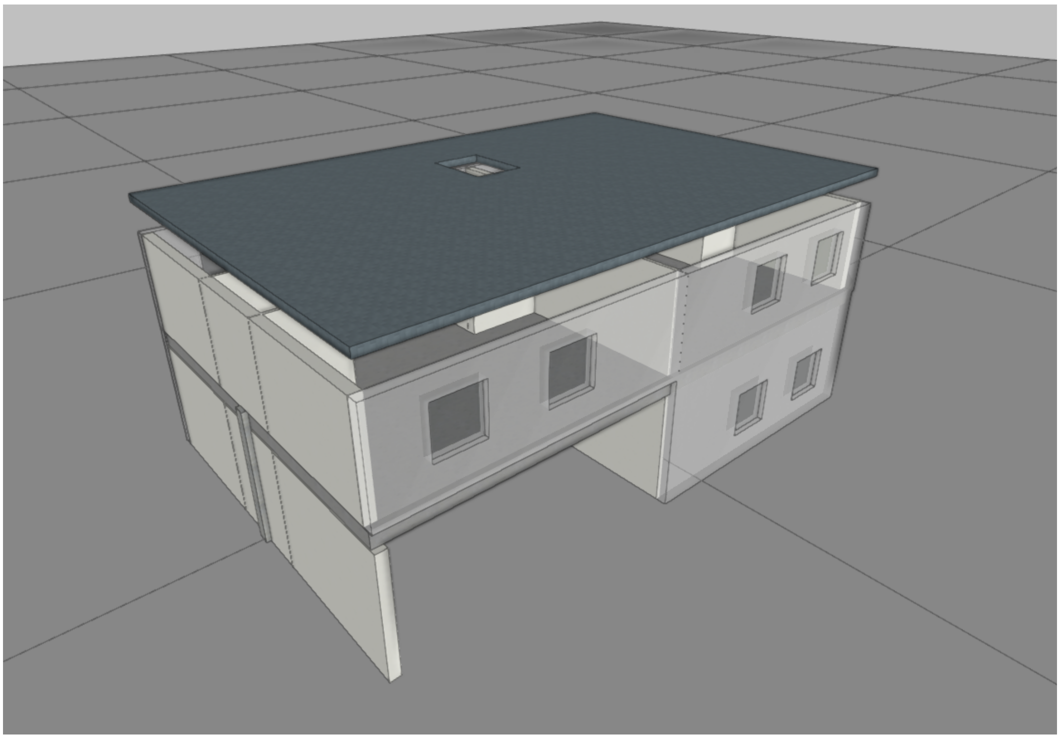


Figure 86. 3D view of the model converted in IFC Builder: The curtain wall is not present.

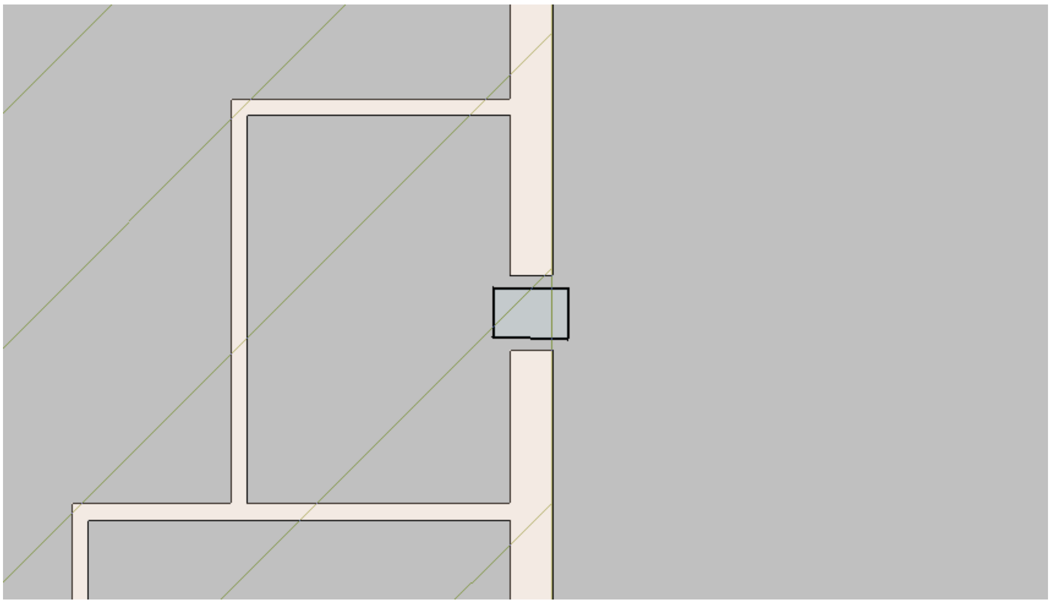


Figure 87. Plan view of the column converted in IFC Builder: The column is not present.

4.2.2 EDILCLIMA EC 700

The following table evaluates elements of the adapted model that cannot be imported (elements the EPC software can read) or converted (elements the EPC software cannot translate into its counterpart needed for analysis) within the EC700 software for evaluation. For each element, modelling solutions are provided as temporary fixes until the EPC software is adapted.

	Imported	Converted	Solutions
Architectural model			
Curved wall	✓	✗	• model the curved wall as segments in Revit and export the IFC file • model the curved wall as segments directly in EC700
Curtain wall	✓	✓	• The parameters can be configured directly in the EC700 [Figures 96-97]
Skylight window	✓	✗	• model the skylight window in EC700
Windows between levels	✓	✗	• move the window to the upper or lower level • divide the window into two corresponding windows for each level
Discontinuity (column)	✓	✗	• model the pilar in EC700

	Imported	Converted	Solutions
Analytical model			

Plenum space	✓	✓	
Virtual space partition	✓	✓	

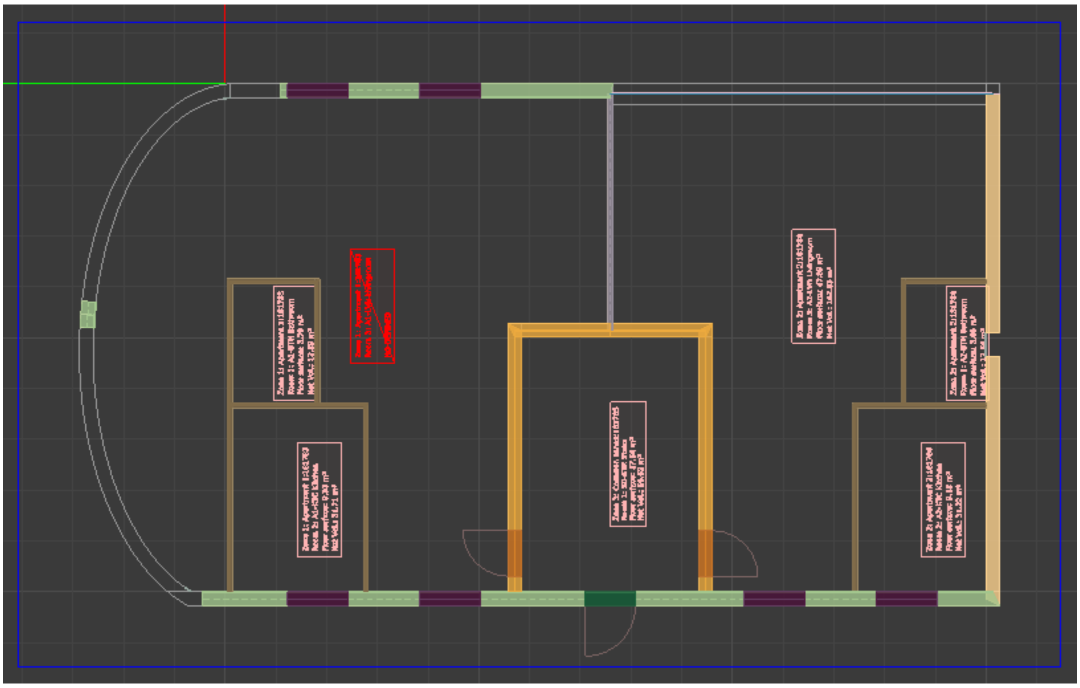


Figure 88. Graphic input of the model converted in EC700: The curved wall and the column are not present.

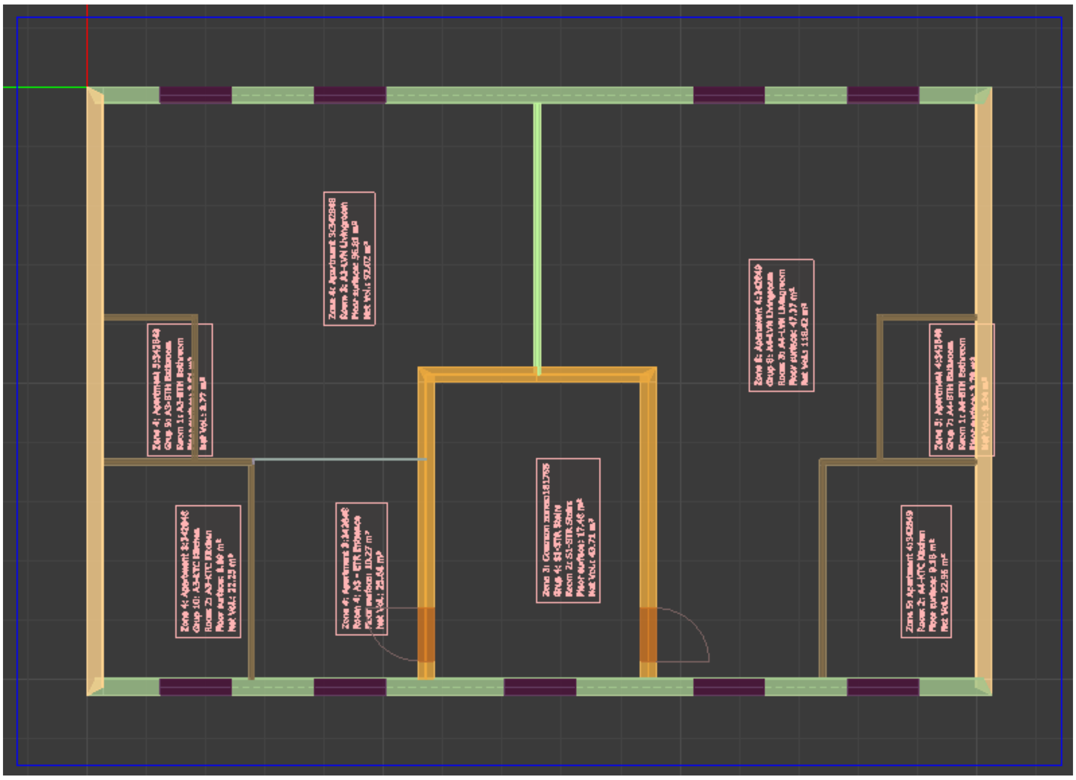


Figure 89. Graphic input of the model converted in EC700: The window is present.

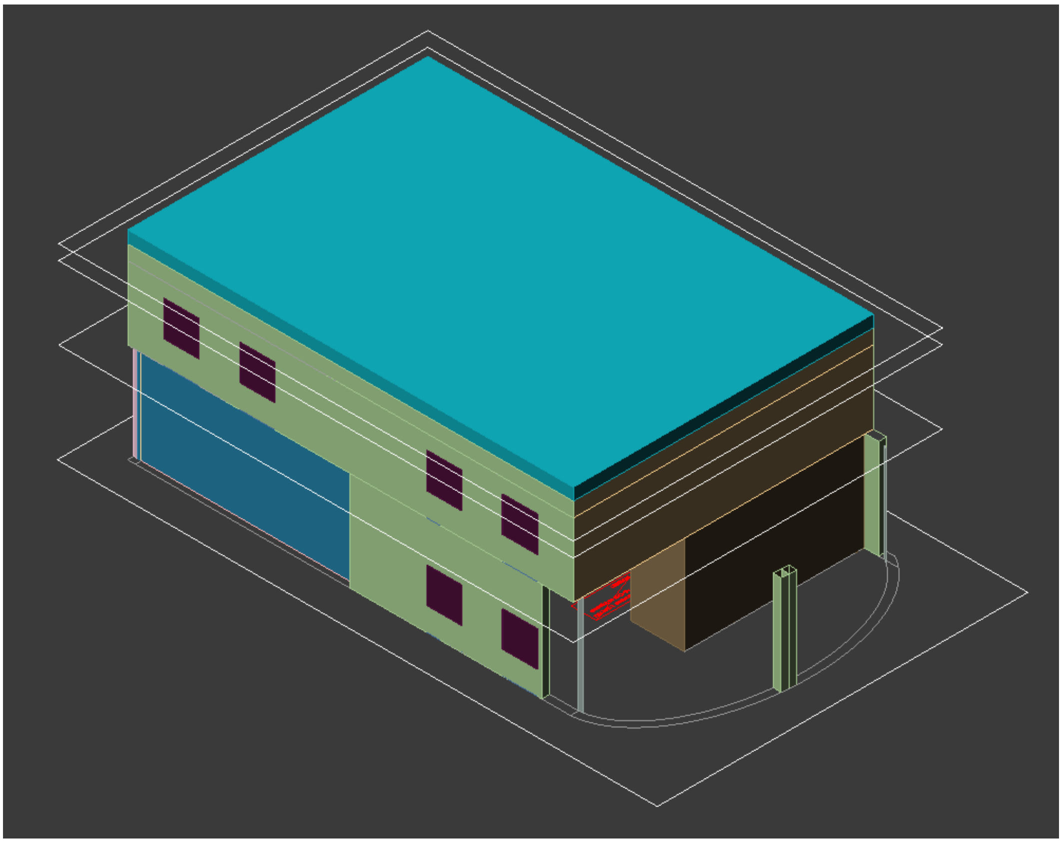


Figure 90. 3D view of the model converted in EC700: The curtain wall is present while the curved wall and the skylight are not.

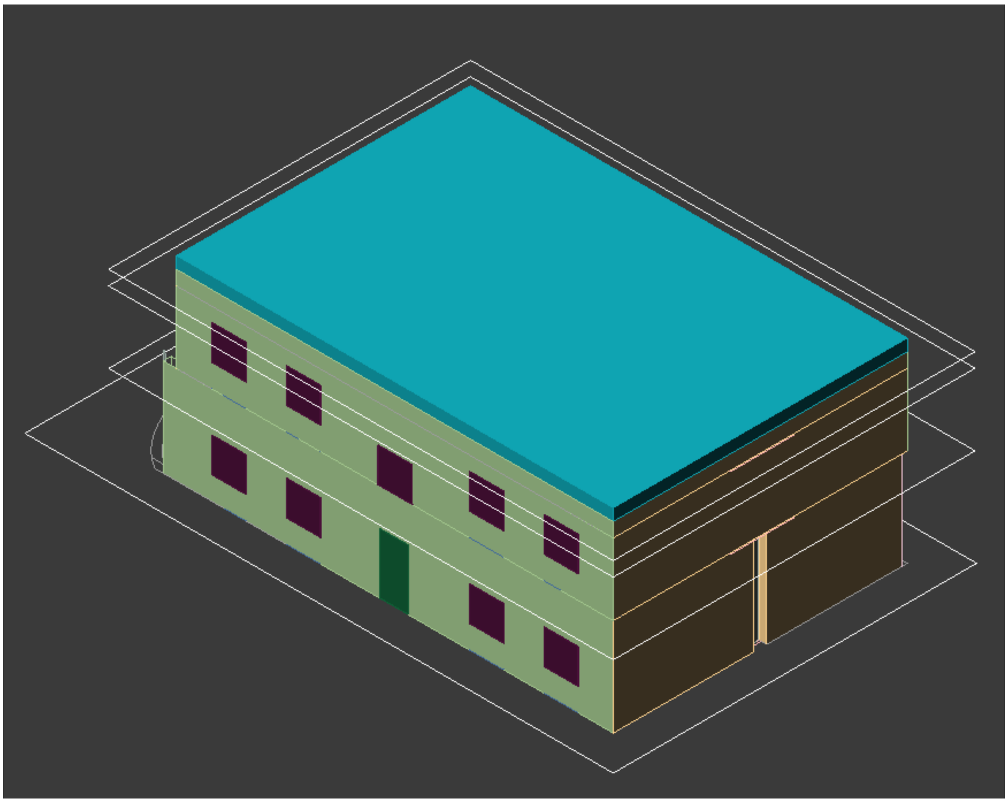


Figure 91. 3D view of the model converted in EC700: The window is present, but the column and the skylight are not

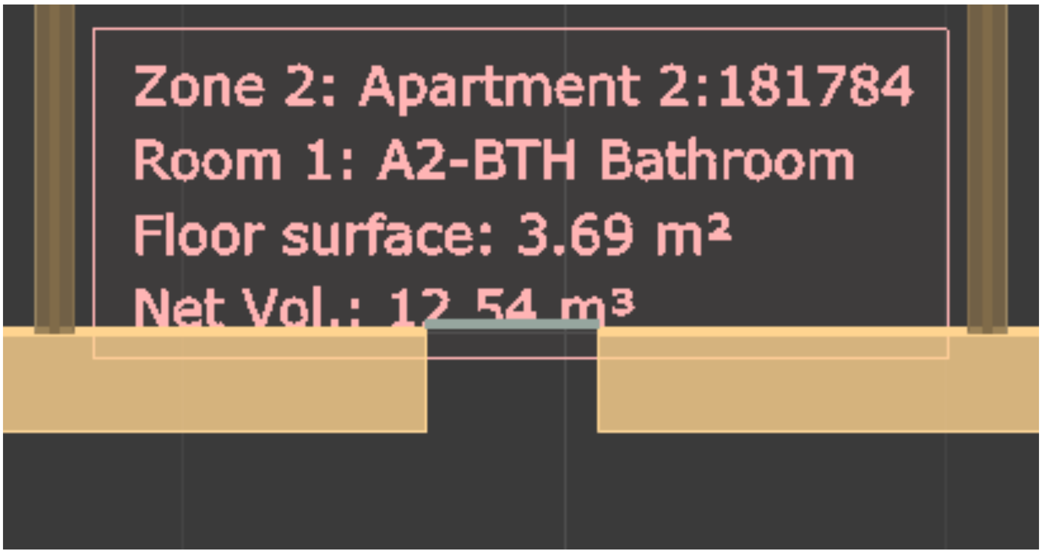


Figure 92. Graphic input of the discontinuity in EC700: The column is not present.

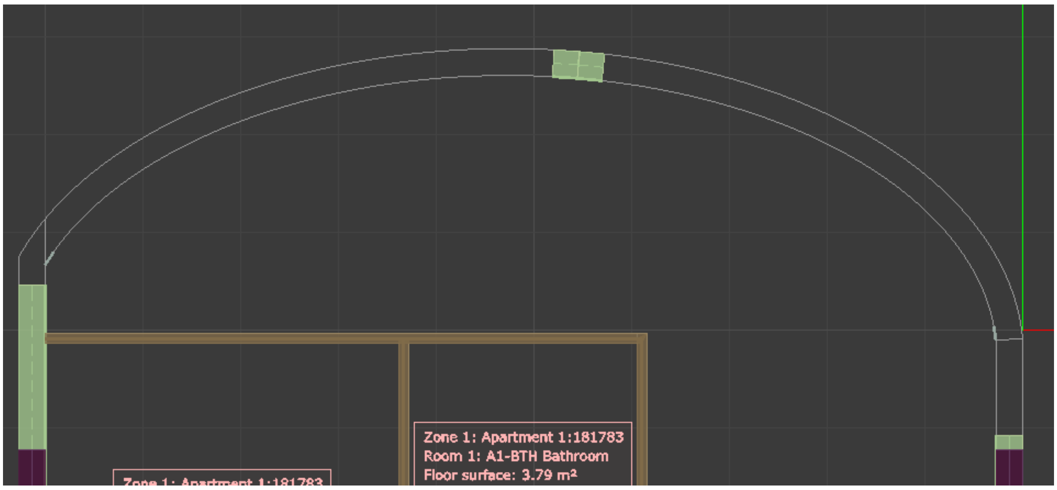


Figure 93. Graphic input of the curved wall in EC700: The curved wall is not present.

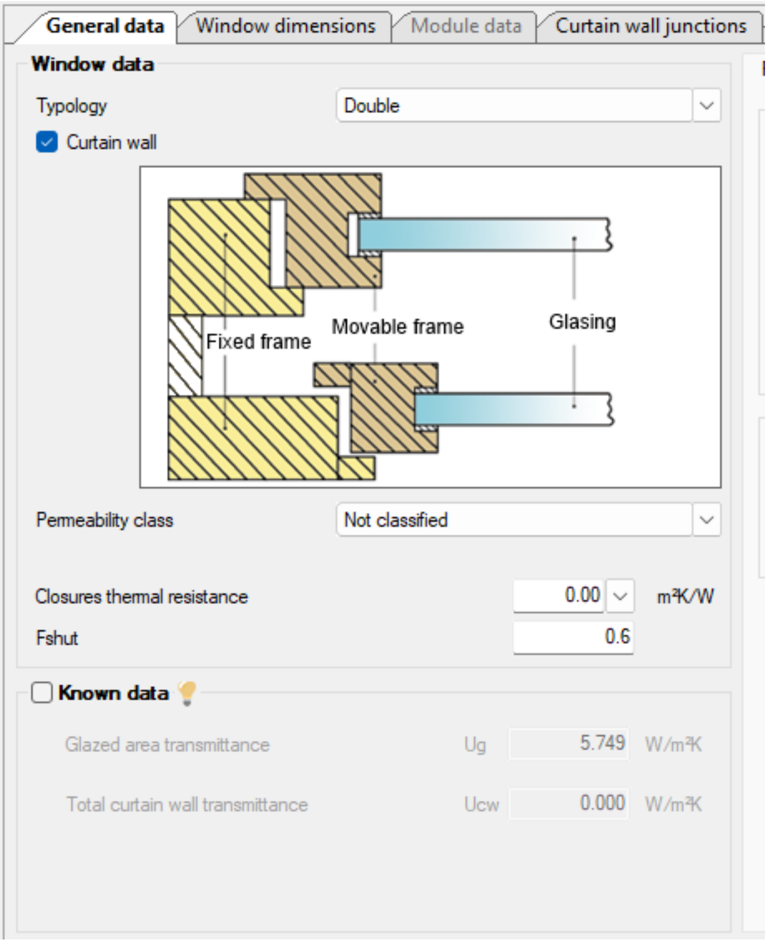


Figure 94. Curtain wall configuration in EC700: The curtain wall is converted and can be parametrically configured

Figure 95. Curtain wall configuration in EC700: The curtain wall is converted and can be parametrically configured.

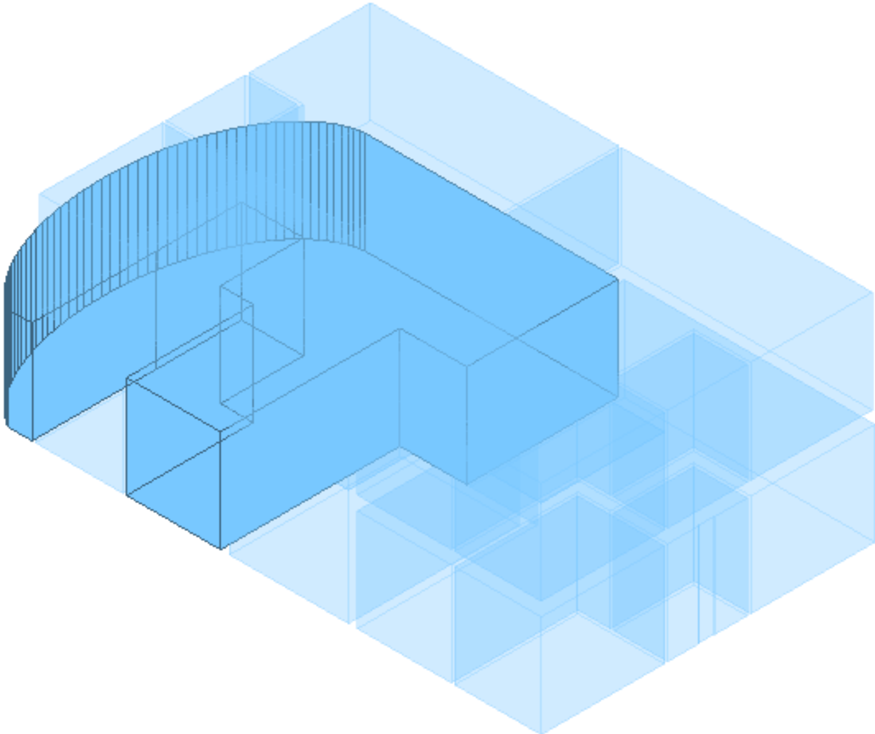


Figure 96. 3D view of the imported analytical space in EC700: Even without the wall, the inner spaces are correctly imported and converted.

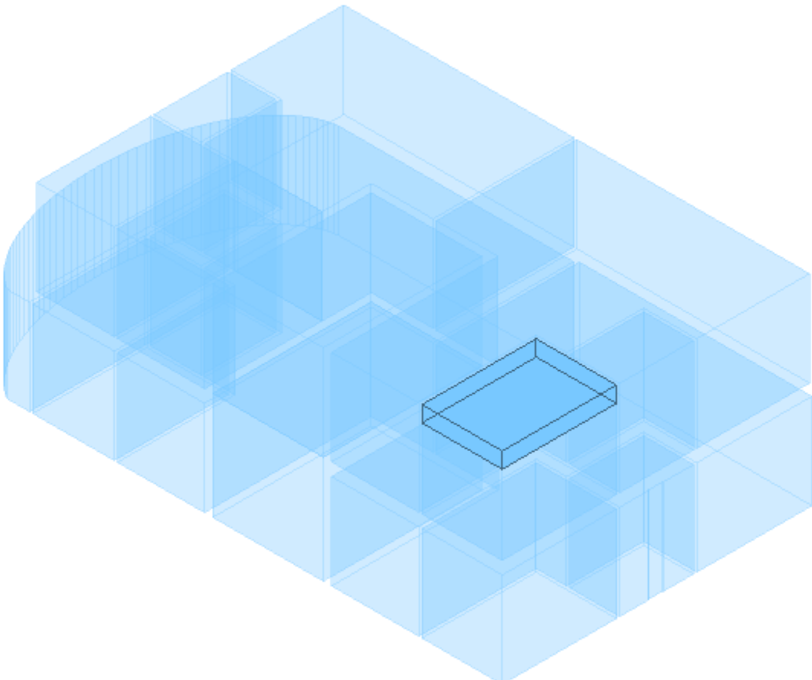


Figure 97. 3D view of the plenum space correctly imported and converted in EC700.

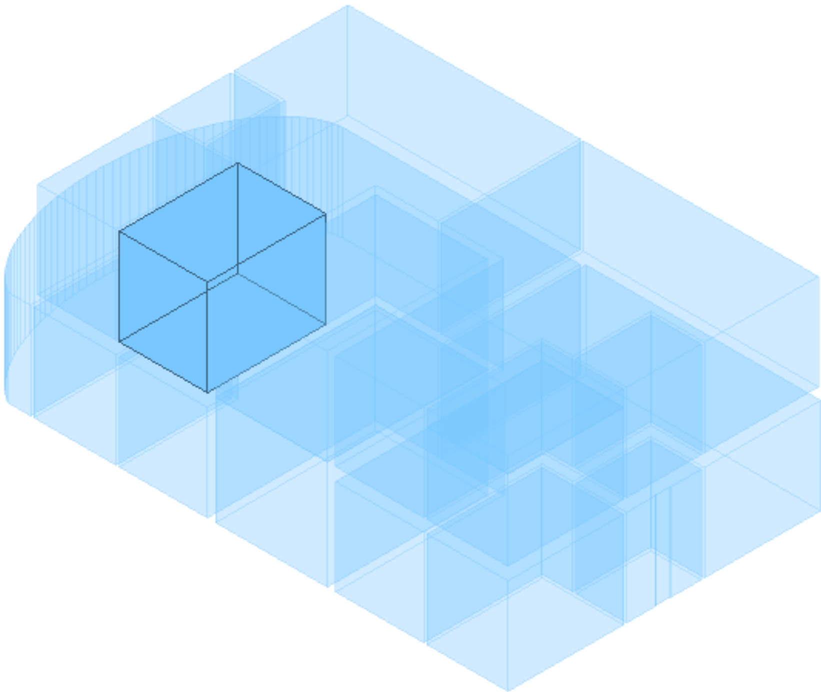


Figure 98. 3D view of the virtual space imported in EC700: The spaces separated by a virtual partition are correctly represented.

4.2.3 ETU-SOFTWARE

The following table evaluates elements of the adapted model that cannot be imported (elements the EPC software can read) or converted (elements the EPC software cannot translate into its counterpart needed for analysis) within the ETU software for evaluation. For each element, modelling solutions are provided as temporary fixes until the EPC software is adapted.

	Imported	Converted	Solutions
Architectural model			
Curved wall	✓	✗	• model the curved wall as segments in Revit and export the IFC file • model the curved wall as segments directly in HottCAD
Curtain wall	✓	✗	• model the curtain wall as windows in Revit and export the IFC file • model the curtain wall as windows directly in HottCAD
Skylight window	✓	✗	• Model the roof window in HottCAD [Figure 105]
Windows between levels	✓	✗	• move the window to the upper or lower level • divide the window into two corresponding windows for each level [Figure 106]

Discontinuity (column)	✓	✓	• the column is converted into a wall with the corresponding transmittance

	Imported	Converted	Solutions
Analytical model			
Plenum space	✓	✓	
Virtual space partition	✓	✓	

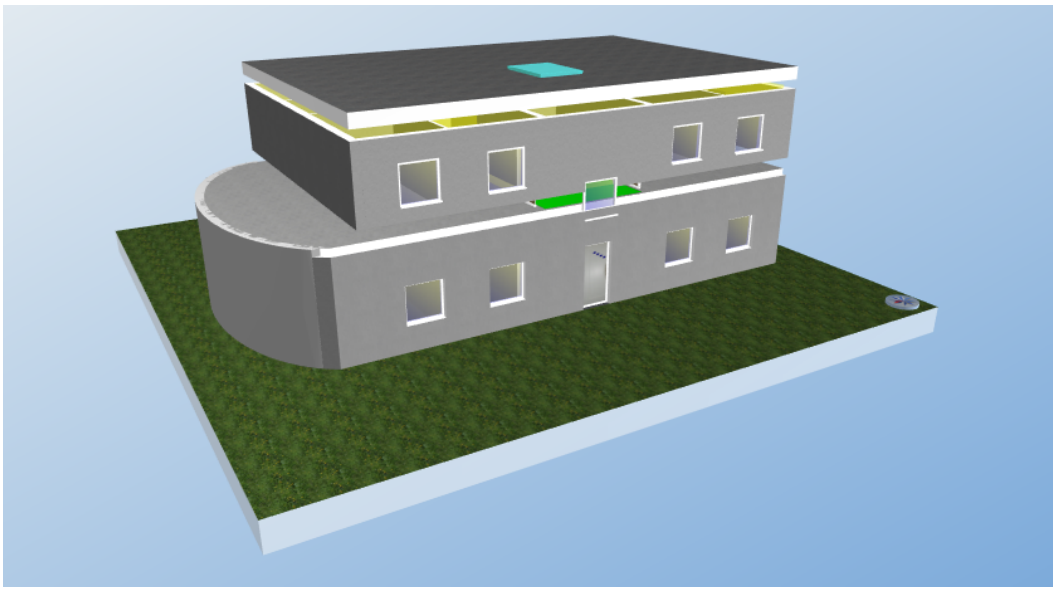


Figure 99. 3D view of the model imported in HottCAD: The curved wall, the window and the skylight are present.

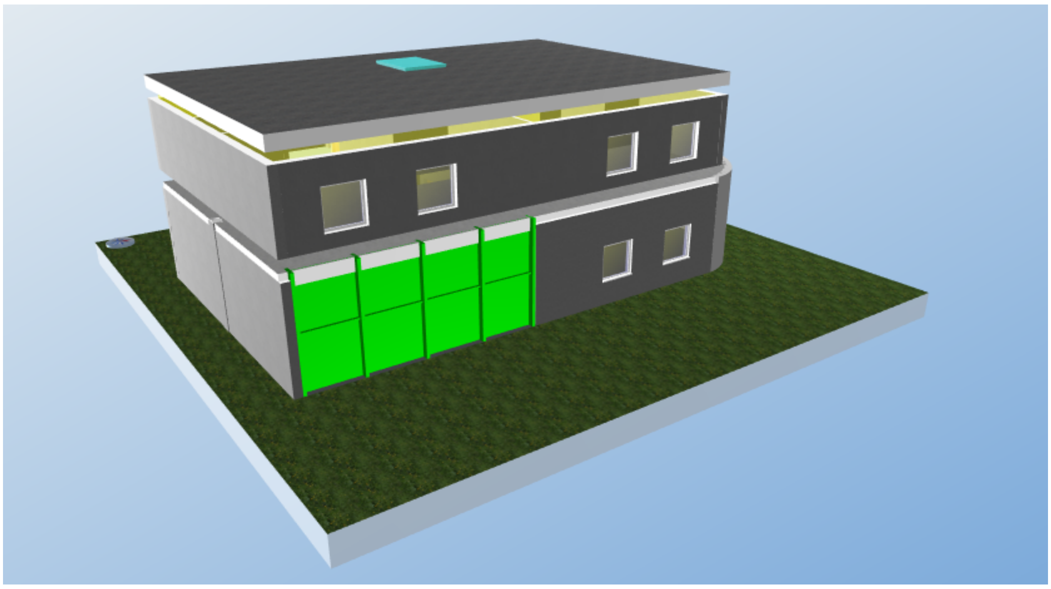


Figure 100. 3D view of the model imported in HottCAD: The curtain wall and the column are present.

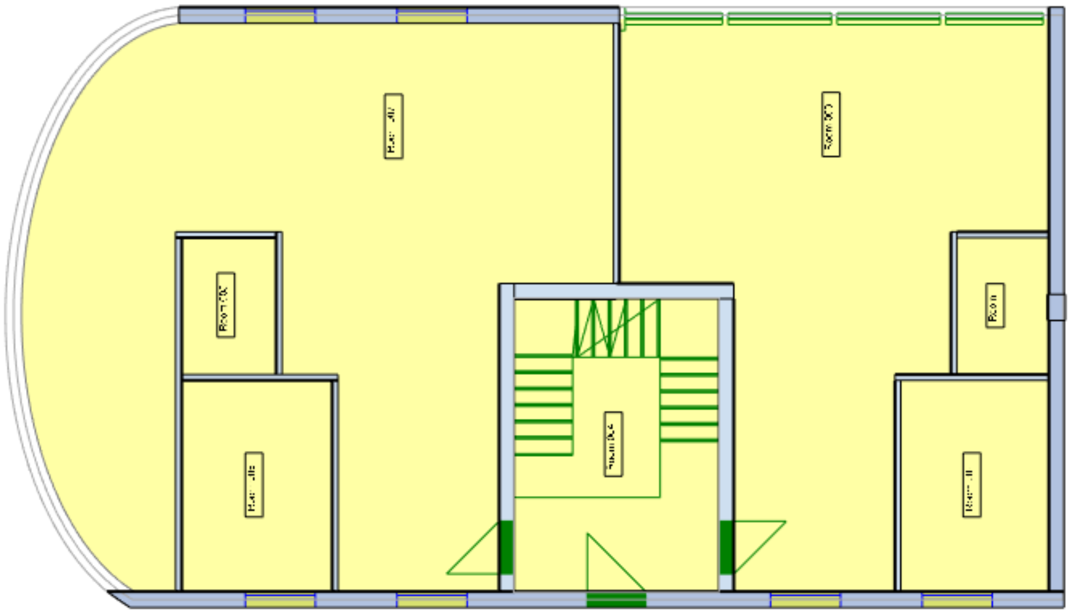


Figure 101. Plan view of the model converted in HottCAD (first floor): The curved wall and curtain wall are missing while the column is present.

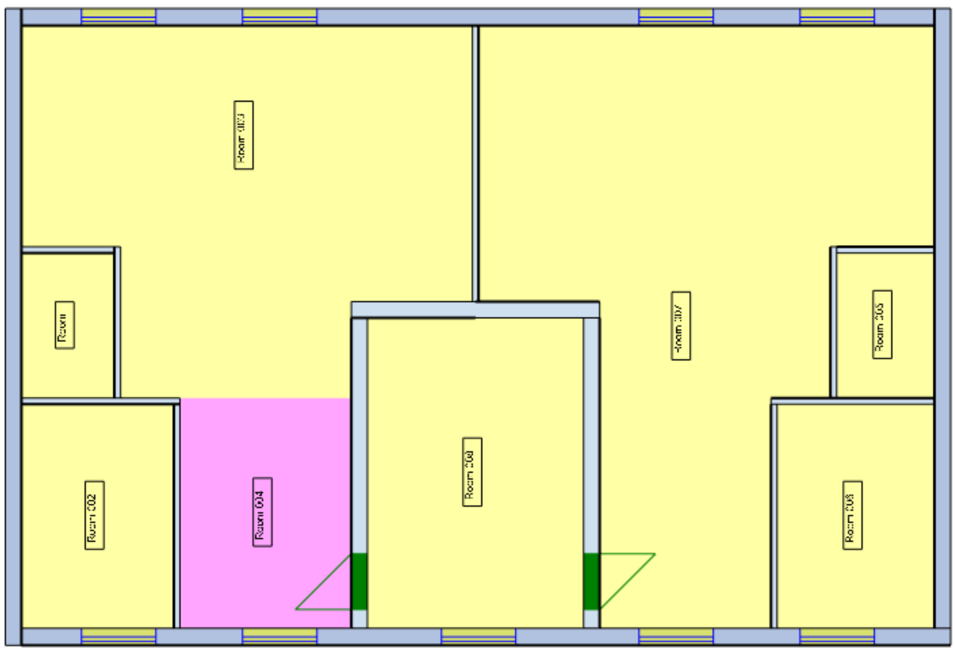


Figure 102. Plan view of the model converted in HottCAD (second floor): The window and the skylight are not correctly converted while the inner spaces are.

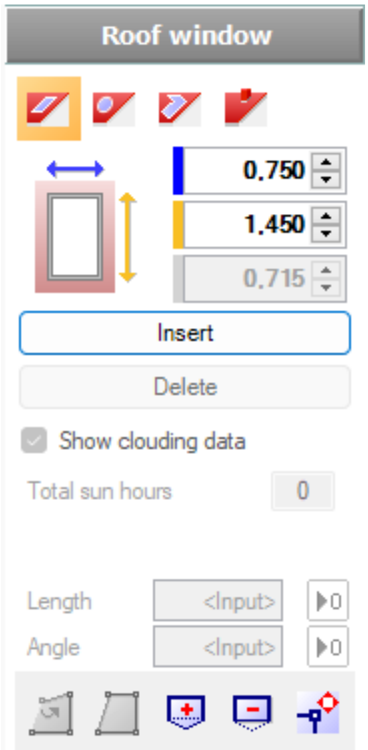


Figure 103. Roof window generation in HottCAD: The skylight can be introduced directly in the EPC software even if it was not converted correctly.

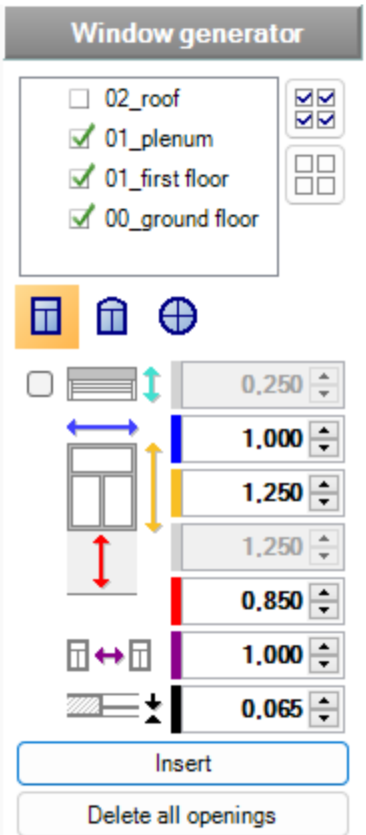


Figure 104. Window generation HotCADD: The window can be introduced directly in the EPC software even it was not converted correctly.

5. ANNEXES

The subsequent sections feature various tables offering step-by-step guidance on different parameters and recommendations essential for modelling within Revit and Cype. These are aimed at developing both the architectural model (Annex 5.1) and the analytical model (Annex 5.2).

In reference to the architectural model, the Annex 5.1 subsection presents six tables corresponding to the minimum required categories for modelling. These tables delineate specific parameters for each category within the two distinct BIM modelling software platforms. Conversely, the Annex 5.2, concerning the analytical model, comprises four tables outlining the procedures for space and zone development within each software.

Each parameter listed in the tables reflects those encountered within the BIM software interface during the modelling of minimum required elements within their respective categories. Consequently, users can ascertain the methodological approach to modelling each element, comprehend the significance of individual parameters, and adhere to recommendations for crafting a model suitable for EPC purposes.

5.1 Annex 1– Information requirement for the architectural model

The information presented in the following tables serves as an example of the fundamental geometric and parametric rules, tips, and tools for modelling a building with the minimum requirements to enable its evaluation with an EPC software. For guidance on modelling with REVIT or CYPE, please refer to the respective REVIT or CYPE modelling guidelines.

5.1.1 Table 1.1.1 - Minimum required category for Building Envelope in REVIT

Building Envelope
BUILDING WALLS (EXTERIOR AND INTERIOR)
CONSTRAINTS Not all constraints will be explained, but the ones having a great impact in the IFC when exported if they are inadequately defined.
Location Line: The reference plane on which the wall is positioned. The significance of this line is associated with the structural and insulation layers of the wall. It is recommended to reference the wall to the exterior core layer plan of the walls in relation to the floors.
Base Constraint: The base level on which the wall resides. It is recommended to split the walls by levels. Therefore, the wall in different levels will start at the immediate lower level.
Top Constraint: The level that the wall will extend to. It is recommended to split the walls by levels. Therefore, the wall will terminate in the immediate upper level.

Room Bounding: If selected, the wall will be used as room boundary. It is recommended to enable this option for all walls (whether interior or exterior) that demarcate a space.
Cross Section: Defines the inclination of the wall. It could be chosen between vertical, inclined, and trapezoidal (inclined only in the exterior part, the interior part, or both) walls. It is important to keep in mind that extremely inclined walls could cause problems with the unions between walls and windows/doors (see windows constraints for more information) and between walls-slabs/roofs. Additionally, the trapezoidal option will only be available if the variable parameters of the layers are checked within the *Structure* tab (See Structure Concept). It is recommended to check the connections with other elements for this type of walls. However, since some EPC software are not capable of evaluating trapezoidal walls, this option should not be selected. Instead, an equivalent thickness of a vertical wall must be defined.
PHASING
Creation Phase: The time condition of the building element. It includes existing or new construction phases by default. However, additional phases can be created if necessary. For energy purposes model exportation, it is recommended that all elements belong to the same phase.
DIMENSIONS Dimensions are automatically defined based on the following criteria.
Length: The length of the wall is defined during the drawing process.
Height: The height of the wall is defined with the base constraint and top constraint parameters. It is recommended that the height of the wall corresponds to the difference between two consecutive levels.
PROPERTIES Available in the properties' toolbar
Family: The available system families to which the wall can belong. The available system families to which the wall can belong include: • Ventilated Façade, if the wall is a façade and part of a ventilated system. • Partition, for partition walls. • Curtain Wall, for glazed walls. It is recommended to choose the family that corresponds to the specific construction requirements. Otherwise, modifying the type of information will require more effort from the modeler.
Type (Edit type option): The exact construction type of the wall. In REVIT it is defined by the type parameters of the wall. It is important to utilize the duplicate option when beginning to create a type by modifying an existing family type.
CONSTRUCTION Available in Edit type option (See Type concept)

Structure: Each layer should be defined by its function, material, and width. The layers composing the structure of the wall should be marked as Structure material. Additionally, layers wrapping the structure in isolated walls at one or both ends should be defined by checking the "Wrapping" parameter. For trapezoidal walls, the inclined layers should be marked by checking the Variable parameter. It is recommended to accurately define the function of the layers as it will be considered when drawing the wall through its Location line, as well as in the joints and connections with other elements. The same recommendation applies to the materials used to wrap up the ends of the wall. Materials for the elements should be selected from the material library. Since the properties of the materials and the width of the layers determine the thermal properties of the wall, it is important to choose materials with thermal properties from the material library (See *Materials* category table for more information)
Wrapping at Inserts: The adjustment of wall layers when including windows and doors families. Users can choose between options such as without wrapping, exterior wrapping, interior wrapping, or both. It is recommended to select the option that accurately reflects the reality of the construction.
Wrapping at Ends: The adjustment of the wall layers, when a wall ends without connecting with other building elements. Users typically have options such as without wrapping, exterior wrapping, or interior wrapping. It is advisable to choose the option that best reflects the reality of the construction.
Width: Read-only parameter which indicates the width of the wall automatically defined based on the sum of its layers' widths (refer to *Structure* concept).
Function: This parameter determines the connections between different environments separated by the wall. Functions include exterior, interior, foundation, retaining, ceiling, and elevator core. It is crucial to define and verify this parameter because simulation tools determine the heat exchange conditions of the elements based on it.
CROSS SECTION PROPERTIES Available in *Edit type* option (See *Type* concept). Only available when *variable* parameters of the layers are checked within the *Structure* tab (See *Structure* concept).
Exterior angle: This parameter defines the angle with respect to the vertical axis at which the outer layer of the wall is inclined. A positive angle indicates an inclination towards the centre of the wall, while a negative angle indicates an inclination away from the centre of the wall. Some EPC software cannot evaluate walls with varying angles within their layers. Therefore, if a wall has different inclinations between the exterior and interior layers, it is recommended to approximate the entire wall thickness to the median thickness and avoid defining different exterior and interior angles.
Interior angle: Specifies the angle with respect to the vertical axis at which the inner layer of the wall is inclined. A positive value indicates an inclination towards the centre of the wall, while a negative value indicates an inclination away from the centre of the wall.

Some EPC software are unable to assess walls with varying angles within their layers. Therefore, if a wall has different inclinations between the exterior and interior layers, it is advised to approximate the entire wall thickness to the median thickness and avoid defining different interior angles from the exterior angle.
Width measured: Position in which the wall width will be measured in the case of inclined layers. It can be chosen between Superior (upper part of the wall), Inferior (bottom part of the wall), or Base (base level). If the previous recommendations are followed (using the same exterior and interior angles), this parameter will not be applicable in the model.
ANALYTICAL Most of the properties are defined by default based on material characteristics (See Material category).
Absorptance: Capacity of the wall to absorb radiation. For thermal purposes, this parameter holds significance, especially in determining the inertia of the wall. However, for EPC purposes, it may be better defined by the characteristics of the material layers.
MODIFY Available within the tab toolbar in REVIT
Wall Joins: Defines the options for joining two walls, up to a maximum of four walls. It aligns the layers according to the designer's requirements. The joins should accurately represent the real construction system joins to define the appropriate thermal bridges in the EPC software.
BUILDING FLOORS (EXTERIOR AND INTERIOR)
CONSTRAINTS Not all constraints are considered, but those with significant impact on the IFC when exported if they are inadequately defined.
Level: Reference level in which the floor will be created. The floor is typically generated under the selected reference level. It is recommended to maintain it in this position to ensure its connection with the walls due to top and bottom level restrictions. However, in case of need, it could be moved through Offset option (See *Height offset from the level* concept).
Height offset from the level: Specifies the elevation of the floor relative to the reference level. It is recommended to keep it at 0.00 to ensure connections between walls and floors and to avoid envelope discontinuities. If the height offset is modified, it is advisable to double-check the connections between walls and floors.
Room bounding: If selected, the floor will be used as room boundary. It is recommended to enable this option for all floors (interior or exterior) that demarcate a space to be analysed.
PHASING

Creation Phase: The time condition of the building element. It includes existing or new construction phases by default. However, additional phases can be created if necessary.

For energy purposes model exportation, it is recommended that all elements belong to the same phase.

DIMENSIONS

Directly available when selecting the Floor creation option or in the Modify Tab when selecting a floor.

Boundaries: It enables the creation of the floor shape by drawing it using the available modelling drawing tools. The boundaries correspond to the exterior edge of the floor. It also facilitates the creation of a slope on the floor. If the edges of the floor are not defined by angles, the radius option can be utilized to define circular splices.

It is advisable to align the exterior edge of the floor in the same manner as it is placed in real construction. Typically, it should be positioned coincident with the exterior line of the structure. The placement of the floor is crucial to consider thermal bridges. All wall layers outward of the floor boundary line will be regarded as continuous layers when joining the elements.

PROPERTIES

Available in the Properties' toolbar

Family: The available system families to which the floor can belong.

It is recommended that the chosen family correspond to the specifications of the reality of the construction. Otherwise, modifying the type of information will require more work for the modeler.

Type (Edit type option): The exact construction type of the floor. It is defined by the type parameters.

It is important to use duplicate option when starting to create a type with the modification of an existing family type.

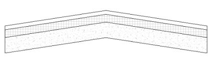
CONSTRUCTION

Available in *Edit type* option (See *Type* concept).

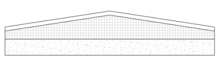
Structure: Defines the composition of a multi-layered floor.

Each layer should be specified by its function, material, and width.

Layers composing the structure of the floor should be designated as *Structure material*. If the floor has a slope, the *variable* parameter should be selected in the layer defining the slope. If no layer is selected, all the materials will be inclined.



No variable layer



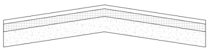
Variable mortar layer

It is recommended to accurately define the function of the layers as it will affect joints and connections with other elements.

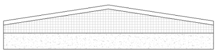
Materials should be selected from the material library. Since material properties and layer widths determine the thermal properties of the floor, choosing materials with appropriate thermal properties from the library is important (See *Materials* category table for more information).

Since some EPC software cannot evaluate variable thickness layers, it is important not to select the *variable* parameter. Doing so may result in the building element differing from reality. Therefore, it is advised to model the layer with a continuous thickness (without selecting the *variable* option), but in a way that simulates the behaviour of the layer with variable thickness.
Width: Read-only parameter. The width parameter of the floor will be automatically defined based on the sum of its layers' width (See *Structure* concept).
Function: Defines the connections between different environments separated by the floor. Therefore, the function can be chosen among exterior or interior. This parameter is extremely important to define and check, as simulation tools will determine the heat exchange conditions of the elements based on it.
ANALYTICAL Most of the properties are defined by default based on material characteristics (See Material category).
Absorptance: Capacity of the floor to absorb radiation. While this parameter holds significance for thermal purposes, especially in understanding the inertia of the wall, for EPC purposes, it may be more effectively defined by the characteristics of the material layers.
MODIFY Available within the tab toolbar in REVIT
This parameter allows joining building elements to prevent two materials from being placed simultaneously. It aligns the layers of walls and floors according to the location of the floor boundary and prioritizes their structure layers. The joins should accurately replicate real construction to define adequate thermal bridges in the EPC software.
BUILDING ROOF
CONSTRAINTS Not all constraints are considered, but those with significant impact on the IFC when exported if they are inadequately defined.
Base Constraint: The base level on which the roof resides. The roof will be placed below the level with reference to the structure layer. It is recommended to maintain this way of placement to ensure continuity with the walls. However, if the designer needs to modify the reference, the *Height offset from the level* option can be used.
Height offset from the level: Defines the elevation of the roof with respect to the reference level. It is recommended to maintain it in 0.00 to ensure connections between walls and floors and avoid envelope discontinuities. If the height offset is modified, it is recommended to double-check the joins between walls and floors.
Top constraint: The level that the roof will extend to.

It is recommended to organize the model by levels. Therefore, the roof will terminate at the immediate upper level. If there are varying heights, different levels should be created accordingly.
Room bounding: If selected, the roof will serve as room boundary. It is recommended to enable this option for all floors (whether interior or exterior) that demarcate a space to be analysed. In the case of under-roof non-conditioned spaces, they must be evaluated for energy purposes. Therefore, room bounding must be activated, and the space below the roof should be defined as unconditioned (See Analytical model chapter).
PHASING
Creation Phase: This parameter represents the time condition of the building element. By default, only existing or new construction phases are available, but additional phases can be created as needed.
For energy purposes model exportation, it is recommended that all elements belong to the same phase.
DIMENSIONS Directly available when selecting the roof creation option or in Modify Tab when selecting a roof.
Boundaries: This parameter enables the creation of the roof shape by drawing it with the available modelling drawing tools. The boundaries refer to the exterior edge of the roof. It also facilitates the creation of a slope for pitched roofs by defining the slope option and specifying the degrees of the slope. Alternatively, the slope arrow can be defined. Cantilevered roofs can also be created by specifying the length of the cantilever. It is recommended that the exterior edge of the roof be positioned in the same manner as in real construction to avoid discontinuities in the building envelope.
PROPERTIES Available in the properties' toolbar
Family: Specifies the available system families to which the roof can belong. It is recommended to select a family that corresponds to the specifications of the construction reality. Otherwise, modifying the type of information will require more work for the modeler.
Type (Edit type option): The construction type of the roof. It is defined by the type parameters. It is important to use the duplicate option when starting to create a type with the modification of an existing family type.
CONSTRUCTION Available in *Edit type* option (See *Type* concept).
Structure: Defines the composition of a multi-layered roof. Each layer should be defined by its function, material, and width. The layers that compose the structure of the roof should be designated as *Structure material.* In case of slope of the roof, the *variable* parameter should be selected in the layer that defines the slope. If no layer is selected, all the materials of the roof will be inclined.



No variable layer



Variable mortar layer

It is recommended that the function of the layers be accurately defined since it will affect joints and connections with other elements.

Materials should be chosen from the material library. Since the properties of the materials and the width of the layers determine the thermal properties of the roof, it is important to select materials with appropriate thermal properties from the list of the material library (See *Materials* category table for more information).

Since some EPC software are unable to evaluate variable thickness layers, it is important not to select the *variable* parameter. Doing so may result in the building element differing from reality. Therefore, it is recommended to model the layer with a continuous thickness (without selecting the *variable* option), but in such a way that the layer with the continuous thickness value will resemble the behaviour of the layer with the variable thickness.

Width: Read-only parameter: The width parameter of the roof will be automatically defined based on the sum of its layers' width (See *Structure* concept).

ANALYTICAL

Most of the properties are defined by default based on material characteristics (See Material category).

Absorptance: Capacity of the roof to absorb radiation.

While this parameter is important for thermal purposes, especially for understanding the inertia of the wall, for EPC purposes, it may be better defined by the characteristics of the material layers.

MODIFY

Available within the tab toolbar in REVIT

Joins: This parameter allows joining building elements to prevent two materials from being placed simultaneously. It aligns the layers of walls and roofs according to the location of the floor boundary and prioritizes their structure layers.

The joins should represent the real construction systems joins to define adequate thermal bridges in the EPC software.

BUILDING CEILINGS

CONSTRAINTS

Not all constraints are considered, but those with significant impact on the IFC when exported if they are inadequately defined.

Level: Specifies the reference level in which the ceiling will be created. The reference level is immediately below the ceiling placement.

Height offset from the level : Defines the elevation of the ceiling relative to the reference level. It determines the clear height of the room.

Room bounding: If selected, the ceiling will be used as room boundary. It is recommended to enable room bounding for all ceilings that delineate a space to be analysed. Failure to do so will result in the ceiling being ignored, and the floor will be evaluated as the room boundary. For energy purposes, it is advisable to enable room bounding for both the floor and the ceiling. This ensures that the space between the two elements is analysed as non-conditioned space to evaluate thermal flows (See Analytical model chapter)
DIMENSIONS Directly available when selecting the ceiling creation option or in Modify Tab when selecting a ceiling.
Boundaries: The ceiling can be created in two different ways: automatically or manually. When selecting automatically, the boundaries of the ceiling are created based on the limits of the walls, while when selecting manually, the ceiling must be drawn. It is recommended to use the inner boundary of the wall to create the ceilings. Ceilings must completely enclose the space. This is done automatically when selecting *automatic ceiling* creation, therefore, this option is recommended. However, the correct placement of the ceilings must be verified.
PROPERTIES Available in the properties' toolbar
Family: The available system families to which the ceiling can belong. It is advisable to select a family that corresponds to the specifications of the actual construction. Otherwise, modifying the type of information will require more effort from the modeler.
Type (Edit type option): The exact construction type of the ceiling. It is defined by the type parameters. It is important to utilize the duplicate option when beginning to create a type by modifying an existing family type.
CONSTRUCTION Available in *Edit type* option (See *Type* concept).
Structure: Defines the composition of a multi-layered ceiling. Each layer should be defined by its function, material, and width. The layers that compose the structure of the ceiling should be checked as *Structure material.* It is recommended that the function of the layers is correctly defined since it will be considered in joints and connections with other elements. The materials of the elements should be chosen from the material library. (See *Materials* category table for more information).
Width: Read-only parameter. The width parameter of the ceiling will be defined automatically depending on the sum of its layers' width (See *Structure* concept).
BUILDING WINDOWS
CONSTRAINTS

Not all constraints are considered, but those with significant impact on the IFC when exported if they are inadequately defined.
Level: Reference level in which the window will be created. The reference level is immediately below the window placement.
Sill height: The height of the sill in relation to the reference level where the window is placed. The placement of the window is crucial for energy purposes, particularly concerning daylighting and solar gains. It is recommended that the sill height accurately reflects reality.
Orientation: This parameter is only available when placing windows in inclined walls. It allows to define if the window is inclined with the wall or remains vertical. The parameter orientation must be manually changed for each window. In cases where an inclined wall exists, it is recommended to individually verify if all the windows are in the desired orientation. The combination of inclined walls and vertical windows can lead to continuity problems if the inclination of the wall is too high. If this is the case, it is recommended to create a specific family for the wall and pay special attention to the joints.
PROPERTIES Available in the properties' toolbar
Family: The available system families to which the roof can belong. It is recommended that the chosen family is as approximate as possible to the specifications of the actual construction.
Type (Edit type option): The construction type of the window. It is defined by the type parameters. It is important to use duplicate option when starting to create a type from modifications to an existing family type.
MATERIALS AND FINISINGS Available in *Edit type* option (See *Type* concept).
Separated in multiple options depending on the window: Glass, Frame, Sill, Blind, Blind Structure... Defines the materials of the window selected from a library. It is recommended that the chosen materials have thermal properties to be suitable for energetic purpose (See Materials section). However, another option is possible (See Analytical properties of Building windows).
DIMENSIONS Available in *Edit type* option (See *Type* concept).
Height: Defines the height of the window. The window height should accurately represent reality.
Length: Defines the length of the window. The window length must accurately represent reality.

ANALYTICAL PROPERTIES Available in *Edit type* option (See *Type* concept).
Define thermal properties by: List of options to define the thermal properties: Building type, Schematic type or user defined. It is recommended to use user-defined if the exact properties of the window are known. Otherwise, it is recommended to use schematic type.
Analytic construction: List of window options with analytical properties. This can only be modified when the schematic type is chosen. If using schematic type, the selection of the type of window will automatically define the analytical properties.
Visual light transmittance: Defines the percentage of visible light transmission through the glass. This parameter is only adjustable when the user-defined option is chosen. If other options are selected, the parameter is set automatically.
Solar heat increase coefficient: The amount of solar radiation that can pass through the window. It is only adjustable when the user-defined option is chosen. If other options are selected, the parameter is set automatically.
Heat transfer coefficient (U value) [Thermal transmittance]: Defines how much heat flows through the window per unit area when the thermal difference between the two separated areas is 1 Kelvin. It is only adjustable when the User-defined option is chosen. If other options are selected, the parameter is set automatically.
BUILDING DOORS
All the properties are the same as windows, except that in the door, the Function parameter must also be defined (exterior or interior). This parameter can be defined within the *Construction* group of parameters within the *Edit type* option.

5.1.2 Table 1.1.2 - Minimum required category for Materials in REVIT

Minimum required category: Materials
MATERIALS IN REVIT: MATERIAL LIBRARY WITHIN MANAGE TAB
GENERAL RECOMENDATIONS
When using the material library, it is recommended to begin composing the material based on a similar existing material. By doing this, the identity, graphics, and appearance tabs do not need to be modified. The Physical tab can be adjusted if the parameters for structural analysis of the material are known, although this is not crucial for energy purposes. It is necessary to duplicate the material and the object of the material (Appearance, physical, and thermal tabs). This recommendation does not apply for loadable materials since all the real properties are specified in the input files.

Additionally, it is recommended to fill out all the parameters of the Thermal Tab properties that are shown in this table (Table 1.1.2). These parameters are used to automatically calculate Analytical properties of all the building elements from the previous table (Table 1.1.1).
THERMAL TAB - PROPERTIES
Light transmission
Specifies whether the material can let light pass through it.
Thermal conductivity
Indicates the material's ability to conduct heat.
Specific heat
Represents the amount of heat required to raise the temperature of a unit mass of the material by one degree.
Density
Describes the relationship between the mass of the material and the volume it occupies.
Permeability
Defines the material's capacity to allow liquid to pass through it without altering its inner structure.
Reflexivity
Indicates the proportion of radiation reflected by the material.

5.1.3 Table 1.1.3 - Minimum required category for Solar protections in REVIT

Minimum required category: Solar protections
OVERHANGS
GENERAL RECOMENDATIONS
Non-mobile overhangs are commonly integral to the structure of the building. Because they play a pivotal role in evaluating both solar gains and thermal bridges, it is recommended to model the overhangs. They should adhere to the recommendations and minimum requirements set for roofs or floors, but with the consideration of their function as exterior elements.
SLATS
GENERAL RECOMENDATIONS
As with overhangs, slats play a crucial role in evaluating solar gains. If the construction includes a significant number of slats, it is recommended to model them as part of the window family in REVIT.

OTHER PROTECTIONS (Blinds and mobile protections)
GENERAL RECOMENDATIONS
Mobile protections present challenges in evaluation as they rely on the behaviour of building occupants, impacting heat gains during both winter and summer. Consequently, the decision to model them depends on the discretion of the modeller. However, it is advisable that if a schedule for the protections cannot be established, and the simulation software cannot interpret when the protections are active or inactive, the modeller should avoid investing time in modelling them. Alternatively, their influence on the building can be assessed by incorporating their thermal characteristics within the window's properties, such as modified solar factor and/or thermal transmittance.

5.1.4 Table 1.2.1 - Minimum required category for Building Envelope in CYPE

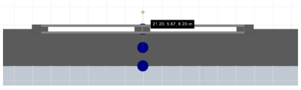
Minimum required category: Building Envelope
BUILDING WALLS (EXTERIOR AND INTERIOR) IN CYPE: CYPE ARCHITECTURE SOFTWARE *The parameters also apply for curtain walls
GEOMETRY *Not all parameters in the geometry will be explained, but the ones having a great impact in the IFC when exported if they are inadequately defined.
Level
The reference level in which the wall is positioned.
It is recommended to model the walls split into different levels. Therefore, a façade of a four stores building will be divided into four façades started each one in each level.
Introduction mode
The way of modelling the wall can be chosen from polyline, points, and surface options. • Polyline: Walls are defined as vertical based on two coordinates of the reference system. • Points: Walls are defined by inserting points that delineate the boundaries of the wall. • Surface: Walls are defined with reference to a previously modelled surface. This surface can be created using the sketching tools option.
It is advisable to define walls according to reality. Typically, except for inclined walls, the Polyline walls definition is recommended. This saves time for the BIM modeller, as they do not have to draw all the surfaces in the model. Using points to define walls can be useful for trapezoidal or inclined walls. However, since some EPC software cannot evaluate this kind of walls, this option is not recommended in such cases. Instead, it is recommended to define an equivalent thickness for a vertical wall.

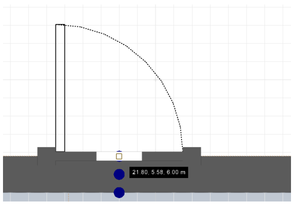
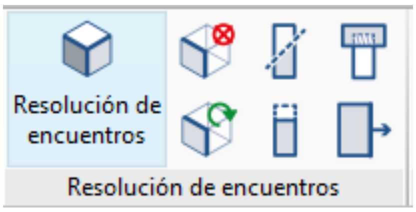
Height
The height of the wall. This parameter will only appear if the Polyline introduction mode is selected.
It is advisable that the height of the wall aligns with the vertical distance between two successive levels. This guidance remains applicable to both *By points* and *By surface* definitions, notwithstanding that in these instances, the wall's height is determined manually by positioning either the uppermost points of the wall or the reference surface's elevation.
PROPERTIES *Not all parameters in the properties will be explained, but the ones having a great impact in the IFC when exported if they are inadequately defined.
Category
Defines the connections between different environments that the wall separates. Therefore, the category can be chosen among interior, exterior, party wall, or underground wall.
This parameter is extremely important to define and check, since the simulation tools will define the heat exchange conditions of the elements based on it.
Thickness
The whole thickness of the wall. In this case, the CYPE Architecture software does not allow defining the thickness of the wall based on its layers, as these will be defined later with another software (Open BIM Construction Systems).
It is recommended that the thickness of the wall matches the sum of its layers' thicknesses. This ensures compatibility with the next software. If the thicknesses do not match, the Open BIM Construction Systems software will prompt the BIM modeler to adjust either the wall thickness or the thickness of its layers. Failure to align these parameters will result in a model that does not accurately represent reality.
ADJUST
Adjust
It determines the position where the wall will be modelled in relation to the drawing line introduced by the BIM modeler. The available options include: left alignment, right alignment, and centre alignment.
It is advisable to select the "Adjust" parameter based on the chosen reference for measuring spaces in existing buildings or on drawing plans. Establishing prior rules for the alignment line ensures that the volume of interior spaces aligns with reality.
Note: In CYPE architecture the inclination of the wall is defined manually by drawing the wall by points.
BUILDING FLOORS (EXTERIOR AND INTERIOR) AND ROOFS IN CYPE: CYPE ARCHITECTURE SOFTWARE
Level

The reference level of the floor.
The floor must be positioned with reference to a predefined level.
Introduction mode
It refers to the method used to model the floor. It can be selected as either "points" or "surface." • Points: The floor is defined by inserting points that outline its boundaries. • Surface: The floor is defined using a previously modelled surface as a reference. This surface can be created using sketching tools.
It is recommended to adequately model the floor considering its connections with the walls. Therefore, the edges of the floor should align with the hypothetical layer of the wall to which they will be connected. This can be achieved by creating a drawing reference line at the correct position of the wall and using it as a reference for placing points or drawing the surface of the floor.
Including surface holes
This option allows you to create the floor while considering any openings or holes in the previously sketched surface. It is only available when the *By surface* floor introduction mode is selected.
It is recommended to enable this option when using the *By surface* introduction mode since it streamlines the modelling process. This option eliminates the need to manually create holes using the hole tool in CYPE Architecture. To use this feature, you need to draw the floor surface using the sketching options, including any overlapping surfaces where the holes are located. This action will divide the surface into multiple segments based on the drawn shapes. Then, you can manually erase the surfaces representing the holes. Ultimately, you will achieve a surface with holes that can be used to model the floor accurately.
PROPERTIES *Not all parameters in the properties will be explained, but the ones having a great impact in the IFC when exported if they are inadequately defined.
Category
The category parameter defines the connections between different environments that the floor separates. It can be chosen among interior, exterior, in contact with the ground, or roof.
This parameter is crucial for defining and evaluating heat exchange conditions within the simulation tools. Therefore, it is essential to accurately specify the category based on the floor's function and its relationship with the surrounding environments.
Thickness
The thickness parameter defines the total thickness of the floor. In CYPE Architecture, the software does not allow the thickness of the floor to be defined based on its layers, as the layers will be defined later with another software (Open BIM Construction Systems).
It is recommended that the thickness of the floor matches the sum of its layers' thicknesses to ensure consistency with the next software. Failure to match these thicknesses may result in warnings from the Open

BIM Construction Systems software, prompting the BIM modeler to adjust either the floor thickness or the thickness of its layers to ensure alignment with reality.
ADJUST
Adjust
It defines the position in which the floor will be modelled with respect to the drawing line introduced by the BIM modeler. The options available are: above the line, below the line, or in the centre of the line.
It is recommended to select the *adjust* parameter based on the chosen reference for measuring space in existing buildings or for defining the modelling based on drawing plans. Establishing clear rules for the adjustment line beforehand ensures that the volume of interior spaces aligns with reality.
BUILDING CEILINGS IN CYPE: CYPE ARCHITECTURE SOFTWARE
Level
The reference level in which the ceiling is positioned.
The ceiling must be aligned with a predefined level.
Introduction mode
The ceiling can be modelled using one of three methods: points, surface, or floor edges. • Points: The ceiling is defined by inserting points that delineate its area. • Surface: The ceiling is modelled above a surface, created using sketching tools, which serves as a reference. • Floor Edges: The ceiling is automatically defined using the external edges of the walls that enclose the space.
It is advisable to model the ceiling accurately, ensuring proper connections with the walls. The *by points* ceiling tool is recommended for this purpose, although the choice depends on the BIM modeler's needs and available time. It's crucial to enclose the spaces both above and below the ceiling with appropriate construction elements. Failing to do so can lead to thermal losses due to a connection between the plenum and habitable spaces.
PROPERTIES
The properties parameters of the ceiling are category (continuous or registrable) and the length and width of the panels. Since no recommendations are necessary for these options they will not be explained. However, it must represent the reality of the construction.
BUILDING WINDOWS
Level
The reference level in which the window is positioned.

The window should be positioned with reference to the level immediately below it.
PROPERTIES (Description option within the Window type reference) *Not all parameters in the properties will be explained, but the ones having a great impact in the IFC when exported if they are inadequately defined.
Shape of the window
The shape of the window can be selected from circular or rectangular options.
It is advisable to choose a shape that accurately represents the real window geometry.
Dimensions
The length and height of rectangular windows or the diameter of circular ones.
The widow dimensions must be accurate when compared to those of the real building. They are defined for the complete hole of the window, so it's recommended to input the dimensions of the hole in the wall, including glazed surfaces and frames.
Number of panels of the window
The quantity of glazed panels within the window.
It is important to input this parameter to accurately define the inner separation frames between the leaves of the window. This ensures that the thermal and physical geometry parameters are correctly interpreted by the EPC software.
Height from the floor
Indicates the elevation at which the window will be positioned, measured from the floor level.
Insertion point
It determines the location within the window geometry that will be used for placement, based on its position in the model and the height from the floor. The options for window placement are illustrated in the following diagram: 
It is important to ensure that the insertion point aligns with the desired height from the floor to accurately position the window within the mode.
Adjust
It determines the positioning of the window relative to the drawing reference line. The available options include aligning the window to the left of the line, to the right of the line, or at the centre of the line.

Ensuring the correct adjustment of the window is important, as it impacts the representation of reality within the model. Proper placement within the wall is essential for managing thermal bridges effectively, especially concerning its position relative to the insulation.
**PLACEMENT POINT IN THE WALL (Is not a parameter but the options for placing the window when modelling)
It defines the position of the window with respect to the layers of the wall. The software allows the modeller to choose between the exterior edge of the wall thickness, the middle point of the wall, and the interior edge of the wall thickness. 
BUILDING DOORS
Level
The reference level in which the door is positioned
The door should be positioned with reference to the level immediately below.
PROPERTIES (Description option within the Door type reference) *Not all parameters in the properties will be explained, but the ones having a great impact in the IFC when exported if they are inadequately defined.
Dimensions
The length and height of the door hole, including the width of the door frame.
The dimensions of the door must be accurate when compared to the real building. The dimensions are defined for the door hole and the frame to automatically determine the dimensions of the door leaf. Therefore, it is recommended to manage the door's information accurately to ensure it is correctly introduced into the model.
Glazed surface
Definition of a glazed portion within the door leaf. If selected, it also permits the specification of the dimensions of the glazed area.
It is important to accurately represent the glazed portions of doors, especially when dealing with fully glazed doors in a building. Using this option to define glazed surfaces within doors, rather than using the window option, is recommended. This ensures proper categorization by EPC software.
Insertion point
Defines the point of the geometry of the door that will be used to place it, according with the position in the modelling. The possibilities of placing the door are shown in the following schema:


Adjust
It sets the position of the door accurately concerning the drawing reference line that appears during the door placement. The options allow you to position the door to the left, right, or centre of the line for proper alignment within the model.
Ensuring the correct adjustment of the door is essential for maintaining model accuracy and effectively representing reality. Proper placement within the wall, considering factors such as insulation and thermal bridges, contributes to an accurate depiction of the building's structure and characteristics.
**PLACEMENT POINT IN THE WALL (Is not a parameter but the options for placing the door when modelling)
It defines the position of the door with respect of the layers of the wall. The software allows the modeller to choose between the exterior edge of the wall thickness, in the middle point of the wall, and in the interior edge of the wall thickness. 
JOINTS SOLUTION TOOLS
Package of different tools designed to address encounters between building elements. While some tools enable the modeler to manually define these encounters, one tool automates the resolution of all encounters across the project. 
It is advisable to review the automatically resolved encounters to ensure they align with reality. If any discrepancies are found, manual adjustments should be made accordingly to ensure accuracy in the model.

5.1.5 Table 1.2.2 - Minimum required category for Materials in CYPE

Minimum required category: Materials

MATERIALS IN CYPE: OPENBIM CONSTRUCTION SYSTEMS SOFTWARE (Within the materials category all analytical and physical properties of the building elements and construction systems were define. However, instead of defining them in the same modelling software as REVIT, CYPE split the modelling into two software. This could be beneficial for the cases in which there are more than one BIM modellers, and they have different tasks based on their expertise)
GENERAL RECOMENDATIONS
There are two possible options for defining materials and their characteristics within the construction systems software: • Option A, also known as the simplified approach, does not require detailed material specifications. Instead, it considers the general thermal parameters of the construction element. The thickness of the element is determined based on the information provided in the architectural model within the CYPE Architecture software. Additionally, users can select from a range of pre-defined construction systems stored in the CYPE library (OBDatabase), which is particularly useful for existing buildings. • Option B, on the other hand, involves specifying all materials and their characteristics in detail. This includes defining the layers of the construction element and providing information about each layer's thermal properties. Option B offers a more comprehensive approach and provides detailed information about the composition of the wall. When choosing between these options, the user should consider the available data for the building. If detailed material information is not available, Option A may be more suitable. However, whenever possible, Option B is recommended for its ability to provide a more accurate representation of the construction element.
Layer type
Specifies the type of layer being defined. Users can choose from three options: Solid layer (any material except air or vapor barrier), Air chamber, and Vapor barrier.
The type of layer must be accurately defined.
*When choosing solid layer:
Thickness
The thickness of the material composing the layer.
The thickness must be precise. Otherwise, the simplified option (Option A) should be chosen.
Thermal resistance
It defines the material's resistance to heat transfer. It is the inverse of thermal conductivity.
Specific heat
The amount of heat required to raise the temperature of a unit mass of the material by one unit.
Vapour resistance coefficient

The permeability of the material to water vapour.
*When choosing an air chamber layer:
Thermal resistance
Defines the resistance of the material to be traversed by heat. It is the inverse of thermal conductivity.
*When choosing a Vapour barrier layer:
Equivalent air thickness
The resistance to vapor diffusion by comparing it to the resistance of water vapor moving through a layer of air with a specific thickness (Sd).
THERMAL BRIDGES DEFINITION GENERAL RECOMMENDATIONS
With Open BIM Construction Systems, there is an option to input evaluation parameters for thermal bridges resulting from encounters. To do this, the modeller needs to know the height, width, and linear thermal transmittance of the encounters between all the systems. While providing this information could be valuable for EPC developers, it requires time from the modeller. Hence, it is recommended to utilize Open BIM Analytical software for a better evaluation of thermal bridge dimensions and to use specific software to calculate their values. Some EPC software also offer thermal bridge calculation capabilities. If the EPC software, such as CYPEtherm, supports calculating these values, it us advisable to use it as it will provide the best solution for evaluating thermal bridges.

5.1.6 Table 1.2.3 - Minimum required category for Solar protections in CYPE

Minimum required category: Solar protections
OVERHANGS
GENERAL RECOMENDATIONS
Non-mobile overhangs, integral components of building structures, significantly influence assessments of solar gains and thermal bridges. To accurately represent these features, it's advisable to model them according to the recommendations and minimum requirements for roofs or floors, while emphasizing their function as exterior elements.
SLATS
GENERAL RECOMENDATIONS
Similar to overhangs, slats are critical in evaluating solar gains. When a construction features a significant number of slats, it is recommended to model them using the Lattice tool in CYPE Architecture.
OTHER PROTECTIONS (Blinds and mobile protections)

GENERAL RECOMENDATIONS
Modelling mobile protections, such as blinds or shades, poses challenges due to their dependence on occupants' behaviour. If establishing a schedule for these protections is not feasible and simulation software cannot interpret their activation, it is recommended to refrain from modelling them. In such cases, their influence on the building can be approximated by adjusting the thermal characteristics of the window, such as the modified solar factor and thermal transmittance. This approach allows for a simplified assessment of their impact on solar gains and thermal performance without the need for detailed modelling of the protections themselves.

5.2 Annex 2 – Information requirement for the analytical model

Note: The information shown in the following tables is an example of the basic geometrical and parametrical rules, tips, and tools to model a building with the minimum characteristics to ensure its evaluation with an EPC software. To learn how to model with REVIT or CYPE, please use the REVIT or CYPE guidelines for modelling.

5.2.1 Table 2.1.1 – Minimum required category for Rooms/Spaces in REVIT

Minimum required category: Room/Space
SPACE
CONSTRAINTS
Level
The base level indicates the level on which a space resides within the building.
As with architectural elements, it is recommended to organize spaces into levels. This helps prevent interoperability issues between BIM software, IFC format, and EPC generation software.
Upper Limit
The designated reference level for determining the upper boundary of the space.
It must align with the inner part of the upper floor. In cases where a false ceiling is present, the upper boundary can be defined up to the height of the false ceiling. However, it is necessary to assign a separate space for the area between the false ceiling and the upper floor, known as the plenum.
Base Offset
It defines the distance from the base level to the lower boundary of the space.
It is advisable to minimize the use of offset to maintain consistency between spaces and their respective levels. Excessive offset may cause interference in simulation software. If necessary, consider creating new intermediate levels instead of relying heavily on offset.

DIMENSIONS
Area
The net area computed from the room-bounding elements.
The net area, computed from the room-bounding elements, is a crucial parameter for generating an EPC. Serving as the functional unit for energy performance calculations, it is imperative that the space is accurately modelled without any gaps in relation to the actual structure.
Perimeter
The perimeter of the room.
Volume
The volume of the space.
Similar to area, volume serves as a functional unit for energy calculations. It is highly recommended to model volumes as faithfully to reality as possible to ensure accurate energy performance assessments.
IDENTITY DATA
Number
A unique identifier assigned to each space within a project.
It is advisable to use an alphanumeric code for space identification, ensuring uniqueness and clarity. For instance, 'A1-KTC' could represent the kitchen of Apartment 1.
Name
The name assigned to the space, indicating its function or purpose, such as 'Restroom' or 'Kitchen'.
It is recommended to use to use descriptive names that clearly indicate the intended function of the space; for example, 'Kitchen'.
Occupant
The individual, group, or organization that will utilize the space.
PHASING
Phase
The stage of the project to which the space belongs.
For energy modelling and export purposes, it is recommended that all spaces belong to the same phase.
ENERGY ANALYSIS

Zone
The name of the zone assigned to the space.
This value is automatically populated when the zone is assigned to the space.
Occupiable
Indicates if the space is occupiable or not.
Clear the check box for spaces such as shafts, chases, restrooms, and other that are typically unoccupied.
Condition Type
Determines how heating and cooling loads should be calculated.
The *Condition Type* parameter determines how heating and cooling loads are calculated for a space. It offers options such as *Heated*, *Cooled*, *Heated and cooled*, *Unconditioned*, *Vented*, and *Naturally vented only*. Each option corresponds to a specific method of load calculation, ranging from heating only, cooling only, both heating and cooling, or no conditioning at al.
Space Type
Defines default schedules and settings for the building and space parameters used to calculate heating and cooling loads.
Construction Type
The type of construction for different elements such as roofs, walls, floors, etc., within the space.
You can open the *Construction Type* dialog to select a predefined construction type or define custom constructions specifically tailored for the space.
People
To specify the methodology used to calculate the heat gains from occupants within the space.

5.2.2 Table 2.1.2 – Minimum required category for Zones in REVIT

Minimum required category: Zone
ZONE
CONSTRAINTS
Level
The base level on which the zone resides.

Since zones can span multiple levels, the reference level is defined as the level where the lowest space is situated.
DIMENSIONS
Occupied Area
The cumulative sum of all the areas occupied by spaces within the zone.
This value is automatically calculated.
Gross Area
The total sum of areas encompassing both occupied and unoccupied spaces within the zone.
This is a calculated value.
Occupied Volume
The total sum of volumes occupied by all spaces within the zone.
This is a calculated value.
Gross Volume
The total sum of volumes occupied by all spaces, both occupied and unoccupied, within the specified zone.
This is a calculated value.
Perimeter
The perimeter is the total sum of the perimeters of all spaces within the zone. This calculation excludes any common parameters shared by these spaces.
This is a calculated value.
IDENTITY DATA
Name
Name of the zone.
It is important that each name is unique within the project. Preferably, the name should reflect the function or purpose of the zone within the building.
PHASING
Phase
The project phase to which the zone belongs.

For energy modelling purposes and model exportation, it is recommended that all zones belong to the same phase within the project.
ENERGY ANALYSIS
Service Type
The heating and cooling service for the zone.
Users can select a specific service type from the available options or accept the default service type specified as <*Building*> for the zone. Common options include Central Heating, Radiant Heater, Forced Convection Heater, VAV (Variable Air Volume), Fan-Coil, among others.
Coil Bypass
The manufacturer's coil bypass factor.
This is a measure of efficiency that indicates the volume of air passing through the coil unaffected by the coil temperature.
Cooling Information
Here it is possible to specify the cooling information for the zone.
• Cooling Set Point: The temperature at which the system will maintain cooling in all spaces within the zone. • Cooling Air Temperature: The supply air temperature used to cool all spaces within the zone. • Humidification Control: Activates the humidification control for the zone. When Humidification Control is activated, reheat loads are calculated. • Dehumidification Set Point: The percentage (%) of humidity that the system will maintain for all spaces within the zone.
Heating Information
Here it is possible to specify the heating information for the zone.
• Heating Set Point: The temperature at which the system will maintain heating in all spaces within the zone. • Heating Air Temperature: The supply air temperature used to heat all spaces within the zone. • Humidification Control: Activates the humidification control for the zone. • Humidification Set Point: The percentage (%) of humidity that the system will maintain for all spaces within the zone. A humidification set point is specified for each zone.
Outdoor Air Information
Here it is possible to specify the outdoor air information for the spaces in the zone.
• Outdoor Air per Person: The quantity of outdoor air needed for each person in a space, applicable to all spaces within the zone. • Outdoor Air per Area: The amount of outdoor air required per occupied square area for all spaces in the zone.

• Air Changes per Hour: The frequency of air volume replacement, measured in times per hour, for all occupied spaces within the zone.
Outdoor Air Method
The method for calculating outdoor air for the zone.
The ASHRAE 62.1 calculation method utilizes the Ventilation Rate Procedure outlined in ASHRAE Standard 62.1. For accurate calculation results using this method, it's imperative to define the Primary Airflow for every space within the zone.

5.2.3 Table 2.2.1 – Minimum required category of Rooms/Spaces in CYPE

Minimum required category: Room/Space
SPACE IN CYPE: CYPE ARCHITECTURE AND OPEN BIM ANALYTICAL MODEL AND CYPE IFC BUILDER
SPACES
Reference
A text that identifies the space in the project.
It is recommended to use to use descriptive names that clearly indicate the intended function of the space; for example, 'Kitchen'. Also, it is possible to use an alphanumeric code to identify spaces that identifies the reference zone.
Type reference
Represents a text that identifies the type of space in the project.
Multiple spaces may possess similar characteristics, allowing this parameter to be utilized for shared reference across them.
Location
Indicates whether it is an internal space or an external space. The external environment option allows all the space outside of the building to be represented.
It is crucial to define this parameter accurately, as it significantly influences energy demand and consumption calculations.
Surface
The net surface computed from the room-bounding elements.
The area of a space is an extremely important parameter for the generation of an EPC. This area serves as the functional unit for energy performance calculations. Thus, it's essential to ensure that the space is accurately modelled without any gaps in relation to the actual structure.

Volume
The volume of the space.
Just like surface, volume serves as a functional unit for energy calculations. Therefore, it is advisable to model volumes as accurately as possible to ensure the reliability of energy performance assessments.
SURFACES
Reference
A textual identifier for surfaces within the project.
Surfaces delineate the boundaries of a space and are typically associated with construction elements such as walls and roofs. The parameter is automatically generated based on the architectural model, so it is important to ensure the consistency of these elements. For instance, a reference might be: "Basic Wall: Ventilated Façade_Thermal".
Type reference
A textual identifier for the type of surface within the project.
Multiple surfaces can have common features, enabling consistent categorization and analysis.
Type of surface
Indicates if it is an opaque or glazed surface.
This distinction is crucial for accurately calculating energy demand and consumption, as it determines the type of heat transfer affecting the surface.
Element in opening
Indicates whether a surface is part of an opening, such as a door or a window.
Associating the correct element type with surfaces is crucial for accurately calculating heat transfer.
External
Indicates that the surface is in contact with the exterior, like the external face of a façade.
Associating the correct surface function is essential for accurately calculating heat transfer.
Space
Indicates the space to which the surface belongs.
It is generally recommended not to change this parameter to maintain consistency between the geometry of the space and the associated surfaces for calculation purposes. However, it can be modified in special design cases.

Adjacency
Indicates the surface of the analytical model that is adjacent to the selected surface.
This information is crucial for establishing relationships between spaces in the analysis of thermal transmissions. It is recognized automatically during the generation of the analytical model. However, for special design cases, it is possible to modify the parameter to change the adjacency of the surface with a customized space, such as a conditioned or unconditioned space.
Layout
Indicates whether the surface is horizontal or vertical. If it is horizontal, it is also necessary to indicate whether it is the ground or the roof.
In general, it is recommended not to change this parameter to maintain consistency between the geometry of the surface and the construction element associated with it. For example, a wall is automatically recognized with a vertical layout. However, it is possible to change it in the event of special design cases, such as defining the behaviour of inclined surfaces.
Geometric parameters
Geometric parameters provide thermal and acoustic calculation models with information about surfaces independently of their representation. These parameters include Width, Height, Surface, Depth, Orientation, Slope, and Perimeter.
In general, it is recommended not to change these parameters as they are automatically calculated during the generation of the analytical model from the architectural model. However, adjustments can be made if necessary for corrections.
EDGES
Reference
Represents a text that identifies an edge in the project.
This parameter is named according to the surfaces that generate it. For instance: Basic Roof: Roof_Thermal - Basic Wall: Ventilated Façade_Thermal. Nevertheless, customization of the reference is also possible.
Space
Indicates the space to which the edge belongs.
In general, it is recommended not to change this parameter to maintain consistency between the geometry of the space and the associated edge. However, it is possible to modify it in special design cases.
Surface 1
Indicates the surface that converges with Surface 2 at the edge.

It is advisable not to alter this parameter to ensure consistency between the geometry of the surface and its associated edge.
Surface 2
Indicates the surface that converges with Surface 1 at the edge.
It is advisable not to alter this parameter to ensure consistency between the geometry of the surface and its associated edge.
Angle
Indicates the angle formed between Surface 1 and 2.
This angle is automatically recognized during the generation of the analytical model, so it is advisable not to modify this parameter unless there are specific design considerations.
Edges
Indicates the edges of the model that, together with the selected edge, form the joint of the construction elements involved.
It is recommended not to change this parameter.
Length
Indicates the length of the edge.
This parameter provides thermal calculation models with information about the edges, regardless of their representation.

5.2.4 Table 2.2.2 – Minimum required category of Zones in CYPE

Minimum required category: Zone
ZONE IN CYPE: OPEN BIM ANALYTICAL MODEL AND CYPETHERM HE PLUS AND CYPE IFC BUILDER
ZONE CLASSIFICATION
Habitable
Area consisting of one or more contiguous habitable rooms.
It is recommended to associate this parameter with all zones that share the same use and equivalent thermal conditions, grouped together for the purpose of calculating the energy demand for EPC. For example, an area composed of the habitable rooms of an apartment.
Non-habitable
An area consisting of one or more contiguous non-habitable rooms.

It is recommended to associate this parameter with all zones that share the same use and equivalent thermal conditions, grouped together for the purpose of calculating the energy demand for EPC. For example, technical spaces or stairwells. It is allowed to decide whether a non-habitable area is included in the thermal envelope of the building or not.
OPERATIONAL CONDITIONS AND INDOOR COMFORT
Setpoint temperatures
The setpoint temperatures for heating and cooling can be defined separately using time profiles.
Selecting the correct setpoint temperature is crucial to ensure indoor comfort within the zone, considering factors such as climate, building type, and occupancy patterns. Recommended setpoint temperatures for heating typically range between 20°C and 22°C during occupied hours, with lower temperatures during unoccupied hours or when the building is not in use.
Unconditioned area
This option applies to buildings for various uses and, in residential buildings, specifically to thermal zones containing enclosures belonging to the common areas of residential blocks.
It is recommended to associate this parameter with areas such as storage zones or mechanical zones that may not require as much heating or cooling as conditioned spaces.
VENTILATION AND INFILTRATIONS
Mechanical ventilation
Ventilation provided by an independent mechanical system.
It is recommended to select this option if the rooms in the zone have a system that is exclusively responsible for ventilation, known as mechanical ventilation.
Ventilation through the air-conditioning system
Ventilation provided by a centralized HVAC system.
It is recommended to select this option if the air will enter the zone through the defined air-conditioning system, known as ventilation through the air-conditioning system. Proper ventilation is important for indoor air quality and occupant health. HVAC systems should provide ventilation based on building occupancy and usage patterns.
Natural ventilation
Ventilation provided using for example operable windows, ventilation louvers, or other building features to allow natural ventilation.
It is recommended to select this option if the zone do not have ventilation systems, , using operable windows, ventilation louvers, or other building features to allow natural ventilation. Even so, the ventilation defined in the

rooms is considered as a thermal load in the zone. Natural ventilation can be an effective way to reduce energy use and improve indoor air quality in building.
Infiltrations
It is possible to define the existence of infiltrations in each zone, which refers to a flow of air from outside that enters the group of rooms in an undesired way.
Infiltration can have a significant impact on the calculation of energy demand, so it is recommended not to ignore it. Proper air sealing of the building envelope can help reduce infiltration and improve energy efficiency.
DOMESTIC HOT WATER (DHW)
Daily DHW demand
Volume of domestic hot water (DHW) consumed in a day.
DHW demand can vary based on factors such as building occupancy and usage patterns. To address DHW demand effectively, it is advisable to consider the adoption of energy-efficient water heating systems, which can help reduce overall energy consumption.
Reference temperature
Production temperature of the DHW volume defined in daily DHW demand.
This parameter should be configured based on various factors, including the type of water heating system in use, the temperature of the cold water entering the system, and the desired temperature of the hot water leaving the system.
Contribution of renewable thermal energy produced on site
The contribution of renewable thermal energy produced on-site represents the percentage of domestic hot water (DHW) demand covered by on-site production facilities utilizing renewable sources like solar thermal energy.
This parameter can be set on an annual or monthly basis, depending on the specific requirements. It is important to configure it if renewable thermal energy systems, such as solar thermal or geothermal systems, are integrated to supplement the heating and cooling systems of the building.
CONDENSATIONS
Condensations
Indoor environment parameters necessary for evaluating the presence of surface and interstitial condensation.
Condensation may occur when warm, moist air encounters cooler surfaces, leading to moisture buildup. To mitigate condensation risks, it is advisable to employ effective insulation and air sealing measures within the building envelope.

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