Erasmus+ Project ID: 2023-1-ES01-KA220-HED-000156652

This Erasmus+ Project has been funded with support from the European Commission. This publication reflects the views only of the authors, and the European Commission and Erasmus+ National Agencies cannot be held responsible for any use which may be made of the information contained therein

Methodology of the Case Studies

Terraced houses in Spain

5-story residencial building in Lithuania

Primary and lower secondary school located in Petrindu/Cuzăplac village, Sălaj County, Romania.

Summary

1-Introduction.

One of the objectives of the WP2 of the BIM4Energy project is to develop a study to evaluate the energy performance of 3 cases of existing and representative buildings in the municipalities of the Project partners using the BIM methodology and propose several alternatives for the energy rehabilitation of these building to improve their energy efficiency. This specific objective will contribute to satisfy different identified needs, as the first step is to evaluate the energy performance of three common place buildings in Spain, Romania and Lithuania, so that results may be extrapolated to other constructions.

This document explains how to use the BIM Methodology to evaluate the energy efficiency of the three buildings to be studied.

Case study number 1 consists of analysing the energy demand and consumption, as well as proposing alternatives that improve its efficiency, of a single-family house, type terraced house, located in the municipality of Ceutí Spain.

Figure 1: Terraced houses in Spain

Case study number 2 will study the energy performance of a five-storey residential building located in Vilnius, Lithuania.

Figure 2: 5-story residencial building in Lithuania

Case study number 3 will study the energy performance of a educational building Romania.

Figure 3: Primary and lower secondary school located in Petrindu/Cuzăplac village, Sălaj County, Romania.

(Built in 1962)

2-Methodology summary

The methodology to be used in the study cases basically consists of following the next procedure:

1. Compilation of information on the buildings to be studied. This information consists of:
    a) Location of the building.
    b) Orientation of the building.
    c) Climate data from the building site.
    d) Plans of the geometry of the building.
    e) Materials and their thicknesses in the different layers of the construction elements he building's thermal envelope (façades, party walls, roof, openings).
    f) Materials of the walls in contact with the ground and the flooring in contact with the ground in the basement of the building.
    g) Materials and their thicknesses in interior partitions and intermediate slabs.
    h) Characteristics of the services: Heating, ventilations and air conditioning systems.
2. Build 3D BIM geometric model of the building to be studied using the plans of the building as reference (with the BIM modeler Cype Architecture).
3. Upload the model in IFC format to a server or common data environment (CDE).
4. Download BIM IFC model and obtaining the geometric parameters of the BIM model for the energy model of the building, using OpenBIM Analytical Model. After that the analytical model of the building is uploaded to the CDE.
5. Characterization of the building's energy model using CypeTherm EPlus:
    a) Using CypeTherm EPlus, we downloaded the BIM model and the analytical model from the CDE to use them to create the energy model.
    b) Entering the location of the building in the model.
    c) Entering the energy generated for self-consumption, if any.
    d) Definition of inhabited and uninhabited areas of the building
    e) Definition of the different spaces in the building.
    f) Entering the model of the materials, thicknesses and conductivities and other properties of the envelope, partitions, slabs, openings and other constructive elements of the building.

g) Entering into the model of the transmittances of the building's thermal bridges. These values can be obtained from catalogues of analysed thermal bridges.

h) Characteristics of the heating, ventilations and air conditioning systems

i) Entering the characteristics of the domestic hot water system into the model.

6. Performing the thermal analysis, using EnergyPlus as engine of the calculations.
7. Obtaining the results reports:

   a) Energy Demand Report

   b) Report on energy consumption and CO2 equivalent emissions produced.

   c) Obtaining the building's energy rating.

The procedure described will be applied to first, study the buildings in their current situation. And then we will go back to step 5 to modify the materials of the thermal envelope and the HVAC systems to quantify the improvement in the energy performance of the buildings studied.

Several alternatives will be studied to improve the thermal envelope of the buildings. And several alternatives to improve the HVCA System will also be considered.

Each improvement measure proposed for the building will be accompanied by the economic cost of its implementation.

A comparative analysis of the alternatives proposed for the improvement of the building energy efficiency in each case of study will also be carried out.

3-Workflow with the Open BIM software

The term Open BIM refers to working with open BIM standards. That is, working with models in IFC format.

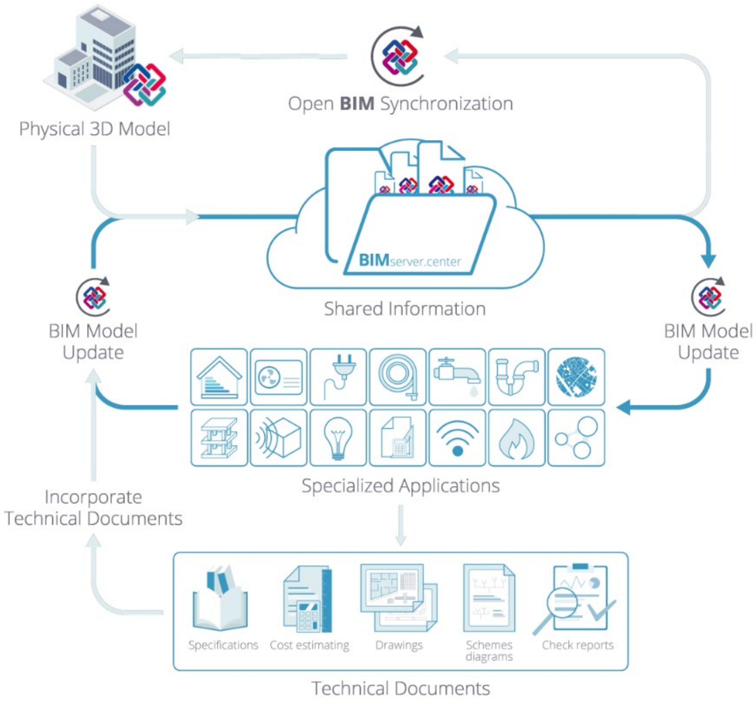

Figure 4: Open BIM workflow of Cype's package for the design of a building.

Cype software has developed a series of BIM tools for the design of building structures, architecture and facilities, through IFC models.

Cype has a common data environment (CDE), called BIMServer.center, where you can share the IFC models of the same building project. The design Cype software of each building discipline are connected to the Building Project in BIMServer.Center, so that users can share the work done through IFC models. In this way, the agents (developers, structural engineers, facilities engineers and architects) working on the same project, in the different disciplines, can see the progress of the work carried out by the rest of the participants.

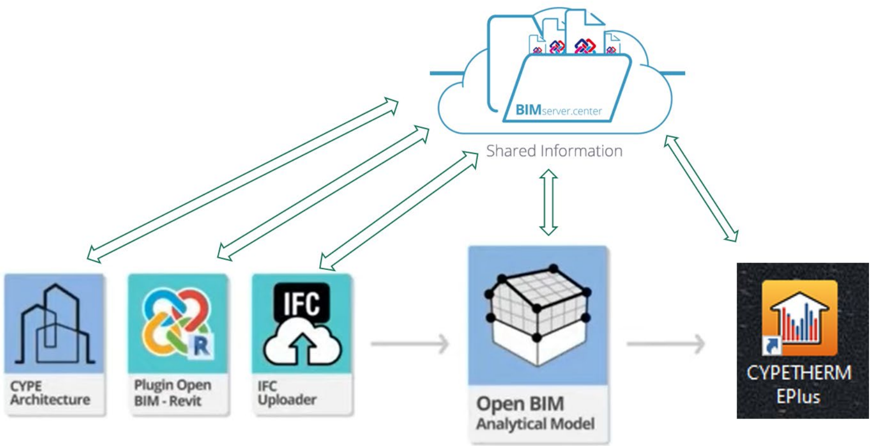

Figure 5: Open BIM Energy Simulation Workflow.

The workflow to carry out the energy simulation of a building using Cype's Open BIM programs consists of using at least 3 different programs sequentially (Fig. 5):

- The first is *Cype Arquitecture*, with which to build the BIM Architectural model
- The second is the *Open BIM Analytical Model*, which calculates the geometric parameters of the different building spaces to be studied.
- And the third is *CypeTherm EPlus* that performs the energy simulation.

To characterize the construction elements as well as the thermal properties of the materials, you can use the *Open BIM Construction System* program or perform this work within *CypeTherm EPlus*, before the energy simulation.

To create the BIM model of the building in IFC format, there are two alternatives to Cype Arquitecture. You can use Revit and the Open BIM plugin to create the IFC and submit it to BIMServer.Center. Or make the BIM model in IFC format with any other program and upload it to BIMServer.Center using IFC Uploader.

The following article from the BIMServer.Center blog provides a detailed explanation of this workflow.

OPEN BIM IN ENERGY SIMULATIONS: CYPE ARCHITECTURE – CYPETHERM WORKFLOW

4-Cype Arquitecture

The architectural development will be carried out in CYPE Architecture, which is a free and complete program for creating BIM models. A notable feature of CYPE Architecture is the possibility of designing the building through a digital sketch. This sketch, within the program itself, is transformed into a BIM model and exported to IFC.

If the user wishes to export information from the architectural model to analysis programs, such as those in the CYPETHERM family, when modelling with CYPE Architecture, it is essential to carry out the obligation of:

4.1-Inserting construction elements

The model must include construction elements from the “Architecture” tab, such as walls, floor slabs, doors and windows. The construction elements can be created either using elements in the “Sketch” tab or inserted from scratch. Each construction element has an associated reference, which will be used later.

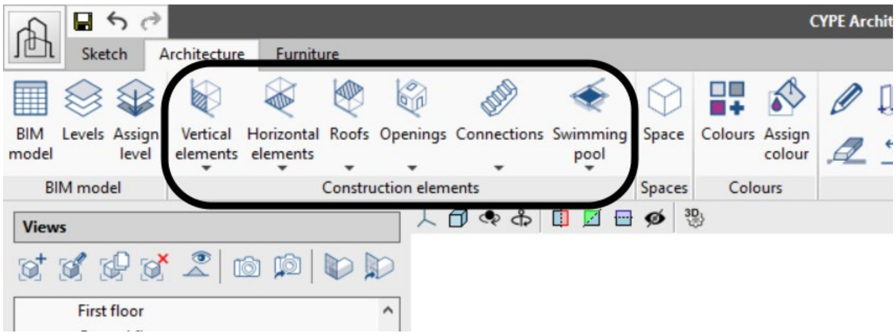

Figure 6: Inserting elements. Screenshot of Cype Architecture

4.2-Defining spaces

In order to conduct energy simulations, the BIM model must contain defined spaces. To define them, use the “Spaces” option in the “Architecture” tab. The perimeter of the spaces must coincide with the internal face of the wall, and the visible face of the floor slabs that form the border. Additionally, if it is a closed space or inside a building, in the "Properties" of the space in the lower part of the definition panel, it is important to mark it as "Indoor" so that the analytical model is generated correctly.

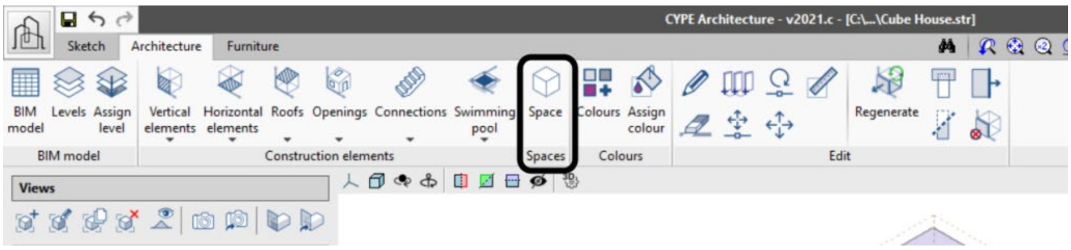

Figure 7: Defining spaces. Screenshot of Cype Architecture

4.3-Creating and assigning levels

All construction elements are assigned to a previously created level. Levels can be created using the “Levels” option in the “Architecture” tab. The “Assign level” tool in the Architecture tab allows the user to assign multiple types of elements to a given level. This action can be done in an elevation or section view, or floor by floor, to make it easier to select elements assigned to a given level.

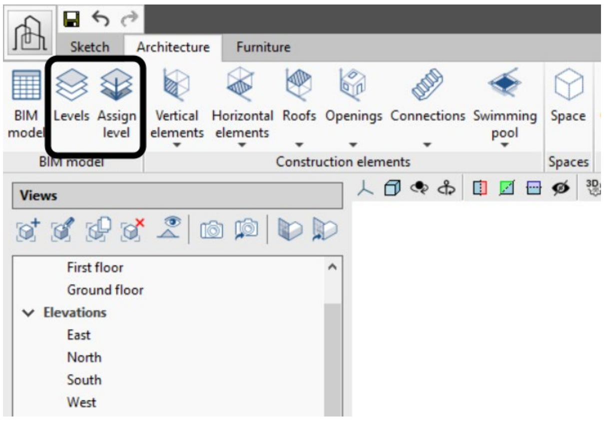

Figure 8: Assigning Levels. Screenshot of Cype Architecture

4.4-Exporting to BIMserver.center

After completing the architectural modelling with CYPE Architecture, the model must be exported to BIMserver.center to integrate it into the Open BIM workflow. To do this, the job must be linked to a new or existing project on the platform. The export generates an IFC file with the architectural model's information which allows it to be read by the rest of the applications integrated into this workflow.

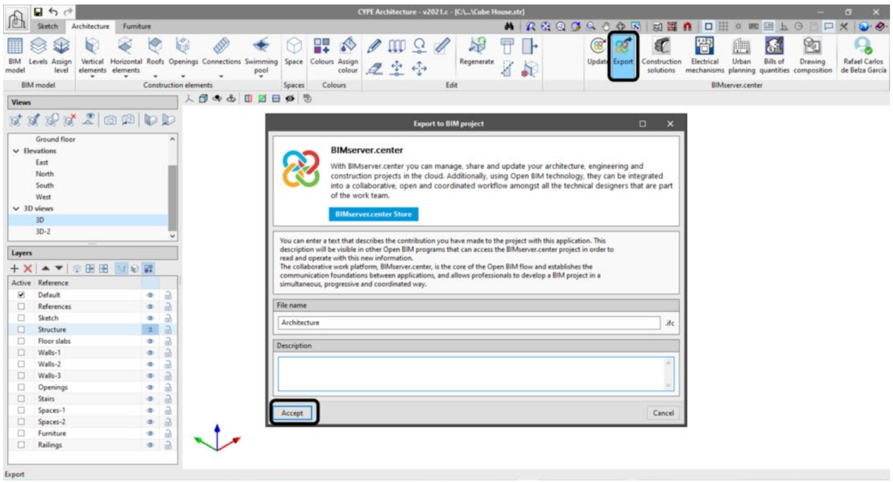

Figure 9: Exporting to BIMserver.center. Screenshot of Cype Architecture

5-OpenBIM Analytical Model

Open BIM Analytical Model is a tool designed to generate an analytical model using geometrical data from the architectural model created in CYPE Architecture and other programs. The analytical model is necessary in acoustic and thermal analysis simulations such as those that can be performed in the CYPETHERM family of programs, among others.

In order to achieve this objective, these are the most important tasks:

5.1-Importing the architectural model developed in CYPE Architecture

Upon creating a new job in Open BIM Analytical Model and linking it to the same project on BIMserver.center where the model was previously exported, the program automatically takes the CYPE Architecture model as an initiator.

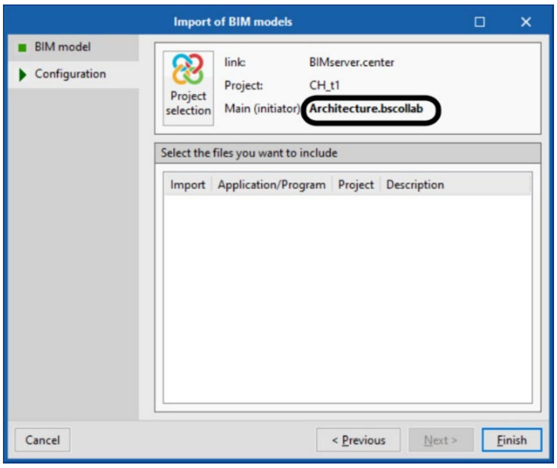

Figure 10: Importing Cype Architecture Model from BIMserver.center. Screenshot of OpenBIM Analitical Model.

5.2-Generating the analytical model

To generate the analytical model, the user just has to use the “Analytical model” option.

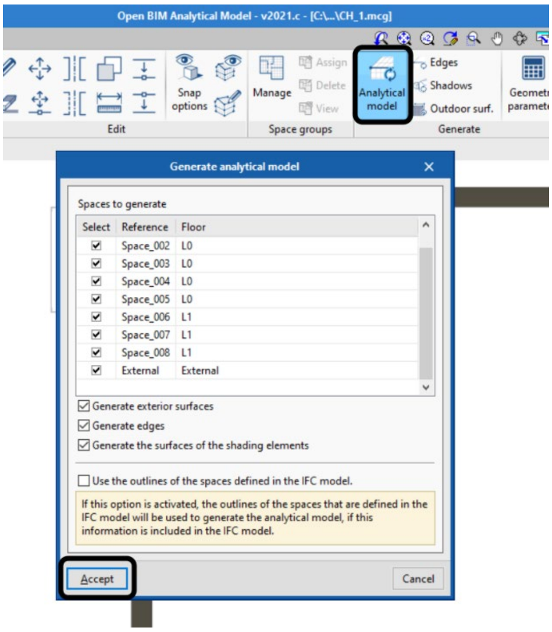

Figure 11: Generating the Analytical Model. Screenshot of OpenBIM Analytical Model.

5.3-Exporting the model to BIMserver.center.

After generating the analytical model, the job is exported to the project stored on BIMserver.center. This process generates a second IFC file containing the analytical model information.

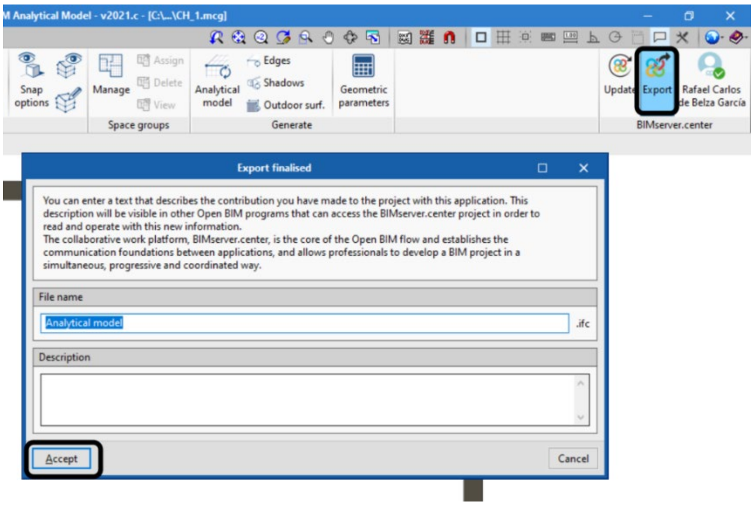

Figure 12: Exporting to BIMserver.center. Screenshot of OpenBIM Analytical Model.

6-CypeTherm EPlus

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

CYPETHERM EPlus includes some of the following features:

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

In order to complete the Building Energy Model of the building and perform the thermal analysis and energy simulation, it is advisable to consider the following:

6.1-Importing the analytical model generated in Open BIM Analytical Model

The file corresponding with the analytical model generated with Open BIM Analytical Model should be the one used as an initiator file in the program.

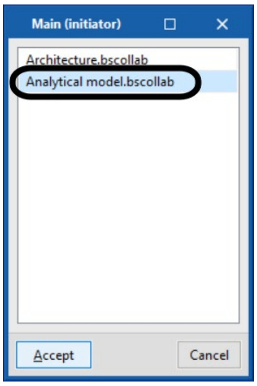

Figure 13: Importing Analytical Model. Screenshot of CypeTerm EPlus.

6.2-Finishing the analysis model

Upon accessing the general interface of CYPETHERM EPlus, the analysis model is completed in the “General data (general info, location data and energy sources)”, “Library”, “Zones”, “Systems” and “Edges” options in the “Building” tab.

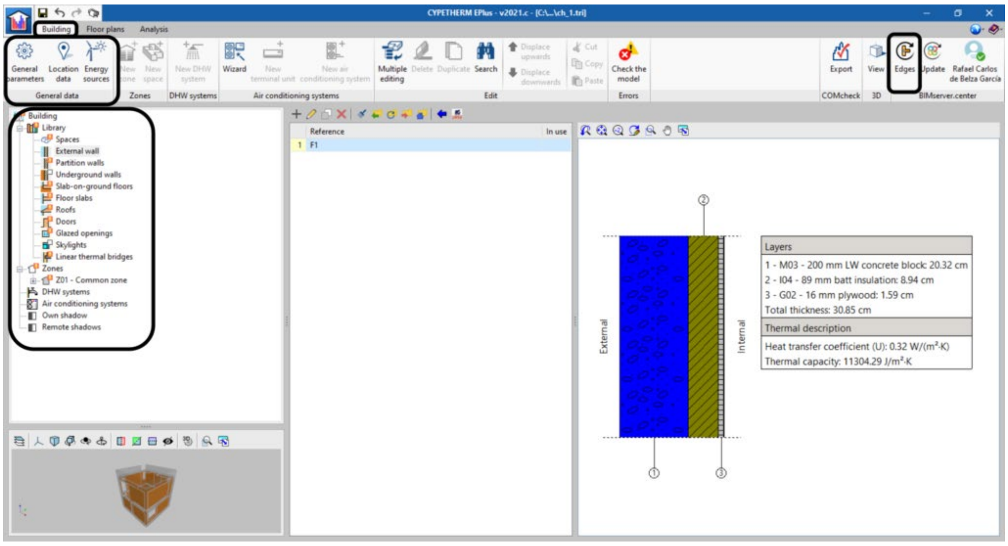

Figure 14: CypeTherm EPlus interface.

The Building tab defines the general parameters, the location data and the building model.

The building model is contained in a tree diagram consisting of the following branches:

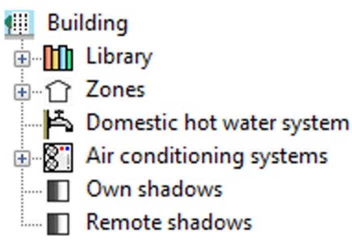

Figure 14: Components tree of the building model.

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

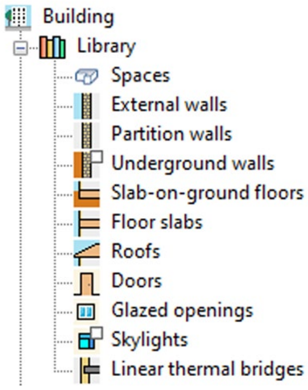

Figure 15: Type of elements in the model.

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

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

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

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

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

6.3-Analysing and obtaining results

After making the final adjustments, in the "Analysis" tab, CYPETHERM EPlus allows users to launch the analysis and obtain the results. Among them, the energy demand and consumption reports are highlighted, as well as a series of complementary reports.

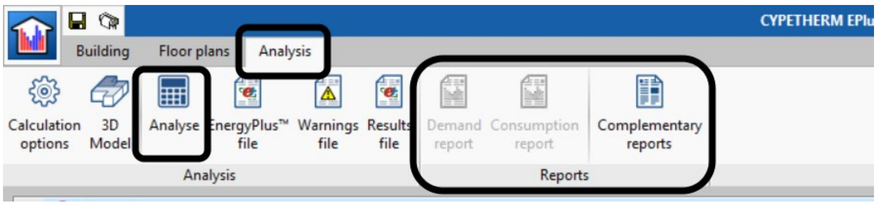

Figure 16: Analysis Tab in CypeTherm EPlus.

Some of the calculation results offered by the program include:

- **Energy demand report**
  Results of the energy demand calculation, detailed by thermal zone.

- **Energy consumption report**

Results of the energy consumption calculation, detailed by thermal zone and energy vector.

CYPETHERM EPlus also offers a series of additional features that broaden the results obtained by the program:

- **Condensatio**
  Allows users to check for the presence of surface and interstitial condensation in accordance with ISO 13788, integrating the calculation carried out by the CYPETHERM HYGRO program into each construction system of the building's thermal envelope.

- **Description of materials and construction elements**
  Report of the different construction elements present in the job along with their materials, quantities, transmission coefficients, etc.
- **Lineal thermal bridges**
  Report of the linear thermal bridges introduced in the building, with their length and thermal transmittance values.

- **Internal comfort**
  Allows the comparison of the indoor temperature of each zone of the building throughout the year with the outdoor temperature and with the maximum comfort temperatures established. In addition, it collects the unmet load hours of each zone.

7- References:

CYPETHERM User's Manual https://www.cype.net/documents_en/manuals/termint_09.pdf

CYPETHERM website: https://info.cype.com/en/product/cypetherm-eplus/

BIMserver.center blog: OPEN BIM IN ENERGY SIMULATIONS: CYPE ARCHITECTURE – CYPETHERM WORKFLOW