

## **KNAUFTERM3D – SOFTWARE FOR MODELLING AND CALCULATION OF BUILDINGS ENERGY EFFICIENCY PROPERTIES**

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### **ABSTRACT**

KnaufTerm3D is a unique software, completely designed and produced in Serbia, aimed for calculations in the field of energy efficiency of buildings. After 3 years of designing, we published it 4 years ago, and it is still growing and improving. We use it on a daily basis, in different architectural projects, for over 1.5 million sqm of space. Main difference comparing with the other BIM software, is in modelling process: here, the model is built from the "cells", which are creating "rooms", which are organised in "groups", "levels" and "zones" – one may say: as in a children brick game ("Lego"). User is not using objects as "walls", or "slabs" or "roofs", to create the space model, like in the rest of the similar programs, but the software creates the space automatically, and all positions (walls, roofs, floors, etc.) are created automatically. The rest of the calculation process is conducted according to the Regulations of Serbia. Last year, Regulations of Montenegro were included also. Some of the project's design and model properties, through the software capability, are presented here.

**KEYWORDS** \_ *Energy efficiency, Software, 3D modelling, KnaufTerm3D, Serbia*

## INTRODUCTION

A building unit, which can have a single or multiple functions (several different purposes and technologies) can have a single energy certificate, or several energy certificates. The calculation scope is similar for all buildings, regardless of their size, and includes the following main phases of work:

- **Preparation phase:**
  - Taking over the architectural project, adapting it to the needs of the calculation,
  - Observing the architectural characteristics of the building, getting to know the structures, descriptions, materials, etc. used in the project
  - Calculation of relevant (necessary) geometric data:
    - Area of heated spaces
    - Net volume of heated/ventilated space
    - Volume of the thermal envelope
    - Surface area of thermal envelope positions (facade walls, windows, roofs, etc.)
- **Calculation phase:**
  - Calculation of relevant positions from the aspect of building physics (heat transfer, diffusion and condensation, thermal stability)
  - Calculation of the building's energy needs - energy balancing (heat losses, heat gains, required energy for heating)
  - Energy certification

Regarding previous experience according to the current RS regulations, it can be concluded that more time is spent in the PREPARATION phase than in the CALCULATION phase.

Apart from this, working with geometric data is a "game of big numbers", which means that it is necessary to be precise, because small deviations (accidental and intentional errors) in surfaces and volumes lead to significant fluctuations in the final result (energy class of the building).

In the current methodology of energy efficiency calculations, the values of geometric properties (area and volume) were treated as a parameter that is entered into the calculation directly ("on foot"), and they come from:

- Project documentation of the classic ("paper") type or 2d computer model, where they depend on the accuracy and consistency of information transmission
- Projects of a more modern approach - by extracting the necessary information from the 3D model. In this sense, professional tools (ArchiCad, Revit, etc.) that use BIM can be singled out. Using such programs implies:
  - Detailed modelling of the object
  - Significant time commitment required for work

## KnaufTerm3D SOFTWARE SOLUTION CONCEPT

Considering the above, it can be said that the main features of the KnaufTerm3D program are the following:

- It is based on a geometric model (it has a built-in "modelling engine"),
- The principle of operation (use) of the modelling module is simplified compared to the mentioned professional programs, because only what the designer needs for the calculation is modelled,
- The program automatically detects relationships in space and declares all positions in the

appropriate types (facade walls, roofs, floors on the ground, etc.). There is no possibility to “forget” a position and exclude it from the calculation, thereby affecting the quality of the calculation. There is also no way to change the function of a position (e.g. to declare a facade wall as a partition wall, etc.), all for the sake of accuracy of calculations.

- The net usable area (floor) is automatically calculated. The level of precision depends on the level of detail of the model, e.g. whether individual spaces (rooms) were modelled, in which case the area under partitions is excluded from the calculation,
- The net volume of the heated/ventilated space is automatically calculated, with a precision that also depends on the detail of the model,
- All building physics calculation procedures from the predecessor KnaufTerm2 have been retained, and some have been supplemented.

### THE PRINCIPLE OF MODELING IN THE KnaufTerm3D SOFTWARE

The building is a complex geometric and functional assembly, which, for the purposes of calculating the energy efficiency of the building, can be structured as follows, from the smallest to the largest:

**Table 1.** Structure of 3D entities in the software

1	Cells	A cell is a 3D body, most often a cuboid, a cube, in general a regular or irregular prism.
2	Rooms	One or more cells can form a closed or limited space, which is characterized by rooms, The outer surfaces of the cells united in this way are actually the envelope of the room, and the inner (contact) surfaces between the cells are ignored (there are no reactions on them and through them).
3	Groups	One or more rooms can be grouped into one functional or logical unit, e.g. apartment, premises, communications, etc.
4	Zones	The zone includes a group of rooms that have the same or very similar function, as well as exploitation conditions. In most cases, one building has one functional zone (unique space with the same function). Each zone can be independently certified.
5	Building	A building unit, which can have a single or complex function (several different purposes and technologies). The building can have a single energy certificate, or if it is a complex of several zones, it can have several energy certificates.

The main feature of the modelling principle used by KnaufTerm3D is that individual elements that form a space are not “drawn”, as is normally done in all 3D modelling programs, e.g. first the walls are drawn, then the partitions, then the ceilings, and then a space/room is declared “on foot”, but the space is directly worked with, i.e. first with the cells, and then on their unification into rooms, etc., then the rooms are united into Groups, similar as in LEGO game.

The modelling procedure usually involves the following operations:

- Importing the base (raster image), to the appropriate level. The image must be scaled on the adequate measure. The operation is repeated for each level in the project (levels are actually floors)
- “Drawing” auxiliary lines (horizontal and vertical) over the main directions in the project, based on which the design matrix (raster) is formed. Such a raster can be changed, divided, moved, rotated, etc. The fields (cells) of the raster should actually correspond to the cells of the rooms we are forming.

During the formation of the basic model, the program continuously, on request (Render) provides partial and final results (energy class), based on the default structures of the assemblies. The user can and should adjust the composition of those positions, so that they correspond to the projected state.

## DESKTOP AND MODELLING

The working environment (desktop) is shown in the Figure 1. There are 4 windows in the central zone (2D grid, base with walls and windows, 3D view, Results). In the right margin are windows for navigation (structure of the space and assemblies), as well as the Property grid of the selected object. In the upper margin are tabs with commands, and in the left margin are Tool bars with commands.

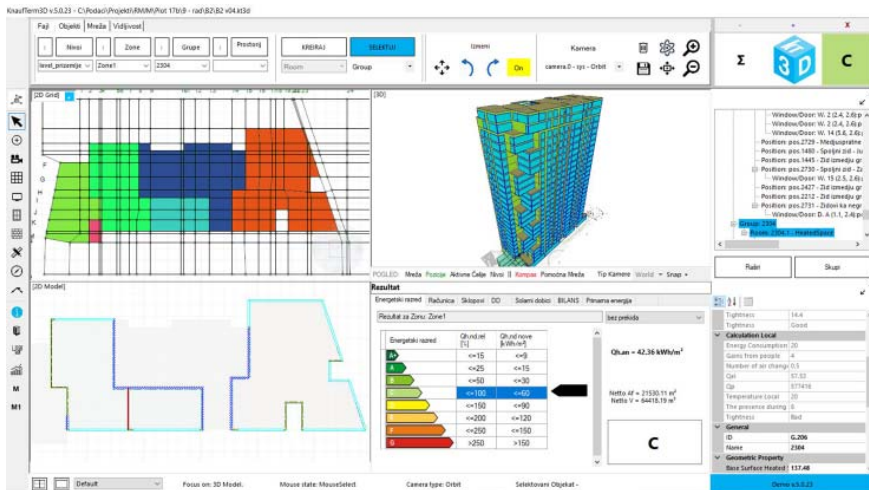


Figure 1: Main Desktop view

The basic working surface for modelling (over the project) is given in the Figure 2. The base of the floor of a residential building is shown, where the modelled apartments (Group type object), which contain 1 or more rooms) as well as public communications. The user defines the type of the room (heated, unheated, terrace, ground, neighbour...), on the basis of which the program makes a 3D analysis and determines which boundary surfaces of the cells represent the positions of the thermal envelope (facade wall, wall facing unheated, roof, etc.), and which are divided positions (wall between apartments, ceilings between apartments, etc.)

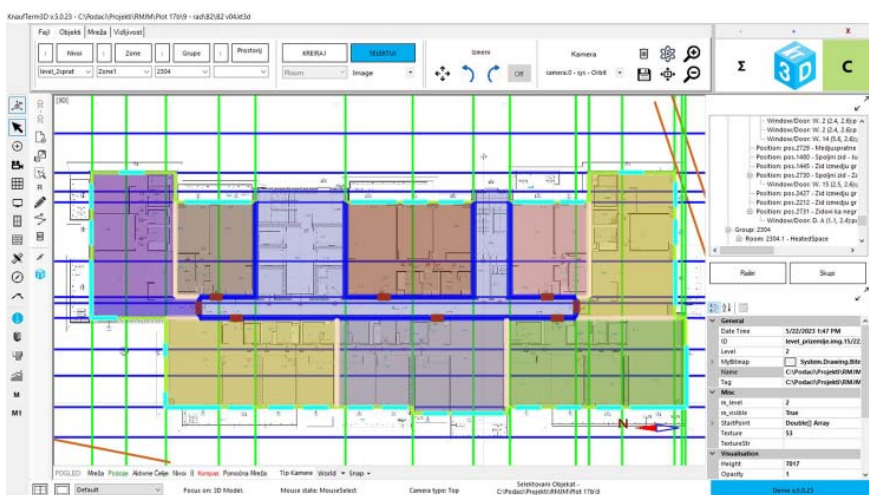


Figure 2: Desktop view in module 2D plan

Work with materials and products takes place in dedicated modules (windows). The novelty compared to its predecessor KnaufTerm2 is that users are enabled to define their own materials and products (Figure 3). User has possibility to create own libraries of materials, as well to exchange assemblies between different projects.

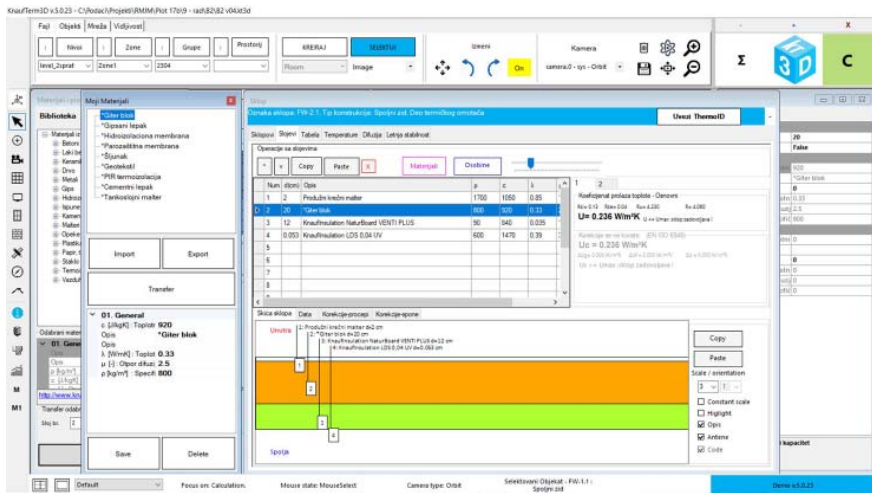


Figure3: Desktop view in module Materials

## PREPARATION OF THE ENERGY EFFICIENCY REPORT

Bearing in mind that the complete model of the object is available, the preparation of geometric data (area and volume) is done automatically. In the same way, illustrations of positions by orientation towards the sides of the world are generated. The program exports raster images of those illustrations and saves them in a separate folder, from which they are later called when creating reports (Figure 4).

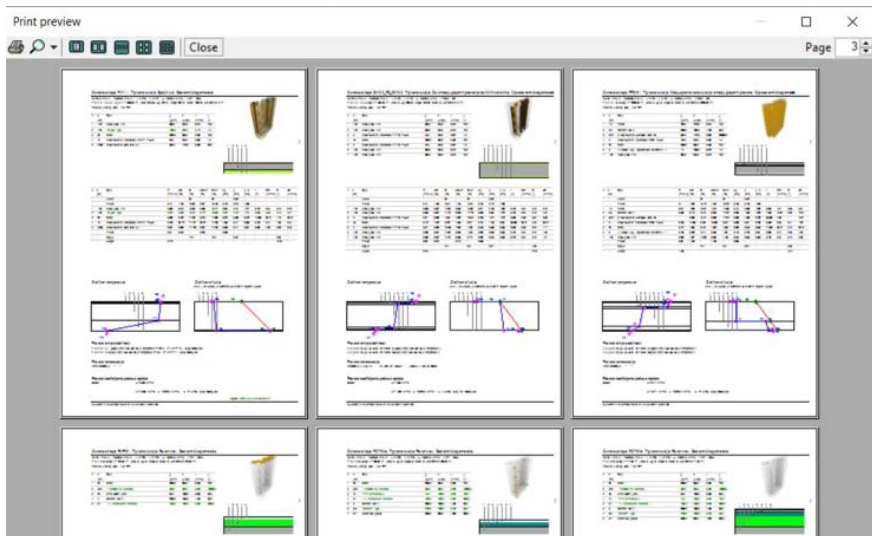


Figure 4: Preview print mode

### SPECIFICITY OF THE SOFTWARE KnaufTerm3D

The KnaufTerm3D software therefore enables quick calculation of the basic characteristics of the positions, as well as the entire building. What is new and what the other similar (foreign) programs do not have, is the ability to quickly calculate the energy characteristics of separate spaces in building, for example rooms or groups (apartments).

The domestic regulation provides the possibility to produce energy certificates for individual apartments, business units or other entities that are subject to legal transactions. Thanks to the presented modelling concept, the user can simply select from the list, or graphically from the 3D model, the desired functional unit (apartment, for example) and obtain its energy characteristics (energy class).

This enables numerous spatial / energy / economic analyses, on the characteristics of individual apartments in a building, depending on its location in the building. It is clear that apartments in the central part of the building (which are surrounded by neighbouring apartments) will be in an energetically more favourable position than those located on the top floor, or above a passage, hallway, or have an edge position.

Variations in the final result can be large, from 1 and even up to 2 energy classes. Therefore, although it is the legal obligation of the designer and contractor that the new building, as a whole, must be in the C energy class (at least), this does not mean that its constituent parts (individual apartments) will always meet that criterion. On the contrary, in modern designed buildings, large apartments (penthouse apartments) are designed on the top floors, often with higher floor heights than standard ones and even more often with a large proportion of glazing on the facade. There is a high probability that such apartments will be certified in D energy class, and that perhaps the apartments in the central area of the building will be in the lower zone of C class, possibly in B class (Table 2).

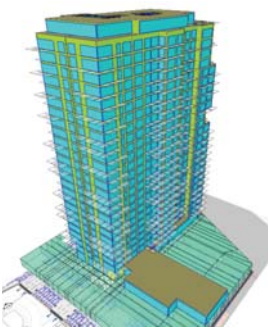


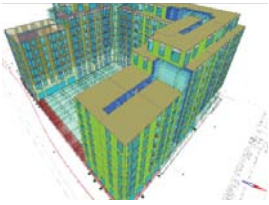
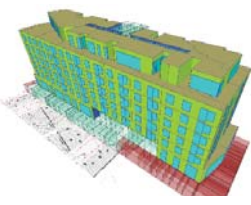
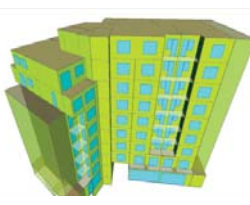
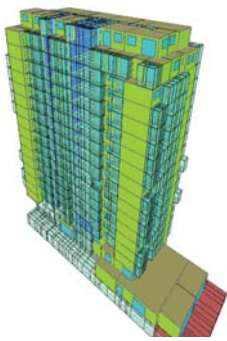




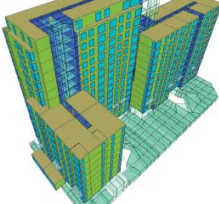
**Table 2:** Case of residential – business building in Belgrade



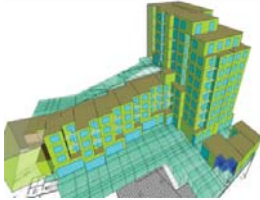

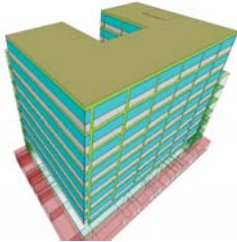
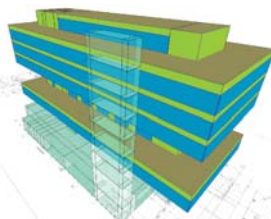
		QH.an [kWh/m <sup>2</sup> ]	En. class
	Whole Building	36.04	C
	1 (Flat)	37.36	C
	2 (Flat)	29.98	B
	3 (Office)	62.90	D

### CONCLUSION - SELECTED PROJECTS AND RESULTS

The KnaufTerm3D software enables fast work and reliable results. The following Table 3, presents some of the processed projects, this year and the previous year, with basic results (function, heated area, required energy for heating, energy class) all located in Belgrade:

**Table 3.** Comparative review of basic energy characteristics some of our projects

		
Residential, $A_{H_i} = 24054 \text{ m}^2$ $Q_{h_{an}} = 43.38 \text{ kWh/m}^2$ , C class	Residential, $A_{H_i} = 21530 \text{ m}^2$ $Q_{h_{an}} = 42.26 \text{ kWh/m}^2$ , C class	Residential, $A_{H_i} = 26363 \text{ m}^2$ $Q_{h_{an}} = 36.06 \text{ kWh/m}^2$ , C class
		
Residential, $A_{H_i} = 9920 \text{ m}^2$ $Q_{h_{an}} = 39.12 \text{ kWh/m}^2$ , C class	Residential, $A_{H_i} = 5730 \text{ m}^2$ $Q_{h_{an}} = 46.37 \text{ kWh/m}^2$ , C class	Residential, $A_{H_i} = 5045 \text{ m}^2$ $Q_{h_{an}} = 34.77 \text{ kWh/m}^2$ , C class
		
Residential, $A_{H_i} = 14342 \text{ m}^2$ $Q_{h_{an}} = 38.18 \text{ kWh/m}^2$ , C class	Residential, $A_{H_i} = 12254 \text{ m}^2$ $Q_{h_{an}} = 39.90 \text{ kWh/m}^2$ , C class	Residential, $A_{H_i} = 14112 \text{ m}^2$ $Q_{h_{an}} = 40.07 \text{ kWh/m}^2$ , C class
		

RESIDENTIAL, $A_H = 6760 \text{ M}^2$ $Q_{H,AN} = 41.72 \text{ kWh/M}^2$ , C CLASS	RESIDENTIAL, $A_H = 9429 \text{ M}^2$ $Q_{H,AN} = 39.69 \text{ kWh/M}^2$ , C CLASS	RESIDENTIAL, $A_H = 18118 \text{ M}^2$ $Q_{H,AN} = 39.92 \text{ kWh/M}^2$ , C CLASS
		
Residential, $A_H = 7214 \text{ m}^2$ $Q_{H,an} = 42.61 \text{ kWh/m}^2$ , C class	Residential, $A_H = 12826 \text{ m}^2$ $Q_{H,an} = 38.85 \text{ kWh/m}^2$ , C class	Residential, $A_H = 6905 \text{ m}^2$ $Q_{H,an} = 38.59 \text{ kWh/m}^2$ , C class
		
BUSINESS, $A_H = 7342 \text{ M}^2$ $Q_{H,AN} = 41.84 \text{ kWh/M}^2$ , C CLASS	BUSINESS, $A_H = 7199 \text{ M}^2$ $Q_{H,AN} = 48.32 \text{ kWh/M}^2$ , C CLASS	BUSINESS, $A_H = 8321 \text{ M}^2$ $Q_{H,AN} = 44.61 \text{ kWh/M}^2$ , C CLASS

One of the advantages of the KnaufTerm3D software is possibility to simply implement the changes that occur in the process of creating projects, either in terms of different stages of project documentation, or in terms of changing materials or characteristics of glazing, solar gains and similar parameters.

From the projects presented above, it can be seen that they all meet the requirements of energy certification, class C, in the middle part of the range. Even relatively large buildings (over 20000 m<sup>2</sup>) cannot be certified in a better energy class, e.g. B class, and there is no possibility for buildings designed in this manner to be certified in A energy class.

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Note: Professional projects that are the source of information are not referenced in this paper