Study regarding the impact of the new EPB standards on the energy performance evaluation

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Abstract. Energy Performance of Buildings (EPB) set of standards offer an accurate methodology for calculating the energy performance of buildings, thus supporting the implementation of the EPBD. In recent years, the Romanian authorities have started the process of updating the national methodology for calculating the energy performance of buildings to align with the set of European EPB standards. At present, the energy certification of buildings in Romania is based on the Methodology for Calculating the Energy Performance of Buildings (Mc001-2006) but the new methodology has been approved and is about to enter into force. This paper proposes a comparison between the calculated energy consumption with the existing and upgraded calculation procedure. For this purpose, a residential building in Romania was investigated in terms of energy need for space heating, domestic hot water and artificial lighting. This study aims at enhancing the main differences between the two calculation procedures in terms of input data and results.

Keywords. Energy performance calculation, EPB standards, energy calculation software.
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1. Introduction

According to the Energy Performance of Buildings Directive (EPBD) [1], the energy performance of buildings should be calculated based on a methodology, which may be differentiated at national and regional level. Moreover, the calculation methodology should consider existing European standards. The set of Energy Performance of Buildings standards, developed by CEN under mandate M/480, constitute the basis for an accurate methodology for calculating the energy performance of buildings, thus supporting the implementation of the EPBD. The use of an European set of standards as basis for national calculation methodologies among the Member states aims at obtaining an internationally harmonised procedure for the assessment of the overall energy performance of buildings. According to [2], the use of European standards allows for better comparison of best practices within Member States, as well as improving accessibility, transparency, and objectivity of energy performance assessments. The first Romanian Methodology for Calculation the Energy Performance of Buildings, referenced as Mc001-2006, was launched in 2006 [3]. The technical regulation Mc001-2006, aimed to establish a coherent method of evaluation and certification of energy performance for both new and existing buildings, transposing the provisions of the Directive of the European Parliament and of the European Council 2002/91/EC [4] on the energy performance of buildings through Law no. 372/2005 on the energy performance of buildings [5]. In recent years, the Romanian authorities have started the process of updating the national methodology for calculating the energy performance of buildings to align with the set of European EPB standards. According to the Romanian laws [3], the calculation methodology should be defined based on general standards, namely ISO 52000-1, 52003-1, 52010-1, 52016-1 and 52018-1 [6-10]. The methodology sets out the minimum energy performance requirements for both new and existing buildings or building units and applies them differently to different types of building categories. The requirements provided in the methodology consider the conditions of a comfortable and healthy indoor climate, including adequate indoor air quality [5]. At present, the energy certification of buildings in Romania is still based on the Methodology for Calculating the Energy Performance of Buildings (Mc001-2006). The new methodology Mc001-2021 has been approved on 13th September 2021 by the Ministry of Development, Public Works, and Administration and on 10th January 2022 by the Technical Regulations Information System at European level. This paper proposes a comparison between the energy needs calculated with the existing and upgraded calculation procedure. For this purpose, a residential building in Romania was investigated in terms of energy need for space heating/cooling, domestic hot water energy need, and artificial lighting energy consumption. The study aims at enhancing differences between the two calculation procedures in terms of input data and energy consumption results. For this purpose, an energy certification software available on the Romanian market was used. The first version of the program Doset-PEC was validated in Romania in 2010 and follows Mc011-2006 and will be referenced as Doset-PEC v1007. Currently, the software is in the process of update in accordance with the new methodology Mc001-2021, referenced as Doset-PEC v1008.

2. Overview of the calculation of energy performance of buildings software

2.1 General description

The Romanian software Doset-PEC, based on Mc001-2006 [3], is a commonly used tool in Romania for determining the building energy performance class and energy performance certificate. The calculation program Doset-PEC for the energy performance of flats was validated in Romania in 2010. In the following years, it was completed with the modules for determining the energy consumption for mechanical ventilation and cooling. The energy needs for heating and cooling are determined using monthly calculation procedures and allows the calculation of a single thermal zone. However, in the program there is an additional calculation module for three unheated spaces in the case of buildings: unheated technical basement, unheated staircase, and unheated attic. Unheated technical basements are characteristic of most existing blocks of flats in cities. The supply of these multi-storey buildings is made partially through a centralized system of preparation and distribution of the thermal agent for heating. The new version of the software, currently under development, is based on the Romanian methodology Mc001-2021 and the set of European standards for determining the energy performance of buildings.

2.2 Energy certification and labelling

According to the Mc001-2006 methodology [3], the energy performance of a building and the classification in energy classes are determined according to the final energies calculated at the level of technical systems. The certificate also highlights the renewable energies used on each technical system. The energy rating scale is the same for all categories of buildings. The classification in the energy performance class is made based on the final energy consumption. One of the major changes in Mc001-2021 is related to the way the energy performance of the building is expressed. In the energy certificate, the classification of buildings in energy classes is made according to the total annual specific consumption of primary energy expressed in kWh/ m^2/year (usable floor area of the building). Furthermore, there are several energy classes defined for eight categories of buildings and the 5 climatic zones of Romani. This is a major change in comparison with the previous methodology, which had the same energy scale, regardless of the building category or climatic zone. In the new energy performance certificate, the specific annual consumptions of primary energy calculated accordingly for each technical system are highlighted, the specific annual consumptions of energy from renewable sources and share of renewable energy from total energy consumption. Depending on the total primary energy consumption, the building falls in a certain energy performance class. Also, depending on the total primary energy and the share of renewable energy, the building can be classified as nearly zero-energy building, Moreover, based on the greenhouse gas emissions expressed in kg CO_2 /m^2 year, the building falls into a certain class that expresses the level of pollution.

2.3 Calculation features – energy needs

In order to align with the EPB standards and Mc001-2021, a major upgrade of the software Doset-PEC consists in the fact that allows the subdivision of a building in several thermal zones and service areas, following ISO 52000-1:2017 [6]. The monthly calculation method is still used because there is no official input data at national level for the hourly calculation. The overall energy performance assessment of the buildings follows the general framework and procedure indicated in EN ISO 52000-1 [6] for determining the heating and cooling energy needs. The procedure implies the assignment of the heating and cooling needs to heating and DHW system service areas, respectively cooling service areas. The energy consumption of technical systems is calculated in accordance with the standardized methods which considers the retention of recoverable thermal system losses retention for the next calculation interval when these losses are accounted as internal heat gains. With respect to the heating energy need, the new software takes into consideration the solar contributions through opaque and transparent envelope elements and a monthly extra heat flow due to thermal radiation to the sky. In the current version, this flow was considered only for cooling energy need for opaque envelope elements. Also, in the new version of the program, the possibility to consider the different influence of shading devices when calculating energy needs for heating and cooling was created. Thus, a separate simulation is no longer necessary in the case of solar input through windows during the winter and summer, respectively.

The heat transfer through ground is also an important aspect, which suffered important update in the new software version. As the requirements regarding the thermal performance of NZEB type buildings at the level of 2021, 2022 and for the following years are more restrictive from the point of view of energy consumption, it was necessary to update the calculation module of the thermal fluxes transmitted by elements in thermal contact with de ground in accordance with the European standard ISO 13770: 2017 [11]. The calculation is more flexible and covers any situation existing in energy certified buildings. In the current program version, it is possible to simulate the influence of slab-on-ground floors in four cases, considering the outer wall uninsulated or thermally insulated and the floor on the ground uninsulated or insulated. The thickness of the insulation is imposed at a usual value that ensures the minimum requirement regarding the thermal transmission of the slab on the ground imposed by Mc001-2006.

2.4 Calculation features – technical systems

In the upgraded software, the definition of the technical systems and the corresponding service area that deserves the thermal zones of the building is made based on the algorithm indicated in Figure 1. For each technical system the following are defined: space heating/cooling emission sub-system including control, the distribution system, the storage sub-system and the generation system. For all these subsystems additional heat/cooling losses are determined, highlighting recoverable losses and auxiliary energy consumed. The energy consumption of the technical systems of the building will be satisfied based on priorities by the generation subsystem. The electrical uses can be partially or entirely covered by on-site electricity production. The excess production can be exported to the grid. The energy performance of a building can be determined either without accounting the energy that is exported to the grid (calculation step A) or considering the exported energy (calculation step B), in accordance to EN ISO 52000-1 [6].

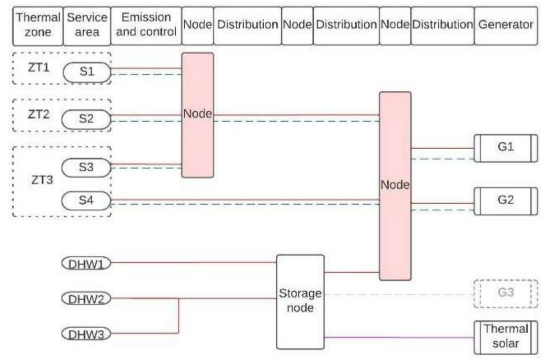

Fig. 1 – Technical systems definition.

Domestic hot water (DHW) demand and lighting energy calculations have been updated in the new software version, following Mc001-2021 and the European standards [12-13, 16]. In case of DHW energy demand, the calculation method is similar to the one in Mc001-2006, with some differences that will be enhanced through the case study. Currently, the determination of the electricity consumption for lighting, in case of residential buildings is made using a tabular method in accordance with Mc001-2006. which provides standard values of the specific energy consumption for lighting that were obtained by direct measurement for collective multi-storey residential buildings.

2.5 Renewable energy systems

In order to respond to the market needs related to the design and energy certification of nearly zero-energy buildings, the new version of the software will also include renewable energy calculation modules, thus allowing the analysis of buildings that have such systems. For this purpose, a calculation module that estimates the monthly energy production from photovoltaic systems has already been implemented and is functional. Other calculation modules for renewable energy that are in process of implementation include: thermal solar panels based on EN 15316-4-3:2017 [14] and heat pumps following standard SR EN 15316-4-2:2017 [15]. This ensures a standardized calculation at European level, but also a compact calculation by running the Doset-PEC program, without the need for separate calculations with the help of other specialized programs and the subsequent introduction of the results obtained in the basic program.

3. Case study

The case study presented in this chapter aims at providing a comparison between Mc001-2006 and Mc001-2021, by applying the calculation procedures to a collective residential building. Doset-PEC v1007 software was used for the assessment based on Mc001-2006 and the new version was used for the energy assessment based on the new methodology Mc001-2021. Because the Doset-PEC v1008 is not fully updated with all the calculation modules, the study was limited in comparing the heating and cooling energy needs, DHW energy need and electrical energy consumption for lighting.

3.1 Building description

The case study building is a residential building with 5 floors, including the ground floor. It is composed of 10 apartments per storey and has a total usable and heated area of approximately 3538.09 m^2. The characteristics of the envelope of the building can be seen in Table 1. The U'-values are below the maximum required for new NZEB buildings in Romania through Mc001-2021.

Tab. 1 – Envelope characteristics of the case study buildings.

Envelope element		Area [m^2]	U'-value [W/m^{2}K]
Ground floor		770.2	0.19
Flat roof		770.2	0.14
Exterior walls	NE	441.3	0.24
	NW	318.0	
	SE	318.0	
	SW	428.4	
Windows	NE	286.1	0.90
	NW	100.4	
	SE	100.4	
	SW	299.0	

The building is located in west side of Romania, climatic zone II, where the outdoor conventional temperature for calculations during winter is -15°C.

3.2 Heating and cooling energy need

This subchapter will only discuss a comparison between the energy needs for heating and cooling determined using Doset-PEC v10007 and Doset-PEC v1008. Both assessments follow monthly calculation procedures. The results of the assessments are presented as monthly values in Figure 2 and Figure 3. As we can see the two calculation procedures led to very close results in monthly values.

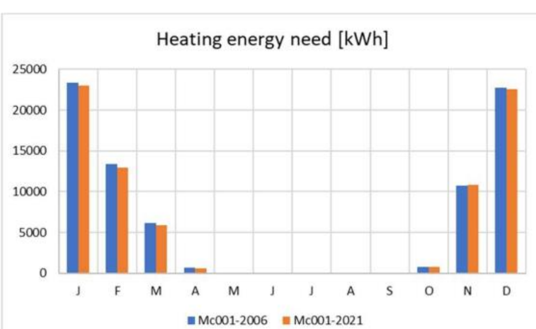

Fig. 2 – Heating energy demand.

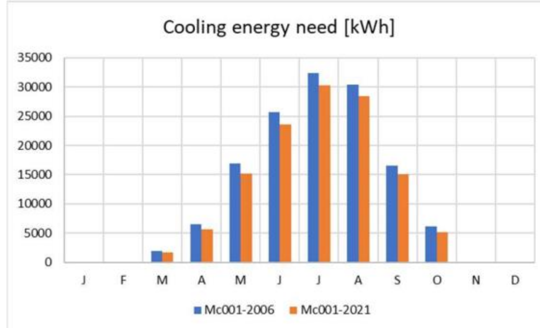

Fig. 3 – Cooling energy demand.

Table 2 presents the specific annual heating and cooling energy demand for the two calculation procedures.

Tab. 2 – Annual heating/cooling energy need.

	Mc001-2006 Doset-PEC v1007	Mc001-2021 Doset-PEC v1008
Annual heating energy demand [kWh/m^2]	21.96	21.64
Annual cooling energy demand [kWh/m^2]	38.61	35.32

In case of heating, DOSET-PEC v1008 leads to a slightly lower energy demand, approximately 2% lower than the heating energy demand resulted in DOSET-PEC v1007. For cooling energy demand, the difference is a bit higher. In this case, DOSE-PEC v1008 leads to a value that is approximately 9% lower than the value obtained in Doset-PEC v1007. The obtained differences for heating can be attributed in the first place to the different calculation procedures for elements in contact with ground (as explained in chapter 2) and also due to the fact that Doset-PEC v1008 also takes into account solar gains through opaque envelope elements and a monthly extra heat flow due to thermal radiation to the sky. In case of cooling the difference can be mainly attributed to different consideration of the utilisation factors (with different conditions).

3.3 DHW energy need

This subchapter will discuss the calculation procedures for the energy needs for domestic hot water. In both Doset-PEC v1007 and Doset-PEC v1008, the energy needs for domestic hot water depends on the delivered hot water volume and on water temperatures. The main difference consists in the value of daily volume of domestic hot water, which in case of Doset-PEC v1007 is determined considering the number of persons in the building and specific volume of hot water needed daily per person. The value of the specific volume of hot water needed daily per person is determined using a tabular method, depending on the building category and type of domestic hot water system. For this case study, 60 l/person/day was used, corresponding to residential buildings and for hot water preparation using gas boilers. In Doset-PEC v1008, daily volume needs for domestic hot water is determined depending on the specific daily needs for domestic hot water and the number of equivalent consumers. Thus, following the procedure in Mc001-2021 based on EPB standards, the equivalent number of consumers were calculated, resulting 68 consumers and 40.71 l/person/day. In both cases, the temperature for preparing the hot water was considered 60°C, while the cold-water temperature 13.5°C. The number of persons/consumers was set to 68 for both calculations, thus the only difference consisting in the daily hot water volume. The assessment results are presented in Table 3.

Tab. 3 – DHW energy need.

	Mc001-2006 Doset-PEC v1007	Mc001-2021 Doset-PEC v1008
Specific DHW energy needs [kWh/m^2]	26.65	18.89

By analysing the results and the input data for the two calculations, it cand be said that while in Mc001-2006, the volume of hot water needed for a person daily, had a fixed value, depending on the category of building and DHW system, in Mc001-2021, this daily volume/person is calculated depending on the usable area of the building and can have a maximum value of 40.71 l/person/day. As seen in Tab.2, this leads of course to lower energy needs for DHW in residential buildings.

2.1 Lighting energy consumption

As mentioned in the previous chapter, in Mc001-2006 an implicitly in the current Doset-PEC v1007, the specific energy consumption for lighting in case of residential buildings is determined using a tabular method. Thus, the corresponding values for each type of apartment were selected and further an average specific energy consumption for the entire building was obtained (Tab.1). Doset-PEC v1008 has a lighting energy calculation module which is based on Mc001-20021 and SR EN 15193-1 [13]. The calculation procedure can be used for both residential and non-residential buildings. The calculation can be performed separately for each type of room, and it requires information such as: the time tD in which the lighting of the building/building zone is ensured also using natural light, the time tN in which the lighting of the building/building zone is ensured using only artificial light, the total installed electric power of the luminaires, for recharging batteries and automation devices, the space occupancy factor Fo, the factor for dependency on constant lighting level FC. Using the mentioned input data, Doset-PEC v1008 performs annually calculation and the result of the calculation is the energy consumption expressed in kWh/year, and LENI, expressed in kWh/m^2/year. The results are presented in Table 4.

Tab. 4 – Lighting energy consumption.

	Mc001-2006 Doset-PEC v1007	Mc001-2021 Doset-PEC v1008
Specific lighting energy consumption [kWh/m^2]	11.43	14.08

The specific energy consumption for lighting calculate with Doset-PEC v1008 is higher than the one determined using Doset-PEC v1007, which means that the current method in Doset-PEC v1007 tends to underestimate the energy use for lighting. However, the calculation procedure implemented in Doset-PEC v1008 requires very accurate information related to the lighting systems. This means that the accuracy of the energy consumption results is strongly dependent on the knowledge of the software user but also on the information available for the analysed building.

4. Conclusion and discussion

This study aimed at enhancing some of the differences between the Methodology for Calculating the Energy Performance of Buildings in Romania Mc001-2006 and the new one Mc001-2021 as they were implemented in the Romanian software Doset-PEC. Although most of the calculation principles are similar in the two methodologies as they follow monthly calculation methods, the approach is different starting from the very beginning with the process of thermal zoning and ending with the energy certificate of buildings.

The case study is limited to heating and cooling energy demand, DHW energy demand and lighting energy demand as these are the modules that were implemented and fully tested until now in DOSET-PEC v1008, which follows Mc001-2021 and EPB standards. The heating and cooling energy demand obtained with Doset-PEC v1008 have very close values with the ones obtained with Doset-PEC v1007, even though there are differences in the calculation procedures. Higher differences are noticed in case of energy consumption for lighting and DHW energy demand. Nevertheless, a more comprehensive study will be conducted in the future, which will go beyond energy needs and will include energy losses final energy consumption as well for heating and cooling. Moreover, primary energy, renewable energy and renewable energy ratio are to be calculated. The new methodology Mc001-2021, based entirely on the EPB standards, provides very complex calculation procedures for all the situations that can be encountered when assessing the energy performance of a building. However, due to its complexity and multitude of possible situations, the implementation in a calculation software can be extremely difficult and time consuming.

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