

The impact of building function on energy performance class under identical building parameters

Az épületfunkció hatása az energetikai osztályra azonos épületparaméterek mellett

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Abstract

Hungary's Decree 9/2023 of the Ministry of Construction and Transport defines the energy performance requirements and calculation methodology for buildings, setting a limit of 76 kWh/m²a of non-renewable primary energy demand for residential buildings. The research examines how energy performance ratings change across different building functions using three sample residential designs with identical geometry and structures. Various HVAC systems (e.g., gas boilers, heat pumps, with and without mechanical ventilation) were applied to the models. The results show that building function has a significant impact on energy classification. The study contributes to improving the assessment of buildings undergoing a change of use.

Keywords: building energy performance, building function change, energy performance class, energy certification, reference building method

Kivonat

A 9/2023. ÉKM rendelet az épületek energetikai követelményeit és számítási módszertanát határozza meg, lakóépületek esetében 76 kWh/m²a nem megújuló primerenergia-igény határértékkel. Kutatásunk három mintaterv épület példáján vizsgálja, hogyan változik az energetikai besorolás különböző funkciók esetén azonos geometriai és szerkezeti paraméterek mellett. A modellekhez eltérő gépészeti rendszereket (pl. gázkazán, hőszivattyú, szellőztetés) rendeltünk. Az eredmények rámutatnak, hogy az épület funkciója jelentősen befolyásolja az energetikai minősítést. A vizsgálat hozzájárulhat a funkcióváltások energetikai értékelésének pontosításához.

Kulcsszavak: épületenergetika, funkcióváltás, energetikai osztály, energetikai tanúsítás, referenciaépület módszer

1. INTRODUCTION

In Hungary, from 1 November 2023, the former Decree 7/2006. (V.24.) TNM [1] was replaced by Decree 9/2023. (V.25.) of the Ministry of Construction and Transport (ÉKM) [2], which significantly changed the methodology of energy calculations and the way of classification. The new Regulation aims to align itself with the revised EU directives [3]. Previously, the classification into categories was based on the specific primary energy demand per square meter. According to the new regulation, the classification is based on the specific non-renewable primary energy demand on the one hand, and on the basis of CO₂ emissions on the other. According to the new decree, buildings are classified in two ways: in the case of residential buildings, we have to meet the requirements specified in the decree, but in the case of buildings with other functions, we have to make a reference building-based classification [4].

We started our research with the fundamental question of the extent and direction of the energy certification of a building that was originally residential for a different purpose, to what extent and in what direction it affects the specific non-renewable primary energy demand allowed for the building, the carbon dioxide emission limits and the energy classes derived from them. The issue becomes particularly topical with

the introduction of the new decree 9/2023 ÉKM, which applies a different methodological approach and different requirements for residential buildings and buildings for other purposes [5]. While in the case of residential buildings, compliance must be adjusted to fixed requirements specified in the decree, in the case of buildings with other functions, compliance must be determined in relation to a reference building. This difference fundamentally affects the energy rating of a building with the same physical parameters for different functions. The aim of the research is therefore to explore the extent to which the change of purpose causes a difference in the calculated primary energy demand and CO₂ emissions, and what effect this difference has on the energy rating. In addition, we also sought to answer the question of the extent to which the current regulatory environment allows for objective comparability between buildings with different functions, and what advantages and possible limitations the reference building-based approach has in practice.

2. THE STUDY

In the course of the research, three single-story model houses were selected from the National Model Design Catalogue published by the Lechner Knowledge Centre (Figure 1). The geometry and structural features of the buildings were recorded according to the construction plans available in the catalogue and remained unchanged throughout the entire examination. We have fitted several different building engineering systems to each of the three buildings, a gas boiler and a heat pump heat generation solution, with and without mechanical heat recovery ventilation, so we have four versions for each building. On the Hungarian market, two software programs are suitable for preparing building energy certifications, WinWatt and Auricon. In the present research, version 9.56 [6] of the WinWatt software was used for the energy certification of the building versions.



Figure 1 – Floor plans and visualizations of the selected sample designs [7], [8], [9]

In the course of the research, we changed the way the buildings are used on a theoretical level and examined the specific non-renewable primary energy demand and carbon dioxide emission value of the resulting buildings, as well as the related requirement values calculated using the reference building method, along with the energy ratings that can be achieved in this way. We changed the use of the buildings to non-residential functions that can be imagined in a building the size of a family house in a suburban or rural residential area. These were: restaurant, dentistry, office, library, daycare and shop. Thus, together with the basic version, where we took into account the building with a residential function, we examined a total of seven variations with different functions, with four types of building technology systems for each function.

We examined 28 versions of all three buildings, i.e. we prepared 84 energy calculations. Table 1 shows the system and marking of the building versions. Table 2 shows the conditions of use for each function, as well as the function-dependent data of the operation of the hot water supply and lighting system [5] [10]. These data specified in the decree appeared in our calculations as variable parameters related to the building function.

84 building versions of the research (3 buildings, 4 engineering, 7 functions)

Table 1

building	heating	domestic hot water	cooling	ventilation system	residential building (L)	restaurant (É)	dentistry (F)	office (I)	library (K)	daycare (N)	store (Ü)
A [7]	condensing Gas boiler	condensing gas boiler instant	split AC	0 no	ALG0	AÉG0	AFG0	AIG0	AKG0	ANG0	AÜG0
				1 yes	ALG1	AÉG1	AFG1	AIG1	AKG1	ANG1	AÜG1
	air-to-water Heat pump	heat pump, indirect storage		0 no	ALH0	AÉH0	AFH0	AIH0	AKH0	ANH0	AÜH0
				1 yes	ALH1	AÉH1	AFH1	AIH1	AKH1	ANH1	AÜH1
B [8]	condensing Gas boiler	condensing gas boiler instant	split AC	0 no	BLG0	BÉG0	BFG0	BIG0	BKG0	BNG0	BÜG0
				1 yes	BLG1	BÉG1	BFG1	BIG1	BKG1	BNG1	BÜG1
	air-to-water Heat pump	heat pump, indirect storage		0 no	BLH0	BÉH0	BFH0	BIH0	BKH0	BNH0	BÜH0
				1 yes	BLH1	BÉH1	BFH1	BIH1	BKH1	BNH1	BÜH1
C [9]	condensing Gas boiler	condensing gas boiler instant	split AC	0 no	CLG0	CÉG0	CFG0	CIG0	CKG0	CNG0	CÜG0
				1 yes	CLG1	CÉG1	CFG1	CIG1	CKG1	CNG1	CÜG1
	air-to-water Heat pump	heat pump, indirect storage		0 no	CLH0	CÉH0	CFH0	CIH0	CKH0	CNH0	CÜH0
				1 yes	CLH1	CÉH1	CFH1	CIH1	CKH1	CNH1	CÜH1

Terms of use variables [5]

Table 2

function	characteristic	sign	unit	residential building	restaurant	dentistry	office	library	daycare	store
terms of use	temperature, heating season	$t_{int, heating}$	°C	20	20					
	temperature, cooling season	$t_{int, cooling}$	°C	26	26					
	lighting	$E_{lighting}$	lx/m ²	-	200	500	500	500	300	300
	daily average heat gain	q_b	W/m ²	5	14	7	7	9	9	9
	required ventilation volume flow during operating time	$V_{operating}$	[m ³ /m ² h]	0,5 1/h	18	10	4	8	10	4
	daily usage time	T_{daily}	h/day	24	14	10	11	12	10	12
	annual use	a	day/a	365	300	250	250	300	220	300
domestic hot water supply system	DHW heat demand	q	kWh	-	1,1	0,4	0,4	0,4	0,4	1
	unit of reference	-	-	-	/seats	/person	/person	/person	/person	/person
	number of units	-	-	-	15	4	5	5	10	3
	calculated heat demand	Q	kWh/m ² a	25	16,5	1,6	2,0	2,0	4,0	3,0
lighting system	usage index	F_{usage}	-	<i>not to be counted</i>	0	0,2	0,2	0	0,2	0
	daylight hours	t_{day}	h/a		1250	2250	2250	1800	1800	3000
	night hours (without sunlight)	t_{night}	h/a		1250	250	250	200	200	2000

3. RESULTS OF RESIDENTIAL BUILDINGS

During the examination of residential buildings, energy calculations were made of three different building variants (A [7], B [8], C [9]), taking into account four types of mechanical systems. The structures of the buildings were classified according to their construction plans available in the National Model Design Catalogue. The structures taken for each building are shown in Table 3. As the plans include extensions to existing buildings and were made before the entry into force of the decree on the ÉKM, not all structures meet the requirements for the current average heat transfer coefficients, but the majority of structures meet them. All building versions meet the specific heat loss factor requirements.

In the case of residential buildings, the requirement value of the aggregate energy characteristic, i.e. the specific non-renewable primary energy demand, is 76 kWh/m²a, and the requirement value of the specific carbon dioxide emission is 20 kgCO₂/m²a. The values calculated for the 12 residential building versions and the classifications available based on them are shown in Figures 2 and 3. Overall, it can be stated that the structural design of the buildings fundamentally determined the energy performance, but the choice of the mechanical system also had a significant impact. In all cases, the combination of the heat pump system and heat recovery ventilation gave the most favourable results. In the case of the largest building, B, this solution has provided outstanding performance in terms of both primary energy and CO₂ emissions, and this building also meets the requirements of nearly zero-energy buildings with this mechanical configuration.

building	A [7]	B [8]	C [9]
heated volume, V	290,7 m ³	398,57 m ³	294,74 m ³
cooling surface, A	94,5 m ²	154,61 m ²	106,08 m ²
floors on ground < 0,300 W/m ² K	12 cm reinf. concrete + 14 cm EPS foam + tiles / parquet 0,176 / 0,177 W/m ² K	12 cm reinf. concrete + 14 cm EPS foam + tiles / parquet 0,171 / 0,151 W/m ² K	12 cm reinf. concrete + 14 cm EPS foam + tiles / parquet 0,156 / 0,169 W/m ² K
facade walls < 0,240 W/m ² K	30 cm ceramics + 10 cm gEPS 0,222 W/m ² K 38 cm ceramics + 10 cm gEPS 0,197 W/m ² K	30 cm ceramics + 10 cm gEPS 0,218 W/m ² K 38 cm brick + 10 cm gEPS 0,357 W/m ² K	30 cm ceramics + 10 cm gEPS 0,235 W/m ² K 38 cm brick + 15 cm gEPS 0,208 W/m ² K
ceiling under attic < 0,170 W/m ² K	25 cm reinf. concrete + 22 cm rockwool 0,171 W/m ² K	20 / 24 cm reinf. conc. + 22 cm rockwool 0,156 / 0,179 W/m ² K	25 cm reinf. concrete + 22 cm rockwool 0,205 W/m ² K
attic wall < 0,400 W/m ² K	25 cm ceramics + 15 cm rockwool 0,150 W/m ² K	-	-
roof < 0,170 W/m ² K	wooden structure + 25 cm rockwool + tile 0,161 W/m ² K	-	-
flat roof < 0,170 W/m ² K	-	-	18 cm reinf. conc. + 17 cm EPS + PVC 0,181 W/m ² K
doors, windows < 1,100 W/m ² K	PVC frame + double-layer glazing 1,150 W/m ² K	PVC frame + double-layer glazing 1,150 W/m ² K	PVC frame + double-layer glazing 1,150 W/m ² K

4. RESULTS OF PUBLIC BUILDINGS

In addition to the residential function, the buildings examined in the research were also examined with six different functions (restaurant, dentistry, office, library, daycare and shop). During the changes of function, neither the floor plan, nor the load-bearing structure systems nor the mechanical systems of the buildings were modified, only the operation and the method of use, i.e. the profile of the building, were changed on a theoretical level. Thus, the difference between the building versions is only given by the method of operation, i.e. the use profile of the building.

The six different functions have different usage characteristics. The residential function means a continuous, 24-hour, relatively even load with moderate energy demand. The office is typically used during the day, with balanced but time-limited operation. The library and the daycare centre are similarly used periodically, but the need for fresh air in the daycare is higher and the use is more intensive. The store shows a turnover-dependent, variable load, while the restaurant and the dentistry are among the most intensively demanding functions, with high domestic hot water and air conditioning requirements.

As the design of the boundary structures and the mechanical engineering remained unchanged in all building versions, the differences in energy performance were solely due to changes in the usage profiles describing the operation of the building. These profiles determine the time use, internal heat loads, air exchange demand and domestic hot water use. As a result, the same building shows different energy behaviour for different functions. These conditions of use are also reflected in the reference building taken up during the certification process for the purpose of determining the energy requirements, so the change in the profile directly affects the requirement values of the total energy characteristic and carbon dioxide emissions.

The values calculated for the 6×12 building versions with other functions and the classifications available based on them are also shown in Figures 2 and 3. Overall, it can be stated that all other functions except the restaurant function easily met the requirements for nearly zero-energy buildings and obtained at least a class “A” rating in both aspects. Building versions with heat pump heat generators achieved particularly good results based on the carbon dioxide emission classification. The graphs show that the requirement values and the calculated characteristics move nicely together due to the peculiarities of the calculation method. For functions that assume higher energy consumption, the reference building method allows for a higher requirement value. The requirement values change not only because of the conditions of use, but also because of the mechanical engineering used. Comparing the three buildings, it can be seen that a scale effect can be observed in the case of each function, which has already been shown in our previous research [3]. According to this, the largest building marked B met the requirements with a high degree of certainty, while the calculated values of the smallest building marked A were much closer to the limit values.

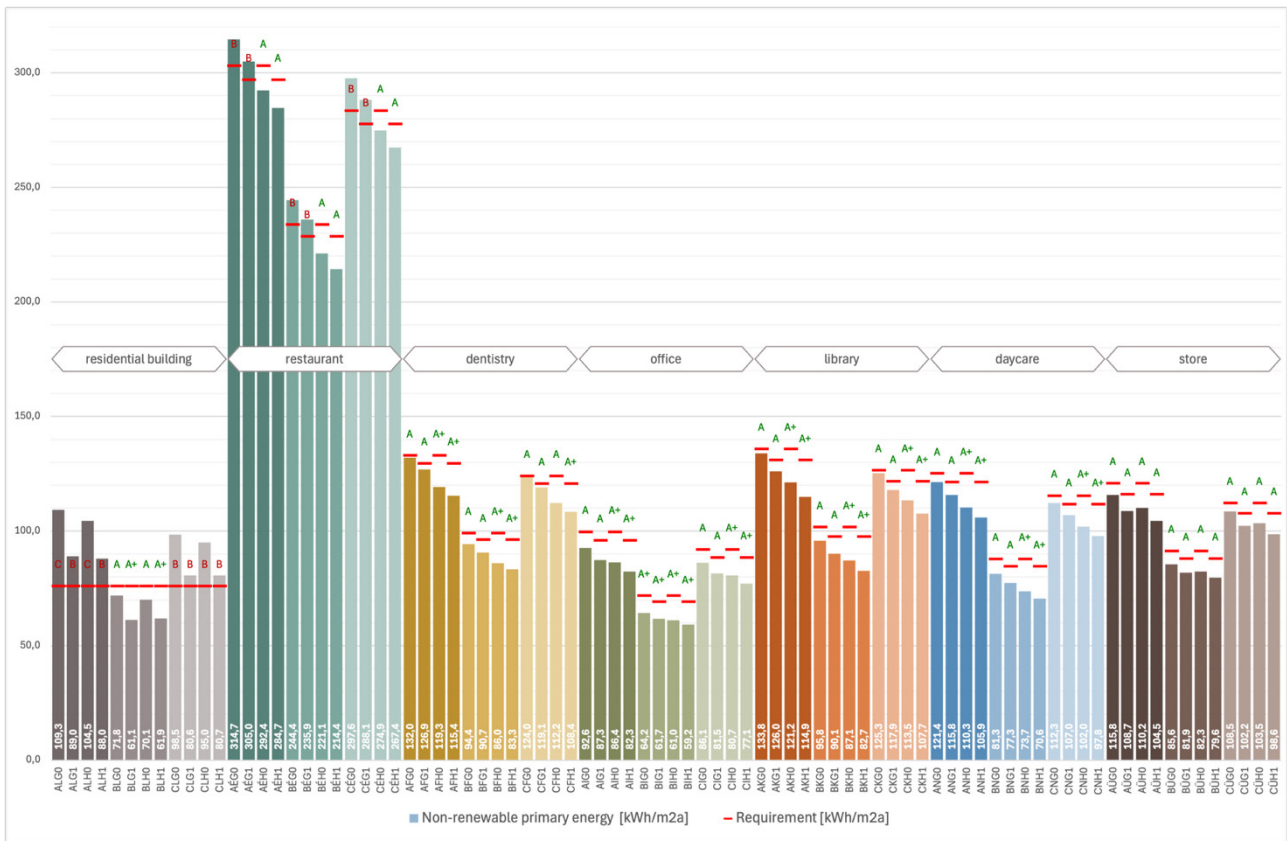


Figure 2 – Specific non-renewable primary energy consumption of the building versions and the energy efficiency classes that can be determined in this way

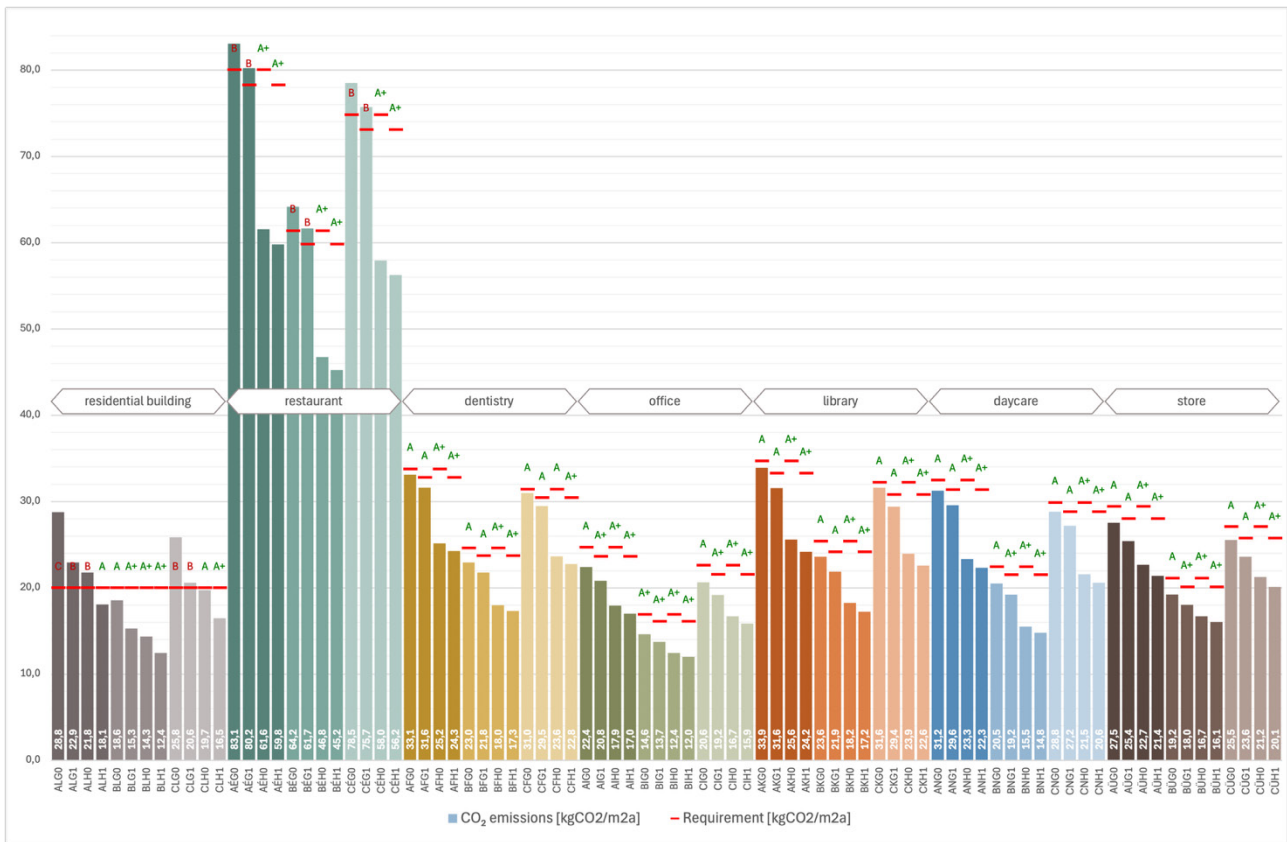


Figure 3 – Specific carbon dioxide emissions of building versions and efficiency classes that can be determined in this way

5. CONCLUSIONS

The basic question of our research was how the energy indicators and classification of a residential building change if we prepare its energy certification according to a different function. Based on our results, it can be clearly seen that the requirement values for certain non-residential building functions differ significantly. In the case of residential buildings, the requirement is 76 kWh/m²a as defined in the decree, while in the case of restaurants, for example, this value can be up to four times higher (~300 kWh/m²a). In the case of the other functions examined, the change in the requirement values was not so outstanding, the changes can be explained by the differences in building operation and the fact that in the case of non-residential buildings, the energy demand of lighting must also be included in the rating of the building. However, it is worth emphasizing that due to the reference building method, the requirements for non-residential buildings also depend on the mechanical system used in the building, as the requirements of the building versions calculated with and without heat recovery ventilation are different.

The non-renewable primary energy demand of the building versions was developed in the calculations according to the building profiles. Needs and requirements move nicely together. Less energy-intensive residential, office and library functions typically achieved a more favourable rating of “A” or “A+”, while the energy-intensive restaurant function has already been upgraded to class “B”. Overall, it can be stated that due to the flexibility of the requirements, it was much easier for non-residential building functions to meet the requirements of nearly zero-energy buildings and obtain at least an “A” rating. But this also means that in absolute terms, the same class “A” can mean one and a half or even four times the specific energy consumption of public buildings compared to the function of a residential building. The values nicely illustrate the extent to which “nearly-zero” is relative in the phrase “nearly-zero energy demand”.

In terms of classification, there is a clear trend, with the same function, heat pump systems always give a more favorable result, often providing a better classification by an entire category. It is also striking that while residential buildings could only be classified in class “B” or “C” when using gas boilers as heat generators, non-residential buildings certified using the reference building method could be classified as class “A”.

An examination of CO₂ emissions shows a similar picture. The requirement values are also function-dependent here, and the total emissions are closely related to the primary energy demand. In all cases, heat pump systems significantly reduce emissions, often resulting in an “A+” rating, while gas boiler solutions give higher values and lower categories. The restaurant has outstandingly high emission values here as well, while the residential, office and library functions are more favourable.

From the point of view of energy policy, it is interesting to compare the fixed and strict limit values of residential buildings [11] [12] with the somewhat more permissive regulation of non-residential buildings. It seems that it is easier to hold the population accountable for energy efficiency than the owners of non-residential buildings, e.g. small and medium-sized enterprises and institutions. It is likely that in this question, the difficulty of regulation (e.g. the diversity of non-residential buildings) met the interests of economic operators, which together pointed in the direction of making the requirements less stringent in the case of non-residential buildings.

Based on our research, it can be concluded that if the physical parameters of a building remain unchanged, the change of function, i.e. the modification of the operating and usage profile, has a significant impact on both its energy characteristics and CO₂ emissions. The change in the reference profile alone is capable of causing differences of several energy classes, which clearly shows that the method of use is at least as decisive a factor in the certification of buildings as the technical design.

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