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METHODS AND SOLUTIONS REGARDING ENERGY EFFICIENCY IN PUBLIC BUILDINGS

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Abstract: *The following work aims to offer proposals, to determine the energy efficiency for the studied building-hospital, offering technologies, techniques and methods for reducing energy consumption by: improving environmental quality, reducing greenhouse gas emissions (GHG), reducing annual primary energy consumption ensuring air quality in the occupied environment. The objectives of the paper are to present a newly built building that is the subject of a study regarding energy consumption as low as possible consist of analyzing and developing energy optimization options for the structural elements of buildings, the use of highly efficient and durable insulating materials and systems, which ensure efficient insulation, and the determination of the geometric, thermal, optical and functional characteristics of the constructive elements of buildings and systems that ensure thermal comfort.*

Keywords: *Energy efficiency, thermal rehabilitation, renewable resources, high-efficiency installations*

1.INTRODUCTION

Under the framework of Directive 2010/31/EU, as updated by Directive (EU) 2018/844, a nearly Zero-Energy Building (nZEB) is characterized by exceptionally low energy consumption, with the remaining demand primarily met through renewable energy sources (RES), preferably generated on-site or in close proximity.Romania incorporated this requirement into its national legislation in 2016, initially setting a minimum of 10% of a building's total energy use to come from renewable sources. This threshold was later increased to 30% starting in July 2020, reflecting the country's commitment to sustainable development. Additionally, Directive (EU) 2018/844 obliges all EU member states to establish comprehensive renovation strategies targeting a fully energy-efficient and low-carbon building stock by 2050. These strategies aim to gradually upgrade both residential and non-residential buildings, promoting energy savings and reducing environmental impact over the long term. [1] .

The aim of this study is to define the most promising renovation strategies applicable to all buildings, by developing an analysis method, to increase energy efficiency and improve environmental quality by reducing greenhouse gas (GHG) emissions, reducing the annual primary energy consumption, and ensuring a healthy indoor climate. The objectives of the work are to present a newly constructed building that is the subject of a study on minimizing energy consumption and calculating the possibility of using alternative energy-efficient systems regarding the installation of energy supply systems from renewable sources.

The energy performance of a building is assessed through a standardized calculation process that results in one or more measurable indicators. These indicators reflect a variety of factors, including the effectiveness of thermal insulation, the technical characteristics of the building and its systems, as well as the design and location of the building in relation to external climatic conditions, such as exposure to sunlight and the influence of neighboring structures. In addition, the building's ability to

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produce its own energy and the indoor environmental conditions are taken into account, all of which directly influence the total energy demand of the building. Improving energy performance is achieved through good insulation measures and intelligent systems that reduce energy consumption, especially those from fossil fuel combustion, thereby reducing CO_2 emissions.

The construction industry is one of the largest consumers of energy and non-renewable natural resources, but also an important factor in increasing global warming through the production of greenhouse gases [2]. Because buildings serve human occupants, ensuring environments that safeguard health should always be a primary concern. To reduce the energy consumption of buildings, optimal design options could be selected to considerably improve energy efficiency, to promote the development of green buildings using environmental resources.

Renewable energies in practice are considered energies that come from sources that either regenerate themselves in a short time, or are practically inexhaustible sources. To create nZEB buildings, different technologies must be used for both the structure, thermal insulation, and their installations. These systems must be designed to provide more than half of the total energy consumption Various approaches have been developed for energy efficient buildings including building orientation (climate, sun, wind, etc.). It is essential to involve and prioritize the energy renovation of buildings, both to increase indoor comfort and to reduce the impact on the environment, [3]. Law 372/2015, with subsequent amendments and additions, provides that increasing the energy efficiency of buildings and reducing CO_2 emissions can be achieved by improving equipment performance, educating and raising awareness among the population. The research is based on the design technology and the principle of application of methods applied to both new buildings [4-6] and existing ones [7-9]. The integration of the energy auditor into the architectural design team, as mandated by Law 121-18.07.2014, has facilitated the early-stage implementation of the concept within the building design process, [10].

According to the specialized literature (Papadopoulos, 2005), envelopment is currently an important aspect in Europe and worldwide, without which energy-efficient design and construction cannot be discussed [11]. Heat transfer is an inevitable consequence of the exchange of energy between two dissimilar bodies, and thermal insulation acts as a barrier, maintaining a constant temperature as a buffer zone between these two materials [12]. This study proposes the best technologies used to modernize educational buildings in Craiova, taking into account the reduction of heat loss, leading to economic growth.

2. MATERIALS AND METHODS

2.1 Case Study Building Description:

It is proposed to construct a monobloc hospital consisting of 5 tower-type bodies interspersed with another 5 bodies (see fig.1).

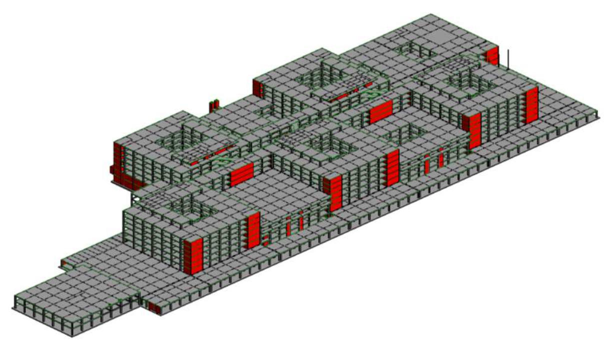


Fig 1. Hospital building

The studied building, with an irregular shape, is located in Craiova Municipality in climatic zone II, with Te = -15°C (see Fig. 2). The land area is 246,127 square meters, with a built-up area of 37,492.48 square meters, a gross floor area of 191,643.22 square meters, a net area of 144,229.78 square meters, a heated net area of 129,114 square meters, and a maximum height regime of 2S + P + 5.

From a climatic standpoint, the region is characterized by a continental climate, with very hot summers, moderate precipitation, and moderate and cold seasons without very low temperatures. The standard temperature over an year is 10.8 degrees Celsius, rarely dropping below -2.5 degrees Celsius in January, while the standard temperature in July exceeds 22 degrees Celsius. The average annual precipitation is 523 mm (depth of water column). According to STAS 6054-77, the maximum depth of ground frost is 0.80 meters. The building mentioned before can be described as having a moderate level of sheltering in opposition to wind activity (see fig. 3).

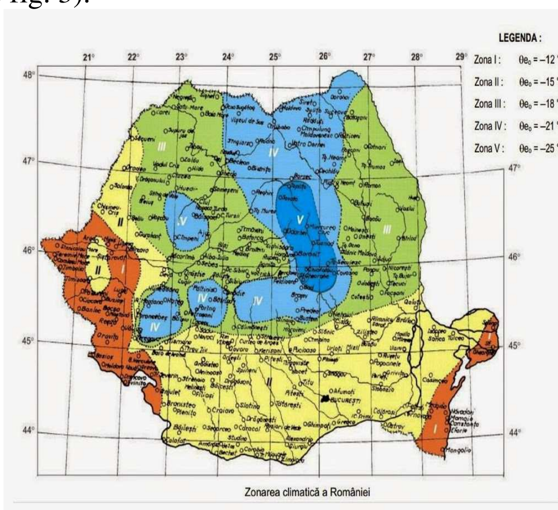


Fig.2. Source: weather Romania/Website of the National Meteorological Administration.

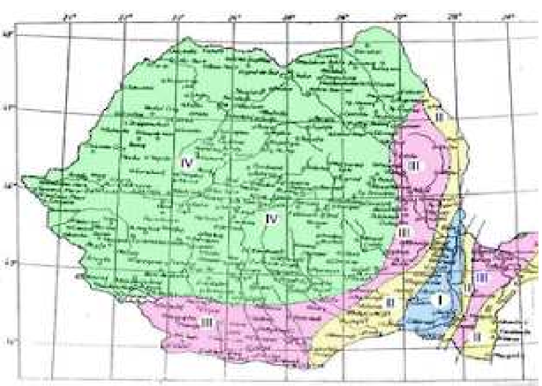


Fig.3. Source: google.com

• Theoretical number of Heating Degree Days: 1284;

• Theoretical duration of the heating season: 164 days;

• Theoretical number of Cooling Degree Days: 1175;

• Theoretical duration of the cooling season: 153 days;

In fig. 4, the monthly average values of solar radiation intensity are presented:

• Is- [W/m2] - Solar radiation intensity for south orientation;

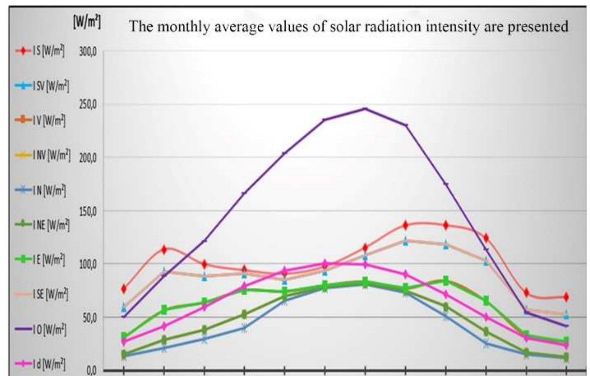
• I SV- [W/m2] - Solar radiation intensity for southwest orientation;

• I V- [W/m2] - Solar radiation intensity for west orientation;

• I NV- [W/m2] - Solar radiation intensity for northwest orientation;

• I o [W/m2] - Solar radiation intensity for horizontal plane orientation;

• Id [W/m2] - Diffuse solar radiation intensity.



	Ian	Feb	Mar	Apr	Mai	Iun	Iul	Aug	Sep	Oct	Noi	Dec
I S [W/m²]	76,9	113,6	99,7	94,1	90,8	97,5	115,2	135,9	136,0	124,0	73,2	68,8
I SV [W/m²]	59,4	92,6	88,3	91,0	85,3	93,5	108,3	121,9	118,4	102,8	57,3	52,9
I V [W/m²]	31,0	56,6	64,0	75,6	74,3	80,0	83,5	77,1	84,2	65,4	33,0	27,3
I NV [W/m²]	15,0	28,8	38,2	52,6	69,9	78,6	82,0	75,0	59,9	36,2	16,5	12,3
I N [W/m²]	13,6	20,9	29,8	39,5	65,5	77,3	80,5	72,9	51,1	25,2	15,3	11,8
I NE [W/m²]	15,0	28,8	38,2	52,6	69,9	78,6	82,0	75,0	59,9	36,2	16,5	12,3
I E [W/m²]	31,0	56,6	64,0	75,6	74,3	80,0	83,5	77,1	84,2	65,4	33,0	27,3
I SE [W/m²]	59,4	92,6	88,3	91,0	85,3	93,5	108,3	121,9	118,4	102,8	57,3	52,9
I O [W/m²]	49,8	88,8	121,3	166,1	203,5	235,5	245,8	229,8	174,7	113,1	54,2	41,3
I d [W/m²]	27,2	41,9	59,6	79,1	93,7	100,7	99,7	89,8	71,1	50,4	30,7	23,5

Fig.4. Solar radiation intensity

2.2 Energy efficiency solutions applied within the project

Law 372/2015, with subsequent amendments and additions, stipulates that for the purpose of increasing energy efficiency in buildings and reducing CO_2 emissions, new buildings, starting from December 31, 2020, must be nearly zero-energy buildings. Renewable Energy Systems (RES) / Alternative Energy Production Systems have the role of supplying a portion of a building's energy consumption, thereby reducing CO_2 emissions. Hospitals are complex facilities that run multiple simultaneous systems, including access control, diverse installations, HVAC, including patient management and surveillance. These systems depend on a reliable network and centralized management to operate efficiently. Their integration helps reduce initial and ongoing costs, while improving overall process oversight. Solutions must be customized based on the scale and complexity of the hospital. Due to significant energy consumption, hospitals prioritize green approaches. Energy-saving technologies are developed specifically for healthcare facilities, with the aim of optimizing patient comfort along with cost efficiency.

Proposed modernization solutions

- The estimated measures involve comparison between thermal resistances of the building envelope elements and the minimum corrected thermal resistances outlined in "calculation methodology of the energy performance of buildings, Mc 001-2022".

The building is designed as a reinforced concrete structure consisting of columns and structural walls, with slabs connected by beams supported on raft foundations.

The exterior walls of the basement and semi-basement will be made of reinforced concrete, insulated with a 20 cm extruded polystyrene thermal insulation system, regardless of whether the wall is in contact with the ground or with air (in the areas of access ramps and external arrangements). In open areas, they will be finished with decorative plaster or ceramic/fiber cement cladding in a ventilated opaque facade system. In some places, the basement walls will have the same composition as the upper floors, insulated with 20cm mineral wool and finished with ceramic/fiber cement cladding or similar materials.

- Unidirectional thermal resistance (R): 6.513 m2K/W
- Correction coefficient for thermal resistance (r): 0.85
- Corrected thermal resistance (R'): 5.54 m2K/W

The external walls of the aboveground area (ground floor - 5th floor) will be made of reinforced concrete or ceramic masonry with vertical voids 30 cm thick. They will be thermally insulated with a 20 cm mineral wool thermal system and, together with the finishing material (ceramic cladding/ fiber cement or similar), make up the opaque ventilated facade system. The outer face of the thermal insulation layer will be naturally ventilated to avoid the accumulation of condensation in the cold season and to correct its drying in the warm season.

- Unidirectional thermal resistance R-9,708 m2K/W;
- Reduction coefficient of the corrected thermal resistance r – 0,752;
- Corrected thermal resistance R'- 7,30 m2K/W.

Table 1

Characteristics of the materials used and thermal resistance

Element envelope: External walls, under the CTS, in the semi-basements or heated basements — Element code: Basement exterior wall EW

Nr.	Type	Layer	δ [m]	ρ [kg/m³]	λ [W/mK]	c [J/kg/K]	a	λ' [W/mK]	R [m²K/W]
1	Surface resistance	To the outside							0,042
2	OTHER	Extruded polystyrene	0,2	0	0,038	0	1,00	0,038	5,263
3	OTHER	Porotherm brick 25	0,25	0	0,300	0	1,00	0,300	0,833
4	Surface resistance	Horizontal flow/vertically ascending	0,03	0	0,000	0	1,00	0,000	0,125
5	OTHER	Plasterboard	0,025	0	0,200	0	1,00	0,200	0,125
6				0	0,000	0			
7				0	0,000	0			
8				0	0,000	0			
9				0	0,000	0			
10	Surface resistance	Horizontal flow/vertically ascending							0,125

Unitary mass [Kg/m2]: 0 — Thermal resistance R= 6.513 [m²K/W] — Type: OPAQUE

Table 2

Characteristics of the materials used and thermal resistance

Element envelope: External walls (exclusive of glazed surfaces, including walls adjacent to open joints) — Element code: CWS-01

Nr.	Type	Layer	δ [m]	ρ [kg/m³]	λ [W/mK]	c [J/kg/K]	a	λ' [W/mK]	R [m²K/W]
1	Surface resistance	To the outside							0,042
2	OTHER	Alucobond 4mm	0,004	0	1,770	0	1,00	1,770	0,002
3	OTHER	sealing membrane	0,002	0	2,300	0	1,00	2,300	0,001
4	OTHER	mineral wool Rain Screed or similar	0,15	0	0,032	0	1,00	0,032	4,688
5	OTHER	Construction steel	0,003	7850	58,000	480	1,00	58,000	0,000
6	OTHER	mineral wool Rain Screed or similar	0,075	0	0,032	0	1,00	0,032	2,344
7	OTHER	ACC 30cm	0,3	500	0,120	0	1,00	0,120	2,500
8	OTHER	Antibacterial wallpaper	0,002	0	0,340	0	1,00	0,340	0,006
9				0	0,000	0			
10	Surface resistance	Horizontal flow / vertically ascending							0,125

Unitary mass [Kg/m2]: 173.55 — Thermal resistance R 9,708 [m2K/W] — Type: OPAQUE

The closing of the gaps in the masonry or concrete walls will be done with carpentry with aluminum profiles with thermal break and triple heat-insulating glass with solar protection. In the area of the windows, located on the outside, there will be vertical slat type sunshades with variable orientation, made of aluminum profiles on a metal structure, with an "airplane wing" type section, Figure 5, painted in an electrostatic field, with electric drive (south facade) and fixed (west, east, north facades). This measure aims to reduce the solar input through direct sunlight in the summer and the transfer of heat from the interior to the exterior in the cold season.

Fig. 5. Aluminum sunshades

Additionally, a system of curtain walls in the "stick" (classical) system is proposed, made of aluminum profiles (uprights and bars) with thermal break, glass panels fixed in pressure caps and ornament, which together with the aluminum carpentry form a "double-skin" type system.

The unitized panels have an aluminum profile frame with thermal break, each panel extending over the height of an entire floor. The unitized panels used are opaque in the lower and upper part and glazed in the middle.

Each unitized panel is fixed at 4 points. All anchors will be double and have thermal insulators between them to minimize thermal bridges, fig. 6 and fig. 7.

Using these stratifications and constructive solutions, the following thermal resistances were obtained (Table 3 and 4):

• Unidirectional thermal resistance R-5,456 m2K/W;

• Reduction coefficient of the corrected thermal resistance r – 0.846;

• Corrected thermal resistance R'- 4.62 m2K/W.

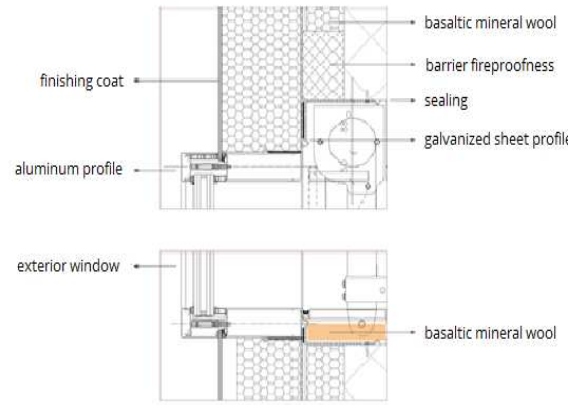


Fig. 6. Layers of the unitized pannel

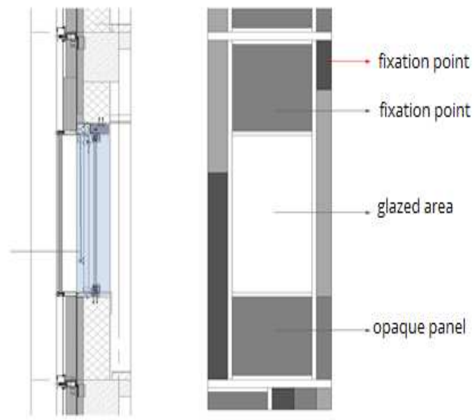


Fig 7. Unitized opaque panel in the lower and upper part and glazed in the middle.

Table 3

The thermal resistance of the opaque wall resulting after the installation of the curtain walls

Element envelope: External walls (exclusive of glazed surfaces, including walls adjacent to open joints) — Element code: EWS-01

Nr.	Type	Layer	δ [m]	ρ [kg/m³]	λ [W/mK]	c [J/kg/K]	a	λ' [W/mK]	R [m²K/W]
1	Surface resistance	Horizontal flow/vertically ascending							0,125
2	Mortar	Mortar cement cousin	0,01	1700	0,870	840	1,00	0,870	0,011
3	Concretes	Reinforced concrete (2400 kg/m³)	0,4	2400	1,620	840	1,00	1,620	0,247
4	OTHER	Barrier	0,001	1800	0,170	0	1,00	0,170	0,006
5	OTHER	Basaltic mineral wool	0,18	0	0,037	0	1,00	0,037	4,865
6	OTHER	Tristral film for vapor diffusion	0,0016	175	0,070	1460	1,00	0,070	0,023
7	OTHER	Poorly ventilated air layer	0,045	0	0,333	0	1,00	0,333	0,135
8	OTHER	Alucibond 4mm	0,004	0	1,770	0	1,00	1,770	0,002
9				0	0,000	0			
10	Surface resistance	To the outside							0,042

Unitary mass [Kg/m2]: 979.08

Thermal resistance R= 5.456 [m²K/W] — Type: OPAQUE

• Unidirectional thermal resistance R-9,708 m2K/W;

• Reduction coefficient of the corrected thermal resistance r – 0.752;

• Corrected thermal resistance R'- 7.30 m2K/W.

Table 4

Calculated resistance, Unitized Facade - CWS-01

Element envelope	Exterior walls, under CTS, in heated half-basements or basements						Element code		Basement exterior wall B E W
Nr.	**Type**	**Layer**	**δ [m]**	**ρ [kg/m³]**	**λ [W/mK]**	**c [J/kgK]**	**a**	**λ' [W/mK]**	**R [m²K/W]**
1	Surface resistance	To the outside							0,042
2	OTHER	XPS	0,2	0	0,038	0	1,00	0,038	5,263
3	OTHER	Porotherm brick 25cm	0,25	0	0,300	0	1,00	0,300	0,833
4	Surface resistance		0,03	0	0,000	0	1,00	0,000	0,125
5	OTHER	Plasterboard	0,025	0	0,200	0	1,00	0,200	0,125
6				0	0,000	0			
7				0	0,000	0			
8				0	0,000	0			
9				0	0,000	0			
10	Surface resistance	Horizontal flow / vertically ascending							0,125

mass [Kg/m2]			Type
0	Thermal resistance R=	6.513 [m2K/W]	OPAQUE

For the lower floor in contact with the ground, PIR thermal insulation with a thickness of 5 cm above the floor, in the basement, is considered. The exception will be the two ALA spaces and the car corridor in the basement, which will be thermally insulated in the soffit of the slab above the basement with basalt mineral wool with a high density of 20 cm. The wall delimiting the car lane will be thermally insulated with 10 cm mineral wool towards the other interior spaces.

- Unidirectional thermal resistance R-6,725 m2K/W;
- Reduction coefficient of the corrected thermal resistance r – 0.795;
- Corrected thermal resistance R'- 5.35 m2K/

Table 5

Calculated resistance, floor above the basement (unheated area)

Element envelope	Exterior walls, under CTS, in heated half-basements or basements						Element code		Unheated area
Nr.	**Type**	**Layer**	**δ [m]**	**ρ [kg/m³]**	**λ [W/mK]**	**c [J/kgK]**	**a**	**λ' [W/mK]**	**R [m²K/W]**
1	Surface resistance	Vertical downward flow							0,167
2	Surface resistance	Antibacterial wallpaper	0,01	0	0,340	0	1,00	0,340	0,029
3	Surface resistance	Heat insulating adhesive	0,005	0	0,890	0	1,00	0,890	0,006
4	Surface resistance	Reinforced concrete (2600kg/m³)	0,3	2600	2,030	840	1,00	2,030	0,148
5	Surface resistance	Mineral wool Rain Screed or similar	0,2	0	0,032	0	1,00	0,032	6,250
6				0	0,000	0			
7				0	0,000	0			
8				0	0,000	0			
9				0	0,000	0			
10	Surface resistance	Horizontal/vertical upward flow							0,125

Unitary mass [Kg/m2]			Type
780	Thermal resistance R=	6.725 [m2K/W]	Inside

The roof will be terrace type with slopes of 1-2%. It will be thermally insulated with prefabricated elements of the extruded polystyrene slope. At the lowest point of the slope, it will be at least 30 cm.

- Unidirectional thermal resistance R-8,450 m2K/W;
- Reduction coefficient of the corrected thermal resistance r – 0.871;
- Corrected thermal resistance R'- 7.36 m2K/W.

Table 6

Calculated resistance, plan above the last level

Element envelope	Floor above the last level, under terraces or bridges						Element code		Roof
Nr.	**Type**	**Layer**	**δ [m]**	**ρ [kg/m³]**	**λ [W/mK]**	**c [J/kgK]**	**a**	**λ' [W/mK]**	**R [m²K/W]**
1	Surface resistivity	Outside layer							0,042
2	OTHER	Bituminous membrane	0,001	0	0,170	0	1,00	0,170	0,006
3	OTHER	Slope concrete	0,06	0	0,930	0	1,00	0,930	0,065
4	OTHER	XPS	0,3	0	0,038	0	1,00	0,038	7,895
5	Concretes	Reinforced concrete (2500 kg/m3)	0,25	2500	1,740	840	1,00	1,740	0,144
6	OTHER	Layer of unventilated air	0,05	0	0,454	0	1,00	0,454	0,110
7	OTHER	Plasteboard	0,0125	0	0,200	0	1,00	0,200	0,063
8				0	0,000	0			
9				0	0,000	0			
10	Surface resistivity	Horizontal/Verical flow							0,125

Unitary mass [Kg/m2]			TYPE
625	Thermal resistance R=	8.450 [m2K/W]	Roof

Checking the conditions regarding the recommended values of the thermal resistance of the building elements. In Table 7, it can be seen that the tire elements comply with the requirements recommended in the calculation methodology, MC001-2022.

Table 7

Recommended values of thermal resistances

		nZEB	Proposed project
External walls:	U' $_{max}$[W/m^{2}K]	0.33	0,21 [W/m^{2}K]-EWS-01),13 [W/m^{2}K]- CWS-01 0,17 [W/m^{2}K]-CWS-020,16 [W/m^{2}K]-F Tehn
	R' $_{min}$ [m^{2}K/W]	3,00	62 [m^{2}K/W]- EWS-01 3 [m^{2}K/W]]-CWS-01 5,83 [m^{2}K/W]-CWS-02 6,12 [m^{2}K/W]- F Tehn
Exterior carpentry	U' $_{max}$[W/m^{2}K]	1.20	0,71 [W/m^{2}K] – GL100 0,71 [W/m^{2}K]- GL200
	R' $_{min}$ [m^{2}K/W]	0.83	1,28 [m^{2}K/W] – GL100 1,37 [m^{2}K/W] - GL200
Curtain wall type glazed facades and skylights	U' $_{max}$[W/m^{2}K]	1,3	1, [W/m^{2}K]
	U' $_{max}$[W/m^{2}K]	0.15	0,13 [W/m^{2}K]

I cried over the last level	R'$_{min}$ [m^{2}K/W]	6,67	7,36 [m^{2}K/W]
Floors over unheated basements and cellars	U'$_{max}$[W/m^{2}K]	0,29	0,21
	R'$_{min}$ [m^{2}K/W]	3,40	4,70
Ensuring a level of air tightness of the tire: n50 at 50Pa	[h^{-1}]	≤ 1.00	<0,14

3. SOLUTIONS FOR RENEWABLE ALTERNATIVE ENERGY

The following installation systems were used to obtain alternative energy:

• Solar panels for hot water preparation: minimum 1200 square meters of solar panels (approximately 300 panels);

• Photovoltaic panels for electricity: 6500 sqm (with an average installed power of 1.3MW);

• Water-ground heat pumps: 331 geothermal wells;

• Ventilation with heat recovery;

• Air-to-air heat pumps with high efficiency having a COP>4;

• LED lighting fixtures.

• Heat recovery from cooling towers in order to prepare DHW

Photovoltaic panels will be installed with an area of approximately 6,500 square meters and an average installed power of approximately 1.3 MW.

The evaluation of the degree of monthly coverage of electricity from the production of the photovoltaic system was carried out taking into account the monthly electricity consumption related to Heating, the production of domestic hot water, air conditioning and cooling.

Regarding the results, it can be seen that the degree of coverage of the monthly electricity consumption from the renewable source photovoltaic panels is estimated to be between 14.9% and 91.2%, as seen in Table 8.

Table 8

Evaluation of the degree of monthly coverage of electricity

Monthly electricity consumption	Ian	Feb	Mar	Apr	Mai	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Units	[kW]	[kW]	[kW]	[kW]	[kW]	[kW]	[kW]	[kW]	[kW]	[kW]	[kW]	[kW]
Electirc heating	358.715	270.953	235.526	68.617						80.208	264.771	348.922
Electri DHW	25.550	25.550	25.550	25.550	25.550	25.550	25.550	25.550	25.550	25.550	25.550	25.550
Electric Ventilation	103.508	96.607	103.508	103.508	103.508	103.508	103.508	103.508	103.508	103.508	103.508	103.508
Electric cooling	-	-	-	-	75.933	166.158	226.809	206.635	70.725			
Total consumption	487.773	393.110	364.584	197.675	204.991	295.216	355.867	335.693	199.783	209.266	393.829	477.980
Ectricity generation by solar panels	72.474	85.056	145.818	172.755	186.991	165.632	199.213	194.401	162.503	130.334	77.291	70.253
Cover by solar panels(%)	14,9%	21,6%	40,0%	87,4%	91,2%	56,1%	56,0%	57,9%	81,3%	62,3%	19,6%	14,7%

For the production of domestic hot water, modern equipment was utilised and the provenance of heating agent required for its preparation are: the thermal power plant connected to the hospital through the heating boilers, a system of solar panels located on the terrace of the building and heat recovery from the towers cooling used in the air conditioning system. With this system combined with the use of conventional resources, the use of non-conventional resources and heat recovery through state-of-the-art equipment ensures the domestic hot water system high reliability over time and low energy costs. Thus, in Fig.8 (a,b), the following obtained values can be observed:

- Total energy produced 1208075,029 kWh/year
- Total specific energy produced 9,36 kWh/m^2, year (Fig.8a)
- Total CO_2 emissions avoided 285516,452 kg CO_2/year
- Total CO_2 emissions avoided in relation to surface area 2,21 kg CO_2/m^2, year (Fig.8b)

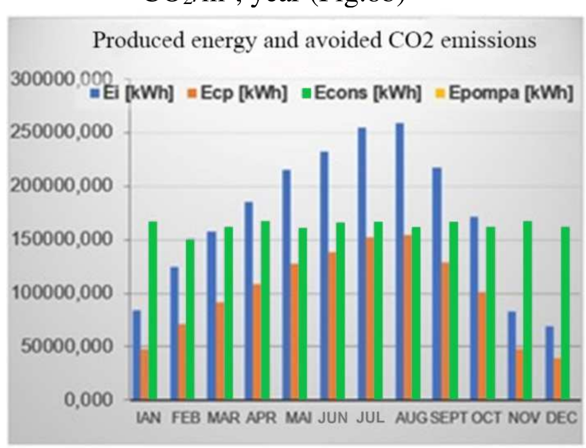


Fig. 8 a. Produced energy and avoided CO_2 emissions

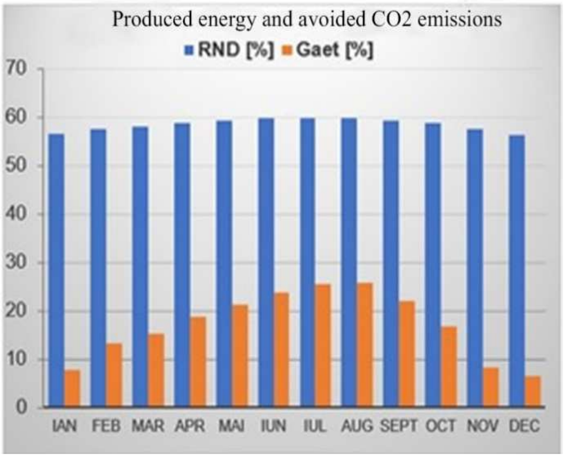


Fig. 8 b. Produced energy and avoided CO_2 emissions

Water-soil heat pumps (geothermal wells) described below will be used to obtain the energy needed for heating.

Total capture capacity = 331 pcs x 5.00 kW = 1655 kW, fluid used = 33% ethylene glycol and 67% water at P=2 bar. It will be ensured that the geothermal wells cover more than half of the hospital's heating needs (Table 9).

Calculation of the energy produced from photovoltaic panels, thermal solar panels, panels with heat pumps is seen in Table 10.

Table 9

Electrical energy consumed, amount of energy from renewable sources, auxiliary energy

Final calculation - energy performance of the heat pump final calculation - (PdC)	
Total energy consumed; EH, gen, in	652376.259 [KWh/year]
Total heat losses calculated from the auxiliary source; $Q_{H, gen, IS, rbl}$	0.000 [KWh/year]
Total amount of energy from renewable sources; $Q_{H, gen, ren, in}$	3371517.282 [KWh/year]
Total auxiliary energy, $W_{H, gen, aux}$	65237.626[KWh/year]
Total energy consumption of the reserve source; $E_{H, gen, bu, in}$	0.000[KWh/year]
Total energy supplied for heating; $Q_{H, gen, out,}$	4023893.541 [KWh/year]
Total energy supplied for domestic hot water;QW,gen, out	0.000[KWh/year]
Energy supplied for storage; Q_h, gen, Sb, out	0.000[KWh/year]

Table 10

Produced Energy

Thermal Area	Solar Photovoltaic	Solar thermal	Solar thermal	WIND TURBINE	Heat Pomp	
		Heating	A.C.C.		Heating	A.C.C.
ZT1	1686703,6	0,0	1208075,0	0,0	4023893,5	0,0
ZT2	0,0	0,0	0,0	0,0	0,0	0,0
ZT3	0,0	0,0	0,0	0,0	0,0	0,0
ZT4	0,0	0,0	0,0	0,0	0,0	0,0
ZT5	0,0	0,0	0,0	0,0	0,0	0,0
TOTAL	1686703,6	0,0	1208075,0	0,0	4023893,5	0,0

TOTAL ENERGY PRODUCED	6918672.168	[KW/year]
TOTAL SPECIFIC ENERGY PRODUCED	53.59	[KW/m2, year]
TOTAL CO2 EMISSIONS AVOIDED	1167266.274	[Kg CO2/year]
TOTAL CO2 EMISSIONS AVOIDED SURFACE RATIO	9.04	[Kg CO2/m2. year]

Exported thermal energy	0.0 KWh_t/year (produced on-site)
Exported electricity	0.0 KWh_e/year (produced on-site)
Thermal energy imported from renewable sources	0.0 KWh_t/year (produced on-site)
Electricity exported from renewable sources	0.0 KWh_e/year (produced on-site)
Primary energy indicator EP_P	129.4 KWh(m^2, a)
Index REP_P	45.83%
CO_2 emissions indicator	12.1 $kgCO_2/(m^2, a)$
SRI index(smart readiness indicator)	-

Table 11 shows the annual primary energy consumption and energy class.

Table 11

The energy class of the studied building

Types of Installations	The energy class of the studied building[kWh/m^2,year]							
	A+	A	B	C	D	E	F	G
Heating	42,0	48 ... 68	68 ... 137	137 ... 230	230 ... 324	324 ... 404	404 ... 485	> 485
DHW	21,5	28 ... 39	39 ... 78	78 ... 90	90 ... 102	102 ... 128	128 ... 153	> 153
Cooling	≤ 21	21 ... 30	31,2	59 ... 92	92 ... 125	125 ... 156	156 ... 187	> 187
MVHR	≤ 9	9 ... 12	20,4	25 ... 40	40 ... 54	54 ... 68	68 ... 82	> 82
lighting	≤ 11	14,3	16 ... 32	32 ... 49	49 ... 66	66 ... 82	82 ... 98	> 98

4. CONCLUSION

The presented paper suggests an important step for energy retrofitting buildings by presenting new efficient facilities or changing the not efficient ones with superior alternatives accessible in the market.

The solutions proposed for the analysis are based on the potential of the area regarding the use of renewable energy, the layout of the construction in the environment, the type of consumer and the legislation in force.

Renovating the area of major opportunity to modernize Romania's building stock in a sustainable way, which offers multiple benefits for the public sector.

This strategy establishes a long-term framework until 2050 for the renovation of Romania's building stock to very high levels of energy performance.

Increasing energy performance to near-zero energy consumption requires mixed energy efficiency measures (increased thermal insulation, ventilation, etc.) and a high degree of integration of renewable sources.

Thermal insulation is one of the important technologies in energy conservation. The proposed solutions are to create a curtain wall, insulation of floors and walls with basaltic mineral wool with a coefficient of reduction of thermal resistance corrected by r - 0.752, natural ventilation to avoid the accumulation of condensation in the cold season and to correct drying thermal insulation in the season. warm.

Closing the gaps in the carpentry with aluminum profiles with thermal break and triple heat-insulating glass, with solar protection with the coefficient of reduction of the corrected thermal resistance r - 0.846, and in the area of the glazing, located on the outside, there will be vertical slat type sunshades with variable orientation, made of aluminum profiles on a metal structure, aiming to reduce the solar input through direct sunlight in the summer and the transfer of heat from the interior to the exterior in the cold season.

Photovoltaic panels will be installed where the degree of coverage of the monthly electricity consumption is estimated to be between 14.9% and 91.2%.

The increase in energy performance is achieved through good insulation measures and intelligent systems that reduce energy consumption, especially those from burning fossil fuels, while also reducing CO_2 emissions.

Under these conditions, it is found that the project fulfills the hospital's compliance requirements in order to comply with the requirements regarding the primary energy requirement at least 10% lower than the requirement for nZEB-10% constructions, according to Regulation 2020/852 on the establishment of a framework for facilitating sustainable investments, EU taxonomy.

From the analysis of what has been presented, it is found that the construction is efficient by an energy viewpoint, provided that using the construction materials and installations with high energy efficiency is respected.

The building was investigated through calculation methodology of energy performance, by using the Energ- Plus software. Final energy consumed by a building over a time period (year, month, week) it is calculated using the following formula:

$Q_{f,i} = Q_{f,h,i} + Q_{f,v,i} + Q_{f,c,i} + Q_{f,w,i} + Q_{f,l,I}$, [kWh/year], where the terms represent the final energy (for the energy vector i) consumed for: heating Qf,h,i, ventilation Qf,v,i, cooling Qf,c,i, domestic hot water preparation Qf,w,i and lighting Qf,l ,i, values calculated according to the present methodology. The maximum value required by these requirements of the primary energy reduced by 10% has the value, Ep = 151.92 [kWh/ year, square meter]. The value achieved by the project is Ep = 129.4 [kWh/year, square meter] and CO_2 emissions < 30 [kg/m2, year].

The proposed curtain wall as well as the insulation solutions applied seems promising for construction applications, both from the viewpoint of saving energy and the effect over the nature.

In conclusion, it is worth emphasizing that the aim of the work is not to find an exemplary project, but to find innovative solutions and materials to influence energy performance, operating costs and environmental issues.

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Metode și soluții privind eficiența energetică la clădiri publice

Următoarea lucrare își propune să ofere recomandări și să stabilească performanța energetică a unei clădiri publice-spital-x și să ofere soluții și măsuri pentru creșterea eficienței energetice și îmbunătățirea calității mediului prin reducerea emisiilor de gaze cu efect de seră (GES) prin reducerea anuală. consumul de energie primară și pentru a asigura un climat interior sănătos. Obiectivele lucrării sunt de a prezenta o clădire nou construită care face obiectul unui studiu privind un consum de energie cât mai redus, ținând cont de izolarea termică, de caracteristicile tehnice ale clădirii și instalațiilor, de proiectarea și amplasarea clădirii în relația cu factorii climatici externi, expunerea la soare și influența clădirilor învecinate, sursele proprii de producere a energiei și alți factori, inclusiv climatul interior al clădirii, care influențează necesarul de energie.

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