IMPROVING THE ENERGY EFFICIENCY OF A STUDENT DORMITORY BUILDING BY MEANS OF SIMULATIONS

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This paper presents the technical and financial analysis of reducing the energy consumption of a student dormitory building located in Bucharest, Romania. The studied residential building is an old construction with high energy requirement for both heating (435 MWh/year) and electricity (252 MWh/year). The energy reduction by implementing several efficiency measures (proper thermal insulation, lighting system replacement and integrating renewable energy systems) was analyzed. In this way, the energy requirement for heating could be reduced with up to 86%, the hot water consumption with 58% and the electricity for lighting with up to 83%. Finally, the economic analysis emphasizes the feasibility of the project.

Keywords: buildings retrofitting, RETScreen simulations, technical and economic analysis, nZEB

1. Introduction

The buildings sector represents a key factor in European Union (EU) energy strategy, whereas it is a major contributor to the final energy consumption. This sector is continuously and rapidly expanding, being estimated that it will grow with more than 25% until 2050 [1]. The share of residential buildings is up to 75% from total, and the large majority (up to 80%) were built before 1991, when no energy efficiency guidelines were available, implying improper or no thermal insulation at all [2]. These facts are emphasized by the large share in the final energy consumption: the residential building stock is accountable for an estimated 40% energy consumption and 36% greenhouse gas emission [3]. The main intent of a building is to provide shelter and comfort; thus, the energy consumption breakdown can be split between heating and air conditioning systems (up to 65%), domestic hot water preparation (up to 14%) and appliances (up to 12%) – which tend to be more efficient [4].

The Romanian building stock consists mainly of old and energy inefficient buildings, having the total final energy consumption estimated at 45% from total

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primary energy consumption [4]. The total build area is around 5 million m^2, from which, more than 85% are residential buildings [5]. Up to 70% were built prior to 1980 and their heating systems are technologically outdated, fact indicated by the overall energy consumption range: 150 and 400 kWh/m^2/year. It is worth mentioning that the energy consumption levels were improved for buildings constructed from 2000 onward, ranging from 120 to 230 kWh/m^2/year [5].

These facts emphasize the need of proper and urgent actions aiming to mitigate the energy impact of building across EU. In this regard, a powerful instrument is the nZEB (nearly Zero Energy Building) principle, whose definition was first mentioned in the recast version of EPBD (Energy Performances of Buildings Directive) [6]: "[nZEB is] *a building that has a very high energy performance. […] the amount of energy required should be covered to a very significant extent by energy from renewable sources, including energy from renewable energy sources produced on-site or nearby*". Transposing this definition into national legislation is mandatory for all Member States. For Romanian climate and building culture, the following minimal requirements are to be met for nZEB classification, according to the studies conducted by BPIE (Building Performance Institute Europe) [7]:

- For individual and collective dwellings:
  - yearly primary energy consumption: 30 – 50 kWh/m^2
  - renewable energy usage share: more than 40%.
  - yearly CO_2 emissions: less than 3 – 7 kg$_{CO2}$/m^2.
- For office buildings:
  - yearly primary energy consumption: 40 – 60 kWh/m^2
  - renewable energy usage share: more than 40%.
  - yearly CO_2 emissions: less than 5 – 8 kg$_{CO2}$/m^2.

These values were obtained through dynamic simulations taking into consideration the cost-efficient criteria and are recommended for buildings constructed from 2020 onwards, but also for old buildings subjected to retrofit actions.

Given these facts, this paper analyses the possibility to transform an old dormitory building, designed to accommodate students from POLITEHNICA University in Bucharest in Regie Campus, into a building that meets nZEB requirements. For the technical and economic analysis, the RETScreen software was used. The results showed that it is feasible to obtain nZEB in Bucharest using renewable energy systems. The building, named P22, was chosen to be analyzed since it already had an Energy Performances Certificate obtained according to Romanian legislation and normative. The results obtained using RETScreen are similar with the data from energy performance certificate but using the proposed software it is possible to conduct feasibility and cost-effectiveness analysis.

Moreover, if the proposed solution is convenient, it can be easily adapted to analyze all dormitory buildings from Regie Campus, and not only.

2. RETScreen Expert software

With more than 430,000 downloads by 2015, RETScreen is the most used simulation and analysis tool [8, 9]. It has a free version which can be downloaded from Natural Resources Canada website [10]. It is a powerful tool used to analyze the feasibility of renewable energy projects, helping the decision-makers to find the best cost-effective solution [8, 10, 11]. Moreover, it is used to evaluate the feasibility of energy models, energy production systems (based on renewable energy or high efficiency systems), or to evaluate the efficiency of existing models [12]. Using the RETScreen software, the user can analyze comprehensive projects regarding the implementation of most clean energy technologies and it offers the possibility to increase the energy efficiency of a building, thus to decrease its greenhouse gas emissions [13, 14]. The fundament of the program is to compare two cases: the *base case*, representing the current state of the system or facility and the *proposed case*, containing the improvements to be analyzed. This way, in a simpler manner, the user can analyze the feasibility and the improvements of an individual measure (e.g. improving the thermal envelope of a building), or several comprehensive strategies (for example integrating a trigeneration system) [15]. Moreover, the user can evaluate different *individual measures* to improve the efficiency of a system or component.

A very useful feature is that the software contains comprehensive data bases including: the most renewable energy-based systems (product data), cost data, climate data, hydrology data, project data, benchmark data (average consumption patterns for most of world's countries and power plants), energy resource maps, etc. The tool has been widely used to analyze different renewable energy infrastructures and their feasibility; to date, RETScreen is directly responsible for an estimated $ 8 billion in energy savings. In addition, the use of software contributes to the decrease of greenhouse gas emissions by 20 million tons per year, as stipulated by NASA Research Center [16]. Given these data, the RETScreen software was used to analyze best scenario to increase the energy efficiency, and implicitly to reduce the greenhouse gas emissions, of a multi-unit housing building serving as dormitory for students from University POLITEHNICA of Bucharest.

3. Modelling, assumptions and results

The analyzed building is placed in Regie Campus (latitude 44,45°N and longitude 26,06°E) and it is used to accommodate students from University POLITEHNICA of Bucharest. The precise location of the building is shown in

Fig. 1, as a Google Maps capture. The P22 dormitory is an old building, first used in 1974, thus no energy efficiency standards were considered at that time. Even if throughout time it was refurbished several times, the building lacks proper thermal insulation and heating systems. It is a 5-storey building (P+4) and has 44 rooms on each floor, accommodating maximum 440 students. Each room has a useful surface of 11,76 m^2, while each floor has the following secondary spaces: hallway (153 m^2), bathrooms (47 m^2) and staircase (33,85 m^2).

Fig. 1. Location of the analyzed dormitory building (P22)

Regarding the daily occupancy rate, we considered the students are in the dorms in average 15 hours per day from Monday to Friday (considering that they have courses to attend) and 20 hours/day on Saturdays and Sundays. This resulted in an annual occupancy rate of 5996 hours per year (68,5%). Moreover, it was assumed that the building is only 40% booked during students' summer holiday, 80% booked during Christmas and Easter holidays and fully booked during the semesters. In unoccupied periods, the temperature setpoints were set at 18 °C (winter) and 28 °C (during summer), while when occupied we considered the comfort temperature: 20 °C for heating periods and 25 °C for cooling periods. The outdoor air temperature at which the HVAC system will normally change from heating to cooling and vice-versa was set at 17 °C, resulting an estimated 211 days when heating is needed and 154 days when cooling is mandatory to maintain the comfort temperatures.

To conduct the simulations, the climate data from the RETScreen database must be selected. The closest location containing the required data is Bucharest/Băneasa site (latitude 44,5°N and longitude 26,06°E), located at just 6 km from Regie Campus, thus no significant differences regarding the results of the simulation. The weather data for this location contains monthly mean values of: ambient air temperature, relative humidity, amount of precipitation, solar radiation–horizontal, atmospheric pressure, wind speed, ground temperature, heating and cooling degree days at 18 °C and 10 °C respectively. The average monthly and annual values can be analyzed in Fig. 2. To estimate the energy requirement for heating and cooling, the most important factors are: ambient air temperature, heating degree-days (at 18 °C) and cooling degree-days (at 10 °C). The degree-days for a given day represent the number of Celsius degrees that the mean temperature is above or below a given base. Thus, heating degree-days are the number of degrees below 18 ºC in this case, while the cooling degree-days are the number of degrees above 10 ºC.

	Unit	Climate data location	Facility location	Source
Latitude		44.5	44.5	
Longitude		26.1	26.1	
Climate zone		4A - Mixed - Humid		User-defined
Elevation	m	91	91	Ground – Ground
Heating design temperature	°C	-10.1		Ground
Cooling design temperature	°C	32.0		Ground
Earth temperature amplitude	°C	22.2		NASA

Month	Air temperature	Relative humidity	Precipitation	Daily solar radiation - horizontal	Atmospheric pressure	Wind speed	Earth temperature	Heating degree-days 18 °C	Cooling degree-days 10 °C
	°C	%	mm	kWh/m²/d	kPa	m/s	°C	°C-d	°C-d
January	-2.4	88.3%	59.71	1.44	100.9	2.4	-1.6	632	0
February	-0.1	82.3%	45.40	2.30	100.8	2.7	0.3	507	0
March	4.8	75.0%	49.16	3.40	100.7	2.8	6.3	409	0
April	11.3	71.7%	55.10	4.85	100.3	2.6	13.3	201	39
May	16.7	69.1%	65.99	6.04	100.3	2.1	19.6	40	208
June	20.2	71.0%	70.88	6.55	100.2	1.7	23.6	0	306
July	22.0	69.4%	78.39	6.49	100.3	1.6	26.5	0	372
August	21.2	69.7%	74.28	5.77	100.4	1.4	26.3	0	347
September	16.9	74.5%	76.95	4.40	100.7	1.5	21.1	33	207
October	10.8	81.1%	56.64	3.06	101.0	1.7	14.1	223	25
November	5.2	86.9%	53.77	1.36	100.9	2.2	5.7	384	0
December	0.2	88.9%	57.55	0.95	100.8	2.2	-0.4	552	0
Annual	**10.6**	**77.3%**	**743.81**	**3.89**	**100.6**	**2.1**	**13.0**	**2,982**	**1,504**
Source	Ground	Ground	NASA	Ground	Ground	Ground	NASA	Ground	Ground
Measured at					m	10	0		

Fig. 2. Average monthly values of main climate data for Bucharest (Băneasa site)

The energy requirement for heating and cooling is estimated based on the thermal properties of the building envelope, the overall surfaces of the windows, indoor and outdoor climate data. For modelling the heat transfer across the envelope, RETScreen computes the overall thermal resistance based on the thermal conductivity and thickness of each layer. It also estimates the joint thermal bridges. The main orientation of the buildings is East-West; thus, the most significant part of the envelope is given by these walls. The East and West exterior walls are composite structures containing layers of interior plaster, masonry brick and exterior plaster. Moreover, the software computes the interior and exterior convective resistance based on estimate heat transfer rate. The thickness, thermal conductivity and overall thermal resistance of each layer are detailed in Fig. 3.

Building envelope properties

Type	Wall - above-grade	
Units	m² - °C/W	R-value

Description	Layer	Thickness (mm)	Conductivity (W/m - °C)	Resistance (m² - °C/W)
Exterior film coefficient				0.012
Interior plaster	1	20	0.930	0.022
Masonry brick	2	250	0.800	0.313
Aparent brick	3	20	0.800	0.025
Exterior plaster	4	20	0.930	0.022
Interior film coefficient				0.120
R-value - nominal			m² - °C/W	0.513
U-value - nominal			(W/m²)/°C	1.951

Fig. 3. Thermal characteristics of eastern and western exterior walls

As observed above, the overall thermal resistance of exterior walls is small, indicating a first possible method to increase the energy efficiency of the buildings; decreasing the overall U-value by installing thermal insulation. This strategy will be analyzed later. The northern and southern walls are composed of 5 layers, detailed in Table 1:

Table 1

Thermal properties of northern and southern exterior walls

Layer	Thickness [mm]	Thermal conductivity [W/m^2/K]
Interior plaster	20	0,930
Concrete rectification	22	0,930
Reinforced concrete	200	1,740
Autoclaved cellular concrete	50	0,340
Exterior plaster	30	0,930

The computed overall nominal R-value is estimated at 0,638 m^{2}K/W, value that illustrates poor thermal characteristics of North and South walls, requiring solutions for improvements. The same analysis was conducted for the exterior roof and slab above the ground. The results are presented in Fig. 4.

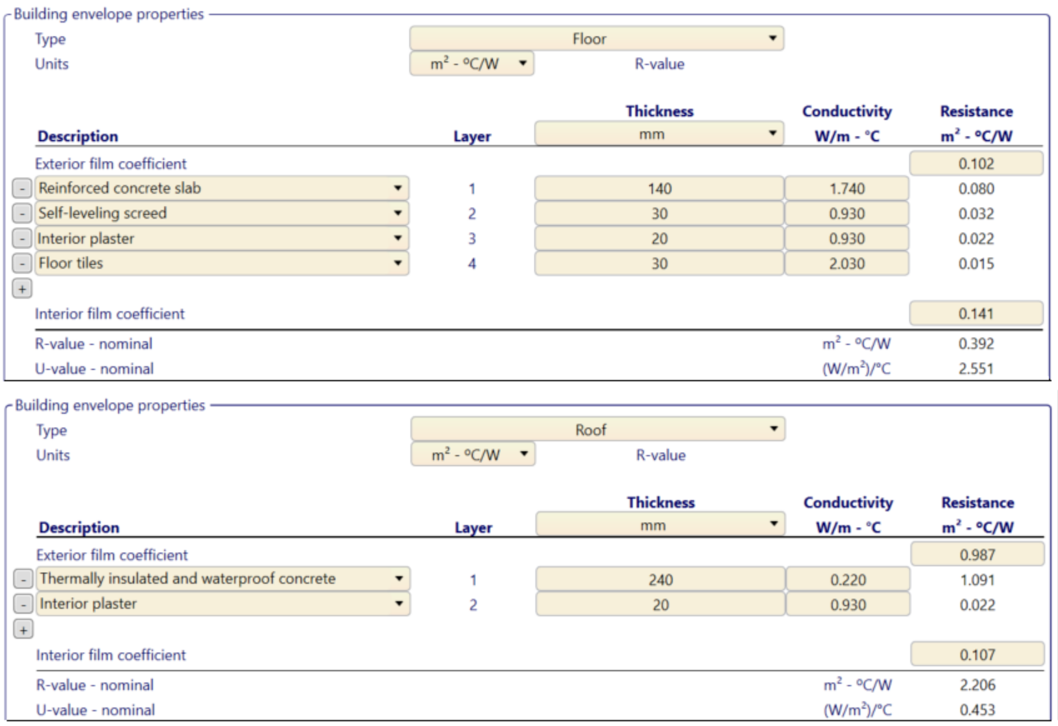


Fig. 4. Thermal characteristics of ground floor and roof

The U-coefficient of the windows is 2 W/m^2/K and solar absorption factor is rated at 0,6. The total window surface is approximately 1250 m^2; the Est façade has a 50% window-to-wall ratio, while the ratio for West façade is 46%. The low energy efficiency of the windows, combined with the large area occupied by them, leads to significand thermal losses. The resulted overall energy requirement for heating is 435 MWh/year, comparable with the results from the Energy Performance Certificate. If considering the total useful surface of 3796 m^2, the specific energy for heating calculated with RETScreen is 117,66 kWh/m^2/year, while according to the Energy Certificate, the building is C–rated (117,7 kWh/m^2/year). This indicates a very good accuracy of RETScreen mathematical model. The benefit of using this software is that once obtaining the energy requirement, the user can analyze a multitude of strategies to decrease the specific energy consumption of the building. For this, a comprehensive analysis was conducted gradually, starting from simple methods (e.g. increasing the thermal insulation and improving the existing lighting system) to more complex ones (integration of renewable energy systems such solar heaters and PV systems).

3.1. Installing the thermal insulation

The most common method of lowering the energy consumption for heating is to improve the thermal characteristics of the envelope of the building. For this purpose, the insulation of building using expanded polystyrene (EPS) was considered. EPS is a widely used material, having medium price and good thermal insulation properties. The exterior walls are insulated with 100 mm thick EPS insulation with a thermal conductivity of 0,043 W/m/K. Thus, the overall thermal resistance has increased to 2956 m^{2}K/W for northern and southern walls and to 2838 m^{2}K/W for eastern and western walls (Fig. 5).

The roof was insulated with extruded polystyrene – XPS (150 mm thickness and 0,04 W/m/K thermal conductivity); the overall R-value increased to 4,966 m^{2}K/W. The above the ground floor stab was insulated with XPS of 180 mm thickness; moreover, the tiles are replaced with 8 mm layer parquet with an R-value of 0,04 m^{2}K/W, increasing the overall thermal resistance to 4.897 m^{2}K/W. The glazed surface was replaced with triple pane windows with a U-coefficient of 0,5 W/m^2/K. The energy reduction obtained by installing thermal insulation is 86%, from 434538 kWh/year to 59936 kWh/year.

This simple method of decreasing the energy consumption of a building is among the most cost-effective procedures adopted by stakeholders. The large percentage of heat requirement reduction emphasizes this, encouraging the investors. Moreover, the large diversity of insulation materials and methods assure that the desired building's aesthetics is obtained, beside the desired energetic reduction.

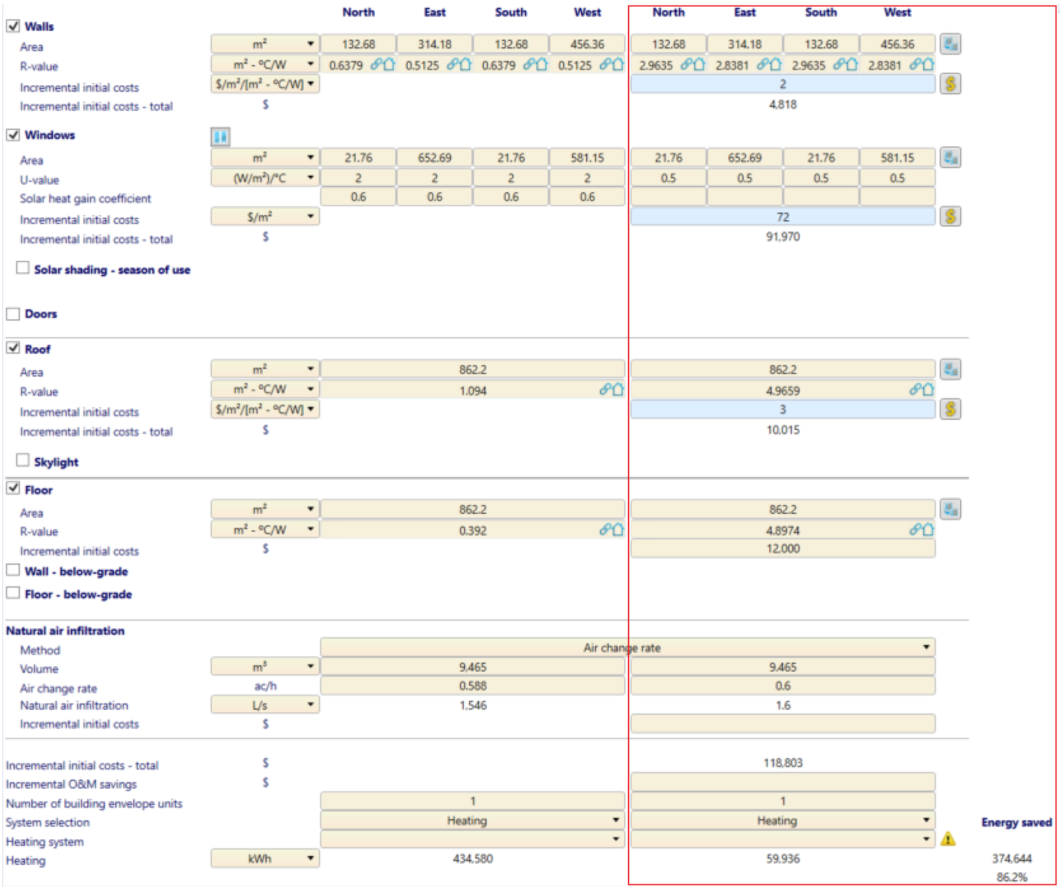
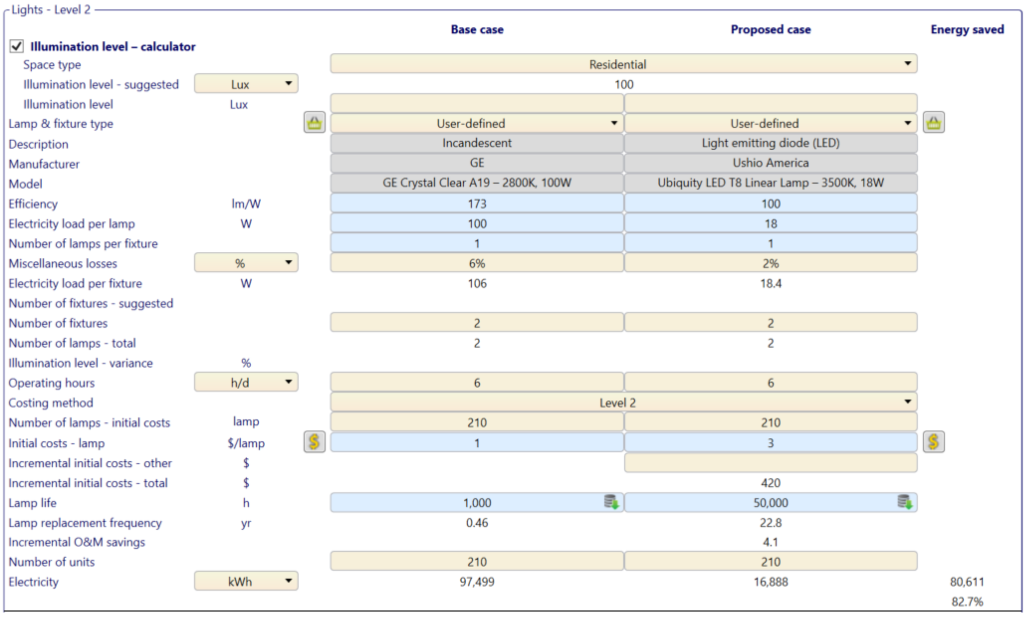


Fig. 5. Comparison between the base case (uninsulated building) and the proposed solution (insulated building) – highlighted

3.2. Improving the lighting system

In the first step of the analysis the "before" (existing) system was described, then the "after" scenario (containing the proposed improvements to be adopted) was created. In the "before" system, lighting in each room is assured by 2x100 W incandescent bulbs; it was considered that the artificial lighting is used used in average 6 hours/day. The total electricity consumption was estimated at 97499 kWh. For mitigating this, it was considered that all light bulbs are replaced with 18 W LEDs lamps, maintaining the same utilization schedule – 6 hours/day. The LEDs have an efficiency of 100 lm/W and 2% miscellaneous losses. The overall electricity reduction was estimated at 83%, as detailed in Fig. 6.



Lights - Level 2		Base case	Proposed case	Energy saved
Illumination level – calculator				
Space type		Residential		
Illumination level - suggested	Lux	100		
Illumination level	Lux			
Lamp & fixture type		User-defined	User-defined	
Description		Incandescent	Light emitting diode (LED)	
Manufacturer		GE	Ushio America	
Model		GE Crystal Clear A19 – 2800K, 100W	Ubiquity LED T8 Linear Lamp – 3500K, 18W	
Efficiency	lm/W	173	100	
Electricity load per lamp	W	100	18	
Number of lamps per fixture		1	1	
Miscellaneous losses	%	6%	2%	
Electricity load per fixture	W	106	18.4	
Number of fixtures - suggested				
Number of fixtures		2	2	
Number of lamps - total		2	2	
Illumination level - variance	%			
Operating hours	h/d	6	6	
Costing method		Level 2		
Number of lamps - initial costs	lamp	210	210	
Initial costs - lamp	$/lamp	1	3	
Incremental initial costs - other	$			
Incremental initial costs - total	$		420	
Lamp life	h	1,000	50,000	
Lamp replacement frequency	yr	0.46	22.8	
Incremental O&M savings			4.1	
Number of units		210	210	
Electricity	kWh	97,499	16,888	80,611 82.7%

Fig. 6. Electricity reduction by replacing the lighting system of the building

At this stage of simulation, the electricity used by the appliances was estimated. Each room is equipped with: one refrigerator (200 W nominal power, 10 hours/day operating hours), 2 laptops (35 W nominal power, 6 hours/day operating hours and 80%), 0,45 irons (1000 W nominal power, 0,5 hours/day operating hours), resulting 154526 kWh/year electricity consumption.

3.3. Integration of renewable energy systems

The analysis extends to integrate a thermal solar system to assure the hot water requirement and PV panels to reduce the electricity consumption from national grid. For estimating the hot water consumption, we considered a mean occupancy rate of 82%, given the fact that the building is used as accommodation for students outside Bucharest, excepting the national holidays, the exam periods, etc. The occupancy, by month is presented in Table 2. Considering the hot water temperature at 60 °C and average utilization of 6 hours/day, the heating energy requirement for supplying the hot water at these parameters is 125978 kWh_t/year.

Table 2

Considered occupancy rate

Month	I	II	III	IV	V	VI	VII	VIII	IX	X	XI	XII
Occupancy rate [%]	80	90	100	80	100	100	40	40	70	100	100	80

To optimize the energy requirement, it was considered a thermal solar system composed of 100 panels. It was chosen a fixed evacuated tube system with a gross area per solar collector of 2,031 m^2 and the aperture area per solar collector of 1,845 m^2. Each evacuated tube has the following thermal parameters: optical efficiency $F_R(\tau\alpha)$ = 0,681 and thermal losses F_RU_L = 4,071 $W/m^2/K$. We considered 100 collectors, summing a total surface of 203 m^2 and a total installed capacity of 129 kW_t. The monthly thermal energy production can be analyzed in Fig. 7.

Month	Percent of month used - base case %	Percent of month used - proposed case %	Daily solar radiation - horizontal kWh/m²/d	Daily solar radiation - tilted kWh/m²/d	Heating delivered kWh
January	80%	80%	1.44	1.79	2,075.176
February	90%	90%	2.30	2.67	4,344.871
March	100%	100%	3.40	3.72	8,124.030
April	80%	80%	4.85	5.08	8,490.644
May	100%	100%	6.04	6.11	12,433.302
June	100%	100%	6.55	6.53	12,063.658
July	40%	40%	6.49	6.51	4,857.037
August	40%	40%	5.77	5.96	4,647.804
September	70%	70%	4.40	4.75	6,528.373
October	100%	100%	3.06	3.54	7,205.763
November	100%	100%	1.36	1.60	2,005.438
December	80%	80%	0.95	1.12	349.168
Annual	**81.5%**	**81.5%**	**3.89**	**4.12**	**73,125.264**

Fig. 7. Monthly and total energy production of the analyzed thermal solar system

The total energy delivered by the passive solar panels system is 73125 kWh_t, representing 58% of the total energy requirement. Moreover, it was considered a storage system composed of hot water boilers with a storage capacity of 100 liters/m^2. The boilers will assure the hot water requirements in low production periods.

The same analysis was conducted to estimate the electricity reduction by installing a PV panels system. For this, we considered a mono-Si system composed of 100 PV panels, totaling 22 kW_e nominal power and 149 m^2 active area; the efficiency of each panel is 14,8 %. Both monthly and total energy production can be analyzed in Fig. 7. Moreover, is presented the daily solar radiation. The total electricity delivered is 24477 kWh_e/year.

Due to its space positioning, the dormitory is shaded on all 4 orientations, thus, the only reasonable place to install the renewable energy systems is the roof. Consequently, when the number of thermal and PV panels was chosen, it was also taken into consideration the total space required between the panels (not to be shaded by others) and the space required for installing the boilers.

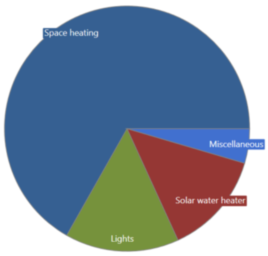
Solar tracking mode	Fixed
Slope	15
Azimuth	45

Show data

Month	Daily solar radiation - horizontal kWh/m²/d	Daily solar radiation - tilted kWh/m²/d	Electricity rate – annual $/kWh	Electricity production kWh
January	1.44	1.79	0.64	992.281
February	2.30	2.67	0.64	1,311.939
March	3.40	3.72	0.64	1,964.654
April	4.85	5.08	0.64	2,503.135
May	6.04	6.11	0.64	3,025.096
June	6.55	6.53	0.64	3,080.074
July	6.49	6.51	0.64	3,142.709
August	5.77	5.96	0.64	2,893.248
September	4.40	4.75	0.64	2,289.377
October	3.06	3.54	0.64	1,824.924
November	1.36	1.60	0.64	832.775
December	0.95	1.12	0.64	616.594
Annual	**3.89**	**4.12**	**0.64**	**24,476.804**

Fig. 8. Monthly and total energy production of the analyzed PV system

A complete energy reduction analysis is shown in Fig. 9. Before the improvements, the yearly energy requirement for space heating and domestic hot water production was approximately 504 MWh and the overall electricity need approximately 252 MWh. All the previous mentioned efficiency strategies assured a total heating energy reduction of 432 MWh and electricity reduction of 101 MWh. The largest reduction is due to the proper thermal insulation of the building (67%), followed by changing the lighting system (15%), two simple and cost-effective methods.



Section	Energy saved kWh	Energy saved %
Space heating	358,790	66.8%
Lights	80,611	15%
Solar water heater	73,125	13.6%
Miscellaneous	24,477	4.6%
Power	24,477	4.6%
Mechanical equipment	-3,951	-

Fig. 9. Energy reduction percentage

The overall energy reduction is quantifiable in terms of gross annual reduction of greenhouse gas emissions. Compared with the base case, the proposed case emits 40% less GHG, considering an emission factor of 0,536 tCO_2/MWh and including energy transport and distribution losses (7%). In this way, the overall GHG emission is 54,2 tCO_2, that is equivalent to:

- 5 hectares of forest absorbing carbon, or
- 9,9 cars and light trucks not used, or
- 23302 liters of gasoline not consumed, or
- 126 barrels of crude oils not consumed, or
- 54,2 people reducing energy use by 20%, or

- 18,7 tons of waste recycled.

Furthermore, by using the RETScreen software a comprehensive financial analysis was conducted. Based on the available data regarding equipment prices, inflation rate, available debt possibility and energy prices, the model estimates the cumulative cash flows of the project, which represent the net pre-tax flows accumulated from year 0.

The equipment and insulation costs were given based on a detailed market research. For the 10 cm EPS insulation material, it was considered 2 €/m^2, totaling 4818 €, while the 15 cm XPS insulation totals 10015 € (3 €/m^2). The ground floor insulation and parquet had an estimated cost of 12000 €, while the specific cost of the triple glazing windows was considered 72 €/m^2, totaling 91970 €. The LEDs used to replace the existing light bulbs have an estimated unitary cost of 3 €. The total cost of the proposed renewable energy systems is estimated at 261925 € (solar water system: 193725 € and PV panels: 68200 €). It is considered that the utility of the project expands over 40 years, and the yearly operation and maintenance costs are approximatively 823 €. Moreover, we considered initial incentives and grands totaling 50000 €. The overall cost of the project is 469073 €. The cumulative cash flow is presented in Fig. 10.

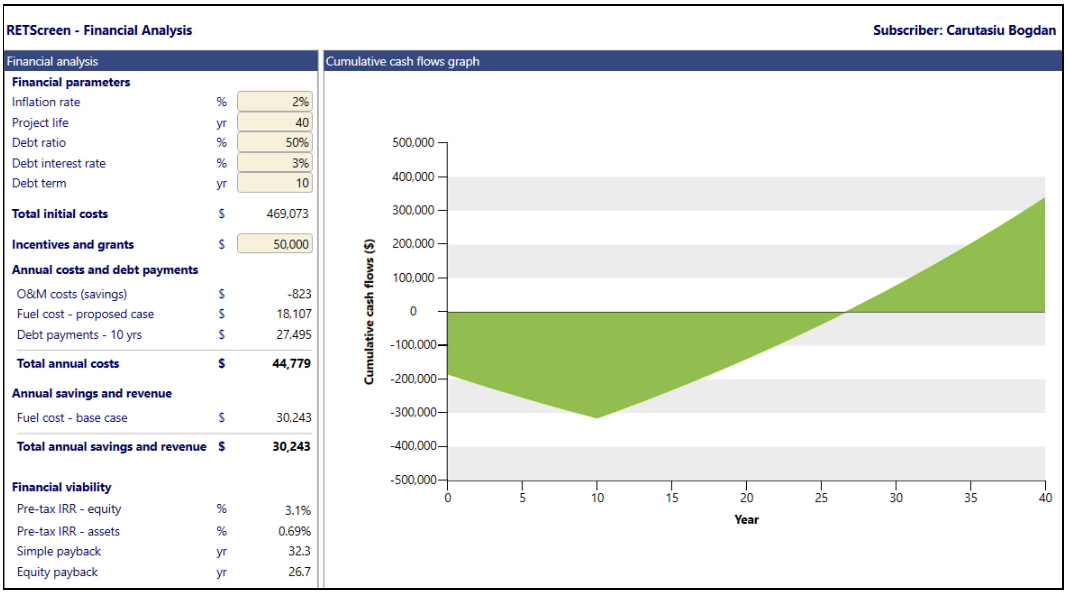


Fig. 10. Cumulative cash flow of the project

The debt ratio, which is the ratio between debt and the sum of the debt and the equity of a project, is projected at 50%, meaning that only half of these costs should be supported by the beneficiary. The debt term is 10 years at an interest rate of 3%, resulting a yearly dept payment of 27495 €. To assure a proper economic analysis, we considered that the natural gas price is 0,03 €/m^3 and the electricity price is 0,12 €/kWh. These prices are selected form the RETScreen database. Based on these prices, on the energy savings obtained and the economic parameters described above, the equity payback (represents the period the owner of a facility needs to recoup its own initial investment out of the project cash flows generated) is 26,7 years. The simple payback (which represents the time that it takes for a proposed facility to recoup its own initial cost, out of the revenue or savings it generates – the more quickly the cost of an investment can be recovered, the more desirable is the investment) is 32,3 year.

4. Conclusions

This paper presents a feasible way to increase the energy efficiency of an old residential building used as dormitory for the students attending University POLITEHNICA of Bucharest courses. The analyzed facility was built in 1974, when no energy efficiency codes were available, thus, it has high specific energy consumption: 435 MWh/year for heating, 126 MWh/year for domestic hot water and 252 MWh/year for electricity consumption. Several energy reduction measures were proposed. Firstly, the installation of proper thermal insulation and high efficiency windows, which minimized the thermal losses, thus decreasing the overall energy requirement with 86%. For the thermal insulation EPS (exterior walls) and XPS (for the rest of the building envelope) were considered. Secondly, by replacing the inefficient incandescent lighting system with a LED-based system, the yearly energy reduction was 83% (from 97499 kWh – the base case to 16888 kWh – proposed case). The third measure was to integrate systems based on renewable energy. In this way, for the hot water preparation it was considered an evacuated solar tube system and for the electricity generation a mono-Si PV system. These were chosen based on the maturity and market availability of the systems. The simulations showed that the thermal solar system could provide up to 58% of the hot water requirement, while the roof mounted PV panels can produce 24478 kWh_e/year.

Finally, the feasibility of the project was emphasized based on the payback economic analysis, showing that the simple payback is not greater than 33 years, while the equity payback less than 27 year. This study shows the energy reduction potential of using proper thermal insulation and efficient lighting systems. Moreover, the relatively low payback periods should encourage the stakeholders to properly refurbish old buildings instead of rising new ones.

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