ECONOMIC AND FINANCIAL ANALYSIS OF THE BUILDINGS REHABILITATION SOLUTIONS

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Abstract - The paper includes a simplified economical and financial analysis of the buildings rehabilitation solutions, for heating and lighting. The most important economic and financial indicators analyzed and determined are: economic return on investment and payback period of investment in dynamic form, net present value, and internal rate of return economic residual value of the investment on thermal insulation, building maintenance costs, energy costs.

In order to reduce the electricity consumption: the methods consisted in replacing inefficient lighting with some efficient energy and for heat consumption: the proposed solution was building rehabilitation (exterior wall insulation, floor insulation board).

The analysis consists in determining the economical and financial indicators before and after the building rehabilitation.

The 3 rooms apartment is located in Craiova town, (wind zone IV), 2nd floor, orientation is S.

Keywords: building rehabilitation, economic, cost analysis, thermal insulation, lightning.

1. INTRODUCTION

The new concept of sustainable energy develops a different approach from the conventional that we are used to when it comes to building. Currently, the building is considered as an organism in constant evolution, which in time it should be treated, rehabilitated and modernized to meet the requirements set by the user in a certain stage. [1]

Of a great actuality are the assessments and interventions related to energy savings ensuring at the same time proper conditions of comfort. This was called the energy efficiency of the building. In parallel with reducing energy demand, it accomplishes two important objectives of sustainable development, the saving of primary resources and reduces emissions into the environment.

Understanding how a building works, both in terms of construction and in terms of equipment and facilities they serve is essential to identifying strategies that should be adopted for rehabilitation. Each part of the building is linked to all other parties and any changes produced in one place effects elsewhere. [3]

In any rehabilitation intervention forces that manifest in a building must be kept in balance: load structural effects of wind and weather, flows from moisture, heat and air. For example, adding insulation or vapour barrier and air affects the conditions for humidity, ventilation and air needed for combustion in heating.

The strategies for energy rehabilitation of buildings must consider providing indoor comfort conditions, health and safety for all users of the building. The characteristics of building materials and rehabilitation, installation procedures and construction techniques are normally specified in codes and standards, focusing on health and safety issues, such as ventilation and fire protection. For this reason, if the rehabilitation measures can not be implemented neither by users nor by owners of the building, it is recommended to appeal to specialists. [3]

On the other hand, costs of thermal rehabilitation of a building are lower than the costs of installing an additional capacity of thermal energy for heating. In Romania, the energy consumption for household sector is about 40% of the country's total energy consumption.

From literature review it shows that the percentage of energy consumption for a residential building is presented in Fig. 1.

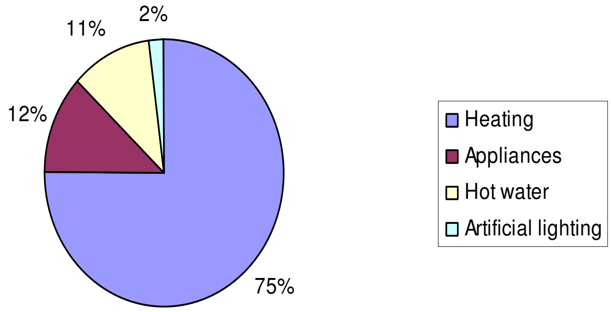

Fig. 1. The percentage of energy consumption for a residential building in Romania

Major renovations of existing buildings, regardless of their size, provide an opportunity to adopt effective measures in terms of cost to enhance energy performance.

2. DYNAMIC INDICATORS FOR CALCULATION THE ECONOMIC EFFICIENCY INVESTMENTS [4], [5]

The most important dynamic indicators for calculation the economic efficiency investments are [4, 5]:

a) Economic efficiency of investment and payback period of investment in dynamic form:

Economic return of the investment in static form is calculated using the relationship:

$$R_e = \frac{P_n}{I_t} \quad (1)$$

or

$$R_e = \frac{P_t}{I_t} \quad (2)$$

Where:

Re - economic return of the investment;

In - net profits;

It - the total investment;

Pt - total profits.

In terms of upgraded total investment (ITA) using investment flows that takes into account the moments of time, they will be calculated using the relationships:

$$ITA = \sum_{h=1}^{s} I_h \frac{1}{(1+a)^h} \quad (3)$$

In the case of using the flows with values which take into account duration, computing relations will be similar:

$$ITA = \sum_{h=1}^{d} I_h \frac{1}{(1+a)^h} \quad (4)$$

Where:

ITA - total investment upgraded to the start of construction;

In - the investment made in the course of the year *h* from period *d*;

$\frac{1}{(1+a)^h}$ - Discount factor for the year h.

b) Net present value (NPV) [4], [5]

Net present value (NPV) includes the effects and the effort of the investment process throughout the project life. This indicator expresses the difference between the total upgraded revenue and total expenditure upgraded (operating and investment), the update is performed at the same period of time for both revenue and expenditure.

The calculation formula is as follows:

$$NPV = \sum_{h=1}^{n} [V_h - (C_h' + I_h)] \cdot \frac{1}{(1+a)^h} \quad (5)$$

Where:

NPV - net present value;

V_h – the revenues in the year *h*;

C_h- operating expenses in the year *h* (less depreciation, it is excluded to eliminate the double influence of the investments);

I_h – the investments made in the year *h*;

$\frac{1}{(1+a)^h}$ - discount factor;

n - the project life time;

The indicator calculated by the above relation can not be used in the comparison of investment alternatives that are characterized by different production capacities and different volumes and hence investment.

The comparable form of the indicator and hence efficiency indicator itself is the net present value obtained for 1 monetary unit actualized investment:

$$NPV_i = \frac{NPV}{ITA} \quad (6)$$

Where:

NPV - net present value updated for 1 monetary unit upgraded investment;

NPV - net present value;

ITA – the upgraded total investment;

Economic internal rate of return determination used successive approximations in the sense that it determines net present value at a discount rate appropriate to the minimum rate considered and that must be positive.

Determining exactly the economic internal rate of return is made by interpolation, according to

$$IRER = R_{min} + (R_{max} - R_{min}) \cdot \frac{NPV(+)}{NPV(+) + |NPV(-)|} \quad (7)$$

Where:

IRER - internal rate of economic return;

R_{min} - the minimum update rate;

R_{max} - maximum update rate;

NPV (+) - positive net present value, obtained at the minimum rate;

NPV (-) - negative net present value obtained at the maximum rate.

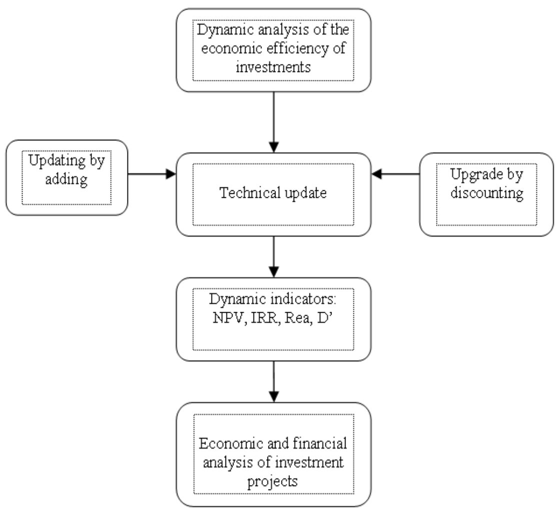

Fig. 2. Flowchart of dynamic analysis of economic efficiency [3]

3. ENERGY COSTS DETERMINATION BEFORE AND AFTER THE REHABILITATION PROCESS [1]

Initial investment costs include all the costs related to modernization of the existing building.

Undiscounted residual value of the investment on thermal insulation:

$$V_R^{NA} = \frac{Cost.inv \cdot (D_V - D_{REF})}{D_V} \quad (8)$$

Where:

V_R^{NA} - Undiscounted residual value of the investment;

Cost. inv. - investments costs;

D_V = life time;

D_{REF} = length of reference

Investments costs for building thermal rehabilitations are:
Investments costs = Cost of the additional insulation of the external walls + cost insulating with the floor + cost insulating walls staircase adjacent = 4107.57 monetary unit (u.m).

Residual value of the investment on thermal insulation:

$$V_R^{A} = V_R^{NA} \cdot (1+R)^{-D_{REF}} \quad (9)$$

$$V_R^{NA} = \frac{4107.57 \cdot (50-30)}{50} = 1643.028 \text{ u.m}$$

$$V_R^{A} = 1643.028 \cdot (1+0.4)^{-30} = 0.0678 \text{ u.m}$$

Positive NPV means that the project generates a positive net benefit and is desirable.

a) The building heating and lightening systems maintenance costs

- The cost of boiler maintenance: 50 Ron/m^2;
- Heating system maintenance costs/cooling: 10.65Ronm/m^2
- Planned annual costs for boiler repairs: 16.80 Ron/m^2;
- Planned annual costs for the repair of the heating/ cooling: 5.32 Ron/m^2;
- Costs of changing bulbs (reference duration is 30 years)

– Incandescent:
- The service life = 2.000 ore ⇒ 47 replacements
- Light bulb price: 2 Ron/piece - Incandescent lighting installed power: 75.138kW
- Specific cost: 34. 90 Ron/ m^2

– Energy saving light bulbs:
- The service life = 2.000 hours ⇒ 12 replacements
- Energy saving light bulbs price: 20 Ron/piece
- Specific cost: 24. 60 Ron/m^2

b) Energy costs [5]

In calculating energy costs were considered the following parameters:

- Annual growth rate for heat energy r_t = 0.03;
- Annual growth rate in electricity prices r_{el} = 0.03;
- Discount rate = 0.04;
- Regulated tariffs for electricity supplied to final consumers ultimately providers who have not exercised their eligibility other than household and assimilated household and reactive energy prices valid from 1 January 2013 in accordance with Order no. 54/2012 (published in Official Gazette no. 892 / 12.28.2012).

Energy costs are determined using the formula (10): [1]

$$C_e = Q_t \cdot c_t \sum_{k=1}^{D_{REF}} \left(\frac{1+r_t}{1+R}\right)^k + Q_{el} \cdot c_{el} \sum_{k=1}^{D_{REF}} \left(\frac{1+r_{el}}{1+R}\right)^k \quad (10)$$

Table 1. Fuel prices (year 2015) [2]

Fuel	Unit	Price/ measure unit [€/u.m]	Calorific power [kW/u.m]	Efficiency	Price /kWh [€/kWh]
Woods	m^3	50	1700	75	0.022
Electrical	kWh	0.12	1	98	0.123
Pellets	Kg	0.16	4.5	80	0.028
Gas	kWh	0.028	1	85	0.022

Gas = 0,102 RON /kWh
Electric= 0, 55 RON /kWh [2]

To determine the consumption of electric energy were considered: energy consumption for lighting or electricity used by electrical devices and appliances available: iron (500 W) washer (900 W), refrigerator (500 W), and vacuum cleaner (700 W), TVs (2 x 500 W), laptop (100W), etc.

Table 2. Specific values for the calculation of heat and electricity before the rehabilitation process

Thermal energy costs		
R- discount rate	0.4	
r_t - annual growth rate for heat energy	0.03	
Q_t – thermal energy consumption	34079.136	kWh/year
c_t – cost/ heat unit	0.22	Euro/kWh
C_{et} - thermal energy cost	154.446	Euro/year
TOTAL	687.287	Ron/year
Energy costs		
R - discount rate	0.4	
r_{el} - annual growth rate for electricity	0.03	
Q_{el}– electricity consumption	2000	kWh/year
c_{el} – cost/ power unit	0.123	Euro/kWh
C_{el}– cost of electricity	180.99	Euro/year
TOTAL	805.386	Ron/year

$$C_e = 34079.136 \cdot 0.22 \cdot \frac{(1+0.03)}{(1+0.4)} + 2000 \cdot 0.123 \cdot \frac{(1+0.03)}{(1+0.4)} = 154.446 + 180.99 = Ce = 335.43 \text{ euro/year}$$

$$C_e = C_{et} + C_{el} = 687.287 + 805.405 = = 1492.69 \text{ Ron / year}$$

Table 3. Specific values for the calculation of heat and electricity after the rehabilitation process

Thermal energy costs		
R- discount rate	0.4	
r_t - annual growth rate for heat energy	0.03	
Q_t – thermal energy consumption	24880.128	kWh/year
c_t – cost/ heat unit	0.22	Euro/kWh
C_{et} – thermal energy cost	112.76	Euro
	501.767	Ron
Energy costs		
R - discount rate	0.4	
r_{el} - annual growth rate for electricity	0.03	
Q_{el}– electricity consumption	2000	kWh/year
c_{el} - cost/ power unit	0.123	Euro/kWh
C_{el}– cost of electricity	180.99	Euro
	805.386	Ron

$$C_e = 24880.28 \cdot 0.22 \cdot \frac{(1+0.03)}{(1+0.4)} + 2000 \cdot 0.123 \cdot \frac{(1+0.03)}{(1+0.4)} = \\ = 112.76 + 180.99$$

$$C_e = 293.740 \ \ euro/\ year$$

$$C_e = C_{et} + C_{el} = 501.767 + 805.386 = \\ = 1307.153\, Ron$$

Figures 3 and 4 presents the costs of heat before ($C_{et}1$) and after rehabilitation ($C_{et}2$) in euro/year, respectively RON/year.

Table 4. Energy costs and heat before and after rehabilitation

	Before rehabilitation (Cet1, Ce1)		After rehabilitation (Cet2, Ce2)	
	Euro/year	**Ron/year**	**Euro/year**	**Ron/year**
The cost of thermal energy	154.446	687.287	112.76	501.767
Cost of electricity	180.99	805.386	180.985	805.386
The total costs of heat and electricity	**335.432**	**1492.674**	**293.740**	**1307.153**

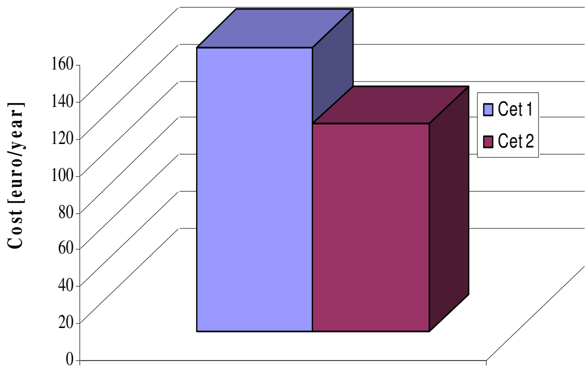

Fig. 3. Thermal energy costs before and after the rehabilitation process [EUR / year]

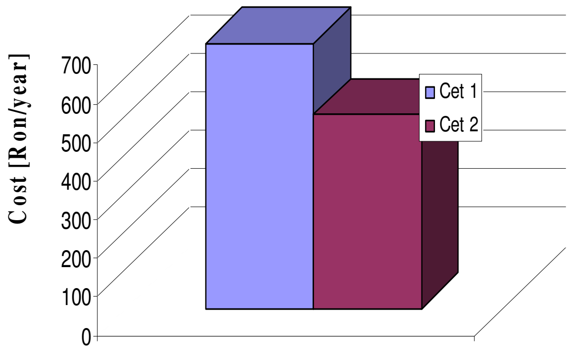

Fig. 4. Thermal energy costs before and after rehabilitation. [Ron/year]

Figures 5 and 6 presents the variation of energy costs before and after rehabilitation in [euro/year] and [Ron/year].

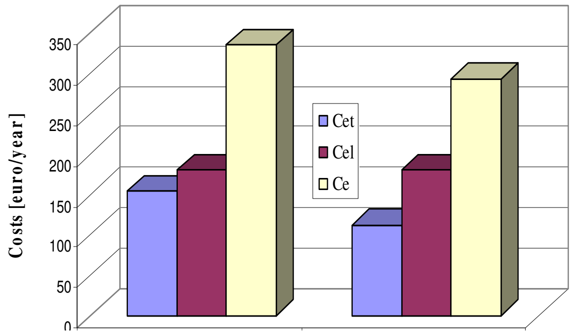

Fig. 5. Energy costs before and after thermal rehabilitation [euro/year]

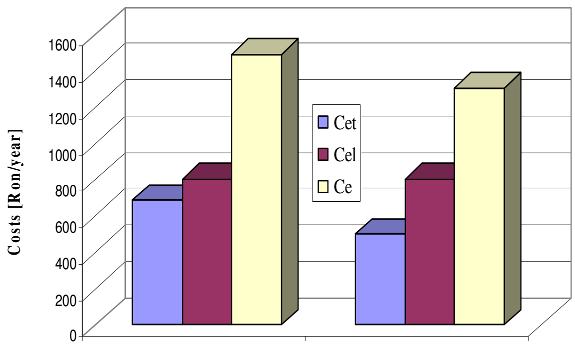

Fig. 6. Energy costs before and after thermal rehabilitation. [Ron/year]

Total investment upgraded:

$$ITA = 4107 \cdot \frac{1}{(1+5)^1} = 684.5 \quad [\text{ Ron}]$$

The length of payback due to the rehabilitation of apartment (Tr):

$$T_r = \frac{Initialinvestment}{Anual\ economy} = \frac{4107}{1139{,}4} = 3.61\ years$$

Table 5 and figure 7 presents comparative energy performance for electricity and heating. final and primary energy consumption.

Table 5. The energy consumption for the analyzed flat

	Before rehabilitation	After rehabilitation
Thermal energy [kWh/an]	34079.11	24880.28
Electricity consumption [kWh/an]	2000	2000
Primary energy [kWh/an]	50783.96	40665.05
Final consumption [kWh/an]	36079.11	26880.28

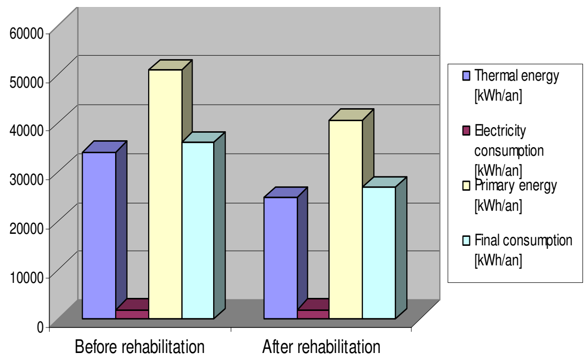

Fig. 7. Comparative energy performance for electricity and heating, final and primary energy consumption before and after rehabilitation

4. CONCLUSION

An important issue of the optimal cost calculation is the payback of investment associated with building modernization. The payback rate of return related to the process of modernization is 3.61 years, which means that these costs can be recovered in a period of less than 4 years. which proves that the investments were made in an efficient manner both in terms of reducing consumption of thermal energy and in terms of depreciation of investments.

In terms of building energy modernization it is consider that the simple and robust solutions are those that can ensure sustainability. In this economic approach through the overall cost for a period of 30 years is a highlight solutions support long-term performance with significant social impact. Unlike analysis based on cost recovery of investment through energy savings that are based on periods of recovery relatively low and efficient time-limited approach in terms of minimizing the overall cost on long and medium term lead to superior solutions technically and reliable. its development sustainable.

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