THEORETICAL RESEARCHES ON THE THERMO-ENERGY MODERNIZATION AT HOTEL UNITS IN THE BRASOV AREA

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Abstract : *In this article we deal with the issue of modernization of thermo-energetics at an existing hotel unit that has energy losses through the walls of the building, thus proposing the solution of its thermal energy modernization. Modernization of the thermo-energy means increasing the energy performance of the building to the level of the current requirements, normalized by the application of heat insulating materials on the exterior walls, the floor above the basement and on the terraces, as well as by the modernization of the heating and hot water heating systems, the replacement of the windows and doors with more energy efficient ones.*
Keywords : *hotel unit, thermo-energy modernization, mass and heat transfer.*

1. INTRODUCTION

The concept of sustainable energy development requires improved energy management, which leads to economic growth, pollution reduction, saving resources so that they can be used as productively as possible. Modernization of thermo-energy is aimed at reducing the annual specific consumption for heating. The realization of the thermo-energetic modernization works has the effect of increasing the energy performance of the analyzed hotel unit, reducing the energy consumptions necessary for the climatization of the building, both during the winter and in the summer. It can be noticed that the annual energy consumption of a building irrespective of its destination, the heating energy and domestic hot water supply represents the main annual energy consumption of about 75%. The very high values of the heat consumption indices for thermal comfort in the inhabited spaces attest to the strong dissipative character of the existing buildings but also to the high potential of the energy modernization solutions of the buildings.

2. TECHNICAL REQUIREMENTS

In this paper are proposed two variants of the thermo-energetic modernization solutions of the hotel unit in Braşov area. The proposed energy modernization solutions will considerably reduce the energy consumption needed to heat the hotel unit under review. The proposed hotel unit for the thermo-energetic modernization has a capacity of 15 rooms, which accommodates 30 people and is located in the Brasov area. The building characteristics of the hotel unit analyzed: the ground floor height and 2 floors; Concrete reinforced concrete foundations, brickwork walls, reinforced concrete pillars and beams, reinforced concrete floors, roof tiles, PVC joinery windows. Construction dimensions: Built surface 175,59mp; Volume 1126,46mp, useful area: 390,19mp; Table 1 presents the thermal resistances by type of elements of the analyzed building

Table 1: The thermal resistances by type of elements of the analyzed building

Elements	Area of the building $[m^2]$	Thermal resistance Variant I $[m^2K/W]$	Thermal resistance Variant II $[m^2K/W]$	Factors
Exterior walls:	$P_E = 340$	$R^{1}_{op,E} = 2{,}96$	$R^{11}_{op,E} = 4{,}15$	$\tau_{PE} = 1{,}00$
Plan over the attic:	$P_{P,P} = 142{,}59$	$R^{1}_{op,p} = 4{,}61$	$R^{1I}_{op,p} = 5{,}10$	$\tau_{PP} = 0{,}90$
Floor on the ground:	$P_{P,S} = 142{,}59$	$R^{1}_{op,S} = 4{,}55$	$R^{1I}_{op,S} = 5{,}50$	$\tau_{PS} = 0{,}50$
Glazed areas:	$P_V = 73{,}38$	$R^{1}_{0I,PV} = 0{,}57$	$R^{1I}_{0I,PV} = 0{,}68$	$\tau_{PV} = 1{,}00$

The average thermal resistance corrected on the building envelope. R_M^1 [m^2K/W]

$$R_{M,}^{1} = \frac{\sum A_{mj}}{\sum \frac{A_{mj}\times \tau_{mj}}{R_{mj}}}; \; [\; m^2K/W \;] \qquad (1)$$

A_{mj} - the area of the building envelope; τ_{mj} - factor of external temperature correction; R_{mj} - average thermal resistance on the whole building.

- Proposals for constructive solutions and installations for the energy modernization of the analyzed hotel unit.
Two thermal insulation solutions for the building envelope elements are proposed as follows:
At the facade walls:
Placing the opaque area with polystyrene facade with
- Variant - I - polystyrene cladding with thickness of 10cm
- Variant - II - polystyrene cladding with thickness of 15cm
- Placing vertical stairs, glazing and lined corridors with 3 cm thick facade polystyrene.
The bridge floor:
A thermal insulation with semi-rigid mineral wool slabs protected by M100 mortar screed will be installed over the existing structure
- Variant - I - thickness of 15cm
- Variant - II - thickness of 20cm
Plate on the ground:
Placing the slab on the ground with fireproof expanded polystyrene
- Variant - I - thickness of 8cm
- Variant - II - thickness of 12cm
For carpentry the variants are provided:
- Variant I - on double wooden carpentry, on the inner sash is mounted double insulating glass, untreated with corrected resistance $R_V^I = 0{,}57 m^2K/W$, with $g_i = 0{,}75$.
- Variant - II - on wooden double-glazed joinery, on the inner sash are mounted double insulating glass, treated on a surface with reflective layer, having an emission coefficient: e <0.10; with corrected thermal resistance.
The base of the foundation is insulated on the outside with 6 cm thick polystyrene (moisture-proof), which extends below the 30 cm systematiyat ground.
Thermal plant has yield $\eta = 0{,}90$ of thermostated bodies

The thermo-energetic performances of the hotel unit with the energy modernization solutions
Unidirectional thermal resistances

$$R_0 = R + \frac{d^I}{\lambda^I} \qquad (2)$$

R - the unidirectional thermal resistance of the existing layer; d^I - thickness of the layer added; λ^I - thermal conductivity.

Thermal resistances corrected on tire assembly

Variant - I

R_{0M}^I -thermal resistances corrected on tire assembly

$$R_{0IM}^{1} = \frac{\sum A_{uj}}{\sum \frac{A_{uj}\times \tau_{mj}}{R^{I}{}_{0mj}}} = \frac{699{,}04}{\frac{340}{2{,}960}\times 1 + \frac{142{,}58}{4{,}612}\times 0{,}9 + \frac{142{,}58}{4{,}55}\times 0{,}5 + \frac{73{,}88}{0{,}57}} = 2{,}427 m^2K/W; \qquad (3)$$

Variant - II

R_{0IIM}^I -thermal resistances corrected on tire assembly

$$R^{1}_{0IIM} = \frac{\Sigma A_{uj}}{\Sigma \frac{A_{uj} \times \tau_{mj}}{R^{I}{}_{0mj}}} = \frac{699{,}04}{\frac{340}{4{,}15} \times 1 + \frac{142{,}58}{5{,}10} \times 0{,}9 + \frac{142{,}58}{5{,}50} \times 0{,}5 + \frac{73{,}88}{0{,}68}} = 3{,}05 m^2 K / W; \quad (4)$$

Global heat loss coefficients

$$G^{R}_{ef} = \frac{A}{R^{1}_{0M} \times V_{înc}} + 0{,}34 \times n \quad [W / m^3 K] \quad (5)$$

$$A_{anv} = 844{,}15 m^2; \quad V_{înc} = 1126{,}46 m^3;$$

$$R^{1}_{0IM} = 2{,}427 m^2 K / W; \quad R^{1}_{0IIM} = 3{,}05 m^2 K / W; \quad n_0 = 0{,}5 h^{-1}$$

Global heat loss coefficients G_{0ef}

Variant - I -

$$G_{0Ief} = \frac{A}{R^{1}_{0IM} \times V_{înc}} + 0{,}34 \quad n = \frac{844}{1126{,}46 \times 2{,}427} + 0{,}34 \times 0{,}5 = 0{,}478 W / m^2 K \quad (6)$$

Variant - II -

$$G_{0IIef} = \frac{A}{R^{1}_{0IIM} \times V_{înc}} + 0{,}34 \quad n = \frac{844}{1126{,}46 \times 3{,}05} + 0{,}34 \times 0{,}5 = 0{,}415 W / m^2 K \quad (7)$$

Consumption of heating energy required for heating, in relation to the heated value

$$Q^{year}_{înc} = \frac{24}{1000} \times G_{0ef} \times C_{0ef} \times N^{\theta i}_{12} \times (Q_{01} + Q_{Se}) \quad (8)$$

The global heat loss coefficient G_{ef} $[W / m^3 K]$

$$G_{oef} = G_{1ef} + G_{2ef} \quad [W / m^3 K] \quad (2) \quad (9)$$

G_{1ef} - the overall coefficient of thermal

G_{ef} - the global heat loss coefficient;

C_{ef} - correction coefficient; $N^{\theta i}_{12}$ - the annual number of days of calculation days corresponding to the place where the building is located; $N^{\theta i}_{12}$ = 4030 k days according to C107/2005; Q_{O1} - the useful heat input from the building; Q_{se} - the useful heat input from solar radiation;

Calculation values: G_{ef} =1,479 $[W / m^3 K]$; Vînc=1126,46 m³; $A_{uînc} = 390{,}31$ m²

$C_{ef} = 0{,}942$ -thermal power station without thermostat;

Variant - I -

$$G_{0Ief} = 0{,}478 W / m^2 K; \quad C_{0ef} = 0{,}878; \quad N^{\theta i}_{12} = 4030 kdays;$$

$$Q_{0i} = 7 KW / m^3 year; \quad Q_{se} = 3{,}93 KW / m^3 year$$

$$Q^{an}_{înc} = \frac{24}{1000} \times 0{,}478 \times 0{,}878 \times 4030 \quad (7 + 3{,}93) = 29{,}66 KWh / m^3 year$$

Variant - II

$$G_{0Ief} = 0{,}415 W / m^2 K; \quad C_{0ef} = 0{,}878; \quad N^{\theta i}_{12} = 4030 kdays;$$

$$Q_{0i} = 7 KW / m^3 year; \quad Q_{se} = 2{,}62 KW / m^3 year$$

$$Q_{înc}^{year} = \frac{24}{1000} \times 0{,}415 \times 0{,}878 \times 4030 \times (7 + 2{,}62) = 25{,}62 KWh / m^3 year$$

Heat consumption in relation to the heated area

$$q_{înc}^{year} = \frac{O_{înc}^{year} \times V_{Înc}}{A_{uÎnc}} \quad [KWh/ m^3 \text{ year}] \qquad (10)$$

$V_{Înc}$ -the heated volume of the hotel unit analyzed; $A_{uÎnc}$ - the useful area of the hotel unit;

Variant - I -

$V_{înc} = 1126{,}46 m^3$; $A_{uînc} = 390{,}31$ m^2 $\quad Q_{oIînc}^{year} = 29{,}66 KWh / m^3 year$

$$q_{0I,înc}^{year} = \frac{O_{0II,înc}^{year} \times V_{Înc}}{A_{uînc}} = \frac{29{,}66 \times 1126{,}46}{390{,}31} = 85{,}66 KWh / m^3 year$$

Variant - II

$V_{înc} = 1126{,}46 m^3$; $A_{uînc} = 390{,}31$ m^2 $\quad Q_{oII,înc}^{year} = 25{,}62 KWh / m^3 year$

$$q_{0II,înc}^{year} = \frac{O_{0II;înc}^{year} \times V_{Înc}}{A_{uÎnc}} = \frac{25{,}62 \times 1126{,}46}{390{,}31} = 73{,}99 KWh / m^3 year$$

Energy consumption for heating $q_{E0,înc}^{an}$ $[KWh / m^2 year]$

Variant - I -

$q_{0I,înc}^{year} = 85{,}66 KWh / m^2 year$

the technical yield of the installation $\eta = 0{,}90$

$$q_{0I,înc}^{year} = \frac{85{,}66}{0{,}90} = 95{,}17 KWh / m^2 year$$

Variant - II

$q_{0II,înc}^{year} = 73{,}99 KWh / m^2 year$

$$q_{0II,înc}^{year} = \frac{73{,}99}{0{,}90} = 82{,}21 KWh / m^2 year$$

Emissions of CO2 I_{CO2} $[Kg / m^3 year]$

For the methane gas fuel the CO2 emission 0,19 $KgCo_2 / KWh$

Variant - I -

$$I_{I,CO2} = q_{oE,înc}^{year} \times 0{,}19 = 97{,}17 \times 0{,}19 = 18{,}623 KgCo_2 / m^3 year \qquad (11)$$

Variant - II

$$I_{II,CO2} = q_{oEII,înc}^{year} \times 0{,}19 = 82{,}21 \times 0{,}19 = 15{,}61 KgCo_2 / m^3 year \qquad (12)$$

Figure 1 shows the grid with the values for the classification of the hotel unit in this grid depending on the specific energy consumption

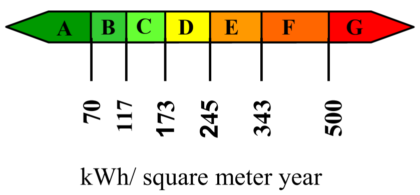

Figure 1. Energy grid according to annual energy consumption for heating

Table 2. Comparison of results at the hotel unit analyzed after applying the thermo-energy modernization solution

Building	R_M^I [m^2K/W]	G [W/m^3K]	$q_{înc}^{year}$ [KWh/m^3year]	$q_{Eînc}^{year}$ [KWh/m^3year]	Grid framing	I_{co2}
Audited hotel unit	0,678	1,479	356,51	434,7	F	82,6
Hotel unit reference	1,680	0,610	115,50	140,85	C	26,75
Hotel unit variant -I-	2,427	0,478	85,66	95,17	B	18,46
Hotel unit variant -II-	3,050	0,415	73,99	82,21	B	15,61

R_M^I - average corrected thermal resistance [m^2K/W]

G - the global heat loss coefficient [W/m^3K]

$q_{înc}^{year}$ - specific heat consumption [KWh/m^3year]

$q_{Eînc}^{year}$ - specific energy consumption [KWh/m^3year]

I_{co2} - the annual carbon emission index CO2.

3. CONCLUSION

The hotel unit analyzed has very high energy losses through the construction elements, so it is enclosed in the grid at the letter F with a consumption of 434.7[KWh/m^3year]. With the thermal energy upgrading solutions, energy consumption has been reduced from 434.7 [KWh/m^3year] to 95.17[KWh/m^3year] and 82.21[KWh/m^3year] respectively, so these solutions are effective for reducing energy consumption at a hotel unit that is built.

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