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# Glazed elements in constructions. Evaluation methods of characteristics and their impact on energy performance

Elemente vitrate în construcții. Metode de evaluare a caracteristicilor și impactul acestora asupra performanței energetice

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**Abstract.** *In Glazed elements play an important role in total energy consumption of buildings. They significantly influence total energy consumption through energy consumption for heating and cooling, ventilation and lighting. To optimize these consumptions, the glazed elements must be treated taking into consideration several characteristics, namely: thermal transmittance, degree of transparency and solar factor. Moreover, the choice of glazed elements must be studied and calibrated by the type of building but also by location, from a climatic point of view. The purpose of this paper is to highlight the main characteristics of glazed elements and the ways in which these can be measured. The equipment and its operation are presented as well as examples of measurements performed on different types of glazed elements. Also, the paper presents a case study that includes the thermal balance performed on a building in Timisoara taking into account the characteristics of the measured glazed elements. In order to highlight their importance, a parametric study of the transmittance and the solar factor was performed, taking into account the investment costs, respectively, the cost over the life of the investment.*

***Key words:*** *U-value, g-value, low-e, glazed elements*

## 1. Introducere

Reducing energy consumption and increasing the energy performance of buildings are two of the most important issues that need to be considered today, whether we are talking about the headquarters of large companies, state institutions or housing, either individually or collectively [1]. The thermal rehabilitation of the building involves improving the thermotechnical characteristics of the envelope elements by adding new layers (in the case of walls, floors when we add a layer of thermal insulation) or by replacing these elements with more energy efficient ones (in the case of windows, doors).

Glazed elements require more attention when discussing their energy performance [2]. In the design phase of a building, energy consumption can be optimized by correlating the dimensions and properties of glazed elements with the supply of natural light [3,4]. For existing buildings, it can be established by calculation, the replacement of glazed elements with others that can benefit from the available natural light, thus reducing energy consumption.

## 2. Description of the essential characteristics of glazed elements in terms of energy efficiency

Thermal transmittance of glazing

Thermal transmittance or heat transfer coefficient (U) is the steady-state heat flux, relative to the surface area and the temperature difference between the average temperatures on either side of a system [5]. This is the inverse of thermal resistance. In the case of glazed elements, this is denoted Ug.

Solar heat gain coefficient

Solar heat gain coefficient (g) measures as a percentage the total energy efficiency of the glazed system compared to solar radiation. This is the amount of heat allowed by the sun to pass through the glazed elements [6]. This factor is found directly in the calculation of the heat input of the solar radiation Qs.

Solar spectrum

In order to better understand the measurements in this paper, the different energy spectra produced by the sun will be explained below. These are the energy spectra that a building is subjected to every day. Some features are positive and we want to benefit from them as much as possible, some are undesirable and should be reduced as much as possible, and others should be kept in a certain balance.

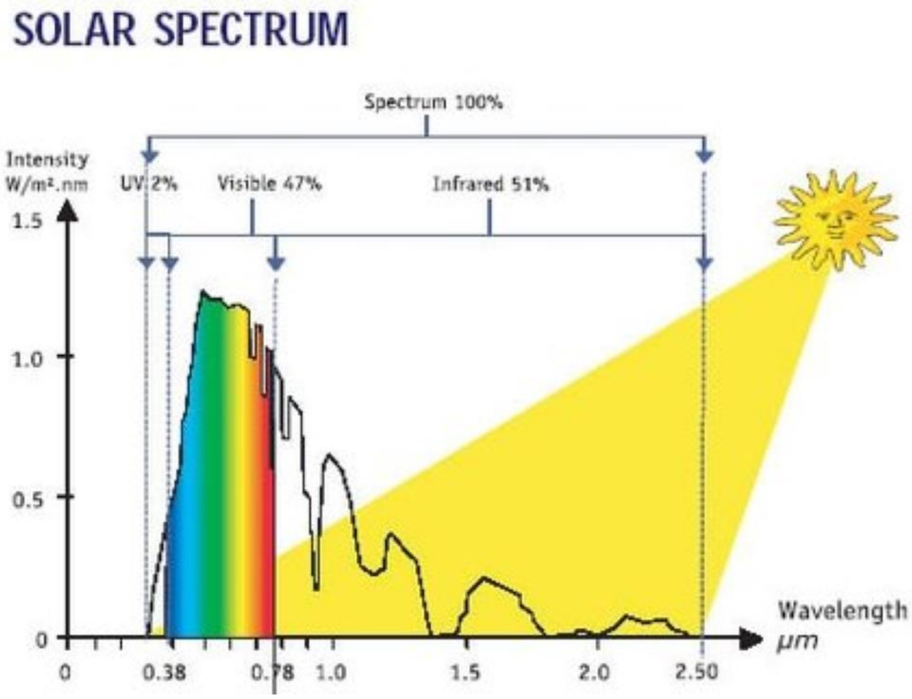


Fig.1. Solar spectrum

Ultraviolet energy is represented by UV rays with wavelength dimensions of 365 nm. This energy is not visible to the human eye and is divided into 3 categories: UVA, UVB, UVC.

Visible light is the only part of the solar spectrum that the human eye can see. This includes the natural light of day and all the colors of the rainbow. A sufficient amount of natural light will reduce the need to use artificial light, thus reducing the cost of utilities.

Infrared energy refers to the thermal energy that is emitted by the sun. It can also be called radiant heat. This is the light that the human eye cannot see, but the bodies feel it as heat. Infrared energy is divided into 2 types: shortwave infrared energy (NIR) and longwave infrared energy (FIR).

The property of a glazed element to repel infrared energy will be directly related to solar heat gain coefficient [6].

## 3. Case study

In order to be able to carry out the case study, it was proposed to perform measurements to identify the real parameters of the glazed elements.

It is proposed to conduct a case study on a residential building. The study involves calculating the energy required for heating and cooling using, in turn, the types of glazed elements for which the characteristics have been obtained are presented below. The analyzed building is a collective residential building located in the municipality of Timișoara, having a height regime S+P+4E. It was built in 1985, the resistance structure being made of reinforced concrete structural walls. The building is moderately sheltered and has more than one exposed façade.

The calculation of the energy required for heating and cooling was performed using the non-stationary calculation method. This calculation was performed using the energy simulation program „EnergyPlus". For all the models, all the characteristics of the building, except those of the glazed elements, remained the same.

The simulations involved calculating the energy required for heating and cooling using, in turn for the entire building, the following types of glazing elements:

• a single glass panel;
• two glass panels;
• two glass panels with a selective layer;
• three glass panels with two selective layers;

As the types of windows improve, so does the permeability of the building. Thus, the number of outdoor air exchanges varies from 0.9 corresponding to a high permeability (case 1-window with 1 glass panel) and decreases to 0.5 corresponding to a low permeability (4 case -window with 3 glass panels with 2 selective layers), according to ISO 13790.

The data entered as well as the energy requirements obtained are presented in the following table:

*Table 1*

**Glazed element type and energy demand**

| Glazed element type | Ug [W/m$^2$K] | Uf [W/m$^2$K] | Uw [W/m$^2$K] | g | na [h$^{-1}$] | Heating energy demand [kWh/m2] | Cooling energy demand [kWh/m2] |
|---|---|---|---|---|---|---|---|
| **1 glass panel** | 5.7 | 1 | 4.8 | 0.86 | 0.9 | 135.85 | 15.2 |
| **2 glass panels** | 2.90 | 1.00 | 2.60 | 0.78 | 0.7 | 116.24 | 14.89 |
| **2 glass panels with 1 selective layer** | 1.10 | 1.00 | 1.10 | 0.38 | 0.6 | 110.28 | 9.45 |
| **3 glass panels with 2 selective layers** | 0.50 | 1.00 | 0.76 | 0.40 | 0.5 | 101.39 | 9.97 |

To have a better point of view for the obtained data, the energy demand is represented in the next graph:

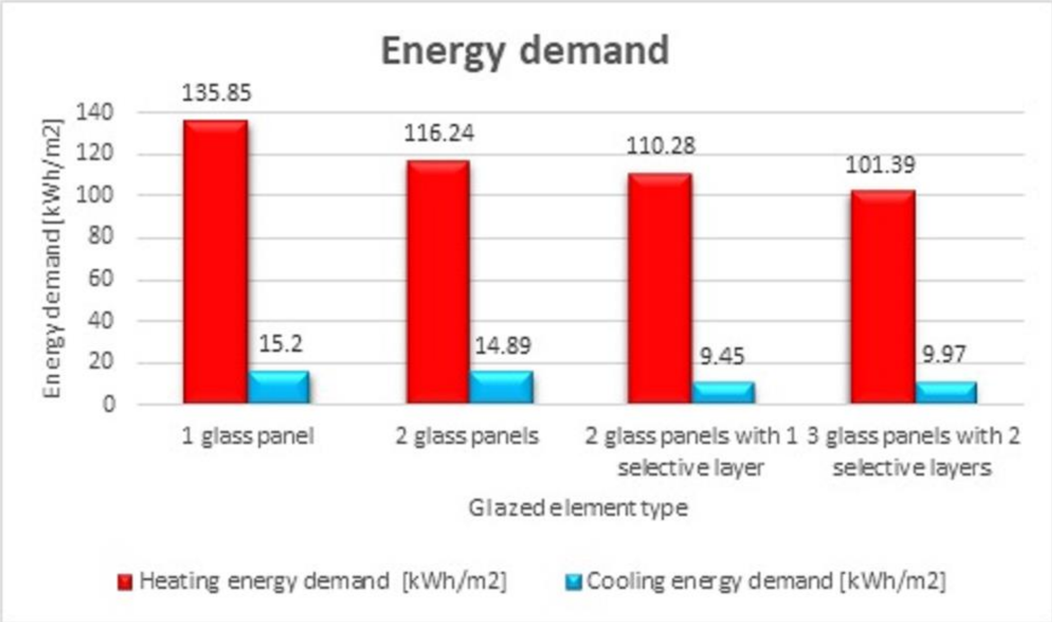


Fig.2. Energy demand graph

Double glazed windows (case 1, Ug = 2.7 W/m2K) reduce the energy required for heating by about 15 % and double glazed windows with a selective coating (case 2, Ug = 1.1 W/m2K) bring a reduction of about 19 % compared to the initial situation. The heat requirement in the case of triple glazing (case 3, Ug = 0.5 W/m2K) decreases by about 25 % compared to the initial situation. Thus, the importance of the solar heat gain coefficient in the heat demand is highlighted, but also the importance of reducing the air infiltrations through the leaks of the glazed elements.

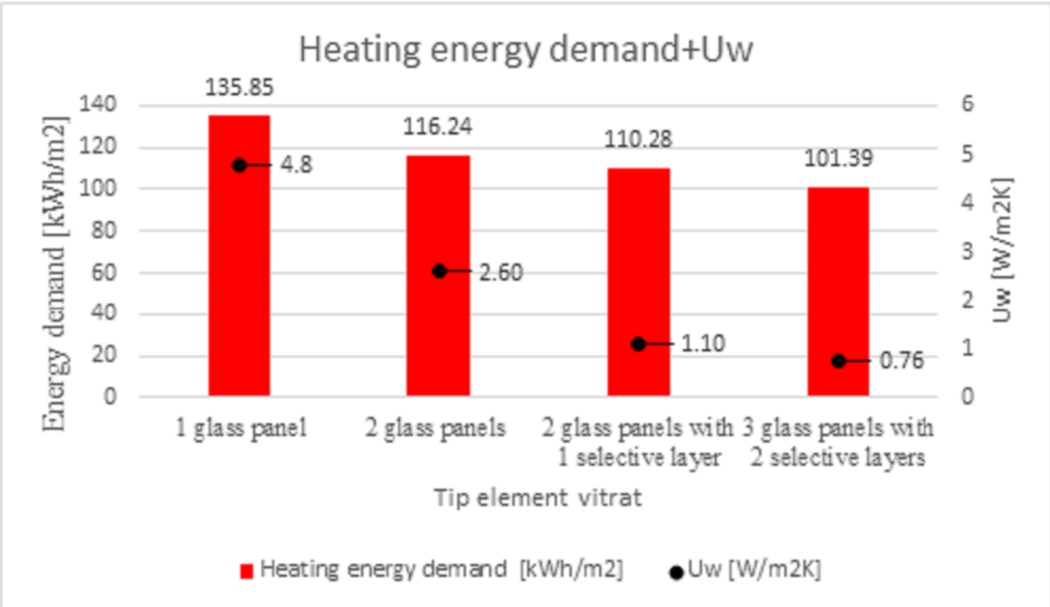


Fig.3. Heating energy demand + Uw graph

At the same time, the energy requirement for cooling, in the case of double-glazed windows without a selective layer (case 1, g = 0.78) decreases insignificantly, by about 2 %, but the presence of a selective layer (case 2, g = 0.38) leads to a decrease of 37.8 %. Thus, the importance of reducing solar contributions during the summer is highlighted, in order to avoid overheating of living spaces. The triple glazing with 2 selective layers (case 3, g = 0.40) leads to a decrease in the cooling requirement of 34.4 % compared to the initial situation, but is about 3 % more than in case 2.

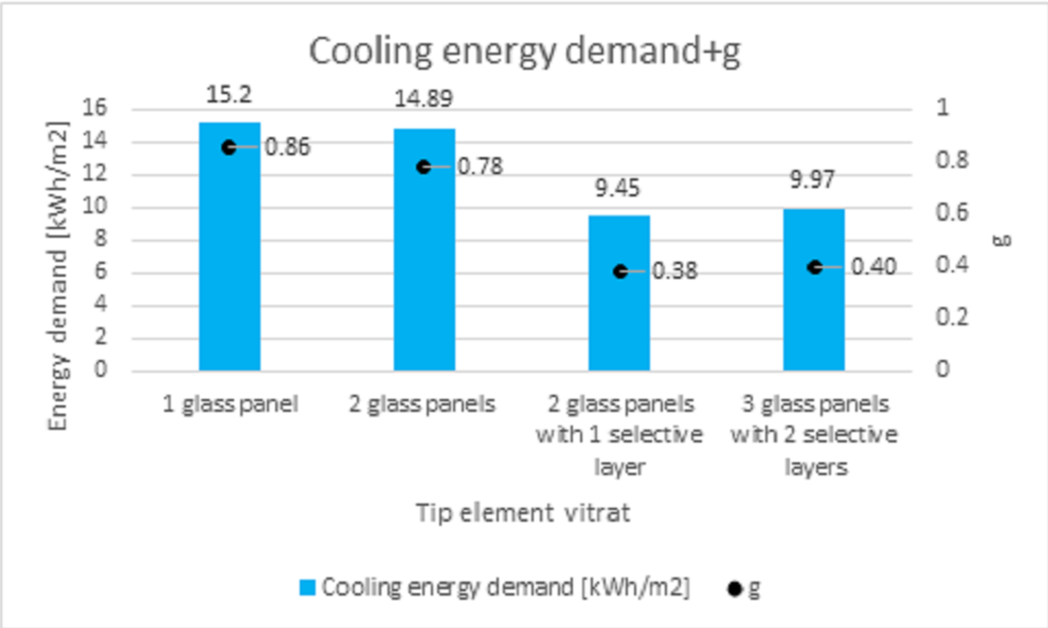


Fig.4. Cooling energy demant + g graph

The financial analysis has been carried out in order to determine whether the proposed investments are profitable and can be repaid within a reasonable period of time. We consider two situations from which we start:

• situation 1: we assume that the whole building has windows with a glass panel;

• situation 2: we assume that the whole building has windows with two glass panels.

The data entered as well as the payback periods of the investments are presented in the following table:

*Table 2*

**Investment recovery time**

| Case | Glazed element type | Energi saving S1 [kWh/m2] | Energi saving S2 [kWh/m2] | Cost [lei/m2] | Investment recovery time S1 [ani] | Investment recovery time S2 [ani] |
|---|---|---|---|---|---|---|
| Initial situation | 1 glass panel | - | - | | | |
| Case 1 | 2 glass panels | 19.92 | - | 480.00 | 8.23 | - |

| | | | | | | |
|---|---|---|---|---|---|---|
| Case 2 | 2 glass panels with 1 selective layer | 31.32 | 11.40 | 720.00 | 7.94 | 16.31 |
| Case 3 | 3 glass panels with 2 selective layers | 39.69 | 19.77 | 912.00 | 7.92 | 13.27 |

In situation 1, we start from the hypothesis that the existing block has single glazed windows and we analyze the investments related to the double glazing (case 1), double glazing with selective coating (case 2) and triple glazing with two selective layers (case 3). Following the evaluation of the economic indicators, for case 1 there is an investment recovery time of 8.23 years and 7.94 and 7.92 years for case 2 and 3 respectively. All 3 cases studied are financially efficient, the investment being recovered over the life of the glazed elements (20 years). Even if the lifespan of the windows would be shorter (10-15 years), any of the 3 options would be suitable. This evolution is shown in the following graph:

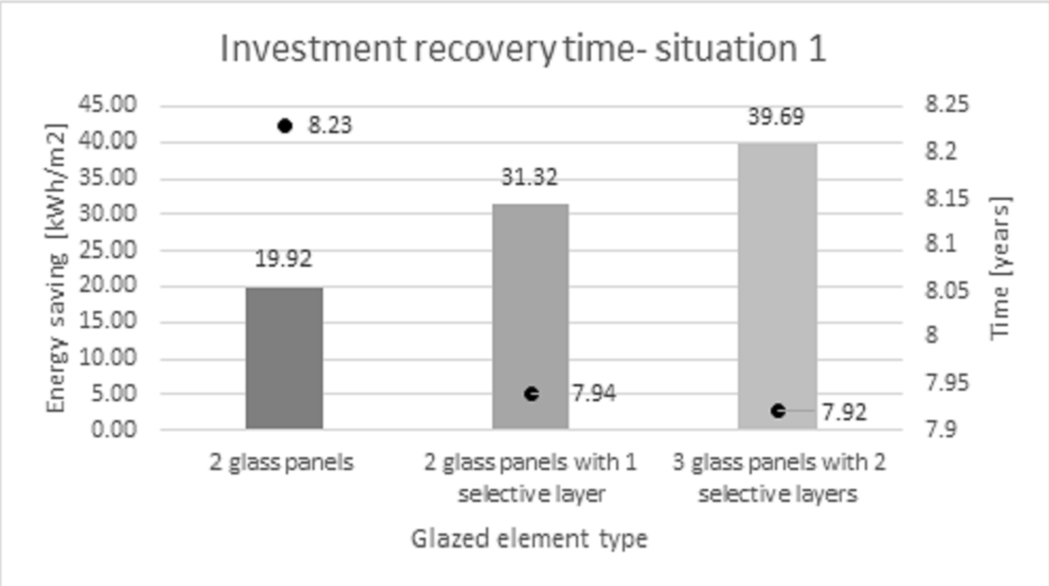


Fig. 5. Investment recovery time – situation 1

In situation 2, it is assumed that the existing block is already equipped with double glazed windows and the investments related to the double glazing with selective layer (case 2) and the triple glazing with two selective layers (case 3) are analyzed. In case 2, the recovery of the investment takes place in 16.31 years, and in case 3, in 13.27 years. Case 2 is only financially effective if the life of the glazed elements is 20 years. Perhaps a good option in this case would be to improve by adding a selective coated glass sheet and not completely replace the glazed elements. At the same time, case 3 is feasible even for a period of 15 years of glazed elements. This evolution is shown in the following graph:

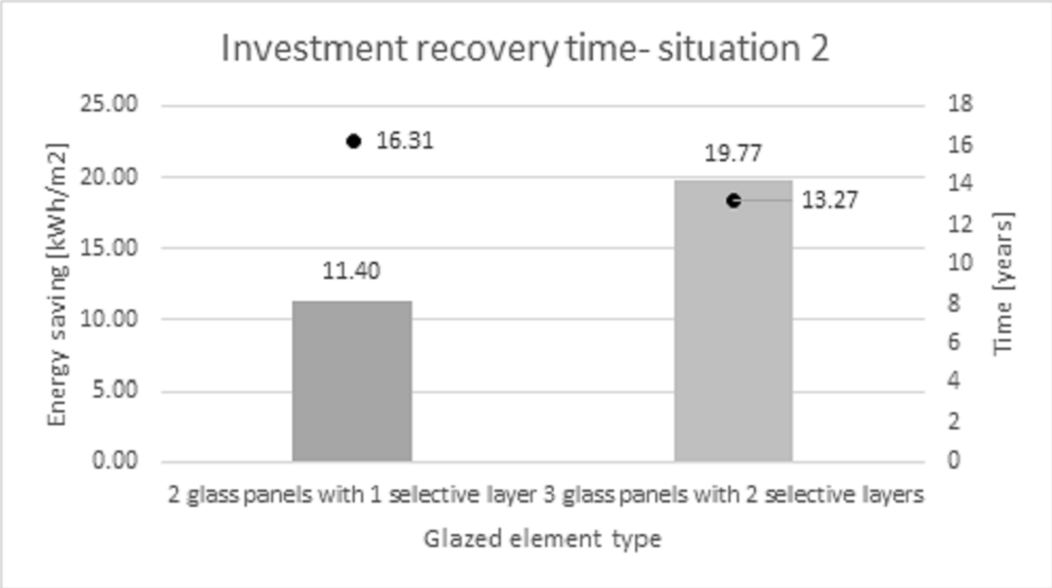


Fig. 6. Investment recovery time – situation 2

## 4. Conclusions

Nowadays, the energy rehabilitation of buildings is a preventive action, which is becoming more and more necessary to increase the sustainability of our cities [7]. This paper brings to the fore the importance of glazed elements in the energy performance of a building, by measuring and studying some parameters:

- full solar spectrum: UV, visible and IR rays;
- solar heat gain coefficient;
- heat transfer coefficient;
- tightness of glazed elements.

Their influence can be quantified in reducing the need for heat by using glazed elements with high thermal resistance given by multiple glazing and gas layers [8]. Moreover, the supply of seals considerably reduces air infiltration and at the same time the energy required for heating. This is highlighted in the case study presented in Chapter 4. At the same time, the glazed elements have a significant contribution in reducing the need for cooling. The use of glass with a high solar heat gain coefficient (g) corresponds to high solar inputs, which is beneficial in winter, but which can cause overheating in summer. Reducing the solar heat gain coefficient by applying selective layers on glass sheets leads to a decrease in solar inputs, as highlighted in the case study. The case study presents the importance of the parameters of the glazed elements justified by the energy efficiency, but also by the financial efficiency.

The author considers that special attention should be paid to the choice of glazed elements of buildings. A type of glazed element suitable for the climatic zone and the chosen orientation can only bring benefits, from the reduction of energy costs to the pleasant sensation produced by natural light.

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