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WINDOWS SELECTION INFLUENCE ON ENERGY HEAT GAIN AND LOSS IN HOUSE

Abstract: *This paper presents investigation of a proper window selection to reduce energy consumption in is zero-net energy house. Usage of different types of gases between glazing is investigated. Investigated windows have different number o glazing such as one glass, double glazing and triple glazing. Used inert gases are air, argon, krypton and xenon. Simulation is done for whole year, as for heating but also for cooling period. Investigated house is zero-net energy house. Results show that there is heat gain and loss through the windows and that selection of number of glazing is more important than the selection of the inert gas.*
Keywords: *Zero Net Energy Buildings, EnergyPlus, Heating and Cooling Period, Energy Consumption, Single double and triple window glazing*

1. INTRODUCTION

Energy efficiency is one of the leading tracks for researchers nowadays. Building energy use presents about 40% of the total final energy use in Serbia. A substantial part of the energy use in the construction sector is directly related to the construction, operation and decommissioning of the actual buildings. The energy consumption is to a large extent related to the heating and cooling demands as well as lighting demands. Envelope is one of the main factors that contribute to energy demands. Except the thermal insulation, windows have big influence on heat gains or heat loss. Heat gains are available through solar gains through windows, but there are also heat losses through window as U-factor of the windows is higher than the U-factor of the external walls. Windows can have single, double or triple glazing. Also, U-factor of the windows can be lowered by adding inert gas that is not air. It can be argon, krypton, and xenon. Bojic and Yik investigated influence of the application of switchable and advanced glazing types in their papers [1-2]. Gasparella et al. did an analysis and modelling of window and glazing systems energy performance for a well insulated residential building [3]. Jaber and Ajib investigated thermal and economic windows design for different climate zones, and presented difference between single, double and triple glazing but also the difference in the orientation of the windows [4]. Hassouneh et al. Researched on the influence of windows on the energy balance of apartment buildings in Amman [5]. Yasar and Kalfa researched effects of window alternatives on energy efficiency and building economy in high-rise residential buildings in moderate to humid climates [6]. Leskovar and Premrov made an approach in architectural design of energy-efficient timber buildings with a focus on the optimal glazing size in the south-oriented façade [7]. Tsikaloudaki assessed cooling

energy performance of windows for residential and commercial buildings in the Mediterranean zone [8-9]. Karabay and Arici assessed multiple pane window applications in various climatic regions of Turkey [10].

This paper presents investigation of a proper window selection to reduce energy consumption in is zero-net energy house. Also it shows how much energy is gained and lost through windows during the year. Investigated windows have different number of glazing such as one glass, double glazing and triple glazing. Also, usage of different types of gases between the glazes is investigated. Used inert gases are air, argon, krypton and xenon. Investigated house is zero-net energy house. Simulation is done for the heating and cooling period. House is modelled in EnergyPlus software.

2. MODEL

2.1 Geometrical and thermal description

An investigated house model is located in Belgrade and it presents the house for one family of four members. During the winter house is heated by using electric baseboard radiators, and during the summer house is cooled by air conditioners. The house is shown in Figure 1.

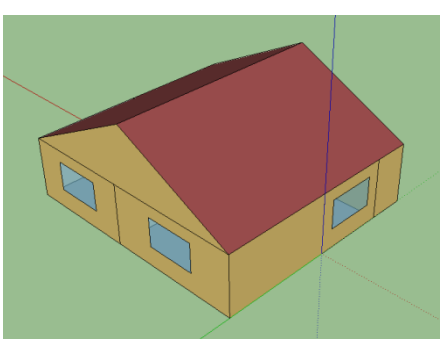

Figure 1. Investigated building

The house basement plan is given in Figure 2. Investigated house has 1 living room, 2 bedrooms, kitchen, corridor, toilet and WC. Area of conditioned space is 90 m^2.

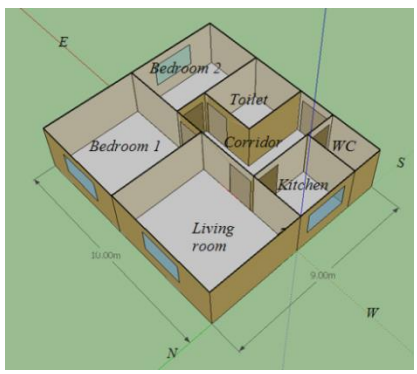

Figure 2. House plan

According to Serbian heating regulations, the desired air temperatures are set in the living room to 20°C, the bedrooms to 20°C, the kitchen to 20°C and the bathroom to 22°C. WC and corridor desired air temperatures are 18°C. Heating is controlled by the use of thermostatic valves.

As for cooling, only conditioned rooms are living room, bedrooms, and kitchen which all have 1 window. There is no need for cooling of the toilet, wc and corridor. The setpoint temperatures for cooling is from 6 am to 24pm is at 24°C.

2.2 Type of windows investigated

Investigated windows have single, double and triple glazing. Intersection view is given in Figure 3. Thickness of glazing layer is 3 cm while thickness of gas layer is 13cm.

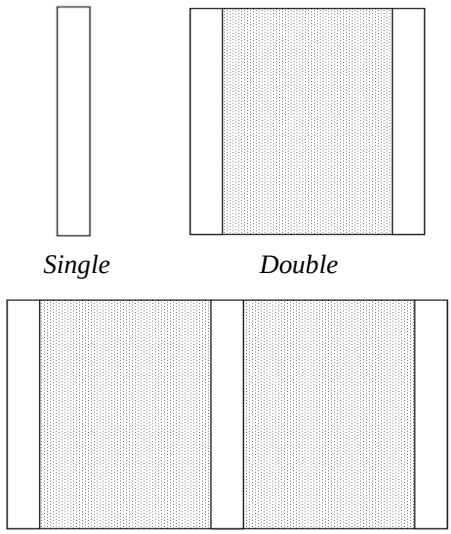

Figure 3. Type of glazing (intersection view, clear block presents glazing, doted block presents gas)

Used gases are air, argon, krypton and xenon. Their prices rise up as air is the cheapest and it doesn't need sealed frame to stop leaking, while others require sealed frame. Xenon and Krypton are more expensive than Argon. Still, all of these presented types of windows and gas types can be purchased.

2.3 Weather description

The investigated buildings are located in Belgrade. Belgrade is the capital city of Serbia. Its average elevation is 132 m, latitude 44°48 N, and longitude 20°28 E. The city has a moderate continental climate with four distinct seasons (winter, spring, summer, and autumn). The weather file used in the simulation is obtained by measurements at the Belgrade weather station.

3. RESULTS AND DISCUSSION

Results show that heating consumption is influenced by the type of the gas used more than the cooling consumption (Figure 5). Total energy consumption presents sum of the heating, cooling, lighting, fans and electrical equipment consumption. It can be seen that the difference between single and double glazing is about 9%-10% in saving when total energy consumption is considered. When only heating energy consumption is considered then the saving is from 16%-18.5% of energy needed for heating depending on the gas type. As for gas type difference between xenon and air goes up to 3.5% when energy needed for heating is taken into consideration.

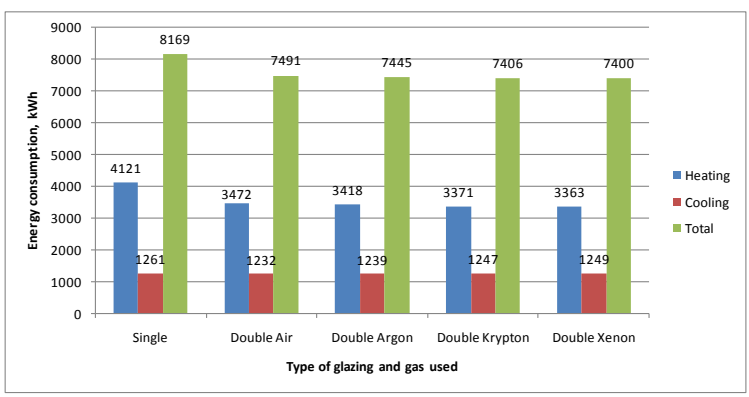

Figure 5. Energy consumption when single and double glazing is used by gas type selection

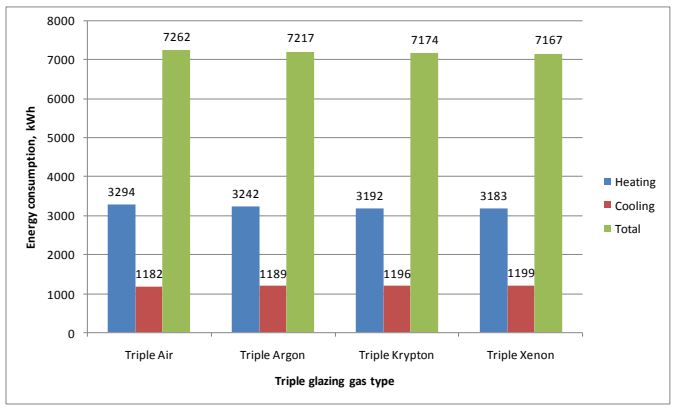

Figure 6. Energy consumption when triple glazing is used by gas type selection

Results show even smaller energy consumption when triple glazing is used (Figure 6). Difference in total energy consumption between single and triple glazing is about 12% when total energy consumption is considered while when only heating energy consumption is taken into account it goes up to 23% in saving. Difference between the double and triple glazing is 3%-4% when total energy consumption is considered while when heating energy consumption is only taken into consideration it goes between 5%-6%. This leads to conclusion that at least double glazing needs to be used while the triple glazing installation depends on the payback period to see if it is economically viable to install it.

These differences are due to the different U-factor of each of the glazing-gas combination. Values of the U-factor are given in the table 1.

Table 1.U-factor of the windows

	Single glazing	Double glazing	Triple glazing
Air	5.89	2.72	1.76
Argon	-	2.56	1.62
Krypton	-	2.51	1.56
Xenon	-	2.47	1.54

Heat gains in living room are presented on Figure 7. This room is investigated as it is faced north and the influence of the windows selection can be best seen here.

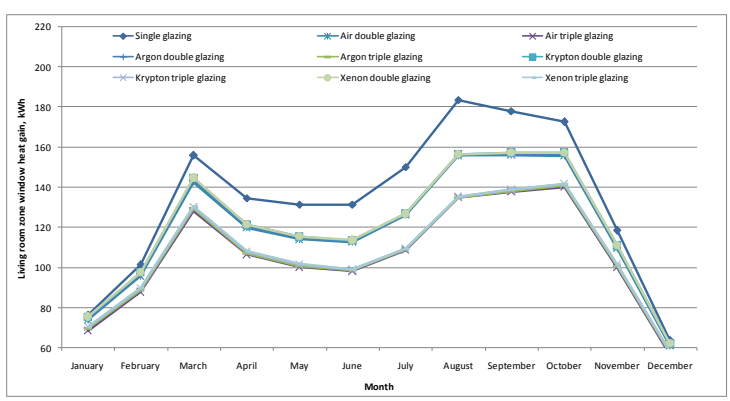

Figure 7. Living room zone window heat gains

It can be seen that during winter heat gains are from 60 kWh in December to 120 kWh in the November. This amount of energy saves energy needed for heating. Also it can be seen that there is not much difference between selections of the gases. This furthermore puts into the questions usage of the inert gasses different than the air, even more as they are expensive and needs sealed frame. It can be seen that gains during summer are high, especially for single glazing.

Window heat loss in the living room is presented on Fig. 8. It can be seen that the biggest difference is between the single and double glazing. Heat losses go to 100 kWh in December and January for single glazing, while this value is just 55 kWh when double glazing air is used. It is even 38 kWh when triple glazing is used. Again difference in heat loss is small between the inert gasses and it goes up to 7 kWh in January when air and xenon are compared.

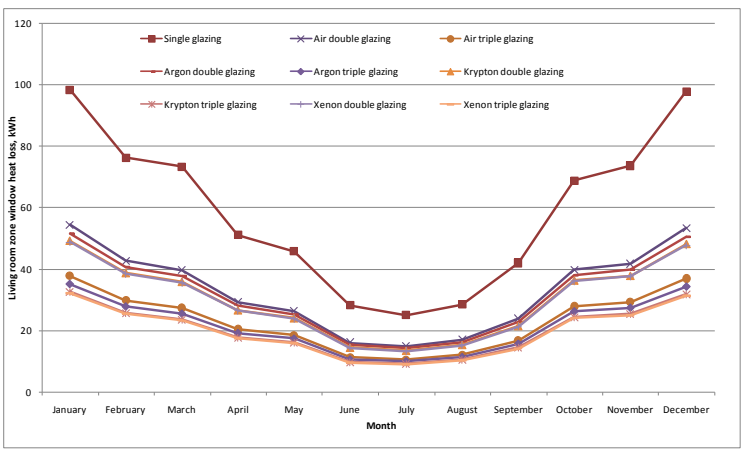

Figure 8. Living room zone window heat loss energy

5. CONCLUSION

Difference between installations of single, double or triple glazing is bigger than selection of gas type used.

Difference between glazings goes from 9-10% when total energy consumption is considered when single and double glazing is compared. When triple and single glazing is compared difference in total energy consumption is about 12%. Difference between double and triple glazing is 3-4% in total energy consumption.

Difference between single and double glazing in heating energy consumption is 16-18.5%, while difference between single and triple glazing is 23%. Difference in heating energy consumption between double and triple glazing is between 5-6%.

Energy consumption difference between selected gases goes to 3-4%.

Heat gains and losses in living room during the year shows that double glazing should be definitely taken into consideration while triple glazing is recommended, but it depends on the economic payback period and if the investment in other envelope is better at given time.

It also shows that single glazing shouldn't be used in any case.

REFERENCES:

[1] Yik, F., & Bojić, M. (2005). Application of switchable glazing to high-rise residential buildings in Hong Kong. *Energy and Buildings, 38*(5), 463-471.

[2] Bojić, M., & Yik, F. (2006). Application of advanced glazing to high-rise residential buildings in Hong Kong. *Building and Environment, 42*(2), 820-828.

[3] Gasparella, A., Pernigotto, G., Cappelletti, F., Romagnoni, P., & Baggio, P. (2011). Analysis and modelling of window and glazing systems energy performance for a well insulated residential building. *Energy and Buildings, 43*(4), 1030-1037.

[4] Jaber, S., & Ajib, S. (2011). Thermal and economic windows design for different climate zones. *Energy and Buildings, 43*(11), 3208-3215.

[5] Hassouneh, K., Alshboul, A., Al-Salaymeh, A. (2010). Influence of windows on the energy balance of apartment buildings in Amman. *Energy Conversion and Management, 51*(8), 1583-1591.

[6] Yaşar, Y., & Kalfa, S. M. (2012). The effects of window alternatives on energy efficiency and building economy in high-rise residential buildings in moderate to humid climates. *Energy Conversion and Management, 64*, 170-181.

[7] Žegarac Leskovar, V., & Premrov, M. (2011). An approach in architectural design of energy-efficient timber buildings with a focus on the optimal glazing size in the south-oriented façade. *Energy and Buildings, 43*(12), 3410-3418.

[8] Tsikaloudaki, K., Theodosiou, T., Laskos, K., & Bikas, D. (2012). Assessing cooling energy performance of windows for residential buildings in the Mediterranean zone. *Energy Conversion and Management, 64*, 335-343,.

[9] Tsikaloudaki, K., Laskos, K., Theodosiou, T., & Bikas, D. Assessing cooling energy performance of windows for office buildings in the Mediterranean zone. *Energy and Buildings, 49*, 192-199.

[10] Karabay, H., & Arıcı, M. (2012). Multiple pane window applications in various climatic regions of Turkey. *Energy and Buildings, 45*, 67-71.

[11] Todorović, B. (2005). *Design of installations for central heating (in Serbian)*. Beograd: Mašinski fakultet Beograd.

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