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Economic, Environmental And Energy Loss Investigation Of Multi Glazed Windows

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ABSTRACT

Design and selection of windows has a significant impact on the building energy loss. The proper windows not only determine the energy waste, but also has a strong effect on the initial cost, CO_2emission, and embodied energy. In this research the effect of multi glazing window glass and cities average monthly temperature, on the energy waste, initial cost, payback period, CO_2 emission, and embodied energy was investigated. The use of triple glazed window, significantly decreased the energy waste and related cost. It was observed that in the first installation, the capital payback period in the range of 0.7 to 2.6 years, therefore in the first installation economically it is strongly recommended to use a double or triple glazing window.

Keywords: Multi glazed windows, Energy waste, Embodied energy, Cities average monthly temperature, CO_2 emission

1. INTRODUCTION

Windows are one of the most important sources of the energy waste of the buildings. The energy waste margin of windows is 3%, 6%, and 7% in the United states of America, Sweden and United Kingdom respectively [1]. The specification of glass, insulator gas determines the U-Value of windows and initial cost, which directly affects the energy waste and related cost. Asif et al. investigated the effect of window frame on the embodied energy as is shown in the Fig. 1. It can be seen that the embodied energy of uPVC window is 50% less than aluminum window.Shaeri et al, simulated the effect of multi glazed windowsinsulator gas on the cooling and heatting load[2].

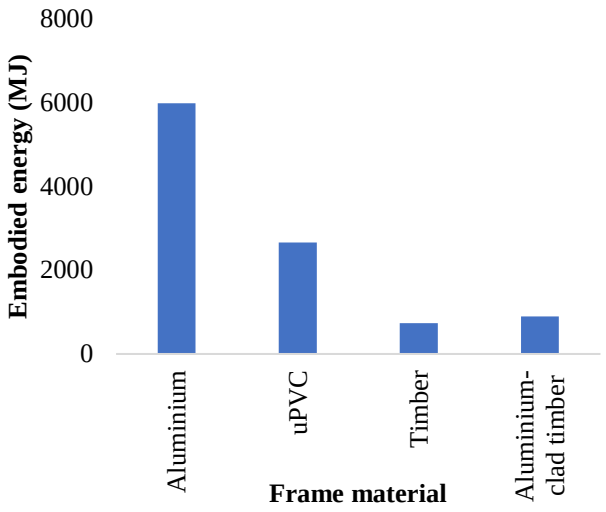

Fig. 1 The effect of window frame on the embodied energy[1]

In the Islamic republic of Iran, in the recent years the cost of energy and row material has been changed. The aim of this research is to answer the question that in the different cities is it economically and environmentally reasonable to use a double or triple glazed window? How long is the payback period of time for the multi glazed windows? Is it reasonable to replace old windows with new multi glazed windows? The block diagram of the research is shown in the Fig. 2.

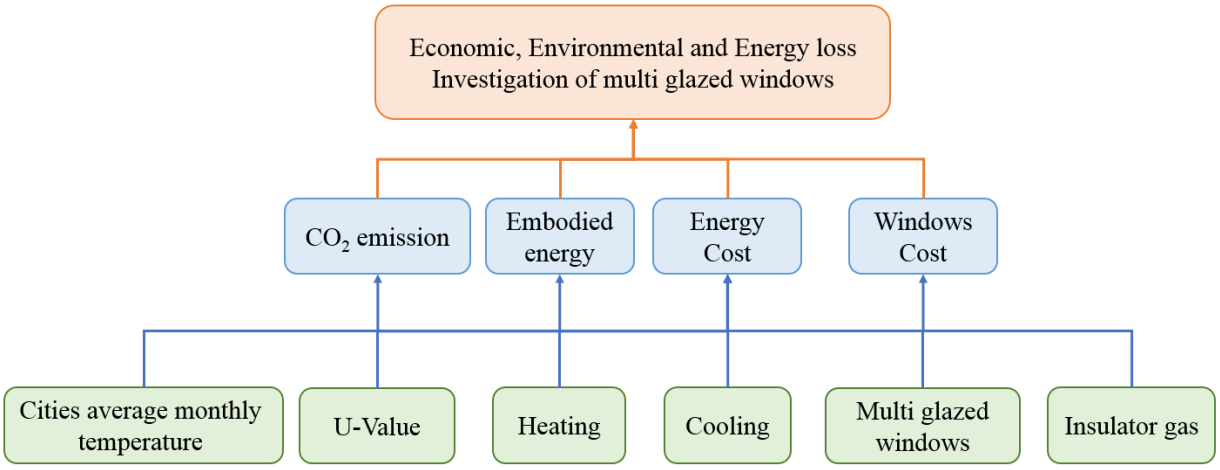

Fig. 2 The block diagram of the research

2. EXPERIMENTAL DETAILS

In the first step, the average monthly temperature of 10 cities was extracted (Ardabil, Urmia, Esfahan, Bandar Abbas, Tabriz, Tehran, Zanjan, Shiraz, Mashhad)[3]. It is assumed that if the average

temperature is lower than 12℃, the heating system is on and if the maximum temperature is higher than 30℃, the cooling system is on. It is also assumed that the heating system works using natural gas and the cooling system, works using electricity.

The average monthly temperature and the cities which uses the cooling and heating system are shown in the Table 1 and Table 2. It is assumed that the building area is 100 m^2, the window area is 15 m^2 and the inside temperature is 25℃. The energy which is wasted through windows is:

$$P = U \times A \times (T_{Out} - T_{In}) \quad (1)$$

$$Q = P \times t \quad (2)$$

Where P is the wasted Power (W-J/h), U is the heat transfer coefficient (W/m^2.K), A is total windows area, T_{Out} and T_{in} are Inside and outside temperature. The total wasted energy (Q) was calculated using Equation (2). The assumptions of the calculations are presented in the Table 3.

The cost related to the energy waste calculated as:

$$\text{Gas Price} = Q_{Heat} \times \text{Gas Consumption Factor} \times \text{Unit Gas Price} \quad (1)$$

$$\text{ElectricityPrice} = Q_{Cooling} \times \text{ElectricityConsumption Factor} \times \text{Unit ElectricityPrice} \quad (2)$$

$$\text{Total Price} = \text{Gas Price} + \text{ElectricityPrice} \quad (3)$$

Table 1 The average temperature of cities which uses the cooling system

Mashhad	Shiraz	Zanjan	Tehran	Tabriz	Bandar abbas	Esfahan	Urmia	Ardabil	
									Jan
									Feb
									Mar
					32				Apr
	35				37				May
31	39	30	34	30	39	34			Jun

34	41	33	36	33	39	36	32		Jul
34	40	32	36	33	38	35	32		Aug
30	37		31		37	31			Sep
	31				35				Oct
					30				Nov
									Dec

Table 2 The average temperature of cities which uses the heating system

Mashhad	**Shiraz**	**Zanjan**	**Tehran**	**Tabriz**	**Bandar abbas**	**Esfahan**	**Urmia**	**Ardabil**	
0.5	10	-2	5	-1		4	-1.5	-1	Jan
3.5		1.5	7	1		6	2	1	Feb
8.5		6.5	11.5	6		10	6.5	5.5	Mar
		11					11.5	9.5	Apr
									May
									Jun
									Jul
									Aug
									Sep
									Oct
8		6		7		10	6	5.5	Nov
2	11.5	1	7	1.5		5.5	-0.5	1	Dec

Table 3 The assumptions of the calculations [4][5][6][7]

U ($W/m^2.K$) - Single	U ($W/m^2.K$) - Double	U ($W/m^2.K$) - Triple	Area (m^2)	Efficiency
5.8	1.2	1.1	15	0.9
Gas Price ($Rials/m^3$)	Electricity Price (Rials/KW)	Gas Consumption (KWh/m^3)	A/C Consumption (KW/KW)	T (room)
4830	1350	10	3	25

Window Price-Triple (Rials/m^2)	Window Price-Double (Rials/m^2)	Window Price-Single (Rials/m^2)	Produced CO_2 from Gas ($KgCO_2/m^3$)	Produced CO_2 from Electricity ($KgCO_2$/KWh)
16000000	15000000	14000000	1.86	0.46

The Unit Gas Price and Unit ElectricityPrice was considered based on the value presented by the Ministry of Energy and Ministry of Petroleumin 2019-2020. Base on the window price, the Payback period was calculated in two cases. **First Case:** The cost for manufacturing and installation of single, Double and triple glazed window was calculated in the first installation. **Second Case:** The cost for replacing a Double and triple glazed window with the old single glazed window. The Energy waste related CO_2 emission was calculated based on the produced CO_2 from unit volume of Gas and Electricity.

3. RESULTS AND DISCUSSION

The effect of average monthly temperature on the total yearly heating and cooling cost is presented in Fig. 3. it can be concluded that using a triple glazing window instead of double or single glazing window, significantly decreases the heating and cooling cost. In the cities with very cold winters or very hot summers it is extremely recommended to use a highly insulated window.

The effect of average monthly temperature and Multi glazed windows on the capital payback period is shown in the Fig. 4. It is observed that in the first installation, the payback period is negligible and the investment will be returned in the range of 0.7 to 2.6 years, therefore it is extremely recommended to use a double or triple glazed window. On the other hand, the payback period for the window replacement is in the range of 10 years.

The effect of average monthly temperature and Multi glazed windows on the CO_2 emission, due to the energy waste is shown in the Fig. 5. It is observed that using a double or triple glazed window, reduces the CO_2 emission, due to the energy waste down to 20% ($\frac{1}{5}$ of single glazed window).

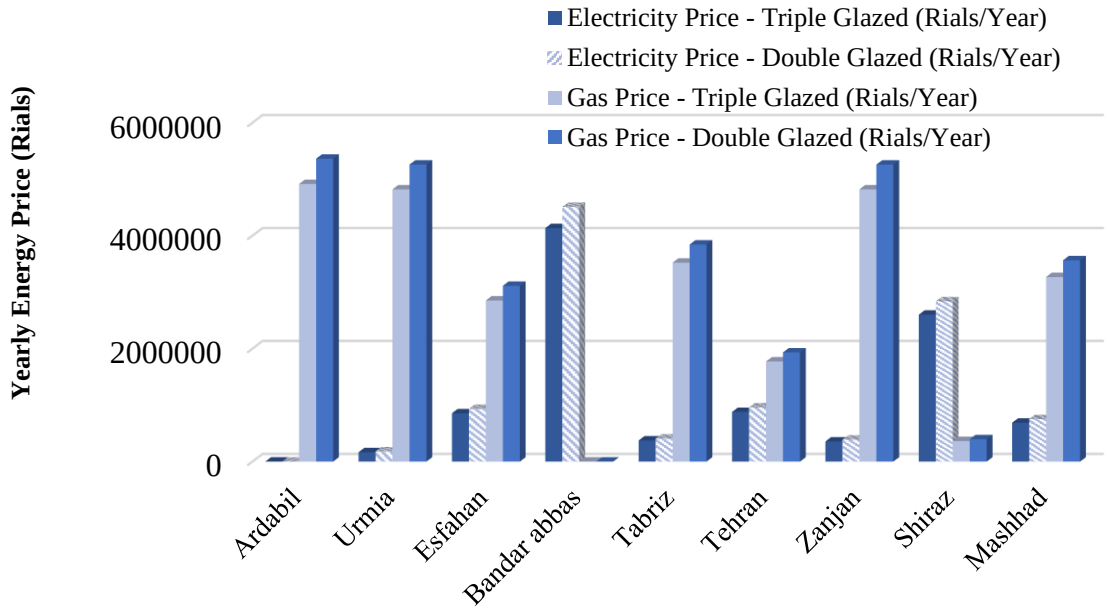

Fig. 3 The effect of cities average temperature and Multi glazed windows on the yearly heating and cooling energy price

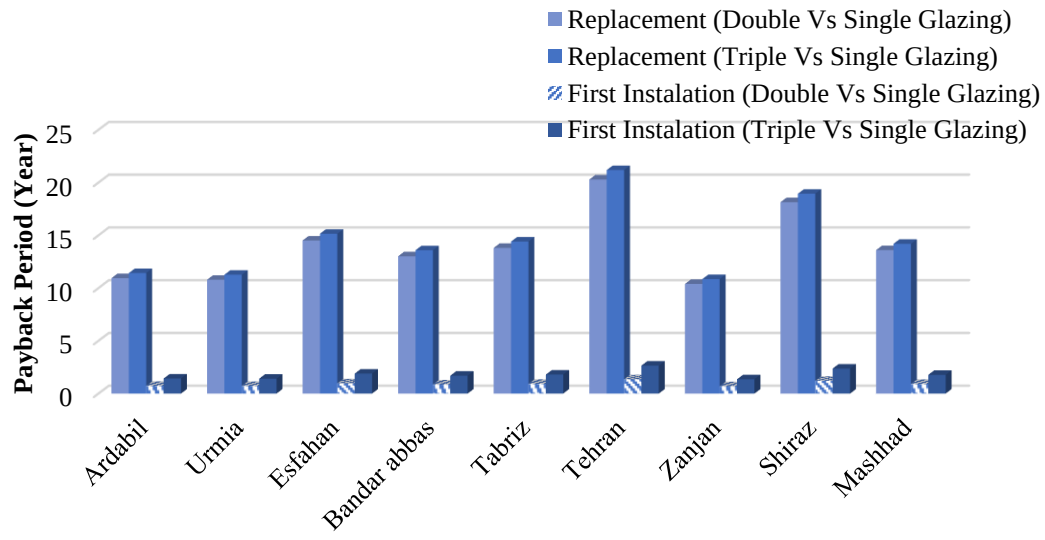

Fig. 4 The effect of cities average temperature and Multi glazed windows on the payback period (First installation and Replacement)

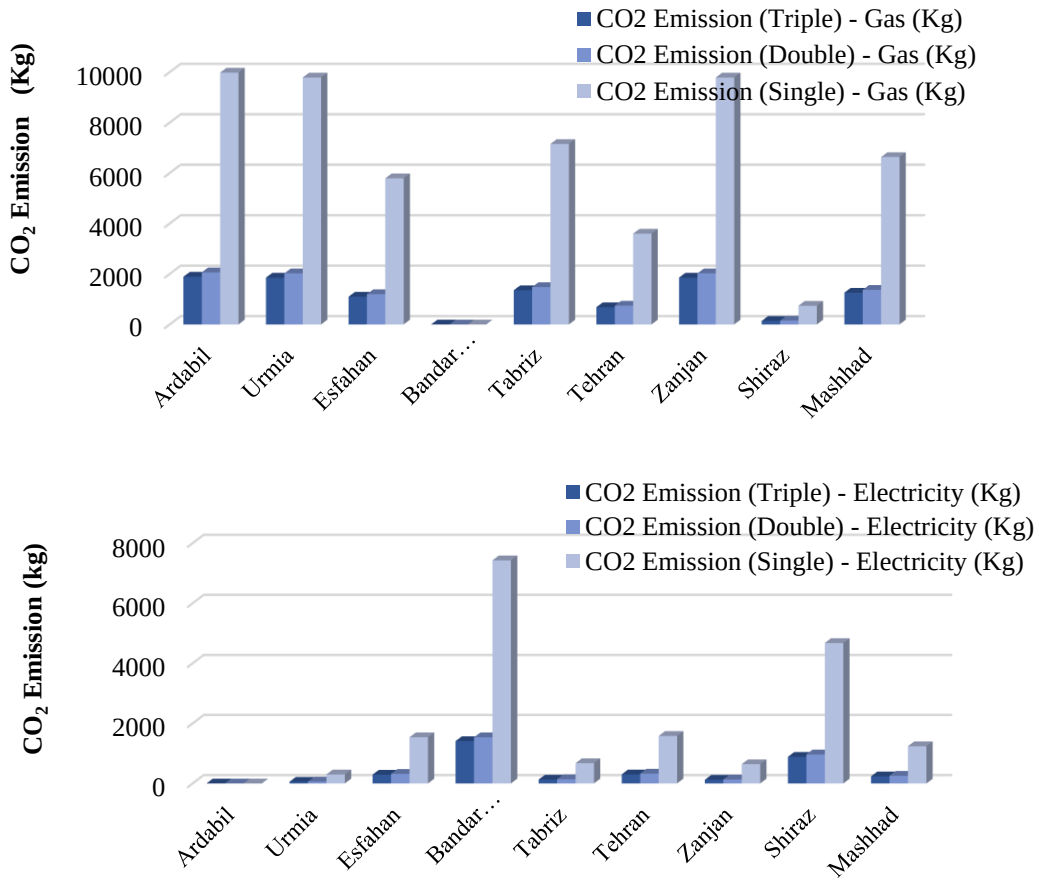

Fig. 5 The effect of cities average temperature and Multi glazed windows on the CO_2 emission

4. CONCLUSIONS

The effect of effect of multi glazing window glass and cities average monthly temperature, on the energy waste, initial cost, payback period, and CO_2 emission was investigated. The use of triple glazed window, significantly decreased the energy waste and related cost. It was observed that in the first installation, the capital payback period in the range of 0.7 to 2.6 years, therefore in the first installation economically it is strongly recommended to use a double or triple glazing window. It is observed that using a double or triple glazed window, reduces the CO_2 emission, due to the energy waste down to 20% ($\frac{1}{5}$ of single glazed window).

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