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Comparing the Performance of Conventional Windows and Double Glazed Windows in Building Energy Consumption

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Abstract

In this paper, a building is chosen as a case study and its annual energy consumption and carbon dioxide emissions are calculated. Simulation software (Designbuilder) is employed in this study, where DesignBuilder simulations are applied to enable facade design studies considering building materials, window sizes and orientations. Building loads and wasting heat from various parts of the building are calculated as well. To improve the performance of building, windows replaced with double glazed PVC windows. It was observed that the thermal load of the building in the cold months decline by 46 percent. With the reduction of energy consumption in building, the annual carbon dioxide emission decline by 11 percent.

Key words: Energy consumption, double glazed, CO_2 emission

1 Introduction

Based on Figure 1 the building and housing sector with the energy consumption more than 40 percent is considered as a biggest consumer of energy in Iran [1]. How to design buildings as one of the major energy consumers will have an important effect in reducing energy consumption [2]. The wasting of energy causes air pollution in cities as well as destroying natural resources [3]. It is estimated that Buildings in Tehran produce more than 40 percent of the carbon dioxide in Iran [4].

Iran has rich resources of fossil fuels such as crude oil and natural gas but these resources are non-renewable energy and Sooner or later come to an end [1]. On the other hand, fossil fuels are the main source of carbon dioxide in Earth. Increasing in the amount of carbon dioxide in recent decades causes an intensification of the greenhouse effect and the most distinctive change Earth's environmental crisis of the century means global warming [5]. Thus conserving fossil fuels is one of the goals of sustainable development at the global level [6]. Figure 1 shows energy consumption in different sector. As it has been shown, this amount is approximately 41% in the residential and commercial sector.

2 Methodology

The educational building in Tehran is simulated in DesignBuilder software [7]. Building information such as its function, The information of the number of people living in each sector, heating and cooling systems, fuel type, materials used in the construction of the building shell and the type and size of opening entered as input data [8]. One of the main indicators in this study which is considered for evaluating the effect of replacing the windows on the building's energy consumption, are heating and cooling loads. So the heating and cooling loads of the building are calculated for detecting the changes associated with replacing the windows. Base temperatures for heating and cooling considered 21 and 25 degree.

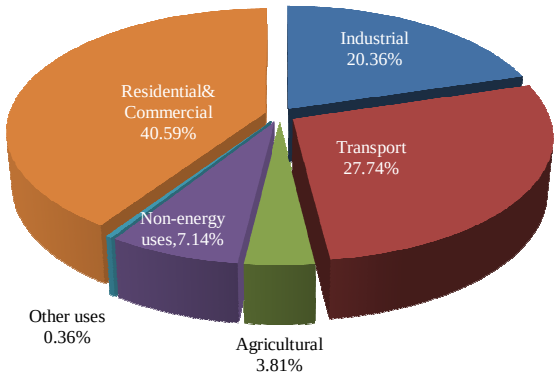

Figure 1: Energy Consumption in different sector

3 Results and Discussion

Following tables show the heating and cooling loads of the building before replacing the windows as well as heat exchanged from different parts of the building. In the reporting of data has been tried that a set of output which comprise the total heating and cooling load of the building, considered next to each other. Thus, accurate knowledge of heat transfer components for building and the contribution

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of each of them will gain and the effects of optimization will be assessed separately. According to Table 1, the most heat loos occur through the windows.

Table 1: Heating and cooling loads before Optimization

Heat Transfer in Building	Internal heat gain	Ventilation		Windows		Building shell		Heating/ cooling loads
		Heat loss	Heat gain	Heat loss	Heat gain	Heat loss	Heat gain	
Heating period 6 months	58791	80996	0	11287	23652	56915	2389	64508
Cooling period 6 months	45928	9825	9259	480	32575	11976	34167	99309
Year	103719	90821	9259	11767	56227	68893	36256	173195

3.1 Evaluation the performance of existing windows

Windows used in building are single glazed with painted frames. In general, these kinds of buildings considered as major weaknesses due to their high heat transfer coefficient. In total, the building has 55 northern, southern and western facing windows. Area of windows varies quite a bit, and the average is equal to 4 m.

Table 2 shows Direct and diffuse solar radiation in summer and winter from northern and southern facing windows. As the Expected, southern facing windows receive direct sunlight in winter in high amount and far less in summer. For northern facing windows the situation is different. Also receiving diffused solar radiation on both southern and northern facing windows is worth noticing issue.

Table 2: Comparing radiation gain

Radiation gain per kWh/ m2	Southern windows/winter	Southern windows/summer	Northern windows/ winter	Northern windows/summer
Direct radiation	3409	2380	0	388
Diffused radiation	2008	3520	1905	2860

3.2 Replacement of windows with double glazed windows

Although the installation of window awnings can partially control the incoming radiation, another key issue is their high heat transfer coefficient. U value of conventional windows is 5 $W/m^2.k$. Characteristics of replaced glass are shown in Table 3 and compared with existing glass.

Table 3: Characteristics of windows

Characteristics of windows	Existing	Double glazed
Coefficient of total solar radiation passing	0.62	0.4
Coefficient of direct solar radiation passing	0.48	0.373
Light Transmittance	0.57	0.505
U [$W/m^2.k$]	5.77	2.665

According to the table 4, the total heat gain would be reduced by 17 percent in the summer by taking advantage of double glazed windows. And table 5 shows, using double glazed windows reduce the total heat loss through the windows in the winter by 57 percent which lead a decline on a cooling load. Carbon emission from the building based on the fuel type will be calculated by the software (Table 7). As Table 8 shows, CO_2 emission will be reduced by such a change in building's windows.

Table 4: Comparison of the heat gain in the summer and winter with two types of windows

Heat gain Wh/m^2	Winter	Summer
Conventional windows	7553	11426
Double glazed	6850	9404

Table 5: Comparison of the heat loss in the winter

Heat loss Wh/m^2	Winter
Conventional windows	4483
Double glazed	1889

According to table 6, the installation of double glazed window reduce the undesired heat transfer and it leads to a reduction in heating load and cooling load. Energy consumption in the building will decrease as a result.

Table 6: Impacts of the installing double glazed building in heat gain and heat loss of the whole building

Heating/cooling loads	Heat loss	Heat gain		
34490	4207	21409	Before optimizing	Heating Period
64508	11287	23652	After optimizing	
-46%	-62%	-9%	Change	
85397	168	19244	Before optimizing	Cooling Period
99309	480	32575	After optimizing	
-14%	-65%	-40%	Change	

Table 7: The amount of carbon dioxide produced per kilogram of energy CO_2 emission

Electricity($KgCO_2/kWh$)	0.658
Gas($KgCO_2/kWh$)	0.195
Oil($KgCO_2/kWh$)	0.273
Solid($KgCO_2/kWh$)	0.34

Table 8: Emissions of carbon dioxide from the results of modeling CO_2 Emission

Changing percentage	Double glazed	Building with conventional building
11	83901	94162

4 Conclusions

According to all results above, installing double glazed windows will reduce the energy consumption in the building. In the heating period which refers to cold seasons, changing the windows of the building leads to a decline in heating loads by 46 percent. Moreover, less use of energy will cause less carbon dioxide emission. As we can see, co_2 emission will decrease by 11 percent after changing the conventional windows of the building.

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