Windows optimization for office buildings in Islamabad Pakistan

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Abstract— The office buildings are main consumers of energy for space cooling in Pakistan. In this study a three storied office building was selected for studying the energy consumption. The data was collected from the selected building and was entered to eQuest software proram for simulation. This model was termed as baseline model. The building was further optimized with the windows area and glazing type separately. The results were compared with the baseline model. Simulation results showed that 10.5% of electrical energy used for cooling purposes can be saved by reducing the windows area. And up to 5% of the energy can be saved by using the double glazed brown tinted windows instead of single glazed windows.

Index Terms— Simulation, Office Building, energy, electrical energy, efficiency, Baseline, Energy efficient model

1. INTRODUCTION

As the world's pursuit for comfort and advancement goes on, the costs in terms of energy are also needed to be paid. This is compelling the whole world to search for new resources as well as make optimum use of the existing resources. Buildings heating and cooling need huge amount i.e. 15% of its energy usage in populated countries like china [1]. Building consumes 25–40% energy for its operation [2].

European Union [3], Germany [4] America [5, 6] and Canada [7] are working on low energy buildings since long. Researchers all over the world are addressing the issue of conserving energy in buildings. For climate of Belgium Elisabeth Gratia et al. [8] studied low energy office building. Milorad Bojic et al. [9] conducted research on the performance of different HVAC systems for office building in Serbia. D Jenkins et al. [10] conducted his research on effects of climatic changes on energy demand for heating and cooling and evaluating the future energy demands of office buildings. Fong et al studied the application of low energy measures in

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low rise buildings in Hong Kong [11]. Mahdavi et al. [12] compared the performance of passive and low energy houses for Vienna climate. Filippin et al. [13] studies the energy behavior and thermal comfort for building in Central Argentina. All these studies belong to specific climatic regions as the climate vary from location to location. This research aims at studying energy consumption in Office Building of Islamabad Pakistan. Pakistan is classified into five regions on the basis of climate that are "hot, warm, mild, cool, and cold". Islamabad is considered as hot and humid location [14]. Statistics shows that the Energy consumption is Pakistan is increasing sharply and the resources are declining rapidly [15].

2. Office Baseline Model

To evaluate the effect of windows area reduction and glazing type on the energy consumption for cooling of the office buildings in Islamabad, Pakistan, an office of 7896 Sqft gross area, was selected. The building has three stories and oriented towards the south. The detailed sketch is as shown in Figure 2.1 (a,bc).

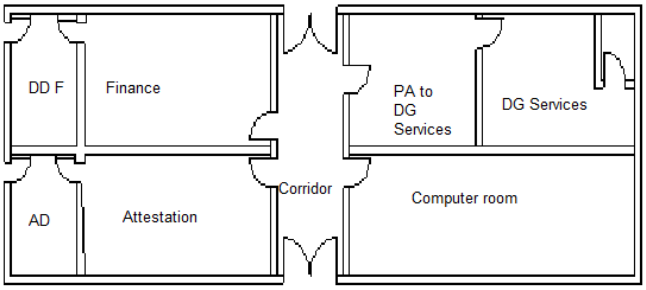

Figure 2.1 (a). Office building ground floor.

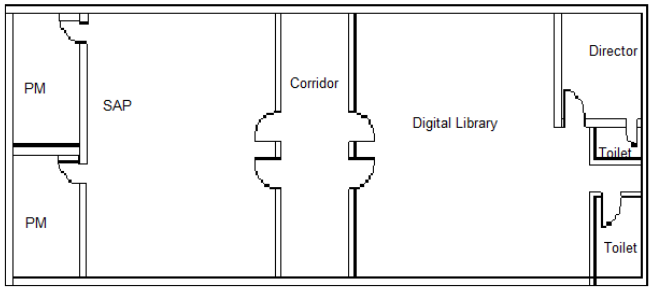

Figure 2.1 (b). Office building first floor

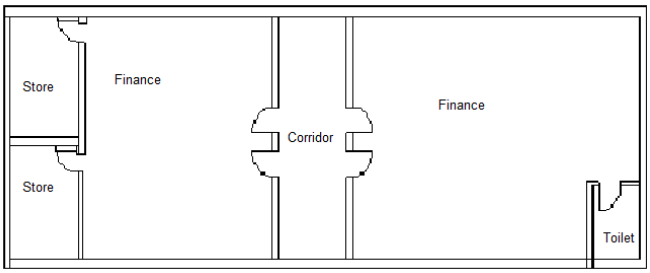

Figure 2.1 (c). Office building top floor

The building envelope was studied and the data was collected. Based on the building construction the overall heat transfer co-efficient was calculated. The values are given Table 2.1:

Table 2.1. Overall coefficient of heat transfer of office building components.

Building Component	**U value (BTU/Hr-ft^2-^{o}F)**
Exterior Wall	0.373
Inner Floors Slab	0.577
Roof	0.298
Partition Wall	0.373
Glass	1.05

Asorptance of 0.7 for walls and 0.6 for roof slab was used for the simulation based on the color of the building [16]. The walls of the actual building Walls are mass type, with and slab is 6 inches reinforced concrete and has 6mm clear glass, single glazed windows. The windows to wall percentages are shown in the Table 2.2:

Table 2.2. Windows to wall percentage of office building.

Walls	Gross area (Ground to Roof) ft2	Windows area
East Wall	1008	19%
West Wall	1008	13.00%
North Wall	3384	19.00%
South Wall	3384	28%

Area lighting is expressed in terms of watts per square feet, was calculated for the baseline model as per the actual building data. The lighting power density is shown in the Table 2.3:

Table 2.3. Lighting power density in W/sqft of office building.

Lighting Power Density	W/Sqft
Executive Office	0.97
General offices	0.92
Computer Room	0.92

An infiltration rate of 0.038 CFM/Sqft was used in this calculation which was calculated using the crack length [17] method. Ventilation rate of 20 CFM/person was used for this study[16].

The occupancy load in square feet per person was calculated based on the building details and are given in Table 2.4.

Table 2.4. Occupancy in sqft/person of office building.

Occupancy	Sqft/Person
Executive Office	95
General offices	80
Computer Room	40

3. Results and Discussion

3.1. Office Baseline Model

The office building was simulated with the data shown above and the results were plotted. This model serves as baseline model for the study. This building is occupied from 8am to 4 pm and Saturday and Sunday are off. The graph given below shows high energy consumption in the months of June, July and August due to peak summer conditions. While January, February and December are enough cool as per the climate of Islamabad. The total annual electrical energy consumption for space cooling of the building under consideration is 358,900.00 Kilo Watt hour. The monthly energy consumption is as shown in Figure 3.1:

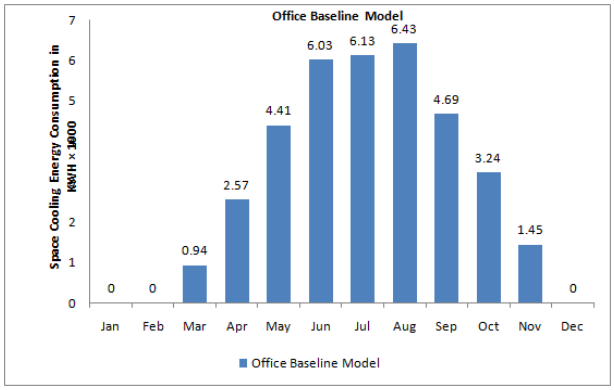

Figure 3.1 Monthly space cooling energy consumption of office baseline model.

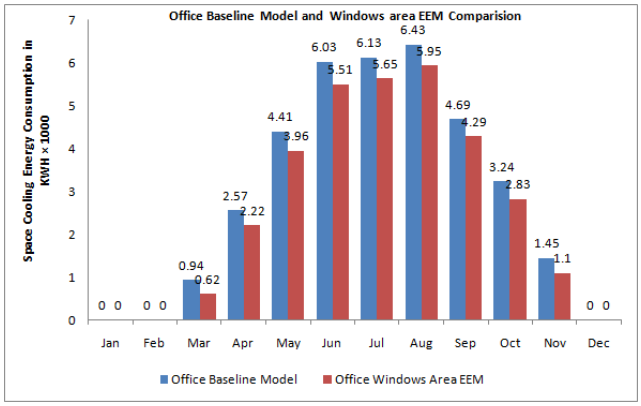

Figure 3.2. Office baseline and windows area EEM comparison.

3.2 Office Baseline Model and Windows area EEM Comparison

Windows to wall percentages calculated for the actual office building was optimized and both of the percentages are mentioned in the Table 3.1.

Table 3.1. Windows area details of office baseline and energy efficient model.

Walls	Baseline Windows area	Windows Energy Efficient model
East Wall	19%	4%
West Wall	13%	4%
North Wall	19%	10.5%
South Wall	28%	15.8%

The size of the windows installed in the building is 8×4.5, each. This size was reduced to 5×4. Applying this size, the annual electrical energy consumption is reduced to 321,300.00 Kilo Watt hour which is 10.5 % of the energy used space cooling energy consumption. The results are plotted as shown in Figure 3.2:

3.3. Office Baseline Model and Double Glazing EEM Comparison

The single glazing was changed to double glazed window brown tinted without changing the window size and the building was resimulated. The details of the windows specification [18] is shown in Table 3.2:

Table 3.2. Windows glazing details of office baseline and energy efficient model.

Windows Glazing	U-Value (BTU/Hr-Ft-^{o}F	Shading Coefficient	Visible Transmission
Single	1.05	0.92	0.9
Double	0.55	0.7	0.62

With the same size windows and windows to wall percentages as basline model the annual electrical energy consumption can be minimized to 342,200.00 Kilo Watt hours which makes 5.0% of the energy used for space cooling compared with the baseline model. The results are shown in Figure 3.3.

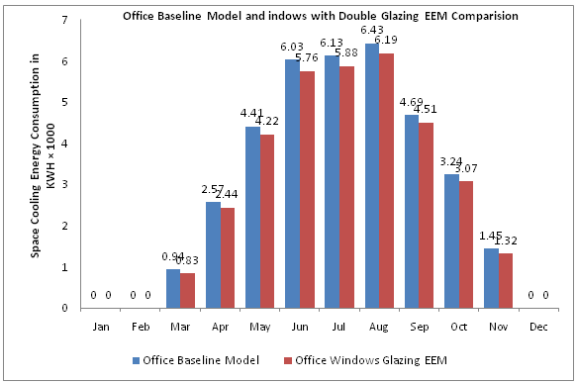

Figure No. 3.3. Office baseline and windows double glazing EEM comparison.

The cost analysis was also carried out and the annual return in terms of electrical energy saving was plotted against the costs required for double glazing. Prices were collected from the local and are shown below.

1. Single Glazing = 450 PKR/Sqft

2. Double Glazing = 650 PKR/Sqft

The additional initial investment is the difference of the prices for double and single glazing. The total additional initial investment for the same size window as of the baseline model with double glazing costs PKR. 272500/-. The first year annual return is PKR. 22044/. The same return was assumed for the following years without including the inflation rates and the tax deductions. The electricity rates were taken from the Islamabad electricity company (IESCO) [19] for commercial buildings i.e. 13.2 PKR/KWH. The Figure 3.4 shows that the additional initial investment can be recovered in less than 12 years.

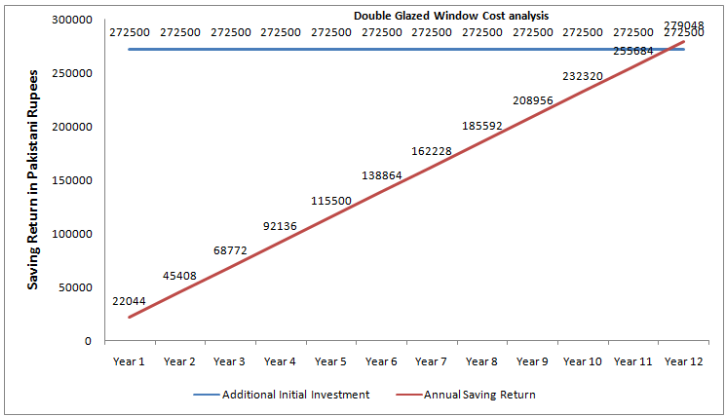

Figure 3.4. Cost analysis of double glazed windows for office building.

4. Summary and Conclusions

Office buildings are very imprtant in the context of energy consumption for space cooling in hot and humid climatic regions like Pakistan. The annual energy consumption of the building selected is 358900 Kilo Watt hours. In countries like Pakistan where there is already shortfall of electrical energy this is a huge amount. This study reveals that the heat gain through glass makes a huge part of the cooling load. Based on the analysis the reduction of window size to 5×4 from 8×4.5 gives the area percentages of windows to wall as mentioned in the building description. This saves 10.5% of energy used for space cooling. It is interesting matter that applying this measure does not require any additional initial investment. Another important measure which saves energy with some initial additional investment is the installation of double glazed

windows. If the window size remains the same i.e. 8×4.5 the energy saving of 5.0% can be achieved. The extra costs for moving from single glazed windows to double glazed costs PKR. 272500/- and annual return is PKR. 22044/- each year. So if both of the measures are applied the saving could be approximately up to 15%, which is a huge amount.

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