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Effect of Windows area reduction and Glazing type on energy consumption of Residential Buildings in Islamabad

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Abstract— Four Bedroom detached house was selected for analysis of energy performance of residential buildings in Islamabad. The actual building was studied for the energy consumption by simulating in eQuest, the whole building energy simulation program. This served as Baseline model for the analysis. This building uses electrical energy for space cooling. Energy efficiency measures were applied to the building by optimizing the windows area and changing the glazing type. Results show that employing the selected windows area reduction measure can save up to 7.2 % electrical energy as compared to the baseline model while applying the double window glazing for the baseline window size pay back 5.9% electrical energy saving of the energy used for space cooling in comparison to the baseline model.

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

1 Introduction

With the advent of modern science and technology, new energy resources have been discovered. The want for efficient use of energy recourses still cannot be overlooked. Statistic shows huge amount of energy consumption in building with a range of 25–40% [1]. Chinese building uses 15% of its total energy consumption for dealing with the heating and cooling requirements [2]. Due to side wise global issues the reliability of the energy resources become uncertain [3] and hence need of energy efficiency in every field is needed. European Union is also targeting to reduce their building energy consumption [4]. German passive house made research on the passive houses and came up with the first house of this kind in 1990 [5]. In America this kind of research is ongoing since 1950 [6, 17]. Canada's national research council worked on super insulated building in 1970 [8]. These show that the purist of low energy

Houses in since long and still the nations around the world are starving for it.

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This subject area is of keen interest around the world and is getting more importance [2,4]. Elisabeth Gratia et al. [9] conducted research on d low energy office buildings for climate of Belgium. Fong et al studied the application of low energy procedures in low rise buildings in Hong Kong [10]. Mahdavi et al. [11] compare the performance of passive and low energy houses for Vienna climate. Filippin et al. [12] 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.

1.1 Climate of Pakistan and energy consumption

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 [13]. Statistics shows that the Energy consumption is Pakistan is increasing sharply and the resources are declining rapidly as in the year 2008 - 2009 the electricity generation decreased by 4.2 % [14].

2. Baseline model

In order to analyze the energy consumption of residential buildings in Islamabad, a 4 bed room detached house was taken for this analysis. The data was collected from the original house and based on that the energy simulation was performed. The gross area of the building is 2352 ft^2. The building is two storied and one main entrance. The orientation is towards the north. It has four bedrooms, with attached Bathrooms, two Lounges and one Drawing room and one kitchen. The detail sketch of the building is show below:

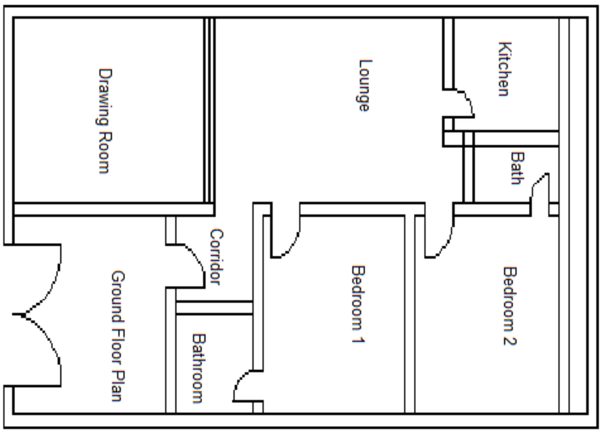

Figure 2.1. Residential Building Ground Floor Sketch.

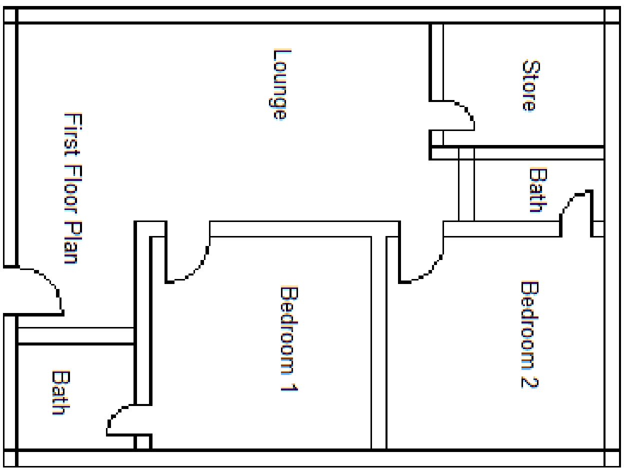

Figure 2.2. Residential Building First Floor Sketch.

The U – Values were calculated as per the construction of the building envelope. These are given in table below:

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

Building Component	**U value (BTU/Hr-ft²-ºF)**
Exterior Wall	0.373
Ground Floor Slab	0.577
Roof	0.298
Partition Wall	0.3.68
Glass	1.05

The selected absorptance of the slabs and the walls were 0.7 and for roof slab 0.6 respectively, based on the color of the construction [15]. Walls are brick constructed with plaster on both sides. The slab is interior finished 6 in RCC constructed. The glass used has 6mm thickness.

The glass construction is as shown in the table below:

Table 2.2. Window to wall percentages of residential building.

Walls	**Gross area of walls (ft^2)**	**Windows area (percentage)**
East Wall	792	0%
West Wall	1056	17.50%
North Wall	616	22.40%
South Wall	616	27%

Lighing power density in Watts per square feet was calculated as follow based on the lights installed in the building i.e.40 Watts florescent lights.

Table 2.3. Lighting power density W/Sqft of residential Building.

Lighting Power Density	**W/sqft**
Bedroom	0.38
Ground Floor Lounge	0.57
First Floor Lounge	0.71
Drawing Room	0.57
Kitchen	0.48
Corridor	0.55
Bathrooms	0.83

Infiltration 0.066 CFM/Sqft was used for the building under consideration.

Based on the occupants of the house the occupancy in square feet per person was calculated as follow.

Table 2.4. Occupancy in Sqft/Person of Residential Building.

Occupancy	Sqft/person
Bedroom	105
Ground Floor Lounge	37
First Floor Lounge	84
Drawing Room	46

The indoor design conditions used for this analysis is as follow;

Table 2.5. Details of Indoor design conditions for cooling load calculation.

Indoor Design Conditions	
Dry bulb Temperature	75.2 °F
Relative Humidity	50%
Minimum Air Flow	0.5 CFM/Sqft
Fan Power	1.25 in.W

3. Results and discussion

3.1 Residential Baseline model

Based on the details given above, the selected building was simulated using eQuest 3.64. The results were plotted and shows high cooling requirement in summers i.e from May to September, as shown below. Results shows that the annual electrical energy requirement for space cooling of the selected residential building is 109,900.00 Kilo Watt Hours.

The detail monthly energy consumption is shown in the graph below.

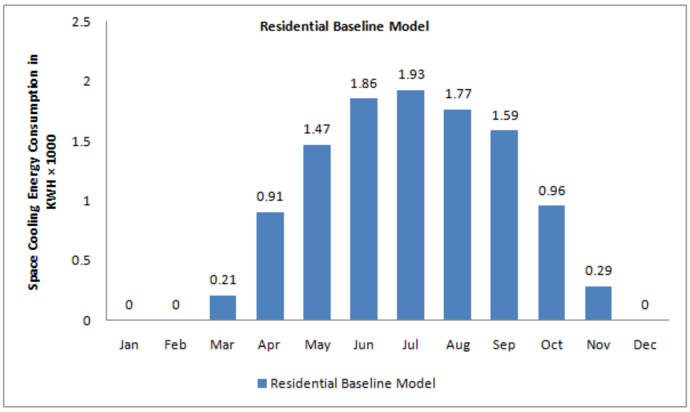

Figure No3.1. Monthly Space Cooling Energy consumption of the Baseline model.

3.2 Residential Baseline Model and Windows Area EEM Comparison

One of the peak load components is window glass which contributes high heat gain through the building envelope. The building was simulated for optimized window glass area and the comparison was plotted the details are given in the table below:

Table 3.1. Windows area percentage of Residential Baseline and EEM.

Walls	Baseline Windows area	Windows EEM
East Wall	0%	0%
West Wall	17.50%	12.20%
North Wall	22.40%	10.20%
South Wall	27%	15.60%

The width× height of the baseline model is of 6× 5 which was optimized to 5×4. The ventilators in the Bath rooms were assumed to be same for both the baseline and the energy efficient model i.e. 3× 2. The values mentioned in the table above are based on these dimensions. Appliying this minimizes the energy consumption to 101,900.00 Kilo Watt Hours which is 7.2 % of the baseline energy consumption. The monthly details of energy consumption are shown in the graph below shown both the baseline model and the windows area reduction model.

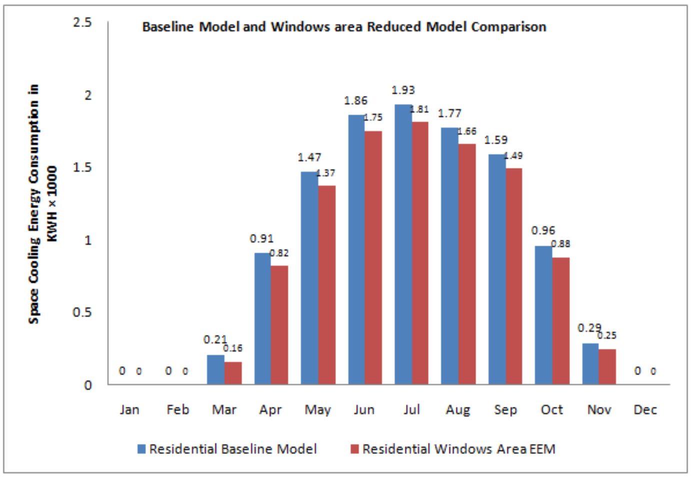

Figure 3.2 Residential Baseline and Windows Area EEM comparison.

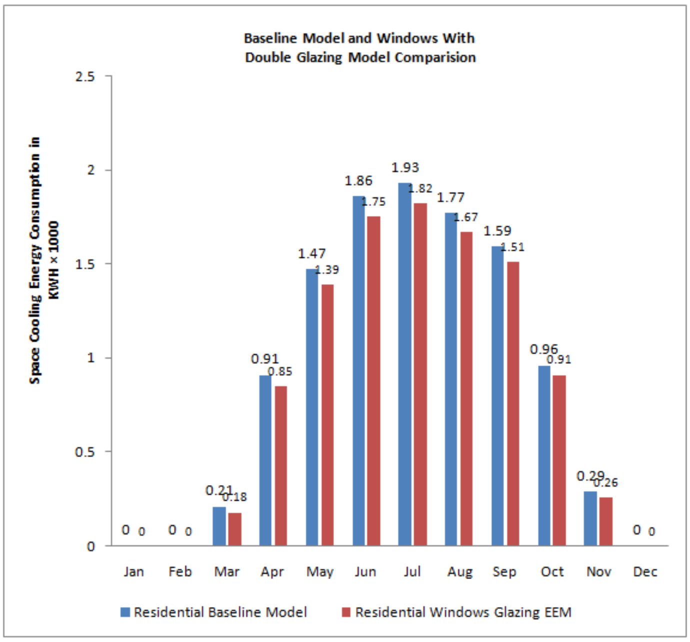

Figure 3.3. Residential Baseline and Double Glazing EEM comparison.

3.3 Residential Baseline Model and Double Glazing EEM Comparison

To evaluate the efffect of glazing on the energy requirement for cooling, the galzing type was change from single glazed to double glazed. The Glazing properties are given below:

Table 3.2. Windows Glazing details of Residential Baseline and EEM.

Windows Glazing	U-Value (BTU/Hr-Ft-°F	Shading Coefficient	Visible Trans-mission
Single	1.05	0.94	0.9
Double	0.55	0.7	0.62

Using the same window size as of baseline model the electrical energy consumption reduced 103,400.00 Kilo Watt Hour. This is 5.9% of the space cooling energy usage for baseline model. The monthly energy consumption of both models is shown in the graph below.

To evaluate the cost to benifet rates of single glazed windows (with frame) as well as double glazed window (with frame), were taken from the local commercial markets of Islamabad. The average rates are shown below:

Single Glazing = 450 PKR/Sqft

Double Glazing = 650 PKR/Sqft

The additional investment for double glazed window is the difference in the rates of the single glazed and double glazed window with frame. This additional initial investment was plotted against the saving results of the simulation of energy efficient model. The electricity rates per Kilo Watt hour was taken from Islamabad Electricity supply company. Graph shows that the initial additional investment can be paid back in approximately 11 years. The saving return in Pakistani rupees is plotted against the initial additional investment in Pakistani rupees.

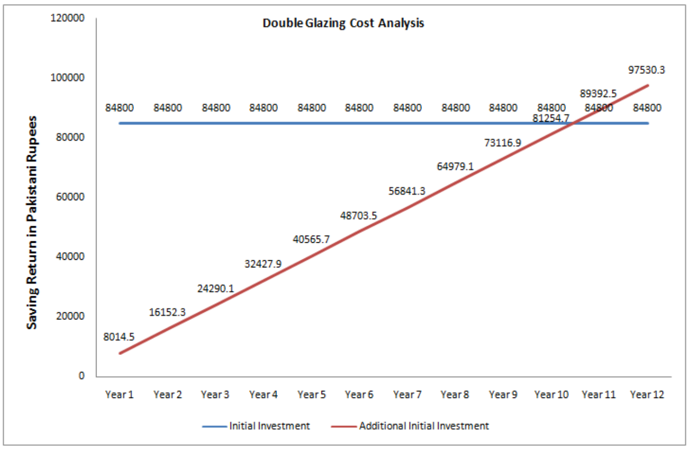

Figure 3.4 Cost Analysis of Double Glazed Windows for Residential Building.

4. Summary and Conclusions

Residential buildings are major consumer of energy. The energy consumption for space cooling is one of the most important components of the bulding operational energy consumption. This paper presents the analysis of a residential building for space cooling energy consumption. The results shows that changes in the window size and windows glazing type can largely affect the energy residential building operational energy requirement for space cooling. It is evedent from the analysis mentioned above that the reducing the window size from 6× 5 to 5×4 save 7.2% of the energy usage for space cooling. Also changing the glazing type without resucing the size save 5.9% of the energy usage for the said purpose. The initial additional investment need for moving from single glazed windows to double glaze with the mentioned specifications are PKR. 84800/- which is very little amount and give a huge benifet.

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