Application of advanced glazing to mid-rise office buildings in Malaysia

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Abstract: - The purpose of this study is to evaluate the energy saving that can be achieved by applying advanced glazing to a typical mid-rise office building in Malaysia, using Integrated Environment Solution (IES) simulation software. The software was used to model the Chancellery office building of Universiti Kebangsaan Malaysia as the test bed for simulation studies for thermal performance analysis .It was found that application of advanced glazing would lead to a reduction in annual cooling energy consumption in the range of 3.4-6.4%.

Key-Words: - Advanced glazing, Building simulation, Energy saving, IES software, Office building.

1 Introduction

The building sector is a major consumer of both energy and materials worldwide, and over the time, that consumption is increasing. It becomes the second largest global carbon dioxide (CO2) emitter after industry that represents approximately 33% of the global total (Price *et al*., 2006) [1].

As Malaysia is located in a tropical region with a hot and humid climate, most buildings are equipped with air-conditioning systems. Since, space cooling using air conditioner is practiced almost constantly throughout the year in tropical areas, the energy consumption and cost for this equipment is quite high. This situation, then, requires the commercial sectors to spend a lot of money for electricity.

In the past three decades, high economic growth in Malaysia causes a dramatic increase in energy consumption. According to the United Nations Development Report, Malaysia ranks as the 26th largest greenhouse gas emitter in the world (UNDP, 2007) and based on its growth rate of CO2 emissions, it appears likely to move up the list quickly [2].

Table.1 shows how Malaysia compared in its GHG emissions (based on CO2 emissions per capita) with the selected countries of top 30 CO2 emitters.

In order to get the higher energy efficiency of a building the appearance of the window system is obliged to improve. Sufficient illumination degree in the interior of buildings is provided by glazing materials in windows, accommodating the observable part of solar radiation. The other part of solar radiation in the infrared region entering through glazing causes upturn of interior temperature.

Table 1: Selected countries of top 30 CO_2 emitters (Source: UNDP, 2007)

Top 30 CO_2 Emitters	Share of World Total %		CO_2. Emissions Per Capita	
	1990	2004	1990	2004
1. United States	21.2	20.9	19.3	20.6
2. China	10.6	17.3	2.1	3.8
4. India	3	4.6	0.8	1.2
5. Japan	4.7	43	8.7	9.9
8. United Kingdom	2.6	2	10	9.8
14. Indonesia	0.9	1.3	1.2	1.7
22. Thailand	0.4	0.9	1.7	4.2
26. Malaysia	0.2	0.6	3	7.5

This study is intended to know the amount of reduction in electricity consumption that can be achieved by applying advanced glazing to mid-rise office building in Malaysia.

It is clear that better performance glazing is another means that can help cut down solar gain. By means of double clear pane glazing and low-E (low emissivity) layer on external or internal panes, the energy consumption in the buildings can be reduced [3].

The energy saving that can be obtained by applying advanced glazing to a representative high-rise residential building in Hong Kong, using Energy Plus simulation software was estimated by Milorad Boji [3]. It was found that application of low-E glazing would lead to a decrease in cooling electricity use by up to 4.2%. The saving according to application of clear plus low-E glazing would be up to 6.6%; double clear glazing up to 3.7%; and low-E reversible glazing up to 1.9%. The amount of saving achieved would be depended upon building wings orientation, and rooms' type and place.

Francis Yik [4] in a research paper investigated the effect of application of switchable glazing on energy consumption for space cooling. Using software, EnergyPlus, is found that application of switchable glazing would lead to a cut down in annual cooling electricity consumption by up to 6.6% where the amount depends upon the existence of overhangs, orientation of building wings, sorts and locations of rooms.

Weir [5] quantified the embodied energy filled the four main materials used in the construction of the inert gas, used double-glazed windows. The four main materials used were infill gas (argon, krypton and xenon), timber, aluminum and glass. It was found that the total embodied energy for argon, krypton and xenon cavity window (1.2 m 1.2 m standard tilt and turn windows) filled to MJ 1031, MJ 5531 MJ 1539 and windows, in that order.

Singh [6] evaluated the energy rating of different window glazing, available in the Indian market.It is determined that savings by a window depend on type of window and its orientation, site location and weather data, dimensions and construction of its walls and roof buildings. The study has been performed for five different climatic zones of India. He advanced energy rating equations for different glazing, buildings and climates by regression analysis.

The research was established the typical office building design, taking Chancellery office as test bed, which is extensively used in typical office in Malaysia.

In present study, all the windows of test bed building are fitted with a single panes clear glass (3mm), but this research investigated also cases where the window glass was reinstated by single low-e, low-e reverse and double glazing. The double glazing studied includes two panes of clear glazing and one pane of low-e glazing plus another pane of clear glazing.The clear glass windows in the toilets and stores, but maintained, in all these cases. The intention was to examine how effectively detect types of glass can contribute up to reduce the annual electricity consumption of cooling in a typical office building across from the use of clear glass one.

2 Simulation Arrangement

2.1 Test Building

The chosen building is Chancellery office building, a typical six-story office building which contains assignable 14848 m^2 of instructional space including office spaces, lobby, meeting rooms and restaurants located in Bangi, Malaysia

2.2 Simulation software

Integrated Environment Solution (IES) <VE-Pro> was used in present study to predict annual energy use in Chancellery office buildings of Malaysia. This software is a flexible, integrated system to perform assessment that brings productivity and excellence to every aspect of sustainable building design.IES software allows designer to design and operate comfortable buildings that use less energy and incorporate low-carbon and renewable technologies. IES software calculates conduction, convective and radiant heat transfer effects using hourly weather data [7].

The model was created based on existing office buildings to evaluate the energy consumed by the selected building.

Fig 1 shows the 3D view of the Chancellery office building model developed in IES.

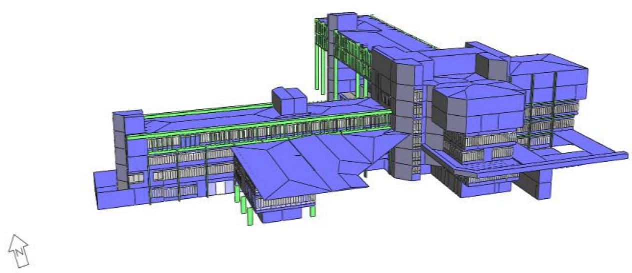

Fig.1. 3D view of the Chancellery office building model developed in IES< VE-PRO> 6.2.0.1

2.3 Data Requirements for Thermal Applications

2.3.1 Site Location and Weather Data

In this study, the climate data of Malaysia with Kuala Lumpur weather data is adopted for analysis. The Malaysian weather is almost same as its neighboring Asian countries. The Malaysian climate has the below characteristics:

- Very small difference in monthly temperatures.

- Mean daily temperatures of the hottest (February/March and coolest (December) month are 27.8°C and 25.9°C respectively.
- Monthly humidities more than 70% with a mean yearly value of 83%

2.3.2 Constructions

The material composition of the walls, windows, and other elements of the building fabric are described in Table 1. The existing window design of Chancellery building is 6mm thick single pane of clear sheet glass and Film coating was not used for the windows. In the case of glazing constructions, the layer properties include solar transmittance, absorptances and reflectance characteristic.

Table.2. Material properties of building

Description	Material	Thickness (m)	Conductivity W/(m·K)	Density kg/m^3	Specific heat capacity J/(kg·K)
External wall	Brickwork	0.117	0.84	1700	800
	Plaster	0.02	0.5	1300	1000
Internal Ceiling/floors	Concrete	0.1	1.4	2100	840
	Cavity	0.012			
	Plaster	0.01	0.5	1300	1000
Metal Roof	Steel	0.01	50	7800	480
	Bitumen	0.005	0.5	1700	1000
	Glass wool	0.15	0.04	200	670
Flat Roof	Stone	0.01	0.96	1800	1000
	Bitumen	0.005	0.5	1700	1000
	Concrete	0.15	1.13	2000	1000

2.3.3 Profiles

In this simulation study, different profiles were used to specify the time variation of office equipment's heat gain, office and corridor lighting as well as occupancy density according to working hours.

2.3.4 Internal Gains

Table 3 shows a summary of the internal loads for the selected building, including occupancy, lighting and office equipment, which include computers, printers, copy machines. The occupancy is estimated based on the office layout, and the information provided by local site staff.

3. Windows and Glazing

It is possible to reduce the amount of space-cooling energy use in the buildings when the standard type of glass (single pane clear glass) on each of the above types of glass to give an idea of the highest energy saving due to the use of the advance glazing

Table.3.Building internal gain

	Value	Units
Occupants	9	Person/m2
Lightings	18	W/m2
Office equipment		
Computers	5	W/m2
Printers	20	W/m2
Copy machines	9	W/m2

types. The advanced glazing is assumed to be used in all air rooms, while all non-air-conditioned rooms, including stores and toilets, would just have the ordinary clear glass at windows. Effect of three types of windows has been studied as follows:

1) Double clear pane glazing
2) Single low-E pane glazing
3) Double low-E pane glazing

The three types of investigated glazing include one type of single pane glazing and two types of double pane glazing. The single pane glazing is low-e glazing. The two types of studied double glazing both include a clear glazing and an air gap between the two glass panes, but one has another clear glass pane while the other type has one pane of low-e glazing.Table.4 shows the optical properties of glasses.

Table.4. Optical properties of advanced glazing

Glass type	clear glazing	low-e reverse glazing	Double low-E pane
Thickness(m)	0.003	0.003	0.003
Solar transmittance	0.837	0.63	0.63
Solar reflectance , front side	0.075	0.19	0.22
Solar reflectance at back side	0.075	0.22	0.19
Visible transmittance	0.898	0.85	0.85
Visible reflectance :front side	0.081	0.056	0.079
Visible reflectance : back side	0.081	0.079	0.056
IR hemispherical emissivity: front side	0.84	0.84	0.1
IR hemispherical emissivity: back side	0.84	0.1	0.84
Conductivity (W/m-K)	0.9	0.9	0.9

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4. Results and Discussion

Based on the building characteristics described above, the annual electricity consumption of the selected buildings, calculated by the use of electricity per hour at the IES. The simulation runs from 1 January to 31 December.

4.1 Energy consumption for single clear glazing

The annual electricity consumption for building the underlying cause is selected in Fig.2. The annual consumption of electricity for this project has shown, 2255.4 (MWh).

Of the total electricity, consumption is 58% of energy consumption of the building of a room air conditioning, cooling and ventilating the room by lighting 21%, equipment, 21% includes following .

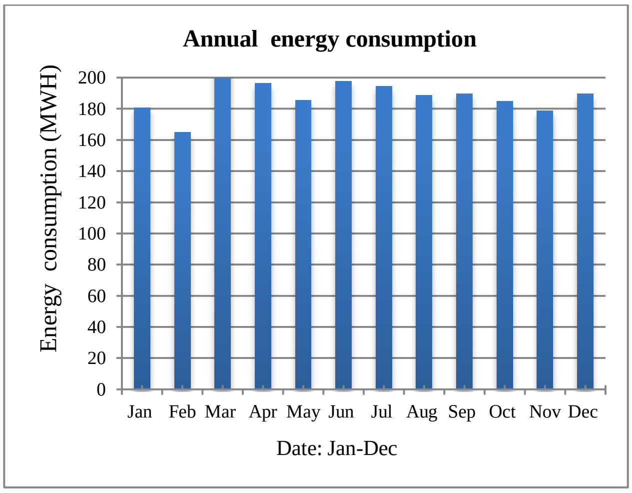

Fig.2. Results of the IES run on Chancellery building energy performance for the base case

4.2. Energy reduction in yearly cooling energy use with different glazing

On the basis of the building characteristics described above, the annual electricity consumption for mid-rise office building was calculated from the hourly electricity consumption predicted by IES. The simulation was run from 1st January up to 31st December.

The decrease in yearly cooling energy utilization in the selected office due to substitute of the standard (single clear) glazing by every form of glazing calculated is declared here as the decrease proportion of the annual cooling energy consumption by reference to the annual energy consumption cooling is available when the building is the standard glass.

The predicted annual electricity consumption for different types of glazing in the selected office building is shown in "Figs. 3 and 4". As these figures show, application of advanced glazing will lead to a saving in electricity consumption in the range from 46747.5 to 87311.3 KWh/year.

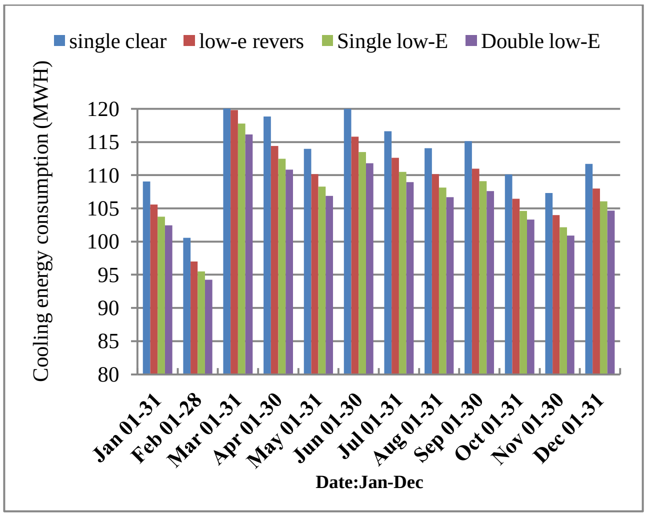

Fig.3. Yearly energy consumption of air conditioned rooms of Chancellery office with single clear, single low-e, single low-e reverse and double low-e+ clear

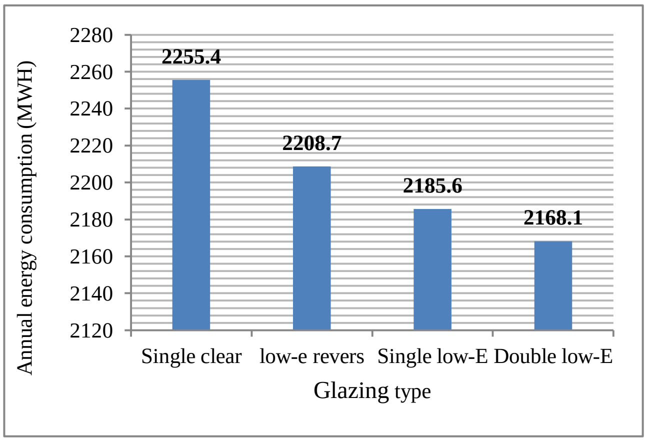

Fig.4.Annual energy consumption and different type of glazing

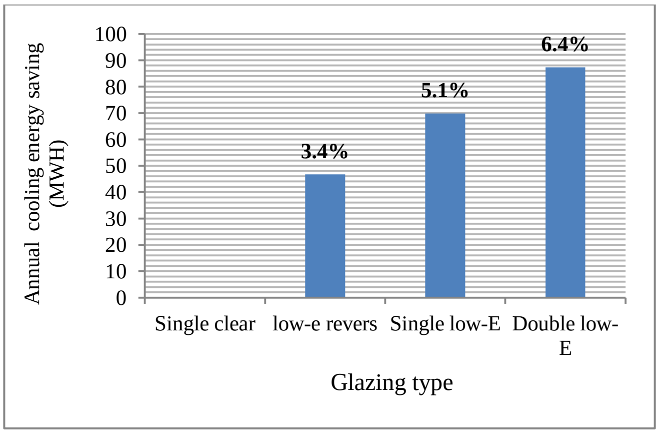

Fig.5.Annual energy saving and different type of glazing

Reductions in the percentage of annual cooling energy use for different windows are shown in "Fig.5", discussed below:

1) The application of advanced glazing will lead to a saving in cooling energy consumption in electricity utilization in the diversity of 3.4 to 6.4%.
2) The implementation of low-e reverse glazing would decrease the annually cooling electricity utilization up to 5.1 %.
3) The implementation of single low glazing would lead to saving in the yearly cooling consumption, up to of 5.1%.
4) Compared to low-e reverse glazing and single low-e glazing, the implementation of double low-e glazing would influence to higher saving in the yearly cooling consumption, up to 6.4%.
5) Among the advanced glazing, the implementation of double low-e glazing in the company of one pane of low-e glazing would yield the highest energy saving.

4 Conclusion

This paper evaluated the annual electricity consumption in a typical office building, using IES software. The simulation results showed that application of advanced glazing would lead to a reduction in the annual electricity consumption by:

- Single low-e glazing—up to 5.1%.
- Single low-e reverse glazing—up to 3.4%.
- Double glazing (clear and low-e)—up to 6.4%.

The annual energy saving would be in the range from 46747 to 87311 KWh in the entire building by the application of advanced glazing. It is deduced that maximum energy saving would be achieved when double low-e glazing is used instead of single clear glass.

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