Energy consumption and energy saving in Malaysian office buildings

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Abstract -Buildings consume more energy and waste more natural resources, which leads to more co2 production and environmental pollution compared to other human enterprises or industries. University buildings consume a large amount of energy and materials, which is comparable to a small commercial city. The office buildings of universities comprise a large portion of the university structures and applying energy saving policies may result in cost saving This study estimated the energy savings potentially achieved by installing insulation material in the external walls and applying advanced glazing to a typical mid-rise office building in Malaysia. IES (Integrated Environmental Solution) software was used to model the office building and for thermal performance analysis. It estimated that 180000(KWh) of annual energy consumption can be saved through the application of low-e glazing and insulation.

Key-Words: - Building simulation, Energy saving, Energy consumption, Low-e glazing, office building, Thermal insulation.

1 Introduction

Energy is increasingly costly and the condition is worsened by global warming due to green house gas emission. Clearly, the need for quality, office buildings in particular, is on the rise [1]. Construction of office development is one of the fastest growing sectors in the construction industry; the energy consumption in office building is 70-300 kW h/m^2 which is 10-20 times bigger than residential sectors (environment-e Yang., 2008) [2]. Saidur et al. (2009) reported that office building air conditioner had the highest energy consumption of 57% and followed by lighting (19%), elevators (18%), pumps and other equipment (6%) [3]. The purpose of this study is to reduce the energy demand by applying advanced glazing and insulation material in the external walls.Clearly improved performance in other ways that can help to glass for reducing the sun light [4]. Reduce through the clear glass windows and double pane low-e (low emission) layer of the discs inside or outside of the energy consumption in buildings [5]. Milorad Oji [6] is a more scholarly work, the possibility of energy saving by applying higher typical glass-storey residential buildings in Hong Kong with the EnergyPlus simulation software reaches evaluated. We learned low- glass because of a decrease in power consumption by implementing cooling of up to 4.2%. The savings from the use of low- glass to be reversible up to 1.9%, double- glazing cleaning up to 3.7%, and clear glass windows with low E up to 6.6%. The savings are on the orientation of building wings, and the type and location of the room from. Clarke et al. [6] presented a research work on optical parameters, U-value and emissivity of different types of advanced glazing materials in order to control the solar heat gain and efficient glazing. Solar heat gain reduction and annual energy saving of 18% through using copper based thin coatings are studied by Genaro et al. [7]. Meanwhile, the energy consumption for air conditioned system can be minimized by insulation. Thermal insulation is therefore the alternative choice which is cost effective for energy reduction. However, the cost of insulation is directly proportional to the insulation thickness. Bolatturk (2008) .[10]. carried out some analysis on the use of insulation for external wall buildings. The results showed that maximum insulation thickness ranges from 2-17 cm, payback duration 1.3-4.5 and energy savings 22-79% .In Denizli Turkey, Dombayci [11] found that using expanded polystyrene as an insulation material with insulating thickness decreased energy consumption by 40.6% and reduced the discharge of CO_2 and SO_2 by 41.53%, while the source of energy was coal. This study was undertaken to evaluate the energy saving and energy consumption via applying advanced glazing and insulation material installation for air conditioned buildings walls in Malaysia.

1.2 Overview of electricity sector in Malaysia

In the past three decades, high economic growth in Malaysia causes a dramatic increase in energy consumption. Several studies reached the conclusion of positive connection between electricity consumption and the economic growth. From 1980 to 2009, the total electricity consumption and domestic product (GDP) increased by 9.2% and 6.2% respectively from 1980 to 2009[12]. Fig.1 shows that the Malaysia has the highest electricity consumption among the ASEAN countries. Fig. 2 shows the distribution of total energy consumption in Malaysia Department. It turns out that the commercial sector, the second-largest user, for about 32% of total energy consumption in Malaysia's accounting [3].

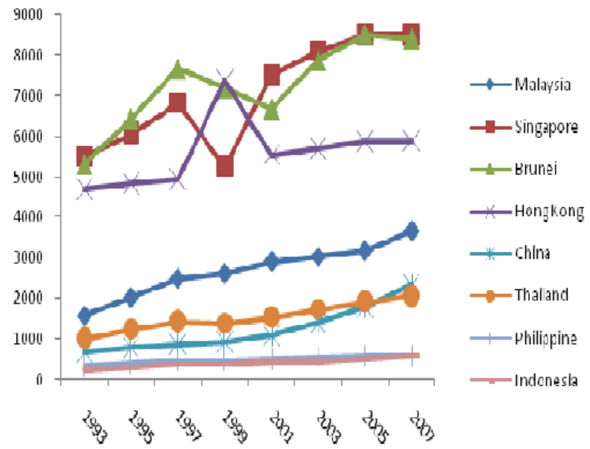

Fig.1.Electricity consumption in kilowatt hour per capita in ASEAN countries.

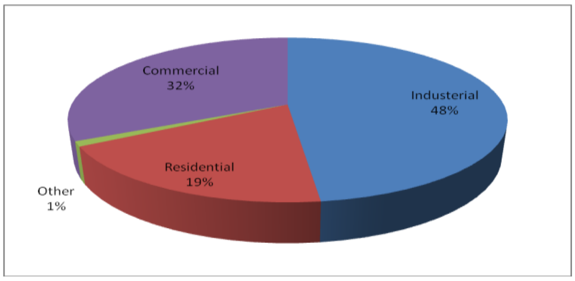

Fig.2. Statistics of energy uses in Malaysia (EC, 2007).

2. Methodology

IES <VE-Pro> (Integrated Environmental Solution) was used to model the office building located at Bangi, Malaysia.The geographic coordinates of Malaysia lies at Latitude 3.12^{o}N; longitude 101.55^{o}E with variable temperatures, and high humidity. The Malaysians' hottest time is around March which is 27.8^{o}C [12].As it shown in **Table.1,** the annual weather data, maximum dry-wet bulb 34.90 ^{o}C and 26.50 ^{o}C respectively.

2.1 An overview of the case study building

The propose building chosen is Chancellery office building, an iconic landmark in UKM (University Kebangsaan Malaysia) which is located at Bangi, Malaysia. The selected building is a typical six-storied office building which contains assignable 12350 square meter of instructional space including office spaces, lobby, meeting rooms and restaurants. The material composition of the walls, windows, and other elements of the building fabric are described in Tables.2,3 .In the case of glazing constructions, the layer properties include solar transmittance, absorptances and reflectance characteristics.

Table.1. Annual dry-wet bulb temperature, Kuala - Lumpur, Malaysia.

Date	Min dry-bulb Tem(C°)	Max wet-bulb Tem(C°)
Jan	25.2	33.7
Feb	25.7	34.6
Mar	26.3	34.9
Apr	26.6	34.9
May	26.8	34.7
Jun	26.1	34.2
Jul	26.0	34.0
Aug	26.0	34.0
Sep	25.9	33.8
Oct	25.8	33.6
Nov	25.7	33.2
Dec	25.6	33.2

Table.2. Material properties of building

Description	Material	Thickness m	Conductivity W/(m·K)	Density kg/m³	Specific heat capacity J/(kg·K)
External wall	Brickwork Plaster	0.117 0.02	0.84 0.5	1700 1300	800 1000
Internal Ceiling/floors	Cast Concrete Cavity Plaster	0.1 0.012 0.01	1.4 0.5	2100 1300	840 1000
Metal Roof	Steel Bitumen layer Glass wool	0.01 0.005 0.15	50 0.5 0.04	780 1700 200	480 1000 670
Flat Roof	Stone Bitumen layer Cast Concrete	0.01 0.005 0.15	0.96 0.5 1.13	1800 1700 2000	1000 1000 1000

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Table.3. Material properties of glazing

Description	Thickness m	Conductivity W/(m·K)	Solar transmittance	Outside reflectance	Inside reflectance
External Window	0.006	1.06	0.78	0.07	0.07
Internal Window	0.004	1.06	0.82	0.07	0.07

2.1.1 IES<VE-Pro> simulation software

The building energy simulation program IES <VE-Pro> (Integrated Environment Solution) was used in present study to predict annual energy use in Chancellery office buildings of Malaysia (Fig.4). This software is a flexible, integrated system for performing assessment that results in productivity and excellence in every aspect of sustainable building design, and is employed by leading sustainable design professionals worldwide. Weather data in these formats is available for a large number of sites worldwide. In this study, the climate data of Malaysia with Kuala Lumpur weather data is adopted for analysis. The summary on the data input for energy audit are as follows, data weather and sites location, building construction, specific variation profiles of casual gain, ventilation and set points, light and office equipments internal gain from occupants and cooling system setting.

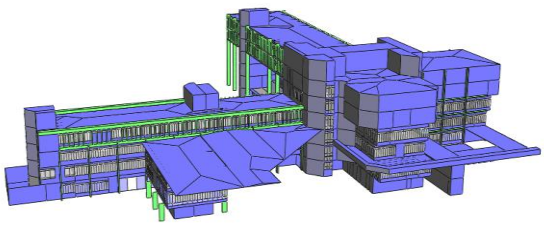

Fig.4. 3D view of the Chancellery office building model developed in IES< VE-PRO> 6.2.0.1

3 Energy analysis

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.

3.1. Four cases to evaluate energy consumptions

Using the same building footprint and structure, four cases were created for comparison.

First case; Original; representing the typical Malaysian office building

1. Single glass
2. Uninsulated roofs and walls.

Second case:

1. Improvement of glazing construction, applying double low-e glazing

Table 4 shows the optical properties of glasses that have been obtained from the glass library of window. All windows were double low-e glazed for energy efficiency because double low-e glazed windows in an exposed area can reduce heat loss compared to a single glazed window

Third case:

1. Improvement of the exterior wall insulation, adding 4 cm extrude polystyrene thermal insulation

Table 5, shows properties of the selected insulation material.

Fourth case; Proposed

1. Improvement of glazing construction, applying double low-e glazing
2. Improvement of the exterior wall insulation, adding 4 cm extrude polystyrene thermal insulation

4. IES results

4.1 First case (Original)

First case represents typical Malaysian office buildings. Exterior walls and roofs have no insulation and windows have single clear glass. The annual electricity consumption for building the underlying cause is selected in Fig.5. The annual consumption of electricity energy consumption for this project was 2256.4 (MWh). Of the total building electricity consumption, 58% is from space air conditioning like cooling and ventilation, followed by lighting (20%), office equipment and other (19%) and (3%). Results of the IES run on building energy performance for first case is shown on Figs.5, 6.

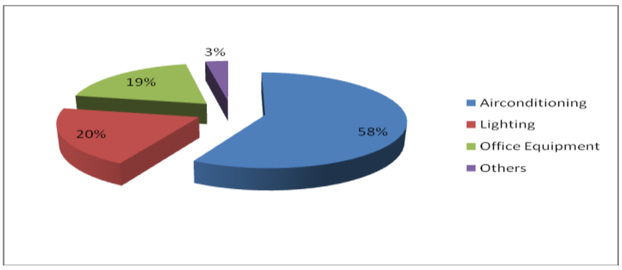

Fig.5. Total energy consumption by all equipments and their breakdown

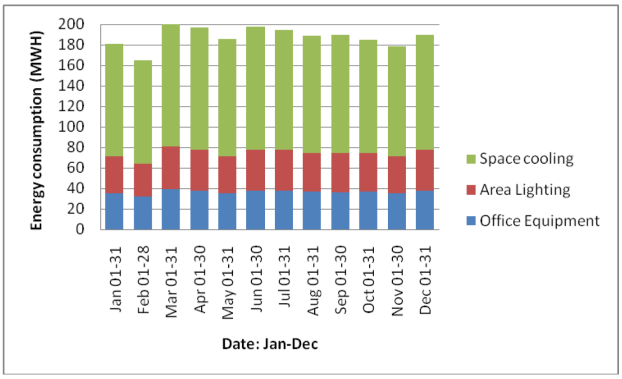

Fig.5. Results of the IES run on Chancellery building energy performance for the base case

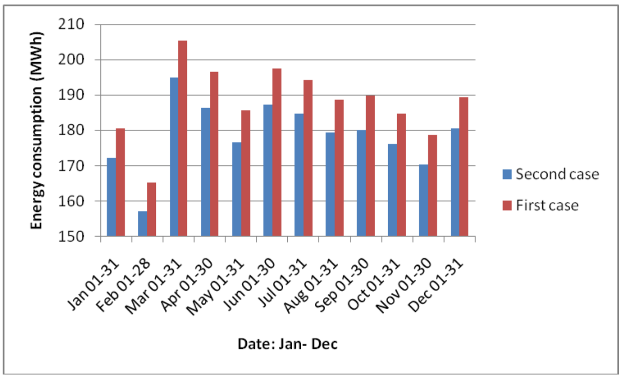

Fig. 6. Reduction in electricity consumption due to use of low-e glazing.

4.2 Second case

The reduction in annual cooling energy use in selected job because changing the standard glass (clear single) by the low-e glazing studied expressed here will reduce the percentage of the annual cooling energy consumption by reference to the annual energy consumption cooling is available when the building is the standard glass. Reductions in the annual cooling energy use for different windows are shown in fig. 6. The application of double glazing with low-e pane would yield a saving in annual electricity consumption of 111000 (KWh).

Table.4. Optical properties of double low-e glass

Description	Mater	Solar reflectance		Solar transmittance	IR hemispherical emissivity	
		front	back		front	back
Double Low-e glazing	Low-e pane 32mm	0.331	0.39	0.496	0.84	0.033
	cavity 12 mm					
	Low-e pane 57mm	0.173	0.25	0.582	0.84	0.083

Table.5. Data of Insulation Materials

Type of insulation	Thickness (m)	Thermal conductivity (W/mº C)	Density kg/m^3
Extrude polystyrene	0.04	0.029	35

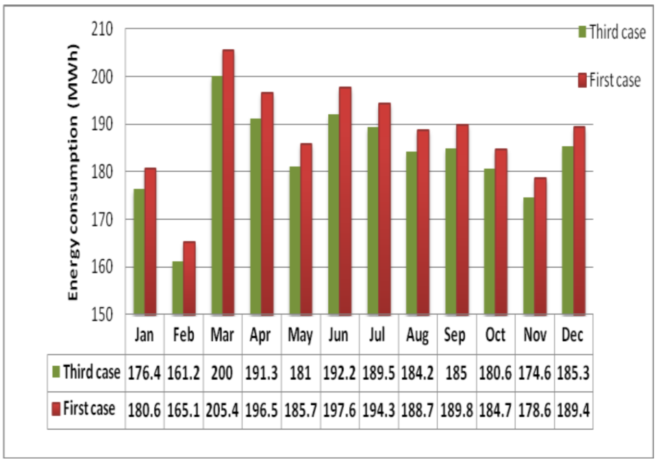

Fig.7. Reduction in electricity consumption due to installing extrude-polystyrene to building external wall

4.3 Third case

Simulation results indicate that in buildings with larger insulation-thickness, cooling load and energy consumption decrease. Fig.7. illustrates extrude-polystyrene insulation thickness of 4cm and how it generally decreases annual energy consumption.

4.4 Fourth case, (proposed)

Fig.8. shows the data regarding extrude polystyrene as insulating material in walls and double low-e glazing as energy conservation opportunities. The cases were compared based on insulation, and glazing. It illustrates the achievements of 180000 (KWh) reduction for total energy consumption. It estimated that of energy can be saved through the application of low-e glazing and insulation. Results of building energy use and amount of energy saved by Energy Conservation Options (ECO) for selected building, electric and gas are shown on Figs. 9, 10.

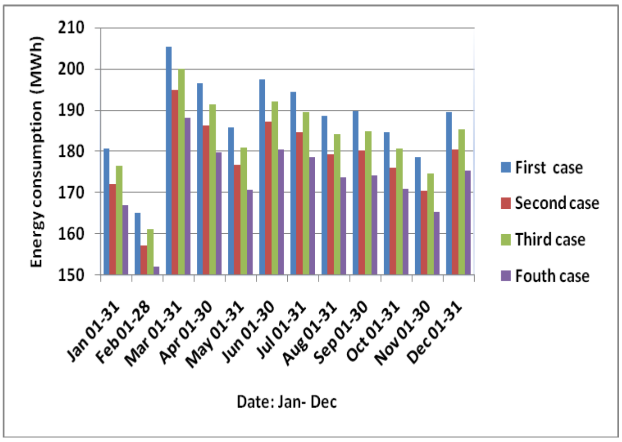

Fig. 8. Results of the IES run and comparison of the cases

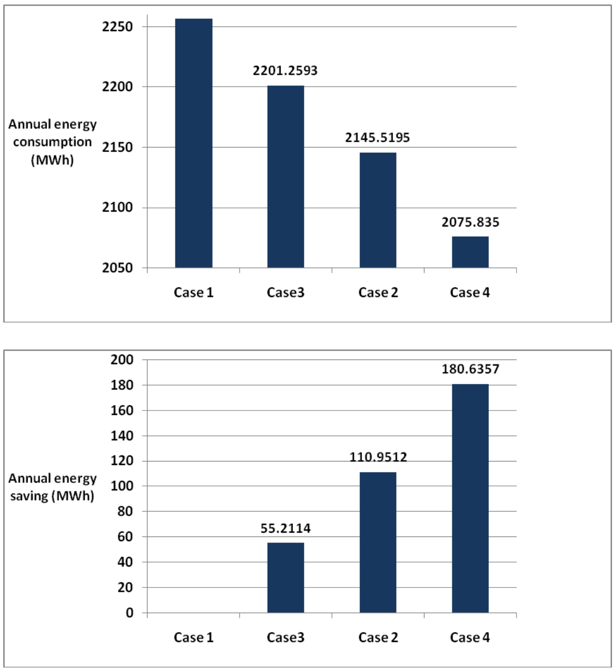

Fig. 9-10. Site Energy Use and energy saving by ECO.

5 Conclusion

This paper examined the energy consumption and energy saving via applying advanced glazing and insulation material installation for air conditioned buildings walls in Malaysia. The decrease in electricity consumption was investigated with IES simulation software.Results demonstrate that through applying advanced glazing and wall thermal insulation annual energy consumption is lowered to a minimum and reached to 2075 (MWh). Overall, the proposed building uses 180000(KWh) less cooling loads than most office building in Malaysia.

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