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Advanced glazing and varied WWR for energy savings of high-rise office buildings in hot-humid climates

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Abstract

ASEAN countries are experiencing rapid growth rate in energy consumption which has raised concerns over energy supply difficulties and negative environmental impacts. High-rise office buildings in Malaysia are having high cooling energy requirements due to high solar radiation through highly or even fully glazed building façades under the hot-humid climatic conditions. This study is aimed to investigate the potential of both WWR and advanced glazing on cooling energy savings of high-rise office buildings in Malaysia. However, in order to further challenge on this issue and studies done by previous researches, the aim of this study extends to compare the significance on energy savings by these two design strategies. This study involved a case study high-rise office building in Kuala Lumpur. IES (VE) software was used in all the building thermal simulations in this study. From the simulation results, this study recommends to prioritize the design of lower WWR at West façade followed by East, South and lastly North façade because the same WWR at different façade orientations has different effect on annual cooling energy savings, ranging from 0.80-6.73%. This study also suggests that reduction of WWR on West façade has highest impact on reduction of Building Energy Intensity BEI, followed by East, South and lastly North façade. In regardless of orientation, lower WWR will result lower annual cooling energy consumption and therefore higher annual cooling energy savings. An annual cooling energy savings of 10.11% is expected when triple glazing is used to replace double glazing of existing high-rise office buildings in Malaysia. This study concludes that advanced glazing is able to perform a more significant annual cooling energy savings compared to WWR strategies under the hot-humid climate of Malaysia. The results and recommendations from this study can be useful guidelines for façade designers when deciding between both strategies for optimized energy savings façade design of high-rise office buildings in Malaysia.

Keywords: Advanced glazing; energy savings; high-rise office building; hot-humid climate; window-to-wall ratio.

1. Introduction

Recent studies has noticed that world energy use is growing rapidly with concerns over supply difficulties, exhaustion of energy resources and environmental impacts [1]. Global energy demand is consequently expected to increase by a third between 2012 and 2035, with 90 % of this growth coming from emerging economies [2]. Analysis by International Energy Agency shows that this growing trend will continue. In the context of ASEAN countries including many developing countries such as Indonesia, Malaysia, Philippines, Thailand and so on, the energy use growing rate is alarming. This is elaborated in Table 1, showing the average annual energy demand growth rate of 2.5 % (2011-2035). As a developing country, Malaysia is predicted to have an average annual energy demand growth rate of 2.3 %. The same data predicted that Malaysia will experience an increase of 29.7 % of energy demand from 2011 to 2020, with average annual growth rate of 3.3 % [3].

Table 1 Primary energy demand by ASEAN countries (Mtoe)

Country	1990	2011	2020	2025	2035	Average Annual Growth Rate (2011-2035)
Indonesia	89	196	252	282	358	2.5%
Malaysia	21	74	96	106	128	2.3%
Philippines	29	40	58	69	92	3.5%
Thailand	42	118	151	168	206	2.3%
Rest of ASEAN	42	119	161	178	221	2.6%
Total ASEAN	223	549	718	804	1004	2.5%

(Source: World Energy Outlook Special Report, 2013)

In the global perspective, buildings consumed up to 40% of total energy use and in Malaysia, buildings consumed a total of 48 % of the electricity generated in the country [4]. Referring to the statistics of electricity use in Malaysia carried out by Energy Commission Malaysia in 2013, commercial buildings consumed a high percentage of 32.7 % of total energy used in Malaysia compared to other sectors [5]. This is because commercial buildings in the hot-humid climate such as Malaysia are often installed with air conditioning systems to sustain indoor thermal comfort. Most of the time, these systems consume the most energy among all building services [6]. Other sectors including industrial, residential, agriculture and transport consumed 45.4 % 21.4 %, 0.3 % and 0.2 % of electricity respectively. This is shown in Figure 1.

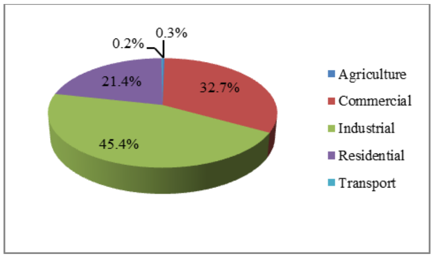

Fig. 1 Statistics of electricity use in Malaysia, 2013
(Source: Energy Commission Malaysia, 2013)

1.1. Hot-humid climate of Malaysia

Malaysia is geographically located at latitude 3.12° N and longitude 101.55° E. It is experiencing hot and humid climatic conditions with characteristics of uniform temperature, high humidity and copious rainfall. Malaysia naturally has abundant sunshine and thus abundant solar radiation [7]. On the average, Malaysia receives about 6 hours of sunshine per day and receives an average solar radiation of 400–600 MJ/m² per month [8]. Table 2 shows the yearly average solar radiation levels throughout different cities in Malaysia.

Table 2 Yearly average solar radiations in Malaysia

S/I	Region/Cities	Annual Average Solar Radiation, kWh/m²
1	Kuching	1470
2	Bandar Baru Bangi	1487
3	Kuala Lumpur	1571
4	Petaling Jaya	1571
5	Seremban	1572
6	Kuantan	1601
7	Johor Bahru	1625
8	Senai	1629
9	Kota Baru	1705
10	Kuala Terengganu	1714
11	Ipoh	1739
12	Taiping	1768
13	George Town	1785
14	Bayan Lepas	1809
15	Kota Kinabalu	1900

(Source: S. Mekhilef et. al., 2012)

Temperatures in Malaysia typically vary from 24 °C to 34 °C and is rarely below 23 °C or above 35 °C (Weatherspark, 2016). The weather condition in Malaysia is such that it is a rare circumstance to witness days completely without sunshine except during the Northeast monsoon season and it is unusual to witness a whole day with a clear sky in drought season [9].

1.2. The problem of high cooling energy consumption due to overheating of high-rise office buildings in Malaysia

In architecture, window glazing is prestigious for its ability to present positive images such as transparency, natural brightness, modernity and indoor–outdoor interaction. Highly glazed buildings have become a worldwide design trend in modern architecture for any climate [10]. However, fully glazed façades will cause higher energy consumption and thermal discomfort due to higher solar gain [11]. From a previous study, high-rise buildings are experiencing overheating condition in hot-humid climates. The same study found that for a high-rise built form, vertical surfaces are most critical to the impact of solar radiation [12]. Another study indicated that ambient temperature plays a vital role in relation to energy consumption of air conditioning system [13]. Largely glazed façades are said to be the main cause of the problem of overheating for buildings [14]. Due to high solar radiation through highly glazed façades which has caused overheating, office buildings in Malaysia consume between 200 - 250 kWh/m²/year of energy of which about 64 % is for air conditioning, 12 % for lighting and 24 % for general equipment [15]. Another study also showed that air conditioners are the major energy users in office buildings in Malaysia with 57 % energy usage, followed by lighting 19 %, lifts and pumps 18 % and other equipment 6 % [16].

1.3. Aim of study

The identified problem of this study is the high cooling energy consumption of high-rise office buildings in Malaysia caused by overheating. This is due to high solar radiation through highly glazed building façades. However, this study has identified that from previous studies, an optimum Window-to-Wall Ratio WWR is believed to be able in yielding significant cooling energy savings for buildings [17, 18, 19, 20]. There are also studies on advanced façade glazing for building energy savings [21, 22, 23]. From the identified problem and previous studies, there are always questions regarding the most suitable WWR for specific façade orientation for maximized solar heat gain reduction for high-rise buildings in hot-humid climate of Malaysia. At the same time, there are also questions regarding the potential of advanced glazing on cooling energy reduction for high-rise office buildings in Malaysia. It is noticed that the gap between previous studies and the identified questions is the recommendation on the selection between WWR and advanced glazing for a more significant cooling energy savings of high-rise office buildings under hot-humid climate of Malaysia. This research gap is set as point of departure for this study. Therefore, the aim of this study is to investigate the potential of both WWR and advanced glazing on cooling energy savings of high-rise office buildings in Malaysia. However, in order to further challenge on this issue and studies done by previous researches, the focus of this study extends to compare the significance on energy savings by these two design strategies. It is aimed that the results and recommendations from this study can be useful guidelines for façade designers when deciding between both strategies for optimized energy savings façade design.

2. Literature review

Many recent studies were carried out investigating the roles and optimum design of window glazing in building energy requirements. A previous study regarded windows as one of the most important building components and windows are acknowledged for their positive influence on the health and well-being of building occupants. The same study noted that windows play an important role not only in providing daylight and view, but also in shaping the overall energy demand in buildings [24]. Façade configurations are predicted to be responsible for up to 45 % of the building's cooling loads [25]. From the study of annual energy requirements per floor area at four climates in Turkey through four different WWR of 20 %, 40 % (Base case), 60 % and 80 %, it was found that energy requirement became higher when the glazed area increased. This study concluded that annual cooling and total energy requirements of the studied office buildings with high quantities of glazing increase significantly as compared to the studied office buildings with lower glazing quantities [18]. Another recent study suggested that the building enclosure plays a relevant role in the management of the energy flows in buildings and in the exploitation of solar energy at a building scale. An optimized configuration of the façade can contribute to reduce the total energy demand of the buildings [19]. The same study defined the WWR as the ratio between the net glazing area and the gross exterior wall area. The results of the study concluded that in a temperate oceanic climate, the optimal WWR are found in the range 35–45 % regardless the orientation. In the research on the HVAC energy consumption, a previous study used building thermal simulation software on office building with different WWR at different building orientation. The study found that the heating energy consumption, air-conditioning energy consumption and total energy consumption were gradually increased with the increase of the WWR under the same orientation [20]. Similarly, results of another research showed that the total building energy consumption increased when the WWR was also increased. In the study on the relationship of WWR and orientation on the building energy consumption, the analysis results showed that the increase of building energy consumption caused by increased WWR appeared more obvious on the East and West orientation [26].

In regard to advanced glazing, many previous studies have contributed to a better understanding of the different aspects of advanced façade glazing including design factors, glazing techniques and thermal performances. In a recent study carried out comparing thermal performance of double glazed and triple glazed windows, the annual energy consumption for the double glazed window was higher than the triple glazed window. The result of this study highlighted that double glazed fenestration systems allowed more solar heat gain compared to triple glazed windows [21]. Another study was carried out with specific focus on the effects of double glazed façade on energy consumption, thermal comfort and condensation of a typical office building under hot and humid climate in Singapore. The simulation results showed that double glazed façade with natural ventilation was able to minimize energy consumption as well as to enhance the thermal comfort [11]. A simulation study was carried out on 10 different glazing types applied to five different climatic zones in India. The study observed that the dependant factors of annual energy savings by a window include thermal conductivity (U-value), solar heat gain coefficient (SHGC or g-value), window orientation, climatic conditions and building parameters such as insulation level, floor area, etc. [22]. A previous study on thermal performance of glazing noted that spectrally selective low-e coatings allow the visible light of the solar spectrum and block the other wavelengths that are generally responsible for solar heat gains. According to this study, low-e coatings are placed on the inside surface of the external glazing pane as most absorbed solar energy will be dissipated to the ambient air [23].

Referring to the literature reviews, many previous researches were carried out studying suitable WWR and different types of advanced façade glazing for optimized energy savings. However, it is the challenge of this study to compare the different effects of these two design strategies on cooling energy savings. This is done through case study of a high-rise office building in Malaysia. This contributes to previous studies by providing guidance to designers in deciding between WWR and advanced glazing for a more significant cooling energy savings for high-rise office buildings in Malaysia.

3. Methodology

3.1. The simulation software and the case study building

Integrated Environmental Solutions Virtual Environment IES (VE) was selected after comparisons of various building simulation software. IES (VE) provides a variety of variables for analysis as well as output graphical forms in simulation of buildings. It provides an environment for the detailed evaluation of buildings and system designs, allowing them to be optimized with regard to comfort criteria and energy use [27]. Previous studies have recommended that IES (VE) is with high accuracy. From previous research findings, it was concluded that there was no considerable statistical difference in the mean values between IES (VE) simulated results and measured data [28]. The Kuala Lumpur weather data from IES (VE) was used in the simulations in this study.

There is no national building code or regulation in Malaysia defining the minimum height or number of floors of high-rise buildings. However, the definition of high-rise building in this study is based on the International Building

Code IBC 2009 and National Fire Protection Association NFPA code. Both codes define high-rise buildings with a minimum height of 75 feet (22.9 meter) above ground level. Referring to typical office buildings' floor height of approximately 3.8m in Malaysia, 22.9 m will be the height of a building higher than 6 floors. Therefore, 7 floors is defined as the minimum number of floors acceptable as high-rise in this study. A high-rise office tower in Kuala Lumpur was selected as the case study building. The building façades are fully glazed with WWR 1.0. This represents the modern façade design trend of office buildings in Malaysia. Furthermore, the WWR 1.0 is suitable to be used as base case model as the WWR can be modified for simulations for possible cooling energy savings. At the same time, the façade glazing can be altered with advanced glazing for possible energy savings. The case study building is located within the Cap Square development in Kuala Lumpur. It consists of a 4-storey high entrance lobby with 41 floors of occupied office levels. The floor-to-floor height is 4,000 mm. Each floor is approximately 1,393.55 m², with total gross floor area of 72,000 m². The design utilizes perimeter of the tower as office spaces whereas the service zone is located at the center of the tower, as shown in Figure 2.

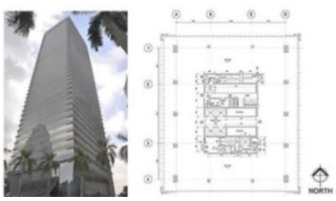

Fig. 2 External view and typical floor layout of case study high-rise office building

3.2. Construction of the case study building

The case study office building model was constructed in the IES (VE) software based on the actual building specification and construction materials. Summary of the specification for the building model is shown in Table 3. This building has fully glazed façade facing all 4 orientations with WWR 1.0. The building envelope comprises curtain wall system with aluminium frames and is set out on 1,160 mm grid. The curtain wall is constructed of double glazed panels with low-e glass.

Table 3 Summary of case study office building specification

Description	Building Design / Material
Number of floors	42
Total gross floor area	72,000 m²
Floor-to-floor height	4,000 mm
Occupancy load	10 m²/person
Roof construction	RC slab with water membrane insulation covered with concrete pavers
Internal ceiling and floor construction	Raised floor system above RC slab with air plenum and suspended ceiling below slab
Window to wall ratio	1.0
External glazing	Double layers of laminated low-e glazing, Shading Coefficient 0.448, U-value 3.35W/m²k
Indoor temperature	23°C
Air conditioning	Chilled water cooling with 23 VAV boxes/floor

3.3. Proposed WWR for simulations

The Malaysia 1986 Uniform Building By-Laws UBBL was referred to determine the lowest WWR proposed for high-rise office buildings in Malaysia. According to 1986 UBBL (32) for commercial buildings, windows or doors opening to the exterior should have a total area of not less than 10 % of the clear floor area of such room. By referring to this regulation, the minimum allowable glazing area for each façade is therefore 34 m², which is approximately 20% of the façade area i.e. WWR 0.2. Therefore, the proposed various WWR in this study are 0.2, 0.4, 0.6, 0.8 and 1.0 (base case). There were total 20 building models being simulated for annual building and cooling energy consumption for comparisons on possible energy savings. Each model has different WWR at one specific façade orientation while keeping the rest of façades with WWR 1.0. This is to study the effects of different WWR on different façade orientations. Figure 3 shows different façades with different WWR for the 20 building models.

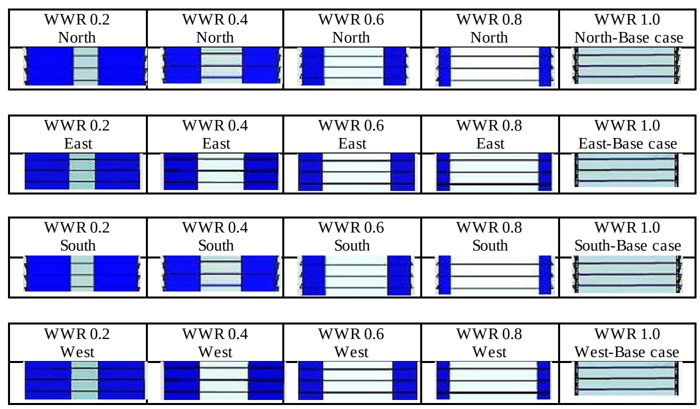

Fig. 3 Proposed WWR at different façade orientation

3.4. Proposed advanced glazing for simulation

Beside the case study building's actual façade construction of double glazing, an advanced glazing configuration was proposed and applied in a duplicated IES (VE) building model. Building thermal simulations were carried out on monthly cooling and building energy consumption (MWh) for the 2 building models with different façade glazing configurations and specifications. Simulation no. 1 was the base case simulation based on actual case study building's double glazing façade with low-e glass. Simulation no. 2 was based on proposed advanced glazing configurations and specifications, as shown in Table 4.

Table 4: Glazing configurations and optical properties for simulations

Glazing Optical Properties	Double Glazing	Triple Glazing
Simulation Number	1 (Base case)	2 (Proposed)
Composition (outside to inside)	4mm low-e + 16mm Argon + 4mm clear	4mm low-e + 16mm Argon + 4mm low-e + 16mm Argon + 4mm clear
Conductivity W/(m.k)	1.0	1.0
Solar Transmittance	0.406	0.406
Solar Reflectance (Outside)	0.301	0.301
Solar Reflectance (Inside)	0.416	0.416
Emissivity (Outside)	0.840	0.840
Emissivity (Inside)	0.094	0.067
Shading Coefficient	0.448	0.289
SHGC	0.390	0.252
U-Value W/m²k	3.35	1.29

4. Results and discussions

4.1. Annual building energy consumption, cooling energy consumption and Building Energy Intensity BEI by different WWR at different orientation

The simulation results on annual building energy consumption for the 20 models are shown in Table 5. The results indicated that the reduction of WWR at West façade caused the most annual energy consumption reduction meanwhile reduction of WWR at North façade caused the least annual energy consumption reduction. For example, by applying the same WWR 0.2, West façade resulted the lowest annual energy consumption of 8,300.55 MWh meanwhile North façade resulted the highest annual energy consumption of 8,425.10 MWh. East façade with WWR 0.2 however resulted annual energy consumption of 8,369.23 MWh and South façade with WWR 0.2 resulted annual energy consumption of 8,423.39 MWh. It is noticed that reduction of WWR at West façade followed by East façade will result more annual energy consumption reduction compared to the South façade and lastly North façade. The results also showed that lower WWR resulted lower annual energy consumption in the increasing sequence from 0.2, 0.4, 0.6, 0.8 to 1.0 regardless of the façade orientation. For annual cooling energy consumption, Table 5 showed that reduction of annual cooling energy consumption by reduction of WWR is more noticeable at West and East façades compared to South and North façades. By applying WWR 0.2, West façade resulted the lowest annual cooling energy consumption of 3,719.9 MWh meanwhile the result is 3,721.0 MWh for East façade. The WWR 0.2 resulted higher annual cooling energy consumption at South façade at 3,753.6 MWh and lastly the highest energy consumption at North façade at 3,755.3 MWh. The results also showed that lower WWR resulted lower annual cooling energy consumption in the increasing sequence from 0.2, 0.4, 0.6, 0.8 to 1.0 regardless of the façade orientation. Analysis on the simulation results indicated that WWR 0.2 at West façade has resulted the lowest BEI at 115.3 kWh/m²/year meanwhile WWR 0.8 at both North and South façades has resulted the same BEI at 121.0 kWh/m²/year. However, Table 5 indicated that the highest BEI at 121.6 kWh/m²/year was recorded with WWR 1.0 at all façade orientations which represent full glazing at all the 4 façades as per the actual case study building construction. BEI was recorded to increase by applying the same WWR at different façades following sequence of West, East, South and lastly North. In regardless of façade orientation, lower WWR has resulted a lower BEI in the increasing sequence from 0.2, 0.4, 0.6, 0.8 to 1.0.

Table 5 Energy consumption and BEI of building models with different WWR and orientation

WWR	Annual Building Energy Consumption, MWh				Annual Cooling Energy Consumption, MWh				Building Energy Intensity BEI, kWh/m²/year			
	N	E	S	W	N	E	S	W	N	E	S	W
0.2	8425.1	8369.2	8423.4	8300.5	3755.3	3721.0	3753.6	3719.9	117.0	116.2	117.0	115.3
0.4	8524.6	8478.1	8492.7	8423.2	3806.9	3788.3	3817.4	3790.5	118.4	117.7	118.0	117.0
0.6	8620.9	8570.2	8613.1	8524.7	3879.2	3857.1	3887.6	3854.5	119.7	119.0	119.6	118.4
0.8	8714.6	8671.2	8711.7	8666.9	3955.4	3926.3	3956.3	3926.8	121.0	120.4	121.0	120.4
1.0	8758.2	8758.2	8758.2	8758.2	3988.2	3988.2	3988.2	3988.2	121.6	121.6	121.6	121.6

N = North, E = East, S = South, W = West.

4.2. Annual cooling energy savings by different WWR at different façade orientation

The simulation results of the 20 building models were analyzed in regards to the annual cooling energy savings by different WWR at different façade orientations. Figure 4 indicated gradual increase in the annual cooling energy savings from WWR 1.0 to 0.8, 0.6, 0.4 and lastly 0.2 at all façade orientations. WWR 1.0 indicated the fully glazed base case building façades. WWR 0.2 at West façade resulted the highest cooling energy savings at 6.73 % meanwhile WWR 0.8 at North façade resulted the lowest cooling energy savings at 0.80 %. For each proposed WWR, higher cooling energy savings were shown at the West and East facades. This is followed by lower cooling energy savings at South façade and the lowest cooling energy savings at North façade.

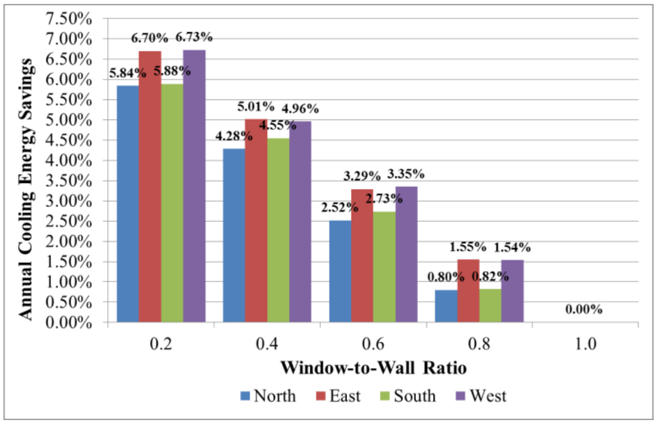

Fig. 4 Annual cooling energy savings by different WWR at different façade orientations

4.3. Cooling energy consumption of models with different glazing configurations

Based on the building characteristics and construction materials described above, 2 different building models were simulated using IES (VE) to predict monthly cooling energy consumption throughout a year. As shown in Figure 5, simulations on the 2 different glazing configurations has resulted different cooling energy consumption. The proposed advanced glazing i.e. triple glazing has resulted lower cooling energy consumption compared to the base case building model, which is with double glazing.

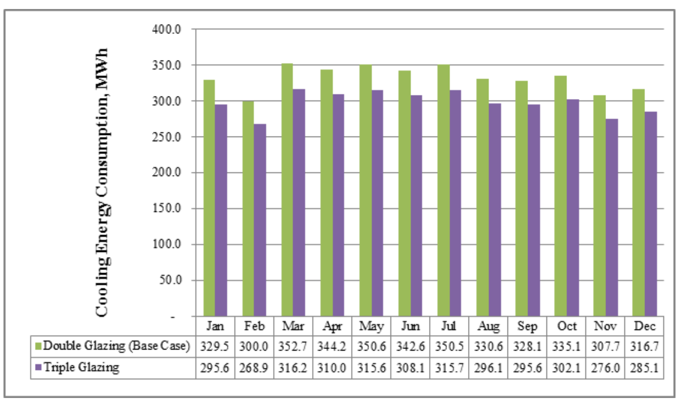

Fig. 5 Monthly cooling energy consumption (MWh) of models with base case and proposed glazing configurations

4.4. Annual cooling energy consumption, annual building energy consumption, BEI and annual cooling energy savings by different glazing configurations

Based on the simulated results of annual cooling energy consumption for the 2 building models as shown in Table 6, double glazing has resulted an annual cooling energy consumption of 3,988.20 MWh. Triple glazing has a lower value of 3,584.80 MWh. The reduction of annual cooling energy consumption also reduced the annual total building energy consumption and the BEI of the building from 121.6 KWh/m²/year for double glazing to 110.7 KWh/m²/year for triple glazing. As shown in the same Table 6, the use of triple glazing has resulted annual cooling energy savings of 403.40 MWh at 10.11% compared to the base case double glazing.

Table 6: Annual energy consumption, BEI and energy savings of building models with different glazing configurations

Proposed Glazing Composition	Annual Cooling Energy Consumption, MWh	Annual Building Energy Consumption, MWh	Building Energy Intensity BEI, KWh/m²/year
Double Glazing (Base Case)	3,988.20	8,758.20	121.6
Triple Glazing	3,584.80	7,971.20	110.7
Energy Savings	403.40 (10.11%)	787.00 (8.99%)	-

4.5. Discussions

Based on the simulated results on annual building and cooling energy consumptions, the case study high-rise office building uses approximately 45.5 % of total building energy for indoor cooling purposes. This was reduced to 44.9 % when triple glazing was used. Both of the figures are lower than the average cooling energy consumption suggested by previous studies i.e. 64 % [15] and 57 % [16]. This is mostly due to the use of low-e coatings for both the double and triple glazing, which minimized solar heat radiation to internal spaces [23]. The use of advanced triple glazing is able to save annual cooling energy by 10.11 % compared to the double glazing of the case study building. From the analysis of cooling energy savings by WWR, the affecting factors are WWR itself and the façade orientations. This was reflected by the difference between the highest energy savings by WWR 0.2 on the West façade at 6.73 %, and the lowest energy savings by WWR 0.8 on the North façade at 0.80 %. In comparison, advanced glazing is able to result almost double amount of cooling energy savings compared to WWR. These findings will form the basis of conclusions and recommendations of this study.

5. Conclusions and recommendations

From the analysis of the IES (VE) simulation results on annual building and cooling energy consumption of the case study building, it can be suggested that high rise office buildings in Malaysia use approximately 45.5 % of total building energy for indoor cooling. This study also concludes that lower WWR will result in higher annual cooling energy savings ranging between 0.80 % to 6.73 %, depending on the WWR and the façade orientations. Advanced triple glazing is able to save annual cooling energy by 10.11 % compared to the case study double glazing. Major conclusions and recommendations can be made as follows:

- It is recommended to prioritize the design of lower WWR at West façade followed by East, South and lastly North façade.
- Reduction of WWR on West façade has highest impact on BEI reduction, followed by East, South and lastly North façade.
- Lower WWR results higher cooling energy savings regardless of orientations.
- Replacing double glazing with advanced triple glazing is able to create almost double amount of cooling energy savings annually compared to WWR strategy.

In responding to the research problem and questions as well as to meet the aim of this study, it is concluded that advanced glazing is able to perform more significant cooling energy savings compared to WWR strategy under the hot-humid climate of Malaysia. Façade designers are recommended to consider carefully the different cooling energy saving implications by the two strategies as recommended by this study for optimized cooling energy savings of high-rise office buildings in Malaysia. This study recommends further economic analysis of various WWR design and different types of advanced gazing with various thermal performances. This will help façade designers to prioritize between financial aspects and thermal performance of façade design and materials for high-rise office buildings in Malaysia.

References

[1] Pérez-Lombard L., Ortiz J. & Pout C. (2008) A review on buildings energy consumption information. Energy and Buildings 40: 394–398.

[2] Sarah Colenbrandera, Andy Gouldsona, Andrew Heshedahl Sudmanta & Effie Papargyropoulou. (2015) The economic case for low-carbon development in rapidly growing developing world cities: A case study of Palembang, Indonesia. Energy Policy 80: 24-35.

[3] Birol F. (2013) Southeast Asia energy outlook. World Energy Outlook Special Report. International Energy Agency.

[4] J. S. Hassan, R. M. Zin, M. Z. Abd Majid, S. Balubaid & M. R. Hainin. (2014) Building energy consumption in Malaysia: An overview. Jurnal Teknologi 70 (7): 33–38.

[5] Energy Commission Malaysia. (2016) Electricity - Final Electricity Consumption. Available at: http://meih.st.gov.my/statistics?p_auth=g5ODWRHT&p_p_id=Eng_Statistic_WAR_STOASPublicPortlet&p_p_lifecycle=1&p_p_state=maximized&p_p_mode=view&p_p_col_id=column-1&p_p_col_pos=1&p_p_col_count=2&_Eng_Statistic_WAR_STOASPublicPortlet_execution=e1s1&_Eng_Statistic_WAR_STOASPublicPortlet__eventId=ViewStatistic3&categoryId=4&flowId=7. (Accessed on 8 May 2016).

[6] Qi Jie Kwong, Nor Mariah Adam & B.B. Sahari. (2014) Thermal comfort assessment and potential for energy efficiency enhancement in modern tropical buildings: A review. Energy and Buildings 68: 547–557.

[7] Ministry of Science, Technology and Innovation (MOSTI). Malaysian Meteorological Department (MetMalaysia): General climate of Malaysia. http://www.met.gov.my/web/metmalaysia/climate/generalinformation/malaysia?p_p_id=56_INSTANCE_zMn7KdXJhAGe&p_p_lifecycle=0&p_p_state=normal&p_p_mode=view&p_p_col_id=column-1&p_p_col_pos=1&p_p_col_count=2&_56_INSTANCE_zMn7KdXJhAGe_page=3 (Last accessed: 8 May2016).

[8] S. Mekhilef, A. Safaria, W.E.S. Mustaffaa, R. Saidurb, R. Omara & M.A.A. Younis. (2012) Solar energy in Malaysia: Current state and prospects. Renewable and Sustainable Energy Reviews 15 (1): 386-396.

[9] Seyedehzahra Mirrahimi, Mohd Farid Mohamed, Lim Chin Haw, Nik Lukman Nik Ibrahim, Wardah Fatimah Mohammad Yusoff & Ardalan Aflaki. (2016) The effect of building envelope on the thermal comfort and energy saving for high-rise buildings in hot–humid climate. Renewable and Sustainable Energy Reviews 53: 1508–1519.

[10] Tin-tai Chown, ChunyingLi & ZhangLin. (2010) Innovative solar windows for cooling-demand climate. Solar energy materials & solar cells 94: 212–220.

[11] Wong Nyuk Hien, Wang Liping, Aida Noplie Chandra, Anupama Rana Pandey & Wei Xiaolin. (2005) Effects of double glazed façade on energy consumption, thermal comfort and condensation for a typical office building in Singapore. Energy and Buildings 37 (6): 563–572.

[12] Chia Sok Ling, Mohd. Hamdan Ahmad & Dilshan Remaz Ossen. (2007) The effect of geometric shape and building orientation on minimising solar insolation on high-rise buildings in hot humid climate. Journal of Construction in Developing Countries, Vol. 12 (1): 27-38.

[13] Taufiq, B. N. M., H. H. Mahlia, T. M. I. Amalina, M. A. Faizul, M. S. Saidur, R. (2007) Exergy analysis of evaporative cooling for reducing energy use in a Malaysian building. Desalination 209 (1–3): 238–243.

[14] Ayca Kirimtata, Basak Kundakci Koyunbabaa, Ioannis Chatzikonstantinoua & Sevil Sariyildiz. (2016) Review of simulation modeling for shading devices in buildings. Renewable and Sustainable Energy Reviews 53: 23–49.

[15] Chan, S.A. (2009) Green Building Index – MS1525 Applying MS1525:2007 Code of practice on energy efficiency and use of renewable energy for non-residential buildings. p. 1–22.

[16] R. Saidur. (2009) Energy consumption, energy savings, and emission analysis in Malaysian office buildings. Energy Policy 37: 4104–4113.

[17] Rizki A. Mangkuto, Mardliyahtur Rohmah & Anindya Dian Asri. (2016) Design optimisation for window size, orientation, and wall reflectance with regard to various daylight metrics and lighting energy demand: A case study of buildings in the tropics. Applied Energy 164: 211–219.

[18] Nurdil Eskin & Hamdi Tu¨rkmen. (2008) Analysis of annual heating and cooling energy requirements for office buildings in different climates in Turkey. Energy and Buildings 40: 763–773.

[19] F. Goia, M. Haase, & M. Perino. (2013) Optimizing the configuration of a façade module for office buildings by means of integrated thermal and lighting simulations in a total energy perspective. Applied Energy (108): 515–527.

[20] Z. Yu, W. L. Zhang, & T. Y. Fang. (2013) Impact of building orientation and window-wall ratio on the office building energy consumption. Applied Mechanics and Materials (409-410): 606–611.

[21] Shakouri MH, Tahmasebia MM & Banihashemib S. (2011) Assessment of the variation impacts of window on energy consumption and carbon footprint. In: proceedings of the international conference on green buildings and sustainable cities: 1-7.

[22] Singh MC & Garg SN. (2009) Energy rating of different glazing for Indian climates. Energy 34 (11): 1986-92.

[23] Robinson PD & Hutchins M. G. (1994) Advanced glazing technology for low energy buildings in the UK. Renewable Energy 5 (1–4): 298-309.

[24] M. Bodart & A. de Herde. (2002) Global energy savings in offices buildings by the use of daylighting. Energy and Buildings 34 (5): 421–429.

[25] Neveen Hamza. (2008) Double versus single skin façades in hot arid areas. Energy and Buildings 40 (3): 240-248.

[26] Qiaoxia Yang, Meng Liu, Chang Shu, Daniel Mmereki, Md. Uzzal Hossain & Xiang Zhan. (2015) Impact analysis of Window-Wall Ratio on heating and cooling energy consumption of residential buildings in hot summer and winter zone in China. Journal of Engineering (2015): Article ID 538254, 17 pages.

[27] Drury B. Crawley, Jon W. Hand, Michael Kummert & Brent. T. Griffith. (2005) Contrasting the capabilities of building energy performance simulation programs. Ninth International IBPSA Conference, Montréal, Canada, page 231-238.

[28] Chinnayeluka S. R. (2011) Performance Assessment of Innovative Framing Systems through Building Information Modeling Based Energy Simulation, Master Thesis, Osmania University.

Commonwealth Energy and Sustainable Development Network (CESD-Net)

CESD-Net is a major global initiative in energy and sustainable development. The objective of network is to promote energy and sustainable development in commonwealth countries.

Focussing on Multidisciplinary Research, Promoting Future Low Carbon Innovations, Transferring Knowledge and Stimulating Networking among Stakeholders to Ensure the UK Achieves World Leading Status in Energy and Sustainable Development. https://www.weentech.co.uk/cesd-net/

The 1st International Conference on Energy, Environment and Economics (ICEEE 2016) was held at Heriot-Watt University, Edinburgh, EH14 4AS, UK, 16-18 August 2016. ICEEE2016 focused on energy, environment and economics of energy systems and their applications. More than fifty eight delegates from 31 countries with diverse expertise ranging from energy economics, solar thermal, water engineering, automotive, energy, economics and policy, sustainable development, bio fuels, Nano technologies, climate change, life cycle analysis etc. made conference true to its name and completely international. During conference total 51 oral presentations and six posters were shared between delegates. The presentations showed the depth and breadth of research across different research areas ranging from diverse background. ICEEE2016 aimed:

- To identify and share experiences, challenges and technical expertise on how to tackle growing energy use and greenhouse gas emissions and how to promote sustainability and economical, cost effective energy efficiency measures.

In total 11 technical sessions and two invited talks both from academia and industry provided insight into the recent development on the proposed theme of the conference. Preparation, organisation and delivery of the conference started from July 2015 and further co-ordinated by vibrant team of Conference Centre, Heriot Watt University. Conference organisers would like to acknowledge support from the sponsors particularly World Scientific Publication ltd and its team members for the delivery of the conference. Organisers are also thankful to all reviewers who contributed during peer review process and their contributions are well appreciated. At the end and during vote of thanks following awards have been announced and we would like to congratulate all well deserving delegates.

- Best Paper –Academia: Amela Ajanovic, EEG, TU Vienna, Austria
- Best Paper – Student : Christian Jenne,University of Duisburg-Essen, Germany
- Best Poster – Student: Yoann Guinard, University of New South Wales, Sydney, Australia
- Best Poster – Academia: E. Salleh, Universiti Kebangsaan Malaysia, Malaysia
- Active Participation Award - Yoann Guinard, University of New South Wales, Sydney, Australia

At the end we would like to extend our gratitude to all of you for your participation and hopefully welcome you again during ICEEE2017.

Editors:

Dr. Singh is Senior Scientist at Indian Agricultural Research Institute, New Delhi, India. Her area of expertise are bio energy and bio fuels, environmental engineering, carbon accounting and renewable energy integration for rural development.

Dr. Kumar is visiting faculty at Prince of Songkla University, Thailand. He have 16 years of research and teaching experience in the field of solar energy, drying and energy efficiency.

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