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Research paper

Preliminary Study on Energy Consumption at UiTMCPP library using IES<VE> simulation

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Abstract

The Universiti Teknologi MARA Cawangan Pulau Pinang (UiTMCPP) library building was consists of three-story including office, reading area, multi-media room, and meeting room. Based on the library record where the average number of students coming to the library is 257 students per day. In other words for an hour, only 17 students have come to the library. The occupant's claimed that they feel uncomfortable because of the cold temperature in the building. Currently, the air conditioner's setting temperature of the building is 17ºC and does not follow the requirement in the Malaysia Standard, MS1525. Therefore, the aim of this case study is to investigate the thermostat temperature in order to control the energy consumption and cost of saving in the library building. In this work, the set point was changed from 17ºC to 20ºC. This adjustment was referring to the MS1525. The IES<VE> software is used as the energy simulation tool to calculate and compare electricity cost and energy consumption. The finding from the simulation shows the annual energy consumption at 17°C and 20°C are 6.14Gwh per year and 5.03Gwh per year, respectively. Thus, the energy saving was increased by 1.11Gwh per year and cost of electricity was save by RM402 thousands per annum. Finally, it can be shown that the raising of the set point can minimize the energy consumption and electricity cost with 18% reduction per year.

Keywords: *energy consumption, energy saving, library, simulation*

1. Introduction

Energy consumption in Malaysia is about the 53% of electricity energy is used in the industrial, residential and commercial factor, and the rest is transportation sector (Shaikh et al., 2017). Heating, Ventilation and Air Conditioning, or HVAC system is widely used in the industrial and commercial building. Due to the whole of Malaysia has a classic equatorial climate, with high temperatures and wet months throughout the year. The temperature in Malaysia is about 21°C to 32°C, and the annual rainfall varies from 2,000mm to 2,500mm. Mostly, the buildings in Malaysia have used air conditioning such as the split-system unit or central HVAC system. The large building like as government building, commercial building, educational building and others are used the central HVAC system. The energy consumption in central HVAC system is higher than the split-system unit. Most of the researchers are focusing on the building energy consumption in central HVAC system (Ke et al., 2013; Kaya & Alidrisi, 2016; Bhaskoro et al., 2013). The central HVAC system or central chiller plants are widely used in commercial buildings, among them chiller plant accounts for 10%–20% of the overall facilities usage (Taylor & Steven, 2012). Chiller is one of the major components in chiller plants and it's consumed about 40% of the energy consumption of the air conditioning system (Vakiloroaya et al., 2013).

As mentioned earlier, the buildings are among the largest consumers of energy. Part of the energy is wasted due to the habits of users and equipment conditions (Roslizar et al., 2014). Among the biggest energy consumers in a building are HVAC systems, lighting systems, elevators, pumps and other equipment. The HVAC systems, which play an important role to ensuring the occupant comfort, are among the largest energy consumers in buildings (Vakiloroaya et al., 2014). On average, most of the office buildings in Malaysia uses 57% of its energy on HVAC systems, followed by lighting at 19%, lifts and pumps at 18% and other equipment at 6% (Saidur, 2009).

Currently, the sustainability and energy conservation have become increasingly important topics in research area because 50% of energy consumed by buildings is wasted, and the total energy consumption by the building sector is projected to increase by 15.7% between 2013 and 2035 (Yang et al., 2016). According to

the previous researcher, the resetting thermostat is one of energy saving method. The thermostat can adjustable as long as the building is still in the thermal comfort. In other words, this method can minimize the wastage of energy consumption. Yamtraipat et al. (2006) reported that the case study in the office building in Thailand has the set-point from 20ºC to 26ºC and the energy saving was increased by 69.09GWh/year. The reduction of energy consumption is 24% and this method can help to save energy in Thailand. Besides that, it also helps to control the use of electricity in the air conditioning while making 80% of occupants comfortable. According to Kwong et al. (2013), the return air temperature in many of the Malaysian buildings was within the range of 18°C–24°C during office hours. However, refers to the MS1252 which is recommended for buildings in Malaysia are around 23ºC -26ºC. Therefore, the Kwong et al. (2013) stated that the raising the set point temperature by only 2^0C can savings of 2,150 GWh per year and an annual savings of RM 730 million.

Researches about of energy saving have been done in many countries with different of buildings which are commercial sector or residential building. But, no study has identified of energy saving in the library building in higher education. Therefore, the purpose of this study is to analyze the potential energy consumption and cost saving by using zero investment method. The zero investment method is a preliminary audit, which will indicate whether a more detailed energy audit is required. An energy audit is a method that can be used to identify and quantify how energy is being used in a plant (Saidur et al., 2009). The proposed method was related to the thermal comfort of occupants in the library building. In this case study, the MS1525 was to refer as a guideline for human thermal comfort. In this research, this method was effective in order to help the management to increase the energy savings. Thus, the management can be focused on to enhance the education process.

2. II. METHOD

UiTMCPP is located in the state of Penang, Malaysia. The campus was established in June 1996 in Permatang Pauh, Seberang Prai. This campus consists of main building, administrative building, laboratory and workshop building, public hall, residential college, and library. In this case study, the new and standalone library building is selected. The name of this library is Perpustakaan Tun Abdul Razak. Figure 1 shows the front view of the library building.

Fig.1: Front view of library building

This study used proposed energy simulation IES<VE> to identify the electricity consumption and costs. The library was operated in May 2011 and its new building on campus. The building has three stories and consists of offices area, multi-media room, meeting room, reading area and other functional areas. The total construction area of the library is 5,707.02 square meters, the total volume of the building model is 25,681.60 cubic meters and the ceiling height of each level is 4.5 meters. Figure 2 shows the library building in the 3D model constructed and created by IES<VE> software (Norasikin et al., 2017). The South and East which is front and right part of the building are mostly glasses and windows. Referring to Figure 1, the front side of the building consists of the main entrance, 24 hours study room on the right, and a locker room on the left for the students to leave their unnecessary stuff before entering the library. This building was consists of the walkway at the East side of the building. The green constructions are the addition made that act as shades to cover the East side of the building from sunlight. The position of the Sun changes according to the time of the day.

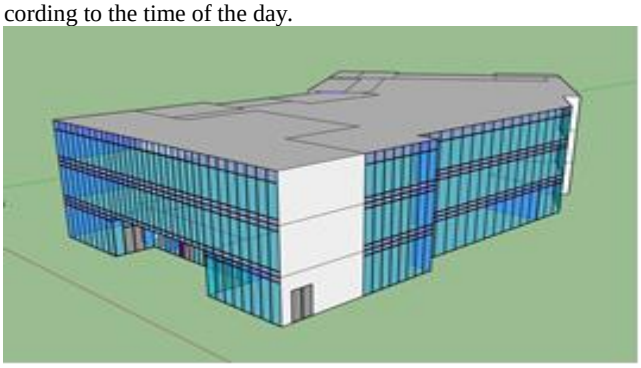

Fig.2: Building model construction in IES<VE> software

In order to run simulation smoothly, the parameters are related to this building were input in IES<VE>. It consists of the library working hours, the internal heat gains such as the number of computers, type of lightings, number of occupants, type of HVAC systems, type of ventilation, and the set point temperature.The chillers are powered on Monday to Friday from 7:30 AM until 10:30 PM and Saturday from 7:30 AM until 5:00 PM, and is powered off on Sunday and public holiday. Temperature control is set at 17°C.

IES <VE> software as known as Integrated Environmental Solutions (Virtual Environment) is widely used in 3D performance analysis software to design tens of thousands of energy efficient buildings across the globe. The technology is supported by integrated consulting services and its competencies are expanding from use on individual buildings to helping create sustainable cities (D.B. Crawley et al., 2008). The IES <VE> is an combined suite of applications connected by a common user interface and a single integrated data model (D.B. Crawley et al., 2008). The <Virtual Environment> modules include:

1. ModelIT – geometry creation and editing
2. ApacheCalc – loads analysis
3. ApacheSIM – thermal
4. MacroFlo – natural ventilation
5. ApacheHVAC – component-based HVAC
6. SunCast – shading visualization and analysis
7. MicroFlo – 3D computational fluid dynamics
8. FlucsPro/Radiance – lighting design
9. DEFT – model optimization
10. LifeCycle – life-cycle energy and cost analysis
11. Simulex – building evacuation

The software offers an environment for the detailed evaluation of building and system designs, allowing them to be optimized with respect to comfort criteria and energy use (D.B. Crawley et al., 2008). The simulation of this case study has done by using Apache Modules for thermal calculation and simulation in terms of setting temperature between 17°C and 20°C has been done. Currently, the library building was setting temperature is 17°C and the indoor temperature is 20°C.

3. III. RESULT AND DISCUSSION

The building simulation model was developed by using IES<VE> software. In order to evaluate and compare the energy consumption in the library by simulation, the monthly usage of the temperature 17°C and 20°C were obtained based on the number of occu-

pants. In this study, location, HVAC operation schedule, numbers of occupants are variables and other characteristics of the library remained as the software's default options. Table 1 shows the number of students coming to the library from 2014 until 2016 (Norasikin et al., 2017). In November and December 2016, the number of students cannot be recorded because of technical problems of student card scanners in main entrance of the library

Table 1: Number of students coming to the library

Month / Year	2014	2015	2016
January	4999	5918	1264
February	4359	4454	4056
March	5011	4684	4800
April	4863	5407	5054
May	2295	2454	3539
June	13549	14781	13500
July	8480	6019	8670
August	5524	7677	7857
September	11241	7688	8995
October	5380	6851	7098
November	3835	2824	N/A
December	7595	2684	N/A
Total	77131	71441	64833

Mostly, more than 12,000 of students come to the library on a June and October every year since 2014, 2015 and 2016. This is because of that months, the undergraduate students were meet and merged with the diploma students. As usual, the diplomas students have come to the library for completed their assignment, preparation and do the revision for final test and final examination in June, while the undergraduate students have started with the new semester in June. Furthermore, this combination was increased the number of students to come in the library. Annually, more than 70,000 students are coming to the library for the specific activities.
Referring to Figure.3, the average student who comes to the library for monthly is 6,500 students equalling with the 257 students per day. The library building and air conditioning system was operated for 15 hours a day and the number of students is 18 people an hour. The situation is not good for the energy consumption in the library because of the lack of students but the air conditioner is operating.

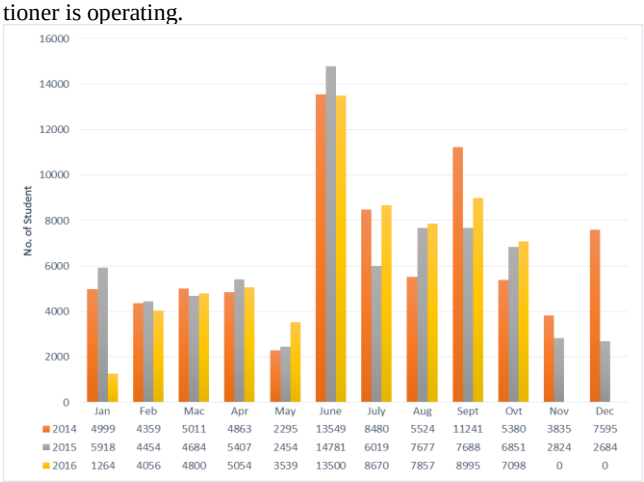

Fig.3: Number of students visited the library from 2014 to 2016

The walk-through assessment is one of the methods in order to investigate the condition of indoor environment in the library. Based on the assessment, most of them come because their want to borrow the reference books and academic references related to the field they studied. They are cannot seating in the library for study and reading purpose because there are feeling not comfortable because of the indoor environment was very cold. The early finding from assessment shows that the thermostat temperature is set 17°C and indoor air temperature is 19°C. Based on that, the air temperature does not meet the requirement of MS1525 and ASHRAE Standard 55. In addition, the set of questionnaire also distributed to the 300 respondents to find out the reason why they are not interested to come to the library. One of the questions asked about the condition of indoor temperature in library affect to their activities. The finding shows that 60% of respondents are claimed that they feel uncomfortable because of the cold temperature in the building (Fig.4).

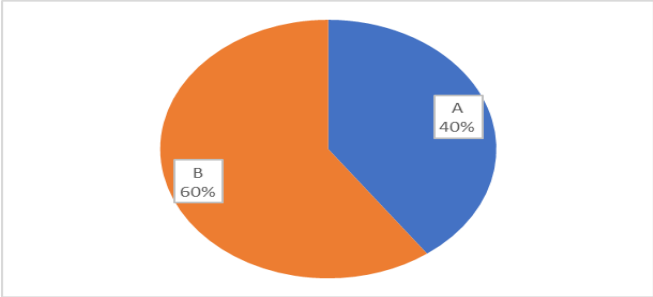

Fig.4: Effect of temperature on study in PTAR

Based on the questionnaire analysis, the temperature in library is cold and affected their activities. The low temperature makes the occupants uncomfortable to do their activities. Low temperature means that the air-conditioning system delivered more cooling load than needed. This is considered as a waste and can be managed properly. Mostly the 63% of respondents are agreed in order to change the current of setting temperature. This recommendation is selected to change the cold indoor environment to be the comfortable environment and more practical according to the MS1525 requirement. In order to meet the MS1525 requirement, the adjustment of setting temperature was changed from 17°C to 20°C. Therefore, the indoor temperature is 22°C.
Based on the setting parameters in this case study, Table 2 shows the simulation results of electricity consumption when the thermostat was set 17°C and 20°C. For the thermostat 17°C, the annual energy consumption is 6,135,173 kWh, while at 20°C was 5,033,191kWh. It shows at 17°C, the largest power consumption is up to 546,183kWh in May. However, the minimum power consumption is the only 450,199kWh in February which is only 82.4 % of power consumption in May. The Figure.5, shows the pattern of energy consumption for each temperature and the energy consumption of each month at 17°C was in the range 400,000 kWh to 600,000kWh.

Table 2: Electricity consumption by IES <VE>

Month	Electricity consumption (kWh)	
	Thermostat 17ºC	Thermostat 20ºC
January	508,882	413,478
February	450,199	365,654
March	531,127	440,497
April	520,097	428,098
May	546,183	451,757
June	509,391	421,138
July	542,752	447,070
August	508,789	418,152
September	502,055	409,922
October	530,912	435,287
November	477,524	390,776
December	507,262	411,362

Meanwhile, the simulation result to 20°C, which is the largest power consumption, is up 451,757kWh in May. However, the minimum energy consumption was 365,654kWh in February which is 80.9% of power consumption in May. Figure.6, shows

the energy consumption per month at 17°C is within 300,000 kWh to 500,000kWh. The adjustable of set-point will reduce the energy consumption of approximately 100,000kWh per month.

The difference in energy consumption of each month when the thermostat is reset from 17°C to 20°C is shown in Figure.5. The resetting of the thermostat can minimize the energy consumption in within of 84,000kWh to 96,000kWh. It's mean, the average of energy consumption was reduced in 91,831.83kWh per month.

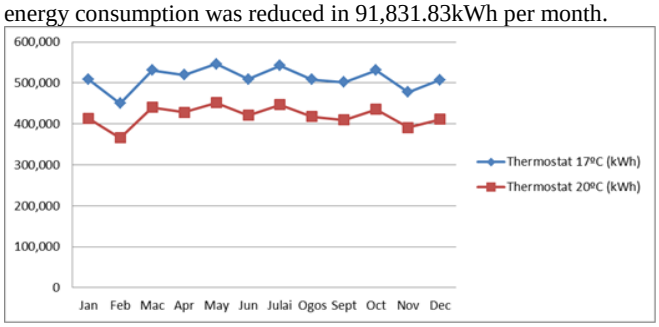

Fig.5: Pattern of energy consumption

The annual cost for electricity was calculated by using IES<VE> software. The latest tariff and price provided by Tenaga Nasional Berhad which is MYR 0.365 per kWh was set in the software, and the annual cost of electricity was generated. Table 3 shows the annual electricity cost calculated by IES VE software. For the thermostat 17^0C, the annual energy consumption is 6,135,173 kWh and equivalence with the cost usage of electricity per year is MYR 2,239,337.69.

Table 3: Cost of usage

Month	Electricity consumption (MYR)	
	Thermostat 17ºC	Thermostat 20ºC
January	185,741.93	150,919.47
February	164,322.64	133,463.71
March	193,861.36	160,781.41
April	189,835.41	156,255.77
May	199,356.80	164,891.31
June	185,927.72	153,715.37
July	198,104.48	163,180.55
August	185,707.99	152,625.48
September	183,250.08	149,621.53
October	193,782.88	158,879.76
November	174,296.26	142,633.24
December	185,150.63	150,147.13

The incremental of set-point was 3°C which is 17°C to 20°C is about 18% of reduction of energy saving and electricity consumption per annum (Fig.6). This can be translated that currently the UiTMCPP was spent about MYR2 million per annum for the electricity usage in the library building. The usage rate is very high and is not worth because of the library building is not always occupied but the chiller still operates 15 hours per day. In order to overcome this problem, the thermostat was changed to 20°C, without affecting to the human comfort. As a result, the UiTMCPP will spend below than MYR2 million per annum. Consequently, the UiTMCPP will be able to save RM 400 thousand a year.

Different the set-point in the library building were investigated and simulated by using the IES<VE> software. The set-point was referring to the MS1525 for the human comfort. In this study, the simulation result shows that the energy consumption and usage rate can be minimized with 18% when the set-point was changed from 17°C to 20°C. However, one limitation of this study was that the author only used the number of occupants as the control variable and the others parameter as the default option. Further studies need to be conducted in order to examine the parameters that influence the energy consumption and energy saving in the library building process.

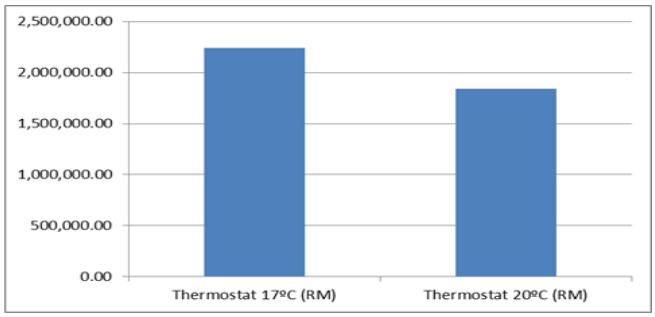

Fig.6: Energy saving potential for 17°C and 20°C

4. Conclusion

Different the set-point in the library building were investigated and simulated by using the IES<VE> software. The set-point was referring to the MS1525 for the human comfort. In this study, the simulation result shows that the energy consumption and usage rate can be minimized with 18% when the set-point was changed from 17°C to 20°C. However, one limitation of this study was that the author only used the number of occupants as the control variable and the others parameter as the default option. Further studies need to be conducted in order to examine the parameters that influence the energy consumption and energy saving in the library building.

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