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ENERGY ANALYSIS FOR LIGHTING AND AIR-CONDITIONING SYSTEM OF AN ACADEMIC BUILDING

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Graphical abstract

Abstract

Energy analysis is important to analyze energy consumption pattern, monitoring on how the energy used varies with time in the building and how the system element interrelate. In this case study, a preliminary energy audit is done on lighting and air-conditioning system. The lighting and airconditioning system consume the highest amount from the total building energy usage. The study was conducted in the Faculty of Mechanical Engineering Building, Universiti Teknikal Malaysia (UTeM) Technology Campus. From the result shows that the air-conditioning system has contributed approximately 48.8% from the total monthly energy usage. The estimation of Building Energy Index (BEI) for the cooling load is 655.19 kWh/m²/year. Meanwhile, the BEI for lighting system is found approximately 150 kWh/m²/year.

Keywords: Energy, lighting, air-conditioning system

1.0 INTRODUCTION

Energy analysis is one of the common methods in measuring and obtaining information regarding actual energy consumption in site or the buildings by purposes to reduce and minimize energy usage in order to improve energy performance. Based on Ahmadzadehtalatapeh [1], buildings consume about 40% of the total energy consumption and most of the energy is used for the purpose of heating, ventilation and air conditioning (HVAC) system. This is followed by lighting load which consumes about 20% of the total building load as indicated by Krarti [2]. With the increasing awareness about energy conservation and optimization usage, there are high demands for efficient ways of building which also assist in reducing cost and carbon emission. For UTeM case, there are several researches have been conducted in the university academic buildings regarding energy consumption from lighting and air-conditioning system such as Tee et. al [3], Rosli [4], Ismail [5], and Hywel et. al [6]. The authors are therefore interested to further conduct a building energy audit and analysis focusing on the those systems at the Mechanical Engineering Faculty's building located in UTeM's Technology Campus

2.0 METHODOLOGY

The building that is chosen for this study is eight-storey academic building of Mechanical Engineering Faculty (FKM) situated in UTeM's Technology Campus, Ayer Keroh, Melaka as shown in Figure 1. This building accommodates the faculty office, lecturers' office rooms, library, student affairs office and lecture rooms. The building is furnished with central air-conditioning system for all levels. The building floor area is about 3120 m² and is equipped with almost 80% of glazed facades.

The interior walls of the building are made from poured concrete and lightweight plaster. Meanwhile for the interior partition wall of the building, a lightweight plaster board is used. Standard glazing is equipped on the building façade which is constructed from polycarbonate and thermoplastic. This study covered for the whole building floors except on the seventh floor as it was still under renovation during the observation period. The methodology of this work is summarized as shown in the Figure 2 below.

Figure 1 The case study building

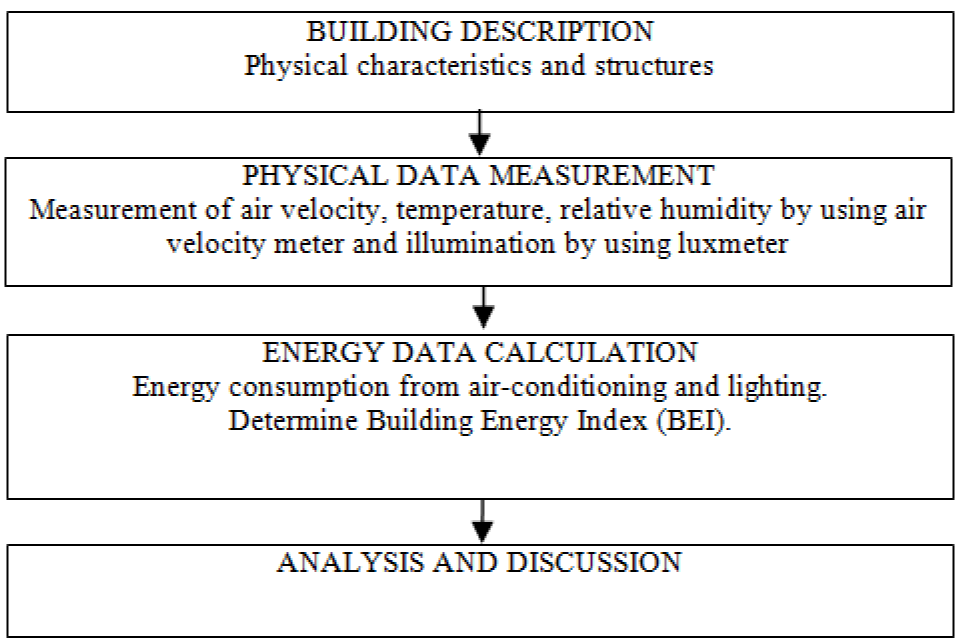

Figure 2 Overall project methodology

3.0 RESULTS AND ANALYSIS

The analysis of the overall monthly energy used pattern is based on the electricity consumption as shown in Figure 3. Based on the figure, the energy consumption was at peak from October 2013 until January 2014 and April until July 2014. This period was during academic terms time. As shown in the figure, the lowest consumption occurred from July until September 2013 which was the university long break period. During this period, the air conditioning system was shut down in certain levels as no academic activities were conducted in the lecture rooms. Based on the observation, the indoor air set point temperature in FKM's building is lower than recommended by MS 1525:2014. The average temperature was set at each level is 22° C which is lower around 2° C as recommended. This condition would give an extra load on the chiller for operating up to 7% from normal [7], hence the chiller would consume more energy along with an increment of electricity bill.

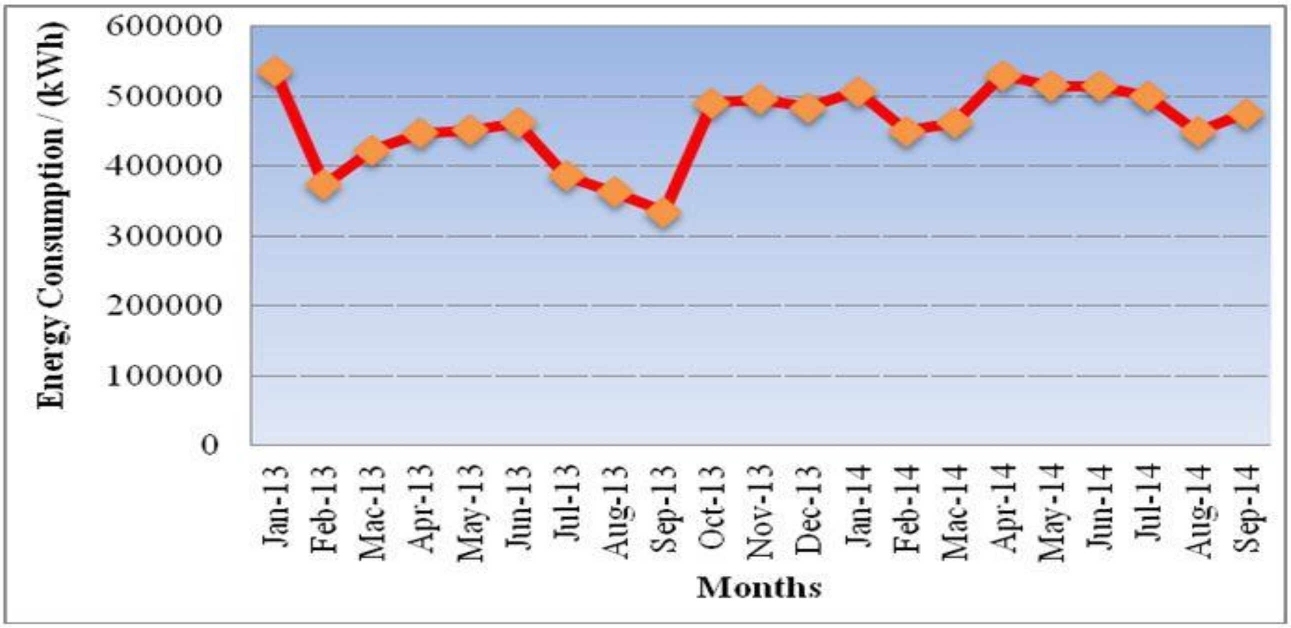

Figure 3 Monthly energy used pattern of the case study building from January 2013 to September 2014

Table 1 tabulates an average of the physical parameter measurement for each floor. Referring to the results, most of the operating temperature and air velocity at each floor are not in the recommended standard range of MS1525:2014. Meanwhile, for the relative humidity, all of the values are within the MS1525:2014 standard except at the Ground Floor and First Floor.

Table 1 Average of the physical parameters measured for all floors

Location	Average Air Velocity (m/s)	Average Operating Temperature (°C)	Average Relative Humidity (%)
Ground Floor	0.075	22.9	72.3
First Floor	0.09	23.1	71.1
Second Floor	0.05	22.7	65.3
Third Floor	0.082	22.2	66.9
Fourth Floor	0.074	22.6	68.2
Fifth Floor	0.074	23.3	67.5
Sixth Floor	0.07	23	67

The Building Energy Index (BEI) based on the cooling load for air-conditioning system is estimated at 655.19 kWh/m²/year. Compare to the MS1525:2014 standard, the value is higher than the recommended BEI. The reason for having higher BEI is due to the building construction. As mentioned before, the case study building was equipped with about 80% of standard glazing facades which is a clear glass type. Generally, this type of glazing has high solar heat gain coefficient (SHGC) characteristic which allows more of the solar energy entering into the building. Therefore, glazing material with low SHGC value is needed in order to reduce solar heat radiation transmitted into the building [7].

Figure 4 shows the energy consumption from the lighting portion of the building. As most of the lecturers' office rooms located in the second, third, fifth and sixth floor, the operational hours were varied and did contribute to the higher energy consumption compare to other floors. The calculations showed that the BEI from the lighting system is 150 kWh/m2/year.

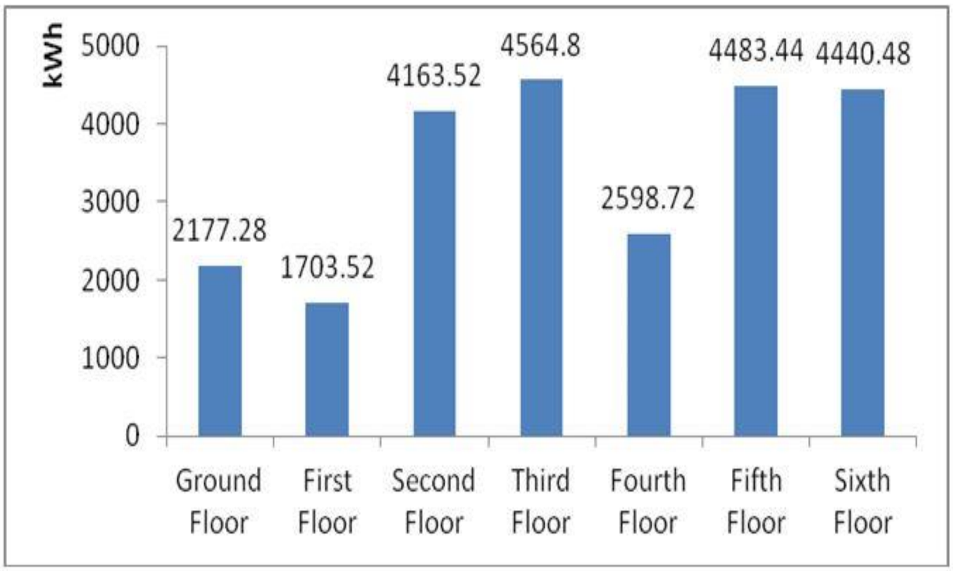

Figure 4 Energy consumption estimation for each floor

4.0 CONCLUSION

Referring to the physical parameter measurement, most of the floors in the building do not achieve the acceptable air velocity recommended by MS 1525:2014 and this is also similar with the operating temperature. Energy analysis of the building indicates that the air-conditioning system was contributed about 48.8% to the total monthly energy usage. From lighting system analysis, the energy consumption is about 24131.76 kWh and costing RM 8928.75 per month.

Overall, the results from this work indicate that there is a need of retrofit plan from the building management in order to optimize the current usage while reducing the current consumption. Recommended retrofit plan include improving the existing of air-conditioning system with variable frequency drive, 7-day programmable thermostat and using energy efficient lighting and sensors.

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