Potential Energy Saving by ACMV Temperature Setting in University Building

Nurzhatul Aziemah Abdul Omar, Noramin Apandi, Asma’i Fayyadh Abd Samad, Nurfatihah Rahim, Ali Abdul Qader Mustafa, Saba Arif, Zamri Noranai

Faculty of Mechanical and Manufacturing Engineering, Universiti Tun Hussein Onn Malaysia, 86400 Parit Raja, Batu Pahat, Johor, Malaysia

E-mail: aziemah.nz@gmail.com

Abstract. Lecturer office building is a particular important building in Universiti Tun Hussein Onn Malaysia. Lecturers will spend their time mostly in office if no learning and teaching process in classroom. This study aims to discover potential energy saving by air conditioner temperature control setting of lecturers building at Block C15, C16 and C17 respectively. Several steps have been done to achieve the objective. A study on type of ACMV, building identification, location, the usage trend, air-conditioner quantity, and the published electrical tariff by TNB were done to familiarize with the building of study. Result was found that about 62% of electrical energy was used on Air Conditioning and Mechanical Ventilation System (ACMV). This is the most energy consumption used in lecturers building. From calculation, the monthly electrical energy consumption of lecturer buildings was near to 56.963MWh. With the proposed potential saving measures, which is air condition temperature setting, lecturers building is estimated to reduce the usage of electrical energy for about 10 to 30% per month. More potential saving could be found in future study if there is designated system that studies the energy consumption trend of the building.

1. Introduction

We are living in an increasingly shrinking world. Instant communication and the internet have seemingly dissolved time, space and cultural boundaries. The international movement of peoples has reached levels previously unheard of. Globalization has become catchphrase for our times. The atmospheric sciences have partly led and partly responded to this process. The extent of continental, hemispheric – and even global – transport of air pollution has become an issue of increasing scientific and policy concern; and nothing emphasises the fragile unity of the planet more graphically than the increasing evidence of climate change – and the portentous implications that emerge as we contemplate the possible consequences of the interaction of air pollution and climate change. Currently, buildings consume about one-third of the world’s energy and the worldwide energy consumption for buildings is expected to grow from 45% from 2002 to 2025. [1-4]. The energy consumed in Malaysia is 90% in the form of electricity. If this trend continues, buildings will consume almost as much as industry and transport combined. By year 2030, 56% of the world’s energy use will be from Asia. Electricity demand will grow by at least 40% by 2032. New power generation equals to nearly 300 power plants (1,000 MW) will be needed to meet electricity demand by 2030. Currently, 50% of electrical generation relies on coal and fossil fuel while 85% of greenhouse gas emissions
result from energy-consuming activities supported by fossil fuels. The purpose of carrying this study is to analyze the energy consumption of Block C15, C16 and C17 per month and discover its saving potential. Solutions and recommendation are discussed in the paper, supported with measurement of approximate saving cost per month in the mosque. Energy audit is a process of reducing amount of energy input without negatively affecting the output.[8,9].

1.1. Energy Resources and Consumption
Energy is the main source to all activities. Today, demand for electrical energy had an increasing rate each day. As energy cannot be created nor destroyed, electrical energy requires energy sources to be generated, In order to understand the energy management; a study on energy resources is a must for estimating the energy consumption and proposes ways of energy saving solution.[15] The generation of electricity is using both renewable and non-renewable energy. However, the trend of world energy consumption indicates that 82% is from non-renewable energy, while the remaining 18% is from renewable energy.[16,17] Currently, there are 10 main sources of energy being used to generate electricity worldwide. The sources include solar energy, wind energy, hydrogen energy, tidal energy, wave energy, hydroelectric energy, biomass energy, nuclear power, and fossil fuels. In Malaysia, almost 80% of electricity was generated by natural gas and coal. Fossil fuel such as natural gas and coal are categorized as non-renewable energy, which cannot be replenished. Continuous usage of fossil fuel without control will finish up the resources in no time.

1.2. Building
University Tun Hussein Onn Malaysia (UTHM) is located in, Parit Raja, which is one of a town of Batu Pahat district. With the coordinates of 1.8553° N, 103.0811° E, it is approximately 4.8 kilometers or six minutes drives from Parit Raja town. There are many buildings in UTHM area such as administers building, faculties block, academics building, Masjid Sultan Ibrahim, Sultan Ibrahim Hall, residential college and lecturers building. Block C15, C16 and C17 is located near to Tun Syed Nasir Residential College and academics building. The blocks are two stories building. The total floor area of the building is 2172 m² and total number 126 rooms to cater up to 210 lecturers. Office hour for academician staff starts at 8.00 am and it ends at 5.00 pm, total sum of 8 working hours, though academic staff is not always working in their room the whole time.

1.3. Air Conditioner Temperature Setting
Air condition temperature setting point is one of the factors that contribute to total cooling load and electric energy. The lower temperature setting cause higher cooling load and higher temperature setting cause lower cooling load. Therefore, it was suggested to set the air condition temperature at higher level within the recommended range. According to the MS 1525:2014 standards, there is a standard for indoor design condition for office building as listed below.

The indoor design conditions of an air-conditioned space for comfort cooling should be as follows;

- Recommended dry bulb temperature 24 – 26 °C
- Minimum dry bulb temperature 23 °C
- Recommended design relative humidity 50 % – 70 %
- Recommended air movement 0.15m/s – 0.50m/s
- Maximum air movement 0.70m/s
2. Methodology
The flow chart of this study is divided into 3 phases, namely Phase 1, Phase 2, and Phase 3 respectively. During phase 1, literature review has been done on several sources in order to grasp a clear conception of this study. A study on building identification, location, the usage trend, air-conditioner quantity, and the published electrical tariff by TNB were done to familiarize with the building of study. Next, Phase 2 is where data being collected and the calculation of estimated energy consumption of Block C15, C16 and C17 were done. Meanwhile in Phase 3, the analysis on potential energy saving method has been discussed, followed by the process of thesis writing. During data collection of building, the building has been studied thoroughly, so that the researcher grasps a clear understanding on the type of the building, its characteristics, and the user trend. During data collection of electrical equipment facilities, quantity of lighting and ACMV device were recorded according to their types, together with their rated power consumptions. Next, the calculation of the estimated energy consumption of lecturers building was done and the energy cost was obtained. Solution and recommendation based on the potential saving is listed afterwards, supported with simple measurement of potential saving. Some general solution includes replacement of device and increase users’ awareness towards electricity usage.

3. Results and discussion
After the data collection phase, the data is presented in the table form for ease of reading and calculation. Table 1 shows the breakdown of estimated energy consumption for office building, while Figure 1 shows the table of energy consumption according to temperature setting.

| Table 1: Breakdown of estimated energy consumption for office building. |
|-------------------------------------------------|
| Equipment | Energy Usage (kwh) | Monthly Cost (RM) | Percent (%) |
|-----------|-------------------|-------------------|-------------|
| Air Conditioning | 42,444.00 | 12,223.87 | 74.5% |
| Lighting | 10,487.81 | 3,020.49 | 18.4% |
| Office Equipment | 4,032.00 | 1,161.22 | 7.1% |
| Total | 56,963.81 | 16,405.58 | 100.00% |

Table 1 shows the breakdown of the estimated electric consumption according to air condition, lighting and other equipment. Electric consumption for air conditioning was the highest (74.5%), followed by electric for lighting (18.4%) and other office equipment is the lower percent (7.1%).

| Room | Temp set | 8:00 AM | 9:00 AM | 10:00 AM | 11:00 AM | 12:00 PM | 1:00 PM | 2:00 PM | 3:00 PM | 4:00 PM | 5:00 PM |
|------|----------|---------|---------|---------|---------|---------|---------|---------|---------|---------|---------|
| 70°F | 46,448.49 | 47,608.47 | 48,868.45 | 48,868.45 | 48,868.45 | 48,868.45 | 48,868.45 | 48,868.45 | 48,868.45 | 48,868.45 | 48,868.45 |
| 71°F | 47,108.49 | 48,268.47 | 49,428.45 | 49,428.45 | 49,428.45 | 49,428.45 | 49,428.45 | 49,428.45 | 49,428.45 | 49,428.45 | 49,428.45 |
| 72°F | 47,768.49 | 48,928.47 | 49,988.45 | 49,988.45 | 49,988.45 | 49,988.45 | 49,988.45 | 49,988.45 | 49,988.45 | 49,988.45 | 49,988.45 |
| 73°F | 48,428.49 | 49,588.47 | 50,648.45 | 50,648.45 | 50,648.45 | 50,648.45 | 50,648.45 | 50,648.45 | 50,648.45 | 50,648.45 | 50,648.45 |
| 74°F | 49,088.49 | 50,248.47 | 51,308.45 | 51,308.45 | 51,308.45 | 51,308.45 | 51,308.45 | 51,308.45 | 51,308.45 | 51,308.45 | 51,308.45 |
| 75°F | 49,748.49 | 50,908.47 | 51,968.45 | 51,968.45 | 51,968.45 | 51,968.45 | 51,968.45 | 51,968.45 | 51,968.45 | 51,968.45 | 51,968.45 |
| 76°F | 50,408.49 | 51,568.47 | 52,628.45 | 52,628.45 | 52,628.45 | 52,628.45 | 52,628.45 | 52,628.45 | 52,628.45 | 52,628.45 | 52,628.45 |
| 77°F | 51,068.49 | 52,228.47 | 53,288.45 | 53,288.45 | 53,288.45 | 53,288.45 | 53,288.45 | 53,288.45 | 53,288.45 | 53,288.45 | 53,288.45 |

Figure 1: Table of energy consumption according to temperature setting.
The figure 2 showed total cooling load was reduced about 6,153,638.4 Btu/hr per month when design temperature setting was changed from 70 °F to 77 °F. This reduced the cooling load by 5.7%, which translate into potential saving in electric energy consumption around RM697 per month with near zero cost.

Figure 2: Graph of energy consumption according to temperature setting.

3.1 Suggestion and Recommendation
There are a few ways of solution and recommendations that were proposed in this topic. Some components or equipment replacement were included in the proposal in order to achieve cost saving objectives. Recommendation that would bring some cost saving benefits to the building has been made at the end of this study. The potential saving measures can be categorized into two categories, which are technical saving measures and manual saving measures respectively. For technical saving measures, switch off air conditioner when not use and increase its temperature in the morning and night. Meanwhile, reminder sign placement and human control are the proposed manual saving measures. Table 4 above shows the comparison between current usage and after increasing air condition temperature.

4. Conclusion
This study set out to identify building’s characteristic and analyze the estimation of monthly energy consumption of Lecturers buildings (Block C15, C16 and C17) of University Tun Hussein Onn Malaysia. This study also discovers the saving potential that can be applied in lecturers building based on the data collected. However, there is no record or system that can track the electrical energy consumption of these three buildings as the electricity bill comes in bulk with several other buildings in UTHM. Hence, it is important to have estimation on the monthly electrical energy consumption to visualize the usage trend. Block C15, C16 and C17 electrical energy consumption was estimated at nearly 56,963 MWh, costing around RM 16,405.58. From these figures, the ACMV system was identified as the biggest contributor of electrical energy consumption with 74.5%, compared to others. However, the electric energy consumption usage of ACMV can be reduced by air condition temperature setting. The temperature setting that suggested to use is 77°F equivalent to 25°C. Therefore, this method not only can save electric energy consumption but in the same time in will reduce the operation cost and suitable for all building that used ACMV.
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