Energy audit and analysis in UTeM: Library

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ABSTRACT – This paper presents the study on auditing energy consumption at UTeM's main library. By investigating the building energy profile such as analysing previous utilities bill, using instrument and calculation using major energy consumption equation such as cooling load equation and sub-meter reading. The detail on part to be audit will give a perspective for what and how the energy audit will be performed. At the end of this paper is the recommendation for energy conservation step that can be implemented based on suggestion by the Energy Commission policies and Malaysian Standard along with the visitation to the case studies site. The result shows that that the maximum power consumption per day is 2141.35 kWh and the minimum is 1912.28 kWh.

1. INTRODUCTION

The case study is conducted on the UTeM's Main Campus library located on Durian Tunggal. This building has started its operation on 29 September 2009 may provides a seating capacity of 500 users at one time. This building consists of four levels including the ground level and for every level it have different layout depend on the purpose it served. Total area of the building is 10063.68m^2. On average, the energy consumption in office building is 70-300 kWh/m2 which is 10-20 times bigger than residential sectors as previous study [1].

The combustion of fossil fuels from electricity generation for commercial and domestic use somehow contributed to the increasing atmospheric carbon dioxide (CO2) concentration. Thus, increase energy demand will consequently increase carbon dioxide concentration in the atmosphere as previous study [2].

Based on the previous data shows that energy consumption needs to be used wisely and monitored. For that purpose, energy audit is one of the ways that can keep track on distribution of energy in building which for this case is UTeM's library itself. For instance, with every saving made can be channel to increase the productivity and some improvement in term of the service consequently, students of UTeM may benefit from it indirectly.

2. METHODOLOGY

This case study focussed more on the main energy consumption part by obtaining the information from building blueprint and room data of air conditioning, lighting and plug load and potential heat load contributor. Moreover, a survey on thermal environment and comfort in UTeM's Library was conducted to gather information from the perspective of regular occupant and make a conclusion based on real condition out of it. Basically, several steps in performing energy audit will begin with pre-audit by having a discussion with building occupant and technical staff in charge to understand the energy usage. Then, audit phase consists of collecting plant data and electric bill, and taking measurement to find irregularities. Eventually, the post-audit to present the data from the audit and analyzed it for the purpose of proposing an energy saving recommendation as previous study [3].

Other method such as the data collection procedure and estimation of energy use intensity and detailed audited-age of building which consist of the types of building, weekly hours, air conditioned area, number of occupancy and the appliances specification was being considered thoroughly. As audit complexity increases, so does thoroughness of the site assessment as previous study. A huge amount of energy and it cost can be saved thus the emission of greenhouse gasses can be reduced by introducing different energy savings option including installing insulation and glazing at appropriate part of building [4].

2.1 Parameter analysis for cooling load calculation

The value for the parameter accounted for the whole equation for this case study is mostly resources from the ASHARE Fundamental Handbook 1997 [5], ASHRAE Standard 62 and the latest weather condition. The calculation will be divided to external and internal load where external load consists of calculation for wall, roof and glass surface while for internal load consist of light, people equipment and ventilation component.

(a) The heat conduction through exterior surface is through the wall and the roof of the building.

$$Q_{wall} = U \times A \times (t_o - t_i) \quad (1)$$

(b) The second component of the heat gain come from the solar heat load which will be divided into two that is solar heat load through conduction and through transmission radiation through the glass window. Its value varies with time, orientation, shading and storage effect.

$$Q_{glass,\ conduction} = U \times A \times (CLTD)_c \quad (2)$$

$$Q_{glass,\ radiation} = SHGF \times A \times SC \times CLF \quad (3)$$

(b) The instantaneous rate of heat gain from electric lighting.

$$Q_{el} = 3.41 \times W \times F_{ul} \times F_{sa} \quad (4)$$

(d) Heat gain from the occupant can be calculated as the equation below and it is divided by latent heat and sensible heat.

$$Q_{sensible} = N \times Q_s \quad (5)$$

$$Q_{latent} = N \times Q_l \quad (6)$$

(e) Obtain the outside air sensible heat (OASH) and outside air latent heat (OALH) with equation below.

$$V_{ventilation} = \text{cfm/person} \times N \quad (7)$$

$$OASH = 0.02044 \times V_{ventilation} \times (t_{db1} - t_{db2}) \quad (8)$$

$$OALH = 50 \times V_{ventilation} \times (w_1 - w_2) \quad (9)$$

3. RESULTS AND DISCUSSION

3.1 Cooling load calculation

The estimation made based on the calculation provides an appropriate total value of the cooling load that supposed to be able to provide by the current HVAC system which is about 937.54 kW.

Table 1 cooling load at each level of library at 12pm.

Level	Total, (kW)
G	67.17
1	460.63
2	217.88
3	137.88
R	53.98
TOTAL	937.54

3.2 Thermal microclimate analysis

It can be concluded from the thermal environment analysis that the condition inside the library is proved to be within a comfort zone since the resulting PMV value generated is within a recommended range which is -0.16 for level 1, -0.14 for level 2 and 0.35 for level 3. For PPD the value is 5.77 for level 1, 5.46 for level 2 and 7.73 for level 3. Overall the thermal condition inside the library is consider of neutral and proved that the HVAC system is work accordingly well to provide comfort for the occupant.

3.3 Estimation of power consumption

Below show an estimation of maximum and minimum power consumption by HVAC system, lighting and other several electrical equipment:
Maximum power consumption per day: 2141.35 kWh
Minimum power consumption per day: 1912.28 kWh

3.4 Estimation of water consumption

For the water consumption calculation will be made by the assumption that the library occupant per day is the full capacity of the library itself which is about 500 occupants and about 65 staff:
Total watr consumption =8.63 m^3

3.5 Luminousity

Overall the library provide more than 400 lux at various location and may reach up to 1199 lux even at night. The ground floor however is an exceptional since it is rarely having an occupant.

3.6 Survey analysis

The survey questions more on thermal comfort aspect that may influenced the sample occupant decision of their state of mind about the thermal environment. It is because normally muscle activity is converted to heat in the body which might be release to the surrounding to achieve comfort. Whereas sometimes insulation from unpleasant environment an individual made is by optimizing their own thermal comfort with clothing to reduce the body's heat loss. The PMV (Predicted Mean Vote) index predicts the mean value of the subjective ratings of a thermal comfort for group of people in a given environment. Thus, it might differ from person to person. for library environment 3 % experienced hot, 3% warm condition, 7% is slightly warm, 30% is neutral, 27% is slightly cool, 13% is cool and 17% cold condition as in Figure 1.

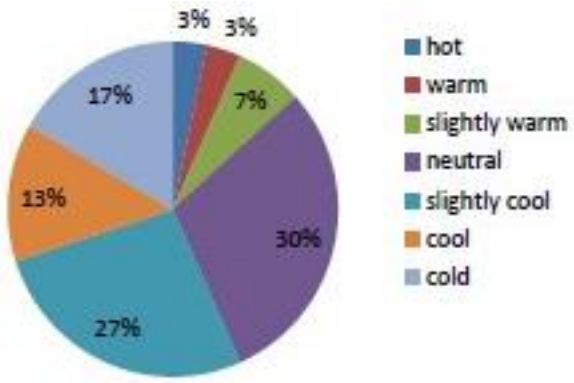

Figure 1 Graph of thermal comfort experiences by the occupant.

4. CONCLUSION

Keeping track, the consumption of energy regularly may help monitoring the performance of equipment that contribute to the energy wastage. To get a better result with a large scale investment but long term benefits is by starting a new process and technology installation that proven to be high in efficiency. By upgrading to variable refrigerant system (VRF), precise retrofitting the lamp and applying energy saving appliance may contribute to energy saving.

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