Energy efficiency monitoring and economic analysis for energy saving potential in UNITEN

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Abstract. This paper discusses on energy efficiency survey for typical buildings in Universiti Tenaga Nasional (UNITEN). Undeniably, wastage of energy will cause the increase of operation cost and depletion of fossil fuel resources which contributes to the climate change issue in the world. UNITEN was commenced in the late 1990s and most of the buildings in this university are not equipped with energy management system. Such system is the solution to reduce energy use while maximizing the comfort levels of the occupants. Disregard to the energy management system, the implementation of other energy saving measures is the main objective of this paper. By taking the right measures, the energy wastage in the buildings of this university can be reduced.

1. Introduction

Energy efficiency is an act of using less energy to accomplish the same task. It is something that affects every single individual, from purchasing energy saving household electrical appliances, to the use of efficient industrial equipment. As a result, this will help the end-users to save energy, lower down the operation cost and still be able to generate the same desired output. Most buildings do not have energy efficiency systems installed. Such system can reduce electricity bill by several methods such as demand side management including load shifting. The efficient use of energy will result in conserving the energy and hence will certainly lower down the energy usage and electricity bills. This paper is focusing on survey of loads installed in typical commercial buildings, energy consumption and usage profiling. In this paper, energy consumption of major electrical appliances in UNITEN buildings such as lightings, computers, and air-conditioners will be taken into account.

There are number of energy saving measures in office buildings in recent years such as Kawamoto et al suggest to minimize the power management delay time of office equipment in Japanese offices [1]. In-Ho Yang et al perform an economic analysis of automatic lighting control system installed in office buildings [2]. Study also shows that office lighting system, double glazing windows heating and air-conditioning plays a key role in reducing energy consumption [3-4].

2. Energy audit

Energy audit conducted at College of Engineering (COE) and Admin Building (BA) to obtain the energy consumption of major electrical equipment and to compare with monthly electricity bill. The
major equipment is lightings, air-conditioners and personal computers (PC). The reason this energy audit conducted at COE and BA because these two buildings are among the firsts to be commenced in 1997 and the buildings do not have Building Automation System (BAS) installed, unlike College of Information Technology (COIT) which has BAS. Therefore, further data analysis is conducted at COE and BA to come up with solutions to save electricity usage in these buildings. The energy consumed by electrical equipment and monthly electricity bill calculated by using equation (1), (2) and (3).

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E = P \times t \quad \text{(1)}
\]

\[
MEB = TE \times \text{Tariff B rating} \quad \text{(2)}
\]

\[
tm = \text{th} \times (5\text{days/week}) \times (4\text{weeks/month}) \quad \text{(3)}
\]

E: Energy, P: Power, t: operational hour, TE: Total Energy, MEB: Monthly electricity bill

\[tm\] Operational hour per month, \[th\]: Operational hour per day, Tariff B: Low voltage commercial tariff.

### 2.1. College of Engineering (COE)

COE consists of 2 main buildings which are Admin Wing (BN) and Classroom and Lab Wing (BL and BM). BN building is mainly for lecturer’s office rooms, BL building is for engineering labs, and BM building is for classrooms. There are 4 floors at BN and 5 floors at BL and BM. On average, COE building consumes about RM75,000 per month for electricity. The percentage distributions of energy usage by major equipment in COE are 47.8% from air-conditioners, 33.8% from lighting, 17.9% from PC and 0.5% from others.

### 2.2. Admin Building (BA)

Admin Building consists of classrooms, lecturer’s office rooms, administration office rooms, and a café. There are 5 floors in this particular building. On average, Admin Building consumes about RM61,000 per month for electricity. The percentage distributions of energy usage by major equipment in BA are 55.7% from air-conditioners, 28% from lighting, 15.4% from PC and 0.9% from others.

### 3. Energy saving opportunities

With reference to the energy audit conducted, air-conditioner consumes most of the energy usage in a building, which is about 50% of the overall energy. The second-highest energy consumption is by lighting (about 30%) and lastly followed by PC (less than 20%). In this section, recommendations on energy saving measures by this major electrical equipment will be proposed. The estimation of energy saving potential will be reviewed, in order for UNITEN Facilities Development and Management (FDM) to take action and implement the possible solutions. The efficient use of energy will result in conserving the energy and hence will certainly lower down the monthly energy usage or electricity bills. The Payback Period and Return on Investment (ROI) for determination of best investment calculated from equation (4) and (5).

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\text{Payback Period} = \frac{\text{Total Initial Cost}}{\text{Cost Savings}} \quad \text{(4)}
\]

\[
\text{ROI} = \frac{\text{Gain} - \text{Investment Costs}}{\text{Investment Costs}} \quad \text{(5)}
\]

#### 3.1. Lighting

3.1.1. Change the daily operation hour of lightings. Currently at COE, the operation hour of lightings at BN is from 7am until 6pm (11 hours) while at BL and BM are from 7am until 8pm (13 hours). At BA, the lightings start to operate from 7am until 8pm (13 hours). Since working hour and classes start at 8am daily, it is recommended that the lightings operate from 8am instead of 7am. By implementing this, UNITEN can save more than RM1,000 per month. Figure 1 shows cost comparison of different
lighting operation hours. From the analysis, the cost savings by implementing this method for COE is RM2, 105 per month and RM1, 292 per month for BA.

3.1.2. Replace current PL-L lamp with MASTER TL5 High Output Eco (Philips). MASTER TL5 uses T5 bulb that can achieve up to 10% energy saving. After 36 months (3 years), the total gain is RM493, 488 (36 x RM13, 708). Therefore, ROI is 49.6% (3 years after installation of T5). Figure 2 shows cash flow after the installation of T5 bulb.

3.2. Personal Computer (PC)

3.2.1. Replace desktops with laptops. From the analysis performed, the average energy consumption, E of a PC are 100kWh per month for a desktop and 4.4kWh per month for a laptop. In conclusion, UNITEN can save up to 95.6% of energy per month in replacing desktop with laptop. By using laptops instead of desktops, UNITEN can cover the replacement cost and starts to gain profit after 4 years as shown in figure 3. After 60 months (5 years), the total gain is RM981, 660. Therefore ROI is 23.3% (5 years after using laptops instead of desktops).

3.2.2. Turn off desktops during weekends. The survey conducted shows 8% of the PC users at COE and 40% at BA leave their desktop turned on unattended during weekends. By turning off desktop during weekends, UNITEN can save up to RM1, 210 (8%) per month at COE and RM3, 692 (40%) per month at BA.

Figure 1. Cost Comparison of different lighting operation hours.

Figure 2. Monthly profits/ gains after the installation of T5.

Figure 3. Monthly profits/gains after using laptops at COE.
3.3. Air-conditioner

3.3.1. Aerosol duct sealing. This aerosol duct sealing can reduce duct leakage up to 90%, which can reduce energy used up to 30%. The installation of aerosol duct sealing can save cost RM10,500 per month. The estimated initial cost for aerosol duct sealing is about RM30,000 per building. From table 1, it can be concluded that after 3 months of aerosol duct sealing process, UNITEN can gain profit whereby there is a reduction of energy usage by air-conditioner by 30%. Therefore the calculated ROI is 10% (on the 6th month after sealing). The ROI indicates the investment on aerosol duct sealing is the best decision.

Table 1. Expected gain after aerosol duct sealing at COE.

| Month | Investment Cost | Cost Savings | Gain/Profit |
|-------|-----------------|--------------|-------------|
| 0     | -RM30,000       | -            | -RM30,000   |
| 1     | -               | RM10,500     | -RM19,500   |
| 2     | -               | RM10,500     | -RM9,000    |
| 3     | -               | RM10,500     | RM1500      |
| 4     | -               | RM10,500     | RM12,000    |
| 5     | -               | RM10,500     | RM22,500    |
| 6     | -               | RM10,500     | RM33,000    |

4. Conclusion

In conclusion, the main objectives of this paper are achieved successfully after completing the data analysis of energy usage in College of Engineering and Administration Building. The aim of energy audit to provide methods to reduce energy wastage is also achieved. Moreover, the list of major electrical appliances (lightings, AHU Fan Motors, Terminal Building Pumps, etc.) at COE and BA are recorded for future references. The wattage ratings, operation hour, and computation on energy usage by these appliances are included as well.

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