



Energy Profiling for Residential College Buildings

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ABSTRACT

The present study aims to provide insight on energy profiling of a residential college in public university. The study involves electrical energy monitoring for six months from the month of March until August 2017. The data utilized to derive the average monthly consumption for both semester period and semester break. The consumption during semester break has been recorded to increase as much as 88% from the consumption during the semester break. The building energy index of the residential college has been recorded to be at 22.90 kWh/m²/year meanwhile the energy intensity was recorded to be at 1,932.08 kWh/occupant/year.

1. Introduction

The demand for energy has ever increasing for the last hundred years. Buildings is one of the highest consumer of energy with European building sector has been reported to consumes 40% of the regional's generated energy [1]. International Energy Outlook report on the current position of the global energy consumption reveals that energy demand will continue to grow by 56% in-between the year 2010 and 2040 [2]. Malaysia as a developing nation also experience increase in national energy demand to propel her economic growth [3,4]. Based on the statistical record released by Malaysia Energy Commission [5], 94% of generated electricity by the country is derive from the fossil fuels. The figure is expected to be unchanged for the next 10 years which rise environmental issue associated to the climate change [6]. In the United State, the Department of Energy (DoE) has estimated that in 2010, buildings have consumed 74% generated electricity and at the same time responsible of emitting 40% of the carbon dioxide emissions to the environment [7].

It is impossible to operate a building without consuming energy thus, the only way to handle the matter is through implementation of energy management and energy efficiency. Systematic implementation of energy management and energy efficiency can minimize the energy consumption of a building while not jeopardizing the operational requirement of the building [8-10]. In principle,

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the first step in implementation of energy management and energy efficiency is to conduct the energy audit. The activity allows the building owner to evaluate and review the current energy consumption pattern and at the same time identify potential saving measures that can be taken to reduce their energy consumption [11,12]. The findings will provide insight to the energy consumption pattern and can be benchmarked with any other building with similar operational requirement or standards.

However, diversity in terms of building operation has limits the used of general benchmarked value in terms of energy consumption of a buildings. Tremendous efforts have been done to provide the benchmark value particularly for commercial building and residential buildings [13-18]. Although Iwaro and Mwashu [19] has reported that the energy consumption for residential building in Malaysia can be estimated to be between 10 to 20 times lower in comparison with the commercial buildings, there are very limited literatures can be found on residential building and residential college buildings. The present study aims to provide energy profiling for residential college building at public university in Malaysia. The study also includes financial and environmental evaluation associated with energy consumption at residential college building.

2. Methodology

2.1 Background Information

The present study focuses on residential college located at Universiti Tun Hussein Onn Malaysia (UTHM), Johor, Malaysia namely Kolej Kediaman Tun Dr. Ismail (KKTDI). The residential colleges have modern building design consist of four blocks of student hostels connected to each other and one block of the administration office together with the cafeteria. The four blocks are design to accommodate 1,244 beds depending on the room configuration. Table 1 shows background information of KKTDI and KKTF.

Table 1
Background Information

| | KKTDI |
|----------------------|-----------------------------------|
| Location | 1.86 °N 103.09 °N |
| Gross Floor Area | 28,599.52 m ² |
| Office Floor Area | 220.31 m ² (0.77%) |
| Hostel Floor Area | 27,353.60 m ² (95.64%) |
| Cafeteria Floor Area | 1,025.61 m ² (3.59%) |

2.2 Data Collection

The electricity consumption of KKTDI is measured by SCADA system installed at the utility room of each building. The system capable to capture electricity consumption (kWh) at the interval of one second, allowing the production of consumption profile for each residential college for the whole year since October 2016. For the purpose of the present study, electricity consumption from March until August 2017 will be used for the analysis. Other data such as hostel occupancy and floor area are collected manually through site survey which is shown in Table 2.

Table 2
Occupancy Data

| | KKTDI | |
|---------|-----------|--------------------|
| | Occupancy | Available Capacity |
| Male | 110 | 622 |
| Female | 229 | 622 |
| Overall | 339 | 1,244 |

2.3 Building Energy Index

One of the energy characteristics that going to be evaluated in the present study is building energy index, BEI. The index representing the electricity consumption of a building for each floor area available in the building. Higher BEI represent higher consumption of electricity per floor area and vice versa. BEI can be determined by Eq. (1)

$$BEI \left[\frac{kWh}{m^2} \right] = \frac{Electricity\ Consumption\ [kWh]}{Gross\ Floor\ Area\ [m^2]} \quad (1)$$

2.4 Energy Intensity

Another energy characteristic that has been considered in the present study is energy intensity. The energy intensity represent the energy consumes per product or in the case of residential college, energy consumes per occupant. Energy intensity indicates the energy consumption per occupant at the residential college thus allow prediction of future consumption based on forecasted number of occupants. Energy intensity can be determined by Eq. (2)

$$Energy\ Intensity \left[\frac{kWh}{occupant} \right] = \frac{Electricity\ Consumption\ [kWh]}{Number\ of\ Occupants} \quad (2)$$

3. Results

3.1 Monthly Profiling

Figure 1 shows the monthly electricity consumption profile of KKTDI from March until August 2017. The figure distinguishes high consumption of electricity in the month of March, April and May in comparison with the electricity consumption in the month of Jun, July and August. The obvious different between these two group of month is contributed by the lecture period and semester break period of the university. The month of March, April and May are during the lecture period while, Jun, July and August are during the semester break. In average, during the lecture period, KKTDI is consuming as much 77,439 kWh of electricity monthly in comparison with only 41,107 kWh during the semester break period. The monthly electricity consumption during the lecture period is increased as much as 88% in comparison with during the semester break.

In terms of financial implication, KKTDI is spending in average RM 28,265.24 monthly during the lecture period in comparison only RM 15,004.06 monthly during the semester break period. Fluctuation in the electricity consumption is more obvious during the semester break period as shown in Figure 1 in comparison with the lecture period. Based on survey during the data collection, the high electricity consumption recorded in the month of Jun and August are contributed by rental of the hostel by third party which is part of the KKTDI strategies for income generation.

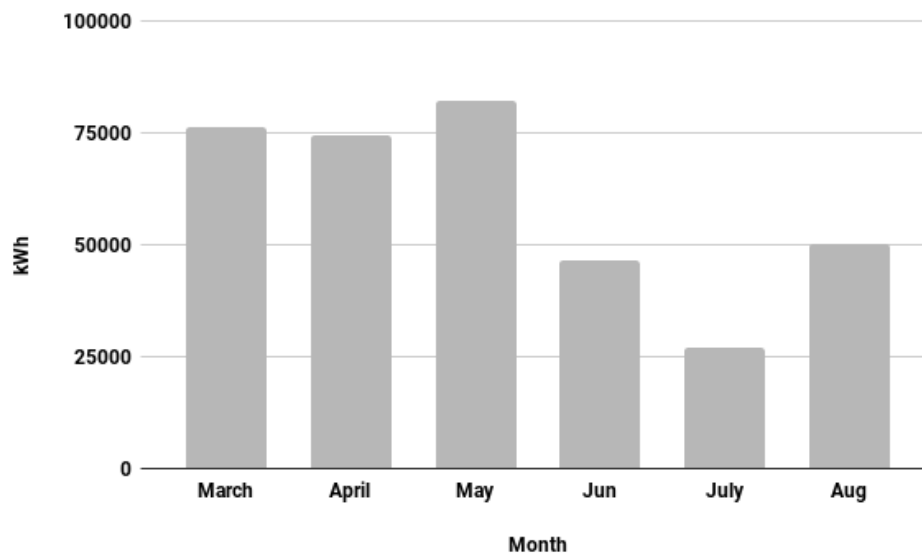


Fig. 1. Monthly Electrical Energy Profile

3.2 Weekly Profiling

Figure 2 and Figure 3 show the daily average electricity consumption of KKTDI during the lecture period and semester break period respectively. Both figures show insignificant difference on the electricity consumption throughout the week from Sunday to Saturday in both periods. The highest electricity consumption is recorded on Wednesday at 23,951kWh and lowest on Saturday at 20,210.42 kWh during the lecture period. Meanwhile for the semester break period, highest electricity consumption is recorded on Sunday at 15,210 kWh and lowest on Wednesday at 12,332kWh. The average daily consumption during the lecture period is recorded to be at 21,482 kWh equivalent to RM 7,841.04 daily. The average daily consumption during semester break is recorded to be at 13,596 kWh equivalent to RM 4,962.43 daily. The difference between daily average electricity cost between the lecture period and semester break period is recorded to be at RM 2,878.61 daily which is at 36.71% difference.

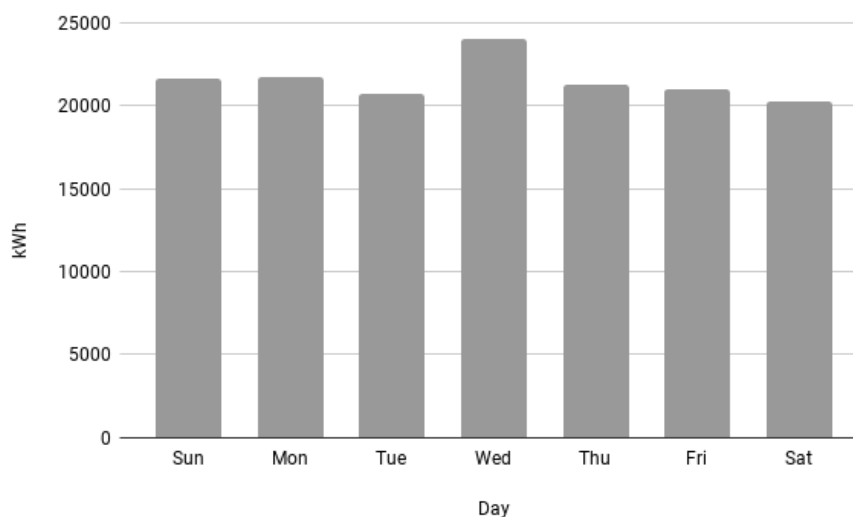


Fig. 2. Daily Average Electricity Consumption During Lecture Period

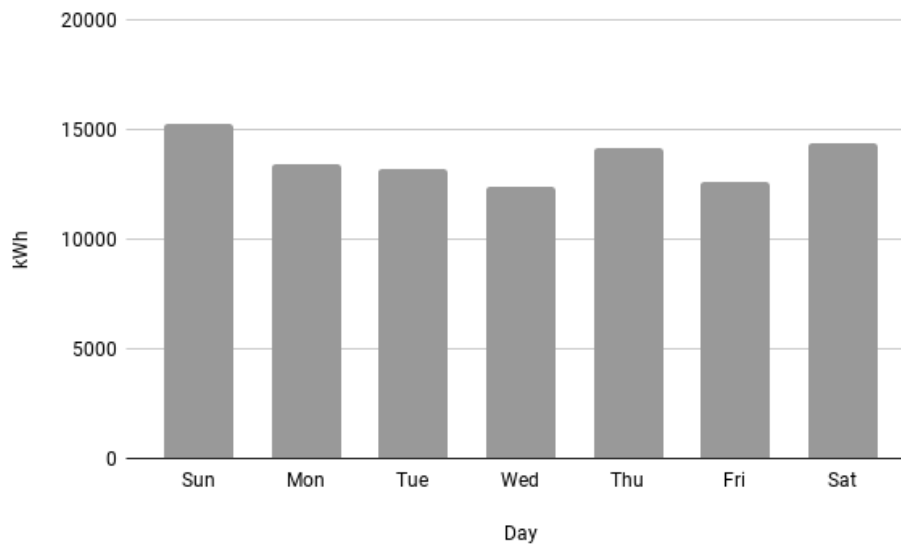


Fig. 3. Daily Average Electricity Consumption During Semester Break Period

Table 3 summarizes the monthly and daily average electricity consumption of KKTDI together with associated cost.

Table 3
 Summary of Electricity Consumption

| | KKTDI |
|---|------------------------------|
| Monthly Average Consumption (Lecture Period) | 77,439 [kWh] RM 28,265.24 |
| Monthly Average Consumption (Semester Break Period) | 41,107 [kWh] RM 15,004.06 |
| Daily Average Consumption (Lecture Period) | 21,482 [kWh] RM 7,841.04 |
| Daily Average Consumption (Semester Break Period) | 13,596 [kWh] RM 4,962.43 |

3.3 Building Energy Index and Intensity

Table 4 shows the building energy index for KKTDI calculated through Eq. (1). The annual consumption is normalized annual consumption which is derived from six month's data mentioned in the earlier section. The normalized annual consumption is calculated based on available six-month consumption data discussed in the earlier section with assumption that the other six months of the year will register similar consumption pattern.

Table 4
 Building Energy Index

| | KKTDI |
|---------------------------------|-----------------------------|
| Annual Consumption (Normalized) | 654,976 [kWh] |
| Gross Floor Area | 28,599.52 [m ²] |
| BEI | 22.90 [kWh/m ²] |

The building energy index recorded for KKTDI is at 22.90 kWh/m² a year. The value is considered to be very low in comparison with 96.60 kWh/m² a year for the overall campus. The main contribution towards this low value are the low occupancy rate, and less demanding space operational requirements. The low occupancy rate of KKTDI is shown in Table 2 with only 339 occupants in

comparison with 1,244 available capacity which is only 27.25 %. Furthermore, the low value is also contributed by less demanding operational requirements. In comparison with most of other spaces in the university, the hostel area at the residential college are not equipped with air-conditioning system which is known to be main consumer of electricity in commercial buildings. Table 5 shows the energy intensity recorded for KKTDI using Eq. (2). The energy recorded energy intensity is at 1,932.08 kWh/occupant a year which is equivalent of RM 705.21/occupant a year.

Table 5
Energy Intensity

| | KKTDI |
|---------------------------------|-------------------------|
| Annual Consumption (Normalized) | 654,976 [kWh] |
| Occupant Number | 339 [occupant] |
| Energy Intensity | 1,932.08 [kWh/occupant] |

4. Conclusions

The study aims to provide energy profile for residential college, KKTDI in terms of consumption profile, building energy index and energy intensity. The conclusions for present study are as follow

- i. The average monthly consumption during semester period is 88.38 % higher in comparison with consumption during semester break period.
- ii. The monthly average electricity cost is at RM 28,265.24 and RM 15,004.06 during the semester period and semester break respectively.
- iii. The building energy index and energy intensity for residential college are at 22.90 kWh/m²/year and 1,932.08 kWh/occupant/year respectively.

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