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A Study on Energy Performance of 3-Star Hotel Buildings in the Capital City of Sarawak

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Abstract

The hotel industry is important to tourist sector in Sarawak and has experienced rapid growth in the past 10 years. However, the hotel industry is categorized as sector with high energy consumption which will lead to unsustainable energy consumption and negative environmental impact. Currently, hotel energy performance studies are still unavailable in Sarawak. Therefore, the objective of this paper is to present a study on energy performance of hotel in Kuching, the capital city of Sarawak. This study was carried out through quantitative methods. This paper presents the results of energy performance which was carried out on a sample of 11 three-star rated hotel buildings in Kuching Sarawak, Malaysia. Building information and operational characteristics which contribute to the variations in hotel energy performance are discussed. The annual average Energy Use Intensity (EUI) for 3-star hotels is 210.8 kWh/m². Pearson correlations between energy consumption and the variables showed that height of the building, gross floor area, area of guest room, total guest room, and total staff number gave a reasonably strong correlations. In regression analysis, area of guest room was found to be highest correlated to the hotel building energy consumption. Area of guest room showed the R^2 value of 0.8262. This research findings could provide a statistical data for the potential of saving hotel energy in future.

Keywords: Energy consumption, Energy performance, Energy use, Hotel building, Sarawak

Introduction

In recent years, tourism has become one of the fastest growing economic industries in the world and Sarawak is not an exception. According to the Ministry of Tourism, Arts, Culture, Youth, and Sports (Boon, 2018), the Sarawak state recorded 4,856,888 visitors who spent an estimated total of RM8.59 billion within this state in 2017. The visitors include both foreign tourist and domestic tourism which recorded 2.6 million and 2.2 million visitors respectively. According to the statistics from the ministry, the tourism sector had contributed 7.9 per cent of Sarawak's Gross Domestic Product (GDP) in 2017. For Sarawak, tourism is an important sector that will continue to drive the state's economy forward. Besides earning on foreign exchange, the tourism industry provides numerous business and employment opportunities. In Sarawak, the hotel average occupancy rate (AOR) in 2017 was recorded at 53.78 percent (Jee, 2019). While average room rate (ARR) in 2017 was RM 148.40.

Kuching is the capital city and the most populous city in the state of Sarawak. The hotel sector in Kuching continues to hold stable with room rates and average occupancies remaining generally unchanged. Kuching city is situated on the Sarawak

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River at the southwest tip of the state of Sarawak on the island of Borneo, and covers an area of 431 square kilometres. It has a tropical rainforest climate, moderately hot but very humid at times and receives substantial amount of rainfall. The main sources of energy consumed by Kuching hotels are electricity (for space cooling, lighting, appliances, drinking water, and boiling), gas (for cooking and heating water) and diesel (diesel generator). Electricity predominantly denotes total hotel energy consumption. Energy consumption is usually higher in hotels than in residential buildings, so there is a larger potential for energy saving measures (Tsoutsos, Tournaki, Santos, & Vercellotti, 2013).

The hotel industry makes a great contribution to the prosperity of Sarawak's tourism economy. Xu, Chan, and Qian (2011) mentioned that varying occupancy rates throughout the year and varied personal preferences of guests for indoor environment will lead to different operating schedules of building services systems, and therefore different level of energy consumption in hotel building (Xu, Chan, & Qian, 2011). Hotel building is considered as one type of large-scale public commercial building and its main energy consuming systems are heating, ventilation and air-conditioning (HVAC), lighting, hot water provision, electricity (lifts, etc.), and cooking. Hotel buildings with higher energy consumption would have a larger potential for the energy efficiency improvement. Tang, Fu, Cau, Shen, Deng, and Wu (2016) explained that the significant variables which are affecting energy consumption are diverse, depending on the physical and operational parameters, such as hotel size, gross floor area, building age, type of energy, and occupancy rate (Tang et al., 2016). Benchmarking energy consumption can give a better understanding of hotel energy performance and enables hotel managers to take appropriate energy efficiency strategies in future.

According to Smitt, Tolstorebrov, Gullo, Pardinas, and Hafner, (2021), they stated that the hotel sector is being featured as high energy consumption which greatly contributes to the global warming effect. They further strengthened that there is a need to investigate environmentally friendly technologies that have the potential to reduce energy usage within sector. Therefore, information regarding the current status of the energy consumption in hotels is essential. Despite of many past research on energy performance of hotel buildings, there is still lack of statistical data about detailed energy performance in Kuching, Sarawak. Not only in Sarawak, but studies on energy performance of hotels in the tropical country has generally been meagre. The purpose of this study is to bridge this gap by performing a detailed investigation of the energy use conditions in tropical hotels. Effective measures can subsequently be taken in areas where inefficiencies haven been discovered.

In this study, the research question attests the relationship between energy consumption and the significant variables. The objective of this paper is to present a study on energy performance of hotel in Sarawak's capital city. In addition, relationship between energy consumption and selected variables which include physical and operational parameters are examined. The investigated items cover energy use information and building energy related factors. The significant variables include building age, height of the building, gross floor area, area of guest room, total guest rooms, average occupancy rate, total of floor, and staff. This paper will provide an understanding of the relationship between energy use characteristics and energy performance of hotel buildings in the capital city of Sarawak.

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This research is helpful in enhancing knowledge regards energy performance of hotels. On the other hand, the research findings could be used as references among hotel managers, maintenance personnel, and engineers in hotel industry in order to attain a sustainable and healthy environment through enhancing energy conservation practice. By understanding the energy performance in hotels, the hotel managers and engineers are able to conduct evaluation towards their own building, so they can know the current energy performance level in their hotel. Subsequently, they are able to take some effective continual improvement measurements to optimizing the energy consumption and reduce wasteful of limited resources of hotels.

Literature Review

Smitt et. al. (2021) mentioned that hotels are energy-intense building due to the nature of their operation and the behavior of the occupants. Tsai, Lin, Hwang, and Huang, (2014) stated that accommodation supply and demand is necessary for the tourism and hospitality sector as travelling usually requires an overnight stay accommodation. Many studies have shown that the energy consumption of hotels differs from other industries and hotels are among the highest energy consumption types of building. The largest contributor to excessive energy consumption within the hotel sector is hot water and cooling (Dibene-Arriola, Carrillo-Gonzalez, Quijas, & Rodriguez-Uribe, 2021; Smitt et al., 2021). Farrou, Kolokotroni, and Santamouris (2012) further emphasized that hotels are the highest energy consuming buildings of the tertiary sector due to their operational characteristics and the large number of users, data indicated that they are the highest of the building stock after shopping malls and hospitals. Their energy consumption can differ widely from hotel to hotel which are depending on factors like location, size, and guest facilities (Salehi, Filimonau, Asadzadeh, & Ghaderi, 2020). Thus, energy consumption is highly diversified and very difficult to quantify in detail.

According to Yao, Zhuang, and Gu (2015), compared to other types of commercial buildings, hotel building has many different functional areas, such as guest room, business center, restaurant, and laundry room. Study on the energy use characteristics of hotels enhances the understanding of building energy consumption level and establishes the possible action plan to improve energy efficiency of hotel buildings. A growing concern on the high amount of energy consumption in hotel buildings has been addressed by many studies on energy performance of hotel buildings in various regions across the world. For example, the past researches of Energy Use Intensity (EUI) of hotels are shown as below:

a. Yao, Zhuang, and Gu (2015) and Bohdanowicz and Martinac (2007) found out that the average EUI of 73 Hilton hotels and 111 Scandic hotels in Europe, which were recorded as 364 kWh/m² and 285 kWh/m² respectively.
b. Yao, Zhuang, and Gu (2015) and Priyadarsini, Wu, and Lee, (2009) found out that the annual average EUI of 29 Singapore hotels, including 3-star, 4-star, and 5-star hotels were at 427 kWh/m².
c. Tang et al. (2016) reported EUI results of hotel buildings in Lijiang, China based on hotel star rating including 4-star hotels, 3-star hotels, 2-star hotels, and 1-star hotels were at 180.8 kWh/m², 113.3 kWh/m², 74.2 kWh/m² and 70.2 kWh/m² respectively.

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A number of physical and operational factors will influence the hotel energy use (Mechri & Amara, 2021; Hui & Wong, 2010) and it is summarized by Bannister (2008) as following:

- Service level
  This approach is pragmatic but does not carry some risks, as there is still some diversity within star bands and not all hotels are rated.
- Number of rooms
  This is a preferred variable for benchmarking as it is relatively well defined.
- Floor area
  This factor is strongly correlated to the number of rooms but is not measured to any consistent metric by the industry and as such is not a preferred index for hotel size.
- Scale of meeting / conference facilities
  This varies independently of other hotels and can be a significant contributor to the overall energy use of an individual site.
- Scale of restaurant facilities
  While this is to some extent correlated to hotel quality, other independent factors also play a strong role.
- Swimming pools
  The scale of swimming pools offered varies widely, again with a marginal correlation to the hotel star rating.
- Laundries
  While most hotels have some form of house laundry, this may range from a small facility for washing a few selected items to a large facility washing sheets, towels and other linen for more than 1 hotel.
- Retail operations
  Many hotels also house some limited independent retail operations. These are typically but not always sub-metered.
- Level of occupancy
  In principle, the level of occupancy should have a large influence on hotel energy and water consumption, although in practice for energy at least this is not as significant as might otherwise be the case due to the propensity of hotels to provide service to empty rooms in preparation for unexpected arrivals.
- Other facilities
  Such as health club, casino, theatre, and retail.

All of the hotels above taken into consideration and integrated in the questionnaires for this study.

Methodology

In this research, energy use characteristic and building factors will be examined to find out their influence on energy performance. This study was carried out through quantitative methods. Before the real survey was conducted, a pilot test was launched in order to check the reliability of the questionnaire. Both printed and online-survey were conducted in 5 respondents of three-star hotels of Sibu, together with an interview visitation and follow-up with them every week. Unfortunately, the overall response rate was poor due to the lack of personal contact and data confidentiality. Only 2 respondents

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replied the given questionnaire and give the feedback. Subsequently, the real survey was conducted targeting at three-star rated hotels in Kuching by using a self-administered questionnaire whereby managers and employees at maintenance department are the main targeted respondents.

To determine the sampling frame, a list of hotel types was provided by the Sector of Tourism and Hospitality. This frame provides the necessary information for the sampling units (registered three-star hotels). Three-star hotel properties were selected as the case study as they have similar operational characteristics that possess by the majority of other hotels in term of the extent of comfort, thus being largely representative of this specific category of hotels in capital city of Sarawak. The focus on the three-star hotels is justified by the ability of this category of hotel to transform and lead the hotel sector in its quest towards the goal of environmental sustainability. The sampling consists of 34 potential respondents in capital city of Sarawak as this group contains most quality hotels and is believed to have the largest potential in making energy savings. Although the research was ambitious and foreseen to survey all identified managers/ maintenance staff, but only 11 responded, representing a 47.8% response rate.

The instrument of this study was a set of questionnaire which consists of 3 parts, i.e., a) hotels' background and building information, b) energy consumption, and c) operational characteristics. To obtain the raw data, hotel managers were initially contacted by telephone to make appointment for hotel facility visitation and conduct the survey. During the survey, they were asked to provide fundamental data of their hotel, such as building information, functional and operational level, and energy use for year 2017. In addition, other data on energy use and operating-related information such as occupancy rate, number of guests and so on were also collected. Data analyses were done through correlation and regression methods to distinguish the determinants of energy consumption and energy use intensities in hotels. Correlation and regression analysis were then performed using SPSS statistical software to explain the relationship between the variables and electricity consumption from the selected hotels.

Findings

As showed in Table 1, the sampled hotels are heterogeneous in terms of size. For the purpose of data privacy, they are labelled thereafter as Hotel ID No. 1-11. The sampled hotel differed significantly in the number of rooms available. The number of rooms within a hotel varied remarkably, ranging from 40 rooms to 167 rooms even though they are the same rated hotel, i.e., 3-star hotel. In the sampled hotels, the total number of guest rooms was 1025. The ages of sampled hotels were also not equal, with the oldest building having been built in 1991 and the newest completed in 2014.

There were significant differences in the gross floor area (GFA) of the sampled hotels, which ranged from 1,760 m² to 6,188 m², with an average of 3,228 m². The guest rooms cover on average 65% of the hotel's GFA. Among the 11 hotels, 8 hotels provide some dining facilities, which vary approximately at 426 m² (1.2% of GFA). The area categorized under dining facilities, include café, restaurant, and kitchen. Besides this, 9 hotels have conference hall. The average percentage of GFA contributed to these functions is 7.3%. The rest of the areas in the hotels are also used for common areas (lobby and corridor), back of the house (housekeeping, laundry, etc.), recreational facilities (swimming pool, gym, etc.), and technical service rooms.

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Table 1 Summary of the Data Collected From Sampled 11 Three-Star Hotels of Kuching In 2017

Hotel ID No.	No. of Rooms	Building age	Height (m)	Annual Mean Occupancy Rate (%)	Gross Floor Area (m^2)	No. of Floors	Area of Guest room (m^2)	No. of workers	Annual electricity consumption (kWh)	EUI (kWh/m^2)
1	68	6	13.6	69	2523	3	1537	45	593751	235.34
2	135	12	9.6	59	1760	3	1485	25	435828	247.63
3	75	5	10.7	59	3300	3	1260	8	382263	115.84
4	49	19	11.8	67	1920	3	1323	10	447591	233.12
5	40	18	12.7	43	2655	4	1270	40	465731	175.42
6	70	13	12.7	47	2449	4	1087	32	436365	178.18
7	91	29	19	50	4476	5	3148	35	724125	161.78
8	155	8	18.7	54	6188	6	3084	85	1126487	182.04
9	67	3	17.4	62	2319	7	1843	30	413929	178.49
10	108	24	18.7	47	3416	7	3040	55	1166274	341.42
11	167	23	27	46	4500	7	4050	87	1213344	269.63

Source: Author

In general, there are three types of energy used in the sampled hotels, including electricity, gas, diesel, and water. Electricity is mostly used for cooling, lighting, and equipment, whereas gas and diesel are used as fuel for heating, boiling, and cooking. In this study, electricity consumption is selected as a type of energy statistical analysis. It will be used in energy use intensity with kWh/m^2. These energy use intensities vary significantly from one building to another building. Energy use intensities of 11 sampled three-star hotels are showed in Table 2. The annual average of EUI for 3-star hotels is 210.8 kWh/m^2, the pattern of energy consumption is different to the hotel in China (Teng, Wu, & Xu, 2017), but similar to the hotel in Nigeria (Oluseyi, Babatunde, & Babatunde, 2016) where they were from the same category of hotels. China and Nigeria had recorded 92 kWh/m^2 and 266 kWh/m^2 respectively. The energy consumption per area in capital city of Sarawak is higher than in China as Sarawak has an equatorial climate. The temperature is relatively uniform throughout the year i.e. within the range of 23°C early in the morning to 32°C during the day (Sarawak Government, 2018). Thus, the hotels require air-conditioner to comfort the overall operation of the building as well as guests and visitors. It is different from China which has four seasons per year. Meanwhile, it is lower than Nigeria in terms of energy consumption per area. Basic facilities and space requirement were the main causes of the difference among three-star hotels. The highest GFA were found in three-star hotels, with an average of 3227.8 m^2.

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Table 2 Statistical Results of Energy Use Intensity of Sampled Hotels

Type of hotels	Annual electricity consumption per area, EUI (kWh/m²)			
	Minimum	Maximum	Average	Standard deviation
Three-star hotels	115.8	341.4	210.8	62.12

Source: Author

As shown in Table 3, Pearson correlation analyses were carried out between 8 surveyed variables namely GFA, number of guest rooms, building age, height of the building, annual occupancy rate, number of floors, GFA of guest rooms, and number of workers. For annual energy consumption, most of the variables are significant at 0.01 level, including height of the building, gross floor area, area of guest room, total guest room, and total staff numbers. Among all the variables, areas of guest room presents the strongest correlation with the hotel annual energy consumption.

Table 3 Pearson Correlations between Operational Parameters with Energy Consumption and Energy Use Intensity (EUI)

Variable name	Energy consumption	EUI
Building Age	.440	.412
Height of the building (m)	.823**	.338
Gross Floor Area (GFA) (m²)	.760**	-.095
Area of guest room (m²)	.909**	.399
Total Guest Rooms	.745**	.368
Average Occupancy Rate (%)	-.433	-.083
Total number of floors	.711*	.349
Total Staff Numbers	.883**	.382

Source: Author

*Correlation is significant at the 0.05 level (2-tailed).
**Correlation is significant at the 0.01 level (2-tailed).

Table 4 R^2 of Linear Models Correlated Energy Consumption with Primary Factors

Capacity indicators	Annual energy consumption
Height of the building (m)	0.678
Gross Floor Area (GFA) (m²)	0.578
Area of guest room (m²)	0.826
Total Guest Rooms	0.554
Total Staff Numbers	0.779

Source: Author

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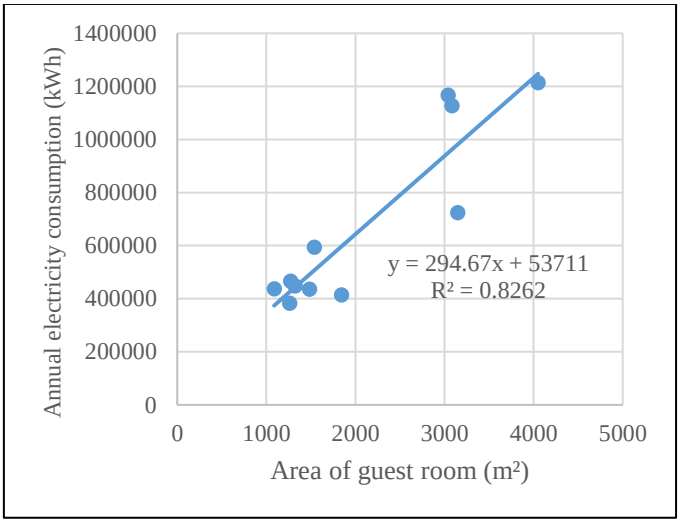

Figure. 1: Area of Guest Room vs. Annual Electricity Consumption

Discussion

Source: Author

Based on the correlation analysis, area of guest room is the highest correlated with energy consumption among all the variables. Significant correlations are reasonable because massive energy consumption of hotels often indicates that the scale of this hotel is substantially bigger with large space of gross floor area and large size of hotel's facility. Large size of gross floor area indicates those hotels offer more services and facilities which means more guest rooms are provided, more staff are employed, and more energy consumed. Besides this, total number of floors presents a weak significance relevance at 0.05 level. However, building age and average occupancy rate presents a non-significant correlation with energy consumption. For EUI, none of the variables has significant correlation. This means that there is no correlation between GFA, number of guest rooms, building age, height of the building, annual occupancy rate, number of floors, area of guest room, and number of workers.

Regression analyses were carried out to correlate energy consumption with height of the building, GFA, area of guest room, total guest room, and total staff number. Most of these variables are moderately correlated with energy consumption but area of guest room is the best correlated variable, which is manifested by highest R^2 in Table 4. Linear regression of area for guest room and the hotel annual electricity consumption was illustrated in Fig. 1 with the R^2 value of 0.8262, it is different from Nigeria (Oluseyi et al., 2016) which shows R^2 value of 0.588. It shows a positive correlation between area of guest room and annual electricity consumption. As one can expect, with the increase of guest room area, annual electricity consumption of a hotel also increases. The R^2 value of 0.8262 indicates that total floor area can explain 82.6% of the variation of energy use in the hotels of the capital city, Sarawak. The R^2 value of 0.779 in relation to the total staff number means that workers' density alone is able to explain 79.9% of the variation energy consumption. It means that more hotel employees, the energy demand increases in hotels as number of staff reflects the level of business activities in hotels (Oluseyi et al., 2016). The hotels provide more services usually required more employees to support the business activities. In this study, the hotel services is not limited to accommodation, but also offers event, conference, and meeting facilities which includes conferences, weddings, exhibitions, seminars, and private intimate functions. Superficially, it is

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because guest room area increases electricity demand in hotels. A less obvious but more important reason is that guest room area actually reflects the level of business activities in a hotel. The hotel with increasing guest room area means that hotel provides more services which usually need to consume more electricity.

Conclusion and Recommendation

This paper provides data showing how much energy is consumed in the forms of electricity, and the type of building and operational characteristics which contributes the most energy consumption in hotels. Building features and operational characteristics which are contributing to the variations in hotel energy performance were discussed. Mean energy use intensity in the surveyed hotels was found to be 210.8 kWh/m², which is below the average for hotels in the developed countries but slightly higher than those in China. Based on the Pearson correlation analysis, most of the variables are significant at 0.01 level, including height of the building, gross floor area, area of guest room, total guest room, and total of staff for energy consumption. Among all the variables, areas of guest room presents the strongest correlation with the hotel annual energy consumption. This result is also in line with simple linear regression analysis, whereby, there is a significant and positive relationship between area of guest room and annual electricity consumption for the surveyed hotels. Electricity consumption is not well correlated with occupancy; some possible reasons may account for this, but it also suggests that hotel managers should improve energy management when occupancy rate is low.

Findings from this paper can help to formulate policies in an attempt to promote energy saving practice among the hotels in Kuching. The study continues to show some discrepancy in energy performance in registered three-star rated hotels of capital city in Sarawak. This paper provides both theoretical and empirical contributions. From the viewpoint of theory, it gives further evidence to how the variables influence the energy efficiency performance in hotels. From the empirical angles, this paper provides a first known of energy efficiency performance in capital city of Sarawak with progressively developing tourism. Thus, it encourages multiple stakeholders to carry out some actions to reduce inadequate energy performance of hotel in Sarawak. Besides, a database about energy use, building characteristics, and operational function should be set up for the purpose of monitoring and energy audit use in hotel buildings. Hoteliers and the relevant stakeholders can initiate to monitor energy use in their hotel buildings from time to time in order to propose measures of conservation. In the meantime, they should influence and encourage the hotel guests to save energy by raising their awareness.

Main limitation of this study is the low response rate from three-star hotels in Kuching. As mentioned in above, the data collection about energy data is hardly to obtain as many respondents considered it as confidential. This study can be expanded to other category of hotels, homestay and resorts in Kuching and other parts of Sarawak, so that hotels with same features can be grouped together. Separate analysis conducted for different groups will give some different patterns. By doing so, comparison among the groups can be carried out to identify the desirable features which contributes to energy efficiency.

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