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Factors affecting electricity consumption intensity of hotel buildings in Thailand

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Abstract

This paper presents a study on energy performance of Thailand's hotel buildings. Energy consumption data, hotel characteristic and hotel operation data were collected from 63 hotels through a technical survey. The annual Electricity Consumption Intensities (ECI) of the sampled hotels were then calculated and the hotel parameters affecting electricity consumption of the hotels were analyzed by Pearson correlation. Results indicated that most of the sampled hotels in Thailand consumed electricity, Liquefied Petroleum Gas (LPG) and diesel. Electricity is the main energy source, accounted for 69% to 94%. The electricity was mainly used in air conditioning (57%), followed by lighting (18%), escalators (9%), water heating (8%), and fans and pumps (8%). The average annual ECIs of hotel buildings in Thailand were 321.84 kWh/m^2, 35,210.40 kWh/guest room and 2,292.36 kWh/room night. Pearson correlations showed that worker density had a positive correlation with monthly ECI in kWh/m^2 at 99% confidential level whereas Occupancy Rates (OR) had a negative correlation with monthly ECI in kWh/room night at 95% confidential level. The predictive model determined based on a stepwise linear regression indicated that the optimization of some hotel operational factors such as number of room nights, number of workers, worker density and OR could lead to the significant decrease in electricity consumption of hotel building in Thailand.

Keywords: Electricity Consumption Intensity, Factors, Hotel Buildings, Thailand

1. Introduction

As a major sub-sector of the tourism industry, the hotel sector accounts for a significant amount of the overall resource consumption, as well as for a substantial portion of the environmental impact it generates [1]. In the United States of America, hotel facilities rank among the top five in terms of energy consumption in the commercial/service building sector (minor only to food services and sales, health care and certain types of offices) [2]. Many studies presented that electricity was the main energy source in hotel buildings. For examples, 73% of energy consumed in Hong Kong hotels was found to be electricity [3] while in Singapore hotels where diesel boilers were used, the percentages of electricity, gas and diesel were 77%, 8% and 15%, respectively [4]. Electricity was therefore the main cause of greenhouse gas emission accounted for 93.60% in 29 Singapore hotels [5], 79.14% in Taiwanese hotels [6] and 91.0% in 51 Australian hotels [7].

Energy consumption in Thailand has increased gradually due to continuous economic growth. It was reported that the value of energy consumption was about 15% of GDP, while in many developed countries their energy consumptions accounted only 8 % of their GDP [8]. In 2002 the Ministry of Energy reported that the electricity consumption in building sector was 19,100 Gwh, accounted for 33 % of total electricity consumption in Thailand. The largest contribution was from office building accounted for 7,139 Gwh, followed by hotel, hypermart, shopping mall, condominium, hospital and school, respectively. The electricity consumption of hotel buildings in

Thailand was approximately 12% of total electricity consumption in building sector. The Tourism Authority of Thailand reported that the revenue from hotel business was one of the main revenues in country. In 2010, the hotel business earned 9 thousand millions baths [9]. This is due to the fact that the expansion of hotel business was still increasing continuously with the growth rate of 258 hotels per year and in concord with the growth rate of 1.1 million tourists per year [10, 11]. The hotel business is one of the targeted sectors that should adopt the concept of low carbon economy and sustainable development according to the Eleventh National Economic and Social Development Plan (2012-2016) [12]. However, the basic information such as energy consumptions broken down by types of hotels, types of energy sources, hotel location etc. has not been reported elsewhere. This information is the key factor for hotel owners and policy makers to establish appropriate energy management measures.

This paper aims to report the Electricity Consumption Intensities (ECI) of the sampled hotels in Thailand, and studied factors affecting ECIs of Hotels. The study is a good understanding of relevant factors and the ways they affect hotel electricity consumption may lead to the development in new designs, retrofitting projects as well as energy management programs.

2. Materials and methods

2.1 Samplings

In this study, the energy consumption data in 2011 from 187 hotels in Thailand that have been regulated by the Royal Decree on Designated Buildings, B.E. 2538 of the Energy Conservation Promotion Act, B.E. 2535 were collected. According to the Royal Decree, hotels that consume electricity, heat or steam greater than 20 million MJ equivalent to electricity should submit their annual energy reports directly to Department of Alternative Energy Development and Efficiency, Ministry of Energy [13]. The hotel characteristics such as star rating, Green Leaf Foundation certification and classification of hotel were collected from the Thailand Hotels Association and the Green Leaf Foundation of Thailand. The data regarding hotel age, number of guest rooms, gloss floor areas (GFA), regions, location, types of hotel classified by functions, number of floors, number of workers, occupancy rate (OR), monthly room nights and monthly guests were collected by questionnaires and in-depth interviews. The monthly consumptions of electricity, Liquefied Petroleum Gas (LPG), diesel and fuel oil that were used for hotel operation were collected by electricity bills.

2.2 Electricity Consumption Intensity

Due to the difference in hotel sizes, hotel activities and hotel energy management, the electricity consumptions of each sampled hotel are tentatively different. Therefore, ECI was chosen as a criterion to compare the energy performance between the different hotels.

The normalization factors used in this study were GFA, guest room and room night which are most common factors used to calculate electricity or energy consumption intensity as reported elsewhere [4, 7, 14-15]. Thus, ECI will be proposed in accordance with the unit of the normalization factors such as kWh/m^2, kWh/guest room and kWh/room night.

2.3 Data Analysis

A linear regression model analyzed by the commercial statistic software SPSS version 16.0 was used to describe the relationship between the hotel factors and electricity consumption from the sampled hotels. A regression analysis was then performed to examine the influences of the hotel factors on the ECI in the unit of kWh/m^2, kWh/guest room and kWh/room night. The ECI was the dependent variable and the hotel factors were the potential independent variables. Next, the impacts of the significant hotel characteristics on the electricity consumption of hotels in Thailand were analyzed.

3. Results and discussion

3.1 Hotel Building Characteristics

The hotel building characteristics were collected by questionnaires in 2011. The questionnaires were sent directly to 187 hotels listed in the Royal Decree on Designated Buildings, B.E. 2538 of the Energy Conservation Promotion Act, B.E. 2535, Thailand. However, the complete data sets were received from 63 sampled hotels. Even though the completed questionnaires were only 33.69 %, the number of the sampled hotels was found to be consistent with the Yamane sample size at 90 % confidence level. A summary of the data is shown in Table 1 and 2.

Table 1 The physical characteristics of 63 Thailand's sampled hotels.

Hotel Characteristics	Number of Hotels	Percentage
Star rating		
Unclassified	28	45
3-star	4	6
4-star	17	27
5-star	14	22
Main function		
Resort hotel	17	27
Conference hotel	16	25
Commercial hotel	28	45
Residential hotel	2	3
Type of hotels classified by Hotel Act 2004		
Type 3[a]	31	49
Type 4[b]	32	51
Green Leaf Certification		
Uncertified	28	44
Certificated	35	56
Location		
Rural	25	40
Urban	38	60
Regions		
Central	2	3
Northern	8	25
Southern	16	13
Eastern	6	10
Western	2	3
North-eastern	5	8
Bangkok	24	38

a: Hotels provide accommodation, catering or restaurant services, the size of each room is not less than 14 square meters, and which has either conference rooms or entertainment venues which under the Place of Service Act B.E. 2509 could be a place for dancing, bars and night clubs, spa.
b: Hotels provide accommodation; catering or restaurant services, conference rooms and entertainment venues, the size of each room are not less than 14 square meters.

As presented in Table 1, the sampled hotels were classified as type 3 and type 4, which are mainly commercial hotels that provide accommodation, catering or restaurant services, conference rooms and entertainment venues. The majority of the sampled hotels were unclassified star rating. However, the number of hotel certificated by the Green Leaf Foundation was a bit more than that of the uncertificated ones. Most of the sampled hotels were located in urban area, especially in Bangkok.

The operational factors of the sampled hotels are shown in Table 2. The average hotel age, number of guest rooms, floors and GFA were 20 years, 378 rooms, 14 floors and 39,667 m^2, respectively. The average number of hotel workers, worker density, OR, monthly guests and monthly room nights were 326 workers, 0.33 workers per 1000 m^2, 57.33%, 11,576 guests and 6,139 room nights.

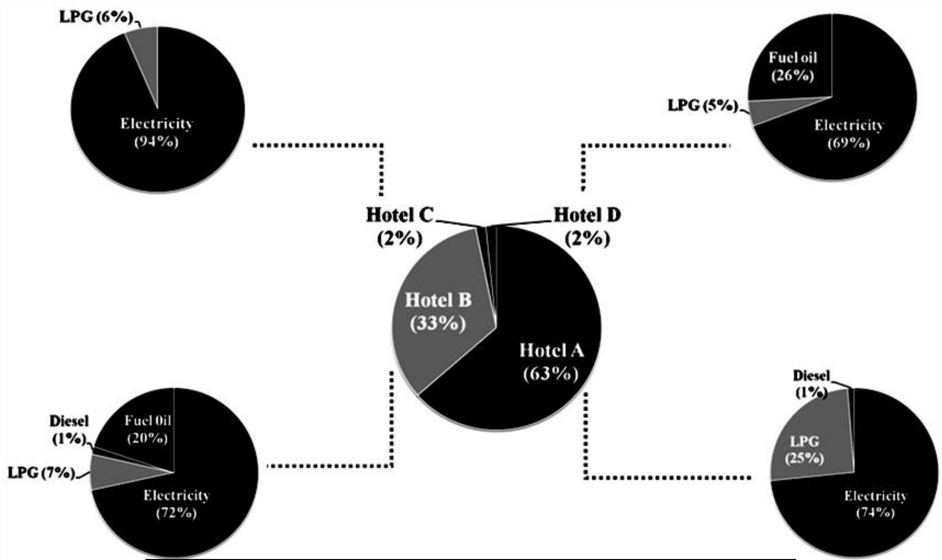
Table 2 The operational characteristics of 63 Thailand's sampled hotels.

Hotel characteristics	Mean	Std. Deviation
Age (years)	20	9
Number of guest rooms (rooms)	378	516
GFA (m^2)	39,667	53,614
Number of floors (floors)	14	12
Number of workers (workers)	326	241
Worker density (number of workers per 1,000 m^2 of GFA)	0.33	0.24
OR (%)	57.33	16.14
Monthly average room nights (room nights)	6,139	5,878
Monthly average number of guests (guests)	11,576	11,161

3.2 Hotel Energy Consumption

3.2.1 Energy sources

Unlike office buildings in Thailand, in which only electricity is consumed, hotels often use more than one type of energy source due to the diverse activities accommodated. The percentages of energy sources from the sampled hotels are shown in Figure 1.



	Electricity	LPG	Diesel	Fuel oil
Hotel A:	✓	✓	✓	X
Hotel B:	✓	✓	✓	✓
Hotel C:	✓	✓	X	X
Hotel D:	✓	✓	X	✓

Figure 1 Types of energy sources consumed in the sampled hotels.

According to the received data, the majority of the hotels are the hotels that consume electricity, LPG and diesel (Hotel A) accounted for 63% of the total hotels. The monthly average energy consumptions of Hotel A are 4,534 kJ. Second comes the hotels that consume electricity, LPG, diesel and fuel oil (Hotel B), accounted for 33%. The monthly average energy consumptions of Hotel B are 6,258 kJ. The rests are the hotels that consume only electricity and LPG (Hotel C) and electricity, LPG and fuel oil (Hotel D). The monthly average energy consumptions of Hotel C and Hotel D are 229.87 kJ and 3,006.42 kJ, respectively.

It is observed that electricity is the main energy source consumed by hotels in Thailand which ranges from 69% to 94%. Electricity, the primary energy source, is used to power Heating, Ventilation and Air-conditioning (HVAC), lighting, escalators, elevators, and other electric equipments. Like electricity, LPG is also consumed in all sampled hotels, mainly for cooking. Diesel and fuel oil are used in the hotels for the following purposes: hot water and steam production, and standby electricity generation. The latter incurs very little consumption, as diesel is only consumed in regular (monthly, or even quarterly) test-runs of the emergency generator to ensure it works when in need. Similar to the electricity consumption in worldwide hotels, the percentages of electricity consumption compared to the total energy consumption were the highest shares as shown in Table 3. Interestingly, the shares of electricity consumption in Saudi Arabia's hotels were affected by the star rating of hotels. The higher star-rating hotels had larger electricity shares than the lower star-rating hotels. In contrast to the Saudi Arabia's hotels, the shares of electricity consumption in Thailand's hotels decreased as the star rating increased. This is because the higher star-rating hotels mostly provide banquet with international cuisine, fitness, sauna and spa which consume additional LPG and fuel oil for cooking and heating hot water. Even though, the share of electricity in the higher star-rating hotels decreased, their annual electricity consumption in MJ per square GFA increased. The five-star hotels consumed electricity more than 100 MJ/m^2/year. It is noticed that the annual electricity consumption of five-star hotels was approximately three times higher than that of three-star hotels. Accordingly, the energy conservation should be focused on the hotels that have higher star-rating. Despite the fact that the higher star-rating hotels need to provide luxury and best services to their customers, the hotels should take more consideration on energy conservation as well.

Table 3 Energy sources and shares of electricity consumption in worldwide hotels.

Studies	Energy sources							Shares of electricity (%)	Annual electricity consumed		
	Electricity	Natural gas	LPG	Diesel	Fuel oil	Wood	Coal		(MJ/m^2)	(MJ/room)	(MJ/guest)
Thailand (this study)	✓	X	✓	X	X	X	X	94	34.97	2,243.75	46.26
	✓	X	✓	X	✓	X	X	69	84.46	4,921.28	102.15
	✓	X	✓	✓	X	X	X	62[a]	109.46	14,006.48	452.53
	✓	X	✓	✓	X	X	X	75[b]	122.95	10,990.92	309.97
	✓	X	✓	✓	X	X	X	91[c]	30.42	3,597.73	168.72
	✓	X	✓	✓	✓	X	X	76[a]	114.46	14,330.64	379.45
	✓	X	✓	✓	✓	X	X	75[b]	66.58	6,055.83	289.19
	✓	X	✓	✓	✓	X	X	84[c]	36.30	3,342.14	111.90
Singapore (4)	✓	✓	X	X	X	X	X	91	1,301.01	91,656.00	X
	✓	✓	X	✓	X	X	X	77			
Hong Kong (3)	✓	✓	X	✓	X	X	X	73	2,030	X	X
Mauritius (16)	✓	✓	X	✓	X	X	X	65.67	X	X	X
New Zealand (17)	✓	✓	✓	X	✓	✓	✓	73.41	X	X	X
Greece (14)	✓	X	X	✓	X	X	X	68.33	X	X	X
Saudi Arabia (15)	✓	X	X	✓	✓	X	X	89[a]	X	X	X
	✓	X	X	✓	✓	X	X	75[b]	X	X	X
	✓	X	X	✓	✓	X	X	76[c]	X	X	X
	✓	X	X	✓	✓	X	X	66[d]	X	X	X
Australia (7)	✓	✓	✓	✓	X	X	X	66	X	X	X

a: 5-star rating , b: 4-star rating , c: 3-star rating , d: 2-star rating
✓: Applicable sources but energy consumption data were not reported
X: Not applicable

3.2.2 Energy end use

Only 34 from 63 sampled hotels were able to provide a reasonably detailed breakdown of energy end-use. Figure 2 indicates that the major electricity consumption was air conditioning, contributed for 57%, followed by lighting, lift and escalators, water heating, and fan and pumps.

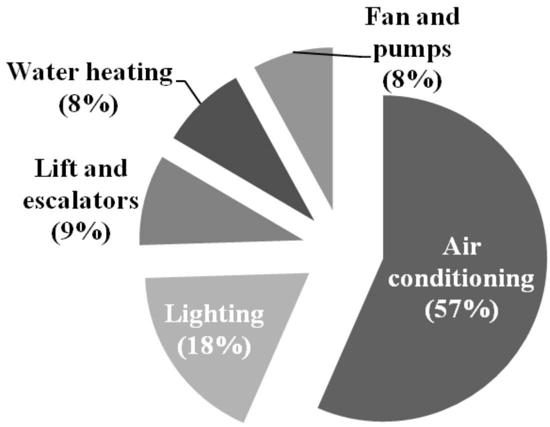


Figure 2 The percentages of energy end uses from 34 sampled hotels**.**

The energy end use from the sampled hotels in Thailand is similar to that from 16 sampled hotels in Hong Kong [3]. It is found that air conditioning was the highest electricity consumption (45%), followed by miscellaneous (31%), lighting (17%) and elevators and escalators (7%) [3]. Similarly, energy end use from the air conditioning of Cairns Hilton hotel in Australia was also the highest share accounted for 37.4% [7]. Due to hot and humid climate in Thailand, the contribution of electricity used for air conditioning in hotels is tentatively higher than the hotels located in temperate area. Adelphi has conducted the surveys in 125 hotels located in the Koh Chang designated area, Thailand. The study reported that cooling is the main end use of electricity consumption. The electricity was mainly consumed for cooling and refrigeration which accounted for 45 % and 6%, respectively [18]. The analysis of energy end use from this study indicated that the hot sports of electricity consumption in hotel building in Thailand were air conditioning and lighting. Thus, the appropriate energy conservation in there functions should be implemented.

3.2.3 Correlations of hotel's characteristics and electricity consumptions

Table 4 shows Pearson correlation between monthly electricity consumption and independent variables which were hotel characteristics listed in Table 1 and 2. It is noticed that only six variables (number of guest rooms, number of floors, number of workers, monthly average number of guests, monthly average number of room nights and GFA) are proportionally correlated with the electricity consumptions at the significant level of 0.01. While, the hotel location in Bangkok (dummy variable, 1 for hotels located in Bangkok, and 0 for hotels located in other regions) is proportionally correlated with the significant level of 0.05. The other variables are insignificant. Regression analyses were further conducted to correlate monthly hotel electricity consumption with the significant determinants.

Table 4 Pearson correlations between monthly electricity consumption and hotel characteristic variables.

Variables	Pearson Correlation
Number of guest rooms	.743[b]
GFA	.818[b]
Number of floors	.520[b]
Bangkok	.269[a]
Number of workers	.804[b]
Monthly average room night	.771[b]
Monthly average number of guests	.770[b]

a: The correlation that significant at the 0.05 level (2-tailed).
b: The correlation that significant at the 0.01 level (2-tailed).

GFA exhibited the best correlation with the hotel monthly electricity consumption, followed by the number of workers, the monthly average room night, monthly number of guests, number of guest rooms, number of floors and hotels location in Bangkok. The linear regression of GFA and the hotel monthly electricity consumption was illustrated in Figure 3 with the R^2 of 0.6698.

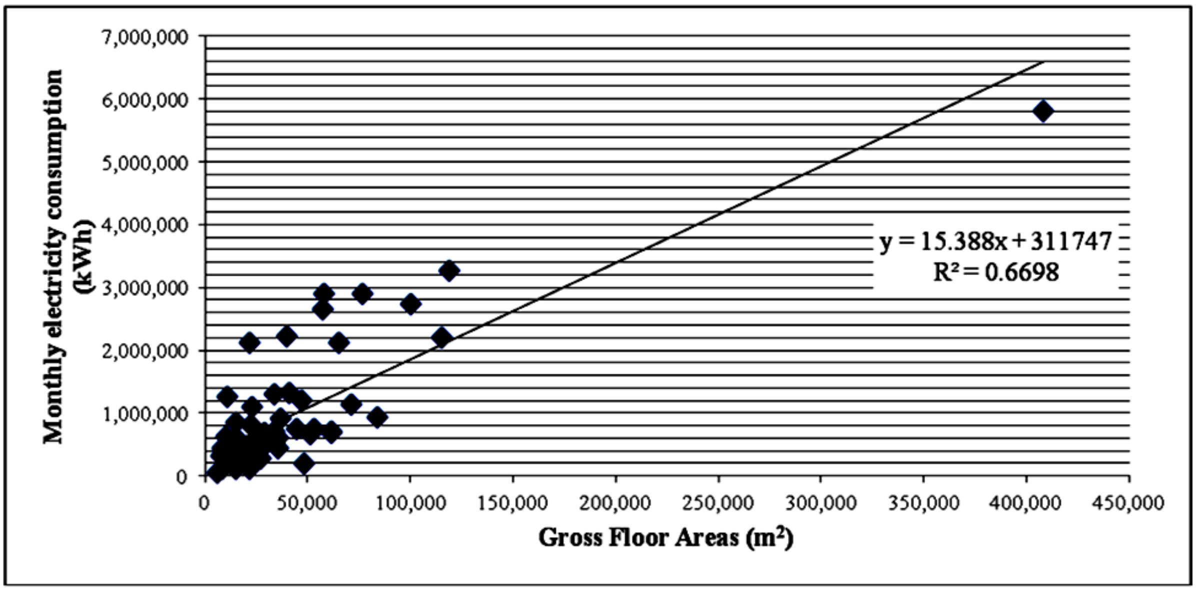


Figure 3 Monthly average electricity consumption (kWh) and GFA (m^2).

The hotel characteristic factors affecting electricity consumption from this study are consistent with the other studies in Singapore, Australia, Japan, Hong Kong, USA and European countries similar to this study, the main factor affecting energy use in Singapore, Australia Japan and Europe hotels was GFA [4, 7, 19-20]. The relationship between energy consumption of 51 hotels in Australia and GFA was not particularly strong for accommodation hotels and resorts but the relationship was much stronger for business hotels [7]. In 29 hotels in Singapore, GFA strongly correlated with total energy consumption (R^2 = 0.90) and electricity consumption (R^2 = 0.86). While, number of workers and guest rooms correlated with electricity consumption as R^2 of 0.81 and 0.72, respectively [4]. The number of room nights affected energy use in hotels located in Singapore, Europe, Trang Province in Thailand and San Francisco in the USA [4, 19, 21-22]. In Hong Kong hotels, the number of guests was found to be a main factor affecting energy use in hotels [3].

Unlike hotels located in temperate and microthermal climates, hotels located in tropical areas like Thailand usually keep air-conditioning on in guest rooms even when they are not occupied in order to make the room more comfortable. As a result, the average electricity consumption of hotels in Thailand was higher than others. Hotel’s worker was one of the significant factors influencing the electricity demand in hotels. This is because the hotel staffs were also defined as electricity consumers. With an increase in worker numbers, the average electricity consumption of the hotel was also increased. Similarly, number of guests which can be expressed in terms of room night significantly affected the electricity consumption in Thailand’s hotels. This result is in agreement with the studies in Hong Kong and a 5-star Cyprus hotel. The studies of Hong Kong and a Cyprus hotel indicated that electricity consumption strongly correlates with the number of guests (R^2 = 0.93 and 0.95, respectively) [3, 23]. The hotels located in Bangkok were mostly commercial hotels. Excluding accommodation, some hotels provided catering or restaurant services, conference rooms and entertainment venues. These luxury services caused significant increase in energy intensity. Similar to, the report from the Energy Conservation Center of Japan, hotels provided banquet service (hall, meeting rooms and ballroom), food and drink service (bars, restaurants, Karaoke, etc.), bathhouse and sauna, esthetic salon, athletic and swimming pool had large energy intensity [20]. However, this study provided the interesting results that Green leaf certificate did not show the significant correlation with electricity consumption as we expected. The Green leaf certificate is an environmental standard of Green Leaf Foundation, Thailand. The criteria of Green leaf certification is composed of 18 sections with 367 indicators covering various aspects such as policy, personal development, waste management, indoor air quality, facilities and services, culture promotion and efficiently use of water and energy. Among all indicators, the indicators regarding to energy conservation are found to be only 12% [24]. Therefore, hotels that received Green leaf certificate might have low scores in energy conservation section but have high scores in other aspects. In order to increase awareness and promote energy conservation in hotel industry, the criteria of Green leaf certification should be paid more attention in quantitative indicators that strongly affect energy consumption or given more weighting on energy related indicators.

According to the correlation results, the electricity consumption was affected by both adjustable inputs such as number of workers, number of guests and room nights, and non adjustable inputs such as GFA and guest rooms. Even though number of workers was defined as a significant controllable input, it is difficult to reduce the number of workers in the hotels due to the fact that hotels should maintain the quality of services. Thus, the comparative ECIs proposed by normalizing the electricity consumption with the uncontrollable inputs as GFA and guest rooms were more reasonable than normalizing with the controllable inputs. However, the ECI in the unit of kWh/room night was also investigated in order to find out how much electricity consumed per room night. This information will be beneficial to improve electricity efficiency and conservation of hotels in Thailand.

3.2.4 ECIs of hotel buildings in Thailand

The ECIs obtained from this study in the unit of kWh/m^2/year are compared with the ECIs from other studies as shown in Table 5.

Table 5 The comparison of the annual ECIs from this study and other studies.

Studies	Number of hotels	Units of ECIs		
		kWh/m^2/year	kWh/guest room/year	kWh/room night/year
Thailand (this study)	63	321.84	35,210.40	2,292.36
Singapore (4)	29	361.39	25,460.00	X
Hong Kong (3)	1	266.75	X	X
Australia (7)	51	218.83	X	X
Hilton (19)	73	179.59	X	X
Scandic (19)	111	137.65	X	X
Greece (14)	1	X	3,196.99	X

X: Not applicable

According to Table 5, the differences of ECIs were influenced by climate. As discussed previously, electricity was the primary energy source, which was used to power HVAC in the tropical climate hotels. The hotels located in dry climates and cold climates need lower electricity consumption than the hotels located in moist tropical climates. Thailand, Singapore and Hong Kong are in a moist tropical climate. The annually average temperature in Thailand is 26.8 ^{o}C [25]. Hong Kong's climate is subtropical and monsoonal with cool dry winters and hot wet summers while Australia and most of Europe countries are in temperate zone, dry climate, and cold climates [26-27]. As a result, the annual ECIs of hotels in Thailand and Singapore were higher than that of Australian, European and Greece hotels. Not only the annual ECI in unit of kWh/m^2 were proposed in this study, the annual ECIs in unit of kWh/guest room and kWh/room night were also calculated.

3.3. Factors influencing ECI and predictive model

3.3.1 Secondary Energy Drivers

The Pearson correlations between monthly ECIs in units of kWh/m^2, kWh /guest room and kWh/ room night and 24 independent variables as secondary energy drivers were investigated. A list of these independent variables as well as their Pearson correlations with the monthly ECIs are shown in Table 6.

Table 6 Pearson correlations between monthly ECIs in kWh/m^2, kWh/guest room and kWh/room night and significant independent variables.

Variables	Pearson correlation		
	kWh/m^2	kWh/guest room	kWh/room night
Worker density	.615^a	-	-
OR	-	-	-.253^b

a: The correlation that significant at the 0.01 level (2-tailed).
b: The correlation that significant at the 0.05 level (2-tailed).

Worker density had positive correlations with monthly ECI in kWh/m^2 at 99% confidential level. However, OR had negative correlation with monthly ECI in kWh/room night which was significant at the 95% confidential level. The others were insignificant. The R^2s of the two factors were 0.3782 and 0.0640, respectively. The R^2s indicates that worker density can explain 37.82 % of the variation of electricity use in kWh/m^2 while OR can explain 6.40 % of the variation of electricity use in kWh/room night. It is reasonable that more OR can significantly decrease ECI in the unit of kWh/room night. On the contrary, excess worker density leads to a significant increase in electricity consumption. Accordingly, the relevant energy conservation measures of hotel industry should be paid more attention on worker density and OR. The number of workers per floor area should be optimized to decrease the ECI of the hotel. Moreover, the proactive sales and customer services should be implemented to increase the OR.

3.3.2 The Predictive Regression Model

The predictive regression model was determined by a stepwise linear regression using by the statistical software package SPSS. The monthly ECIs (kWh/m^2, kWh/guest room and kWh/room night) and 24 independent variables were applied as dependent variables and potential independent variables, respectively. The predictive regression models in Log scale and their R^2 are shown in Table 7.

Table 7 The predictive regression models of the relationships between ECIs and characteristics of hotels in Thailand.

Unit of dependent variables (Y)	Predictive models	R^2
kWh	$\text{Log}(Y_A) = 2.190 + (0.705)\text{Log(workers)} + (0.424)\text{Log(GFA)}$	0.649
kWh/m^2	$\text{Log}(Y_B) = 0.806 + (0.560)\text{Log(worker density)} – (0.277)\text{(the 3-star hotel)}$	0.309
	$\text{Log}(Y_C) = 0.529 + (0.560)\text{Log(worker density)}$	
	$\text{Log}(Y_D) = 0.806 + (0.560)\text{Log(worker density)}$	
kWh/guest room	$\text{Log}(Y_E) = 4.832 + (0.723)\text{Log (workers)} – (7.615)\text{Log(guest rooms)} + (0.498)\text{Log(GFA)} + (6.472)\text{Log(room-nights)} – (6.074)\text{Log(OR)}$	0.614
kWh/room night	$\text{Log}(Y_F) = 4.832 + (0.723)\text{Log(workers)} + (5.472)\text{Log(room-nights)} + (0.498)\text{Log(GFA)} – (6.615)\text{Log(guest rooms)} – (6.074)\text{Log(OR)}$	0.622

$\text{Log}(Y_A)$: The predicted average electricity consumption in kWh
$\text{Log}(Y_B)$: The predicted ECI in kWh/m^2
$\text{Log}(Y_C)$: The predicted ECI in kWh/m^2 for the 3-star hotel
$\text{Log}(Y_D)$: The predicted ECI in kWh/m^2 for the 4 and 5-star hotel
$\text{Log}(Y_E)$: The predicted ECI in kWh/guest room
$\text{Log}(Y_F)$: The predicted ECI in kWh/room night

According to the predictive regression models, there are lots of factors influencing electricity consumption. Some factors are related to physical characteristic of hotels and designs such as number of guest rooms and GFA. Some factors are relevant to hotel's operations such as star rating, number of room nights, number of workers, worker density and OR. Among all factors, number of workers and worker density were found to be important factors affecting the electricity consumption and ECIs. Moreover, the electricity consumption was also proportional to GFA. The Star rating had the significant effect on the ECI in the unit of kWh/m^2. In comparison to the four and five–star hotels, the three-star hotels consumed less electricity per floor area. This is in accordance with our previous discussion. Apart from number of workers and GFA, guest room and OR showed the negative relationship with the ECI in the unit of kWh/guest room and kWh/room night. While, number of room nights had positive correlation on hotel's electricity consumption. These results are meaningful for setting up management programs regarding to electricity conservation in hotels. Even though there is nothing to do with the hotel characteristic factors such as number of guest rooms and GFA to decrease the electricity consumption in the existing hotels, some hotel operational factors such as number of room nights, number of workers, worker density and OR are able to be optimized to achieve the lowest electricity consumption whereas the hotels still maintain the quality of their functions and services.

4. Conclusion

In this study, the majority of the sampled hotels in Thailand were the hotels that consume electricity, LPG and diesel which were accounted for 63%. The highest share of energy consumed in the sampled hotels belonged to electricity with the average contribution ranged from 69% to 94%. The electricity was mainly consumed for air conditioning (57%), followed by lighting (18%), escalators (9%), water heating (8%), and fans and pumps (8%). The ECIs of the sampled hotels in Thailand were 321.84 kWh/m^2/year, 35,210.40 kWh/guest room/year and 2,292.36 kWh/room night/year. Pearson correlation indicated that worker density had positive effect on monthly ECI in kWh/m^2 at 99% confidential level. While OR had negative effect on monthly ECI in kWh/room night at the 95% confidential level. The predictive regression model revealed that the factors related to hotel's staffs such as numbers of worker and worker density were the important factors affecting the electricity consumption. The optimization of hotel's workers during low season and high season as well as the capacity building and training were recommended to reduce energy consumption. The Star rating also had a major impact on energy consumption. Thus, the Star rating scheme should be used as a tool to encourage the hotels establishes the energy reduction program.

5. Acknowledgement

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6. References

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