

# A STUDY ON ENERGY CONSUMPTION OF HOTEL BUILDINGS IN VIETNAM

Mac Van Dat<sup>a</sup>, Tran Ngoc Quang<sup>a,\*</sup>

<sup>a</sup>*Faculty of Environmental Engineering, National University of Civil Engineering,  
55 Giai Phong road, Hai Ba Trung district, Hanoi, Vietnam*

## **Article history:**

*Received 13 July 2018, Revised 13 August 2018, Accepted 25 August 2018*

---

## **Abstract**

This paper aims to determine energy use intensity (*EUI*) and the percentage of end-use energy consumption in hotel buildings in major cities of Vietnam, including Hanoi, Da Nang and Ho Chi Minh City (HCMC). Data from 32 hotels were gathered from the website on energy efficiency promotion of Ministry of Construction. The average *EUI* in the whole country was 151 kWh/m<sup>2</sup>.year, and the figures for Hanoi, Da Nang, and HCMC were 184; 71 and 212 kWh/m<sup>2</sup>.year, respectively. At the same time, the structure of end-use energy consumption was estimated, of which 54% for heating, ventilation and air conditioning (HVAC), 10% for lighting, 19% for plug equipment and 17% for lifts.

**Keywords:** energy consumption; energy use intensity (*EUI*); end-use energy consumption.

[https://doi.org/10.31814/stce.nuce2018-12\(5\)-11](https://doi.org/10.31814/stce.nuce2018-12(5)-11) © 2018 National University of Civil Engineering

---

## **1. Introduction**

Hotels are classified as one of the highest energy consumption building categories. According to [1], hotels together with offices and retails were the most energy consumption, typically accounting for over 50% of the total energy consumption in UK, 64% in US, and 85% in Spain. In a study on the energy efficiency of 29 hotel buildings in Singapore, the average energy use intensity (*EUI*) in these hotel buildings was determined as 427 kWh/m<sup>2</sup>.year [2]. In a similar study of 16 hotels in Hong Kong, the average *EUI* was calculated about 564 kWh/m<sup>2</sup>.year [3]. And the average *EUI* for hotel buildings was 160 kWh/m<sup>2</sup>.year in New Zealand [4].

In recent years, the number of hotel buildings has been increasing rapidly in Vietnam. By the end of 2016, the number of upper 3-star hotels reached 784 in Vietnam, 31.1% higher compared to those in 2013 [5]. Simultaneously, the number of visitors came to HCMC, Hanoi, and Da Nang has kept increasing in recent years [5]. High demand for hotel service is associated with the massive consumption of energy, and it is an important issue that needs to be solved in Vietnam. However, there was only a study in 2000 mentioned on energy consumption of hotels in Vietnam [6]. Therefore, this paper aims to generalize the situation of electrical energy consumption for hotel buildings in three largest cities in Vietnam, and primary assess factors affecting energy consumption in this building category.

---

\*Corresponding author. E-mail address: [quangtn@nuce.edu.vn](mailto:quangtn@nuce.edu.vn) (Quang, T. N.)

## 2. Methodology

### 2.1. Source of data and classification of hotels

Data used for this study were gathered from the website on energy efficiency promotion of Ministry of Construction, which built up based on surveys data for buildings in Vietnam in 2015 by the project “Vietnam Clean Energy Program - VCEP”. Data for hotel buildings in Hanoi, Da Nang and HCMC were collected by survey form, which consists of information on building characteristic, architecture and energy consumption by building equipment. At the same time, the comfort and luxury levels of hotels normally classified by star (from 3-star to 5-star) were applied for the energy consumption assessment.

### 2.2. Calculation of energy use intensity

#### a. Building energy use intensity (EUI)

Energy use intensity (EUI) is expressed by a ratio between annual energy consumption and total gross floor area (GFA) of building. The formula is as below [7]:

$$EUI = \frac{\text{Annual Energy Consumption}}{GFA} \quad (1)$$

where  $EUI$  is energy use intensity (kWh/m<sup>2</sup>.year); Annual Energy Consumption is energy consumption of the building for one year (kWh);  $GFA$  is total gross floor areas of the building including basement floors (m<sup>2</sup>).

Energy consumption of the building was calculated based on monthly electricity bills in the year of 2015, while  $GFA$  data were gathered from as-built drawings and/or directly measured on site.

#### b. End-use energy consumptions

End-use energy consumption, including heating, ventilation and air conditioning (HVAC), lighting, plug equipment and lift was determined based on the number of equipment and their installed capacity, coincident factor, operating time, capacity used factor.

First, energy consumptions of lighting and lift are determined by formulas:

$$EC_{day} = \sum_{i=1}^n (n_i \cdot P_i \cdot h_i \cdot K_i \mu_i) \quad (2)$$

$$EC_{year} = EC_{day} \cdot D \cdot K \quad (3)$$

where  $EC_{year}$  is daily energy consumption (kWh/day);  $n_i$  is the quantity of lamps or lifts type  $i$ ;  $P_i$  is the installed capacity of lamps or lifts type  $i$  (kW);  $h_i$  is the daily operating time of lamps or lifts type  $i$  (hours),  $K_i$  is the coincident factor of lamps or lifts type  $i$ ;  $\mu_i$  is the efficiency of lamps or lifts type  $i$ ;  $EC_{year}$  is annual energy consumption (kWh/year);  $D$  is the number of days lamps or lifts operated in a year (day);  $K$  is lamps or lifts coincident factor.

Second, energy consumption by HVAC is total electric energy consumption of split and centralized air conditioners. Split air conditioner is determined by formula (2) and (3), while centralized air conditioner (CAC) is determined as below:

$$EC_{day}^{Center} = (Q_i / COP_i) \cdot K_i \cdot h_i \quad (4)$$

$$EC_{year}^{Center} = EC_{day}^{Center} \cdot D \cdot K \quad (5)$$

where  $EC_{day}^{Center}$  is daily energy consumption (kWh/day);  $Q_i$  is the cooling capacity of CAC type  $i$  (kW);  $COP_i$  is the coefficient of performance of CAC $_i$ ;  $K_i$  is the coincident factor of CAC type  $i$  during a day;  $h_i$  is the duration of daily operation of CAC type  $i$  (hours);  $EC_{day}^{Center}$  is annual energy consumption (kWh/year);  $D$  is the duration of annual CAC operation (day);  $K$  is CAC coincident factor.

Finally, energy consumption by plug equipment is estimated by extracting from the total building energy consumption by excluding the energy consumption of HVAC, lighting and lift.

### 2.3. Data analysis

Data analysis is based on SPSS software version 16.0 (SPSS Inc.) with a confidence level of 5%.

## 3. Results and discussion

### 3.1. General information on surveyed hotel buildings

The information of 32 hotel buildings in Hanoi, Da Nang and HCMC was analyzed and presented in Table 1. By locations, the number of hotels was comparable among three cities, of which 9 buildings (28%) in Hanoi, 12 (37%) in Da Nang, and 11 (35%) in HCMC.

The classification of hotels by their star is presented in Table 1. The number of 4- and 5-star hotels (over 75%) were higher than 3-star hotels (below 25%) in Hanoi and HCMC, while it is opposite in Da Nang, where the figure for 4- and 5-star hotels was lower than 3-star hotels (42% and 58%, respectively).

Table 1. General statistic of surveyed hotels in three major cities in Vietnam

Type of hotel	Hanoi		Da Nang		HCMC	
	Number	%	Number	%	Number	%
3-star	2	22.2%	7	58.3%	1	9.1%
4- and 5-star	7	77.8%	5	41.7%	10	90.9%
Total	9	100%	12	100%	11	100%
% for whole country	28%		37%		35%	

### 3.2. Electric energy consumption

#### Monthly electric energy consumption

According to the data from monthly electricity bills, it is clear that building electric energy consumption in Hanoi was higher in summer and winter (May to November). In Da Nang, highest building energy consumption was during summer (June to August), while building energy consumption in HCMC was quite stable all year round (Fig. 1). The energy consumption for lighting, lift and equipment was quite stable round the year, while HVAC is heavily dependent on weather conditions [2]. With high temperature all year round, energy consumption for HVAC in HCMC was highest, while in Da Nang, HVAC energy consumption is just few summer months, leading to lowest building energy consumption. In case of Hanoi, HVAC is used for both hot summer months (cooling) and cold winter months (heating), it makes hotel energy consumption in Hanoi be higher compared to those in Da Nang, but still lower than those in HCMC.

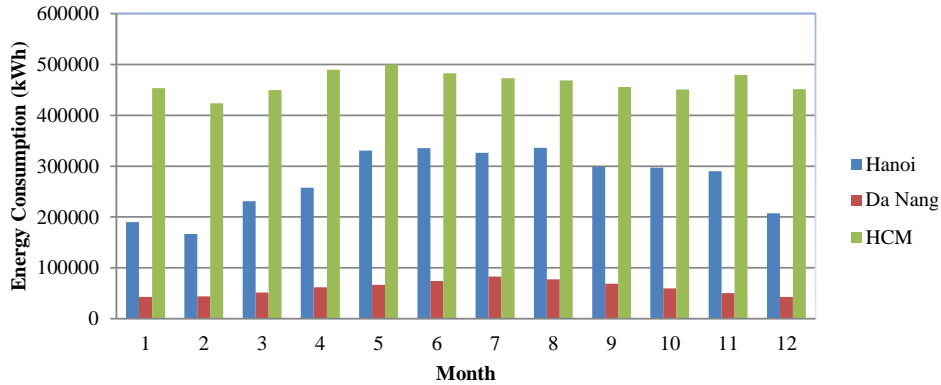


Figure 1. Average monthly energy consumption of hotel buildings in Vietnam

### Key end-use energy consumption

The percentages of end-use energy consumption of the hotel buildings in Vietnam are shown in Table 2. Overall, the percentage of energy consumption for HVAC was highest with 54%, the figure for lighting was lowest at 10%, while the figures for equipment and lift were 19% and 17%, respectively. The results of this study were similar to those in US, UK, Spain [1] and Hong Kong [3] (Table 3).

Table 2. The percentage of end-use energy consumptions at hotel buildings in three cities in Vietnam

Energy end uses	Hanoi		Da Nang		HCMC		Vietnam	
	Mean (%)	SD	Mean (%)	SD	Mean (%)	SD	Mean (%)	SD
Lighting	12	7	7	6	12	7	10	7
Equipment	17	8	23	19	16	7	19	13
HVAC	50	12	53	24	60	18	54	19
Lift	21	10	18	18	11	11	17	14
Total	100		100		100		100	

Table 3. The comparisons of end-use energy consumptions of hotel buildings in Vietnam and the World

Energy end uses	This study (%)	USA (%)	UK (%)	Spain (%)	Hong Kong (%)
Source		[1]	[1]	[1]	[3]
Lighting	10	22	17	33	17
Equipment	19	13	5	10	-
HVAC	54	48	55	52	45
Lift	17	-	-	-	7
Others	-	21	23	5	31

Overall the percentage of energy consumption for HVAC was highest, at about 50%, 53% and 54% in Hanoi, Da Nang and HCMC, respectively; for lighting ranged of 7–12%; while equipment from 16–23% and lift from 12–21% (Table 2, Fig. 2).

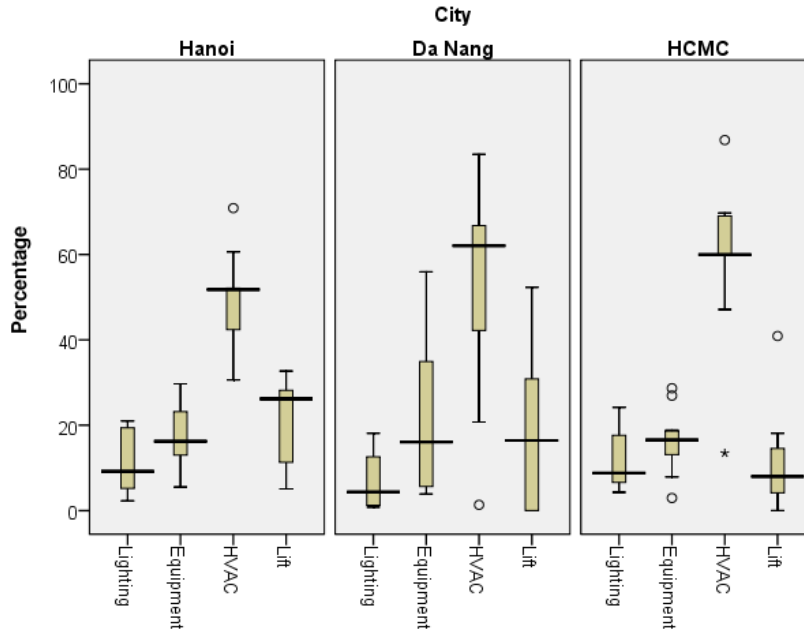


Figure 2. The percentage of end-use energy consumptions of hotel buildings in Vietnam

### 3.3. Energy use intensity (EUI)

The statistical description of *EUIs* for hotel buildings is presented in Table 4. The average *EUI* for the whole country was 151 kWh/m<sup>2</sup>.year; the detail figure for Hanoi, Da Nang and HCMC was 184; 70.6 and 212.3 kWh/m<sup>2</sup>.year, respectively.

Table 4. *EUIs* of hotel buildings in three cities in Vietnam (kWh/m<sup>2</sup>.year)

City	Number of Hotel	Mean	Std. Deviation	Maximum	Minimum
Hanoi	9	184.0	59.16	265.90	99.65
Da Nang	12	70.6	48.28	203.35	28.16
HCMC	11	212.3	59.62	326.15	115.24
Whole Country	32	151.2	83.85	326.15	28.16

The difference of hotel *EUIs* in different regions could be understood. Firstly, energy consumption of hotel buildings depends on the number of visitors in a year [8]. Secondly, the main reason is the influence of climate conditions. The relationship between energy consumption of HVAC (the highest energy usage in the buildings) and weather conditions was studied by many researchers [2]. In this study, Hanoi (the north of Vietnam) represents for monsoon tropical climate with hot and humid weather during summer and cold weather during winter; while HCMC (the south of Vietnam) locates at a hot climate region with high yearly average ambient temperature. Da Nang (the center of Vietnam) is middle of the two regions, where the weather is milder. These climate conditions are strongly influenced the use of energy for building air conditioning. The lowest hotel energy consumption in Da Nang may be due to the practice of visitors. Unlike Hanoi and HCMC, visitors in Da Nang usually spend more their time outside going to the beach, traveling to attracted tourism places in and

surrounding Da Nang than staying inside hotels. Furthermore, during nighttime, they can open hotel room windows for utilizing natural beach cool wind instead of using air conditioning.

The other reason to consider is that the energy consumption in hotels is strongly dependent on their stand (number of star). Across the country the average *EUI* of 4- and 5-star hotels was about 170 kWh/m<sup>2</sup>.year, significantly higher than that at 3-star hotels (111 kWh/m<sup>2</sup>.year) (Fig. 3). According to [6], the average *EUI* of 4-star hotels was identified 141 kWh/m<sup>2</sup>.year, which was lower than this study, but for 3-star hotels of 143 kWh/m<sup>2</sup>.year, which higher compared to this study. For international comparison, the average hotels *EUI* of this study were lower than those in Spain, where the average *EUI* of 4- and 3-star hotels were about 179 and 129 kWh/m<sup>2</sup>.year, respectively [9]. The other study in Shanghai was determined that average *EUI* of 3-, 4- and 5-star hotels were about 126, 235 and 280 kWh/m<sup>2</sup>.year, respectively [10] (Fig. 3).

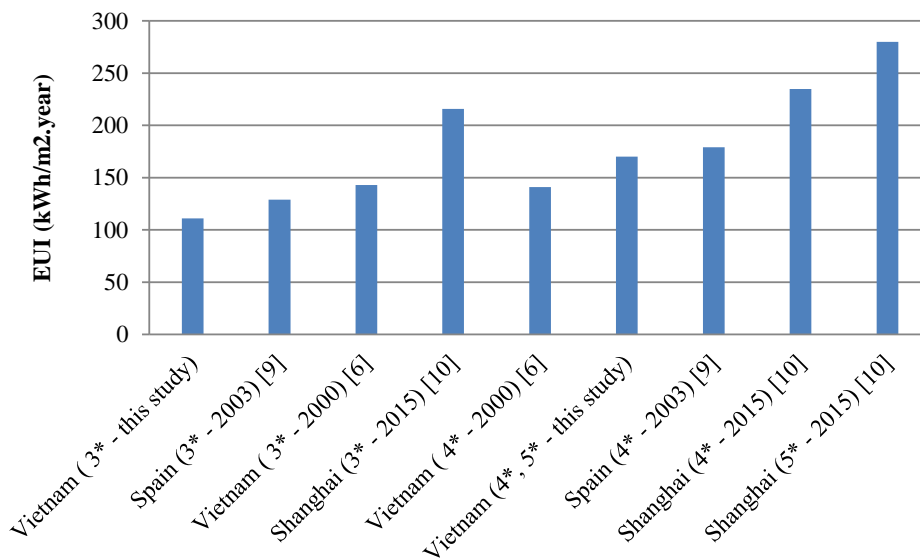


Figure 3. Average *EUI* of 3-, 4- and 5-star hotels in Vietnam and the world

### ***EUI* of hotel buildings in Vietnam and the World**

Overall, the average *EUI* of hotel buildings in Vietnam was about 151 kWh/m<sup>2</sup>.year, which was lower than those in other countries [1–4, 8, 11–13].

There are many studies about average *EUI* of hotel buildings in Asia. In Singapore, the average *EUI* of 29 hotel buildings was about 427 kWh/m<sup>2</sup>.year [2], while the figures for Taiwan [8], Hong Kong in 1994 [11] and Hong Kong in 1998 [3] were about 295, 366 and 564 kWh/m<sup>2</sup>.year respectively (Fig. 4).

Compared with some countries in Europe and the USA, the average *EUI* for this study was also lower. In the USA (2003), the figure was identified about 316 kWh/m<sup>2</sup>.year [1], while the average *EUI* for New Zealand in 2000 [4], Europe (Hilton International) [12] and Turkey [13] were about 160, 364, and 388 kWh/m<sup>2</sup>.year respectively (Fig. 4).

The reasons for the *EUI*s of hotel buildings in Vietnam lower than other hotels worldwide could be:

1. Due to the difference in climate conditions – actually, the summer in Europe [12, 13] and New Zealand [4] is cooler, but their winter is longer and extremely colder. It requests more energy

consumption for building heating. In case of Singapore [2], the country is near the equator with year around hot climate. Therefore, they consumed more energy for air cooling.

2. Due to the difference in the definition of building energy consumption: in this study, only electric energy was counted for, while in others [3, 8], it included oil and gas.

3. Due to the difference in the calculation of building gross floor area (*GFA*), which was the total area of all building floors, including basements, while others [2, 3] only counted from ground and upper floors.

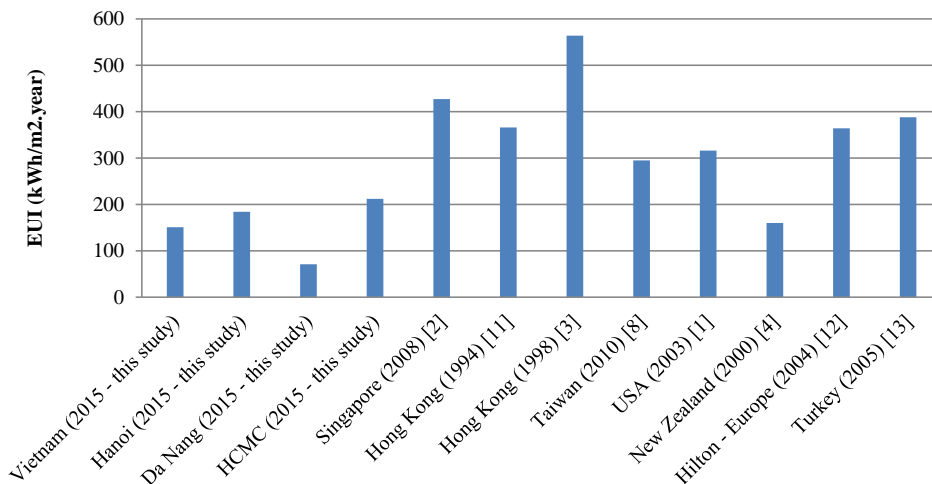


Figure 4. The figures compare average *EUI* between this study and other countries

#### 4. Conclusion

The total building and their end-use energy consumption and average EUIs of 32 hotel buildings in Hanoi, Da Nang and HCMC were quantified. Average *EUI* of hotels building was 151 kWh/m<sup>2</sup>.year. It was significantly lower than other hotels worldwide. The percentages of end-use energy consumptions were estimated for 54%, 10%, 19% and 17% for HVAC, lighting, plug equipment and lift, respectively. The results were relevant to those in some oversee countries.

#### References

- [1] Pérez-Lombard, L., Ortiz, J., Pout, C. (2008). [A review on buildings energy consumption information](#). *Energy Build*, 40(3):394–398.
- [2] Priyadarsini, R., Xuchao, W., Eang, L. S. (2009). [A study on energy performance of hotel buildings in Singapore](#). *Energy and Buildings*, 41(12):1319–1324.
- [3] Deng, S.-M., Burnett, J. (2000). [A study of energy performance of hotel buildings in Hong Kong](#). *Energy and Buildings*, 31(1):7–12.
- [4] Becken, S., Frampton, C., Simmons, D. (2001). [Energy consumption patterns in the accommodation sector—the New Zealand case](#). *Ecological Economics*, 39(3):371–386.
- [5] Vietdata (2016). [General statistic of international and domestic visitors arrived Vietnam in 2015](#).
- [6] Trung, D. N., Kumar, S. (2005). [Resource use and waste management in Vietnam hotel industry](#). *Journal of Cleaner Production*, 13(2):109–116.

- [7] Yahya, S. N. N. S., Ariffin, A. R. M., Ismail, M. A. (2015). [Building energy index and students' perceived performance in public university buildings](#). In *Renewable Energy in the Service of Mankind Vol I*, Springer, 541–550.
- [8] Wang, J. C. (2012). [A study on the energy performance of hotel buildings in Taiwan](#). *Energy and Buildings*, 49:268–275.
- [9] Rosselló-Batlle, B., Moia, A., Cladera, A., Martínez, V. (2010). [Energy use, CO2 emissions and waste throughout the life cycle of a sample of hotels in the Balearic Islands](#). *Energy and Buildings*, 42(4): 547–558.
- [10] Yao, Z., Zhuang, Z., Gu, W. (2015). [Study on energy use characteristics of hotel buildings in Shanghai](#). *Procedia Engineering*, 121:1977–1982.
- [11] Lam, J. C., Chan, A. L. S. (1994). [Characteristics of electricity consumption in commercial buildings: Survey of electricity consumption in fully air-conditioned office buildings and hotels in Hong Kong, implications for energy conservation in buildings](#). *Building Research and Information*, 22(6):313–318.
- [12] Bohdanowicz, P., Martinac, I. (2007). [Determinants and benchmarking of resource consumption in hotels—Case study of Hilton International and Scandic in Europe](#). *Energy and Buildings*, 39(1):82–95.
- [13] Öñüt, S., Soner, S. (2006). [Energy efficiency assessment for the Antalya Region hotels in Turkey](#). *Energy and Buildings*, 38(8):964–971.