

A Study on the Characteristics of Energy Consumption in University Dormitory

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Abstract. This study presents the quantitative by analyzing the energy consumption characteristics of university dormitory. For analysis, it has collected the data of energy consumption by year and month, and has measured the electricity consumption in a 5-minute unit for one month. The target building, mainly consisting of 2-person rooms and 4-person rooms, has an individual cooling system using EHP, and a central heating using LNG. When looking at the energy consumption patterns, the energy used for heating and hot-water supply was the largest with 64%. Compared to the weekend, the weekday electricity consumption was bigger, and peak load occurred between 19:00 and 24:00. The results of analysis by dormitories, for men, the electricity consumed in 2-person rooms and 4-person rooms were similar, but for women, 4-person rooms used twice the electricity than the 2-person rooms.

Keywords: University dormitory, Energy consumption, Peak load

1 Introduction

Even though the dormitory is mainly used for residential use, being equipped with shared spaces such as reading rooms, PC rooms, and sports facilities, it shows different energy consumption aspects to that of apartment housing. In addition, since the dormitory is used by a large number of residents in a limited space, the energy consumption density is high. However, the energy costs are not born by themselves, the energy use for users is relatively free. In addition, since a large number of non-family populations live together in the same space, it is believed to show different energy consumption patterns to that of apartment housing. Therefore, there is a need to analyze the energy consumption patterns of dormitories, and derive the factors that affect the energy consumption of the building. This study, in order to analyze the energy consumption characteristics in an university dormitory, was performed at K' University's dormitories in Daegu. The buildings within the investigation target site are capable of accommodating students up to a 2,000-person scale, and have enough

samples for analyzing the energy consumption patterns by room types, residential characteristics, and building characteristics. For analysis, this study has investigated annual, monthly energy use data, building characteristics, and cooling and heating operations schedule. In particular, in order to determine and analyze the hourly electricity usage, it has measured and recorded the electricity meter of each building in a 5-minute unit for one month.

Based on this, this study, has analyzed the energy consumption patterns by period and application that have been used in the subject site. Then, by comparing and analyzing the amount of electricity used in each building, it has attempted to derive the energy consumption characteristics and the factors that affect these characteristics.

2 Characteristic of target building

An overview of the target buildings is shown in Table 1. The target buildings are 7 buildings, all of which use an individual cooling system using EHP. Heating and hot-water supply are operated by a central heating system using gas (LNG). The electricity is used for cooling, lighting, and general electronic equipments used by residents, and the gas is used for heating and hot-water supply.

The target buildings offer cooling only in summer through means of providing control devices to residents. Residents, even though they are recommended to reduce the use of air conditioning during the peak time of the day, are able to operate the air conditioning in relative freedom, because there are no other systematic constraints. On the other hand, heating and hot water are controlled by administrators.

In the investigated target buildings, the majority of rooms are 2-person rooms with 66.2%, 4-person rooms are 41.9%, 3-person rooms are 1.3%, and 1-person rooms are 0.5%, thus mainly consisting of rooms for 2-person and 4-person rooms. The room area is 20.06m² for the 2-person room and 22.08m² for 4-person room, with no significant difference in the heating areas. For the target building, cooking was performed in a separate building, and health facilities such as shower rooms and restrooms were used in a sharing basis in the same building.

Table 1. Overview of Dormitories.

	Scale	Area(m ²)	capacity	Gender	Room type		Energy use	
					Type	Number	Electricity	Gas(LNG)
A	B1,4F	4455.63	270	Male	2people	135		
B	B1,5F	5675.6	560	Male	2people	4	Cooling	Heating
C	B1,4F	4314.14	428	Female	4people	138		
					4people	107	Lighting	
D	B1,5F	4822.64	227	Male	1person	4		
					2people	104	Electronic equipment	Hot water
					4people	5		
E	B1,5F	5525.08	326	Female	2people	163		
F	B1,5F	4810.14	167	Male	2people	76		
					3people	5		
G	2F	882	52	Female	2people	26		

3 Analysis of energy consumption pattern

The energy sources used in the target building are electricity and gas. For comparison of the two energy sources, the consumption amount has been converted in a toe unit based on the Conversion table for energy calorie as of the 2011 standard that has been notified in laws and regulations. As a basis of the gross calorific value, applying the electricity of 2,300kcal and gas of 10,430kcal, this has converted in the toe by using the following equation.

$$\text{toe} = \text{calorific value(kcal)} / (10^7 \text{kcal}) \quad (1)$$

Figure 1 is a distribution in monthly energy consumption by use. Despite the subtle differences during the year, the public electricity and residential electricity consumption were generally similar throughout the year, and the use of electricity for cooling increased rapidly starting from June. Gas, while having used the largest amount in January, maintained a high amount of use in the winter vacation period, when the outside air temperature was the lowest. Since then, the amount of gas used was largely reduced from May, and it showed a low level during the summer. The overall energy consumption was greater in the winter season than that of the summer season. Through this, the energy load that generated in dormitories is considered to be largely affected by gas.

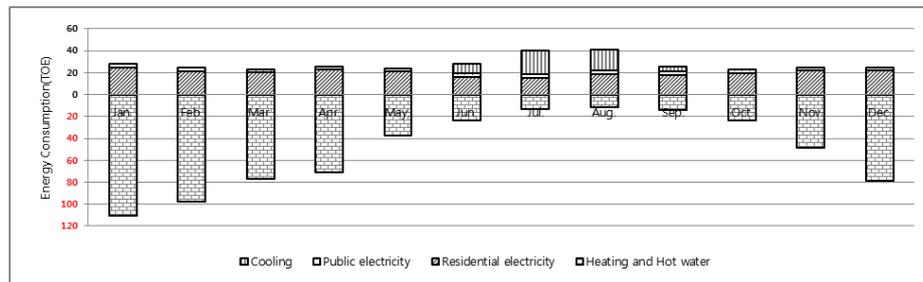


Fig. 1. Distribution in monthly energy consumption by energy use

Daily and hourly electricity consumption that have been used during the winter semester are shown in Figure 2. In the weekdays, there are differences for each day of the week, but it uses the largest electricity on Tuesday, and it was found that it uses more electricity on the weekdays than on weekends. The reason of low electricity use on weekends seems to be due to the fact that the administrative rests, and the accommodations do not offer their services. Moreover, even from the residents aspect, it is understood that their activity time gets slowed down with no class, and the time for external activities also grows longer.

In order to find out the electricity consumption propensity including the peak time of the day, by classifying as weekdays, Saturday, and Sunday, have we observed the amount used by the hour. The peak loads that occur in the target building have occurred between 19:00 and 24:00 in the three sectors. Weekdays and Sunday have similar levels in the peak load, but Saturday showed a lower one than the other days of the week. Unlike weekdays and on Sunday where there are classes next day classes, the occupancy rate gets lower for reasons such as the homecomings and gatherings.

When looking at the aspects of daytime electricity loads, the electricity loads during weekday increase from 07:00 when residents start activities for classes, and maintains in constant before and after 08:00. On the other hand, on Sunday, it can be seen that the electricity load is low because the cafeteria is not operating while the residents day starts to be slower. In the case of Saturday, the fluctuation in the electricity load appear large. Seeing this, most of the residents get up late on Sunday, but on Saturday, it is considered that the time that the residents start their activities are diverse.

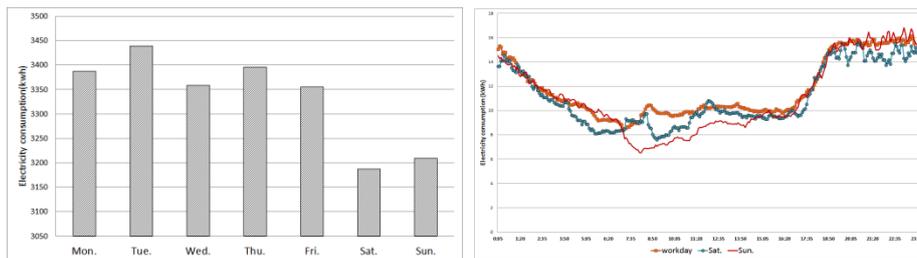


Fig. 2. Daily electricity consumption and hourly electricity consumption (5min unit)

Depending on room types and genders, we have analyzed the hourly electricity consumption patterns on the basis of weekdays. In order to minimize the error depending on factors, we have excluded building F with a high composition of business facilities and cafeteria, and building G with different architectural characteristics, from the analysis. The electricity consumption used in a single dormitory room is shown in Figure 3.

The electricity consumed in 4-person rooms was for women about 1.5 times to that for men. On the other hand, for 2-person rooms, although women consumed more electricity in the morning, men used about 1.5 times than women during the peak period. The electricity used in the men's dormitory showed no significant difference in 2-person rooms and 4-person rooms. On the other hand, in women's dormitory, 4-person rooms used more electricity, and in the case of the peak time, they used two times more in comparison to the 2-person rooms

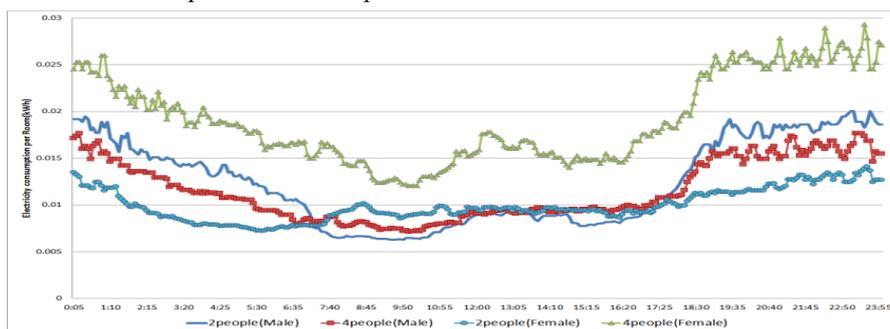


Fig. 3. Hourly electricity consumption used in single dormitory room (5min unit)

4 Conclusion and discussion

This study, with the target of K' University's dormitory, has investigated the energy consumption, and analyzed the energy consumption characteristics. In addition, it has considered the factors that affect the electricity consumption characteristics through a comparative analysis of the hourly electricity consumption amount of the target building. Its results are as follows.

(1) Target building, by application, has used energy in the order of heating and hot-water(64%), residential electricity(26%), cooling(6%) and public electricity(4%). The energy used for heating and hot-water supply out of the total energy consumption are superior to other applications. Therefore, there is a need for the introduction of the heating and hot-water supply facilities with high efficiency in cases of dormitory extension or planning in the future.

(2) For the electricity usage during the week, there is a difference for each day of the week, though the largest electricity is consumed on Tuesday. The electricity consumption on the weekend was smaller compared to the weekdays, which is considered that external activities of residents were more often than on weekdays. Also, for daytime electricity consumption, there is a variation for each section, though the time at which the peak electricity is generated has appeared between 19:00 and 24:00 for three sectors.

(3) As a result of having performed the analysis by dormitories, for the case of 4-person room, women have used electricity of 1.5 times compared to men. In addition, when comparing 2-person and 4-person rooms in the same gender ratio, men had no significant difference, whereas women used of two times more electricity in 4-person rooms than 2-person rooms.

This study's purpose is to analyze the energy consumption patterns in university dormitory, and to derive the factors that affect the electricity consumption characteristics, thus, considering that more efficient construction facility planning needs to be performed through this material.

Acknowledgments. This work was supported by the National Research Foundation of Korea(NRF) grant funded by the Korea government(MSIP) (NRF-2013R1A2A1A01014020).

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