International Journal of Hybrid Information Technology
Vol. 9, No.9 (2016), pp. 433-440
http://dx.doi.org/10.14257/ijhit.2016.9.9.39

A Study on the Living Behavior Associated Electricity Consumption of Single-Household in University Town

Jin-Woong Son[1], HyunCheol Seo[2], Won-Hwa Hong[3*], Jung-Ha Hwang[4] and Yong-Seo Park[5]

[1,2,3]School of Architectural, Civil, Environmental and Energy Eng.,Kyungpook National University, 80 Daehakro, Bukgu, Daegu, Rep. of Korea
[4,5]Department of Architecture and Architectural Engineering of Kyungpook National University, 80 Daehakro, Bukgu, Daegu, Rep. of Korea
sonjw1222@gmail.com[1], notsools@gmail.com[2], hongwh@knu.ac.kr[3], peter@knu.ac.kr[4], archipark@knu.ac.kr[5]

Abstract

In Korea, single-household is constantly increasing. Residential electricity consumption and living behavior at home are closely connected in single-household. Therefore, to determine electricity consumption characteristic of single-household, this study was investigated living behavior of single-household in university town using questionnaire survey. The survey, which focused on use of electric cooker, laptop and washing machine, investigated that 22% of respondents cooked everyday and they spent about 1 to 4hours per day using laptop and used washing machine two or three times a week. Derived electricity consumption in reference to this result was that laptop, washing machine and electric cooker consumed each 356.3W/week, 962.4W/week and 660.2W/week. Also expected reduction was each 5.7%, 24.6% and 46.5%.

Keywords: *Living behavior, Single-household, University town, electricity consumption characteristic, Questionnaire survey*

1. Introduction

The population structure is rapidly changing and the trend of changing to single-household is significant in Korea. Such single-household has shown the growth of more than 1.21 million of households in recent 10 years and it is expected to reach 24% of the total households in 2030[1][7]. As the importance of single-household emerges like this, various studies have been conducted, but they are focusing mainly on spatial distribution and improvement method of residential environment of single-households[2]. Usually, electricity consumption of residential building is greatly affected by the living behavior of resident. Especially, single-household is showing the different energy consumption pattern due to different lifestyle such as use of highly efficient small appliances, few appliances and a high frequency of eating out compared to traditional household[3]. Therefore, to establish rational energy planning, building database related to energy consumption of single-households is required, but it is a situation where relevant studies are lacking due to its diversity. Therefore, this study investigates living behavior of single-household of university town which is one of representative type of single-household through the questionnaire survey and analyzes electricity consumption characteristic and reduction level.

2. Material

According to the behavior classification table of life time survey, energy consumption behavior of resident is divided into essential life time, mandatory life time and leisure life

ISSN: 1738-9968 IJHIT

time and they are classified more specifically[4]. However, this study investigated energy consumption behavior based on previous research results on the energy consumption by the purpose of use shown in Table 1[5]. In electricity consumption by purpose of use in residential sector, heating takes the largest percentage, 62.9%. But heating energy mostly comes from non-electricity energy source. Therefore, this study conducted the questionnaire survey on cooking, hygiene and leisure which occupy relatively high ratio among living behaviors except for heating.

Table 1. Energy Consumption by Living Behavior in Residential Sector (TOE)

Type	Non electricity	Electricity	Total
Lighting	-	0.024(11.0)	0.024(1.9)
Heating	0.775(73.6)	0.023(10.8)	0.798(62.9)
Cooling	-	0.020(9.5)	0.020(1.6)
Leisure	-	0.020(9.3)	0.020(1.5)
Information	-	0.010(4.6)	0.010(0.8)
Hygiene	0.202(19.1)	0.031(14.6)	0.233(18.4)
Cooking	0.077(7.3)	0.086(40.2)	0.163(12.9)

Questionnaire was distributed for university students living in rental housing around Kyungpook national university located in Daegu for one month, October 2014. The contents of questionnaire consist of personal information, information of housing type and living behavior. Total of 30 questionnaires were collected and 27 questionnaires where 3 copies were excluded due to no answer or poorly answered were put into database. In order to estimate electricity consumption by energy consumption behavior, electricity consumption data of surveyed electronic devices were selected through literature review and they are shown in Table 2. The investigation was made based on small cooker with 3.5 serving capacity, drum washing machine of 7kg capacity and laptop which are frequently used in single-household. In case of electric cooker, electricity consumption by cooking was calculated based on standard which consist of cooking and 6hours of warming.

Table 2. Electricity Consumption Outline of Electric Device

Electric device	Content	Electricity consumption
Elc, Cooker	Cooking	163.4W
	Warm	28.6W
Laptop	In use	24W
	Standby	0.7W
Washing machine	In use (once)	363W

3. Investigation of Living Behavior of Single-Household

3.1. Investigation of Stay Time

Living behavior made in house varies depending on the time of day and electricity demand by it also changes. Therefore, identifying stay time of single-household resident is important. After examining stay time of residents every 2hours, results are shown in Table 3 and Figure 1. Single-household near university town has a higher trend that residents are away from home from 8:00 to 22:00. It is believed because all subjects are

university students so that they do outdoor activities in that time such as class activities and activities with friends. The average stay time of the day was analyzed 13.5 hours. In this study, 22:00 to 6:00 was considered as bedtime. Given this, 11% of single households in university town spends most of their time in outside aside from bedtime, whereas 37% of respondents stayed more than 16 hours. Reason of this result was considered due to wide range of bedtime which is 8hours.

Table 3. Current State of Daily Stay Time At Home

Classification	Response	Frequency(person)
Stay time at home	22:00 - 06:00	26
	06:00 - 08:00	23
	08:00 – 10:00	10
	10:00 – 12:00	7
	12:00 – 14:00	10
	14:00 – 16:00	5
	16:00 – 18:00	4
	18:00 – 20:00	7
	20:00 – 22:00	12

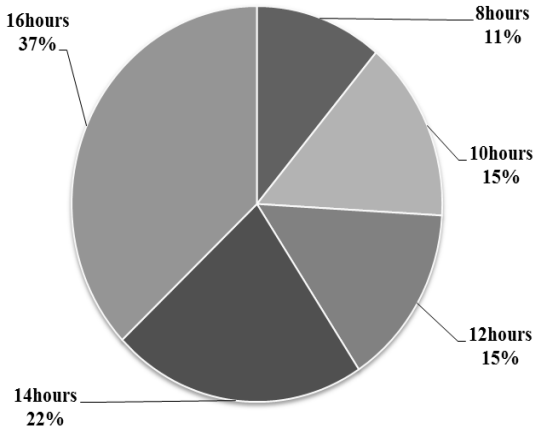

Figure 1. Distribution of Stay Time of Single-Household

3.2. Analysis of Living Behavior Associated Electricity Consumption

Cooking, leisure and laundry behaviors which have a high ratio of electricity consumption among living behaviors taking place at home are set as the target of the study. In order to quantify characteristic by each behavior, the frequency of use on electric cooker, laptop and washing machine was analyzed and its results of investigation are as shown in Table 4, Figure 2 and Figure 3[6].

Table 4. Current State of Daily Stay Time at Home

Classification	Response	Frequency(person)	Percentage(%)
Number of meal	Zero	9	33
	Less than once	12	45
	Twice	6	22
Number of cooking	Zero	14	52
	Once	5	19
	The rest	8	29
Rice warm	Until empty	11	85
	Don't use	2	15

When analyzing the status of cooking behavior in single household of university town, respondents who do not eat at home were 33% in survey. It's considered because they eat with friends for companionship and in many cases, they use a house only for the purpose of sleep. Also even though eating at home, respondents who do a cooking daily was only 19% of the total. The frequency of using a laptop in single households of university town is as shown in Figure 2[6]. Respondents who own a laptop were surveyed 14 people out of the total respondents. 43% of them responded that they use a laptop 1~2 hours a day. Also, 29% of respondents answered that they use more than 5 hours and time of using a laptop in single household is considered relatively short. However, 43% of laptop owners keep it connected to power supply for 24 hours even when they are not using a laptop so that it appears that the standby power consumption was occurred for a long time. The frequency of using a washing machine for 1 week is shown in Figure 3[6]. Unlike cooking and use of laptop, it was investigated that all respondents are using a washing machine, but the respondent who answered to wash everyday is only one person and respondents who use a washing machine every 2-3 days were most common with 37%. However, as every 4-7 days was 26% and respondents who answered that they do when the laundries pile up a lot were 33%, they were seen relatively evenly distributed.

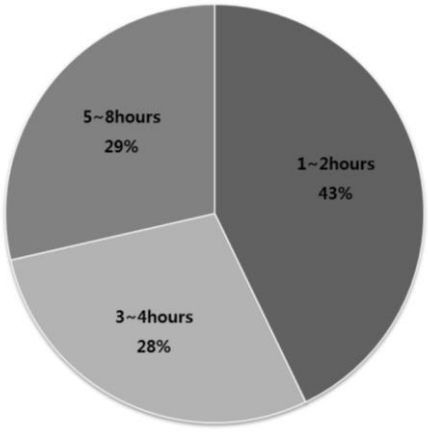

Figure 2. Frequency of using Laptop

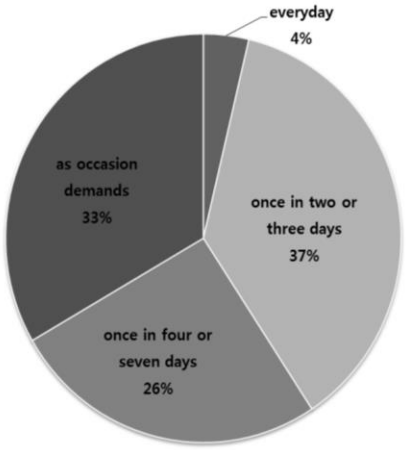

Figure 3. Frequency of using Washing Machine

4. Electricity Consumption Characteristic by Living Behavior

4.1. Electricity Consumption of Appliances

In this section, electricity consumption was estimated for leisure, cooking and laundry among living behaviors happening at home. In order to compare electricity consumption by each living behavior, the electricity consumption for a week was derived and shown in Figure 4. When looking at the average electricity consumption of a week for single household in university town, it was seen that the laptop consumes 356.3W/week, washing machine 962.4W/week and electric cooker 660.2W/week. When comparing the electricity consumption ratio of each electronics, unlike ordinary household, single household in university town showed a higher electricity consumption for laundry than cooking. It's considered because a washing machine should be used periodically and mostly, the drum type washing machine is installed so that electricity consumption is high for each laundry while the frequencies of both laundary and cooking are low compared to the ordinary household. On the other hand, the electricity consumption by laptop was the lowest and it's considered because there were many respondents who answered that they do not use a laptop at home and if using it, they use 1~2 hours of short time only.

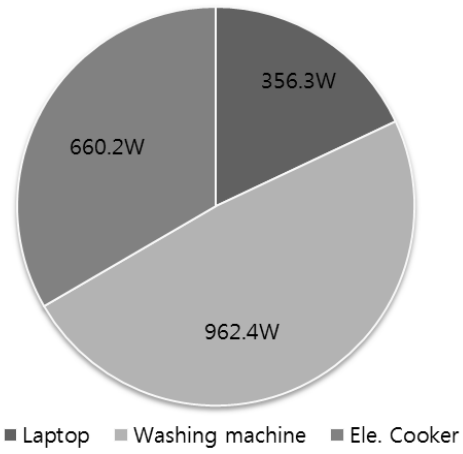

Figure 4. Ratio of Weekly Electricity Consumption by Living Behavior

4.2. Reduction Potential of Electricity Consumption

Based on the use behavior of each electricity consumption unit, potential reduction in electricity consumption by each behavior was derived. There are many who do a small amount when cooking rice in single household residents and even if they cook one serve or more they often keep it for a while and abandon it. Therefore, the amount of reduction was calculated by assuming that a resident cooks the right amount of rice every meal and doesn't do a warming. Also, a resident in single household often uses a laptop as the replacement of desktop so that they often put the plug in the outlet even when they are not using a laptop. The standby power consumped by this was considered to be reduction amount. In the case of washing machine, considering the answers of respondents, reduction amount was calculated based on the "laundry twice a week". The result of calculated reduction is shown in Figure 5. As a result, if it's unpluged while not using a laptop, the amount of power that can be saved was 20.3W/week. This is 5.7% of the total power consumption by the use behavior of laptop and the time of using a laptop is short so that electricity-saving factor is only standby power and there's a less influence by electricity-saving behavior. On the other hand, if the number of washing for a week is reduced to 2 times, the electricity reduction amount was 271W/week and the amount of power that can be saved when not using the warming function of the electric cooker was found to be 307.2W/week. These are 24.6% and 46.5% of the total electricity consumption respectively and it's considered that the electricity consumption at home can be greatly reduced only by simple energy-saving behaviors.

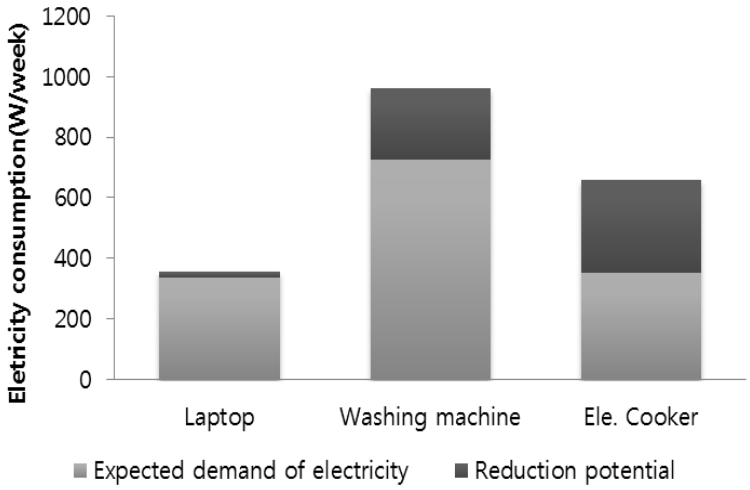

Figure 5. Expected Reduction of Electricity Consumption

5. Conclusion

This study analyzed the status of living behaviors which can affect the electricity consumption, for single households in university town in order to identify empirical power consumption characteristics of the single household and build database. Generally, a low level of occupancy rate is shown from 8:00 to 22:00 and residents appeared to spend an average of 13.5 hours at home. It could be because setting the bedtime by the range of 8 hours in the survey items causes to make quite long. The survey result on living behavior affecting the energy consumption has shown that while only 67% of respondents answered that they eat at home, respondents who answered that they cook

everyday were only 19%. Also, regarding the laptop, it was investigated that the household using a laptop more than 5 hours a day was only 29%, but 43% of respondents always plug it in. While the frequency of using a washing machine is evenly distributed, but there are respondents who answered that they do not use other electric devices, it appeared that all respondents use a washing machine essentially. The result of calculated power consumption based on the investigation result on such living behavior has shown that a laptop consumes 356.3W/week of power, washing machine 962.4W/week and electric cooker 660.2W/week. Also, the potential reduction by each energy saving behavior could be 5.7% for laptop, 24.6% for washing machine and 46.5% for electric cooker and two other items except for a laptop is believed to significantly reduce the electricity consumption by improving living behaviors. The empirical electricity consumption characteristics on single household in university areas which are derived in this study are expected to be utilized as a basis for predicting the electricity demand of single household and single household areas.

Acknowledgments

This work was supported by the National Research Foundation of Korea(NRF) grant funded by the Korea government(MSIP) (NRF-2016R1A2A1A05005459).

References

[1] M. K. Kim and E. H. Jang, "Satisfaction and Preference of Private and Shared Space of Student Housing for one Person Household-Focused on the University students in Cheongju, Chungbuk", Korean journal of human ecology., vol. 20, no. 5, **(2011)**, pp. 1059-1074.
[2] J. Y. Chang and W.N. Kwang, "Spatio-Temporal Distribution Analysis of One-Person Household –The Case of Busan City-", Journal of the Korean Association of Geographic Information Studies., vol. 17, no. 2, **(2014)**, pp. 59-71.
[3] S. J. Lee, "Interfuel Substitution in Residential Energy Demand in Korea", **(2014)**.
[4] Y. L. Kim, W. H. Hong, Y. K. Seo and G. Y. Jeon, "A Study on the Electricity Consumption Propensity by Household Members in Apartment House", Journal of the Korean Housing Association., vol. 22, no. 6, **(2011)**, pp. 43-49.
[5] K.C. Lim, "Development of Bottom-up model for Residential Energy Consumption by Use", Journal of Energy Engineering, vol. 22, no. 1, **(2013)**, pp. 38-43.
[6] J. W. Son, H. C. Seo and W.-H. Hong, "A Study on the living behavior of Single-household in University Town through the Questionnaire survey", Advanced Science and Technology Letters., vol. 124, **(2016)**, pp. 93-97.
[7] Korean statiscal information service, http://kosis.kr.

Authors

Jin-Woong Son, he is currently a first year PhD candidate under the supervision of professor Won-Hwa Hong in the School of Architectural, Civil, Environmental and Energy Engineering, Kyungpook National University, Daegu, Korea. His research interests are energy consumption of buildings and urban heat island phenomenon.

HyunCheol Seo, he is currently a forth year PhD candidate under the supervision of professor Won-Hwa Hong in the School of Architectural, Civil, Environmental and Energy Engineering, Kyungpook National University. His main research interests are energy demand and consumption in existing and future buildings,

especially effect of socio-cultural changes on energy demand of buildings and cities.

Won-Hwa Hong, he received the Ph.D. degree in Architectural Engineering from Waseda University, Tokyo, Japan in 1994. He is a professor in Department of Architecture and Architectural Engineering of Kyungpook National University since 1999. He is currently working as a head of Disaster and safety Management Institute funded by Ministry of Public Safety and Security, South Korea(MPSS). His research interests are energy demand and consumption in existing and future buildings, resilience technologies for the built environment, IoT Based Technologies for Smart City.

Jung-Ha Hwang, he is a professor in School of Architecture of Kyungpook National University, Daegu, Korea. He received his Ph.D. degree in Architectural Engineering from Chungang University, Seoul, Korea in 1992. He is currently working as a president of Korean Institute of Architectural Sustainable Environment and Building Systems. His research interests include assessment of indoor thermal environment, building energy and renewable energy system.

Yong-Seo Park, he is a professor in School of Architecture of Kyungpook National University, Daegu, Korea. He received his Ph.D. degree in Architecture & Plastic Arts from University Paris 1 Pantheon-Sorbonne, France in 2007. He is currently working as a academic director of The Regional Association of Architectural Institute of Korea. His research interests include Landscape Direction, Plastic Arts and Architectural Planning and Design