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City Gas Consumption Analysis per 1m^2 according to Exclusive Dwelling Area in Residential Buildings - Focused on case of Ulsan -

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Abstract: Currently, effective energy management of buildings is necessary because of accelerated global climate change and resource crisis. Especially, in the case of South Korea, city gas consumption occupies 11.8% of the total energy and 39.6% is residential use among them. Therefore, for reducing the city gas consumption, the effectiveness of residential use is needed. To address this issue, the objective of this study is to analyze the difference of the city gas consumption according to the space arrangement in the apartment building. To achieve this objective, an apartment complex having over 1,000 households was selected then, according to the space arrangement such as south-east and south-west, the data of 59.97m2 and 84.96m2 were analyzed by using statistics method. As a result, in 59.97m2 and 84.96m2, the total city gas amount in 2012 showed that 9.2% and 8.4% were more increased at south-west than south-east respectively. In the future, the findings of this study can be used to develop the prediction model of city gas consumption in apartment building.

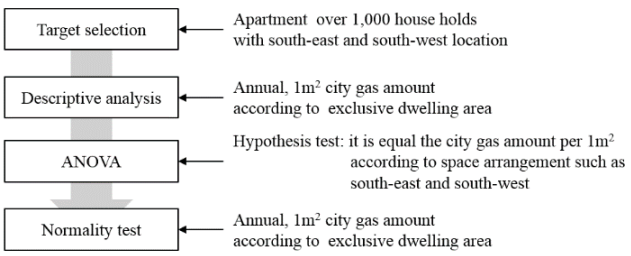
Keywords: City Gas; Apartment Building; Space Arrangement; Analysis of Variance

I. Introduction

As the city gas consumption in 2013 is 24.878 mil. TOE, it occupied 11.8% of the total end-use energy. In addition, according to the Korea city gas association report, approximately 39.6% of the total city gas used in 2013 was consumed as a residential use. Therefore, the effective use of city gas in residential use is necessary.

Therefore, to address this issue, the objective of this study is to analyse the differences of city gas consumption according to the space arrangement such as south-east and south-west. In this study, the apartment complex having over 1,000 households is selected and the data of city gas consumption in the households of 59.97m^2 and 84.96m^2 are collected then analysed whether or not there is different between exclusive dwelling areas by using Analysis of Variance (ANOVA). In the future, the findings of this study can be used to develop the prediction model of city gas consumption in apartment building. In addition, major stakeholders can be utilized as a basic data for operating apartment buildings. Fig. 1 shows the methodology of this study.

FIG. 1. Methodology



II. Data Collection Methods

For analysing the city gas consumption, this study utilizes ANOVA analysis to identify whether or not the average differences of two group is statistically significant and following hypothesis was established.

Hypothesis 1 (59.97m^2):

$$H_o: \mu_{CFE} = \mu_{CFW}$$
$$H_1: \mu_{CFE} \neq \mu_{CFW}$$

Where
μ_{CFE}: City gas amount (south-east)
μ_{CFW}: City gas amount (south-west)

Hypothesis 2 (84.96m^2):

$$H_o: \mu_{CEE} = \mu_{CEW}$$
$$H_1: \mu_{CEE} \neq \mu_{CEW}$$

Where
μ_{CEE}: City gas amount (south-east)
μ_{CEW}: City gas amount (south-west)

Hypothesis 1 and 2 is to represent whether or not the average differences of city gas consumption is statistically significant according to the south-east and south-west of 59.97m^2 and 84.96m^2. In other words, Hypothesis 1 means that the city gas consumption difference is statically significant between south-east and south west in 59.97m^2 and Hypothesis 2 shows that the city gas consumption difference is statically significant between south-east and south west in 84.96m^2.

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A. Descriptive Analysis

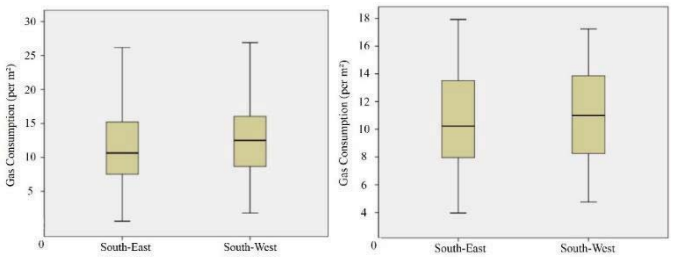
Table 1 shows the city gas consumption per $1m^2$ in $59.97m^2$ and $84.96m^2$ according to south-east and south-west.

TABLE 1. DESCRIPTIVE ANALYSIS OF CITY GAS CONSUMPTION PER $1M^2$

Statistics	59.97 m^2		84.96 m^2	
	South-East	South-West	South-East	South-West
Mean	11.42	12.48	10.61	11.99
Median	10.64	12.49	10.22	11.98
Std. Dev	5.50	5.27	3.44	3.35
Skewness	.38	.23	.09	.02
Kurtosis	-.35	-.38	-.99	-.99

Fig. 2 is the box plot of $1m^2$ consumption of in $59.97m^2$ and $84.96m^2$. As shown in Fig. 2, it can be identified there were differences between the averages of $59.97m^2$ and $84.96m^2$. In detail, in $59.97m^2$ and $89.64m^2$, south-west was more increased by $1.06m^3$ and $1.38m^3$ than south-east respectively. In other words, it was increased by 9.2% and 8.4% in each exclusive dwelling. In addition, it can be analysed that $1m^2$ consumption of $59.97m^2$ according to the space arrangement such as south-east and south-west is more than $84.96m^2$.

FIG. 2. BOX PLOT OF GAS CONSUMPTION PER $1M^2$
(a) 59.97 m^2 and (b) 84.96 m^2



(A) (B)

B. Analysis of Variance

To verify the hypothesis established in this study based on the descriptive analysis, ANOVA analysis was conducted. Table 2 shows the F-test results of $1m^2$ city gas consumption in $59.97m^2$ and $84.96m^2$. The p-values are 0.04 and 0.03 respectively. Therefore, it is confirmed that there are statistically significant like annual consumption.

TABLE 2. F-TEST RESULTS OF $1M^2$ AMOUNT

Statistics		Sum of Squares	df	Mean Square	F	sig
$59.97m^2$	Between Groups	116.42	1	116.2	4.03	.04
	Within Groups	12,259.69	425	28.84		
	Total	12,376.12	426			
$84.96m^2$	Between Groups	16.47	1	16.47	4.78	.03
	Within Groups	5,136.82	425	3.46		
	Total	5,153.29	426			

Although the average difference between two groups is identified through ANOVA analysis, Normality test is necessary to verify whether or not the collected data is normally distributed. In this study, Normality test is conducted to check the normality of collected data. Generally, to check goodness of hit of selected samples, Kolmogorov-Smirnov and Shapiro-Wilk test are used. Especially, Kolmogorov-Smirnov test is used when samples are over 50.

As shown in Table 3, the residuals of samples in $59.97m^2$ and $84.96m^2$ were analysed. As a result, as the p-value of Kolmogorov-Smirnov test is over 0.05 in both of them, null-hypothesis is accepted and this means that the residuals are normally distributed.

TABLE 3. NORMALITY TEST

Test		Kolmogorov-Smirnov			Shapiro-Wilk		
Group		Statistic	df	Sig	Statistic	df	Sig
$59.97m^2$	South-East	.063	182	.07	.982	182	.062
	South-West	.038	245	.20*	.990	245	.102
$84.96m^2$	South-East	.07	212	.08	.973	212	.07
	South-West	.06	235	.20*	.972	235	.13

* This is a lower bound of the true significance.

III. CONCLUSION

The objective of this study is to analyse the difference of the city gas consumption per $1m^2$ according to the space arrangement in the apartment building. As a result, $1m^2$ city gas consumption of $59.97m^2$ and $84.96m^2$ with south-west is more increased by $1.06m^3$ and $1.38m^3$ respectively. It means that $1m^2$ consumption of $59.97m^2$ is larger than the consumption of $84.96m^2$. In addition, it was confirmed that the results are statistically significant through ANOVA analysis. The limitation of this study is that, although data are collected and analyzed in one apartment complex to minimize the impact of exterior factors, it is necessary to verify and compare with various complexes' data in the future.

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REFERENCES

[1] 2013 Performance Record, Retrieved September 22, 2014 form http://citygas.or.kr
[2] Kang, B. and Jang, J., "A Study on the Planning of Block Housing Considering Daylight Condition", Journal of Architectural Institute of Korea, 21(2), pp. 79-88, 2005
[3] Shim, Y., "A study on the Estimation of Standard Heating City Gas Consumption of Apartment Housing", Journal of the Korean Solar Energy Society, 26(3), pp. 89-97, 2006
[4] Year Book of Energy Statistics, Retrieved January 2, 2014 form http://www.keei.re.kr/