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Correlation Analysis between Energy Exclusive Dwelling Area and City Gas in Apartment Building - Focused on Cases in Ulsan, Korea-

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ABSTRACT

Purpose: Currently, since the energy consumption of apartment buildings is on the rise, it is necessary to reduce the total amount of the energy through the survey and analysis of energy consumption data. Although various studies for energy efficiency have been conducted, studies are more focused on the measurement of energy by using analysis tools. In addition, the studies are sufficient to analyze real data of the city gas in apartment buildings. Therefore, the objective of this study is to identify the property of annual and 1 ㎥ city gas amount according to the exclusive dwelling area. Method: To achieve the objective, this study used the statistics such as descriptive, correlation, and analysis of variance (ANOVA) analysis. Result: As a result, there is positive relationship between the annual average of city gas and the exclusive dwelling area. However, in the case of 1 ㎥ city gas amount, a negative relationship is mored. In the future, the findings of this study can be applied to develop the prediction model of the city gas consumption and implement it as basic data for energy efficiency of apartment buildings of future.

KEYWORD

City gas
Exclusive dwelling area
Apartment building
Correlation analysis

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1. Introduction

1.1. Research background and objectives

Now, Korea is facing problems such as unsettlement in world energy market, burden from greenhouse gas reduction due to climate change agreement and global economy recession. Thus the government presented 'low carbon green growth' as a new national vision in next 60 years setting reduction goal by 30% compared to obsevation value of greenhouse emission in 2020 then enacted 'fundamental law of green growth' on January, 2010. Besides, according to the energy statistics announced in 2014, foreign dependency ratio of domestic energy consumption was very high with 84.5% with oil products taking 50.5% while oil products take up 38%, coal 29%, other LNG and nuclear energy each take up 18%, 11% upon comparison of consumer thus it is our current situation that the burden of energy cost is getting bigger. Therefore the country faces its crucial point where it has to implement overall energy management over the whole industrial fields.

Especially, total 208,120,000 Toe final energy was consumed in domestic land based on 2012 and 37,877,000 Toe among this was consumed in building (household and commerce)[1]. This is a tremendous amount taking up 18.2% of final energy consumption amount and shows efficiently using energy is very important in buildings.

Ulsan has about energy consuming 140 business places that consume more than 2,000 TOE yearly concentrated and falls into the category of energy consuming city having 52 business places that should be managed with a goal in it. Also, it is the current point that energy consumption amount is getting higher in apartment houses so endeavors to reduce total energy consumption amount of city is needed through investigation and analysis of energy consumption status.

Recently, various researches are being done for energy efficiency of apartment houses. Jung, Jin-Woo analyzed and evaluated indoor thermal environment in the summer and winter in various conditions by establishing 8-story zero carbon green home apartment houses inside Korean Institute of Construction Technology. Lim, Chung-Hwan (2014) constructed system that evaluates bioenergy potential, carbon emission amount, energy cost, energy amount used in the building utilizing the web in his research. Ahn, Min-Hui (2006) intended to analyze the energy according to the location of generation by investigating consumption amount of yearly heating energy in pilotis generation in apartment houses.

Besides, Kim, Jin-Gwan(2005) investigated energy loss status

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1) Energy economic research, 2013 Annual report of energy statistics, 2013, pp. 16-17

by allocation features of division and block by understanding usage amount of city gas per generation levied from 2002 to 2003 of high-rise apartment in Jinju region with approval of use from 1990 to 2000 but did not conduct verification whether it is statistically meaningful not to mention that it has different conditions with the target of this research. Kim, Young-In (2014) examined consumption amount in 2012 targeting heating, hot-water, ventilation, lighting energy after selecting 181 complexes in Seoul but analysis by each generation was not done.

Likewise, prior researches mostly conducted analysis and evaluation using energy analysis examined in design step and researches that measure the energy consumption amount in maintenance management aspect regarding existing buildings are being done. Also, there have been several researches that collected and analyzed data on consumption amount of actual city gas but researches on correlation analysis of consumption amount of city gas by exclusive dwelling area which are the objective of this research are still lacking.

Thus, this research selects apartment complexes more than 1,000 generations and understands energy consumption status targeting apartment houses in Ulsan then analyzes correlation of city gas consumption amount by exclusive dwelling area. This is expected to be utilized in development of forecasting model of city gas consumption amount of apartment houses and basic data of energy efficiency plan of apartment houses in the future.

1.2. Research background and scope

This research intends to examine actual consumption amount of energy targeting apartment houses for household and understands features of gas consumption amount per 1㎡ analyzing transition of yearly gas consumption amount by exclusive dwelling area to develop forecasting model for city gas consumption amount of apartment houses in the future then utilizes them as basic data of energy efficiency plan of apartment houses.

For this, this research utilized ANOVA analysis, correlation analysis, technical statistics which are statistical analysis method. In case of technical statistics, it analyzes status by generation and intends to examine the distribution of consumption amount of city gas by 1㎡, monthly and yearly and correlation intends to analyze what correlation lies between exclusive dwelling area and city gas consumption amount.

ANOVA analysis set a null hypothesis that average gas consumption amount by 1㎡ exclusive dwelling area is same to verify whether it is true and conductd analysis regarding this. Data collection, basic data, such as city gas consumption amount, total generation number, exclusive dwelling area was taken from complex basic information of information management system of

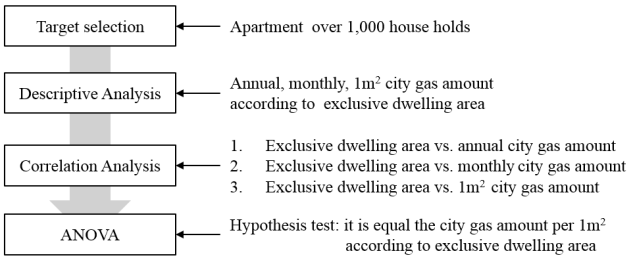


Fig. 1. Research methodology

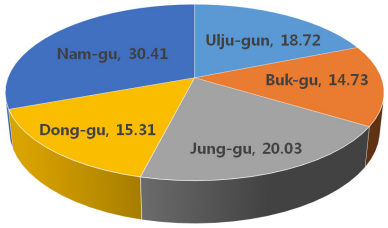


Fig. 2. Population distribution(Ulsan)

apartment houses. Fig. 1 shows the method of this research.

Total number of household in Ulsan in 2012 is 422,177 and the population is approximately 1,150,000. Population distribution by 5 borough is shown in Fig. 2, with Nam borough 30.41%, Dong borough 15.31%, Jung borough 20.03%, Buk borough 14.73%, Ulju borough 18.72%. [2] In population distribution chart by borough, major residing group of Ulsan is Nam borough and this is the main consumer of energy. Besides, current Nam borough has its position as the main energy consumer because it is also the central industrial area. Thus this research conducted research targeting apartment houses more than 1,000 generations of Nam borough which is the center of Ulsan.

2. Theoretical contemplation

2.1. Current status of Ulsan region

Like Table 1, Ulsan consumes 25,529,000 TOE, 12.27% of 208,120,000 TOE which is total energy consumption amount, so is the city that consumes the energy the most showing the highest consumption amount at megapolis level and 37% of it is consumed for industry. We can see that population distribution and living basis has features of industrial city.

Besides, Ulsan has 104,7% average supply rate of housing and 85% of it is apartment houses, further, energy consumption of it is significantly bigger than that of general housings. [3] For energy

2) Utilized and referred to current situation data of demographics of resident registration from Ministry of Public Administration and Security in 2012.

3) Cited and utilized yearly report of energy statistics by region and sum data of apartment houses in 2013 Ulsan.

Table 1. End-use Energy Amount Consumption (Unit: 1,000 TOE)

Content / Province	Industry	Transportation	Residential and Commercial	Public	Total
Seoul	1,133	4,576	8,844	1,014	15,568
Busan	1,656	2,458	2,133	222	6,470
Daegu	1,284	1,266	1,726	159	4,434
Incheon	3,980	4,605	1,931	182	10,697
Gwangju	426	900	1,010	66	2,403
Daejeon	410	795	1,187	120	2,513
Ulsan	22,673	1,743	818	295	25,529
Whole Country	115,155	36,938	37,256	4,483	208,120

Source: 2013 Energy statistics annual report, Ministry of Trade, Industry & Energy

Table 2. Apartment Households proportion (Ulsan)

Division	Complex	Households	Proportion(%)
Under 100	242	9,967	15.2
101~300	84	15,061	22.9
301~500	20	8,187	12.5
501~700	16	9,805	14.9
701~1000	9	7,481	11.4
Over 1,000	8	15,132	23.1
Total	379	65,633	100.0

efficiency and reduction in fossil energy of this centered households, we can comprehend the pattern and quantitative amount of consumption energy by analyzing consumption amount of city gas used currently and this will hep us review the estimated amount of alternative energy like waste heat of industrial complexes of Ulsan that would be supplied to apartment houses in the future. Thus, this research selected Nam borough where population is the most among 5 boroughs as a target for energy analysis of apartment houses for household in Ulsan.

Besides, Table 2 shows ratio of generation by complex of apartment houses in Ulsan. As a result of categorizing 65,633 generations in total 379 complexes, we could see that the number of complexes more than 300 generations take up 62% of total generation. Complexes below 100 generations were 242, with generation taking up 15.2% although its number was many. [4] So this research examined gas consumption amount of complexes taking up the most generation numbers and especially targeted apartment complexes that use city gas more than 1,000 generation and selected A apartment complex which is the biggest in size in Nam borough.

In case of energy resource of dwelling house, it is largely electricity and city gas and the amount of city gas of apartment houses corresponds to hot water and heating excluding some cooking. In the trend of city gas consumption amount, consumption amount from July to August can be seen as cooking amount rather than heating or hot water and the consumption

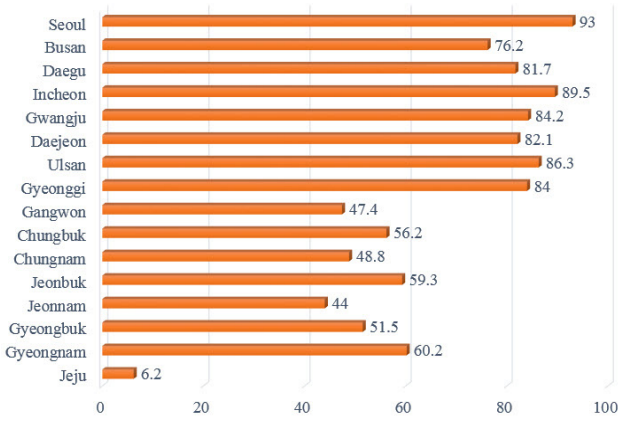


Fig. 3. Nationwide City Gas Supply Ratio

amount in other seasons can be estimated to be for heating and hot water. Especially from January to February and December in winter shows high consumption amount which shows heating load. Like the report that energy consumption amount by use in our country's household is divided into 44.2% for heating, 23.8% for hot water, 19.1% for electronic devices, [5] we can see that most energy is consumed for heating and hot water.

Fig. 3 is the national penetration rate of city gas shown in national major statistics index investigated by Ulsan in 2013. 86.3% of 422,177 generation in Ulsan uses city gas and this shows high city gas penetration rate following Gwangju, Seoul, Daejeon, Incheon in the country steadily increasing. Therefore, analysis of city gas consumption amount becomes an index that can see energy trend of housing fcaility and through variance in city gas consumption amount, we can analyze various variables that affect other consumption amount.

Table 3 shows city gas consumption amount of apartment houses in Ulsan in 2010. City gas consumption amount of total 139,570 generations that are apartment houses more than 300 generations was examined to be 943,505 Gcal/yr. Nam borough among this takes up high ratio with 45%.

Like mentioed, 86.3% of Ulsan household uses city gas and they can be said to be individual heating generation that uses city gas. Besides, according to the basic plan of city, household,

Table 3. Apartment Households proportion (Ulsan)

Province	Households	Amount (Gcal/day)	Proportion(%)
Nam-gu	42,258	397	319,894
Jung-gu	17,427	194	112,350
Buk-gu	36,303	446	242,941
Ulju-gun	24,036	253	149,680
Dong-gu	19,546	170	118,640
Total	139,570	1,460	943,505

4) Cited and utilized sum data of apartment houses in 2013 Ulsan

5) Lee, Sung-Gn, Research on retrospective estimation and energy consumption amount by use in household field, Energy economics research Institute, 2012, pp.10-11

environment organization, in Ulsan in 2020, city gas supply ratio would be bigger if gas supply in about 91 places, 6,537,000㎡ be included because they are still being developed or to be developed after being selected as the region for organization and re-development.

Moreover, creation of society where energy is lowly consumed with high efficiency is being propelled for reinforcement of oil escape, independent energy among 10 policies directions for green growth of government and since there is a plan to expand the supply of group energy such as local heating of building, Ulsan needs measures for it. So this research intends to comprehend current situation in using city gas targeting apartment complexes in Nam borough where gas consumption amount is the highest among apartment houses in Ulsan to expect consumption amount of city gas of apartment houses in the future and analyze the correlation of city gas consumption amount according to the exclusive dwelling area by selecting apartment complexes with more than 1,000 generations.

3. Data analysis

3.1. Introduction

This research utilized actual data of gas consumption amount generated from January to December of 2010 and conducted statistical analysis on variance of gas consumption amount by exclusive dwelling area of apartment houses. Research target is A apartment complex in the biggest size in Nam borough of Ulsan that uses city gas for heating fuel. Furthermore, it conducted analysis of gas consumption amount by each exclusive dwelling area by selecting complex 1 and 2 with same move-in year.

Building outline is shown in Table 4. Selected apartment is a linear apartment and in a form used the most in our country because of its unit composition and composed of 2 complexes and 2,505 generations in total.

1 complex is composed of 6 residential building with 21-25 story that moving in started in 1999, there are 1,085 generations in total. They are classified into 40.80㎡, 59.97㎡, 81.87㎡, 84.96㎡, 114.60㎡ by exclusive dwelling area and generation numbers are relatively 75, 365, 150, 345, 150. Complex 2 is the apartment with 16~25 story and composed of 9 residential buildings, moving in started in 1999 and has now 1,420 generations in total. They are classified into 40.80㎡, 59.97㎡, 81.87㎡, 84.96㎡, 114.60㎡ by exclusive dwelling area and the number of generations are relatively 97, 474, 99, 550, 200.

Table 4. Selected Apartment Overview

Content		Complex 1	Complex 2
Location		Yaeum-dong, Ulsan	
Completion date		1999.11	1999.11
Story		21-25	16-25
Floor plan		Flat	Flat
House hold		1,085	1,420
Heating type		City gas	Gity gas
Exclusive dwelling area	40.80	75	97
	59.97	365	474
	81.87	150	99
	84.96	345	550
	114.60	150	200
	Total	1,085	1,420

3.2. Technical statistics

To analyze gas consumption amount by exclusive dwelling area, we conducted technical statistics analysis regarding sum of gas consumption amount for a year by exclusive dwelling area of complex 1 and 2 except the number of generations that has gas consumption amount 0.

To analyze gas consumption amount by exclusive dwelling area, we conducted technical statistics analysis regarding sum of gas consumption amount for a year by exclusive dwelling area in complex 1 and 2 except those with 0 gas consumption amount. Like shown in Table 5, yearly average of 40.80㎡, 59.97㎡, 81,87㎡, 84.96㎡, 114.60㎡ is relatively 575.84㎥, 728.99㎥, 891.86㎥, 896.06㎥, 1097.62㎥ as size of each exclusive dwelling area increases thus we can see that average gas consumption amount increases. Box plot of Fig. 4(a) indicates distribution of collected data and average location of gas consumption amount yearly and it

Table 5. Descriptive Analysis per area(Annual and 1㎡ amount)

Statistics \ Area[㎡]		40.80	59.97	81.87	84.96	114.60
Sample		78	451	169	625	94
Annual city gas amount [㎥]	Average	575.84	728.99	891.86	896.06	1097.62
	Median	577.88	732.51	907.99	894.08	1093.31
	St. Dev.	95.59	162.15	225.41	207.81	97.09
	Min.	415.30	428.21	482.73	527.34	931.74
	Max.	761.26	1,018.00	1,269.77	1,270.69	1,268.78
	Range	345.95	589.79	787.04	743.36	337.04
	Skewness	-.016	-.017	-.09	.023	-.021
	Kurtosis	-1.23	-1.11	-1.06	-1.18	-1.17
City gas amount per 1㎥ [㎥]	Average	14.11	12.15	10.89	10.54	9.57
	Median	14.16	12.21	11.09	10.52	9.54
	St. Dev.	2.34	2.70	2.75	2.44	.84
	Min.	10.18	7.14	5.90	6.21	8.13
	Max.	18.66	16.98	15.51	14.96	11.07
	Range	8.48	9.83	9.61	8.75	2.94
	Skewness	-.016	-.017	-.092	.023	-.021
	Kurtosis	-1.234	-1.114	-1.069	-1.180	-1.173

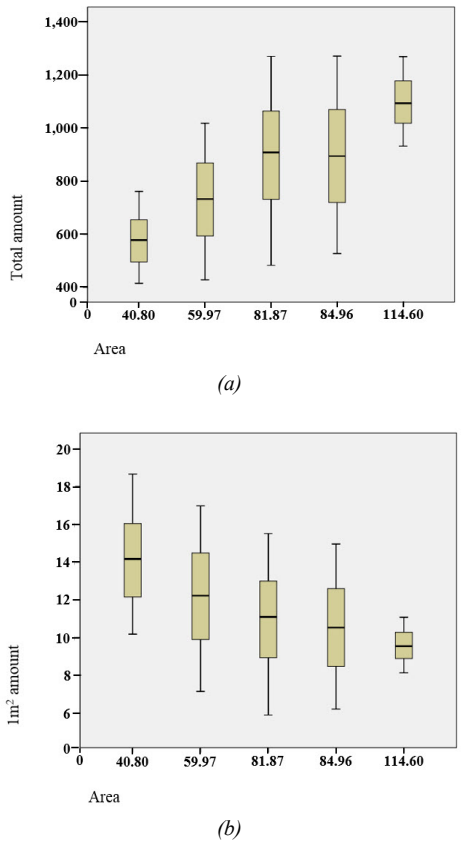


Fig. 4. Box plot per area (annual(a) and 1㎡(b) amount)

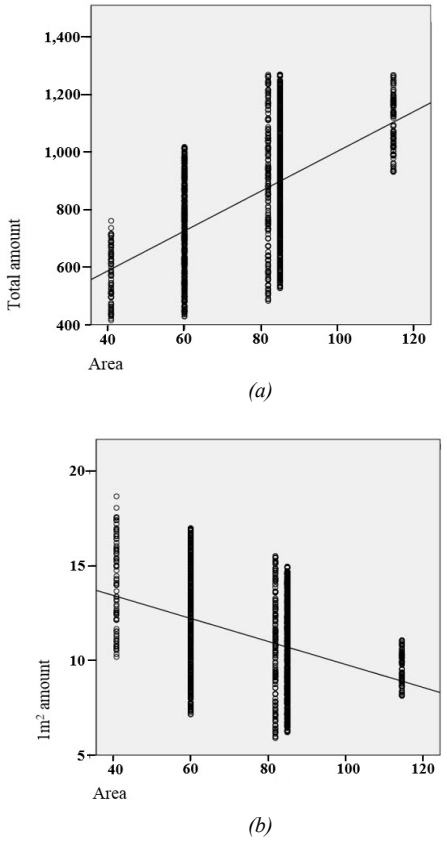


Fig. 5. Scatter plot (annual(a) and 1㎡(b) amount)

also shows that average increases by each exclusive dwelling area.

However, gas consumption amount per 1㎡ of each exclusive dwelling area shows the opposite trend. As exclusive dwelling area increases, gas consumption amount by 1㎡ were 14.11㎥, 12.15㎥, 10.89㎥, 10.54㎥, 9.57㎥ showing the analysis that they are decreased like shown in Box Plot of Fig. 4(b).

3.3. Correlation analysis

3.3.1 Yearly gas consumption amount by unit area per exclusive dwelling area

Measures of association of two variables indicates intensity, direction and existence of linear relation between two variables and the typical criteria to measure this are covariance and coefficient of correlation.

Covariance, correlation coefficient of gas consumption amount by each exclusive dwelling area is shown in Table 6 below. If covariance is positive, two variables are in positive linear relation and if negative, they are in negative linear relation and when covariance is near to 0, they do not have linear relation between.

Table 6. Correlation Coefficient (annual and 1㎡ amount)

		Annual	1㎡
Exclusive dwelling area	Pearson Coefficient	.534**	-.380
	P-vale	.000	.000
	Covariance	1,997.50	-17.49
	N	1417	1417

**. Correlation is significant at the 0.01 level (2-tailed).

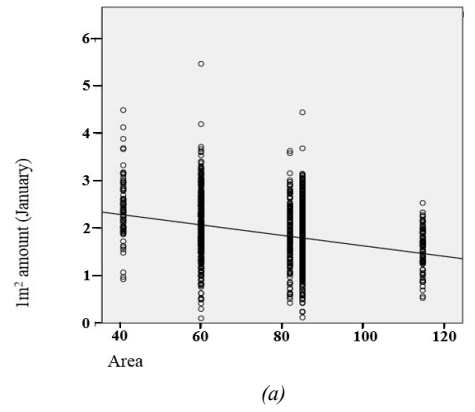
Correlation coefficient has the value between -1 and +1 and if it is positive, two variables are in positive linear relation but if negative, they have negative linear relation. Likewise, when the value of it is near to 0, there is no correlation between two variables. Moreover, intensity of linear relation increases as the absolute value of correlation coefficient is nearer to 1. Thus, correlation coefficient of average gas consumption amount of generation by exclusive dwelling area is 0.534, showing strong and positive linear relation between two variables and negative linear relation with -.380 between gas consumption amount by 1㎡ and exclusive dwelling area. Also, like Fig. 5, scatter plot of gas consumption amount per 1㎡, yearly gas consumption amount and exclusive dwelling area support the analysis result.

3.3.2 Monthly gas consumption amount by unit area per exclusive dwelling area

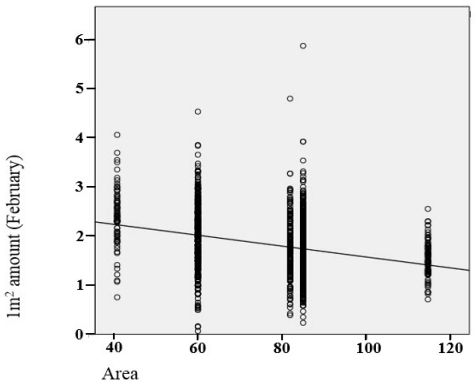
Table 7 shows monthly gas consumption pattern. Like shown in Table 7, energy consumed in winter (December, January, February) takes up approximately 40% of total energy consumption.

Table 7. Monthly Average City Gas Amount and Proportion according to Exclusive Dwelling Area

Area / Month	40.80(78)		59.97(451)		81.87(169)		84.96(625)		114.60(94)	
	Average(㎥)	Proportion(%)	Average(㎥)	Proportion(%)	Average(㎥)	Proportion(%)	Average(㎥)	Proportion(%)	Average(㎥)	Proportion(%)
January	2.44	17.34	2.04	16.89	1.84	16.97	1.77	16.86	1.56	16.40
February	2.39	16.99	1.99	16.47	1.78	16.42	1.71	16.29	1.53	16.09
March	1.94	13.79	1.64	13.58	1.41	13.01	1.36	12.95	1.27	13.35
April	1.83	13.01	1.52	12.58	1.32	12.18	1.27	12.10	1.28	13.46
May	1.18	8.39	1.04	8.61	.89	8.21	.88	8.38	.81	8.52
June	.64	4.55	.61	5.05	.51	4.70	.55	5.24	.49	5.15
July	.30	2.13	.35	2.90	.37	3.41	.34	3.24	.26	2.73
August	.23	1.63	.29	2.40	.28	2.58	.29	2.76	.22	2.31
September	.21	1.49	.24	1.99	.25	2.31	.24	2.29	.18	1.89
October	.38	2.70	.36	2.98	.38	3.51	.34	3.24	.30	3.15
November	.91	6.47	.75	6.21	.71	6.55	.66	6.29	.59	6.20
December	1.62	11.51	1.25	10.35	1.10	10.15	1.09	10.38	1.02	10.73
Total	12.45	88.49	10.83	89.66	9.74	89.85	9.41	89.64	8.49	89.25



(a)



(b)

Fig. 6. Scatter plot 1㎡ amount(January(a), February(b))

Especially, we can see that gas consumption amount per 1㎡ consumed on January and February takes up about 33% of every exclusive dwelling area. Thus this research showed scatter plot of gas consumption amount per 1㎡ on January and February below like Fig. 6.

Average gas consumption amounts by 1㎡ on January of 40.80 ㎡, 59.97㎡, 81,87㎡, 84.96㎡, 114.60㎡ Exclusive dwelling area are relatively 2.44㎥, 2.04㎡, 1.84㎡, 1.77㎡, 1.56㎡ as the size of exclusive dwelling area gets bigger thus we can see that average gas consumption amount decreases. February as well has the same trend that decreases.

Table 8. Correlation Analysis between Area and Monthly Amount

Statistics / Month	Coefficient	P-value	Covariance	N
January	-.28**	.00	-3.19	1,417
February	-.29**	.00	-3.19	1,417
March	-.32**	.00	-2.74	1,417
April	-.28**	.00	-2.33	1,417
May	-.23**	.00	-1.59	1,417
June	-.10**	.00	-.65	1,417
July	-.03	.25	-.13	1,417
August	-.02	.39	-.08	1,417
September	-.01	.48	-.06	1,417
October	-.07**	.01	-.27	1,417
November	-.20**	.00	-1.12	1,417
December	-.24**	.00	-2.08	1,417

**. Correlation is significant at the 0.01 level (2-tailed).
*. Correlation is significant at the 0.05 level (2-tailed).

Table 8 is a table that analyzed correlation by exclusive dwelling area and monthly gas consumption amount by 1㎡. As a result of analysis, monthly gas consumption amount except July, August, September where significance probability is higher than 0.05 showed strong positive correlation with correlation coefficient from -.20 to -.32. But July, August, September showed no change in gas consumption amount monthly by 1㎡ according to the size of exclusive dwelling area.

3.4. Analysis of Variance

To examine if the difference on gas consumption amount is statistically meaningful in exclusive dwelling area, this research conducted hypothesis test (one way variance analysis). Thus, we supposed variance of each group was same after setting antihypothesis, average gas consumption amount by 1㎡ of exclusive dwelling area is different, and a null hypothesis, average

Table 9. ANOVA Result

	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	1602.603	4	400.651	64.385	.000
Within Groups	8786.544	1412	6.223		
Total	10389.147	1416			

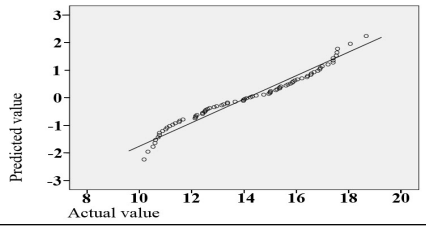
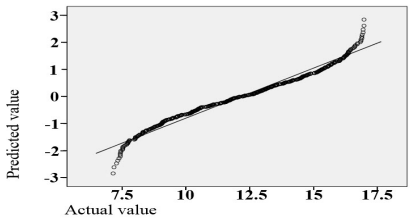
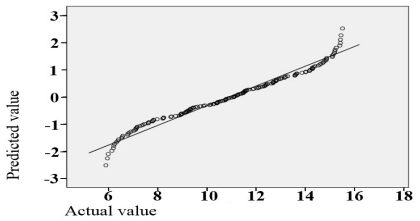
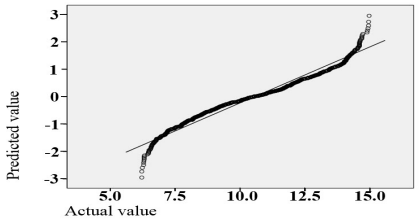
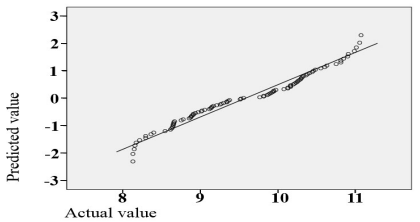
Table 10. Duncan Test

Area	N	Subset for alpha = 0.05			
		1	2	3	4
114.60	94	9.5779			
84.96	625		10.5470		
81.87	169		10.8937		
59.97	451			12.1559	
40.80	78				14.1138
Sig.		000	.228	000	000

Table 11. Normality Test

Area	Kolmogorov-Smirnova			Shapiro-Wilk		
	Statistics	df	Sig.	Statistics	df	Sig.
40.80	.088	78	.20	.951	78	.19
59.97	.064	451	.18	.964	451	.10
81.87	.068	169	.38	.960	169	.13
84.96	.068	625	.15	.958	625	.92
114.60	.104	94	.87	.954	94	.45

Table 12. Q-Q Plot

Area	Q-Q Plot
40.80㎡	
59.97㎡	
81.87㎡	
84.96㎡	
114.60㎡	

gas consumption amount by 1㎡ of exclusive dwelling area is same, to examine if average gas consumption amount by 1㎡ of exclusive dwelling area is same and set significance level at 5%. As a result of analysis, like Table 9 below, F value between groups was 64.385 existing outside acceptance region (-1.96, 19.6) denying the null hypothesis accepting antihypothesis, that is to say, it brings the conclusion that average gas consumption amount by 1㎡ of exclusive dwelling area has difference.

Moreover, as a result of Duncan test as post-mortem, average gas consumption amount by 1㎡ on January for 40.80㎡, 59.97㎡, 81,87㎡, 84.96㎡, 114.60㎡ exclusive dwelling area shows decrease in average gas consumption amount with relatively 14.11㎥, 12.15㎡, 10.89㎡, 10.54㎡, 9.57㎡ as the size of exclusive dwelling area increases and the average difference between two groups, 84.96㎡, 81.87㎡, showed significance probability higher than 0.05 thus analyzed to be not meaningful as shown in Table 10.

ANOVA analysis needs Normality Test that checks if probability distribution of population which is a statistical assumption follows normal distribution curve. This research used Kolmogorov－Smirnov test(K-S test) and Q-Q plotto confirm this. Null hypothesis in normality test is measured data forms normal distribution and the hypothesis that measured data follows the normal distribution is valid because test result cannot deny the null hypothesis at significance level 0.05 for measured data by each exclusive dwelling area in K-S test is higher than 0.05 in its significance level as shown in Table 11. Besides, like Table 12, we could re-confirm that hypothesis above is valid since data in Q-Q plot by each exclusive dwelling area form straight-like normal distribution.

4. Conclusion

Currently, energy consumption amount in apartment houses within a city increases as time goes on and we need endeavors to reduce total amount of energy consumption of city through investigation and analysis regarding current status of energy consumption. In the field, many researches are being done for energy efficiency but they are mostly the ones that measure the energy consumption amount utilizing energy analysis ratio and researches on analysis of actual cases and investigation by exclusive dwelling area of apartment houses regarding actual gas consumption amount are still lacking. Thus this research examines actual usage of city gas targeting apartment houses for residences and intended to grasp features of gas consumption amount by 1㎡ and analyze the trend of yearly gas consumption amount according to the exclusive dwelling area.

For this, this research utilized ANOVA analysis, correlation

analysis, technical statistics which are methods for statistical analysis targeting A apartment in the biggest scale in Nam borough. As a result of analysis, first, yearly average of 40.80㎡, 59.97㎡, 81,87㎡, 84.96㎡, 114.60㎡ increases relatively to 575.84㎥, 728.99㎥, 891.86㎥, 896.06㎥, 114.60㎥ in average gas consumption amount as the size of each exclusive dwelling area increases but gas consumption amount by 1㎡ was shown to have opposite trend. Thus, as exclusive dwelling area gets bigger, gas consumption amount by 1㎡ decreased to 14.11㎥, 12.15㎥, 10.89 ㎥, 10.54㎥, 9.57㎥.

Second, correlation coefficient of yearly average gas consumption amount by exclusive dwelling area has strong positive linear relation with the value of 0.534 and we can see that gas consumption amount by 1㎡ and exclusive dwelling area have negative linear relation with the value of -.380. Besides, as a result of analyzing correlation between monthly gas consumption amount by 1㎡ and exclusive dwelling area, monthly gas consumption amount except July, August, September showed correlation coefficient from -.20 to -.32 showing strong negative correlation.

Third, as a result of ANOVA analysis, average gas consumption amount by 1㎡ of exclusive dwelling area mentioned above shows the conclusion that average difference is statistically meaningful.

Putting them all together, the reason that gas consumption amount is much more as exclusive dwelling area gets bigger is that the size of residential room for heating gets bigger. But bigger exclusive dwelling area doesn't mean that gas consumption amount by total unit area increases because the number of family member of usage time does not change. As floor area increases, basic cost for heating maintenance increases but usage amount per unit area decreases. According to the calculation standard of heating resource of group energy business law, 45kcal/㎡h is uniformly applied for unit heating load upon exceeding 60㎡ in case of apartment houses. Thus, we can see that heat usage per unit area is not proportional and this research is meaningful in that it provided basics by analyzing actual city gas consumption amount. Additionally, the result of this research is expected to be utilized as basic data for energy efficiency plan of apartment houses as well as development of forecasting model in city gas consumption amount of apartment houses in the future.

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