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Determination of excessive energy use buildings

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Abstract — Interest in energy saving is increasing. At the same time, interest particular is growing for energy efficiency in buildings. As such, building energy performance information is needed to determine which buildings require energy-efficiency retrofits. Currently, obtaining building energy-performance information is costly and agreed-upon standards are lacking. To further promote work in this area, we analyzed building energy consumption and suggested methods to determine excessive energy use in buildings

Keywords— ***Energy Save, Building Retrofit, Green Building,***

I. Introduction

Building energy consumption averages 38% of total energy consumption in the world. Korea has lower level at 21.2%, but energy consumption is increasing annually. As such, it is necessary to apply energy policies and practices to reduce energy consumption. Several examples of practices that address this include Building Energy Efficiency Rating, Energy Saving Designing Standard, Green Building Certification Criteria, etc. These regulations and ratings, however, mainly apply to new buildings. Therefore, existing buildings(over 15 years old) are not included. A policy that addresses energy efficiency retrofit of existing buildings will reduce energy consumption in the building sector because existing buildings make up 74.1% of total buildings and comprise most of the energy consumption in the building sector. To further promote energy efficiency retrofits of buildings for energy savings, building energy performance information is needed to implement a building energy efficiency retrofit. Most building owner, however, do not have this information and obtaining building energy performance information is costly and challenge.

Building owner can be obtained easily building energy consumption information. Therefor, energy efficiency retrofit determination method need to building owner using the energy consumption information. However, an appropriate approach does not currently exist in Korea.

This research thus offers an approach for determination of excessive energy use in buildings by analyzing the present energy consumption status of a building. (Only for public buildings.)

II. Scope and Methods

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A. Data Collection

The data that building energy consumption to 2011.01 until 2011.12 was collected public building in Seoul. The total of data is 4589. We were analyzed 3817 data that exclude input data 0 of year, gross floor area and floor, etc ..or get a using permit after 2011.

B. Establishing a Classification Standard for Analysis

First, To make a determination about excessive energy use in buildings, the relationship between primary energy consumption per unit area and multiple variables were analyzed by the Pearson product-moment correlation coefficient or one-way ANOVA

1) Correlation Analysis

The Pearson product-moment correlation coefficient is a measure of the linear correlation between two variables X and Y, giving a value between +1 and −1 inclusive, where 1 is total positive correlation, 0 is no correlation, and −1 is total negative correlation. It is widely used in the sciences as a measure of the degree of linear dependence between two variables. It was developed by Karl Pearson from a related idea introduced by Francis Galton in the 1880s.

2) One-Way ANOVA

One-way analysis of variance (abbreviated as one-way ANOVA) is a technique used to compare the means of two or more samples (using a F distribution). This technique can only be used for numerical data. p -values indicate the relationships between two variables. If a P-value is closer to 0, then the difference between the two variables is large.

C. Outlier Elimination

Second, Some data was considered as being an outlier in determinations of Seoul Public Building Energy Consumption Present Status. If the data was considered to present an obstacle in arriving at a determination of excessive energy use for a building. it was eliminated. We thus eliminated use of the Energy Efficiency Rating and eliminated use of a Box-Plot.

1) Energy Efficiency Rating Method

The Energy Efficiency Rating consisted of 10 ratings. Table # shows Energy Efficiency Rating. This evaluate primary energy consumption per unit area of building. In a non-residence, the primary energy consumption per unit area had an Energy Efficiency Rating of 1+++ at 80kWh/m^2· yr.(Residential building were 60kWh/m^2· yr). When primary energy consumption per unit area increased to 60 ~ 90 kWh/m^2· yr(For residential buildings 30~ 50 kWh/m^2· yr), the rating was increased. We eliminated buildings with building energy consumption of less than 80 kwh/m^2· yr(Residential building were 60kWh/m^2· yr) to eliminate outlier. Because This did not have large impact on determination of overall Building Energy Consumption.

2) Box- Plot method

The Box-Plot method(Emerson and Strenio 1983, Turksy 1977) was introduced to use quartiles by Devore and Peck(1986). It is mainly used to search for outliers in a statistical program. This method at ordered data look for quartile, and F_L is called the first quartile, F_U is called the third quartile. The observed value that is outside of a section (F_L - k × (F_U - F_L)), (F_U + k × (F_U - F_L)) is regarded as an outlier. This section change follows the k value, when k value is 1.5 or 3.0, it is a box plot of typical type. Outlier elimination had to remove target 30 or more examples of data. Because error can occur if there is insufficient data for analysis.

III. Status of Building Energy Consumption

A. Establishing a Classification Standard for Analysis

We were classified 4type. Gross floor area, Year, Floor, Building Use in Architecture scheme. In case of similar type such as building coverage, floor area ratio, building area are Integrated gross floor area. We were analyzed applying the Pearson correlation coefficient or one-way ANOVA about 4 type.

Gross Floor Area : Correlation and gross floor area was analyzed by applying the Pearson correlation coefficient. Table 1 shows the results Correlation and gross floor area was analyzed by applying results of the analysis. Analysis of the two variables resulted in –0.025, and there was no correlation.

TABLE 1 GROSS FLOOR AREA OF CORRELATION ANALYSIS RESULT

	primary energy consumption per unit area	Gross Floor Area
primary energy consumption per unit area	1	-0.025
Gross Floor Area	-0.025	1

TABLE 2 YEAR OF CORRELATION ANALYSIS RESULT

	primary energy consumption per unit area	Gross Floor Area
primary energy consumption per unit area	1	-0.062
Gross Floor Area	-0.062	1

TABLE 3 FLOOR OF ONE-WAY ANOVA RESULT

	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	1,615,281,154.9	22	73,421,870.7	0.396	0.995
Within Groups	346,550,233,045.0	1,867	185,618,764.4		
Total	348,165,514,199.9	1,899			

TABLE 4 BUILDING USE OF ONE-WAY ANOVA RESULT

	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	49819635866.098	25	1992785434.644	12.490	.000
Within Groups	298348551335.711	1870	159544679.859		
Total	348168187201.810	1895			

Year : Correlation and gross floor area was analyzed by applying the Pearson correlation coefficient. Table 2 shows the results Correlation and gross floor area was analyzed by applying results of the analysis. Analysis of the two variables resulted in –0.062, and there was no correlation.

Floor : Meaningful difference between primary energy consumption per unit area and floor was analyzed by applying one-way ANOVA. Table 3 shows the result. Analysis of the two variables resulted in 0.995, and there was no difference.

Building Use : Meaningful difference between primary energy consumption per unit area and Building Use was analyzed by applying one-way ANOVA. Table 4 shows the results. Analysis of the two variables showed 0.000, and reflected difference. This result indicates difference between each Building Use type. Therefore, we pursued further analysis of Building Use for determination of excessive energy use in buildings

Based on the analysis results, we classified 26 Building Use. Average primary energy consumption per unit area of Building Use was calculated to determine primary energy consumption per unit area of Building Use.

B. Status of Building Energy Consumption

Table 5 shows average primary energy consumption per unit area of Building Use. The type of facility with the least amount of primary energy consumption per unit area was Religious Facilities. The primary energy consumption per unit area was 212.06 kWh/m2·yr. The type of facility with the least amount of primary energy consumption per unit area was Sales Facilities. The primary energy consumption per unit area was 99,758.96 kwh/m2·yr.

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TABLE 5 2011 ENERGY CONSUMPTION OF PUBLIC BUILDING IN SEOUL

Building Use	Qty	Average primary energy consumption per unit area (kWh/m^2 • yr)
Detached House	325	823.89
Apartment House	12	366.36
The First calss Neighboring Convenience Facilities	1243	2,653.51
The Second calss Neighboring Convenience Facilities	265	2,531.25
Culture and Assembly Facilities	61	1,001.51
Religious Facilities	2	212.06
Sales Facilities	5	99,758.96
Transportation Facilities	6	2,888.06
Medical Facilities	14	583.49
Education Research Facilities	545	305.93
Elderly and Child Facilities	993	395.23
Training Facilities	24	501.53
Sports Facilities	38	771.47
Business Facilities	78	560.33
Accommodation Facilities	1	1050.11
Recrational Facilities	1	883.51
Factory	22	3,829.93
Storage Facilities	15	940.20
A Dangerous Article and Diposal	4	1,565.65
Automoblie-Realted Facilities	134	3,788.77
Animal and Plants–Related Facilities	1	1,393.22
Correctional and Military Facilities	10	347.74
Broadcating Communication Facilities	3	1,449.19
Cemetery-Related Facilities	4	2,274.98
Tourist and Rest Facilities	11	1,239.71
Total	3817	-

TABLE 2 2011 ENERGY CONSUMPTION OF PUBLIC BUILDING AFTER OUTLIER ELIMINATION IN SEOUL

Building Use	Qty	Average primary energy consumption per unit area (kWh/m2·yr)
Detached House	277	267.14
The First calss Neighboring Convenience Facilities	1016	322.17
The Second calss Neighboring Convenience Facilities	218	671.27
Culture and Assembly Facilities	49	463.16
Education Research Facilities	443	249.25
Elderly and Child Facilities	868	294.00
Sports Facilities	34	647.12
Business Facilities	70	447.69
Automoblie-Realted Facilities	77	236.57
Total	3052	-

C. *Outlier Elimination*

Some data was considered as being an outlier in determinations of Seoul Public Building Energy Consumption Present Status. If the data was considered to present an obstacle in arriving at a determination of excessive energy use for a building. it was eliminated. So We were eliminated outlier using Energy Efficiency Rating and Box-Plot method

First, Using Energy Efficiency Rating was eliminated data under 1+++ rating As a result, rest 3530 data.

Second, Using Box-Plot was eliminated data. As a result ret 3052 data. Table 6 shows a result.

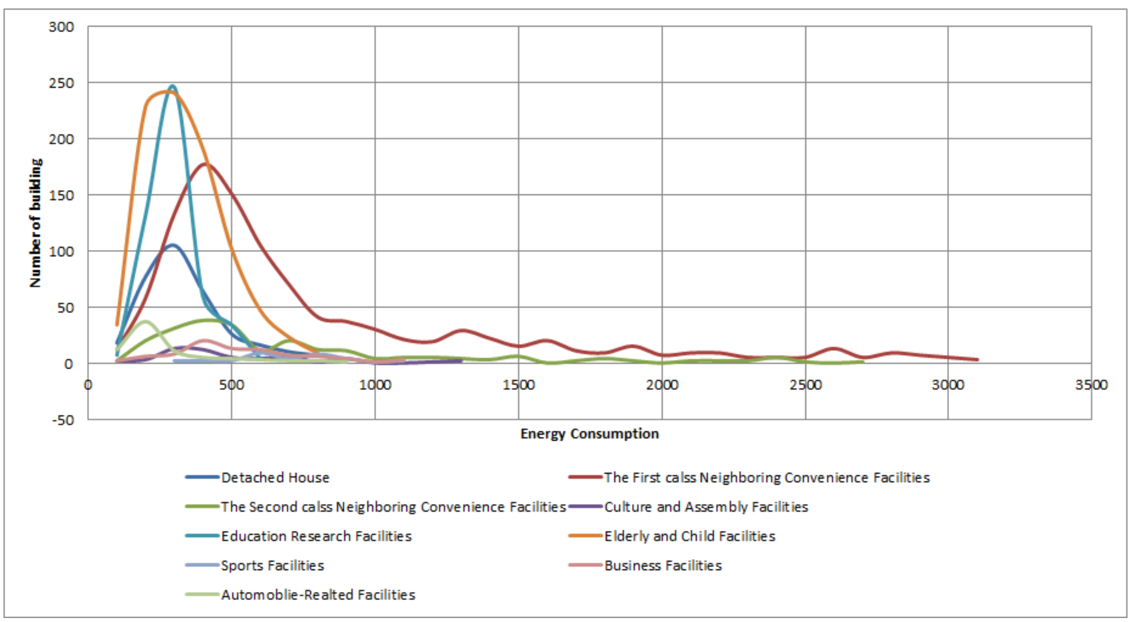

Figure1 Building Use Frequency Distribution Table

IV. Excessive Energy Use Buildings

We used frequency distribution to set up the determination of excessive energy use buildings. A frequency distribution is a table that separate regular range and arranges quantities in each range. This allows one to check primary energy consumption per unit area where there is a density. From the 2011 Energy Consumption of Public Buildings in Seoul data after outliner elimination, We wrote a frequency distribution table that separated primary energy consumption per unit area per 100 units. Fig. 1 shows a distribution of primary energy consumption per unit area in each Building Use category. Fig. 1 shows the distributed primary energy consumption per unit area in terms of each type of Building Use. Primary energy consumption per unit area was gathered to be part of frequency distribution table. We made a determination to separate this into a normal part. and an excessive energy excessive part. Fig. 2 shows primary energy consumption per unit area in a frequency table. As shown in Fig. 3, one part was set up from the first class until half of the class with occupied by those with the most frequency. And twice this part comprises the normal part. Table 7 shows a determination of excessive energy use buildings made using this method. Education Research Facility, the standard range exceeded the data range and so did not exist as standard. When building energy consumption more than standard, a building requires Energy Performance Measurement.

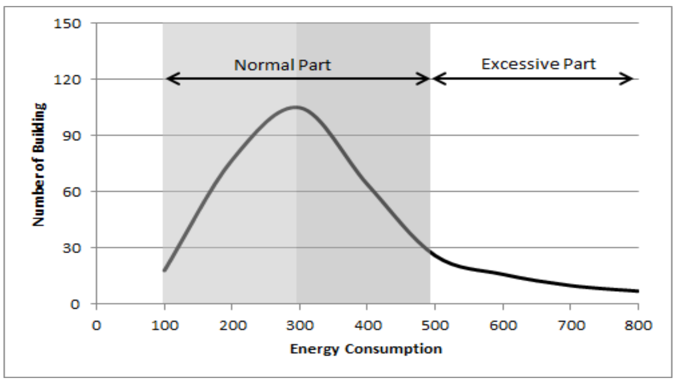

Figure2 Excessive Setting Method

TABLE 3 determination of excessive energy use buildings

Building Use	primary energy consumption per unit area (kWh/m2·yr)
Detached House	520
The First calss Neighboring Convenience Facilities	540
The Second calss Neighboring Convenience Facilities	620
Culture and Assembly Facilities	330
Education Research Facilities	-
Elderly and Child Facilities	730
Sports Facilities	520
Business Facilities	310
Automoblie-Realted Facilities	470

V. Conclusion

Interest in reducing building energy consumption is increasing. It is difficult to make judgments about building energy consumption. Because there is no standard approach to make determination of excessive energy use buildings. This research suggests an approach for designation as an determination of excessive energy use buildings in order to further building energy saving efforts. The relationship between primary energy consumption per unit area and Gross Floor Area, Floor, and Building Use was analyzed by Pearson product-moment correlation coefficient or one-way ANOVA and public building energy consumption was classified. As a result, we were able to confirm building energy consumption differences in Building Use. Outliner existed in the 2011 Energy Consumption of Public Buildings in Seoul data. Therefore, we eliminated outliners from 2011 Energy Consumption of Public building in Seoul data that used an Energy Efficiency Rating and eliminated data from the Box-Plot method. We used a frequency distribution table to set up the determination of buildings with excessive energy use. The frequency distribution table separated primary energy consumption per unit area per a 100 units. As a result, each Building Use difference indicated close positions. However, their close position are gathered table at front. So, we determined close position by normal part. We were able to make at a standard of 8 out of 28 Building Use types. The standard did not make upon all Building Use type. But the Building Use standard comprised 80% of buildings in a component ratio. The results of this research will contribute to reduce building energy use. But, The results of this research can be applied to some Building Use. In further, research is needed to supplement data regarding all building Use types.

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References

[1] Ministry of Land, old building statistics, 2012
[2] IWR, Global CO2 Emissions up in 2011,2011
[3] Ministry of Trade,Industry&Energy,Energy Consumption Survery, 2012
[4] G. Eason, B. Noble, and I. N. Sneddon, "On certain integrals of Lipschitz-Hankel type involving products of Bessel functions," Phil. Trans. Roy. Soc. London, vol. A247, pp. 529–551, April 1955.
[5] J. Clerk Maxwell, A Treatise on Electricity and Magnetism, 3rd ed., vol. 2. Oxford: Clarendon, 1892, pp.68–73.
[6] I. S. Jacobs and C. P. Bean, "Fine particles, thin films and exchange anisotropy," in Magnetism, vol. III, G. T. Rado and H. Suhl, Eds. New York: Academic, 1963, pp. 271–350.
[7] Howell, David (2002). Statistical Methods for Psychology. Duxbury. pp. 324–325. ISBN 0-534-37770-X.
[8] John W. Thkey, Exploratory data analysis, Addison-Wesley, 1977.
[9] Devor, Jay L., and Peck, Roxy L., Statistics: The Exploration and Analysis of Data(4th ed.), Pacific Grove, Ca: Duxbury, 2001.
[10] Devor, Jay L., and Peck, Roxy L., Statistics: The Exploration and Analysis of Data, St. Paul: West, 1986.

[11] Korea Institute of Construction Technology, ITS information reliability improvement and evaluation, pp. 296- 299, 2008.

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