Building Energy Consumption Pattern Analysis of Detached Housing for the Policy Decision Simulator

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Abstract. The Korean government announced its plan to raise the previous reduction goal of greenhouse gas emission from buildings by 26.9% until 2020 on July 2015. Therefore, policies regarding efficiency in the building energy are implemented fast, but the level of building owners and market understanding is low in general, and the government service system which supports decision making for implementing low-energy buildings has not been provided yet. The purpose of this study is to present the design direction for establishing user customized building energy database to perform a role to provide autonomous ecosystem of low-energy buildings. In order to reduce energy consumption in buildings, it is necessary to carry out the energy performance analysis based on the characteristics of target building. By analysing about 20-thousand cases of the amount of housing energy consumption in Korea, this study suggested the real energy consumption pattern by building types. Also, the energy performance of a building could be determined by energy consumption, but previous building energy consumption analysis programs required expert knowledge and experience in program usage, so it was difficult for normal building users to use such programs. Therefore, a measure to provide proper default using the level of data which general users with no expert knowledge regarding building energy could enter easily was suggested in this study.

1. Introduction

After raising the target of greenhouse gas emission reduction in buildings to 26.9%, the Korean Government is implementing the stricter regulation and introducing incentives to increase the building energy efficiency. To ensure that the national policy is successfully established timely, focusing on energy retrofit of existing building since they take up most of buildings is more needed than focusing on new buildings [1]. To improve the energy performance of existing building, it is important to easily assess the energy performances of the buildings and to accurately and quantitatively predict the performances of these energy reducing elements during the energy retrofit decision making stage [2].

EU and advanced countries such as U.S. have developed and provided a reliable national system to support decision making of relevant personnel including public building energy policy makers and building managers on efficient building energy usage and maintenance. In case of Korea, the speed of policies for building energy efficiency is fast but the understanding of market is generally low, and the government service system to support decision making for effective public building energy management is still not provided yet [3].

As such, this study is intended to segment the energy usage based on the actual use of energy source by 507 detached houses using the existing nationwide energy database and national statistics and to analyse the energy consumption patterns for development of policy decision simulator.
2. Energy-related database
Building energy-related database is provided by various subjects such as building permit information and energy usage information. However, it is too complicated to detach the pattern of energy consumption from the sum of energy usage because building energy consumption is influenced by various factors and the pattern of energy usage also changes due to the interaction between those factors. Also, the level of influence from such factors also varies according to the purpose of building and it is very difficult to predict such level due to too many types of variables and wide variations. Currently, there are various government-affiliated organizations but they all collect and manage building-related information for different purposes to each other as below.

Table 1. Energy-related Database Status in Korea.

| Ministry                                      | Agency                                      | Retained information                  | Purpose of information collection                                                                 |
|-----------------------------------------------|---------------------------------------------|---------------------------------------|---------------------------------------------------------------------------------------------------|
| Ministry of Land, Infrastructure and Transport | Korea Appraisal Board[4]                    | Building energy consumption            | Calculate energy consumption unit for each building purpose and establish greenhouse gas emission quantity inventory for home and business                      |
|                                               | Seumteo (e-AIS)[5]                          | Building ledger and energy efficiency level certification | Basic statistical data for national building status analysis                                         |
|                                               | Spatial Information Industry Promotion Institute (V-world) | 3D shape of buildings                  | Provide the national spatial information open platform                                              |
|                                               | Korea Infrastructure Safety and Technology Corporation | Quarterly energy consumption          | Review energy consumption and manage energy performance                                             |
|                                               | Ministry of Strategy and Finance             | 2D plane of buildings                  | Provide the open platform which converges spatial statistical information and various external information to support spatial decision making for small areas |
|                                               | Ministry of Trade, Industry and Energy       | Monthly greenhouse gas emission and energy consumption | Establish the rational energy usage promotion plan for public agencies, check the result and manage the greenhouse gas emission and energy consumption targets |
|                                               | Korea meteorological administration          | Weather information for each area      | Provide national weather service                                                                     |

This study segmented the actual building energy consumption data by region, size and characteristics by analysing the factors included in the building ledger and analysed the actual usage by purpose using the energy pattern of each energy source extracted from the sampling data of the Energy Consumption Survey.
3. Analysis of energy consumption according to purpose by detached houses in Seoul

The data used in this study are the energy consumption according to electricity and city gas energy source from January 2012 to December 2014 of 507 case samples among the detached houses in Seoul and the building ledger data. Each case is the data case that matches the data in the building ledger provided by Seumteo and the monthly electricity energy consumption based on the billing. 1% data were randomly extracted from the detached housing-building ledger of Seoul for the analysis.

3.1. Electricity energy consumption analysis

Figure 1 shows the base unit of monthly energy consumption by detached houses in Seoul. The average consumption base unit was 5.7kwh/m² in 2012, 5.7kwh/m² in 2013 and 5.4kwh/m² in 2014. During the analysed period, the monthly base unit tended to peak in August.

![Figure 1. Electricity Energy Consumption-2nd Energy- of Detached House in Seoul.](image)

The Energy Consumption Survey (2014) reported the annual electricity energy consumption by each detached house in urban regions in Korea was 318.67kwh [6] while the actual annual electricity energy consumption by each detached house case obtained for this study was around 1112kwh. The discrepancy is attributed to the fact that, although the average number of households per detached house in the origin data was two, the cases in the building ledger included the faulty registration of 0 household or more than 10 households in a detached house. Correcting the faulty registration, the annual energy consumption was 350~450kwh/household which was similar to the electricity energy consumption per household analysed by the Energy Consumption Survey.

3.2. Energy consumption disaggregation

The energy consumption disaggregation is usually estimated with simulation or with the method of disaggregating by outside air temperature. Although there are cases of using the real-time aggregation system, it is difficult to consider them representative since some cases have fewer than 10 samples. As such, this study sampled the energy consumption for energy consumption disaggregation of detached houses by applying the ratio according to purpose of energy use extracted from the Energy Consumption Survey (2014).

The actual energy consumption patterns of 507 cases via the ratio of the detached housing energy consumption from the energy consumption survey are as below. Hot water & Cooking, Lighting, Building general power and etc. tend to be similar during the years however, Cooling and Heating have a trend to decrease the consumption by every year. The reason of the decreasing of cooling and heating energy consumption trend is the annual weather effect.
4. Conclusion and Future Work
In the research, the research team has been conducted on the disaggregation of energy consumption of detached housing in Seoul utilizing the energy use pattern ratio from the energy consumption survey in Korea (2014).

Energy consumption disaggregation can be more accurate with 1) non-weather dependent components, 2) weather dependent components, and 3) time and occupancy dependent components [7]. The Whole set of energy related data gathered and managed by the Korean government can be offered more specific energy usage patterns by conducting. The current work shows that the possibility of the level of detail of energy consumption breakdown. The accuracy of the disaggregation needs to consider about complexity of the building and comprehensive of the performance indicators of buildings. To improve the accuracy of energy disaggregation, the research team has to investigate the detailed performance indicators from the existing buildings for utilizing the baseline of the policy decision simulator.

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