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Constructing electricity load profile and formulating load pattern for urban apartment in Korea

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A B S T R A C T

At present, the energy saving in residential buildings becomes an issue through the world. For this energy saving, accurate analysis and prediction for energy consumption pattern should be preceded. Therefore, this paper is drawn up a Load-Profile through the energy consumption pattern in residential buildings, especially in an apartment which accounts for 60% in residential buildings. As the daily operation pattern can decide system performance, it is important to collect accurate hourly energy consumption of the apartment building. Accurate data were collected by conducting survey and actual measurement. For the survey, general items and data sheets were used to collect the power consumption and duration of home appliances and lighting equipment usage every 10 min. To measure the entire power of the sample household, Yokogawa CW240 Clamp-on Power Meter was installed in the watt meter. In addition, a standby watt meter; HPM-100A from AD Power; was used to measure the home appliances power consumption. As a result, the patterns in weekdays and weekend are different and for the appliances are different as well. Based on this result, the calculation formula for the amount of electricity used per housing unit is deduced. Also, the consumption pattern prediction is implemented using ARIMA model. By demonstrating the usage of electricity, understanding the tendency and preparing load profile standard. Through this research, household should reduce peak-load during daily life.

1. Introduction

Due to an outstanding economic growth and population increase, Korea has had a serious housing shortage. This has led to the massive supply of apartment buildings. Recently, the construction rate of apartment buildings continues to increase, accounting for more than 75% of apartment houses. Thus, in Korea, most of the houses are apartment buildings, resulting in high energy consumption. In addition, various high-tech home appliances are distributed fast with bigger capacity than in the past. Accordingly, this study focused on the analysis of the power usage pattern.

Since the energy facilities in apartment buildings are managed by individuals, it is thought to be difficult to manage energy consumption systematically. However, considering every household in the apartment building as a single module, they have the same structure and function. Therefore, if the standard load model is developed with an understanding of characteristics of energy consumption in apartment households, we can save energy efficiently, utilizing it as an indicator of optimizing the size of energy supply facilities, and as the standard for designing facilities, and obtain base data for better integrated alternatives. Thus, this study aimed to analyze the power usage pattern for the summer season to develop the power load profile, which was the first step to analyze the energy consumption characteristic of the apartment building and develop the standard load model. Even though existing studies on power use suggest total energy consuming per unit area and monthly usage, there is few study on the load pattern by time and which part is most attributable to energy consumption in Korea.

In other countries, there are many studies on the residential building Load Profile. Widen et al. [1] created the load profile with data sporadically collected from 1996 to 2007 and compared it with modeled data. They insisted that the detailed load profile of residential energy is very important for distributed power supply or solar energy supply, and tried to create the energy load profile for residential buildings in Sweden. Yao et al. [2] studied energy load profile for domestic buildings in the UK. They insisted that the energy load profile has physical and active elements and created the load profile based on various scenarios. First, home appliances were categorized into five: small home appliances, refrigerators, kitchen appliances, laundry machines and other home appliances, and then their penetration rate and their use were presented by using various research data. Murthy et al. [3] describes the results of

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a survey of electricity consumption in a sample consisting of 1165 households in four districts of Karnataka state in India. William Chung et al. analyzed the respective contributions of changes in residential energy consumption [4]. K.J. Chua and S.K. Chou investigated the energy performance of residential buildings and modelled residential buildings for computer simulations [5]. A. Mavrogianni et al. analysed the existing bottom-up building physics based residential energy models focusing on their purposes, strengths, and shortcomings, and compare five building physics based bottom-up models focusing on the same building stock – UK case study, and identify the next generation of coupled energy–health bottom-up building stock models [6]. Iana Vassileva et al. analysed electricity consumption and behavior of households with identical characteristics [7]. A Grandjean et al. analysed existing building methods capable of building up a residential electric load curve that focused on bottom up models [8]. A bottom-up diversified demand model which can be used to estimate load profile of residential customers in a given region described by Samuel Gyamfi and Susan Krumdieck [9]. W.Chung present in [10] the methodology in order to bench-marking the energy efficiency of commercial buildings. He proposed the use of fuzzy linear regression analysis on benchmarking process in order to benchmarking model can be used by public users.

Teemu et al. present in [11] the methodology they developed in order to create electricity use load profiles. They develop on the basis of self-organizing maps (SOM) and clustering methods(K-means and hierarchical clustering) with large amount of customer-specific hourly measured electricity use data. S. Chen et al. analyze winter energy use of residential buildings in different cities with questionnaire surveys. The survey shows there exist obvious differences in influence factors [12]. M. Aydinalp-Koksal and V.I. Ugursal investigate the use of conditional demand analysis (CDA) method to model the residential end-use energy consumption at the national level [13]. Yuanyuan Wang et al. proposed residual modification models to improve the precision of seasonal ARIMA for electricity demand forecasting in order to help people in the electricity sectors make more sensible decisions [14].

In particular, when it comes to apartment buildings, the entire complex becomes one single unit and receives high voltage power, distributing electricity to each household. Since the meter men record electricity consumption of each household on a monthly basis, it is very difficult to obtain daily/hourly energy consumption data. Furthermore, it is also difficult to identify how much the electricity usage for home appliances and lights account for total power consumption. This study was conducted to give answers to those questions.

2. Scope and methodology

Load profile describes various energy load patterns on a graph. In general, it is presented with annual, monthly, daily and hourly load pattern curves; it is easy to understand the maximum load and is used for various analyses. Thanks to the recent proliferation of electric watt-hour meters, the load profile can be created by collecting power consumption every 15 min. The load profile can be divided into three types, no permanent load profile, permanent with a low base loading and permanent load profile with a high base loading.

In this study, permanent load profile with a high base loading is used. It is because equipment such as the refrigerator is continuously running and the usage of other devices is increasing by occupant's life pattern in the apartment building. In addition, the standby power of various home appliances contributes to a high base loading.

This study collected daily and hourly power consumption behavior to analyze the power consumption pattern and present the summer load profile. For precision measurement, from July 12 to July 19, 2010 and from August 23 to August 30, 2010 (considering peak time in the summer), the Yokogawa CW240 Clamp-on Power Meter was installed in sample household to measure power use every 10 min, and the standby power meter (ADPower HPM-100A) was installed in major home appliance. In addition, 30 sample households were selected to collect daily and hourly data. The progress of the study is shown in Fig. 1.

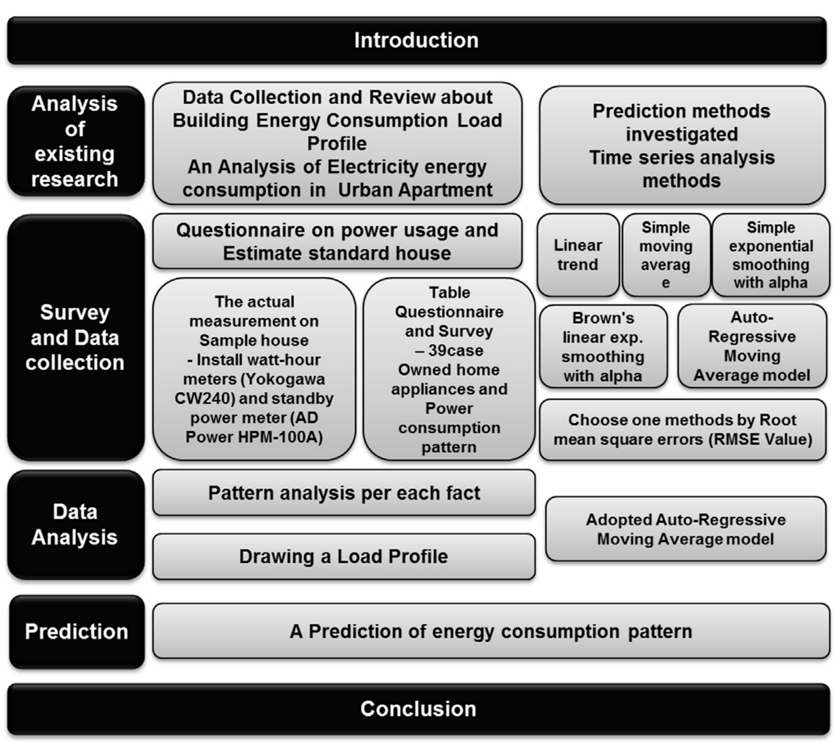

Fig. 1. Flow chart of study.