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Short-term Prediction of Power Consumption for Large-scale Public Buildings based on Regression Algorithm

Huilong Wang[a], Xing Lu[a],Peng Xu[a]*, Dengkuo Yuan[a]

[a] *School of Mechanical Engineering, Tongji University, Caoan Road 4800, Shanghai, 201804, China*

Abstract

Energy consumption monitoring and regulation on large-scale public buildings are always an indispensable part in building energy conservation. With the mounting establishment of the building sub-metering platform, massive amounts of historical power consumption data are provided. In this paper, different building types of six large-scale public buildings in Shanghai are selected, with their sub-metering data deeply analyzed. The concept of CDHs/HDHs (cooling/heating degree hours) is introduced and weekly prediction models of total building power consumption are proposed by the way of multiple linear regression algorithm which is relatively simple and easy to understand. The prediction models are validated to have great accuracy and general applicability in the paper, offering reliable instructions to the building facility manager and relevant competent authorities in terms of decision making and policy implementation.

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Keywords: Large-scale public buildings; Sub-metering; Power consumption prediction; Multi-linear re-gression algorithm;

1. Introduction

Large-scale public buildings generally refer to the building covering an area of over 20000m^2, using the central air-conditioning systems, diversified in types including office building, commercial building, education center and transportation hub, etc. The area of the large public buildings in China only account for 4% of the overall area in cities and towns, while the annual power consumption take up as much as 22% of the whole energy consumption [1].

* Corresponding author. Tel.: +86 136 0197 1494; fax: +86 136 0197 1494.
E-mail address: xupengwb@gmail.com

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In 2011, the area of large public buildings is 7.97 billion m^2, among which the large-scale public building occupies 0.57 billion m^2. The energy consumption excluding heating consumption reaches 90-200 kWh/(m^2·a), roughly 2~4 times than normal public buildings [1]. Unless energy-saving measures being taken, by 2020, merely power consumption of newly-built large public buildings will increase to 200 billion kWh [2]. Thus it can be concluded that the energy consumption of large public buildings possesses a massive proportion in building energy consumption and it is high time that we adopted effective approaches to achieve conservation and efficiency.

Recent years, sub-metering has been widely promoted by the encouragement of relevant government departments. Since 2005, thousands of large public buildings in big cities have installed sub-metering to implement real-time monitoring. Through wireless data acquisition and transmission, sub-item energy consumption in large public buildings can be precisely measured, tackling the problem of lacking detailed sub-item energy consumption data on building energy conservation work [3]. Undoubtedly, energy consumption monitoring platform offer us overwhelming historical data. However, what majority of the monitoring systems are facing at present is the dilemma of data accumulation. Hence, the digging and analysis of the sub-metering data become increasingly important.

We can take full advantage of the data from the sub-metering platform to figure out the characteristics of a certain building and make a study and forecast of energy consumption on the whole-building level and subsystem level. Further diagnosis of the abnormal consumption can be realized by utilizing the prediction model and the conservation strategy can be proposed by analyzing the reason for the abnormal consumption. Moreover, the result of the prediction model can offer reliable instructions to the building facility manager and relevant competent authorities in terms of decision making and policy implementation.

Numerous papers concerned with methods used in building energy prediction can be found in academic databases. The methods can be categorized into the following groups, for example, engineering methods, regression analyses, artificial neural networks (ANNs), support vector machines (SVMs) and grey models [4,5]. Engineering methods are on the basis of physical principles to calculate energy performance on the whole building level or for sub-level components. Simulation programs calibrated with real measured data, such as DOE-2, EnergyPlus, BLAST, ESP-r, are often used to predict the energy consumption. Regression methods use a simple or multivariable regression analysis to correlate the outputs to inputs parameters like climate information, operation data and occupancy behavior. ANNs and SVMs are both intelligent computer systems, which developed from machine learning algorithms that are capable of ‘make decisions’ with an interpretation of data. ANNs are good at solving nonlinear problems to predict building energy consumption. SVMs are effective in solving nonlinear problems even with small quantities of training data.

Each model has its own pros and cons in certain cases of applications [6]. Engineering method is the only method that can fully develop the energy consumption of the sector without any historical energy consumption information [7]. But a well-accepted demerit of detailed engineering model lies in that it is difficult to perform in practice on account of the lack of input information. Intelligent computer systems provide a better prediction for the energy consumption in spite of high complexity. Nevertheless, they are not based on the physical principles and run as a black-box system which makes the interpretability very difficult [8]. As for the regression model, it is easy to develop but it is commonly acknowledged that they are relatively inaccurate and lack of flexibility. The scholars in the past built the prediction model taking various factors into consideration to discover a universal regression equation which has a fine fitness with the buildings in the same type. But the predictive results in most cases are not satisfied in the practice due to the distinct structure, systems as well as the operation time of different buildings. To solve the problem, they had to introduce complex correction coefficient. Nowadays, we are able to set up prediction model of each building on the ground of historical data on the sub-metering platform, thus enhancing the accuracy of the outcome to a certain extent.

To put it in a nutshell, it is really necessary for us to find a simple but effective energy prediction model. In this paper, an accurate prediction to the weekly power consumption of the large-scale buildings is proposed, using the multi-linear regression algorithm with sub-metering data deeply analyzed. According to the result of the prediction, the model is applicable to different types of public buildings in Shanghai, including commercial buildings, office buildings and building complex, setting solid foundation for the large-scale public buildings in energy efficiency diagnosis, energy saving inspection and supervision work.