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Analysis of Factors Influencing the Energy Consumption of Government Office Buildings in Qingdao

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Abstract

There is great potential to improve the energy efficiency of large public buildings due to the intense energy use. Since 2011, a research project has been conducted to study the energy consumption characteristics of the buildings in China. This paper presents the findings particularly related to government office buildings in Qingdao city. It is found that the occupancy density and the type of cooling system are major energy consumption influencing factors. Most of the study buildings have an energy consumption intensity between 20 kgce/m^2 and 30 kgce/m^2. It is suggested that air-conditioning system should be given particular attention when determining energy retrofit subsidies.

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Keywords: energy conservation; government office buildings; occupancy density; cooling system; energy consumption intensity

1. Introduction

Building energy consumption accounts for approximately 30% of the total energy consumption around the world and the proportion is expected to increase with the arising living standard[1]. From 1990 to 2010, China's building energy consumption has grown at an average rate of 10% annually [1]. Therefore, analysis and conservation of building energy consumption is critical to enhance global energy efficiency. Particularly, air-conditioning system is widely recognized as one major contributor to the building energy consumption, hence it will be separated from the building system to conduct an in-depth study.

To support administrative agencies setting appropriate energy conservation targets and determining effective energy retrofit measures, comprehensive investigations of existing building energy consumption characteristics is extremely helpful [2]. A large number of papers are devoted to analyzing the influencing

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factors of energy consumption of large public buildings [3-5]. D. Bing, E.L. Siew, et al. used a holistic utility bill to evaluate the method for baseline whole building energy consumption [3], which concluded that outdoor dry-bulb temperature is a significant influencing factor. Xiaoqing Wei, Nianping Li, et al. carried out an analysis of energy consumption data of office building in Changsha, China [4]. He Xiao conducted a questionnaire survey on the office building energy consumption pattern in both Beijing and HongKong. The results revealed that occupant behaviour exerts a remarkable impact on the energy consumption [5]. A project has been conducted by the authors since 2011 to identify the energy consumption characteristics of large public buildings in Qingdao city. This project studied the energy consumption characteristics of 24 government office buildings. This paper presents the findings related to government office buildings.

2. Basic information of surveyed buildings

Among the investigated 24 buildings, 14 ones are large public buildings (total floor area is more than 20 thousand square meters), 3 ones are medium buildings with floor area between 10 and 20 thousand square meters, and the area of rest 7 ones are less than 10 thousand square meters. It is worth mentioning that, about 36% of the buildings were constructed after 2005, when the "Design Standard for Energy Efficiency of Public Buildings' has already been published. For this reason, buildings built after 2005 are supposed to have higher envelope insulation levels than those built before 2005. Therefore, the age of the investigated buildings can reflect their construction characteristics. Regarding the type of heating and cooling systems, district heating is the major heating source, and there is no centralized cooling system in these buildings.

3. Methodology

3.1. Data processing

In order to eliminate the influence of the size of building area on energy consumption, annual energy consumption per unit area is used for analysis.

$$\mathrm{Q} = \sum u_i q_i / \mathrm{A} \qquad (1)$$

Where，u_i refers to the standard conversion coal coefficient of electricity, natural gas, heat (as shown in Table 2). q_i refers to the consumption of electricity, natural gas, municipal heat consumption. Units are kWh/a、m^3/a、GJ/a respectively. A refers to the construction area, m^2.

Table1.Standard coal coefficient of different energy

Energy kinds	Standard coal coefficient
Electricity	0.30kgce/kWh
Natural gas	1.33kgce/m^3
Heating	34.12kgce/GJ

From Fig.1, we can see that tendency of 24 buildings' monthly electricity consumption is in agreement and there will be a small peak in the summer cooling season. The calculation formula of air-conditioning energy consumption per unit area is as follows:

$$Q_{ac} = (Q_e - Q_{tm} * 12)/A_{ac} \qquad (2)$$