Influential Factors of Energy Consumption in Star-rated Hotels—A Case Study of Hotels in Shandong Province

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Abstract

With the continuous advancement of the concept of green economy, the control of building energy consumption has become a key direction to promote the ecological environment protection. As the main component of the total building energy consumption, the energy consumption of star-rated hotels is growing rapidly with the improvement of the overall level of hotels, which seriously hinders governments’ progress of energy conservation and emission reduction. This paper takes star-rated hotels in Shandong Province of China as an example, builds on the analysis on the energy consumption status of star-rated hotels in Shandong, makes an empirical analysis on the factors affecting the energy consumption of star-rated hotels by using factor analysis, questionnaire and other methods, and further puts forward specific energy-saving measures of star-rated hotels. The research has indicated that the main internal factors affecting the energy consumption of star-rated hotels in Shandong involve the exterior envelope structure of hotel buildings, the number and type of related facilities and restaurant services; the main external influencing factors concern outdoor temperature, indoor environmental standards and consumers’ journey lifestyle; the influence of internal factors is greater than that of external factors; among the internal factors, the impact made by the envelope structure of hotel buildings is the most significant.

Keywords: Shandong Province, Star-Rated Hotel, Energy Consumption, Factor Analysis, Influencing Factors.

1. INTRODUCTION

1.1 Literature Review

The popularization of the concept of low-carbon economy and green consumption has made domestic and foreign scholars attach increasing attention to energy consumption, especially the energy consumption of the large-scale urban carbon emitter: star-rated hotels. Meantime, a number of scholars have studied the energy consumption of star-rated hotels. Wei Wei, Zhang Shasha and others scholars took hotels in Guangdong Province as an example, conducted importance ranking and difference analysis on the hindered influencing factors of energy conservation of star-rated hotels, made a number of energy-saving measures, and provided a reference for all relevant interest bodies to develop effective energy conservation measures (Wei et al., 2010). Chang Xianwen, Qu Guolun et al. argued that the hotel air-conditioning heat recovery system was the main factor influencing the energy consumption of star-rated hotels (Chang et al., 2012). Huang Qi and other scholars believed that the power consumption of hotels was the largest contributor to energy consumption, with heating, ventilation and air-conditioning accounting for the highest proportion (Huang et al., 2014). Yu Dan and Liu Zeyu deemed heating systems as the important part of building energy efficiency (Yu et al., 2015). Bai Yi and Teng Xiao guo believed that the main factors impacting the installed capacity and operation condition involved annual energy consumption, equipment efficiency, gas loss of energy consumption per unit and power loss of energy consumption per unit of direct-fired turbines and boiler equipment (Bai and Teng, 2016). B.L. Mak et al. considered that hotels could realize electric quantity reduction and energy consumption control by cutting down power utilization and the number of hotel staff (Mak et al., 2013). M. Jinwoo, J. Sungkwon and other scholars argued that the effective prediction of the cooling energy of accommodation building could adjust the use plan of electric energy and consequently reduce carbon emissions (Jinwoo et al., 2015). According to P.O. Oluseyi et al., the application of service power and room price level that controlled energy consumption equipment ensured that hotel carbon emissions were within reasonable limits (Oluseyi et al., 2016).

1.2 Research Objectives
China has become the fourth largest tourist destination in the world. As a key economic sector in the tourism industry, China’s hotel industry has been rapidly advancing. Based on the statistics bulletin of the national star-rated hotels released by China National Tourism Administration, as of the end of 2015, there were 789 five-star hotels in China, 2,375 four-star hotels and 7,386 hotels with three-star or below, and the total revenue reached 210.68 billion yuan. Hotel industry has gradually become the pillar industry of tourism. The expanding scale of star-rated hotels brings people a comfortable consumption experience, but also their energy consumption becomes a prominent issue in the development of low-carbon economy (Petrevska et al., 2016). At this stage, as major energy consumers, star-rated hotels in China have backward operation modes of energy-saving emission reduction and experienced serious energy waste such as water, electricity and gas. Plus, the rising energy prices have resulted in an increase in hotel operating costs and a significant amount of carbon dioxide emissions and environmental pollution (Chang et al., 2016). It is obvious that star-rated hotels promote the green low-carbon model and control energy consumption and carbon emissions in order to drive the eco-friendly development and upgrading of the entire hotel industry. Based on this, the paper takes star-rated hotels in Shandong Province as an example, analyzes the basic conditions of energy consumption of local star-rated hotels, applies factor analysis, and makes an empirical discussion of the main factors affecting energy consumption of star-rated hotels, hoping to promote the upgrade and improvement of low-carbon operation model in hotels.

2. BASIC SITUATION OF ENERGY CONSUMPTION OF STAR-RATED HOTELS IN SHANDONG PROVINCE

As high-energy-consuming buildings, star-rated hotels have complete supporting facilities and equipment, which is an important reason for the hotel energy consumption. In case of Shandong, the number of star-rated hotels is relatively large, and the overall energy consumption in buildings is tremendous. As indicated by statistics from ICBC, there were 667 star-rated hotels (three-star and above) in Shandong in 2015, accounting for 8.1% of the total number of hotels above 3-star rating. Specifically, there were 30 five-star hotels with an average energy cost rate of 11.2%, 149 four-star hotels with that of 11.5%, and 488 three-star hotels with that of 14.3%.

Specifically, on the one hand, an enormous proportion of energy is consumed by the infrastructure and catering sectors of star-rated hotels in Shandong. The infrastructure services involves central air conditioning, elevators, integrated services setting equipment, etc. In general, the settings for the central air-conditioning of star-level hotels in Shandong are the temperature of 22°C to 28°C and the relative indoor humidity of 40% to 80% in summer and the temperature of 16°C to 24°C and the humidity of 30% to 60% in winter. In addition, the scale of star-rated hotels in Shandong is generally large, and the majority of single buildings cover an area of more than 20000m². These building features, including large scale, deep dimension and enclosed space, lead to poor natural lighting and ventilation conditions in star-rated hotels, and it is difficult to meet the indoor requirements of consumers. For this purpose, star-rated hotels mainly draw support from central air conditioning, lighting equipment, etc., to take overall control of the indoor hotel environment, which brings tremendous basic energy consumption for star-rated hotels. Moreover, in recent years, with the improvement of Shandong people’s living standard, the number of catering customers in star-rated hotels has been gradually enlarged, making the catering service department the largest energy consumption sector of star-rated hotels in Shandong. According to statistics, the energy consumption of catering service departments exceeds 50% of that of the star-rated hotels. On the other hand, star-rated hotels in Shandong have higher energy costs. Electricity, natural gas and oil are the main energy consumption types of star-rated hotels in Shandong. Among them, electricity is the mostly used energy by star-rated hotels, generally concerning air conditioning, indoor and outdoor lighting and power equipment. Natural gas is chiefly used in cooking and 24 hours of uninterrupted supply of hot water. Oil is primarily applied in oil burning boilers as well as backup generators. The total costs of the above three kinds of energy rank the second in the capital expenditure of star-rated hotels, accounting for more than 11% of the total annual revenue.

3. AN EMPIRICAL ANALYSIS OF THE FACTORS AFFECTING THE ENERGY CONSUMPTION OF STAR-RATED HOTELS IN SHANDONG PROVINCE

3.1 Construct the Index System

The hotel industry’s energy consumption is affected by numerous factors. In order to more comprehensively and truly reflect the main influencing factors, this article summarizes the basis of previous studies and mainly classifies the influencing factors into internal and external factors. Specifically, internal influencing factors include the envelope structure of hotel buildings, the number and type of related facilities and restaurant
services. The external factors mainly involve outdoor temperature, indoor environmental standards and consumers’ journey lifestyle. Furthermore, we took hotels in Shandong as an example, randomly selected five different types of hotels in Jinan, Liaocheng, Heze and other cities for field experimental research, interviewed the deputy general manager, engineering director or relevant persons in charge of hotels, and finally obtained 16 comprehensive index variables, so as to construct an index system for the influencing factors of energy consumption of star-rated hotels, as illustrated in Table 1.

Table 1 The Index System for Factors Affecting Energy Consumption of Star-Rated Hotel

<table>
<thead>
<tr>
<th>Index</th>
<th>Content</th>
<th>Index</th>
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<tbody>
<tr>
<td>X1</td>
<td>Hotel exterior walls can insulate heat in summer, ventilate in spring and in autumn, and keep warm in winter</td>
<td>X9</td>
<td>Increased cooking energy waste in restaurants of star-rated hotels</td>
</tr>
<tr>
<td>X2</td>
<td>Hotel exterior windows can insulate heat in summer, ventilate in spring and in autumn, and keep warm in winter</td>
<td>X10</td>
<td>Outdoor temperature conditions of star-rated hotels</td>
</tr>
<tr>
<td>X3</td>
<td>Hotel roofs can insulate heat in summer, ventilate in spring and in autumn, and keep warm in winter</td>
<td>X11</td>
<td>The level of usage of central air-conditioning ventilation, cooling and heating system in star-rated hotels</td>
</tr>
<tr>
<td>X4</td>
<td>Star-rated hotels have bars, meeting rooms, cafes, sauna and gym and other basic business projects</td>
<td>X12</td>
<td>The service condition of fresh air dilution, cooling or heating and other methods in star-rated hotels</td>
</tr>
<tr>
<td>X5</td>
<td>Star-rated hotels have a variety of restaurants, large-scale banquet halls and conference halls</td>
<td>X13</td>
<td>Indoor environment quality and standards of star-rated hotels</td>
</tr>
<tr>
<td>X6</td>
<td>Star-rated hotels have refrigerators, televisions, air conditioners and other appliances</td>
<td>X14</td>
<td>The usage amount of room electricity and water utilization by star-rated hotels guests</td>
</tr>
<tr>
<td>X7</td>
<td>Restaurants in star-rated hotels have dishwasher, electric oven, microwave cooker, fume extractor, deep frying pan, etc.</td>
<td>X15</td>
<td>The carrying volume of toilets and bed sheets by star-rated hotels guests</td>
</tr>
<tr>
<td>X8</td>
<td>The number of diners in restaurants of star-rated hotels is large and concentrated</td>
<td>X16</td>
<td>The use frequency of room air conditioners by hotel guests</td>
</tr>
</tbody>
</table>

3.2 Data Sources and Processing

During March to June in 2015, site surveys and questionnaires were conducted on staff and customers of 10 star-rated hotels in Jinan, Qingdao, Yantai and Qufu City of Shandong. Besides, the Likert's five-component scale was adopted to score each measurement index variable. The scores of 1 to 5 respectively stand for totally disagree, partially disagree, not clear, agree and fully agree. A total of 300 questionnaires were distributed and 278 were returned, of which 256 questionnaires were valid with an effective rate of 85.3%. Specifically, 140 copies, 100 copies and 60 copies were respectively distributed to three-star, four-star and five-star hotels, and there were 180 hotel guests and 120 hotel staff. In order to avoid information overlapping provided by the correlation among variables and make the analyzed problem more intuitive, this paper applies factor analysis to simplify the index structure and condense information. Data analysis software adopted SPSS20.0.

In order to make the data more clear and complete, the non-positive index and the reverse index in the index system table were transformed in the forward direction, that is, the inverse index was reciprocalized, which was then multiplied by 100,1000 and 100,000 to be transformed for analysis and evaluation. In order to eliminate the dimension between the index variables and keep the index statistical calibre consistent, the index variables after forward transformation were further normalized.

The number of samples was assumed to be n, with a pseudo-random distribution. Each sample could be represented by two indexes, namely x01 and x02, respectively. The original parameters of the k-th sample were $x_{1k}$ and $x_{2k}$. The normalized parameters are:
\[ X_{ik} = \frac{X^0_{ik} - \bar{X}_i}{\sigma_i}, \quad i = 1, 2; \quad k = 1, 2, \cdots, n \]  

Where

\[ \bar{X}_i = \frac{1}{n} \sum_{k=1}^{n} X^0_{1k}, \quad \sigma_i^2 = \frac{1}{n-1} \sum_{k=1}^{n} (X^0_{1k} - \bar{X}_i)^2. \]

### 3.3 Empirical Analysis

The above normalized data was processed by means of EViews7.1 software and Pearson’s correlation matrix method to determine the number of main components that affected the energy consumption of star-rated hotels.

Furthermore, the factor analysis model established \( F \) as the index variable vector, \( A \) as the main factor load matrix, and \( X \) as the main factor column vector. The formula was as follows:

\[ F = AX \]

Where \( F = (F_1, F_2, \cdots, F_6)' \), \( X = (X_1, X_2, \cdots, X_n)' \).

Each variable data and processed data were substituted into the above equation, and the obtained factor score function was:

\[ F = (-0.405)X_1 + (-0.312)X_2 + (0.25)X_3 \\
+ (-0.23)X_4 + (-0.211)X_5 + (0.165)X_6 \]  

As indicated by the above formula, first, the internal factors of energy consumption of star-rated hotels in Shandong exert a greater impact, while the effect of external factors is relatively small. Secondly, among the internal influencing factors, the envelop enclosure structure of hotel buildings is featured with heat insulation in summer, ventilation in spring and in autumn and heat preservation in winter, such as exterior walls, exterior windows, roofs and doors, and generates the greatest impact on energy consumption in hotels, with an impact factor of -0.405. Hotel restaurant services have the least impact on energy consumption with an impact factor of -0.25. However, this impact has been gradually enhanced with the improvement of customer service awareness and demand. Thirdly, in terms of the external influencing factors, the impact factors of outdoor air temperature, indoor environmental standards and consumers’ journey life style are -0.23, 0.111 and 0.165 respectively. The first two impact factors produce a slightly larger impact than the third one on energy conservation and emission reduction in hotels. This is mainly because customers who stay in the star-rated hotels have overall high qualities, strong awareness of water conservation, energy conservation and environmental protection, green behaviours and journey lifestyle, and no redundant energy consumption is brought to star-rated hotels. In comparison, Shandong Province, located in the northern hemisphere, has a large temperature difference among the four seasons, so indoor and central air-conditioners, etc. need to be in long-term use. Coupled with the internal environmental quality and standards of the rooms, energy consumption is accelerated.

### 4. CONCLUSION

As people’s living standards and spending power gradually improve, consumers have set higher requirements for the internal environment and the service level of star-rated hotels, prompting star-rated hotels to continuously optimize indoor comprehensive service facilities and improve relevant services. In the meantime, the costs and the total amount of energy consumption of star-rated hotels are also in gradual expansion. Based on the previous research, this paper takes Shandong as an example, analyzes the influencing factors of energy
consumption of star-rated hotels from an empirical perspective and puts forward corresponding energy-saving measures. The results have indicated that the influencing factors of energy consumption of star-rated hotels can be divided into internal and external ones. In view of the internal factors, the impact of the envelop enclosure structure is the most significant, and restaurant service exerts the smallest influence. As far as external factors are concerned, outdoor temperature conditions and indoor environmental standards have a slightly larger impact than consumers' journey lifestyle, resulting in substantial greenhouse energy consumption in hotels. In the future, we can promote low-carbon management of star-rated hotels by strengthening hotels’ low-carbon management, expanding capital investment in new energy-saving technologies, establishing and improving a carbon emission measurement system and improving the low-carbon awareness of customers and employees.

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