Discussion on Standardization of Energy Consumption Quota in Public Institutions

ZHANG Lan¹, BAI Yan¹*, BAI Xue¹, ZHANG lijuan², YANG yanmei¹
¹ China National Institute of Standardization, Beijing, 100191, China
² National Government Offices Administration, Beijing, 100017, China
*Corresponding author’s e-mail:baiyan@cnis.ac.cn

Abstract. The compilation process of the quota standard of public institutions is the self-checking behavior of their own energy consumption. By analyzing the energy usage and characteristics of different types of public institutions, the refinement of energy conservation management of public institutions is gradually realized. This article introduced the background of energy consumption quota management for public institutions in China and the current situation of energy consumption quota of public institutions at home and abroad, determined the energy quota management mechanism of public institutions, proposed methods of the determination of application scope, the classification of organization, the selection of energy consumption quota index and the determination of energy quota value according to related requirements, and discussed the foreground of applying energy consumption quota standards for public institutions.

1. Background
Energy conservation of public institutions is a key area of energy conservation for the whole society [1]. As of 2018, there were about 1.67 million public institutions in China, and the total energy consumption of these public institutions was about 182.78 million tons of standard coal. Since the “11th Five-year Plan” was initiated, China has adopted the method of year-on-year declining energy consumption index for the energy conservation management of public institutions. This method has played an important role in energy conservation and consumption reduction of public institutions. During the “12th Five-year Plan” period, the comprehensive energy consumption per capita of public institutions in our country decreased by 15% [2], and the energy consumption per unit building area decreased by 12%; since the 13th Five-year Plan, the comprehensive energy consumption per capita of public institutions in China decreased by 7.87% in 2018, and the energy consumption per unit building area decreased by 6.11%, yielding a significant energy conservation effect. Although this method has better promoted the energy conservation in public institutions, the space for energy conservation in public institutions is gradually reduced, and the energy conservation and consumption reduction efforts have been slowed down because of continuously improved energy management concepts and the emergence of bottlenecks in energy-saving technologies enhancement. The energy conservation potential is especially small for the public institutions that started energy conservation earlier and met the requirements of traditional energy conservation transformation. At the same time, due to the area expansion and ability improvement of public services, the further increasing building area, energy-consuming equipment and the number of energy consumers in public institutions, and continuously increasing demand for energy consumption [3], the balanced development of energy conservation and
consumption reduction has been limited by the current management method. Simply reducing energy consumption is not conducive to the business development of public institutions, and the feasibility and scientificity of this management method have been reduced. Therefore, it is urgent to change the existing management method and find a management method that is more suitable for the current energy consumption status of public institutions.

The National Government Offices Administration issued a notice on Guidelines for the Preparation and Application of Energy Consumption Quota Standards for Public Institutions (Trial) [4] (hereinafter referred to as the Guidelines), requiring all regions to attach great importance to the preparation of energy consumption quota standards for public institutions, so as to lay a foundation for the transformation of management methods for the energy conservation targets in public institutions during the “14th Five-year Plan” period. The establishment of energy consumption quota standards for public institutions is an important measure for optimizing the energy conservation management methods of public institutions, and will effectively promote the rapid development of energy conservation in Chinese institutions. Through organizing the status of energy consumption quota of domestic and overseas public institutions, this article extracted a quota mechanism suitable for energy consumption management of public institutions, and provided a method for developing energy consumption quota standards for public institutions, thus providing a guidance for the preparation of energy consumption quota standards for public institutions in various regions of the country.

2. Status of energy consumption quota of domestic and overseas public institutions
Public institutions refer to the state organs, institutions and organizations that use financial funds in whole or in part [5], whose energy consumption means coal, gas, fuel, electricity, heat and other energy used by public institutions. The energy consumption of public institutions refers to the daily energy consumption by people, such as heating, lighting, air conditioning and cooking, most of which is building energy consumption. At present, domestic and international researches on building energy consumption quotas have been carried out, and understanding the current status of building energy consumption quota management is conducive to the development of energy consumption quota in public institutions. The German standard VDI 3807 [6] divides buildings and building energy consumption in detail with energy consumption index values provided, and divides government office buildings into the highest federal agencies, parliaments, administrative buildings, work centers, and public security bureaus; the sub-item energy consumptions are summed to form building energy consumption, and the power consumption is divided into lighting, ventilation, and air conditioning and refrigeration according to energy usage purpose. Based on the actual building energy consumption data, American ENERGY STAR Benchmarking Tools [7] establishes the energy consumption benchmark combined with mathematical statistics, uses a multiple linear regression fitting method to compare multiple combination, screening and fitting results of impact factors for multiple times, and then develop an energy consumption benchmark formula to judge the level of building energy consumption. On the basis of established building classification, British Energy Performance in the Government’s Civil Estate standard introduces the method of judging compound office buildings and correcting application degree-days.

In terms of technology, China mostly studies the quota of building energy consumption for public institutions. The Standard for Energy Consumption of Building (GB/T 51161) gives constraint value and guidance value of public building energy consumption index based on climatic region, building functions and classification; when the actual use intensity is higher than the standard use intensity, the constraint value and guidance value can be corrected according to the actual use time of the building. In terms of management, in 2007, the Standing Committee of the National People’s Congress, based on the promulgated Energy Conservation Law of the People’s Republic of China [8], proposed that relevant departments shall formulate energy consumption quota for public institutions in accordance with management authority, and the financial department shall develop the criteria for energy consumption expenditure based on the quota. In 2008, the Regulations on Energy Conservation by Public Institutions [9] issued by the State Council of the People’s Republic of China proposed specific
requirements for the preparation of energy consumption quota: energy consumption quota shall be developed according to the comprehensive level and characteristics of energy consumption for public institutions in different industries and different systems. In 2016, the 13th Five-year Plan on Energy Conservation of Public Institutions [10] issued by the National Government Offices Administration and the National Development and Reform Commission improved the requirements for preparing energy consumption quota and encouraged the implementation of energy consumption quota management. It can be seen that the state continuously refines and improves the requirements for the preparation of energy consumption quota, and gradually increases the emphasis on energy consumption quota standards, thus guaranteeing and guiding the implementation of energy consumption quota management in China.

Combining the status of building energy consumption quota management at home and abroad and the characteristics of energy usage management of public institutions, the energy consumption quota management mechanism of public institutions shall classify public institutions according to their functions, establish energy consumption database and divide energy consumption quota, and correct the energy consumption quota for the factors that affect energy consumption.

3. Preparation method of energy consumption quota standard for public institutions
Based on the requirements of the Guidelines, the specific preparation methods of energy consumption quota standards for public institutions are proposed, including determining the application scope, scientifically and rationally classifying the quota of public institutions, rationally selecting energy consumption quota index, determining energy consumption quota index values according to local conditions, scientifically setting the correction of energy consumption quota, and proposing energy conservation management measures and suggestions according to the actual situation.

3.1 Determining the application scope of quota standards
According to the actual energy consumption data of public institutions in various provinces, the competent authority of public institutions shall prepare provincial energy consumption quota standards, which are applicable for the public institutions within the whole province. If the energy consumption data of public institutions in some cities of the province deviates from the average level of the province, and the provincial energy consumption quota standards have a decreased constraint on the energy conservation of public institutions in these cities, a municipal energy consumption quota standard can be developed separately for each city, applicable to the public institutions within relevant city; if the energy consumption data of provincial public institutions has weak foundation or covers multiple climatic regions, and it takes a long time to or it’s difficult to prepare the provincial energy consumption quota standard, the energy consumption quota standard for public institutions can be developed by combining energy consumption data of the neighboring provinces, and such standard is applicable to public institutions within the relevant province.

3.2 Scientifically and rationally classifying the quota of public institutions
According to the actual situation of public institutions in various provinces, the competent authority of public institutions shall prepare the quota standards based on the classification principle of “comparable with similar types and refined as appropriate”. In terms of “comparable with similar types”, the public institution quota can be divided into party and government organs, educational institutions, medical institutions, venue institutions and other institutions. In terms of “refined as appropriate”, due to different economic levels and business requirements of province, city, county and township party and government organs, the energy consumption of province-level party and government organs is higher than that of city-level party and government organs, the energy consumption of the city-level party and government organs is higher than that of the county-level party and government organs, and the energy consumption of the county-level party and government organs is higher than that of the township-level party and government organs. Therefore, the party and government organs may be further classified into the province-level, city-level, county-level and
township-level party and government organs. Due to different energy usage requirements of higher education, secondary education, primary education and preschool education, higher education generally has test equipment with high energy consumption and accommodation energy consumption, the energy usage time of secondary education and primary education is different throughout the year, and preschool education involves no energy consumption in accommodation. Educational institutions shall be further classified into higher education, secondary education, primary education and preschool education. Medical institutions can be classified according to the existing hospital grade or hospital type. Due to the large gap between the medical capabilities and energy usage levels of medical institutions of various grades, the existing hospital grades can be further classified into grades 3, 2 and 1. The types of hospitals can be further classified into comprehensive, specialty, traditional Chinese medicine, epidemic prevention station, and community, etc. Due to different social service functions and energy usage levels of culture, sports, and science and technology venues, venue institutions shall be further classified into the culture, sports, and science and technology venues. Most of the other institutions are related to the public security organs, procuratorial organs and people’s courts, and can be further classified into the province-level, city-level, county-level and township-level institutions according to economic level and other factors. See Table 1 for details.

Table 1. Classification of public institutions

| Type                      | Detailed classification                                      |
|---------------------------|-------------------------------------------------------------|
| Party and government organ| Shall be further classified into province-level, city-level, county-level and township-level |
| Educational institution   | Shall be further classified into higher education, secondary education, primary education and preschool education |
| Medical institution       | Shall be further classified into comprehensive hospital, specialty hospital, special hospital, sanatorium, and rest home, etc.; can also be further classified into grades 3, 2 and 1 |
| Venue institution         | Shall be further classified into the science and technology, culture, and sports venues |
| Other institutions        | The public security organs, procuratorial organs and people’s courts shall be further classified into the province-level, city-level, county-level and township-level institutions |

3.3 Rationally selecting energy consumption quota index

Energy consumption quota indexes are divided into main indexes and reference indexes according to climatic region and existing statistical system in China. The main indexes are basic indexes, including comprehensive energy consumption per unit building area and comprehensive energy consumption per capita; and the reference indexes are encouraging indexes, including indexes related to power consumption per unit building area and special energy usage of the conventional energy-consuming system (EUE value from data center room). Regarding the main indexes, the existing statistical system has made statistical requirements on the comprehensive energy consumption per unit building area and comprehensive energy consumption per capita. As the winter heating energy consumption of public institutions in severe cold and cold regions in China accounts for a large proportion of the total energy consumption, it shall be separately evaluated. Therefore, when selecting energy consumption quota indexes in severe cold and cold regions, the comprehensive energy consumption per unit building area is split into heating energy consumption index per heating area and non-heating energy consumption index per building area. The reference index mainly includes conventional power consumption and special power consumption. The conventional energy usage power consumption is mainly the total power consumption of energy-consuming equipment such as office, lighting, air conditioning and elevator. The special power consumption mainly refers to the power consumption of the data center room. For the public institution that includes data center room, the data center room power consumption shall be removed from the total power consumption when formulating the power consumption per unit building area of the conventional energy consumption system, and the special
energy consumption index shall be determined by setting the data center room EUE value. In addition, for public institutions with a good basis for energy consumption data measurement, the power consumption per unit building area of conventional energy consumption system can be divided into individual power consumption such as lighting and air conditioning according to purposes of energy usage, so as to promote the fine management of energy consumption of public institutions. See formulas (1-3) for specific index calculation formula.

\[
E_1 = \sum_{i=1}^{n} (e_i \times p_i) / M \quad \text{(1)}
\]

\[
E_2 = \sum_{i=1}^{n} (e_i / P) \quad \text{(2)}
\]

\[
E_3 = \sum_{i=1}^{n} d_i / M \quad \text{(3)}
\]

Where,

- \( E_1 \) — Comprehensive energy consumption per unit building area, in kilograms of standard coal per square meter (kgce/ m\(^2\)·a);
- \( E_2 \) — Comprehensive energy consumption per capita, in kilograms of standard coal per person (kgce/ p·a);
- \( E_3 \) — Power consumption per unit building area, in kWh per square meter (kWh/ m\(^2\)·a);
- \( e_i \) — Physical quantity of the i-th energy consumed during the statistical period, in the physical unit;
- \( d_i \) — The i-th power consumed during the statistical period, in kWh;
- \( p_i \) — The i-th energy standard coal coefficient;
- \( n \) — Type of energy consumption;
- \( M \) — Building area, in square meter (m\(^2\));
- \( P \) — Number of developers, in persons (p).

3.4 Determining energy consumption quota index values

The energy consumption quota index values are divided into constraint value, reference value and guidance value. The constraint value is the level of energy consumption that the public institution must achieve at the current level. The public institution whose energy consumption exceeds the constraint value shall reach the constraint value within the stipulated rectification period; the reference value is the level of energy consumption of the public institutions under normal operation that achieve a certain energy conservation effect, and the public institutions shall be encouraged to reach the guidance value; the guidance value is the level of the public institutions with better energy conservation effects, and such public institutions shall formulate energy management goals based on their own conditions while maintaining the current level. The data sample database of public institutions is sorted in ascending order by using the sorting method, and the lower 1/5 quintile, median and upper 1/5 quintile are taken as the constraint value, reference value and guidance value respectively. Public institutions can judge their own quota level based on the quota index value, as shown in Figure 1. When determining the quota index value of energy consumption, the application of the quota index value shall be considered. If the index value is too low, it is easy to achieve and does not promote energy conservation effects; if the index value is too high, it is difficult to achieve, which makes the energy conservation staff become unwilling to perform energy conservation and affects the development of energy conservation. At the same time, it is also necessary to consider the impact of factors such as the business level, operation management and energy conservation technology status, energy conservation transformation effect and cost of public institutions in the region on the indexes, and take overall consider of energy conservation and business development of public institutions. When determining the energy consumption quota of public institutions, the regions shall make reasonable determination based on their own actual local conditions.
3.5 Correcting the energy consumption quota
When preparing the quota standards, the influence of energy consumption factors such as climatic region, personnel density and office hour on energy consumption quota indexes shall be considered, and relevant corrections shall be conducted if necessary. Different heating/cooling requirements in different climatic regions directly affect the proportion of heating/cooling energy consumption in the energy consumption of public institutions, and the quota can be corrected according to heating/cooling duration; for personnel density, the number of energy users determines the total energy consumption of energy-consuming equipment such as offices, and the quota can be corrected according to the number of users; office hours directly affect the total energy consumption of public institutions, and the quota can be corrected according to office hours.

3.6 Determining energy conservation management measures and suggestions
When preparing quota standards, energy conservation management measures and suggestions that should be taken to meet the requirements of quota standards shall be provided. Energy conservation management measures and suggestions shall be consistent with the overall energy conservation plan goals of the energy conservation departments of public institutions in the state and regions. The future business development and energy conservation needs of regional public institutions shall be considered, the current status of energy conservation management in public institutions in the region shall be investigated, and a practical guidance shall be provided for the energy conservation management for public institutions in the region. In terms of standardized management, improve the equipping of measuring instruments and strengthen the measurement of energy and resource in public institutions in accordance with the Requirements for Equipping and Managing of Measuring Instruments of Energy in Public Institutions (GB/T 29149) \(^{(11)}\); in terms of energy conservation operation, regulate the energy conservation operation of public institutions according to the requirements of the Economic Operation of Illumination Equipment (GB/T 29455) and other national standards for the economic operation of energy-consuming system (equipment); in terms of market applications, contract energy management and other means can be reasonably used to promote the energy conservation and consumption reduction of public institutions.

4. Summary
Based on the requirements of quota standards in the Guidelines, this article analyzed and studied the method of preparing energy consumption quota standards such as the application scope, classification, index selection, index value determination and correction, and provided energy conservation management measures and suggestions. Guidance shall be provided for common issues in the preparation of energy consumption quota standards. The energy consumption quota standard of public institutions is the technical support for management and supervision. The administrators of public institutions can develop an energy consumption plan according to the quota standards and control the
internal energy conservation management in public institutions; the energy conservation department of public institutions can supervise and evaluate the energy conservation situation of public institutions according to the quota standards of energy consumption, which lays a foundation for the scientific management; the financial department can formulate the criteria for energy consumption expenditure of public institutions according to the energy consumption quota standards, thus providing a basis for the financial department to realize the economic management responsibility system. The introduction of energy consumption quota standards for public institutions is an important measure to implement national guidelines and policies and optimize the energy conservation management methods in public institutions. It is conducive to reducing the energy consumption of public institutions from the source, improving energy efficiency, and reducing energy consumption expenditures, and exerts far-reaching significance on promoting the energy conservation of public institutions.

Acknowledgments
Fund projects from the President of China National Institute of Standardization: Construction and Application of Standardized Technical System for Efficient Use of Resources, Research on Construction and Application of Energy Consumption Quota Index System for Public Institutions in China

References
[1] Zhu Chunyan, Shi Longyu, Liang Xiuying, Bai Xue, Li Yan, Interpretation of the Guides for Energy and Resource Management Performance Evaluation of Public Institutions [J], Standard Science, 2014(03): 55-57.
[2] P Review of Energy Conservation and Emission Reduction of Public Institutions during the “Twelfth Five-year Plan” Period in China [J], Energy and Environment, 2016(05): 77.
[3] Zhu Xiaojiao, Song Bo, Liu Song, Current Status of Energy Conservation and Technological Development Prospects in Public Institutions [J], Construction Science and Technology, 2019(16): 63-66.
[4] Guidelines for the Preparation and Application of Energy Consumption Quota Standards for Public Institutions (Trial)
[5] Wang Jiamo, Chen Lei, Shi Longyu, Research and Practice of Energy Management in Public Institutions at Home and Abroad [J], Standard Science, 2013(09): 89-92.
[6] Cao Yong, Wei Zheng, Liu Hui, Meng Chong, Song Yehui, Liu Yimin, Revelation of German Standard VDI 3807 to Energy Consumption Quota in China [J], Construction Science and Technology, 2011(22): 78-81.
[7] Liu Yimin, Yu Dan, Cao Yong, Wei Zheng, Niu Limin, Research on Evaluation Method of Building Energy Consumption Based on Operation Data —— Taking 5-star Hotel Building as An Example [J], Construction Science and Technology, 2012, 28(12): 57-60.
[8] Energy Conservation Law of the People’s Republic of China
[9] Regulations on Energy Conservation by Public Institutions
[10] 13th Five-year Plan on Energy Conservation of Public Institutions
[11] Bai Xue, Zhu Chunyan, Li Yan, Hu Mengting, Interpretation of National Standards for Energy and Resource Measurement in Public Institutions [J], Standard Science, 2013(09): 69-72.