Research on energy consumption quota of metrology laboratory

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Abstract. The research on energy consumption quota of metrology laboratory is an important part of building energy conservation from the perspective of total amount control. Through the research on the investigation method of basic energy consumption data, the type of quota index and the determination method of quota level. The analysis shows that the metrology laboratory adopts the method of unequal proportion classified sampling survey to obtain the basic data of energy consumption, adopts the energy consumption per unit area, considers the correction of energy consumption time and the proportion of auxiliary room area as the quota index, and uses the quota level method to determine the limit value, reference value and advanced value of energy consumption quota, which is fair, scientific and feasible.
Keywords: metrology; laboratory; energy consumption quota; formulate.

1 Introduction

With the continuous advancement of the process of rejuvenating the country through science and education, the base number of laboratory building area is increasing, resulting in the increasingly prominent problem of high energy consumption, which makes the energy-saving supervision and transformation of the laboratory become very important. Energy consumption quota is not only the yardstick to improve building energy efficiency and implement energy-saving transformation, but also an important means for relevant government departments to implement energy-saving supervision. As the benchmark value of energy consumption quota management and carbon trading, the energy consumption quota of the metrology laboratory can provide data support for the over quota price increase policy and carbon emission trading, effectively improve the energy consumption management level and energy efficiency of the metrology laboratory, and promote the energy consumption units of the metrology laboratory to carry out energy-saving transformation or reduce the energy consumption of the metrology laboratory through behavioral energy conservation, And further promote the in-depth development of energy conservation and emission reduction in the whole construction industry.

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2 Acquisition of basic data of energy consumption

The basic data of energy consumption is used as the basis for formulating the energy consumption quota of the metrology laboratory, as well as the basis for analyzing the energy-saving potential and calculating the carbon emission. At present, there are mainly several survey methods such as statistical statements, general survey, key survey, typical survey and sampling survey [1]. Statistical report is an investigation method that is arranged from top to bottom in a unified form and administrative means, and then summarized and reported from bottom to top to provide statistical data level by level [2]. It is direct and reliable in form, but it is difficult to ensure the authenticity of the reported data. The census is a comprehensive survey specially organized for a certain purpose. Obviously, it is difficult to census a large number of measurement laboratories. Key investigation refers to the investigation conducted by one or several measurement laboratories that play a decisive role in the overall situation [3]. Typical investigation is to take representative laboratories as typical, and then reveal the essence and development law of things through investigating typical. Sampling survey is a survey method that selects some objects from all research objects for investigation, and estimates the overall population according to the characteristics of the objects to be sampled. Although the sampling survey is not a comprehensive survey, its purpose is to obtain information reflecting the overall situation. Therefore, in the case of non census, the sampling survey method is recognized as the most perfect and scientifically based survey method used to estimate the overall situation. Therefore, it is feasible to select the sampling survey method to obtain the basic data of energy consumption in the metrology laboratory.

In addition, due to the great differences in economic development and climate characteristics in various regions of the country, the energy consumption of each laboratory is quite different. Therefore, the basic data survey of energy consumption should also be carried out separately according to the five climate zones specified in the current national standard GB 50176 [4]. At the same time, the actual running time of the laboratory and the scale of auxiliary rooms should also be considered in the investigation. After subdivision, the sampling survey should be classified, so as to ensure the typicality and representativeness of the sampling. Due to the different energy consumption levels of measurement laboratories in each climate zone, even the measurement laboratories in the same climate zone will have great differences in laboratory energy consumption due to the differences in the actual running time of individual laboratories. Therefore, the investigation method of classified sampling should be adopted. Classified sampling can be divided into equal proportion and unequal proportion, which is based on whether the proportion of samples in each climate zone is equal to that of the overall unit in each climate zone. Due to the different number of laboratories in different climate zones, the investigation method of unequal proportion classified sampling is selected for the investigation of basic energy consumption data of measurement laboratories in this paper [5-6].

The research shows that the sample size is related to the change degree of the research object, the allowable sampling error, the confidence level of inference and so on. According to formula (1), it is calculated as follows:

$$n = \frac{Z^2 T^2}{E^2} \tag{1}$$

Where: Z-Z statistics of confidence level; T^2—variance of population; E —allowable survey error.

3 Energy consumption quota data processing

The energy consumption quota of the metrology laboratory refers to the limit of the amount of energy allowed to be consumed by the metrology laboratory to realize the use function within the statistical period. When formulating the energy consumption quota of Metrology Laboratory, we should observe the principle of advanced science, fair and reasonable, practical feasibility and timeliness[7], we usually determine the energy consumption quota based on the scale of buildings, the target of energy consumption, the output value or energy consumption and the output ratio[8~12]. Since the influencing factors of energy consumption index per unit output value of metrology laboratory are affected by laboratory management, local policies, economic development and other factors, and there is no obvious quantitative relationship with laboratory energy consumption, adhering to the principle of fairness, it is not recommended to select economic indicators for energy consumption quota of metrology laboratory. It is fair to select the energy consumption index per unit area to evaluate the laboratory energy consumption, which can reflect the energy consumption of the laboratory to some extent, but the proportion of laboratory energy consumption time and auxiliary room area has a significant impact on the laboratory energy consumption. Therefore, when the proportion of energy consumption time and auxiliary room area in some laboratories exceeds the benchmark value, it should be corrected.

In a statistical period, the non heating comprehensive energy consumption and power consumption per unit building area of the metrology laboratory are calculated as shown in formulas (2) ~ (4).

Non heating comprehensive energy consumption of metering laboratory:

$$E_{zn} = \sum_{i=1}^{n} (e_i \times p_i) \tag{2}$$

Where: E_{zn}—non heating comprehensive energy consumption（kgce）; n—number of energy consumed; e_i—physical quantity of the i th energy consumed; p_i—conversion coefficient of class i energy into standard coal.

Non heating comprehensive energy consumption per unit building area of metrology laboratory:

$$e_{10} = \frac{E_{zn}}{M} \tag{3}$$

Where: e_{10}—non heating comprehensive energy consumption per unit building area（kgce/m^2）; M—the total construction area, it is the sum of the construction area of the experimental room and the construction area of the auxiliary room（m^2）.

Power consumption per unit building area of metrology laboratory:

$$e_{20} = \frac{E_d}{M} \tag{4}$$

Where: e_{20}—power consumption per unit building area（kW·h/m^2）; E_d—power consumption(kW·h).

4 Determination of energy consumption quota index

The determination methods of energy consumption quota usually include statistical quota and technical quota. The statistical quota is based on the actual energy consumption data of buildings and obtained by mathematical statistics method; the technical quota is obtained through the establishment of building energy consumption benchmark model and simulation method [13]. Because the statistical quota has good practical feasibility, it is usually used in the preparation of energy consumption quota. The compilation methods of statistical quota include average value method, regression analysis method and quota level method [14].

The average value method takes the arithmetic average value of the energy consumption data of the effective samples as the quota value. This method is simple and easy. However, since the basic data investigation of the metrology laboratory is not a general survey, the quota value obtained by this method depends on the quantity and quality of the sample size and is not reasonable. The two analysis method is based on the average value, and is improved by two average or multiple averages[15]. Though considering the advanced technology, is still subjective. The regression analysis method is based on the observation of a large number of data and uses the method of mathematical statistics to establish the regression relationship function expression between dependent variables and independent variables [16]. The regression analysis method needs to consider the influencing factors of energy consumption quota. If there are many influencing factors, it needs to adopt multiple linear regression analysis, therefore, the multivariate linear analysis of the energy consumption of the metrology laboratory affected by many factors is not operable. It is found that the quota level method can more truly reflect the actual energy consumption level of the metrology laboratory when the volume of the metrology laboratory is large and the amount of sample data obtained is small.

The quota level method is also called probability method. The quota level refers to the probability that the energy consumption index of the metrology laboratory cannot meet the requirements of energy consumption quota, which is calculated according to formula (5):

$$Q = \overline{v} + Z_a S \tag{5}$$

Where: Z_α—the quota level is (1- α) corresponding standard normal distribution probability density value; $\overline{v}$—the average of the effective values; S—standard deviation.

Among them, under different quota levels Z_α see table 1.

Table 1. Quota level.

Quota level	Z_α	Quota level	Z_α
0.95	-1.645	0.45	+0.125
0.90	-1.282	0.40	+0.253
0.85	-1.032	0.35	+0.385
0.80	-0.842	0.30	+0.525
0.75	-0.675	0.25	+0.675
0.70	-0.525	0.20	+0.842
0.65	-0.385	0.15	+1.032
0.60	-0.253	0.10	+1.282
0.55	-0.125	0.05	+1.645
0.50	0	0.00	+3.900

"Quota level" reflects the strict level of energy-saving control in the metrology laboratory. The higher the quota level, the greater the control of energy-saving in the metrology laboratory. According to the current technical and economic level of each region and comprehensively considering the energy-saving operation management and technical status of the metrology laboratory, the author takes the energy consumption value corresponding to the quota level of 0.15 as the limit value, the energy consumption value corresponding to the quota level of 0.50 as the reference value, and the energy consumption value corresponding to the quota level of 0.75 as the advanced value. See Table 2 and table 3 for details. As the upper limit of the energy consumption of the metrology laboratory, the energy consumption limit value of the metrology laboratory provides a benchmark for the current energy consumption of the metrology laboratory, which can effectively promote the improvement of the energy use efficiency of the metrology laboratory. The guiding value considers the energy-saving potential and the efficient utilization of energy-saving technology, which is the goal of energy-saving work and forward-looking.

Table 2. Quota index of non heating comprehensive energy consumption per unit building area of metrology laboratory.

Climatic region	Non heating comprehensive energy consumption per unit building area [kW·h/(m^2.a)]		
	Limit value	Reference value	Advanced value
Severe cold area	17.98	14.81	12.74
Cold area	19.02	14.68	11.83
Hot summer and cold winter area	17.51	13.28	10.52
Hot summer and warm winter area	16.71	12.63	11.27
Temperate region	18.24	14.80	12.56

Table 3. Power consumption quota index per unit building area of metrology laboratory.

Climatic region	Power consumption per unit building area [kW·h/(m^2.a)]		
	Limit value	Reference value	Advanced value
Severe cold area	45.87	41.10	37.98
Cold area	69.30	60.30	54.40
Hot summer and cold winter area	119.73	85.20	62.61
Hot summer and warm winter area	74.36	57.15	45.89
Temperate region	60.86	46.06	36.37

5 Conclusion

Through the research on the energy consumption quota of metrology laboratory, this paper determines the investigation method of basic energy consumption data, the type of quota index and the determination principle of quota level, and gives the constraint value, benchmark value and guiding value of energy consumption quota in each climate region. The conclusions are as follows:

(1) It is feasible to select the method of unequal proportion classified sampling for the investigation of basic data of energy consumption in metrology laboratory.

(2) The energy consumption index of metrology laboratory adopts the energy consumption per unit area and considers the correction of energy consumption time and the proportion of auxiliary room area as the quota index, which is in line with the principle of fairness.

(3) The quota level method is used to determine the energy consumption quota index of the metrology laboratory. The determined energy consumption quota constraint value, benchmark value and guide value of each climate zone meet the current technical and economic level, which can effectively control the energy consumption of the metrology laboratory, reduce the waste of energy consumption, and promote and guide the energy conservation of the metrology laboratory.

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