Research on the Statistical Method of Energy Consumption for Public Buildings in China

Shuqin Chen Nianping Li
P.H.D Student Professor
Civil Engineering College, Hunan University
Changsha, P.R. China, 410082
E-mail: hn_csq@126.com

Abstract: The purpose of this research is to develop a national statistical system for energy consumption data for public buildings in China, in order to provide data support for building energy efficiency work. The framework for a national statistical system of energy consumption for public buildings is presented in this paper. The statistical index system of energy consumption constitutes three aspects: general characteristics of public buildings, opposition and utilization of energy consumption equipment, and energy consumption quantities. On this basis, a set of statistical reports is derived to measure the energy consumption of cities, provinces and the country.

Key words: public buildings, statistical method of energy consumption, statistical index system, statistical reports

1. INTRODUCTION

A national statistical system of energy consumption for public buildings needs to be established, so as to look into the general actuality of energy consumption, and to provide data support for building energy efficiency work in China. Early in the 1970s, nationwide statistics of building energy consumption were begun by uniform statistical methods in many west countries. The building energy consumption in U.K began to be investigated in 1976, and the statistics of building energy consumption in America was also under the charge of national standards institute at that time [1]. The database of building energy consumption has been established so far in America [2]. But in China, building energy consumption, which belongs to the consumption section of energy statistics, is divided into many fields of energy consumption in statistical departments [3]. Although related institutes have taken statistics of energy consumption for public buildings as a single kind of energy consumption, the statistical items are too simple, and different end-use energy consumption, such as air conditioning and lighting, can not be sorted accurately, due to the absence of a perfect index system and a uniform statistical method [1, 4~6]. Therefore, it is significative to establish a statistical system of energy consumption for public buildings and to put it into effect. But there is still vacant in this research field in China [3, 7].

2. ESTABLISHMENT OF THE FRAME OF A NATIONAL STATISTICAL SYSTEM OF ENERGY CONSUMPTION FOR PUBLIC BUILDINGS

A national statistical system of energy consumption for public buildings should be constituted and brought into effect under the charge of special governmental organizations, in order to take statistics effectively and chronically in China. Fig. 1 shows the frame of a national statistical system of energy consumption for public buildings. On one hand, architectural departments and statistical departments form a transverse system for cooperation, due to the highly professional peculiarity of the statistical work. On the other hand, because of the different climate, heating and cooling ways, and energy consumption structures in five architecture climate divisions in China, divisional statistics should be taken and the statistical methods for different divisions emphasize on different aspects. In each division, the statistics should be taken according to the administerial divisions. Cities, provinces and the nation form a lengthways system, where logistics departments in public buildings, as skeleton units for reporting the data, answer for energy efficiency centers, and inferior departments answer for the superior. A national statistical system of energy consumption with an integrated frame and reasonable cooperation has been set up in this way, to master the actuality of energy consumption for public buildings in China.

3. ESTABLISHMENT OF STATISTICAL INDEX SYSTEM OF ENERGY CONSUMPTION FOR PUBLIC BUILDINGS

3.1 Energy Consumption Characteristics of Public Buildings

The energy consumption characteristics of public buildings can be summed up to four aspects by related investigations and researches [4~6]: (1) There are various end-use energy consumption. Heating and air-conditioning, lighting, and energy utilization of

working equipments constitute the main body of energy consumption, while ventilation, water heating and cooking represent a small percentage. (2) With the adjustment of energy utilization structure, the usage rate of coal has been decreasing while electricity and gas have become the main energy

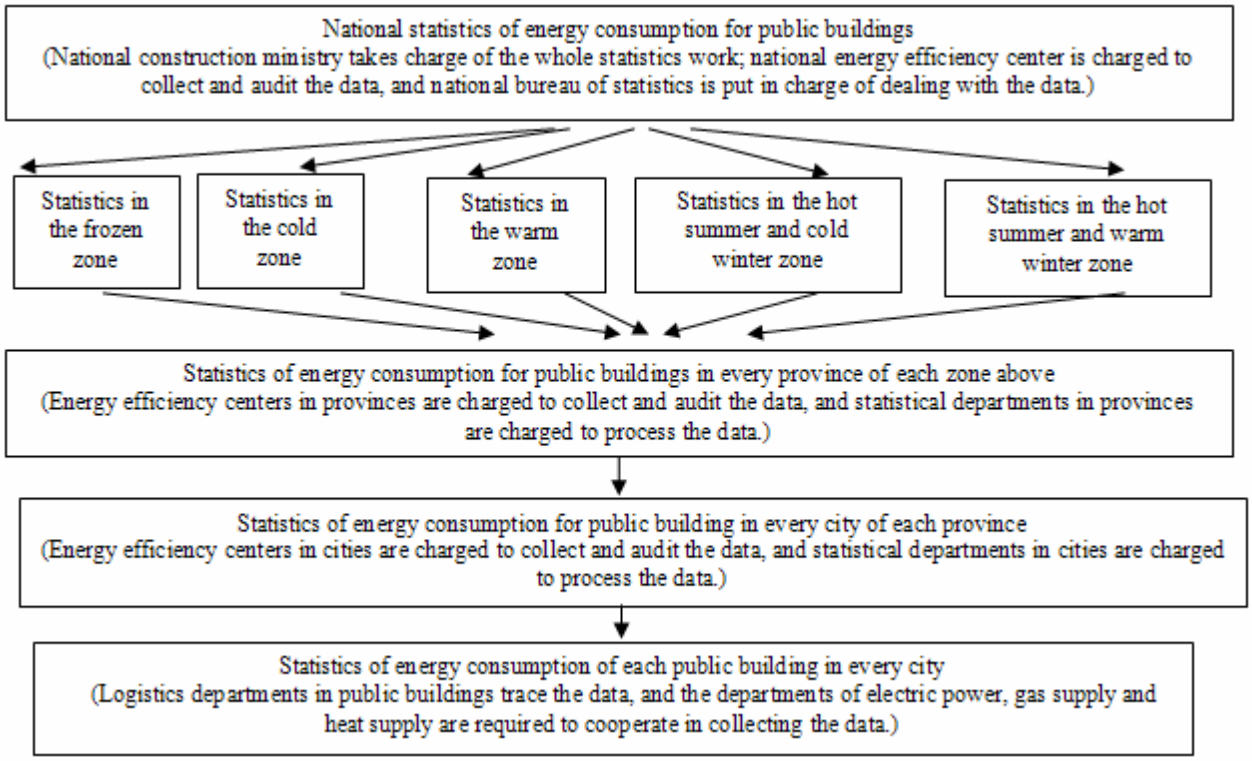

Fig. 1 The frame of a national statistical system of energy consumption for public buildings

sources, and some new energy resources have been utilizing gradually. (3) Energy consumption bears definite seasonal characteristics. The quantities of energy consumption are relatively larger in winter and summer than those in spring and autumn, due to heating and air conditioning. (4) There are complex factors influencing energy consumption, such as the thermodynamic property of enclosures, the efficiency of equipments, and consuming actions of the users.

3.2 Layered Structure and Classified Structure

A set of statistical index system for public buildings is built which not only reflects the actuality and specialty of energy consumption, but also incarnates the influencing factors. The index system is divided to three layers and consists of the indices in three kinds. The first layer is the goal layer, where the integrated level of energy consumption for public buildings in China is reflected by the index system. The second layer is the middle layer, where the goal is disintegrated into three aspects, i.e. general characteristics of public buildings, opposition and utilization of energy consumption equipments, and energy consumption quantities [8]. Fig.2 shows the first layer and the second layer of the statistical index system. The third layer is the index layer, consisting of all the indices in above three aspects. The first kind of the indices refers to architectural conditions of public buildings which directly affect the energy consumption of heating and air conditioning. The indices of architecture structures, floor areas, and characteristics of enclosures are set down, which are shown in Fig.3. The second kind of indices reflects the possession and utilization of energy consuming equipments, shown in Fig. 4. As the performance and running schedule of energy consuming equipments are also the main factors affecting the building energy consumption, they are also the important part of the index system. Fig. 5 shows the third kind of indices, which reflect the daily, monthly, and annual energy consumptions of various energy sources consumed by different system equipments, so as to analyze the energy consumption structure and the energy saving potential of the equipments.

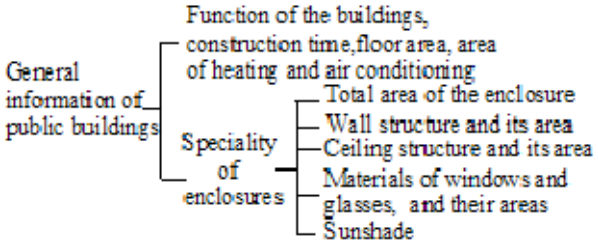

Fig. 2 Statistical index system of energy consumption for public buildings

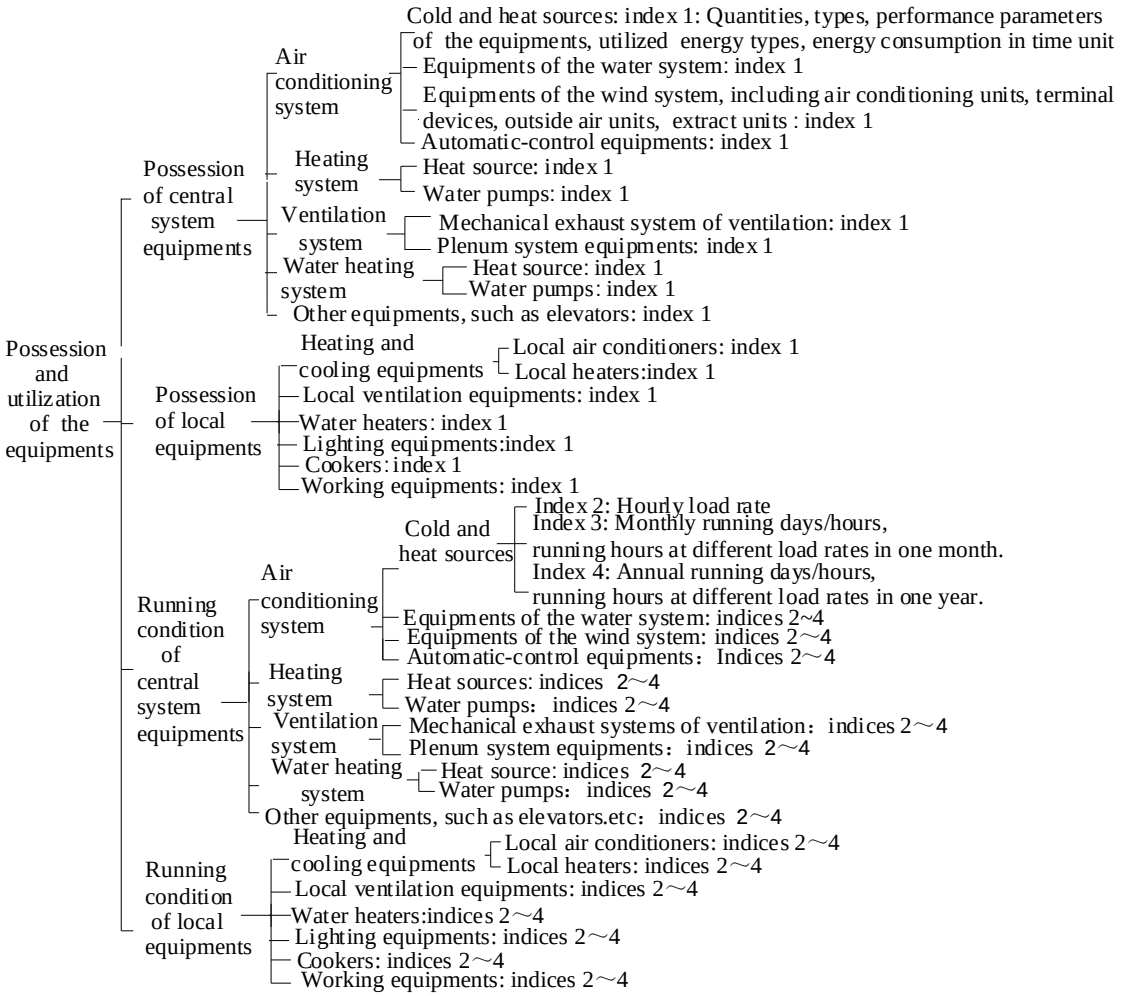

Fig. 4 Statistical indices of the possession and utilization of energy consuming equipment

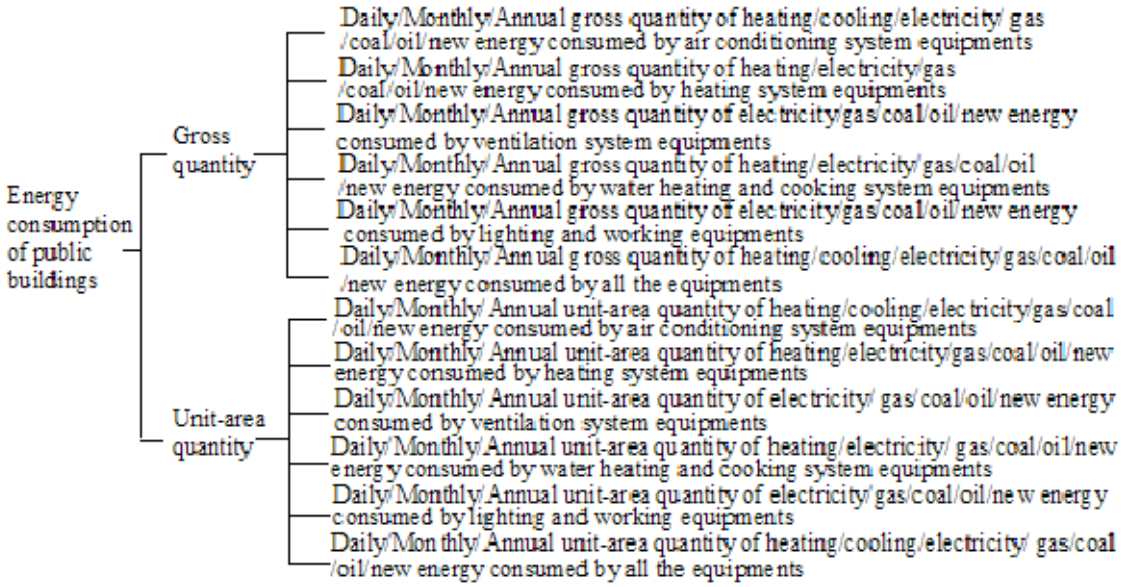

Fig. 5 Statistical indices of energy consumption quantities of public buildings

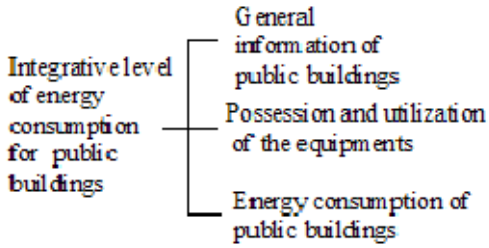

Fig. 3 Statistical indices of general information of public buildings

3.3 Explanations for Some Indices

Some indices need further explanations. The heating and cooling ways are different from each other in the five architecture climate divisions. The city heat supply is used in the frozen zone and cold zone, while central air conditioning systems are mainly used in other three zones. Therefore, this system covers the indices for all the heating and cooling ways in five architecture climate divisions. Indices for central heating systems are applied to the city heat supply and district heat supply; indices for central air conditioning systems cover all the equipments of cold and heat sources, wind systems, water systems, etc, so it can be applied to multiform central air conditioning systems; while indices for local heating and cooling equipment refer to all kinds of local air conditioners and heaters. As for the energy consumption, the power of system equipments can be multiplied by their running hours to calculate their energy consumption, if there are no technical meters to measure the quantities. In condition, only the index of heating quantity is used if there are calorimeters to measure the energy consumption of central heating systems and water heating systems; otherwise the consumption should be calculated by the quantity of electricity/gas/oil/coal.

4. DESIGN OF STATISTICAL REPORTS OF ENERGY CONSUMPTION FOR PUBLIC BUILDINGS

Statistical reporting is an important organization form for investigations and statistics in which the data can be reported regularly from cities, provinces to the nation according to the uniform indices [9]. Therefore it is scientific to take statistics of energy consumption for public buildings by statistical reporting. Based on the index system, a set of energy consumption statistical reports for public buildings is worked out. Tab. 1 lists the names, main indices and report periods of skeleton reporters. All the skeleton reports are reported by logistics departments in the investigated public buildings. Tab. 2 lists the names, main indices, report periods, and applicable objects of comprehensive reports. The reports of C001~C019, C020~022 and C023~C025 are reported by the civic, provincial and national statistical departments respectively.

Centralized process is associated with stage-by-stage process in dealing with the reports [9]. The data of energy consumption is processed stage by stage, from cities, provinces to the country, so as to publicize the data timely for the governments. Meanwhile, all the comprehensive reports for cities are submitted directly to provincial statistical departments, then directly to national statistical department. Therefore a national database is created in this way that all the reports from every city are collected, to improve the veracity of statistical data.

Tab. 1 Skeleton statistical reports of energy consumption for public buildings

Number	Name of the form	Report period	Main indices
S.001	General information of the public building	Annual report	Architecture structure, construction time, floor area, function of each floor, speciality of enclosures
S.002	Summaries of energy consuming equipments in the public building	Semiyearly report	Quantities, types, performance parameters of central and local equipments, energy type utilized by the equipment, energy consumption in time unit
S.003	Daily running condition of energy consuming equipments	Daily report	Hourly load rate of energy consuming equipments
S.004	Monthly running condition of energy consuming equipments	Monthly report	Running days and hours of energy consuming equipments, and their average running hours at different load rates in each month
S.005	Annual running condition of energy consuming equipments	Annual report	Running days and hours of energy consuming equipments, and their average running hours at different load rates in a whole year
S.006~ S.008	Daily/Monthly/Annual energy consumption of the public building	Daily/Monthly/Annual report	Daily/Monthly/Annual gross quantity and unit-area quantity of heating/cooling/electricity/gas/coal/oil/new energy consumed by each kind of system equipments

Tab. 2 Integrated statistical reports of energy consumption for public buildings

Number	Name of the form	Reporting period	Main indices	Applicable objects
C.001	Summaries of general information of public buildings in the city	Annual report	Architecture structure, construction time, floor area, function of each floor, speciality of enclosures	Investigated public buildings in the city
C.002	Summaries of air conditioning system equipments in public buildings in the city	Semiyearly report	Quantities, types, performance parameters of the equipments in public buildings, energy type utilized by the equipments, energy consumption in time unit	Investigated public buildings in the city
C.003	Summaries of heating, ventilation, water-heating, and cooking system equipments in public buildings in the city	Semiyearly report	Quantities, types, performance parameters of the equipments, energy type utilized by the equipments, energy consumption in time unit	Investigated public buildings in the city
C.004	Summaries of working equipments in public buildings in the city	Semiyearly report	Quantity, types, performance parameters of the working equipments, energy type utilized by the equipment, energy consumption in time unit	Investigated public buildings in the city
C.005~ C.007	Daily/Monthly/ Annual running condition of air conditioning system equipments in public buildings	Daily/Monthly/ Annual report	Hourly load rate of the equipments, monthly/annual running days and hours of the equipments, running hours at different load rates in the whole month/year.	Investigated public buildings in the city
C.008~ C.010	Daily/Monthly/Annual running condition of heating, ventilation system equipments in public buildings	Daily/Monthly/ Annual report	Hourly load rate of the equipments, monthly/annual running days and hours of the equipments, running hours at different load rates in the whole month/year	Investigated public buildings in the city
C.011~ C.013	Daily/Monthly/Annual running condition of water-heating and cooking system equipments in public buildings	Daily/Monthly/ Annual report	Hourly load rate of the equipments, monthly/annual running days and hours of the equipments, running hours at different load rates in the whole month/year	Investigated public buildings in the city
C.014~ C.016	Daily/Monthly/Annual running condition of working equipments in public buildings	Daily/Monthly/ Annual report	Hourly load rate of working equipments, monthly/annual running days and hours of the equipments, running hours at different load rates in the whole month/year	Investigated public buildings in the city
C.017~ C.019	Daily/Monthly/Annual energy consumption of public buildings in ×× city	Daily/Monthly/ Annual report	Daily/Monthly/ Annual gross quantity and unit-area quantity of heating/cooling/electricity/ gas/coal/oil/new energy consumed by each kind of energy consuming equipments in public buildings	Public buildings in the city
C.020~ C.022	Daily/Monthly/Annual energy consumption of public buildings in ×× province	Daily/Monthly/ Annual report	The indices are the same as those in C017~C019	Public buildings in the province
C.023~ C.025	Daily/Monthly/Annual energy consumption of public buildings in the whole nation	Daily/Monthly/ Annual report	The indices are the same as those in C017~C019	Public buildings in the whole nation

5. CONCLUSIONS

With the establishment of energy consumption statistical system for public buildings in China, abundant data can be collected for building energy efficiency work, and energy consumption status in different regions can be compared so as to provide instructions for energy management. But the related work just lies on the primary stage of method research and there is much work needs to do: (1) The indices and reports in this paper are waiting for ameliorations in practice. (2) How to choose investigated samples scientifically also needs deeply research and unceasing improvement. (3) How to calculate the energy consumption of the cities, provinces and the whole nation is another main research work. (4) All kinds of equipments need coding and related databases of equipment need establishing to standardize the statistics. (5) It is also an important job to strengthen the construction of energy statistics teams.

REFERENCES

[1] Xianguang. ZUO, Mingfang Tang. Investigation and statistics of architectural energy waste in the world. Architecture in Chongqing, 2003, 2:16-18. (In Chinese)

[2] J. Haberl, R. Sparks, C. Culp. Exploring new techniques for displaying complex building energy consumption data. Energy and buildings, 1996, 24 (1):27-38

[3] Jianing Zhao, Yinghe Yu, Jun Guo, et al. Several problems in the statistics of building energy

consumption. Statistics and Decision, 2003, 2: 32-33. (In Chinese)

[4] Zhifeng Xue, Yi Jiang. Energy consumption and energy saving potential analysis for large-scale public buildings in Beijing. Journal of HV&AC, 2004, 34 (9):8-10. (In Chinese)

[5] Jie Yang, Guangbei Tu, et al. Investigation and analysis on energy consumption of public buildings in Tianjin and Kobe. Gas and heat, 2004, 24 (1):13-16. (In Chinese)

[6] Shuqin Chen, Nianping Li, Jun Guan et al. A study on thermal environment and energy consumption of urban residential buildings in hot summer and cold winter climate of China. Environmental Informatics Archives, 2005, 3: 379-386

[7] Yi Jiang. Current building energy consumption in China and effective energy efficiency measures. Journal of HV&AC, 2005, 35(5): 30-40. (In Chinese)

[8] Chongfu Zhang, Xuyun Chen, Xilin Hu. Statistical and analytical methods and their application. Chongqing: Press of Chongqing University. 1995, 2. (In Chinese)

[9] Book compilation committee of statistics specialty for national technique qualification test. Statistical basic knowledge and practical operation. Beijing: China Statistics Press. 2005, 17, 22-23. (In Chinese)