



Available online at www.sciencedirect.com

ScienceDirect

Procedia Engineering 121 (2015) 1208 – 1214

**Procedia
Engineering**

www.elsevier.com/locate/procedia

9th International Symposium on Heating, Ventilation and Air Conditioning (ISHVAC) and the 3rd International Conference on Building Energy and Environment (COBEE)

Current Situation of Energy Consumption and Energy Saving Analysis of Large Public Building

Jihong Zhu^{a,*}, Deying Li^b

^a*Beijing University of Civil Engineering and Architecture, 1 Zhanlanguan Rd, Beijing, 100044, China*

^b*Key Laboratory of Heating, Gas Supply, Ventilating and Air Conditioning in Beijing, 1 Zhanlanguan Rd, Beijing, 100044, China*

Abstract

In recent years, due to the more and more energy consumption of large public buildings, people increasingly focused on building energy saving. On account of huge energy consumption of large public buildings, we should take effective measure of energy saving management to reduce energy consumption and save resources. Based on investigating the situation of energy consumption of 20 typical large public buildings, this article analyzes and researches the issues of energy consumption of large public buildings and puts out the control measures and solving measures of huge energy consumption of large public buildings from two aspects of technical and management level by analyzing the reason causing high energy consumption. This article has guiding significance for energy saving management of large public buildings.

© 2015 The Authors. Published by Elsevier Ltd. This is an open access article under the CC BY-NC-ND license (<http://creativecommons.org/licenses/by-nc-nd/4.0/>).

Peer-review under responsibility of the organizing committee of ISHVAC-COBEE 2015

Keywords: Large public building; Building energy consumption; Building energy saving

1. Introduction

The large-scale public building is that individual building area is above 20000m² and the buildings are guesthouse, shopping mall, commercial complex and transportation junction which equip slap-up central air conditioning systems, energy consumption of these buildings includes air conditioning system, lighting, elevator, office electric

* Corresponding author. Tel.: +86-134-2602-8355.

E-mail address: zjhustb2008@sina.com

equipment and other auxiliary equipment etc. In recent years, with China's accelerated urbanization process and the improvement of living standards, social demand for energy is increasing, meantime, the relative scarcity of energy become a very prominent problem in current society. During the 11th Five-year Plan, according to China's special national conditions, we do well at the china's industrial energy-saving and emission reduction, however, we need to seek a scientific and reasonable method to achieve the overall goal of energy saving and emission reduction.

2. The general situation of building energy consumption in China

According to statistics, our country buildings total energy consumption accounts for 28.6% of the total energy consumption of the whole society at present, and the energy consumption of large-scale public building accounts for the majority of China buildings total energy consumption which is less than western developed country buildings total energy consumption [1], however, from the society development experience of the developed countries, we can get that the ratio of buildings total energy consumption to the total energy consumption will add to 33% [2], and buildings total energy consumption will take the top spot which is more than industrial energy consumption and transportation energy consumption. The large-scale public building in China have some prominent problems, such as the high energy consumption and the low efficiency. The large-scale public buildings area accounts for less than 4% of the total area of urban and rural construction, but the energy consumption of China's urban construction accounts for more than 20% of the total energy consumption, the large public buildings power consumption is 10~20 times of the ordinary residential per square meter, and it is 1.5~2 times of the similar residential in Japan and Europe [3], besides, it is 2~3 times of the similar residential in developed country with the similar climate conditions, large public buildings energy waste is quite serious, there is a great energy-saving space.

In 2020, our city's population will increase to 56% of the total population, civil construction area will add to 100~150 hundred million m², and the large public buildings area is 1/10 of the construction total area, building energy consumption is bound to greatly increase, our buildings energy consumption will add to 3 times of the current buildings energy consumption if we do not take strong measures. Energy saving and emission reduction is the inevitable choice to solve the issue of large scale buildings big energy consumption and to deal with the issues of the economic development and environment change and it is most efficient and economical way to ease the contradiction between economic development and energy shortage.

The purpose of large public building saving energy consumption is using less likely energy to guarantee the need of the buildings, from point of the energy utilization, it is improving the energy conversion efficiency. To achieve this goal, detailed and accurate energy data is essential, these data are not only the basis for analysis of energy consumption of buildings, statistics, diagnosis, but also are the basis of finding the problem and standard of inspecting energy saving reconstruction effect. Effectively Building energy consumption monitoring system can give specific data of the building energy consumption, describe the specific situation of building energy consumption quantitatively, it is foundation to guarantee building saving energy to work smoothly.

3. Monitoring and stating the energy consumption

3.1. Monitoring building energy consumption

All tables should be numbered with Arabic numerals. Every table should have a caption. Headings should be placed above tables, left justified. Only horizontal lines should be used within a table, to distinguish the column headings from the body of the table, and immediately above and below the table. Tables must be embedded into the text and not supplied separately. Below is an example which the authors may find useful.

Energy consumption monitoring system mainly monitors large public building energy consumption activities, uses data acquisition equipment to collector building information and monitor energy consumption by means of information, uses the wired network and wireless network to transmit date and provides information and decision support to reduce energy and promote saving energy effect [4].The monitoring data of energy consumption is itemized building energy consumption, including lighting and socket, power plant, special equipment, air-condition. We can analyze the various building energy use characteristics through the sub energy measurement, such as energy consumption characteristics of large scale office buildings is shown in Fig. 1.

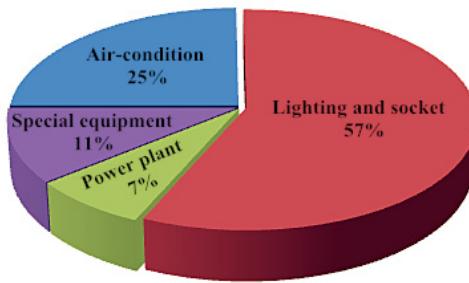


Fig. 1. Each sub graph accounts for the proportion of Office building energy consumption.

As the Fig. 1 shown, to the large scale buildings, the lighting and socket takes the top spot which accounts for the half of total energy consumption, the air-condition accounts for 25% of total energy consumption, the special equipment accounts for 11% of total energy consumption and power plant accounts for 7% of total energy consumption. Because of the different construction time, possible security problems of internal wiring of building and the bad distribution of shunt, the Item energy consumption monitoring may turns out inaccurate information, so, office building monitoring system statistics of all sub consumption may appear errors, but the total energy distribution trend is accurate.

At present, as to the energy consumption monitoring system which focuses on software study to achieve energy-saving emission reduction targets by analyzing and monitoring buildings energy consumption, it ignores the study of the management system and the organizational structure of energy consumption monitoring. Existing studies equate energy consumption monitoring to the energy consumption statistics which is very wrong, energy consumption of building energy consumption monitoring is a point or continuous dynamic statistics, energy statistics is actually stage of static statistics on building energy consumption, they have the essential difference, can't be seen as the equivalent.

What is more, domestic and international energy monitoring technology and energy consumption monitoring equipment is not very perfect. Due to the level of supervision building energy consumption is not high the information and date of industry supervision can't be collected and shared accurately and timely. The implementation of building energy management and macro-control is lack of scientific and effective basis due to the lagging supervision means. It is difficult to accurately grasp the various sub systems energy use status in buildings because of the imperfect equipment, and it is unable to realize the scientific management of energy use. So, in the *The implementation opinions on strengthening the state organ office buildings and large public building energy management work* which is issued by the Department of Housing and the Ministry of Finance, it puts out that strengthening the state organ office buildings and large public buildings construction supervision system using modern technology, promoting the construction of state organ office buildings and large public building energy consumption monitoring platform vigorously and realizing the dynamic monitoring of key buildings energy consumption is the important basic work to strengthen the state organ office buildings and large public building energy efficiency management and to establish and improve the energy efficiency evaluation, energy use standards, energy consumption statistics, energy audits, energy efficiency publicity, energy consumption, energy saving service [5].

In fact, the western developed countries began the study and implementation of building energy conservation technology in the early 70's, and used the unified approach to do the public buildings energy consumption statistics in the nationwide. At present, some countries conducted a comprehensive statistics on building energy consumption and established the detailed database statistics of buildings energy consumption which is richly-detailed. Besides,

they classified the statistical data and set up the perfect system of energy consumption statistics which can be searched and downloaded on the Internet.

The construction of energy-saving work in China started relatively late, compared with developed countries, energy consumption of existing buildings is high, efficiency of energy use is low, and energy use in buildings is growing faster. So, the rational and effective use of building energy consumption monitoring system is a meaningful foundation work and is beneficial to constructing of energy-saving work.

3.2. Stating the building energy consumption

Building energy consumption statistics is to minimize the energy consumption, only we do a good job of statistical work about energy consumption, we can understand the characteristics of building energy consumption and make effective measures to reduce energy waste. At present, China's statistics on energy consumption is not perfect, the main performance is in following.

The total building energy consumption did not form data, but some domestic experts and relevant departments did calculation and analysis in this respect, such as calculate the building energy consumption accounted for 28.6% of the total energy consumption of the whole society in China by the standard quantity of building retains related area climate change. However, due to that the date is imperfect, we can't get the physical truth of building energy consumption which affects the construction of energy-saving work and make us can't effectively evaluate the construction of energy-saving work achievements.

At present, no institution can measure accurate data of China's building energy consumption terminal at home, due to lack this date, we can't describe accurately the specific characteristics of building energy consumption. Although the National Bureau of statistics and the statistics of the Ministry of do lots of testing work on the statistics of building energy consumption, incomplete statistical data and database greatly affected the data detection work, we also failed to reduce the energy consumption gap until now.

4. Research on the energy consumption of large public building

In order to obtain the actual situation and analysis of energy consumption of large public buildings, we investigate and survey the local district 20 representative and typical of large public buildings, including: government house, market, hypermarket, exhibition building and gymnasium. The 20 public buildings is divided into commercial building, office building, style building and tourism building and they are monitored in 2011-2013 and we can get the average energy consumption of large public building per unit which is shown in Table 1.

Table 1. Average energy consumption of large public building per unit.

Year	Commercial Building (MJ/m^2)	Office Building (MJ/m^2)	Culture and Sport Building (MJ/m^2)	Tourism Building (MJ/m^2)
2011	955	527	642	1396
2012	1089	467	601	1294
2013	1090	486	616	1246

As the Table 1 shown, unit energy consumption from large to small in turn is tourism building, commercial building, office building, style construction, the maximum value is near 3 times of minimum value. Through the investigation and study, we find that electric boiler electricity consumption accounts for 40% of total electricity consumption in commercial building, the lighting and socket electricity consumption accounts for 49% of total electricity consumption in office building, commercial lighting electricity consumption accounts for 35% of total electricity consumption in style building, air-condition electricity consumption accounts for 46% of total electricity consumption in tourism building. These electrical equipment and systems are largest consumption items in all kinds of buildings, so large public buildings energy-saving should start from these aspects.

5. The reason analysis of high energy consumption in large public building and the existing in the management of energy saving

The reason of high energy consumption of large public buildings is that it installed a lot of energy system, such as hot and cold water supply system, firefighting system, lighting system, air conditioning system, heating system and so on, the energy consumption of air conditioning system, heating system is biggest. Although most of the buildings have adopted energy-saving materials and energy saving technology, if we do not manage these systems scientifically, the energy consumption of those buildings will be high causing seriously energy wasting. At present, the main problems about Management of large public building energy efficiency in China are in following.

5.1. The national policy is not perfect

China has begun to promote building energy efficiency strategy from the age of 80, but it developed slowly, the reasons are in following:

- Firstly, the legal laws and regulations is not perfect in the public building energy saving aspect, there is no the relevant economic incentive policies.
- Secondly, the initial investment in large-scale public buildings is relatively large, using the energy-saving materials will increase the cost of the investment, although the state issued a series of encouraging policies for the use of energy-saving materials, these policies do not necessarily get good implementation due to the interests between the various interests and high investment.
- Thirdly, lacking of compulsive energy saving measures, consciousness of employees who work with energy saving is not high and there is no advanced management level of energy saving.

5.2. The insufficient of building design

Large public buildings only pay attention to the design of building external appearance and luxury decoration in China and use lots of large glass curtain wall which ignores the energy-saving of buildings, this is a big problem which exists in building design, the most obvious example is the Beijing Capital International Airport Terminal T3.

Unreasonable design and ventilation will make the air conditioning unit cooling capacity be too high. When we do the load calculation and equipment selection, we often choose large rather than choose the small causing energy wasting in most time when the operation of an air conditioning system of a host will meet the conditions. The Chang'an Avenue National Development Bank office building use the VAV variable air volume air conditioning system after the renovation and use advanced ice storage technology, it will achieve very good effect of energy-saving based on the theoretical analysis, however, there are many problems in the actual operating process, these technology which should be energy-saving do not save energy when the system actually operate, even use the higher energy consumption to meet people.

5.3. The energy consumption monitoring platform and the supervision system of large scale building is not perfect

Now a lot of large public building energy monitoring platform are established, but when the platform run, there are lots of problems. Those problems are in following:

- Metering system problem, imperfections of sub metering system lead to sub metering leakage test and retest, classification is not clear, the energy meter is over range and inaccurate.
- The problem of transmission system, instability of data transmission system will cause measurement data be missing or lost long time.
- Storage system problem, when we do the data storage and analysis of data mining, we lack the effective remedy for the missing data and abnormal data.
- Supervision terminal problem, building information is not updated and classification model of the energy consumption monitoring platform is not unified which will cause the platform reflecting inaccurately the building sub energy situation.

5.4. Shortage of energy saving management

There are two views about the problems of management and operation of building energy saving, they are in following:

- Firstly, the key problem of building energy saving is that the industry related policies and regulations is not perfect, such as: lack of compulsive energy-saving policy, economic incentive intensity is not enough, enforcement of mandatory policy is not enough [6].
- Secondly, the main problems exiting in public building energy saving operation are in following: The awareness of the main public buildings energy-saving interests is not high, the public building energy efficiency management is ineffective [7].

6. Energy saving measures to reduce the consumption of the building

6.1. Technical measures

- *Building envelope.* Envelope generates a large part of heat load in large public buildings, so we should improve the heat transfer performance of external wall, staircase and roof enclosure structure, such as Coating absorbing materials on the large areas glass wall to absorb solar to keep room temperature constant which will reduce the time that air-condition operate to reduce energy consumption.
- *The building windows and doors.* According to the survey, the energy consumption of building windows and doors accounts for 1/3 of total energy, the energy-saving potential is large, the best measure is transforming the windows and doors with energy-saving technology, such as increasing shading device, changing the glass of building from single to double and using the LOW-E glass to improve the heat transfer performance of windows and doors.
- *Air-conditioning system.* The energy consumption of air conditioning system is very big in large-scale public buildings, the reason is that when we do the load calculation and equipment selection, we often choose large rather than choose the small causing the units not running efficiently. At present, the effective measure is reforming air-conditioning with frequency conversion technology or using the air-conditioning with frequency conversion technology in new buildings. Besides, we can monitor and analyze the energy consumption of air-conditioning by professional air-conditioning energy service corporation and set up the air conditioner operation plan, retrofit of intelligence system is another measure to save energy.
- *Electrical equipment.* The energy consumption of office equipment, lighting system, power system is very big, and this part of energy consumption is complicated, the measures which can be taken are in following: 1) Establishing the monitoring platform of public building energy consumption, household transforming energy use terminal, using the remote monitoring system monitor the condition of Building energy consumption and doing the statistics and analysis; 2) According to the monitoring date, analyzing and calculating the potential of energy-saving, working out the average value of energy consumption in large public buildings and taking it as the rated value to encourage people to pay attention to energy saving of public building running.

6.2. Management measures

- *The government level.* The government should set up the relative laws and regulations to guide the energy saving management work of large scale buildings and put out the management standards of energy-saving and goal of energy-saving, strengthen the supervision of energy saving management work in large scale buildings, formulate some incentive measures and reward the company which do good at energy-saving.
- *Property level.* Property managers can implement the partition management, meter and analyze the energy consumption of buildings separately, show the statistical energy consumption of different items, transform the system whose energy consumption is high. During the daily management, we should fulfill the idea of saving hourly and improve the quality of the manager and train them regularly to improve their energy-saving awareness and professional ability, so they can find the exiting problems timely to minimize the energy consumption of buildings.

- *The owner level.* The owner and property manager should combine to carry on the management work and strengthen the supervision of the property energy-saving, do the audit work of building energy consumption regularly, evaluate the condition of energy consumption objectively and supervise the implementation of energy-saving management project. We should set up the cooperated mechanism to balance the interests of all the parties and take the reasonable charge mode based on different kinds of buildings. Such as charging the fined rent to the elevator, air conditioning and public lighting and other public energy; charging metrically the cost to the office electricity, office lighting. This mode will stimulate the owners and property manager to promote the work of management of energy saving.
- *The user level.* The user's behavior is also an important factor to affect the management of energy saving work, with the increasing lives standards, users will choose the life way which use high energy if the users do not have good energy-saving awareness. So, we should cultivate the users' energy-saving awareness, restrain their wasteful practices and encourage the users to save energy timely, these measures will decrease the energy consumption without any cost.

7. Conclusion

With the speeding up of China's city level, the energy consumption of buildings will become higher and higher and the proportion that it accounts for of total energy consumption will become higher and higher, we should control and decrease the energy consumption with building energy-saving measures. This article analyze the current condition of energy consumption of large scale building in china and the reason causing the high energy consumption in building, set up the energy-saving measure from two aspects of technology and management. The potential in energy-saving of large scale buildings, in the process of future development, there are more and more effective measures and technology of energy-saving, and more and more new energy-saving buildings to meet people.

Acknowledgements

I appreciate my tutor's help and support very much, and thanks for supporting by laboratory in my college. We also wish to express our gratitude to the authors of the article that cited in this paper.

References

- [1] S.G. Li, H. Wang, Summarization of present building energy consumption and corresponding strategies in China, Environmental Science and Management 33(2) (2008) 6-9.
- [2] W.T. Fan, China's energy challenge in new century, FAXIAN 14(2) (2002) 32-33.
- [3] National Development Reform Commission and Energy Research Institute, Study on the energy conservation management policies for large-scale public building in China, 2007
- [4] D. Liu, Study on the energy conservation management based on the energy consumption monitoring system, Journal of Xi'an University of Architecture and Technology 43(2) (2011) 281-287.
- [5] Ministry of Housing and Urban-Rural Development, The development instruction of the state organ office buildings and large public building energy consumption monitoring system software, 2009.
- [6] L. Wang, W.L. Tian, S.B. Ma, Study on Energy Consumption Assessment and Energy Efficiency Labeling Systems and Related Operational Mechanisms for Residential Buildings, Building Science 24(6) (2008) 2-6.
- [7] J.Liang, B.Z. Li, Investigation of Public Building Energy-saving Management and Retrofit in China, Building Science 23(4) (2007) 10-14.