Available online at www.sciencedirect.com

SciVerse ScienceDirect

Energy Procedia 14 (2012) 1925 – 1930

Energy Procedia

ICAEE 2011

# Energy Consumption and Management in Public Buildings in China: An Investigation of Chongqing

Guiwen Liu[a], Zezhou Wu[a,b*], Mingming Hu[c]

[a]*Faculty of construction management and real estate, Chongqing University, Chongqing 400045, China*
[b]*Department of building and real estate, The Hong Kong Polytechnic University, Hong Kong, China*
[c]*CML – Institute of Environmental Sciences, Leiden University, Leiden, the Netherlands*

**Abstract**

Around 30% of the national energy consumption in China can be attributed to buildings, of which one-fifth is consumed within public buildings. In recent time, public buildings have been reckoned as the dominant objects for conducting energy efficient management. In order to obtain valuable information for the assessment of energy consumption status, an investigation was conducted in Chongqing – the youngest, largest and most dynamic municipal in China. A number of public buildings, including 28 governmental office buildings, 15 emporiums and 5 hotels, were selected for the investigation from the aspect of energy cost. Based on the collected data of electricity, water and gas, the characteristics of the energy consumption in each type of the public buildings are discussed, and the energy management in each type of public buildings is compared.

*Keywords:* Energy consumption; Governmental office buildings; Large-scale public buildings; Energy management; Chongqing

## 1. Introduction

Building industry is considered to be an important contributor to the total national energy consumption. In 2004, building energy consumption in China was equivalent to 16 billion tons standard coal, representing 20.7% of the total national energy consumption. In the meantime, due to the improving living requirements and the rapid urbanization, there will be a dramatic increase in the amount of energy-consuming appliances (such as air-conditioners) and urban building areas, which will result in more energy consumption. It is expected that the proportion of building energy consumption in national energy consumption will keep rising in the coming years [1, 2].

* Corresponding author. Tel.: +852-95136899; fax: +852-27645131.
*E-mail address: bszezhou@polyu.edu.hk.*


doi:10.1016/j.egypro.2011.12.887

To curb the rapid growth of energy consumption, the Chinese central government has issued many standards and regulations concerning building energy efficiency since the 1980s [3]. Besides, substantial studies concerning energy conservation in China have been conducted. In the 1990s, researchers tried to figure out the challenges and defects that encountered in the process of the issuance of energy conservation policies and strategies [4-7]. As research progressed, energy efficiency technologies and management measures concerning buildings were put forward particularly. Lang [8] described the issued standards for residential buildings, afterwards, Liu et al. [9] presented a model to simulate and evaluate the economic and environmental impacts caused by them. To investigate the energy consumption in cities, provinces and the country stage by stage, Chen et al. [10, 11] developed two statistical methods for public and residential buildings respectively. Based on the climate classification in China, the building energy efficiency management was studied. Energy conservation technologies were also introduced from the aspects of solar energy [12], energy envelops [13] and air-conditioning [14]. Towards the market of environmental friendly services and products, green government procurement was believed to be a helpful approach to achieve the overall goal of sustainable development [15]. In addition, Feng et al [2] held the view that an energy efficiency supervision system could improve the operation and maintenance of energy-consuming appliances and promote energy conservation.

It can be concluded that marvelous efforts have been made for the promotion of energy conservation, however, basic data concerning energy consumption status and energy management level of public buildings is still scarce. To fulfill this gap, an investigation was carried out in public buildings in Chongqing. Based on the collected information, this paper introduces the current energy consumption situation of public buildings in Chongqing, analyses current energy management and challenges, and discusses the differences between governmental office buildings and commercial buildings.

## 2. Research Methodology

Energy consumption data from typical public buildings, namely 28 governmental office buildings, 15 emporiums and 5 hotels, was collected. The implemented procedures of this investigation can be described as follows.

Step 1: Collecting basic building information. The first step of this investigation is to find out the basic information of public buildings to the broadest extent. The collected information contains location, floor area, built year, structure and so on. This kind of information can be found in the building database of the local government.

Step 2: Measuring energy consumption. After the basic information of the chosen buildings was collected, the next step is to conduct practical site visits for measuring their energy consumption statistics. With the understanding and support from the owners of the selected public buildings, several groups of postgraduate students were sent out for detailed energy consumption measurements.

Step 3: Energy audit. After the energy consumption situation was indentified, the main energy conservation measures implemented during energy consuming were inquired to the owners. The purpose of this procedure is to find out the weak aspects of energy consumption management.

## 3. Results

### *3.1. Governmental office buildings (GOBs)*

The costs of electricity, water and gas of 28 surveyed GOBs are shown in Fig. 1. The average total cost is 47.25 RMB/$m^2$, while the highest is 103 RMB/$m^2$ and the lowest is 8.77 RMB/$m^2$. The lowest cost is less than one tenth of the highest cost because the types of energy consumption system are different from

each other due to their built ages. The early built building often has a comparatively simple system. The buildings with no central air-conditioning systems are required to use air-conditioning equipments in different places, leading to the enormous cost difference.

In the total energy cost, the cost of electricity, water and gas accounts for 82%, 9% and 9% respectively (see Fig.2). It can be concluded that electricity consumption is the main field of energy consumption. The important factors influencing energy consumption are lighting and air-conditioning system.

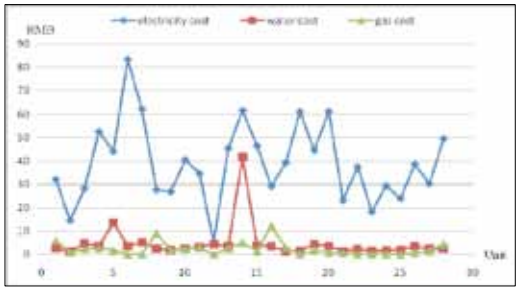

Fig.1 The electricity, water, gas costs of GOBs

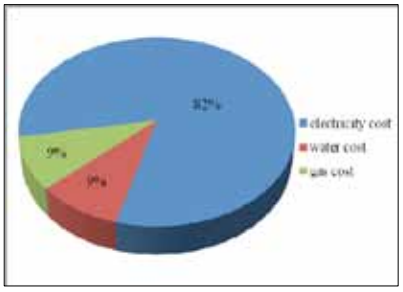


Fig.2 The energy consumption proportion in GOBs

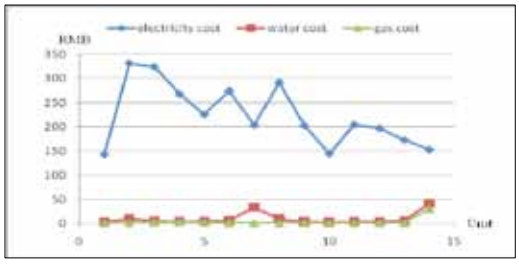

Fig. 3. The electricity, water, gas costs of emporiums

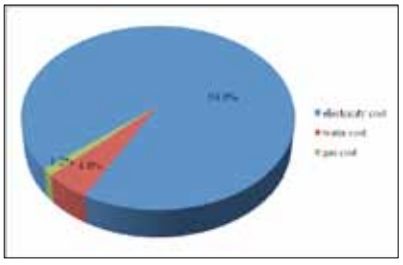

Fig. 4. The energy consumption proportion in emporiums

### *3.2. Emporiums*

The costs of electricity, water and gas of 15 emporiums are investigated; it can be deduced from the information given by Fig. 3 that the mean cost of energy consumption is 249 RMB/$m^2$. The highest total cost could reach up to 344 RMB/$m^2$, while the lowest total cost is 140.59 RMB/$m^2$. An evident difference between the highest and the lowest is 203.41 RMB/$m^2$.

Fig. 4 demonstrates that the electricity cost takes up 94% of the total consumption cost. Meanwhile, the cost of water and gas accounts for 4.8% and 1.2% respectively. This means that the energy situation in emporium is similar with GOBs': the electricity depletion is the predominant field for energy consumption.

### *3.3. Hotels*

Fig. 5 and Fig. 6 depict the energy cost data gathered from 5 hotels. Fig. 5 shows that the mean energy cost is 115.14 RMB/$m^2$, the highest is 141RMB/$m^2$, and the lowest is 58.44 RMB/$m^2$， the difference in hotels is small comparing the one in buildings. Meanwhile, it can be seen from Fig. 6 that the cost of electricity, water and gas represents 68%, 8% and 24% separately. The main energy consumption factor is

electricity as well. However, the rates of energy consumption caused by the other two factors are higher than the emporiums' consumption because of food demand.

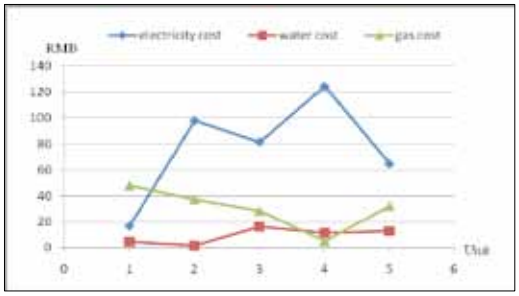


Fig.5 The electricity, water, gas costs of hotels

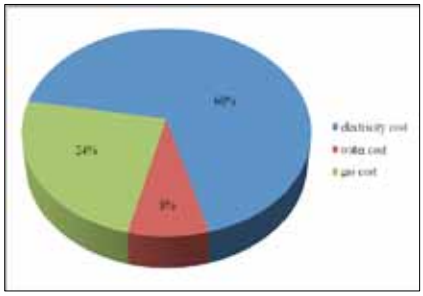

Fig.6 The energy consumption proportion in hotels

## 4. Discussions

### *4.1. Governmental office buildings*

Most executives and staffs of government departments are lack of energy conservation awareness. Considering that the energy cost of a governmental office building has no relationship to their salaries and rewards, the workers are mostly care little about energy conservation. However, as the national central government strengthens the propaganda of building energy-saving, the local governments are required to implement energy efficiency appraisal regulation. Recently, energy saving regulations are formulated in various degrees by different departments.

The main reason for energy wasting is the lack of professional staffs who particularly engaging in energy efficiency management. In the investigated buildings, some managers placed great emphasis on energy conservation, and formed some regulations to control energy consumption. But the stuffs responsible for energy management did not get specialized training, and they have other important work to do at the same time. The energy consumption management is only like a part-time job.

Through the investigation, it can be found that the energy management is more complicated in a building which has a central air-conditioning system. The GOBs are built in various periods; therefore the requirements in different GOBs are different from each other. Generally, buildings built after 2005 mostly have a central air-conditioning system. Fig. 7 depicts the management status in a building with a central air-conditioning system. It can be concluded that the energy management level is low and need to be improved.

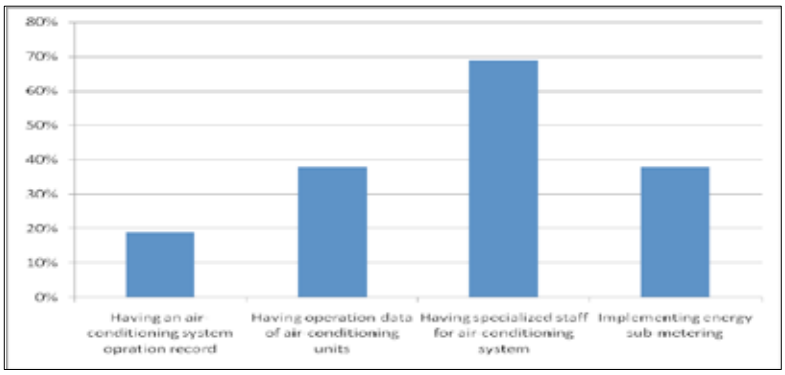


Fig. 7. Management status of air-conditioning system in GOBs

### *4.2. Commercial buildings*

Comparing governmental office buildings, more attentions are paid on energy efficiency management in commercial buildings. In consideration of economic benefits, some owners implemented strict energy saving items on high-energy-consumption systems, mainly focusing on lighting system and air-conditioning system. In addition, related supervision system is enacted in most energy-consuming units. The aim of energy management can be achieved through the implementation of reward and penalty regulation, linking energy saving and department performance together.

The energy efficiency management in an emporium is more difficult than the other two kinds of buildings. The number of customers in an emporium is easily influenced by seasons or holidays, it even changes in different times of a certain working day. This existing situation results in a wide fluctuation on energy consumption in the emporium building. Therefore, the energy efficiency management in an emporium is more complicated to some extent.

The management effect in a hotel is better than the energy-saving implementing status in an emporium. One of the crucial reasons is that the hospitality industry has a strict regulation on energy consumption management. It is confined that the cost of energy consumption cannot exceed 8% of the prime operating revenue. Another primary reason is that it is relatively simple to conduct an energy efficiency management in hotels. Though a fluctuation also exists in the energy consumption in a hotel, it is mainly because of the season changing, the fluctuation range is not so wide and easy to control.

### *4.3. The comparison of energy management in commercial buildings and governmental office buildings*

Since governmental office buildings and commercial buildings both have their own characteristics, the energy management styles are different as a result. The differences are shown in Table 1. It can be concluded that the energy efficiency management implements well in a commercial building due to the requirement of a preferable profitability. Yet little efforts are paid in governmental office buildings because they are non-profit-making, and the costs of energy are paid by national administration. It is the key point that leads to the differences and needs to be focused on.

Table 1. The comparison of the management in commercial and office buildings

| Items | Commercial buildings | Governmental office buildings |
|---|---|---|
| Property | Profitability | Non-profit-making |
| Financial source | Owner | National administration payment |
| Driving force for energy saving | Economic benefits & Operating costs | Government regulation |
| Implementation motive | Strong | Weak |
| Requirement | High | Low |
| Management level | High | Low |

## 5. Conclusions

The energy consumption of the public buildings in China is enormous. It can be concluded that:

- the dominant form of energy consumption in public buildings is electricity. Thus, the focus of energy conservation should be put on electricity consumption.

- within the three types of public buildings investigated, emporiums have the highest energy consumption intensity, more than double of hotels and about 5 times of governmental office building, therefore, further efforts should be conducted to improve their energy efficiency.
- the energy efficiency management level of public buildings is generally far from adequate. This investigation manifests that commercial buildings employ much stricter energy management system than governmental office buildings.

## Acknowledgement

This research was supported by a cooperative agreement from the Chongqing Municipal Commission of Urban-Rural Development.

## References

[1] W.G. Cai, Y. Wu, Y. Zhong, H. Ren, China building energy consumption: Situation, challenges and corresponding measures, Energ Policy, 37 (2009) 2054-2059.

[2] Y.P. Feng, Y. Wu, C.B. Liu, Energy-efficiency supervision systems for energy management in large public buildings: Necessary choice for China, Energ Policy, 37 (2009) 2060-2065.

[3] N. Zhou, M.D. Levine, L. Price, Overview of current energy-efficiency policies in China, Energ Policy, 38 (2010) 6439-6452.

[4] Z.X. Wu, Z.H. Wei, Policies to Promote Energy-Conservation in China, Energ Policy, 19 (1991) 934-939.

[5] J.E. Sinton, M.D. Levine, Q.Y. Wang, Energy efficiency in China: Accomplishments and challenges, Energ Policy, 26 (1998) 813-829.

[6] J. Liang, R.M. Yao, B.Z. Li, Y. Wu, An investigation of the existing situation and trends in building energy efficiency management in China, Energ Buildings, 39 (2007) 1098-1106.

[7] T.Z. Hong, A close look at the China Design Standard for Energy Efficiency of Public Buildings, Energ Buildings, 41 (2009) 426-435.

[8] S.W. Lang, Progress in energy-efficiency standards for residential buildings in China, Energ Buildings, 36 (2004) 1191-1196.

[9] X.L. Liu, G.J.D. Hewings, S.Y. Wang, Evaluation on the impacts of the implementation of civil building energy efficiency standards on Chinese economic system and environment, Energ Buildings, 41 (2009) 1084-1090.

[10] S.Q. Chen, N.P. Li, J. Guan, Y.Q. Xie, F.M. Sun, J. Ni, A statistical method to investigate national energy consumption in the residential building sector of China, Energ Buildings, 40 (2008) 654-665.

[11] S.Q. Chen, N.P. Li, J. Guan, Research on statistical methodology to investigate energy consumption in public buildings sector in China, Energ Convers Manage, 49 (2008) 2152-2159.

[12] Z.S. Li, G.Q. Zhang, D.M. Li, J. Zhou, L.J. Li, L.X. Li, Application and development of solar energy in building industry and its prospects in China, Energ Policy, 35 (2007) 4121-4127.

[13] L. Yang, J.C. Lam, C.L. Tsang, Energy performance of building envelopes in different climate zones in China, Appl Energ, 85 (2008) 800-817.

[14] Y. Ding, B.Z. Li, R.M. Yao, Y. Tan, Part load operation coefficient of air-conditioning system of public building, Energ Buildings, 42 (2010) 1902-1907.

[15] Y. Geng, B. Doberstein, Greening government procurement in developing countries: Building capacity in China, J Environ Manage, 88 (2008) 932-938.