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Energy-efficiency supervision systems for energy management in large public buildings: Necessary choice for China

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ABSTRACT

Buildings are important contributors to total energy consumption accounting for around 30% of all energy consumed in China. Of this, around two-fifths are consumed within urban homes, one-fifth within public buildings, and two-fifths within rural area. Government office buildings and large-scale public buildings are the dominant energy consumers in cities but their consumption can be largely cut back through improving efficiency. At present, energy management in the large public sector is a particular priority in China. Firstly, this paper discusses how the large public building is defined, and then energy performance in large public buildings is studied. The paper also describes barriers to improving energy efficiency of large public buildings in China and examines the energy-efficiency policies and programs adopted in United States and European Union. The energy-efficiency supervision (EES) systems developed to improve operation and maintenance practices and promote energy efficiency in large public sector are described. The benefits of the EES systems are finally summarized.

1. Introduction

IEA (2006) reported that with the Chinese economy continuing to expand by around 8–9% annually, which is likely to continue doing so for the next several years, demand for energy and the consequent CO_2 emission can only continue to grow. Energy security and environmental problems have greatly restricted the sustainable development of China. Furthermore, China is inefficient when it comes to energy use. The amount of primary oil consumed per unit of gross domestic product (GDP) is well over twice that of developed countries according to the report from IEA (2004).

China has mapped out its long-term energy-efficiency schemes. The 11th Five-Year plan, which aims to build an energy-efficient and environmental-friendly society, holds a great commitment to energy efficiency and reducing energy intensity in the Chinese economy while maintaining economic growth. The plan sets the goal of reducing the amount of energy per unit of the country's gross domestic product by 20% between 2006 and 2010 (SC, 2006).

Buildings are important contributors to total energy consumption accounting for around one-third of energy consumed. Energy efficiency in the building sector is a key element of energy savings. By the end of 2005, energy consumption in buildings represented about 28% of the total primary energy consumption in China (NBS, 2006). Economic development and a desire for better living standards have spurred rapid construction in China. During the early 1980s, new construction floor area totaled 700–800 million m^2 per year (Lang, 2004) and the annual total in recent years has been 2.0 billion m^2 (EEB, 2007). This rapid rate of construction has implications for energy consummation.

Energy-efficiency efforts began in the early 1980s in China. The Ministry of Construction (MOC) developed an energy-efficiency design standard for residential buildings in the very cold and cold zones of the country and issued the "Energy Conservation Design Standard for New Heating in Residential Buildings," JGJ 26-86, in 1986. Since 2005, MOC has moved to develop energy-efficiency design standards for public buildings.

The building with a total floor area over 20,000 m^2 occupied by public authorities or by institutions providing public services is called a large public building (LPB) in China. Statistics show that, by the end of 2005, the large public floor area was about 4% of total urban floor area; however, LPB accounted for around 20% of total urban electricity consumption (Wu and Liu, 2007). Improving energy efficiency in large public sector is particularly important because it exhibits considerable potential for energy savings. Energy efficiency in the large public sector may reduce life-cycle costs of buildings and negative environmental impacts. But perhaps the most important effect of energy-efficiency efforts in the large public sector is the potential of an overall impact on

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the market. That is, more efficient products and building practices of the whole market beyond the public sector would be boosted significantly.

This paper aims to analyze barriers to improving energy efficiency of large public buildings in China and examine the mechanisms for implementation of energy efficiency supervision.

2. Barriers to energy efficiency in the large public sector

2.1. Energy performance in large public buildings

In China, government office buildings and large public buildings are the dominant energy consumers. Nowadays, energy use in large public buildings represents a major portion of total energy demand, especially for electricity. Statistics show that, energy consumption per meter square in large public buildings is 70–300 kWh of electricity, which is 10–20 times of that in residential buildings (CC, 2005).

Take Beijing as an example, the large public floor area is around 5% of total urban floor area; however, large public buildings consume 3.3 billion kWh of electricity each year, accounting for about half of that in residential buildings (Kang, 2007). Annual electricity use in different types of buildings is shown in Fig. 1, where RB represents residential buildings, PB represents general public buildings and LPB represents large public buildings (Xue, 2005).

Apparently, large public buildings are significantly less energy-efficient and own great potential for energy savings than other types of buildings.

2.2. Main barriers

As the energy use in large public buildings is growing faster than other sectors and public buildings could play an important role in demonstration for energy-efficiency improvements, much of the energy-efficiency effort is targeting at energy savings in the large public sector, which can help to raise concern and awareness of energy-efficiency issues. However, there are classes of barriers to improving energy efficiency of large public buildings.

Firstly, energy consumption (particularly electricity) in large public buildings will continually increase. In large public buildings, air conditioning has reached saturation. Also there has been an increasing use of curtained wall design for large public buildings. Large public buildings usually use glazing of low shading coefficient and low visible transmittance so that very little daylight can enter, and each building relies heavily on electric lighting. These increase the end-use penetration and intensity, particularly of electricity applications, in large public buildings. Building energy-efficiency standards are important measures to control energy consumption in buildings. It can ensure that cost-effective energy-efficiency opportunities are incorporated into new buildings.

However, the implementation of building energy codes and regulations is weak. China has enforced several mandatory codes targeted to improve the energy efficiency of public buildings. The code for tourist hotels (GB50189-93) (STSB, 1994) aimed to tackle the rapid growth of heated and air-conditioned hotel buildings. The target code GB50189-2005 for new public buildings is to achieve 50% energy savings (13–25% from building envelope, 16–20% from heating, ventilation and air-conditioning (HVAC) system, and 7–18% from interior lighting). Although these energy codes have been developed over decade, there are little published information or research as to their effectiveness. Implementation will continue to be the most difficult part for building energy codes in China. Energy-efficient design has inherent drawback, that is, high initial construction cost. Energy efficiency may result in low ongoing expenses or maintenance costs, but requires a long-term commitment to reap financial benefit. Therefore, many of the buildings are designed to meet mandatory codes and not constructed accordingly. Mandatory inspection and final acceptance by local authorities are of great importance to the effective implementation and enforcement of the standards. Both energy-efficient design and construction could avoid faults from the beginning of a new project. Public education of looking beyond initial construction cost is another work cannot be ignored.

As for existing large public buildings, energy-efficient design and construction are not enough. The operation of the building can severely affect the energy consumption. Much of the variation in energy consumption in large public buildings is due to daily operational routines. A report from Building Energy Research Center Tsinghua University showed that there exists great difference in the energy consumption among buildings of similar nature, see Fig. 2. Why? Operation and maintenance practices and performance of facilities determine energy consumption of buildings. Buildings appear to be fairly efficient could exhibit energy inefficiencies because of improper operations. Therefore, it is critically important to focus on improving building operation strategies, particularly the operation of the air-conditioning and lighting systems, to achieve efficient energy utilization.

Researches show that there are many of large public building designed with excellent energy conserving features tend to exhibit energy inefficiencies in China. These suggest that it is

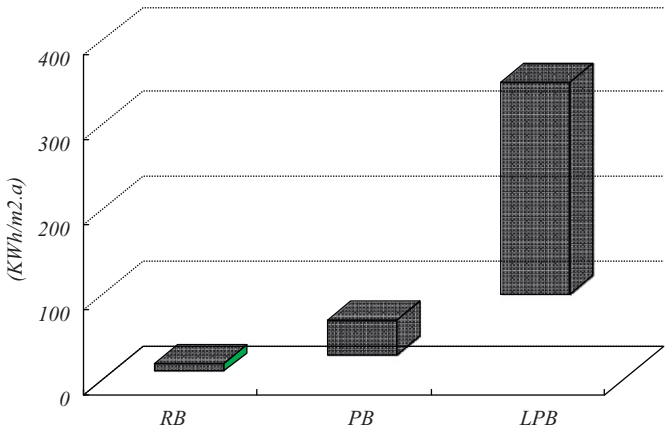

Fig. 1. Annual electricity use.

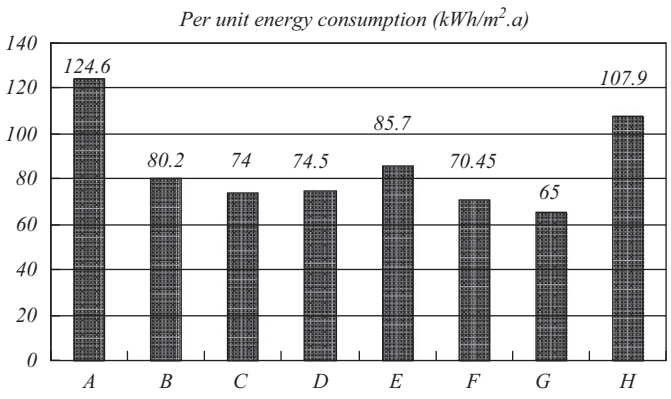

Fig. 2. Energy use among buildings of similar nature.