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Promoting low carbon sustainability through benchmarking the energy performance in public buildings in China

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ABSTRACT

Two main energy performance benchmarking methods under the National Public Buildings Energy-efficiency Design Standards and the Evaluation Standard for Green Building are adopted for saving energy consumption in the public buildings in China. However, several existing barriers and weaknesses in current benchmarking systems prevent the overall energy conservation and carbon reduction from being achieved. This paper explores a new comprehensive energy performance based benchmarking method for addressing the energy saving from both technical and non-technical measures. The overlooked base load energy use is also highlighted in the new method. More importantly, the approach of establishing accurate and efficient data bases and forming sound baselines for assessing and monitoring the energy performance in different types of China's public buildings are recommended in the paper. Governments can play a vital role in improving current benchmarking systems for promote the comprehensive low carbon sustainable development in China's public building sector.

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1. Introduction

High growth of urbanization in China has significantly enhanced the economic development and social changes. About 15 million people would add to the urban population every year between 2000 and 2030 in China through the movement from rural area to cities (UN Department of Economic and Social Affairs, 2011). Cities today are responsible for 67% of total global energy consumption and more than 70% of greenhouse gas (GHG) emissions (UN-HABITAT, 2008) because of increasing demand for urban dwellings with this quick urban development and the constant rise of people's living standards. Otherwise, air pollutions (e.g., SO_2 and NOx) are made by consuming fossil fuels and other pollutions produced by municipal wastes.

Approximately 2 billion square meters of new buildings appear each year and about 21 billion square meters of new buildings are expecting to be constructed by 2020 in China (World Bank, 2001), which is equivalent to the whole existing building area in the EU-15 (Ecofys, 2006). Generally, in a building's lifecycle there are three phases: (i) the construction phase, (ii) the management/occupation phase and (iii) the destruction phase (Davies, 2006). The energy flow runs through every phase of the lifecycle and GHGs and other pollutions are emitted as by-products. If considering all energy consumption in three phases, approximately 25% of total energy in the country is used in the building sector (National Bureau Statistics Yearbook, 2012 and Qiu et al., 2007). Associated with over 5 billion tonnes of CO_2 equivalent (CO_2e) emissions were made with this energy consumption in China's building stock in 2010. With 11% of annual growth of energy consumption in buildings in recent years, the prediction shows that it will continue to increase in next decades (Qiu et al., 2007).

Urban buildings share only 40% of total building area, but responsible for almost 90% of total energy consumption in the building sector in China. Urban buildings can be divided into residential buildings and non-residential buildings. In China, the non-residential buildings are also called as "public buildings" in many occasions. The public buildings contain most of non-residential buildings except plants and factories, such as governmental buildings, commercial buildings (i.e., office building, hotels, restaurants and shopping malls), school buildings and gyms (Qiu et al., 2007).

With more new public buildings, and higher comfortable and convenient levels involving the use of more equipments and appliances, the overall energy consumption (including the direct[1] and indirect[2] energy consumption) in the public building sector continues to increase. The current energy use in public buildings having a higher annual growth rate of 12.9% compared to 12.3% in residential buildings between 2000 and 2010 in China (Fig. 1). During the same period, the average annual growth rate of public building floor area in China was 14.3% comparing 22.4% of the growth rate of residential building floor area (National Bureau Statistics Yearbook, 2012). Furthermore, the overall energy consumption per m^2 in public buildings is over two times higher than that in residential buildings in China (Jiang, 2011). The energy use in public buildings is different in cities under different climate zones. However, at any given latitude, the *U*-value[3] of public buildings in China is about half of that in developed countries (Jiang, 2009). It means that the level of energy efficiency of buildings is much lower in China comparing it in developed countries. Therefore, the priority should be given to public buildings for achieving the long-term low carbon sustainable development in China's building sector.

This paper explores an approach of benchmarking overall energy performance with the aim of effectively improving energy efficiency and reducing carbon emissions in China's public buildings.

2. Energy use benchmarking in public buildings in China

Benchmarking method was firstly adopted in 1970s by some companies for comparing key production parameters and assessing the improvement of companies' performance. Since 1990s, the method

[1] The direct energy consumption is for maintaining thermal comfort and normal operation in buildings.

[2] The indirect energy consumption is associated with the water use, waste disposal and construction of the building, etc.

[3] *U*-value is used to express the rate of heat loss through an external building element such as a wall or window. A construction with a *U*-value of 1 W/m^2 K would lose 1 Watt of energy through a 1 m^2 area for every 1 °C difference in temperature between the inside and outside. The lower the *U*-value, the better insulated the construction.