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Comparative study of commercial building energy-efficiency retrofit policies in four pilot cities in China

Jing Hou[a,*], Yisheng Liu[a], Yong Wu[b], Nan Zhou[c], Wei Feng[c]

[a] Beijing Jiaotong University, No. 3 Shangyuancun, Haidian District, Beijing 100044, China
[b] Ministry of Housing and Urban-Rural Development, No. 9 Sanlihe Road, Haidian District, Beijing 100835, China
[c] Lawrence Berkeley National Laboratory, 1 Cyclotron Road, Berkeley, CA 94720 United States

HIGHLIGHTS

- Data and information were collected through site surveys to the four pilot cities.
- Policy design and effectiveness in four cities were comparatively analyzed.
- Well-designed policy increases market response, energy savings and EMC adoption.
- Lighting is the most common retrofit while envelope is the least common one.
- Subsidy incentive is greatest for educational buildings due to the utility tariff.

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ABSTRACT

The energy efficiency of existing commercial buildings is more challenging to regulate and improve than the energy efficiency of new constructions. In 2011 and 2012, the Chinese Government selected four cities- Shanghai, Tianjin, Shenzhen, and Chongqing- to implement pilot commercial building energy efficiency retrofit program. Based on site surveys and expert interviews in these pilot cities, this research conducted a comparative analysis on incentive policies of local city level. The analysis results show that policy designs of existing commercial buildings should be further improved. The aspects that influence the implementation effect in the future, such as subsidy level, installments, and business model promotion, should be specified in the policy clauses. Referring to the technical solution and cost-benefit in Chongqing, we found that lighting system is the most common retrofit objects while envelope system is the least common one. And the subsidy incentive is greatest for educational buildings, followed by office buildings. In the end, we further discussed the problems and obstacles in commercial building retrofit market, and provided a series of recommendations.

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1. Introduction

1.1. Commercial building sector development overview

As a result of rapid, steady economic growth in the past two decades, China has become the largest energy consumer and carbon dioxide (CO_2) emitter in the world (BP Group, 2010). Rapid urbanization can also be seen in the same period. From 1980 to 2014, the population of permanent residents in Chinese cities and towns increased from 191 million to 749 million, and at the same time, the urbanization rate grew roughly by 1.02% annually, from 19.4% to 54.8% (Fig. 1) (CGPRC, 2014). As a result, a large number of commercial buildings[1] have been constructed in cities all over mainland China. The growing number of commercial buildings also indicates that commercial building energy demand is growing

Abbreviations: CBEER, Commercial Building Energy Efficiency Retrofit; CNY, Chinese Yuan; DRC, Development and Reform Commission; DOE, Department of Education; EUI, Energy Usage Intensity; EIA, Energy Information Administration; EMC, Energy Management Company; GOA, Government Offices Administration; MOC, Ministry of Construction; MOHURD, Ministry of Housing and Urban-Rural Development; M&V, Measurement and Verification

* Corresponding author.
E-mail addresses: houjing0130@gmail.com, houjing0130@163.com (J. Hou), yshliu1@bjtu.edu.cn (Y. Liu), wuyong0715@163.com (Y. Wu), nzhou@lbl.gov (N. Zhou), weifeng@lbl.gov (W. Feng).

[1] In this article, commercial buildings refer to both governmental buildings and buildings used in service sector, which are not used as residences, nor part of industrial facilities. By building functions, commercial buildings mainly include office, retail, hospital, school, hotel and other building types.

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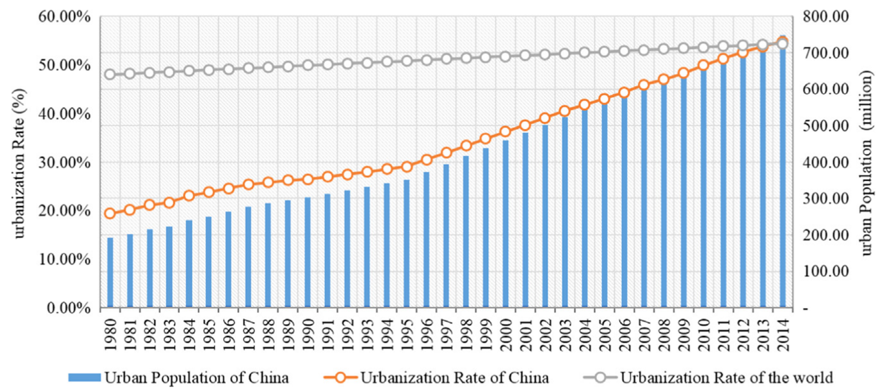

Fig. 1. Urbanization levels in China, 1980–2014 (Source: National Bureau of Statistics data and China's New Urbanization Plan (2014–2020)).

rapidly.

From 1996 to 2012, total commercial floor space in China increased from 2.8 billion square meters (m^2) to 8.3 billion m^2 (NBS, 2013; BECRC, 2014). The average EUI of China's commercial buildings is three to five times more than that of residential buildings. Large-scale, high-end commercial buildings can be as much as 10 to 20 times more EUI than typical commercial buildings (CGPRC, 2007; Liu, 2012; Xu et al., 2012). In 2012, China's commercial buildings consumed more than 182 million tonnes coal equivalent, accounting for 26.4% of overall energy consumption in the building-sector (BECRC, 2014). A study conducted by the EIA projects reveals that commercial building energy use will increase by 2.7% per year in developing countries between 2007 and 2035 (EIA, 2010). These values make clear that commercial building energy efficiency should be kept increasing to help reduce growth in energy consumption.

1.2. *Energy efficiency of new construction commercial buildings*

In an effort to achieve large scale energy savings, the governments typically rely on energy policy tools which can help conserve energy in thousands of commercial buildings such as building energy standards and codes (Azar and Menassa, 2014). In the past two decades, the Chinese Government had implemented energy-efficiency policies for new constructed commercial buildings. In 1993, the MOC[2] issued a building energy-efficiency standard for hotels (GB50189[3]). In this phase, the criteria of the standard were not rigid enough. Besides, the standard enforcement scope was not comprehensively included for all types of commercial buildings (MOC, 1993). In 2005, the GB 50189 was revised to include other types of commercial buildings. The standard required that all new buildings should be 50% more efficient than the baseline defined with 1980s building characteristics (Feng et al., 2014)[4]. The latest revision to this standard has been issued by the MOHURD on May 15th 2015 and taken effect in October 1st 2015, which sets the efficiency level at approximately 30% more than that of the 2005 standard (Hong et al., 2015a), i.e., equivalent to 65% more efficient than the 1980s baseline. Therefore, along with the constant update of the mandatory efficiency standard-GB50189, energy-efficiency in new constructed commercial building sector has been effectively controlled and improved step by step.

[2] The MOHURD was founded in 2008. Its predecessor was the MOC.

[3] GB 50189 is a national standard named "design standard for energy efficiency of public buildings". GB, in Chinese pinyin "Guo Biao" means national standard.

[4] The 1980s characteristics (baseline) assumes that buildings in China were constructed without rudimentary energy efficiency measures.

1.3. *Energy efficiency of existing commercial buildings*

Most commercial building energy efficiency policies target at new construction, whereas technical specification for energy efficiency improvement in existing commercial buildings are still underdeveloped due to inadequate financial and technical capacities (Li and Shui, 2015). In addition, energy efficiency in existing commercial buildings is more challenging to regulate and improve than the energy efficiency of new constructions. Most commercial buildings that were built before GB50189-2005 are in need of retrofitting. In addition, some large-scale and high-end ones that were built according to GB50189-2005 still have a high EUI. Their energy efficiencies need to be improved through retrofit as well.

A lot of energy statistics, energy audit and energy-saving diagnosis revealed that all kinds of commercial buildings have high energy consumption, low energy efficiency issues, in different levels. Jiang et al. (2010) estimated that the average energy saving potential in most large scale commercial buildings are generally over 30%. While Hong (2009) thought the potential is about 50% by combining energy conservation measures with improved operations. Although some researchers have noticed the big energy saving potential in China's existing commercial building sector, further in-depth research or energy efficiency retrofit practice is very limited. Only a few researchers analyzed commercial building retrofit of one single type or one single climate zone by using eQuest or DeST software (Xing et al., 2015; Peng et al., 2014). Some developed countries go faster than China, apart from a lot of retrofit practice, researchers even developed some energy efficiency performance database and energy retrofit analysis toolkits to supports commercial building retrofit (Hong et al., 2015b; Lee et al., 2015a; Lee et al., 2015b). However, the experiences from these researches that China can learn are limited. Because there are many differences exist in not only commercial building type, scale, energy consumption behaviour, etc., but also the CBEER market maturity, data foundation, national promote pattern, etc.. Therefore, a comprehensive study about China CBEER is very necessary and helpful.

This research studied a large number of existing commercial building retrofit projects within a four-pilot-city program in China. With a comparative study of the incentive policies in different cities, this research also aimed at comprehensively probing into some other important aspects associated with existing commercial building retrofit industry. Technical solution, cost-benefit, business model, and barrier and obstacle are focused on in this paper.

2. Methodology

Fig. 2 shows the process, method, and objective of this

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