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Public participation in energy saving retrofitting of residential buildings in China

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HIGHLIGHTS

- We compare public participation in three early cases of residential retrofitting in Beijing.
- Residents' involvement in pre-retrofit activities as well as in the choice and use of technologies varied.
- More involvement of residents during retrofitting improves energy saving performance.
- Taking into account motives and energy use practices of residents improves energy saving through retrofitting.

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ABSTRACT

Retrofitting existing residential buildings has been claimed as one crucial way to reduce energy consumption and greenhouse gas emissions within the Chinese residential sector. In China's government-dominated retrofitting projects, the participation of residents is often neglected. The objective of this paper is to assess the influence level of public participation (before, during and after retrofit) on energy saving by comparing three Beijing neighborhoods with different retrofitting models: a central government-led model, a local government-led model, and an old neighborhood retrofit model. In the three cases data were collected through interviews with neighborhood workers and residents. The results show that residents' involvement in pre-retrofit activities, in technology selection and in the use of technology differs greatly among the three cases. This study concludes that in order to improve the effectiveness of energy saving interventions, the motives, intentions and living habits of residents need to be given more consideration when designing and implementing retrofitting. By highlighting the importance of public participation this paper contributes to energy saving policy development in China.

1. Introduction

Parallel to rapid economic growth and an increase in living standards, energy use in China has increased steadily from 0.59 billion tons of standard coal equivalents in 1980 to 2.92 billion tons in 2009, an average annual increase of 5.7% [1]. Building energy consumption accounted for 27.5% of the total final energy consumption in 2011 [2]. Yao et al. [3] estimated that this ratio will increase to 35% in 2020. The Building Sector is and will continue to be a major energy end-user in the years ahead [4]. Two factors contribute to the large amount of energy use in buildings: large building area and low energy efficiency in buildings (particularly, residential buildings). The majority of residential buildings in urban China – and particularly those built before 2000 – are low-energy-efficient buildings [5], indicating ample room for energy savings initiatives. In northern China, the heat loss from external walls is three to five times higher and from windows two times higher than that of similar buildings in other northern hemisphere countries [6]. Energy use practices in China also demonstrate considerable inefficiencies. An empirical study has shown that heat loss due to the opening of windows, a common form of wasting energy, was responsible for 25.8% of the total residential heat supply in China [7].

The total gross floor area in China is 43 billion m^2, and it is still increasing rapidly. Of the existing residential building floor area of 5.45 billion m^2 in northern China, 4.16 billion m^2 was energy inefficient, and 3.56 billion m^2 used low energy efficient district

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heating systems [8]. The growing residential floor area and the energy inefficiency in existing residential buildings increase the need to retrofit buildings in northern China. From 2007 onwards, the Chinese government has promoted and subsidized the energy efficiency retrofitting of existing urban residential buildings. These buildings consist mostly of multi-store apartment blocks. Enhancing the energy efficiency of buildings has also been an integral part of the Low Carbon City policy objectives and measures [9,10].

Retrofitting projects have traditionally been implemented through a rather conventional (for China) top-down policy procedure with governments of various levels playing a dominant role and using large governmental subsidies [11,2]. However, research has shown that resident participation is important for the energy performance of retrofitted buildings [12,13,14,15]. Building renovation and renewal depend on the degree of participation, cooperation and mobilization of the involved actors to attain a common goal through coordinated action. Cirman et al. [16], in their study on Slovenian households, discovered that residents' positive attitudes and their ability to reach an agreement to collective action were particularly important for successful renovation of multi-dwelling buildings. Valciukas [17] compared the implementation of multi-family housing renovations in Stockholm and Vilnius and found that the main obstacle for energy saving renovation was a lack of precise, reliable and verified resident information. McEwen [18] explored six residential energy upgrading programs in five regions in the USA, and concluded that community engagement contributed to the cost-effectiveness, sustenance and growth of upgrading programs. Residents' participation is usually associated with so-called bottom-up approaches and 'grassroots' development [19,20]. While resident participation is important for the effectiveness of energy saving retrofitting, in the context of a top-down policy implementation approach in a place like China, this element is often neglected. Previous research on residential energy use in China did not focus on the potential connection between residents' participation and energy efficiency. Several studies have assessed and evaluated Chinese refurbishment projects by focusing mainly on retrofitting patterns (e.g. [21], the technical measures that were applied and the retrofitted area [22,23,24].

This study attempts to fill this research gap by examining residents' participation in retrofitting residential buildings in China. This paper investigates residents' participation in energy saving retrofitting by analyzing three exemplary retrofitting projects in Beijing, assesses the contribution of participation to successful energy saving in these projects, and finally develops recommendations for future energy saving retrofitting of residential buildings in China.

2. Background of retrofitting existing residential buildings in China

In China, retrofitting existing residential buildings has become an important measure in increasing the energy efficiency of buildings. The central government decided to retrofit 0.15 billion m^2 of existing residential buildings in China's northern heating region (covering 15 provinces, i.e., Tianjin, Henan, Liaoning, Jilin, Shanxi, Ningxia, Shaanxi, Gansu, Qinghai, Xinjiang, Heilongjiang, Inner Mongolia, Shandong, and Hebei) in the 11th Five-Year Plan (which was implemented from 2006 to 2010) [21]. By the end of October 2010, approximately 0.19 billion m^2 of existing residential building floor area in northern China had been retrofitted, which exceeded the target set in the 11th Five-Year Plan. However, the retrofitted residential building floor area only made up 4.6% of the total building floor area that is in need for retrofitting [22]. From 2007 to early 2012, the Chinese central government allocated 18 billion Yuan to support retrofitting of existing residences in the northern heating zone of China [24]. The retrofitted residential building floor area increased to 0.31 billion m^2 by March 2012, leading to an average energy saving of the equivalent of ten kilogram coal per square meter and an increased indoor temperature of three to six degrees[1]. Retrofitting residential buildings in the northern heating region has remained a key energy efficiency project of the Chinese government in the 12th Five-Year Plan (2011–2015). It is expected that China will complete the 12th Five Year Plan task of retrofitting 0.4 billion m^2 residential building floor area by the end of 2015 [5].

Retrofitting existing buildings is a complex engineering project, as it deals with technological, policy, funding, organizational and management challenges [21]. Retrofitting schemes mainly involve energy efficiency retrofits for building envelopes, the installation of energy efficient windows, retrofitting heat metering; and temperature regulation of heating systems. Almost every retrofit project inevitably includes building envelopes and the installation of energy efficient windows. Most residents have never used energy metering, and introducing energy metering is one of the central government's plans to motivate residents to save energy. In the start-up phase, the central government has provided a subsidy of 6 yuan/m^2 to provincial finance departments for the installation of local heat metering devices. However, apartment-based heat metering has not been applied in all retrofitting projects. Additionally, retrofitting the temperature regulations of the heating system is not always included in retrofitting projects. For example, by the end of 2008, the retrofitted area in China reached 71.48 million m^2, of which only 15.47 million m^2 (or 22%) was retrofitted with both heat metering and heating system temperature regulation [25].

3. Analytical framework and methodology

The analytical framework for studying the participation of residents in retrofitting residential buildings in China consists of three key elements: the actors involved, the distinct type of retrofitting projects, and the different phases of retrofitting.

Agencies and residents are key actors involved in retrofitting. Public and private retrofitting agencies (governments and firms) include not only central and local government authorities, heating supply firms, property firms, house owners, and energy saving service firms, but also planning and design firms, material and equipment suppliers, construction firms, and supervisory and property management agencies [22]. Besides these agencies, residents (individuals) are also important actors in retrofitting. Some scholars argue that bottom-up processes and 'grassroots innovations' with intensive resident participation are key factors to ensure successful retrofitting of residential building projects (e.g. [26]. Education strategies that provide energy tips, information, and factual knowledge, and relevant social interaction in social networks of residents have been acknowledged as playing an important roles in determining household energy use behavior [27,28]. When households do not know, understand or accept advanced energy saving technologies related to retrofitting, implementing such energy efficient technologies can only provide sub-optimal results [29,30].

Retrofitting residential buildings has taken place for several years in China, and three distinct retrofitting models have emerged and spread widely. These models include: (1) the central government-led model, (2) the local government-led model, and (3) the combined retrofit-and-renewal model. The central government-

[1] Data source: http://www.mohurd.gov.cn/zxydt/201203/t20120321_209186.html.