Renewable and Sustainable Energy Reviews 47 (2015) 1–13

Contents lists available at ScienceDirect

Renewable and Sustainable Energy Reviews

journal homepage: www.elsevier.com/locate/rser

Green real estate development in China: State of art and prospect agenda—A review

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ARTICLE INFO

Article history:
Received 8 September 2014
Received in revised form
25 January 2015
Accepted 1 March 2015

Keywords:
Green real estate development
Sustainability
Stakeholder
Research review

ABSTRACT

Green real estate development is one of measures being implemented to reduce negative impacts of the building industry on the environment, society, and economy. However, there is lack of a systematic review of this large number of studies that is critical for the future endeavor. This paper reviews the existing body of knowledge related to green development. At first, the common research themes on green real estate development were identified, including concept, measure, business, and result. Then, the connotation and denotation of green real estate development was introduced in four dimensions. Third, the stakeholders of green real estate development and its benefits and costs were expatiated. Then, how to realize the green real estate development and its current weakness were analyzed in various aspects. It is found that the existing studies mainly focus on the environmental aspect of green building, other dimensions of sustainability of green building, especially the social sustainability is largely overlooked. Future research opportunities were identified such as the innovation of evaluation systems, integration of planning and design frameworks, management mechanisms and financing modes, and future proofing.

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http://dx.doi.org/10.1016/j.rser.2015.03.012
1364-0321/

1. Introduction

The real estate and building industry has a significant impact on society in many aspects, including the environment and the economy [1]. It plays an important role in urbanization by providing buildings and facilities to satisfy human requirements and employment opportunities directly or indirectly in related industries [2]. In addition, the importance of the real estate and construction industry is related to both its size and its role in economic and social development [3]. Indeed, it makes a great contribution to national economic development. For instance, the construction industry contributed 6.86% to China's GDP in 2013 [4]. The industry also consumes a large quantity of raw materials, social resources and human resources [5], with the construction of buildings, for example, one of its main products, consuming 40% of the stone, sand and gravel, 25% of the timber and 16% of the water in the world every year [6]. A great deal of Greenhouse Gas (GHG) is also produced in the process of construction—in the manufacture and transporting of building materials for example.

Many forms of resources (power, fuel, water, etc.) are also consumed in the post-occupancy phase. As Zhang et al. indicate the use of buildings account for approximately 38.5% of all U.S. carbon dioxide emissions, of which 21% and 17.5% are from non-commercial and commercial buildings, respectively [7]. The carbon emissions of buildings all over the world are forecasted to reach 42.4 billion tons by 2035, an increase of 43% on 2007 [8]. In short, buildings are one of the major sources of GHG and have an acknowledged important impact on climate change. Green buildings (GBs), on the other hand, aim to minimize their impact on the environment by promoting life cycle considerations during their planning and development process while enhancing the health of occupants and return on investment to developers and the local community [9]. Hence, GB is an inevitable choice to meet the need for environmental protection and sustainable development.

Dating back to 1960s, it was initially put forward as "Arology" in 1960s by Paolo Soleri, an architect combining ecology and architecture [10]. Since then, many developed countries (e.g., USA, Canada, Germany and France) have been working on the green building development. Generally speaking, they are in the frontiers for going green as they have designed a set of institutional norm and improved the green building evaluation standard (e.g., LEED) by relying on the industry and technology advantages.

For example, the EU approved the Energy Performance of Building Directive (EPBD) in 2002 to strengthen control over the total energy consumption of buildings. In 2007, EPBD adopted a regulation that forces building purchasers and tenants to provide energy performance certificates (EPCs) in the building sale or rental process [11]. In USA, buildings consume approximately 40% of all energy, 72% of all electricity and produce 39% of primary greenhouse gas emissions. In this context, the US Department of energy has put forward the *Building Energy Efficiency & Technology Improvement Act* which aims to define how to make it energy saving by technical details and promote the buildings labeled with "Energy Star" in a nation-wide scale. It is estimated that through all its partnership programs, US consumers will save nearly 50 billion kilowatt-hours of energy over the next 10 years, which translates to a net savings of $3 billion a year [12]. Also, the U.S. Green Building Council (USGBC) became one of the front runners when it launched the Leadership in Energy and Environmental Design (LEED) guidelines in 2000. Several other green building evaluation systems are in various stages of development in North Europe, UK (BREEAM) and Japan (CASBEE), and are enjoying different levels of market impact in their respective countries. In Japan, the CASBEE (Comprehensive Assessment System for Building Environmental Efficiency) was developed in Japan, beginning in 2001. The U. K. announced in December 2006 that it would realize its nearly-zero-energy building target on all new homes in the country by 2016 [13].

Comparing with these developing countries, the green building development in the developed countries is lagging behind as they usually face with challenges such as 'lack of R&D development funds', 'outdated technologies' and so on. In Asian countries, for example, according to a survey, an investment of about $ 50 billion a year by Asian Countries to achieve the target that the clean energy accounting for 20% of total energy supply by 2020 [14]. At the same time, the investment about $ 10 billion each year needs to be input in order to achieve the 2015 target (80 gigawatts as the new energy generation capacity) in developing countries. Hence, the lack of funds becomes a major obstacle for developing countries in the development of new green building technologies. The R&D on low-carbon technologies requires a lot of financial support, and this is a huge amount of money for developing countries.

Over the years, many developing countries, especially low-income developing countries, have invested the majority of its revenue in the infrastructure construction and labor-intensive industries, which leads to a relatively small investment in green technology R&D. Also, the education is relatively underdeveloped which further lead to the lack of R&D experts. In this context, the developing countries introduced many high cost low-carbon technologies from those developed countries. However, the introduced R&D could not be fully undertaken due to a serious lack of research capacity in most of the developing countries. China is one of the examples.

Green real estate development, strongly advocated by government in China, is a new form of development combining ecology concept with real estate. Due to the double pressures of environmental protection and economic growth, green real estate development is now considered a necessary form of contemporary development, in particular, for real estate industry. Green building (GB) is the main product of the green property concept, but green property is not solely concerned with superimposed technologies and their associated costs [15,10]. While GB is mainly focused on building design and methods of construction, green real estate development also encompasses sustainable landscape design, innovative GB materials, building operation and maintenance [16]. Compared with GB, the concept of green real estate development covers a wider range of activities, involving land sites' planning, project planning, materials and technology design, construction, operation, maintenance, demolition, etc. Although it is a relatively new concept, green real estate development has been well known as a thrilling new way to make property healthy and energy-efficient, with better indoor air quality, lighting and temperature controls. It particularly emphasizes all the links between green processes in the whole building life cycle. Green real estate development involves complicated system engineering that aims to achieve a social, economic and environmental win–win situation. Important