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Practice of low-carbon city in China: The status quo and prospect

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Abstract

It is vital to construct low-carbon city in China in order to mitigate the huge cost of climate change especially when considering the great contribution of cities to the national greenhouse gas emissions. Many Chinese cities have made efforts in construction of low-carbon city in recent years from various aspects. The low-carbon practice in Chinese cities was reviewed in this paper, including setting up urban low-carbon development planning, establishing low-carbon demonstrative areas, focusing on such specific fields as sustainable energy system, ecological industry, green transportation, and green building. The effect of the low-carbon practice was also evaluated and certain issues requiring further concerns were discussed. It is expected that the discussion in this paper is helpful for promoting the construction of low-carbon city in China.

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1 Introduction

The report of UN Habitat claims that climate change is “an outcome of human-induced driving forces”, with immeasurable unfavorable consequences for planet and human settlements [1]. According to “Stern Review: The Economics of Climate Change”, the overall costs and risks of climate change will be equivalent to losing at least 5% of annual global GDP, and could rise to 20% of global GDP or more if a wider range of risks and impacts is included [2, 3]. As home to >50% of the World population, cities

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consume 67% of the energy in the world and cause more than 70% of global CO₂ emissions [4]. Under such condition, the vulnerability of cities to climate change will be increased by the limitations on governance and planning especially in developing countries [1]. Undoubtedly, developing low-carbon cities is a feasible and sustainable way which emphasizes the climate change challenge and decouples economic growth from fossil fuel use [5].

China, as the largest carbon emitters in the world since 2006 [6], faces more urgent situation to develop low-carbon cities, for 86% of the energy-related CO₂ emissions comes from the cities [4] and the carbon density per urban areas increases with the rapid urbanization [7]. In fact, China has actively adapted to climate change and made great efforts to construct low-carbon cities. In January 2008, the Ministry of Housing and Urban-Rural Development and World Wildlife Fund jointly launched the demonstration project of low-carbon city when Baoding and Shanghai were selected as the pilot areas, which is regarded as the formal start of construction of low-carbon city in China [8]. Subsequently, the first pilot project of low-carbon city and province (LCCP) was launched by the National Development and Reform Commission in August 2010, when five provinces and eight cities were selected as the cases [9]. Since then, more and more Chinese cities such as Guangzhou, Fuzhou, Nanjing, Dalian, and Ji'nan actively jointed and conducted low-carbon practice from different aspects [10, 11]. And in December 2012, the Ministry of Housing and Urban-Rural Development announced the second pilot project of LCCP where more detailed targets, task, and requirements were proposed based on the specific local situations [12].

Although a series of practice has been taken for construction of low-carbon city in China, there is still a long way to go to mitigate climate change. On 30th June 2015, China launched a series of actions in INDC (Intended Nationally Determined Contributions), e.g., achieving the peaking of CO₂ emission before 2030, and reducing 60–65% of emission intensity (CO₂ emission per unit of GDP) from the 2005 level [13], which puts forward higher requirements for low-carbon city construction. It is necessary to review the practice of low-carbon city construction to further move forward its process.

2 Practice of Low-carbon City in China

Many Chinese cities have made their efforts to construct low-carbon cities. As shown in Fig. 1, the pilot project of LCCP has covered most of regions in China, except for Hunan, Ningxia, Tibet, and Qinghai provinces. Totally, 6 provinces and 36 cities in China are selected as the pilot areas of low-carbon construction, i.e., most provinces have at least one pilot city [12]. It is found that the first group of LCCP mainly locates in the east of the “Heihe-Tengchong Line” [14], where took up 80% of the total population with only 25% of the total area in China in 2008 [15]. Among the first 13 pilot cities and provinces, five low-carbon provinces accounted for 38% of the total number. However, there was only one low-carbon province (Hainan) in the second 29 pilot cities and provinces. Moreover, there appeared more pilot cities in the northwest (e.g., Urumqi) and northeast (e.g., The Greater Higgan Range) of China. Additionally, there was some overlapping area between the first and second group, e.g., Guangzhou in the second group of pilot cities locates in Guangdong, one of the first group of low-carbon provinces. It is estimated that the 36 pilot cities account for 33% of the national GDP and 18.5% of total population in 2011 [16, 17]. It is undoubtedly believed that construction of low-carbon city in these pilot areas will greatly prompt Chinese low-carbon development.

Besides these pilot cities, a number of Chinese cities have also taken construction of low-carbon city into practice with different focuses. Some cities set up the overall low-carbon targets and planning, some conduct the low-carbon management, some establish the low-carbon demonstrative areas, and some pay attention to specific fields including sustainable energy, ecological industry, green transportation, green building, and low-carbon life.

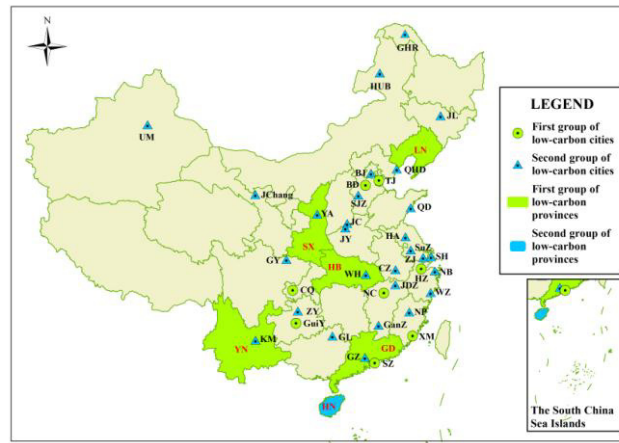


Fig. 1. Distribution of pilot low-carbon cities and provinces in China (BD: Baoding, BJ: Beijing, CZ: Chizhou, GHR: The Greater Higgan Range, GanZ: Ganzhou, GD: Guangdong, GY: Guangyuan, GZ: Guangzhou Province, GuiY: Guiyang, GL: Guilin, HN: Hainan Pro., HZ: Hangzhou, HUM: Hulun Buir, HB: Hubei Province, HA: Huai'an, JL: Jilin, JY: Ji yuan, JChang: Jinchang, JC: Jincheng, JDZ: Jingdezhen, KM: Kunming, LN: Liaoning Province, NC: Nanchang, NP: Nanping, NB: Ningbo, QHD: Qinhuangdao, QD: Qingdao, XM: Xiamen, SX: Shanxi Province, SH: Shanghai, SZ: Shenzhen, SJZ: Shijiazhuang, SZ: Suzhou, TJ: Tianjin, WZ: Wenzhou, UM: Urumqi, WH: Wuhan, YA: Yan'an, YN: Yunnan Province, ZJ: Zhejiang, CQ: Chongqing, ZY: Zunyi)

2.1 Low-carbon targets and planning

Among the 36 low-carbon pilot cities, 30 have released the targeted carbon discharge peak time, 35 have set up target about proportion of non-fossil fuels in primary energy consumption and all have promised forest coverage rate [17]. Most low-carbon cities have stricter reduction ratio of carbon emission intensity than the national lower range value of 40%, while about two-thirds of cities set higher target than the upper range value 45% [17].

Different LCCP must find distinctive development model based on regional resource endowment, social condition and environmental carrying capacity [18]. As the first Chinese city entitled as low-carbon city in 2008, Baoding put forward a series of key projects to construct low-carbon city, including Electricity Valley of China, Solar Energy City, low-carbon official building, low-carbon community, low-carbon transportation system, and improvement of urban environment [19]. Hangzhou drew up fifty policies to construct low-carbon city where low-carbon economy, low-carbon building, low-carbon transportation, low-carbon living, low-carbon environment, and low-carbon society were confirmed as six important ways [8]. Wuxi finished the planning of low-carbon city development strategy, which was regarded as the first acknowledged low-carbon city planning in China.

2.2 Low carbon management

The system of low-carbon management is gradually established. The first group of LCCP have accomplished 2005 and 2010 greenhouse gas emission inventories [20]. By 2015, of the 42 pilot provinces and cities, 36 have built up mechanism of decomposing and assessing carbon emission

reduction target [21]. Additionally, city-level low-carbon management also includes legislation related to climate change, greenhouse gas accounting and reporting [22]. Meanwhile, low-carbon pilot cities and provinces are expected to achieve low-carbon development by means of market mechanism. Seven cities and provinces (Beijing, Tianjin, Shanghai, Chongqing, Guangdong, Hubei and Shenzhen) are carrying out the pilot carbon emission trading [23]. As the first pioneer in China, Shenzhen innovatively includes public transport sector into the carbon emission trading system and regulates direct and indirect emissions from all industrial sectors [24]. Guangdong first hold a carbon auction for permit quotas [23]. Besides explaining how to allocate carbon emission targets, all pilot areas are required to establish a dedicate fund to support trading market [25].

2.3 Low-carbon demonstrative areas

Tianjin was the demonstrative area of low-carbon economy cooperated by Chinese and Japanese cities [19], in which new energy, green building, and green transportation will be mainly developed [26]. The Chongming Dongtan Eco-city in Shanghai was fully designed from urban planning, sustainable energy, green building, and green transportation, which was hopeful to become the first carbon-neutral area in the world. Other cities also established the low-carbon demonstrative area, such as Qingbaijiang District in Chengdu, Wuxi Taihu New Town, and Kunming Chenggong New District [27].

2.4 Sustainable energy system

In order to establish Electricity Valley, six industrial systems including optic-electricity, wind power, electricity saving, electricity storage, trans-electricity, and power automation were formed in Baoding [8]. In Jilin, exploitation of new energy was confirmed as a long-term strategy [28]. It was predicted that energy consumption and carbon emission per unit GDP in 2020 will reduce about 50% compared to that in 2005, and zero-carbon energy consumption will account for 20% of the total energy consumption [8].

2.5 Ecological industry

Zhuhai regulated its industrial structure to strengthen the high-end service industry, advanced manufacturing industry, and high-tech industry. Wuxi has become the biggest production and export base of photovoltaic industry in China, where many manufacturers and related industries were clustered [28]. Hangzhou released development planning of strategic emerging industries and highlighted the importance of R&D investment, cleaner production and circular economy [30]. Chongqing built low-carbon industrial zones in Liangjiang new area, Fuling and Wanzhou district [31].

2.6 Green Transportation

Green commuting was first put forward in Hangzhou, and the public transportation will be developed with priority. It is planned that a big public transportation system will be constructed including subway, bus, taxi, public bicycle, and water bus [8, 28]. Such cities as Tianjin, Chongqing and Shenzhen pay attention to non-motorized transportation, i.e., non-motorized ways (e.g., walking, bicycle and bus) will become the main components of urban transportation. In terms of new energy automobile industry, Xiamen raised to accelerate the R&D process while Nanchang developed related industry chain [30].

2.7 Green building

All LCCP raised the idea of energy-saving renovation towards existing buildings, which mainly focuses on large-scale public buildings (e.g., government, school and hotel) [31]. In Wuxi, the green building was greatly promoted by multiple supporting policies, energy saving technologies, and projects [28]. In Tianjin, it takes green buildings as the basic unit to build low-carbon parks and low-carbon communities and sets evaluation standards of green construction based on this basic unit. It refers to multiple international standards which is more stringent than the national standard [31].

2.8 Low-carbon life

The National Development and Reform Commission released the guideline on construction of low-carbon pilot community in 2015, which emphasizes low-carbon life for urban newly-built community, urban existing community and rural community from aspects of low-carbon culture, low-carbon consumption and low-carbon interior decoration [32]. For the low-carbon consumption, Guangdong and Chongqing implemented low-carbon product certification trials. In order to improve the public participation of low-carbon life, China News Agency held a photography exhibition – “Low-carbon Development and Green Life” [33].

3 Effect of Low-carbon City Construction in China

After making a series of efforts to construct low-carbon cities, it is necessary to evaluate the actual effect of low-carbon construction.

3.1 Evaluation index system of low-carbon city in China

Most of studies select indices of economy, society, resource, environment, life, and technology to form the evaluation index system of low-carbon city in China [34]. For instance, Chatham House and Chinese Academy of Social Sciences developed 12 indicators to assess low-carbon development from aspects of low-carbon productivity, low-carbon consumption, low-carbon resources, and low-carbon policy [35]. Zhou built 20 low-carbon city evaluation indicators from economic development, residential lives, structure and efficiency of resources and low-carbon environment [36]. And other similar index systems were also established based on the driving force-pressure-state-impact-response (DPSIR) model [37-39].

In addition, Yang et al. established a three-layer low-carbon city evaluation index system and calculated a comprehensive score for Beijing's low-carbon city development in 2009 [40]. Similarly, Fu et al. [41], Zn [42] and Hua and Ren [43] also established a three-layer low-carbon city evaluation index system. For instance, Fu et al. chose economy, society and environment as the first-layer three indices, and further divided them into eight second-layer indices (economic structure, resources utilization, technology research and development investment, low-carbon consumption, quality of life, public transportation, carbon sink, and low-carbon buildings), and finally considered 23 third-layer indices.

3.2 Evaluation results of low-carbon city in China

Referring to the low-carbon standard issued by Chinese Academy of Social Sciences, Jilin city - the first demonstrative city of low carbon economy selected by the National Development and Reform Commission -, is still on the way and much further efforts is necessary. It was found that Shanghai performs relatively well in economic development and industrial structure but weak in energy consumption and environmental quality. Wang et al. found that the low-carbon development level in Beijing increased gradually during 2000–2008 and there is more development potential in the future.

Based on a comprehensive evaluation model of urban low-carbon development level, 12 assessed Chinese cities were classified into different development levels during 2005–2009, i.e., Shenzhen, Beijing, Guangzhou, and Shanghai ranked in the first with relatively high low-carbon development level; Chongqing, Kunming, Suzhou, and Baoding ranked in the third with relatively low low-carbon development level; and Zhuhai, Qingdao, Hangzhou, and Tianjin ranked in the middle [3]. No matter ranking at which low-carbon development level, each city performs relatively weak in certain aspects including economic development and social progress, energy structure and usage efficiency, living consumption, and development surroundings.

In summary, there is still a long way to go for low-carbon city construction in China. To achieve better effects in the future, we need to think about certain essential issues which should be paid attention to in the future.

4 Discussion and Conclusions

In order to mitigate the huge cost and risk of climate change, the construction of low-carbon city is urgent in China. Many Chinese cities have made their efforts to construct low-carbon city from different aspects, e.g., establishing the overall low-carbon city planning, constructing the low-carbon demonstrative area, and implementing measures in specific fields. However, more efforts are required to achieve the low-carbon development objective. And certain issues need to be concerned in the future.

Firstly, it is difficult to realize the low-carbon objective in a short period. On the contrary, the construction of low-carbon city is a time-consuming project, which was also stated in the UK's energy white paper as "because energy requires very long-term investment, we look ahead to 2050 to set the overall context" [3]. Therefore, the long-term low-carbon planning should be established and implemented continuously although the governmental managers may change during the long period. The selection of excellent low-carbon cities (or other similar titles) should not be held very frequently, when the final objective of selection is to lead more and more cities to construct low-carbon cities with systematic viewpoints and enough patience.

Secondly, construction of low-carbon city should be differentiated among cities which was also mentioned in the second pilot project of LCCP [12]. During the construction, such factors for the specific city need to be considered as natural condition, economic development, urban development orientation, industrial structure, and social culture. For example, it is possible for cities with abundant sunlight to develop solar energy largely, which is maybe unsuitable for those without good endowment. Taking our previous study [3] as an example, Shanghai should pay more attention to improving its environmental quality (e.g., increase carbon sink), Zhuhai need to regulate the pattern of living consumption, and Baoding should take economic development as the key objective.

Thirdly, it should also be fully realized that construction of low-carbon city is a systemic project. Because city is a complex system composed of many reactive components, construction of low-carbon city needs to consider various correlated factors such as economy, industry, energy, transportation, environment, management, technology, and rule, etc. Thus, multiple experts in these fields are encouraged to collaborate with each other to draw up a feasible blueprint of low-carbon city construction.

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