Strategy and Practice of Low Carbon Urbanization in China

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Abstract. The rapid development of China's economy in the past 35 years is essentially the rapid development of urbanization, which has not only raised the economic level, but also brought huge environmental risks. It is estimated that the urbanization in China will last for another 20 years. How to minimize the impact of the economic growth on the environment is a severe challenge for the development of China. This paper expounds the urgency and necessity of developing low-carbon cities in China, and illustrate the feasibility through examples.

1. Introduction
On December 12, 2015, the 21st United Nations Climate Change Conference (UNCCC) has reached “Paris Agreement”, marking the beginning of a new global climate order. “Paris Agreement” sets a long-term goal, which is to keep a global temperature rise this century well below 2 degrees Celsius above pre-industrial levels and to pursue efforts to limit the temperature increase even further to 1.5 degrees Celsius.

In 2015, the Chinese government stated the national response to the threat of climate change, aiming to reach its carbon emission peak as soon as possible, to reduce its carbon emission per unit of GDP by 60-65% below 2005 levels by 2030, to raise the non-fossil energy consumption ratio to 20% by 2030, and to increase the forest stock volume by 4.5 billion m$^3$ above 2005 levels by 2030[1]. In addition, Chinese government will impose stricter limits on greenhouse gases emissions in the next five-year plan. China is becoming a major force in tackling climate change [1].

However, China is still a developing country and in the process of "urbanization". How to solve the contradiction between the urban development and energy conservation and emission reduction is a difficult problem for Chinese policy makers. China’s leaders have proposed a path of "new-type urbanization" to guide urban development to a low-carbon mode, which is the most efficient and environmentally-friendly way for China’s economy [2].

2. The course of Chinese urbanization
In the past 35 years, China has experienced an unprecedented urbanization process in human history. In 1980, at the beginning of the reforming and opening, there were only 15 megacities in China with more than one million people [3]. In 1990, it reached 31, and in 2017, it reached 89. In 2012, China became the second largest economy in the world after the United States, with a national urbanization level of 52.6%, which reached the medium level of the developing countries.

Chinese urbanization process is unprecedented in human history both in scale and speed. The UK has experienced 120 years with urbanization rate from 20% to 40%, France experienced 100 years,
Germany experienced 80 years, and the United States experienced 40 years, while China has only used 22 years (1981 ~ 2003) [4].

![Figure 1. How long the urbanization rate of major countries has increased from 20% to 40%](image1)

The process of “high-speed urbanization” in China is essentially the expansion of China’s urban construction land. In the past 35 years, China has implemented the “urban priority policy”. Urbanization and industrialization have become the top priority of development, and the “urbanization” promoted “industrialization”. The government attracted a large amount of capital for real estate construction by the auction of urban land. Real estate construction brought the development of the iron and steel, nonferrous metal, cement, glass, plastic and other related industries. At the same time, the government used the auction income to introduce the foreign advanced technology, equipment and management experience. Meanwhile, the "urban priority policy" has moved a large number of agricultural people to cities, and the expansion of urban population has driven the development of the service industry and promoted employment and consumption [5-6].

But the rapidly expanding urbanization process consumed a lot of energy and resources, causing serious pollution, and China has also paid a high environmental cost [7].

![Figure 2. China's energy consumption distribution in 2016](image2)
3. The low carbon city for the future

3.1 Challenges

It is estimated that China's urbanization will last about 20 years, if 80% of the urbanization rate will has been completed. So China's urbanization will face many challenges in the future.

First, China is a relatively resource-poor country. China's most abundant coal reserves are only 55% of the world's average, while the per capita oil and gas reserves are only 7.4% and 6% of the world average respectively [8].

Second, China has overtaken the United States as the world’s largest emitter of greenhouse gases. The data shows that the average annual growth rate of carbon emissions in the United States is about 1%, and the emissions from Germany and Russia have decreased to negative growth, while China is still 4.7%.

At last, the urbanization mode of China is related to the energy security. It was estimated that the energy consumption ratio of buildings, industry and transportation is about 28%, 35% and 34% in 2016, respectively. The urban construction accounted for about 60% of the total energy consumption. So China’s energy security is mainly determined to the urbanization mode [9].

3.2 Low carbon urbanization strategy

Faced this severe challenges, Chinese government has proposed to take a "new-type urbanization" path and build low-carbon and green eco-cities. In March 2014, the national new urbanization planning (2014-2020) pointed out that the basic principle of China's future urbanization is "ecological civilization, green low carbon ", that is combining the ecological civilization idea into the urbanization process, promoting green and low-carbon construction, saving the use of resources such as land, water and energy, strengthening environmental protection and ecological restoration, and reducing the interference and damage of urbanization on natural environment.

In August 2016, the “13th Five-year plan of Urban and Rural Housing Construction” pointed out that Chinese government will promote the construction of low-carbon ecological community and revise the planning and construction standards according to the low-carbon ecological concept, promote green buildings, green transportation, green infrastructure and ecological district, encourage the exploration of low-carbon ecological city planning and construction methods, timely summarize and promote the mature practice and applied technology.

4 Exploration and practice of low carbon city construction in China

4.1 Exploration of ultra-low energy buildings

With the promise of reducing carbon emissions, research institutes in China have been exploring "zero energy buildings" in recent years. In 2014, organized by the Ministry of Housing and Urban Rural Development of PRC, China Academy of Building Research implemented the research of “ultra-low energy passive green building ”, that is combining the ecological civilization idea into the urbanization process, promoting green and low-carbon construction, saving the use of resources such as land, water and energy, strengthening environmental protection and ecological restoration, and reducing the interference and damage of urbanization on natural environment.

In recent years, numbers of “zero carbon building” have been implemented in different climate zones in China. The first “zero carbon building” in China is the “London zero-carbon pavilion” at the Shanghai World Expo. Its prototype came from the UK’s zero-carbon community, the Beddington community. The London zero-carbon pavilion combined the local climate and the geographical environment of Shanghai with the local materials. The total construction area was 2,675m², consisting of two four floors buildings in the north and in the south respectively, which were connected by an overpass bridge. The London zero-carbon pavilion used solar energy driven liquid desiccant and absorption refrigeration system to dehumidify and cool down the indoor air. At the same time, the 22
flexible rotating air caps used wind energy to drive the indoor ventilation and heat recovery. The London zero-carbon pavilion also used the river water source heat pump system as the building power supply, and set up a cold radiation ceiling to provide visitors a comfortable indoor environment with a minimum energy consumption.

Figure 3. London zero-carbon pavilion at the Shanghai World Expo

The public exhibition center of Sino-Singapore Eco-City in Tianjin was the first “zero carbon building” in the cold area of China. The project was located in Sino-Singapore Eco-City, with a total construction area of 3,467 m², two floors above ground, one floor underground. The structural system was steel frame structure, the shape coefficient is 0.22, and the window to wall ratio is 0.2.

This project adopted the super-computer based energy simulation system to continuously optimize the architectural design scheme. During the design process, the design team minimized the energy demand of the building through “passive housing” technology, and improved the energy efficiency by using the “active housing” technology”. Specifically, the designers used ground source heat pump system to reduce the building demand for fossil fuels, and used the photovoltaic power generation system to produce energy to achieve zero energy consumption in one year.

Figure 4. Public housing exhibition center at Sino-Singapore Eco-city
4.2 Exploration of the positive climate community

The “Positive climate development plan” is the world’s leading cities and communities development project. It’s organized by C40 co-founded by the Clinton foundation and the United States green building council, aiming to create an economic development plan for cities and communities with negative emissions of greenhouse gases.

“Positive climate” means that construction projects should have a positive effect on urban climate change. First, minimize the energy consumption and carbon emissions of the project itself; second, help the surrounding areas reducing carbon emissions; last, attain the overall effect of “net negative emissions” after a period of operation. This is the meaning of “positive climate”.

The “new Shougang high-end industrial integrated service zone” is the first project joining the C40’s “positive climate development program”, and also 19th positive climate project in the world [10]. The project introduced best practice experiences of the international cities to cope with climate change, and worked with leading low-carbon cities in different countries to provide a template for Chinese urbanization. The specific ways of reach positive climate change include:

1) Advanced road transportation system

The park has built an advanced road network to encourage people to use the green vehicles. First of all, public transportation network consisted of a rapid transit backbone (bus rapid transit + rail rapid transit) and a conventional public transportation branches. This two networks were connected by a public transportation transfer hub. The project increased the density of the public transportation vehicles and adjusted the density and time of the vehicles according to the working hour schedule. It was unifiedly dispatched by the public transportation command center.

Secondly, the public rental bicycles were arranged in the rail way stations, bus stops, parks, leisure places and other public service facility areas, and the bicycle rental network were established. The size of the bicycle parking lot was set according to the requirements and needs to increase the frequency of use.

![Figure 5. Technical routes in Shougang positive climate project.](image)

Pedestrian network system was the last step, which consisted of the ground pavements, commercial pedestrian zones, underground commercial pedestrian streets, pedestrian corridors, and urban riverside landscape trails.
(2) Water eco-system
Firstly, through the construction of "sponge city", the project can effectively control rainwater runoff and realize natural accumulation, natural permeability and natural purification. "Sponge city" was conducive to the repair of urban water ecology. Secondly, using the principle of species symbiosis and material circulation regeneration, the self-cleaning ecological system of water dominated by artificial wetland was established.

(3) Green building energy systems
The buildings in the park use “passive house” technology to reduce energy consumption and meet green building standards. At the same time, renewable energy was fully used to supply energy for buildings, including solar water heater, solar photovoltaic power generation, ground source heat pump, sewage water source heat pump and biomass energy. In addition, regional energy centers were set up, using combined cooling heat power technology to supply the power and to improve the overall efficiency of the energy system.

(4) Resource utilization
Garbage green collection, garbage green transformation and waste recycling technology were used to reduce the volume and harm of the garbage. First, the garbage classification was strictly enforced. Secondly, food waste were transformed from biomass to energy through biotechnology, which can be used to generate electricity by means of advanced incineration technology, and the hazardous compounds can be treated harmlessly.

5. Conclusion
The rapid development of Chinese urbanization has not only promoted economic development, increased the living standards of people, but also brought great environment risks. In 2015, with the accession to the “Paris Agreement”, Chinese urbanization must be more energy-efficient and environment-friendly. On the one hand, China should minimize the carbon emissions of the new urban areas in the future. On the other hand, China should grasp the opportunity of urban development and renewal to promote the investment of low-carbon cities and the reform of urban management. Through the development of zero-energy buildings and positive climate community projects, China is striving for an earlier arrival of the carbon emissions peak. This is becoming the best way for Chinese urbanization.

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