

Carbon Neutrality Transformation of Chinese Cities

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Abstract. In the context of carbon neutrality, countries around the world are studying how cities transform to them. In recent years, China's research in the field of environmental protection has also developed rapidly and is currently at a leading level worldwide. The transformation of cities to carbon neutrality is also increasingly valued by the Chinese government. This paper mainly discusses how Chinese cities transform to low-carbon and carbon neutrality. Firstly, it was pointed out that in order to achieve this goal, it is necessary to first address the issue of energy transformation, carry out an energy supply revolution, and increase one's own energy advantages. Then it pointed out the role that big cities play in the transformation process. Taking developed country metropolises London, New York, and Guangzhou, China as examples, this paper analyzes their respective development methods, characteristics, and results. Then it gives specific measures for other cities in China in terms of transportation and ecological development, and also points out the path to achieve carbon neutrality in China. Finally, it also mentioned a technology to achieve carbon neutrality - carbon sequestration technology, and explained the corresponding measures from two aspects of plants and buildings in detail.

1 Introduction

After China's reform and opening up, its economy and population have developed rapidly, and the total number of cities has also continued to increase. As of 2023, China has 661 cities, of which nearly 2 have become large and mega cities, and the proportion of medium-sized cities is also increasing. Cities have a large population and provide over 70% of China's Gross Domestic Product (GDP). While achieving remarkable achievements, the large amount of greenhouse gas emissions in cities and the large amount of wastewater discharge from factories have also caused a series of environmental problems. As people's environmental awareness gradually increases, the Chinese government has also taken note of the environmental problems that exist in cities. In recent years, carbon neutrality has set off an academic wave worldwide. Many professors and experts have also turned their eyes to China, and the Chinese government has also noticed this. In this period, more and more people expect cities to be carbon neutrality, so the plan of cities to be carbon neutrality has been put on the agenda. This is necessary for several reasons [1].

Firstly, in previous years, China pursued economic growth and emphasized the importance of GDP, resulting in insufficient harmonious development between the economy and nature. People are almost entirely pursuing the economy without sacrificing other costs, resulting in a sharp reduction in green space and a severe ecological environment. Secondly, the economic development model of Chinese cities is relatively one-sided, with a

large amount of resources being exploited without treatment, and being used at once, resulting in serious waste. Industrial pollution only focuses on costs than consider environmental consequences. At the same time, the high cost of pollution discharge leads to people not treating pollution and worsening the environment. Only pursuing personal profit growth without considering environmental benefits. All of these have made the urban environment in China increasingly severe. A large number of haze and light pollution appear in major cities in China, making people sick. This high pollution and high emissions urban system is completely inconsistent with the current international environment, so the transformation of cities towards low-carbon emission reduction has become an inevitable choice.

2 The energy supply revolution needs to be implemented

Since human society entered the industrial civilization system, energy issues have been the core of social development, and fossil energy has become a long-term focus of attention around the world [2]. As one of the few energy producing countries in the world, China, like the United States, the European Union, South Africa, and other economies, has an energy supply system that integrates the comprehensive development of fossil energy, renewable energy, electricity, and other energy sources. However, at the same time, a series of situations such as excessive dependence on fossil energy, consumption of coal, and thermal power generation have

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gradually become an energy dilemma, which has become the same problem faced by China and most countries. In recent years, the Chinese government has also put forward the idea of "accelerating the energy supply revolution and strengthening international cooperation" at various forums and summits around the world. It can be seen that the Chinese government regards this as an energy strategic idea, indicating the direction for energy transformation and development.

Cities should accelerate the storage and development of renewable energy. Currently, China's structural pattern of excessive dependence on coal has many problems similar to economic and environmental issues. Vigorously developing renewable and clean energy, fully utilizing and storing them, can alleviate current environmental pressures, comply with China's low-carbon emissions and sustainable development strategy, and also enable them to remain invincible in the international energy market competition. Cities can accelerate the elimination of outdated coal-fired units, actively develop energy substitution, and accelerate energy development and conversion. This can weave a sophisticated energy supply network with good structure and high quality.

China should take the initiative in energy, reduce its dependence on other economies for energy, and develop exchanges and cooperation. China's energy demand is huge, and excessive energy demand leads to more energy emissions, which makes China suffer from some international public opinion and has a certain negative impact on the concept of achieving global carbon neutrality. At that time, some economies in developed countries would impose partial restrictions and sanctions on some aspects of China (mainly carbon emissions), which would affect or even terminate cooperation on most joint projects between the two sides. If China does not have its own domestic energy security supply at this time, the economic and ecological losses caused by this will be catastrophic for China itself and even the world, resulting in a series of incalculable consequences. Therefore, based on energy itself, establishment of energy supply network is a win-win solution to energy and environmental issues at this stage.

Each city should give play to its regional advantages, form an energy transportation network in all cities, "where there is a shortage to make up for where", and coordinate resources in different regions to achieve a balance [3]. China's energy resources are unevenly distributed in different regions. For example, the west of China has abundant wind and light resources, the north has land and wind resources, and the south has huge water resources. The economically developed southeast region and the

economically underdeveloped northwest region almost have completely different types of resources. Fossil fuels also have seasonal characteristics, which makes it necessary for Chinese cities to take advantage of the energy advantages of their surrounding areas, adapt measures to local conditions, and strive to maximize resource utilization. For the lack of energy, it is also necessary to have a huge transportation network between each other to ensure that energy can be transported to different cities, forming a complete transportation and storage system and complete the "double carbon" transformation as soon as possible.

3 Large cities should play a pioneering and exemplary role

After the "14th Five Year Plan" period in China, the construction of ecological civilization has been put on the agenda, and carbon reduction has become a key development direction. As a larger city, it should play a pioneering role in the transformation of cities to "dual carbon" [4].

2.1 Drawing on experience from other developed countries around the world

Throughout the world, most developed countries have a complete set of carbon neutrality paths in their international metropolises. London is steadily implementing a transportation carbon reduction plan [5] (See Figure 1). It has formed a parallel travel mode of "public transportation" and "slow traffic", encouraging goods to be transported by water, and increasing the proportion of water transportation. This would allow all vehicles in London to achieve zero emissions by 2050 [6]. New York implements a vehicle mileage management system to guide urban transportation towards a less emission and cleaner direction by controlling mileage [7]. At the same time, establish low emission areas, and strive to achieve less than 20% of traditional vehicle travel by 2050. The difference between China and developed countries is that China will achieve carbon neutrality in 2060 and reach a carbon peak in 2030 [8]. At the same time, China's energy demand is far greater than that of developed countries, which makes it impractical for China to directly and completely transform its industrial structure. As a "leading city", large cities should adapt to accelerating the pace of transformation during a period of steady development and transformation, avoiding the passive formation of a "carbon peak" in 2030 [9].

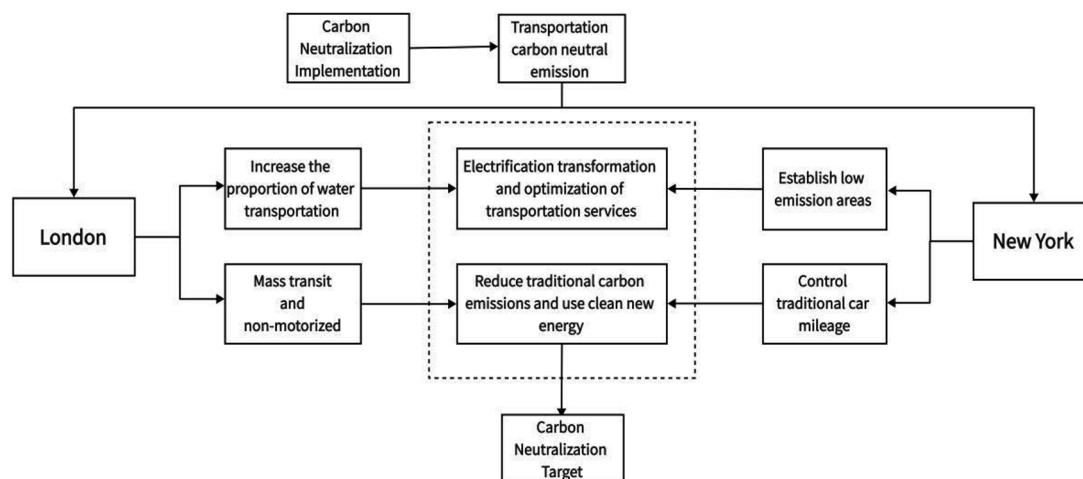


Fig. 1. The Development Model of London and New York (Picture credit:Original)

2.2 Taking the Guangdong Hong Kong Macao Greater Bay Area Guangzhou as an example

Currently, China is actively exploring a green transformation path for a large city that is suitable for China's national conditions. Taking Guangzhou as an example, as a first-tier city in China, it is located in the Greater Bay Area of Guangdong, Hong Kong, and Macao. In the field of ecological environment and technological innovation, these cities have coordinated to promote strategic transformation towards the "double carbon" direction, establishing a model for large cities. By developing low-carbon new facilities and combining them with the ongoing strategy of the Greater Bay Area of Guangdong, Hong Kong, and Macao, the weakness of the financial system can be made up [10]. At the same time, in the face of complex climate change, ecological environmental governance can be conducted and the construction of ecological civilization can be accelerated. In terms of technological innovation, high-end enterprise manufacturing industries such as GAC Aian and Mingyang Intelligent also exert their advantages in equipment, talent cultivation and manufacturing, and accelerate the promotion and application of green manufacturing. At the same time, these enterprises also participate in many social welfare activities, such as afforestation. Currently, it reduces carbon emissions by 17500 tons per year, while reducing a large amount of SO₂, NO_x, and dust emissions, which has good social and economic benefits. All the measures have enabled Guangdong to seize the opportunity of "double carbon", give full play to urban advantages, and establish a new situation of "green Guangdong" [11] (See Figure 2).

It can be seen that the "dual carbon" leadership of large cities has a positive radiation and driving effect on surrounding areas. Other cities should also have their own complete system for achieving "carbon peak" and "carbon neutrality". In the most critical aspect of transportation, the advanced experience of developed countries can be used for reference to establish carbon emission models for urban transportation. With the goal of net zero emissions

by 2060, the analysis is conducted in combination with electricity and new energy in the region's carbon consumption. At the same time, it encourages green travel, advocates chronic travel, and integrates development with technology [12]. In terms of ecological development, promote the optimization of spatial industrial structure and establish green and low-carbon advantageous industrial clusters. Fully enhance the enthusiasm of local government enterprises, enhance their green competitiveness, and accelerate the building of a green, low-carbon, ecological, and civilized economic system.

For China, promoting the green and low-carbon development of large cities with the goal of achieving "carbon peak" and "carbon neutrality" requires long-term efforts, steady development, and the establishment of medium - and long-term transportation emission reduction systems. On this basis, cities interact with each other, radiating and driving the development of the surrounding ecological economy, and finally achieving the low-carbon and carbon reduction goals throughout China, truly achieving the "double carbon" goal as soon as possible and achieving "carbon neutrality".

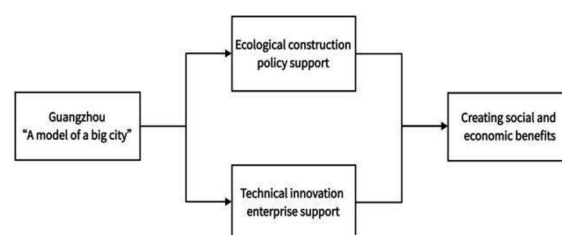


Fig. 2. The Development Model of Guangdong (Picture credit: Original)

3 Specific applications of carbon fixation, low-carbon, and emission reduction technologies

Carbon sequestration, broadly speaking, refers to the capture, absorption, and fixation of carbon containing compounds. Faced with a large amount of carbon

emissions in cities, if this technology can be fully used, it will greatly reduce pollution and protect the environment, which coincides with the concept of carbon neutrality. Even if modern technology cannot fully utilize it, it can still achieve the goal of low-carbon emission reduction in some aspects. Because carbon emissions and energy consumption are inevitable in people's production and life, especially in countries with high energy consumption and emissions, a large amount of production activities have disrupted the natural balance. Therefore, a series of decision-making measures such as artificial carbon sequestration and natural carbon sequestration have also entered people's attention.

The Chinese government proposed the concept of industrialization of carbon sequestration as early as the 12th Five Year Plan period, and has achieved good results in some farmland pilot projects in recent years. China's carbon sequestration technology is also a leader in the world. Until now, the Chinese government has also applied such technology to cities, helping cities transform into carbon neutrality.

3.1 Application of carbon sequestration technology in plants

Firstly, in terms of green plants, also known as green plant carbon sequestration technology [13]. The best organism currently mastered is algae. There are many types and quantities of algae, and the vast majority of photosynthesis on Earth is completed by algae. They can directly use solar energy to fix carbon dioxide, and can also directly convert the absorbed inorganic compound into environmental energy such as hydrogen. Algae have a short growth cycle, strong adaptability to the environment, small size, and are easy to plant and carry. Their respiration also produces almost no greenhouse gases. Therefore, using algae for carbon sequestration has also become the first choice for Chinese scientists.

At present, algae are widely used in residential areas and factories in the suburbs of cities, mainly in residential areas [14]. The combination of algae and other green plants in residential areas not only enhances the three-dimensional sense of greenery in these areas, but also effectively increases the green space area. In addition to extensively planting green plants and algae on the ground ponds in the area, additional greenery is also being planted on the roofs and walls of residential buildings. This is often referred to as a green residential area. The same is true in industry. This approach can effectively intercept rainwater and alleviate the urban heat island effect. At the same time, it is also playing a role in low-carbon emission reduction.

Green plants also play a role in carbon sequestration and emission reduction in other areas of the city. In parks, wetlands, trees, green spaces and other areas, planting green plants can effectively protect the local ecosystem, easily form plant community zones, enhance the diversity of animal and plant populations, and thus achieve long-term carbon sequestration.

3.2 Application of carbon sequestration technology in construction engineering

In terms of construction, the Chinese government is also using carbon sequestration technology on a large scale in cities, and currently has achieved the selection of materials and the treatment of construction waste [15]. In terms of materials, more light building materials such as fibers and wood are used to replace traditional heavy building materials such as bricks, iron, cement, and glass. Compared to light building materials, they emit lower greenhouse gases, making their impact on the climate less significant. Renewable energy sources such as wood can directly fix a large amount of carbon elements contained in them in construction projects. At the same time, fiber materials also play a role in enhancing fixation, preventing the oxidation and decomposition of materials over time to produce carbon dioxide gas.

On the one hand, the Chinese government vigorously develops its own urban carbon sequestration technology, and on the other hand, actively absorbs the excellent achievements of other countries, such as ecological glass from the United States, yeast building materials, ecological cement from Australia, and even some models that have not yet been fully developed. This has also led to an increasing coordination between building materials and the ecological environment, making China a major step towards low-carbon transformation.

Similarly, if there is construction, there will be residual waste. China is also constantly producing a large amount of construction waste. The waste often contains a large amount of carbon dioxide and methane. After the Chinese government noticed this phenomenon and with the efforts of the government and researchers, it has started to recycle construction waste. The use of waste not only beautifies the environment, but also sequesters a large amount of greenhouse gases in buildings. It is also a secondary application of carbon sequestration technology and has achieved significant results. In recent years, Chinese cities have also reduced greenhouse gas emissions by approximately 15 billion yuan through the utilization and treatment of construction waste. This shows the valuable value of carbon sequestration technology for the transformation of cities towards carbon neutrality.

4 Conclusion

There are great opportunities and advantages for Chinese cities to transform to carbon neutrality. All cities should have clear development goals, be good at absorbing and drawing on some advanced international concepts, and use them for their own purposes. At the same time, make good use of the advantages of one's own city, and reasonably and efficiently combine the strategic planning of low-carbon emissions and energy transformation with urban planning to connect them. Large city governments should also connect with enterprises and individuals to adjust the layout of urban industrial structure, optimize urban planning, and form a multi-functional urban structure, and respond to the strategic decision of the

Chinese government, promote the transformation of cities to low carbon emissions, and then radiate and drive the transformation of surrounding cities to carbon neutrality. Other cities, especially economically underdeveloped areas, should also plan and utilize urban functions reasonably, adjust industrial structures, shorten transportation distances, reduce energy consumption, and thus reduce carbon emissions. Only in this way can Chinese cities fundamentally transform to carbon neutrality and achieve sustainable development.

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