

The Paths and Enlightenment for Achieving Carbon Neutrality in China's Megacities

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Abstract: The climate change problem has gradually become the focus of people's attention. Climate change will lead to severe environmental issues, such as global warming and sea level rise. As a responsible country, China positively undertakes the responsibility to face current climate issues and comes up with feasible ideas to solve them. Consequently, China announces realizing carbon peak by 2030 and realizing carbon neutrality by 2060. Based on the rapid urbanization process, the emissions of cities are large, particularly in megacities. According to the research, construction, transportation, and energy fields contribute to higher carbon emissions in megacities. This paper employs a method of literature review and case study to analyze the path towards achieving carbon neutrality in China before 2060. Up to now, China's megacities have explored different paths to realize carbon emissions reduction in previous fields. Meanwhile, there are some experiences utilized by foreign megacities that are worth learning. In the future, China's megacities will find unique paths to realize carbon neutrality, such as regionally coordinated development.

Keywords: Carbon Neutrality, mega-cities, paths, environment.

1. Introduction

Since the beginning of the 20th century, countries all over the world have been facing severe climate change difficulties. Climate change will result in some abnormal phenomena like sea level rise, extreme weather events, global warming, etc. One of the primary causes of the aforementioned phenomena is the excessive emission of greenhouse gases. China is one of the most crucial economic entities in the world, and it ought to undertake the responsibility to face climate change. In order to solve this problem, China announces that it is realizing carbon peak by 2030 and carbon neutrality by 2060.

The urbanization process in China is currently advancing steadily now, and as a result, its cities' carbon emissions significantly contribute to climate challenges. For example, megacities in China like Beijing, Shanghai, and Shenzhen are all characterized by large population density, large economic volume, and other traits, which led to the carbon emissions of these cities being much higher than those of other cities. Consequently, solving the higher carbon emissions of megacities is an urgent difficulty in the process of carbon neutrality.

This paper mainly uses the literature review method to summarize the achieved outcomes of how to realize carbon neutrality in megacities. What's more, this paper will refer to several pieces of

literature about the outcomes of foreign megacities that could offer useful experiences for China's megacities. The main purpose of this paper is to generalize the methods and paths to achieving carbon neutrality which will serve as a reference for other cities.

2. Features of mega-cities

A megacity is defined as having a permanent population of over 10 million people. According to this criteria, the megacities in China overall are 10 cities, including Shanghai, Beijing, Shenzhen, Chongqing, and other 6 cities. These megacities have common characteristics: large population, well-developed infrastructure, developed economy, etc. Because of these characteristics, solving the higher emissions of megacities and realizing carbon neutrality is facing severe challenges. For example, complex and well-developed infrastructure necessitates the reconstruction and transformation of the urban system, which requires long-term planning, significant investment, and technological innovations [1]. Furthermore, a large population presents a variety of challenges. On the one hand, a large population will have an enormous impact on the urban transportation system. The rapid rotation of urban transportation is a constant source of carbon emissions. On the other hand, overconsumption of fuel energy also results from an enormous population. Based on current conditions, there is still a certain difficulty in largely transforming from fuel into clean and renewable energy. Traditional energy consumption will produce higher carbon emissions for the environment. To sum up, the several traits of megacities decide that the emissions of megacities are higher than other cities. Consequently, due to China's rapid urbanization process, it is key to explore how to realize the carbon neutrality of megacities in advance.

Megacities also have some active characteristics that benefit realizing carbon neutrality. These cities possess robust economic and scientific capabilities. What's more, the outcomes of megacities will provide successful experiences with other cities. Until now, China's megacities have given full play to their strong scientific base and leading role, attaining a certain development in realizing carbon neutrality. Take Shanghai as an example. Shanghai formed an intact nuclear power industry chain and established a variety of equity trading platforms [2].

In order to accomplish the goal of carbon neutrality by 2026, scholars have launched many studies to analyze current problems and actively propose particular methods and policies to face them. There are numerous studies that commonly show that we should pay more attention to the following aspects: promoting the development of low-carbon buildings, accelerating the shift of energy, establishing green transportation systems, and increasing carbon sinks. Until now, China's megacities have been gradually propelling the carbon reduction work. Moreover, these cities are actively exploring solutions that are tailored to their specific needs.

3. Discussion and suggestions

The exact data shows that the carbon emissions proportions of different fields in Beijing are as follows: construction, transportation, industry production, and agriculture are 50%, 28%, 21%, and 1%, respectively [3]. In Beijing, a well-developed and international city, the construction industry contributes the most carbon emissions to the environment. Subsequently, transportation and industry also make a significant difference to the environment. These fields also cause large carbon emissions in other China's megacities. So this paper will discuss how to realize carbon neutrality in construction, transportation, and the energy fields. What's more, this paper will introduce other paths to achieving carbon neutrality in megacities.

3.1. Construction

As for the carbon emissions of the construction industry, emissions can be divided into 2 types, including direct emissions and indirect emissions. Direct emissions mean that carbon emissions are caused by inherent activities of construction, including the design of building planning, engineering construction, demolition process, etc. Indirect emissions are carbon emissions caused by relative construction industries, like the emissions of building materials [4].

In order to promote low-carbon construction development, the construction industry should reduce direct emissions. In other words, it is necessary to reduce the reliance on fuel energy and improve energy efficiency during the holistic life cycle of construction. According to the calculation result, the building use and maintenance process contributes the largest carbon emissions to the environment among the whole phases, including the building material production stage, construction phase, building use and maintenance phase, and building demolition recycling treatment stage [5]. Consequently, it is important to strictly control the emissions caused by different stages, particularly in the use and maintenance stages. It necessitates that different engineering construction entities undertake their responsibilities, using green and low-carbon materials and cultivating the innovation of green construction techniques. In addition, it's crucial to develop comprehensive and stringent guidelines, guaranteeing that each phase meets the industry's requirements.

Apart from previous methods, it is also crucial to combine environment-friendly ideas into the holistic design of construction engineering. During the design process, designers should adhere to three key principles, including the principle of thrift, naturalness, and sustainability [6]. Designers should prioritize the use of materials that exhibit low-carbon performance and energy-saving properties, as this can significantly contribute to energy conservation. Because overusing electric energy is the barrier to realizing carbon neutrality. Take Tokyo as an example. In order to better regulate and control the carbon emissions of construction, Tokyo assesses buildings' energy saving, greening, and thermal insulation performance and establishes an architectural details database [7]. In the future, China's megacities should focus on many aspects like the use of materials, design ideas, and disclosure of low-carbon performance.

3.2. Transportation

A large population in megacities means that a city needs a well-developed transportation system to satisfy citizens' travel demands. Therefore, there is a common phenomenon that busy and crowded street conditions cause travel difficulties. Large vehicle numbers will produce severe carbon emissions. In order to realize the reduction of carbon emissions and realize carbon neutrality, feasible paths are as follows.

First of all, promoting the establishment of a rail transit system will effectively relieve the pressure of a city's transportation condition, which is capable of reducing using motor vehicles. Up to now, Beijing, Shanghai, Shenzhen, and other megacities have built relatively complicated and intact rail transit systems. The rail lines can connect the city center and suburbs, which makes people's commute more convenient. In addition, megacities still ought to formulate and establish a coordinating mechanism between rail transit and the city's development, so that promoting compact urban form. Next, the operation of new energy vehicles will accelerate the process of carbon neutrality. For instance, London gives electric vehicle consumers 6,000 pounds in subsidies [8]. This policy provides a useful experience for the government could adopt various policies to encourage people to consume new energy vehicles. Apart from policies, setting up charging stations as much as possible will benefit holders of new energy vehicles. Only by promoting the establishment of infrastructure and implementing policies at the same time can the public rapidly avoid depending on traditional energy vehicles and transform them into green travel. Third, several European and American countries

integrate their street spatial structure into urban planning. They gradually get rid of dependence on motor vehicles. Although China has emphasized improving spatial environment of streets, still existing the disadvantages of the slow system network still exist [9]. In the future, China should pay more attention to designing communal outdoor spaces to attract pedestrians.

3.3. Energy

Increasing demands for energy and the energy structure of mainly relying on coal lead to the difficulty of realizing carbon neutrality. Therefore, current circumstances necessitate an energy transition. China is actively exploring a variety of renewable energy sources to replace traditional and high-pollution fuel energy. For example, China is propelling the pluralism of renewable energy sources [10]. In the future, large-scale employing renewable energy in all kinds of infrastructure and fields will become a momentous direction of carbon neutrality process. Meanwhile, people should realize that replacing fuel energy with renewable energy is a long-term goal. The planner should put traditional energy into energy economy formulation to ensure the smooth transition from traditional energy to renewable power [11]. Moreover, it is important to continuously research and develop new techniques. CCS (Carbon Capture and Storage) and CCUS (Carbon Capture, Utilization, and Storage) can effectively realize the transition from traditional energy to renewable energy. China continues to face several challenges in the development of CCS technology. For example, the fiscal, taxation, and market-based incentive mechanisms directly applicable to CCS technology are still obscure [12]. Consequently, it is necessary to solve the problem of enterprises rarely importing CCS or CCUS technology due to its high costs.

3.4. Other industries

Apart from previous discussions about construction, transportation, and energy, there are some other paths to realize carbon neutrality. For instance, establishing a carbon trading market is conducive to reducing carbon emissions and encouraging some enterprises to promote green technology innovation. When it comes to China's megacities, it is important to realize carbon neutrality depending on the city's characteristics. For example, forests, oceans, and soil can serve as carbon sinks. Forestry carbon sinks function by absorbing and storing carbon dioxide in the atmosphere through photosynthesis, thereby reducing the concentration of carbon dioxide in the atmosphere. The forest resources of Shenzhen are relatively superior. It can focus on protecting and fully utilizing the forest resources and rebuilding suburban parks within the city, which contributes to elevating the forest accumulation volume of Shenzhen [13]. In addition, megacities ought to emphasize collaboration between regions. Beijing, Shanghai, and Shenzhen are all located in crucial economic zones. These cities should formulate the paths to realizing carbon neutrality according to their own characteristics and their surrounding cities' characteristics. Beijing possesses exceptional scientific resources and a well-developed level of economic development. But compared with Beijing, its surrounding city, Hebei, comparatively worse in economy and scientific research aspects. The natural carbon sink resources in Hebei are finite, which causes higher difficulty in realizing carbon neutrality. As a result, Hebei has the potential to continuously enhance its energy structure and elevate the quality of its industry. Meanwhile, Hebei assists Beijing in accomplishing the low-carbon techniques shift from Beijing to Hebei when Beijing realizes the innovation of green techniques [14].

4. Conclusion

Given megacities' large populations and large-scale economies, carbon emissions and the difficulty in realizing carbon neutrality are higher than other cities. There are data showing that construction, transportation, and energy fields contribute more carbon emissions to the environment. Until now,

China's megacities have studied several paths in previous fields. For example, integrating low-carbon ideas into construction planning and urban transportation system planning. Realizing the shift from fuel-based energy to renewable energy is also crucial. However, there are still numerous issues that require resolution in the future. We can refer to the successful experiences of foreign megacities like London and Tokyo. Meanwhile, China's mega-cities ought to explore the pathways that are suitable to their characteristics. This paper demonstrates the common paths to realize carbon neutrality researched by China's megacities and megacities in the world in various fields, which can serve as a reference for other cities. However, this paper is not without its limitations. For instance, there are numerous experiences in foreign megacities that are worth studying and exploring.

China has set up a long-term strategy to realize carbon neutrality. People should put more effort into exploring more effective ways to realize carbon neutrality as fast as possible. The government should not only support the innovation of clean and green techniques in this process, but it also requires the participation of all citizens in the future.

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