Emission reduction strategy between Chinese and foreign metropolitan areas

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Abstract. Because of the important position of metropolitan areas in the national economy, this paper puts forward the important responsibility of metropolitan areas in a country©s emission reduction task. Taking Chicago Metropolitan Area, Manchester Metropolitan Area and Tokyo Metropolitan Area as the research objects, this paper discusses the action of reducing emissions in international metropolitan area from three aspects: formulation of emission reduction targets, specific emission reduction strategies and regional coordination mechanism. Then, by comparing the emission reduction actions of the Yangtze River Delta, the Pearl River Delta and the Beijing-Tianjin-Hebei metropolitan areas in China, this paper analyses the Enlightenment of the emission reduction of the international metropolitan areas to China, and puts forward the areas that need to be further strengthened in the emission reduction of the metropolitan areas in China.

1 Introduction

Metropolitan area is a form of urban area when urbanization develops to a higher stage, and it is a network urban agglomeration with central city as its core [1, 2]. Metropolitan areas have a great impact on the development of the country's social and economic aspects.

At the Copenhagen Climate Conference in 2009, the Chinese government pledged the intensity of carbon emissions per unit GDP decreased by 40% to 45% in 2020 from 2005 [3]. In 2015, China submitted to the Secretariat of the United Nations Framework Convention on Climate Change a document entitled "Enhanced Actions on Climate Change: China's Intended Nationally Determined Contributions", which promised to reduce carbon emissions per unit GDP by 60-65% by 2030 compared with 2005. As an important economic region of a country, metropolitan area has a great responsibility and obligation in the national emission reduction action. Therefore, it is necessary to make a comparative study of China's and international emission reduction actions from the perspective of metropolitan areas. At the same time, because the metropolitan areas need unified targets and cooperation at the regional level in emission reduction, this paper will focus on the efforts made by metropolitan areas at home and abroad in terms of emission reduction targets, action measures and coordination mechanisms to explore the rational path of reducing emission in metropolitan areas.

2 Research on metropolitan areas and carbon emissions

"Carbon emission" is the total greenhouse gas emissions of a country or region. According to the report of the International Intergovernmental Panel on Climate Change (IPCC), urban greenhouse gas emissions account for about 75% of the global total [4], so urban "carbon emissions" have become a hot issue in urban and regional research. Studies in many countries, including China, have shown that urbanization is strongly correlated with energy consumption and carbon emissions [5, 6]. Since the 1980s, carbon emissions accounting research has been widely carried out at the national and regional levels. At the national level, the National Greenhouse Gas Inventory Guidelines issued by IPCC in 1997 and 2007 are the most influential [7, 8]. At the regional level, some scholars use the IPCC national inventory method to calculate regional direct carbon emissions. However, due to the lack of describing the differences and complexities of regional natural conditions, land use and socio-economic systems, most of the studies focus on direct carbon emissions from land use [9, 10]. However, compared with the national and regional "carbon emissions" research, due to the openness of the urban system and the complexity of its interaction by social, economic and natural systems, the method system for calculating urban carbon emissions is not perfect [11]. Developed countries such as North America and Europe started earlier, and a considerable number of cities joined the International Council for Local Environmental Initiatives (ICLEI) to fully account for urban greenhouse gas emissions by using its greenhouse gas assessment and prediction software [12]. There are also some studies using sample plot inventory method to study the impact of urban land use on carbon emissions, and to estimate the overall carbon emissions of cities [13]. In recent years, China has gradually carried out the study of carbon emissions at the urban level, but as a whole, most of them

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are limited to cities such as Beijing, Shanghai and Hangzhou [14, 15]

3 Comparison between foreign metropolitan areas and Chinese on emission reduction strategies

This paper will study the Chicago metropolitan area in the United States, Manchester metropolitan area in the United Kingdom and Tokyo metropolitan area in Japan, discussing target setting for emission reduction, action strategies for emission reduction, and regional synergy mechanisms, then compare and analyze their characteristics to summarize the experiences and practices of each country's metropolitan areas in coping with climate change and reducing carbon emissions.

At present, no specific emission reduction targets have been established. The policies concerning regional ecology and low-carbon development are mainly the "Guiding Opinions on Further Promoting Reform and Opening-up and Economic and Social Development in the Yangtze River Delta" approved by the State Council in 2008, which put forward that by 2020, the Yangtze River Delta urban agglomeration has roughly completed the infrastructure support for the construction of "two-oriented society", forming an environment-friendly, natural and harmonious system and mechanism, establishing a new development model of modern industrialization and urbanization, achieving coordinated development of urban economic development and population, resources and environment [16]. Subsequently, in June 2010, the National Development and Reform Commission promulgated the "Yangtze River Delta Regional Planning". Among them, the content related to carbon emissions is to promote the prevention and control of regional air pollution from the aspect of regional ecological environment protection, to promote energy structure adjustment through "West-to-East Gas Transmission" and "West-to-East Electricity Transmission", to implement total coal use control to improve regional atmospheric environmental quality, to propose that by 2015, sulfur dioxide emissions in the Yangtze River Delta region will be reduced by 8% [17].

The Pearl River Delta regional level is mainly based on the "Outline of the Reform and Development Plan for the Pearl River Delta Region （2008—2020）" issued by the National Development and Reform Commission in 2009, and the "Clean Air Action Plan for the Pearl River Delta of Guangdong Province" issued by the Guangdong Provincial Government in 2010. Among them, the former mainly focuses on regional economic development, and puts forward the requirements of regional coordination in terms of "resource conservation and environmental protection", including circular economy, pollution prevention and control, ecological environment and other aspects [18]. The "Clean Air Action Plan for the Pearl River Delta of Guangdong Province" is the first regional air pollution control action plan in China. It put forward that in the decade from 2010 to 2020, the aim of regional air pollution control is to "building a good foundation in one year, achieving results at the beginning of three years and significantly improving in ten years" [19].

Beijing-Tianjin-Hebei region launched a series of actions centre on the goal of preventing and controlling air pollution. In September 2013, the Ministry of Environmental Protection of China and five other ministries jointly issued the "Rules for the Implementation of the Action Plan for the Prevention and Control of Atmospheric Pollution in Beijing, Tianjin, Hebei and the surrounding areas", which put forward the requirements for the prevention and control of atmospheric pollution at the regional level. At the same time, because air pollution in Beijing, Tianjin, Hebei and its surrounding areas is closely related to industrial development, energy structure, transportation mode and other aspects, some requirements for low carbon and emission reduction are put forward in the "Rules for the Implementation of the Action Plan for the Prevention and Control of Atmospheric Pollution in Beijing, Tianjin, Hebei and the surrounding areas". For example, it is proposed that regional reduction of total emissions of sulfur dioxide, nitrogen oxide, smoke and dust and volatile organic compounds; by the end of 2017, cleaner production audits will be completed in steel, cement, chemical, petrochemical and non-ferrous industries, and promote technological transformation of cleaner production in enterprises; clearly stipulate that total reduction of coal consumption of Beijing, Tianjin, Hebei and Shandong.

In comparison with Chicago, Tokyo and Manchester metropolitan areas, we find that most of the metropolitan areas in foreign countries focus on "addressing climate change" and propose specific carbon emission reduction indicators, which are refined to target years, making emission reduction operable (see table 1).

Table 1. Emission reduction indicators for foreign metropolitan areas

Metropolitan areas	Action plan	Date of issue	Development goals
Chicago metropolitan area	Chicago Climate Action Plan	September 2008	Based on 1990 carbon dioxide emissions (32.3 million tons), it will be reduced by 25% by 2020 to 24.2 million tons; by 2050, it will be reduced by 80% to 6.5 million tons.
Manchester metropolitan area	Manchester Climate Change Delivery Plan	the year 2011	Carbon emissions will be reduced by 41% by 2020 on the basis of 2005. Carbon reduction targets for each city in the metropolitan area have been formulated.
Tokyo metropolitan area	Tokyo Climate Change Strategy	June 2007	By 2020, greenhouse gas emissions will be 25% lower than in 2000.

At present, the three metropolitan areas in China take "prevention and control of atmospheric pollution" as the main action target, and they do not pay enough attention

to "coping with climate change" (see table 2). Because the main problem in the developed coastal areas of eastern China is the prevention and control of air pollution and the reduction of the concentration of PM2.5, the practice of the three metropolitan areas is also in line with the current situation in China. But at the same time, from the current development situation of China's metropolitan areas, there are obvious differences in the economic and social development levels of different cities within the metropolitan area. The development appeals of different cities are different, and it is difficult to clarify carbon emission indicators from the regional level, and it is more difficult to implement to specific cities, so the emission reduction targets are relatively broad, and no clear constraint indicators are proposed.

Table 2 Target of prevention and control of air pollution in three metropolitan areas in China

Metropolitan areas	Action plan	Date of issue	Development goals
Beijing-Tianjin-Hebei region	Detailed rules for the implementation of the action plan for the prevention and control of atmospheric pollution in Beijing, Tianjin, Hebei and the surrounding areas	September 2013	The main purpose is to prevent and control air pollution, the specific substance controlled is PM2.5, and there are no control indicators for carbon emissions. Among them, the related aspects of carbon emission reduction include regional coordinated emission reduction of pollutants, emission reduction of motor vehicle exhaust, industrial structure adjustment and clean energy utilization.
Yangtze River Delta region	Regional planning for the Yangtze River Delta	June 2010	Promote regional air pollution prevention and control from the aspect of regional ecological environmental protection, and implement total coal use control through energy structure adjustment to improve regional atmospheric environmental quality. The content of carbon emissions is not involved, and the specific quantitative target is that by 2015, sulfur dioxide emissions will be reduced by 8%.
Pearl River Delta region	Outline of the Pearl River Delta regional reform and development plan (2008-2020)	December 2008	By 2020, the energy consumption per unit area of GDP will be reduced to 0.57 tons of standard coal; efforts will be made to solve the problem of atmospheric dust haze; by 2020, the per capita green area of urban parks will reach 15 square meters, 900,000 hectares of ecological public welfare forests will be built, and 82 nature reserves will be built.
	Guangdong Pearl River Delta clean air action plan	February 2010	Exploring a new way to prevent and control regional air pollution with Guangdong characteristics, and to construct an advanced comprehensive air pollution preventive treatment system for typical urban agglomerations in the world, and achieve "building a good foundation in one year, achieving results at the beginning of three years and significantly improving in ten years" target of regional air pollution treatment.

From the perspective of specific emission reduction measures in foreign metropolitan areas, mainly centre on clean and renewable energy use, energy utility management, energy saving in building renovation, traffic mode dominated by public transport, waste recycling and other aspects (see Table 3).

Table 3 Emission reduction measures in foreign metropolitan areas

Metropolitan areas	Action plan	Main measures
Chicago metropolitan area	Chicago Climate Action Plan	● Reduce energy consumption in commercial, industrial and residential buildings through building renovation, energy-efficient appliances, and water conservation; ● Promote the use of clean and renewable energy and improve power generation efficiency; ● Use a variety of modes of transportation and use clean energy vehicles; ● Prevent and reduce pollution emissions, reuse and recycling waste; ● Address and reduce the impacts of climate change from heat exchange management, air quality, rainwater management, green urban design, vegetation protection, public and corporate engagement; ● Establish a carbon emissions trading system, including emission rights trading in spot, futures and options transaction.
Manchester metropolitan area	Greater Manchester Regional	● Reduce building carbon emissions and adapt to climate change by transforming buildings and public spaces; ● Establish energy infrastructure

	Climate Strategy 2011-2020	market, promote the construction of heat and cold exchange network and renewable energy to reduce carbon emissions, strengthen energy management and improve energy efficiency; ● Reducing carbon emissions through the use of public transport and electric vehicles, and the transformation of transport modes; ● Develop green space and water systems to improve climate, fuel and food supply, and promote economic development; ● Improve waste recycling, strengthen the supply of low-carbon goods and services, and raise awareness of low-carbon consumption and services.
Tokyo metropolitan area	Tokyo Climate Change Strategy	● Promoting the role of private enterprises in reducing carbon dioxide emissions; ● Reduce household carbon dioxide emissions, reduce light and fuel consumption through a low-carbon lifestyle; ● Stipulate carbon dioxide emission reduction regulations in urban development ● Accelerate the effect of carbon dioxide emission reduction in motor vehicle traffic; ● Create a mechanism for the Tokyo Metropolitan Government to support actions in different areas; ● Tokyo Carbon Limit Trade Plan.

In contrast, China's metropolitan areas put forward major measures mainly target the protection of regional ecological environment and prevention and control of air pollution, taking ecological environment protection and air pollution prevention and control as the main content of regional development. Therefore, these measures mainly involve energy structure adjustment and utilization, traffic emission reduction and traffic pattern transformation, industrial adjustment, ecological essential factor protection and construction, but there are no measures to reduce carbon emissions in building use. Because carbon dioxide emissions have a certain correlation with air pollution, the main measures for air pollution prevention and control in metropolitan areas of China also have the effect of reducing carbon emissions in the implementation process, but the perspectives of action plan formulation is different (see table 4).

Table 4 Emission reduction measures in Chinese metropolitan area

Beijing-Tianjin-Hebei region	Detailed rules for the implementation of the action plan for the prevention and control of atmospheric pollution in Beijing, Tianjin, Hebei and the surrounding areas	● Eliminate small coal-fired boilers, strengthen industry pollution control, and promote regional coordinated emission reduction; ● Advocate public transport, green travel, improve regional transport system, improve fuel quality, promote new energy vehicles; ● Strictly control industrial and environmental access and accelerate industrial restructuring; ● Implement coal consumption total control to promote the clean utilization of coal and clean energy use.
Yangtze River Delta region	Regional planning of the Yangtze River Delta region ("Resources utilization and environmental protection" aspect)	● Implement restrictive protection for important ecological function protected areas, regional ecological corridors and other areas with important ecological status; ● Vigorously promote energy structure adjustment, implement total coal use control, eliminate small thermal power units, vigorously develop new energy sources, and improve regional atmospheric environmental quality; ● Establish and improve the whole process management system for solid waste and improve the disposal capacity of solid waste; ● Strengthen the protection and construction of nature reserves, ecological function areas, water conservation areas, realize the links of natural ecological space, build regional ecological nets, and carry out pilot projects for regional ecological environment compensation mechanisms.
Pearl River Delta region	Outline of the Pearl River Delta regional reform and development plan (2008-2020) ("Enhancing resource conservation and environmental protection" aspect)	● Promote clean production, accelerate the technological transformation of industrial, construction, and transportation energy conservation and consumption reduction, and encourage recycling of power generation; ● Establish and improve the atmospheric complex type pollution monitoring and prevention and control system; ● Protect important and sensitive ecological functional zones, strengthen the construction of water conservation forests in the Pearl River basin, and strengthen the construction of urban networked green open spaces.

Comparing with the regional coordination mechanism of low-carbon development in many metropolitan areas at home and abroad, we can see that the regional coordination mechanism of Chicago metropolitan area is relatively comprehensive in foreign metropolitan areas,

including the regional coordinating body led by the Mayor's Decision-making Committee of metropolitan area, carbon emission reduction targets of the cities, regional carbon emissions trading system, etc. Although the Manchester metropolitan area has formulated many main concrete measures in many aspects, it lacks a unified coordinating body, which has a certain impact on the implementation of the main measures. The Tokyo metropolitan area coordinates regional power distribution mainly through the "regional green power procurement" institution to coordinate energy consumption in each city.

In the case of China, the Beijing-Tianjin-Hebei metropolitan area has not explicitly proposed the establishment of a regional coordination leading group or an independent regional coordination regulatory agency in the regional coordination mechanism of air pollution prevention and control, and has not formulated relevant regional laws and regulations. The Yangtze River Delta Metropolitan Area does not set up special coordinating bodies for air pollution and carbon emissions. Instead, it has conducted regional coordination and reach consensus on relevant issues through the existing "Yangtze River Delta Urban Economic Coordination Committee". The main responsibility of the Coordinating Committee is to focus on cooperation in the economic field, but also related to relevant collaboration matters in the field of energy conservation and emission reduction. The regional coordination mechanism in the metropolitan area of the Pearl River Delta is relatively comprehensive, including the regional coordination organization with the joint conference on the prevention and control of air pollution in the Pearl River Delta region as the core, the formulation of relevant laws and regulations, the formulation of action scheme, and major measures for clear implementation, etc.

4 Conclusion

“Responding to climate change” is a challenge that is currently faced all over the world. As an important gathering place of industries and economies in various countries, metropolitan areas often have a high share of carbon emissions, how to achieve emission reduction in metropolitan areas is of great significance to the global low-carbon construction.

Through the discussion in this paper, we find that the carbon emission reduction action formulation in foreign metropolitan areas is relatively complete, from the formulation of emission reduction targets, specific emission reduction strategies to regional coordination, there are detailed discussions. Among them, the Chicago Metropolitan Area has formulated strategies for building renovation, clean energy use, new energy vehicles, recycling waste, encouraging public and enterprises to participate and establish carbon emissions trading systems. The Manchester metropolitan area has put forward strategies such as building renovation, low-carbon transportation, increasing green space and water systems, recycling waste, and establishing energy management and infrastructure markets. The Tokyo metropolitan area proposed the role of private enterprises and households in emission reduction, traffic emission reduction and the formulation of regulations of the urban government in the field of emission reduction.

Comparatively speaking, China's metropolitan areas are currently developing action plans for urgent air pollution prevention and control that are closely related to national health, and propose specific measures. However, in the field of carbon emissions, there is a lack of specific policies and measures. Based on the national goal of greenhouse gas emission reduction in China, the task of reducing greenhouse gas emissions in metropolitan areas is quite arduous. In the future, China should further combine the prevention and control of air pollution with the goal of reducing carbon emissions, and formulate a long-term plan of action for regional low-carbon development, only in this way can we decompose emission reduction tasks from "country-region-city" step by step, and fulfill the emission reduction targets promised by our country. At the same time, the relevant measures formulated at the metropolitan area level must be effectively implemented in order to improve the effectiveness of the action plan and related plans.

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