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Research Article

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Beijing energy consumption carbon emission characteristics and cause analysis

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ABSTRACT

Urbanization and rapid economic growth make Beijing shoulder heavy responsibilities in carbon emission reduction. Through calculating the total carbon emission in Beijing, summarizing the characteristic of carbon emission and utilizing LMDI decomposition method to analyze the increment of carbon emission in Beijing, the result shows that the growth of per capita economic aggregate is the most important factor for the high-speed growth of carbon emission in Beijing and the improvement of energy utilization efficiency is the main reason to curb carbon emission growth. Under the overall environment of rapid economic growth, adjusting industrial structure, improving energy utilization efficiency, optimizing energy structure and relying on technical innovation and institutional innovation is the basic solution to achieve the target of emission reduction.

Key words: Carbon emission, LMDI method, energy consumption, Beijing city

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INTRODUCTION

With the constant growth of global population and economic scale and the vast consumption of energy, the global catastrophic climate change caused by the rise of carbon dioxide in the air appears frequently and has gravely threatened the survival and development of humans. To cope with the energy crisis and climate warming, people have long been aware of the importance of energy saving and emission reduction. Low-carbon development has become the important issue in the 21st century. During the Copenhagen World Climate Conference held in December 2009, many countries put forward their emission reduction target. The Chinese government promised before the conference that by 2020 Chinese unit GDP carbon dioxide emission will drop 40-45% compared with 2005. Adhering to the low-emission sustainable development path and developing recycling economy and low-carbon economy has become an consensus of the international society. Energy consumption is the main source of greenhouse gases, so calculating the carbon dioxide from energy consumption is the primary task in studying the regional low-carbon development. As the political, cultural and educational center of China, Beijing arouses high attention from all parties in energy emission reduction. In recent years, Beijing has achieved a good result in energy saving and emission reduction. However, the environmental problem is still very severe with the acceleration of the urbanization process and the rapid economic development. From the beginning of 2013, the “hazy” weather has arisen continuously and the environmental problem is put on the working agenda by the government. How to ensure the reduction of carbon emission without influencing economic development becomes an important issue in Beijing’s economic transformation process. Based on statistical analysis on energy consumption carbon emission, the paper uses the LMDI model to analyze the driving factors of the carbon emission change in Beijing, understand the contribution rate of various factors to carbon emission and provide theoretical basis for the formulation and adjustment of carbon emission reduction policies by stages.

BEIJING TOTAL ENERGY CONSUMPTION AND CHARACTERISTICS ANALYSIS

Shown in the following Figure 1 and Figure 2, Beijing’s energy consumption showed an increasing trend from 1980

to 2012, but the gross regional production energy consumption/RMB10, 000 showed an obvious decreasing trend.

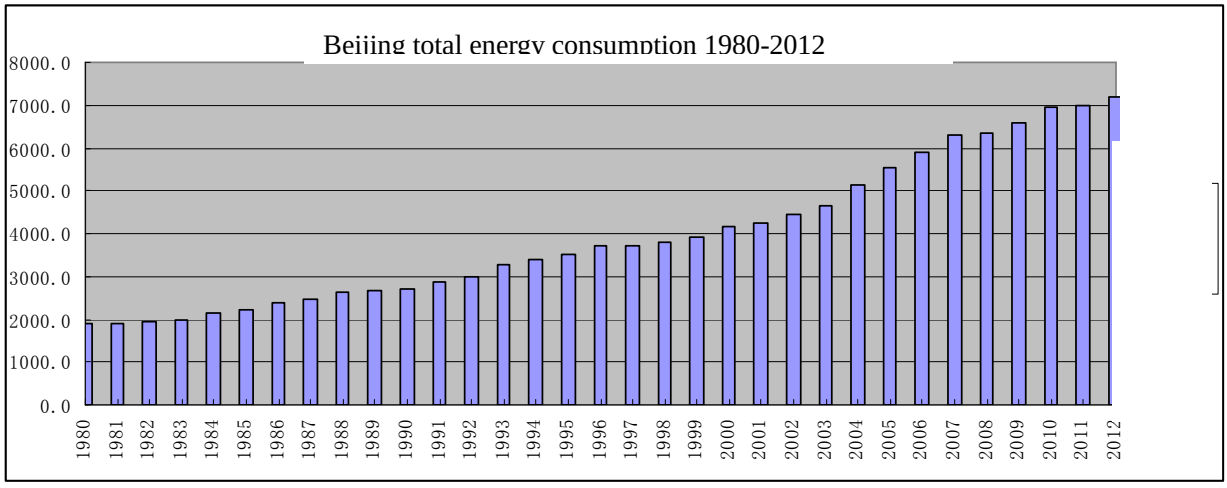

Fig.1 Beijing total energy consumption 1980-2012 (unit: 10,000ton)
Data source: Beijing Statistical Yearbook 2013

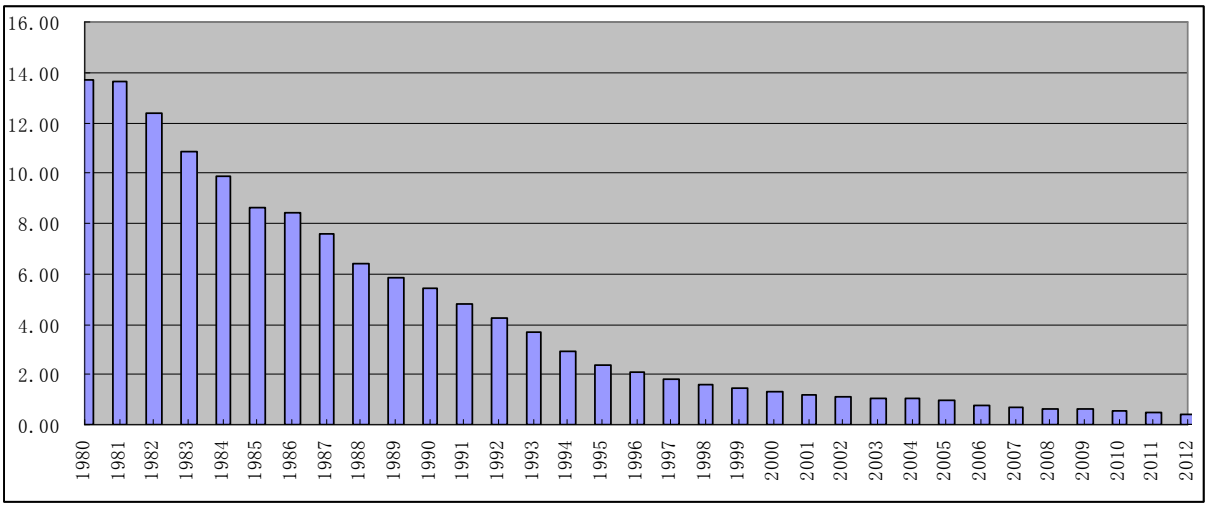

Fig.2 Beijing gross regional production energy consumption/RMB10, 000
Data source: Beijing Statistical Yearbook 2013

BEIJING ENERGY CONSUMPTION CARBON DIOXIDE EMISSION ANALYSIS

The carbon emission factor has been wide used by domestic and foreign researchers and the energy related carbon emission factor has been calculated in details. The energy carbon emission factor is calculated according to related literature. The data used in the paper is from Beijing Statistical Yearbook from 2002 to 2012. The factor of the per capita economic aggregate is from Beijing per capita real GDP (2002 is the base period); the industrial structure factor is the proportion of three industries in the national economy; the selected consumption energies are coal, coke, gasoline, kerosene, diesel, fuel oil, liquefied petroleum gas, natural gas and electric power. The method provided in 2006 IPCC National Greenhouse Gases List Guidelines is adopted in the calculation of carbon emission. The usage amount of different types of energies is converted to standard coal according to different standards and then conversion coefficient is used to convert standard coal to carbon dioxide. The basic formula is as follows:

$$CO_2 = KQ$$

Q is the quantity of standard coal converted from various energy usage amounts; K is the conversion coefficient. The coefficient K is different under different technical conditions in different countries and regions.

The result shows that from 2000 to 2011, Beijing energy consumption showed an increasing trend year by year; the emission of the corresponding energy consumption carbon dioxide was also increasing constantly. From 2002 to 2011, the carbon emission increased by 50.37 million tons in Beijing, and the carbon dioxide emission decreased in

part of years (The economic crisis and the holding of Olympics in 2008 led to the reduction of carbon emission increase). But the growth rate is changed warily. In 2004, the growth rate reached the highest 11% and then the growth rate gradually dropped.

BEIJING ENERGY CONSUMPTION CARBON EMISSION FACTOR DECOMPOSITION

1. Factor decomposition model

The factor decomposition method is a widely used method in studying the change mechanism of carbon dioxide internationally at present. The method decomposes the carbon dioxide emission into the multiplication of related influencing factors and makes re-decomposition according to different definitive weight, to confirm the increment share of each influencing factor. There are many main influencing factors of carbon emission, such as foreign trade, energy consumption structure, fixed asset investment and technological progress all can influence carbon emission. But in conclusion, it will be reflected from one or more factors from economic growth, industrial structure, energy intensity, energy structure and carbon dioxide emission factors. Based on existing factors, an important influencing factor – population is added in the paper, which is of important reference significance in studying the change mechanism of carbon dioxide emission. The total amount of carbon dioxide emission can be expressed in the following formula:

$$C = \sum_{ij} ij = \sum_{ij} \frac{QQ_i E_i E_{ij} C_{ij}}{PQQ_i E_i E_{ij}} = \sum_{ij} RS_i I_i M_{ij} U_{ij}$$

In the formula, C refers to the total carbon dioxide emission caused by various energy consumption; i refers to industry or department; j signifies the types of fossil energy consumption, like coal and natural gas; P stands for the number of resident population in Beijing; Q and Qi respectively refer to economic aggregate and i industry or department output value; E, Ei and Eij respectively refer to total energy consumption, i industry or total department energy consumption, i industry or regional total j energy consumption; R=Q/P refers to per capital economic aggregrate; Si=Qi/Q refers to industrial structure; Ii=Ei/Eij refers to energy intensity; Mij=Eij/Ej refers to energy structure; Uij=Cij/Eij refers to i industry or department j energy carbon dioxide emission factor.

This way, the change of carbon dioxide emission can be decomposed into five influencing factors – per capital economic aggregate, industrial structure, energy intensity, energy structure and carbon dioxide emission factor. 0 and t respectively refer to instant and base periods. According to LMDI model method, the change of carbon dioxide emission is:

$$\Delta C_{toc} = C_t - C_0 = \Delta C_{act} + \Delta C_{str} + \Delta C_{\text{int}} + \Delta C_{mix} + \Delta C_{emf}$$

In the formula, the influence of the five variables to the carbon dioxide emission of different industries or departments can be calculated according to the LMDI method raised by B.W.Ang and other people.

2. Data specification and result analysis

Beijing industry carbon emission is decomposed according to the LMDI decomposition model, and the result is shown in the following Table 1. According to the data in Table 1, the carbon emission in Beijing increased 50.37 million tons from 2002 to 2011. In 2008, the holding of Olympic Games led to the rapid decrease of carbon emission increase. In 2011, as the use of coke reduced more than five times, the carbon emission in the year showed negative growth. Except the special changes in the two years, the carbon emissions all showed an increasing trend year by year. As shown in Figure 3, in the influencing factors promoting carbon emission, the growth of per capita economic aggregate is the main reason for the increase of carbon emission and its contribution rate reached 129.3%. On the one hand, the high-speed economic growth caused the emission of a large amount of carbon dioxide, especially during the high-speed economic development period from 2005 to 2007; secondly, the increase of population has a great influence on the increase of carbon emission and its contribution rate reached 80.9%; the energy structure also has the facilitation effect, but the proportion of its contribution rate is too small. In recent years, Beijing has increased the use of natural gas from 1.09 billion cubic meters in 2000 to 9.207 billion cubic meters in 2012, but the use of coal was 21.6075 million tons in 2000 and reached 30.66 million tons in 2006 and 22.6989 million tons in 2012, still taking a larger proportion. Among the factors curbing carbon emission, energy intensity (energy utilization efficiency) plays a decisive role and its contribution rate reached 94.4%. After 2010, the energy utilization efficiency was further improved, benefiting from the clean coal technology and boiler improvement. The gross regional coal production energy consumption/RMB 10,000 dropped to 0.14 ton in 2012 from 0.77 ton in 2000, obvious in effect. Due to the adjustment of Beijing industrial structure, the contribution rate in terms of carbon emission also reached 15.9%, which indicates Beijing's industrial structure is being in the process of optimization.

Table 1 2002-2011 Beijing carbon emission increase factor decomposition (unit: 10,000 tons)

Time	Carbon emission growth	Per capita economic aggregate contribution	Industrial structure contribution	Energy intensity contribution	Energy structure contribution
2002-2003	364	688	48	-566	1
2003-2004	747	955	70	-498	1
2004-2005	896	821	-167	-50	1
2005-2006	932	1008	-240	-131	1
2006-2007	915	1193	-191	-463	1
2007-2008	66	601	-223	-761	-1
2008-2009	415	768	-11	-769	-1
2009-2010	961	-174	35	-350	2
2010-2011	-259	657	-120	-1165	-10
2002-2011	5037	6517	-799	-4753	-5

Data source: author statistical

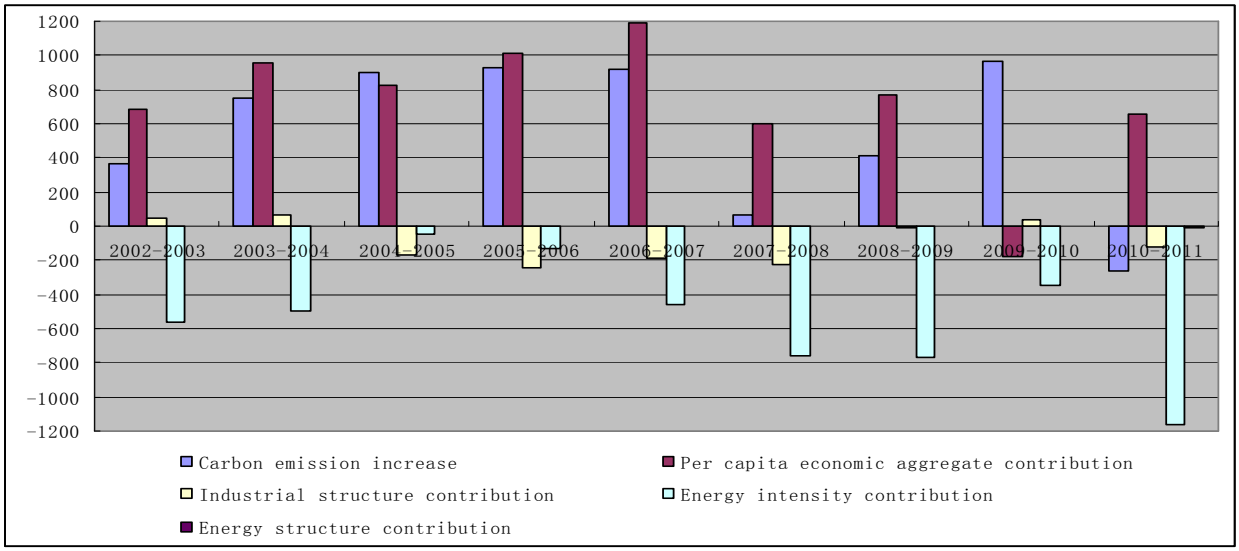

Fig.3 2002-2011 Beijing energy consumption carbon emission factor decomposition

Data source: author statistical

CONCLUSION

The paper uses LMDI decomposition technique to study on the carbon emission increment in Beijing and the study shows that:

(1) The increase of per capita economic aggregate is the most important cause for the continuous rapid growth of carbon emission in Beijing;

(2) The improvement of energy utilization efficiency (energy intensity)is the most important factor curbing the carbon emission increase in Beijing;

(3) The change of energy structure has relatively smaller influence on the increase of carbon emission in Beijing and has not tapped its potential. Due to long-term dependence on high carbon dioxide emission energies like coal, it has little effect in reducing carbon emission.

In view of Beijing economy will continue to maintain high-speed growing trend in a period of time in the future and the population control lacks realistic significance, efforts should be made from industrial structure, energy utilization efficiency and energy structure to control the carbon dioxide emission in Beijing.

Seen from Beijing's industrial structure, the output value proportion of the tertiary industry reached 76.1% and the secondary industry accounted for 23.1%. Most tertiary industries are characterized by low consumption and low emission. The space of increasing the proportion of the tertiary industry through reducing the proportion of the secondary industry is not large. Beijing should focus on the energy utilization planning of the secondary and tertiary industries for the future low carbon development and should put the low-carbon development of the tertiary industry at the first place. Therefore, the industrial structure should be adjusted internally to promote industrial internal upgrading and technology innovation, so as to achieve the target of energy saving and emission reduction.

At present, Beijing has the permanent resident population of more than 20 million and more than 5.2 million cars. The daily energy consumption in Beijing is huge, so the emission reduction task is heavy. Increasing energy

intensity and improving energy utilization efficiency can yield twice the result with half the effort in completing the carbon emission reduction task. Improving energy utilization efficiency is mainly to enhance the energy technological level. The improvement of technologies can not only reduce the emission of carbon dioxide but also promote the economic development and improve enterprises' strength and product quality.

Restricted by national resource endowment, the energy structure is difficult to change in the short term. But in the long term, the contribution of energy structure is the smallest among the carbon emission influencing factors and it has very great development space. To adjust the energy structure, the energy consumption structure based on carbon base energies like coal should be changed at present. In the future, reducing the use proportion of high-carbon energies like coal and petroleum, increasing the use proportion of liquefied gas and natural gas and making heavy use of wind power, hydropower and clean energies are the main routes to achieve urban low-carbon development. Beijing should rigorously enforce the capacity elimination and project access standards, promote industrial optimizing and upgrading with high-end implantation as the core, strengthen economic development momentum with low-carbon technical innovation as the key point, and promote successful economic transformation with mechanism innovation as the guarantee, in order to develop renewable energy resources and achieve the joint development of economy and environment

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