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Research on Influence Factors of Low-carbon Economy Based on Principal Component Analysis (Taking Beijing as an Example)

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Abstract. It is of great significance to identify the influence factors of low-carbon economy in Beijing. In view of this, this paper proposes an analysis model of influence factors of low-carbon economy in Beijing based on principal component analysis method. Firstly, from the perspective of influencing the development of low-carbon economy, the index of influencing factors of Beijing's low-carbon economy is initially selected, and then Pearson correlation coefficient is used to screen the indicators. Finally, the index system of influence factors of Beijing's low-carbon economy is constructed by the principal component analysis method. Coal consumption and per capita GDP are the key factors affecting the low-carbon economy of Beijing. The daily sewage treatment capacity and the total sown area of crops are the major factors affecting the low-carbon economy of Beijing.

Keywords: Beijing, influencing factors of low-carbon economy, Pearson correlation coefficient, principal component analysis.

1. Introduction

The State Council recently issued the "Guidance on Accelerating the establishment and improvement of the Green, low-carbon and circular development economic system" mentioned that: the establishment and improvement of the green, low-carbon and circular development economic system that promotes the comprehensive green transformation of economic and social development is a fundamental solution to the problems of resources, environment and ecology in China [1]. We should ensure that we can achieve carbon peaking and carbon neutrality, implement green planning, green investment, and green construction throughout the whole process, and bring our country's green development to a new stage. Since the 12th Five-Year Plan (2011-2015), Beijing has supported an average annual economic growth of 7.7% with an average annual energy consumption growth of 1.75%, and the energy consumption per 10,000 yuan of GDP is only 0.32 tons of standard coal, which is the lowest among provincial regions in China [2]. More than 200 local standards in the fields of energy conservation, low-carbon and circular economy have been the driving force behind Beijing's achievements in energy conservation and consumption reduction. Across the world, many countries have established markets to trade carbon emissions, so the study of carbon emissions is very meaningful. The purpose of this paper is to accelerate the development of low-carbon economy in Beijing.

First, 18 indicators affecting low-carbon economy are constructed in this paper. Secondly, Pearson correlation coefficient method is used to find out the main indicators with $P>0.3$. Finally, principal component analysis is used to extract the index into a principal component. At the end of this paper, suggestions are put forward to optimize the energy structure and strengthen the innovation of low carbon technology, so as to provide suggestions for the carbon emission of Beijing.

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2. Literature

2.1 Domestic literature review

Sun Jingshui, Chen Zhirui and Li Zhijian [3] analyzed the statistical data of China from 1990 to 2009 using the STIRPAT model, and concluded that the level of economic development, industrial structure and per capita GDP had a significant positive impact on the total carbon emissions. Therefore, it is concluded that in order to reduce our carbon emissions and transition to low carbon economy, we should reduce the proportion of coal and other petrochemical energy consumption, strengthen low carbon technology innovation, and optimize the industrial structure. Xu Guangyue [4] analyzed the provincial data of China from 1990 to 2007 and concluded that except for the proportion of coal consumption, factors affecting carbon emissions vary from region to region. Therefore, reducing the proportion of coal consumption is a way to achieve carbon emission reduction in any region. Li Xiaoyan [5] used the idea of coordinated development of regional economy, society and ecological environment when constructing the criterion layer of Sichuan Province's low-carbon economy evaluation index system, and divided the indicators into three categories: economic development, environmental protection and social progress. According to the author, we should open wider to the outside world, optimize the energy consumption structure, promote the development of low-carbon technology and develop low-carbon industries to achieve the development of low-carbon economy. Chen Yan [6] analyzed the data of Jiangxi Province from 2000 to 2010, and believed that improving forest coverage and developing green ecological agriculture would help Jiangxi Province achieve a high-level low-carbon economy.

2.2 Foreign literature review

Kaya [7] proposed in 1995 a simple mathematical framework "The Kaya identity" for assessing the main factors controlling global CO2 emissions. According to Kaya, the main drivers of CO2 emissions are: population, gross domestic product, total primary energy consumption, energy mix and intensity. Feng et al. [8] considered the impact of population, energy intensity, consumption, industrial structure, consumption pattern and energy structure on carbon emissions when studying the carbon emissions of the United States from 2007 to 2013. The authors believe that changes in the production structure of the US economy have affected the carbon emissions of the US, because during the analysis period, emissions-intensive industries have been gradually offshored to China and other developing countries, and domestic industries in the US have been gradually transformed and upgraded. Jiang et al. [9] concluded that clean energy, including new energy technologies and energy-saving technologies, is crucial to the development of China's low-carbon economy. By analyzing the data of Beijing, Li et al. [10] found that the contribution of some sectors to GDP of Beijing is not proportional to the total emissions. For example, the contribution of electricity and power supply to GDP is small but accounts for a large amount of the total emissions of Beijing, while the financial sector is on the contrary. In addition, there are some industries with high carbon emissions that can make significant contributions to the economy, such as the real estate industry, according to the analysis of Li et al.

2.3 literature review

Most scholars at home and abroad select indicators of low-carbon economy from the aspects of economy, society, ecological environment and technology, especially the importance of technology in the development of low-carbon economy. However, there are few researches on the influencing factors of low-carbon economy in Beijing. In addition, most researches on the influencing factors of low-carbon economy development in Beijing are not time-efficient, and few researches have been conducted in recent years. Based on this, this paper will aim at the data of Beijing in recent years, use the method of principal component analysis, learn from the factors of other provinces, regions and countries, and construct indicators according to the idea of coordinated development of economy, society, ecology and technology.

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3. Pearson correlation coefficient

3.1 Preliminary screening of indicators and data sources

For independent variables, after preliminary index selection, this paper selects four secondary indexes, which are economic factor, technical factor, environmental factor and social factor respectively. Thirteen three-level indicators are selected, which are GDP per capita under economic factors, proportion of tertiary industry, import and export of foreign trade, coal consumption; The amount of fertilizer applied per unit planting area under technical factors, and the completion of investment in waste gas treatment projects; Forest coverage rate under environmental factors, daily treatment capacity of urban sewage, natural population growth rate under social factors, conversion amount of agricultural fertilizer application, total sown area of crops, carbon dioxide emission per capita, carbon dioxide emission intensity.

For the dependent variable, green GDP is selected in this paper. Green GDP (sustainable income) is defined as the level of income that must be guaranteed without reducing the total capital level. Sustainable income assesses the value of the services and flows of environmental capital. Sustainable income is quantitatively equal to the traditional GDP minus the depreciation of man-made, natural, human and social capital. The calculation of green GDP is: Traditional GDP-(all resources consumed in the production process + all environmental pollution in the production process + all resources consumed in the resource restoration process + all resources consumed in the pollution treatment process + all resources consumed in the final use + all environmental pollution in the final use) + (all newly created value in the resource restoration sector + the ring New value created by the environmental protection Department). Green GDP introduces the idea of sustainable development of economy, environment and society. So it can be a good alternative to low-carbon economy.

The figures come from a government website: the National Bureau of Statistics of the People's Republic of China (data.stats.gov.cn). This paper collates data for a total of 15 years from January 2005 to December 2020.

3.2 Pearson correlation was used to screen indicators

Pearson correlation coefficient can be used to measure the degree of linear correlation between variables, with values ranging from -1 to 1. The absolute value of Pearson correlation coefficient can indicate the degree of correlation between random variables, and its positive or negative value can indicate the direction of correlation. When there is a complete positive correlation, the Pearson correlation coefficient is 1; when there is a complete negative correlation, the Pearson correlation coefficient is -1, with no linear correlation and the value is 0. Pearson's correlation coefficient is equal to the covariance divided by the product of the standard deviations of the two variables, as follows:

$$\mathrm{r} = \frac{\sum\left(X-\overline{X}\right)\left(Y-\overline{Y}\right)}{\sqrt{\sum\left(X-\overline{X}\right)^2\sum\left(Y-\overline{Y}\right)^2}} \tag{1}$$

In this paper, SPSS27.0 software is used to test Pearson correlation coefficient, and the results are as follows:

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Table 1: Correlation test table of influencing factors of low-carbon economy

	Influence Factors of Low-carbon Economy	Correlation Coefficient
X1	Per capita GDP (Yuan/person)	0.971**
X2	share of tertiary industry(value-added of tertiary industry/gross regional production	0.949**
X3	total imports and exports of goods (USD million)	0.292
X4	coal consumption (10,000 tons)	-0.963**
X5	Fertilizer application per unit planting area (10,000 tons/thousand hectares)	0.902**
X6	Completed investment of waste gas treatment project (ten thousand Yuan)	-0.296
X7	forest coverage rate	0.936**
X8	Daily municipal sewage treatment capacity (10,000 cubic meters)	0.971**
X9	Natural population growth rate (per thousand)	0.220
X10	Conversion amount of agricultural fertilizer application (10,000 tons)	-0.915**
X11	Total sown area of crops (thousands of hectares)	-0.950**
X12	Carbon dioxide emissions per capita (ton/person)	-0.973**
X13	Carbon dioxide emission intensity (ton CO2/ ten thousand Yuan)	-0.968**

It can be seen from the above table that there are 13 relevant influence factors of low-carbon economy in Table 1. However, it is found from the table that the correlation coefficient between the total amount of imports and exports of goods, the completed investment of waste gas treatment projects, the natural growth rate of population and the y value of low-carbon economy is less than 0.39. According to the property of correlation coefficient, when r is less than 0.39, the degree of linear correlation between variables is low degree correlation and very low degree correlation. Therefore, the three explanatory variables were removed, leaving only the remaining 10 indicators: per capita GDP, proportion of tertiary industry, coal consumption, fertilizer application amount per unit planted area, forest coverage rate, daily treatment capacity of urban sewage, conversion amount of agricultural fertilizer application, total sown area of crops, per capita carbon dioxide emission and carbon dioxide emission intensity. In view of this, this paper initially selects the above 10 indicators to build the index system.

4. PCA (principal component analysis)

4.1 Principal component analysis validity analysis

Before principal component analysis of indicator data, validity analysis of original data, namely KMO value and Bartlett sphericity test, should be carried out. In general, when the KMO value is greater than 0.6, it indicates that the validity test of the data passes, that is, there is correlation between variables, which can be used for principal component analysis. Table 2 below shows that the KMO value of influencing factors of low-carbon economy in Beijing is 0.757, greater than 0.6, which further indicates that data can be analyzed as principal components. Table 2 shows the KMO values of the influencing factors of low-carbon economy and the results of Bartlett's spherical test. Table 3 presents raw data on the factors influencing the low carbon economy for reference.

Table 2: KMO and Bartlett tests

KMO sampling appropriateness measure		0.757
Bartlett's sphericity test	Approximate chi-square	379.583
	DOF	45
	Significance	0

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Table 3: Raw Data of Influence Factors of Low-carbon Economy

index / year	Per capita GDP (Yuan/person)	Share of tertiary industry (value-added of tertiary industry/gross regional product)	Coal consumption (10,000 tons)	Fertilizer application per unit planting area (10,000 tons/thousand hectares)	Forest coverage rate（%）	Daily municipal sewage treatment capacity (10,000 cubic meters)	Conversion amount of agricultural fertilizer application (10,000 tons)	Total sown area of crops (thousandth of hectares)	Carbon dioxide emissions per capita (ton/person)	Carbon dioxide emission intensity (ton CO2/ ten thousand Yuan)
2005	47182	0.72	3068.97	0.04666667	31.7	7990	14.84	318	7.8014	1.722
2006	53438	0.74	3055.67	0.04644321	31.7	9734	14.84	319.53	7.7972	1.519
2007	63629	0.76	2984.67	0.04776211	31.7	10337	13.99	292.91	8.0304	1.332
2008	68541	0.78	2747.73	0.04272593	31.7	11173	13.63	319.01	7.8682	1.2
2009	71059	0.78	2664.7	0.04362925	35.8	12184	13.82	316.76	7.7944	1.126
2010	78307	0.78	2634.62	0.04358778	35.8	13393	13.67	313.62	7.0682	0.983
2011	86246	0.78	2366	0.04634653	35.8	13304	13.84	298.62	6.4066	0.796
2012	92758	0.79	2270	0.04916736	35.8	13693	13.67	278.03	6.3496	0.735
2013	100569	0.8	2019.23	0.05385815	35.8	14653	12.78	237.29	5.7095	0.61
2014	106732	0.8	1736.54	0.05980271	43.8	15124	11.64	194.64	5.815	0.587
2015	113692	0.82	1165.18	0.06117114	43.8	16065	10.53	172.14	5.5954	0.528
2016	123391	0.82	847.62	0.06630024	43.8	16779	9.65	145.55	5.2904	0.448
2017	136172	0.83	490.46	0.07069621	43.8	17037	8.55	120.94	5.2004	0.403
2018	150962	0.83	276.19	0.07023798	43.8	18145	7.29	103.79	5.3694	0.382
2019	161776	0.84	182.8	0.06967815	43.8	19171	6.17	88.55	5.3504	0.326
2020	164158	0.84	134.98	0.06172337	43.8	20405	6.06	98.18	4.8133	0.33

4.2 Principle of principal component analysis

The principal component analysis method can divide the original multiple variables into several comprehensive indexes, which not only simplifies the content of data retention, but also stores the information effectively. It is a kind of dimensionality reduction processing technology. The more widely the data is projected across the dimensions (i.e. the greater the variance), the more information he can retain. The following is a brief introduction to principal component analysis.

4.2.1 Original sample matrix

With sample data of n years and p index data related to influencing factors of low-carbon economy (standardized in order to eliminate units), the initial sample matrix can be written as follows:

$$X = \begin{pmatrix} x_{11} & \cdots & x_{1p} \\ \cdots & \cdots & \cdots \\ x_{n1} & \cdots & x_{np} \end{pmatrix} = \left(\mathrm{x}_{\mathrm{ij}}\right)_{n\times p} \tag{2}$$

Here, i= (1,2... n), represents the ith row of the initial sample matrix, j= (1,2... ,p), represents the Jth column of the initial sample matrix. The meanings of i and j in the following text are the same as here.

4.2.2 Calculate the correlation matrix $\mathrm{R} = \left(\mathrm{r}_{\mathrm{ij}}\right)_{n\times p}$

The calculation formula of r_{ij} is:

-- s is the sample variance

$$\frac{1}{\mathrm{n}}\sum_{i=1}^{n}\frac{(x_{ij}-x_i)(x_{ij}-x_j)}{s} \tag{3}$$

4.2.3 The eigenvalues and eigenvectors of R

According to the characteristics of the equation - lambda expressions |R-λI|=0, λ can be calculated. Here, R represents the correlation coefficient matrix and I represents the identity matrix. According to the descending order of λ, λ1, λ2... you can compute the eigenvectors aj.

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4.2.4 Contribution rate and cumulative contribution rate

$$e_i = \frac{\lambda_i}{\sum_{i=1}^{p} \lambda_i} \quad (4)$$

Formula (4) represents the contribution rate, that is, the proportion of variance of the ith principal component in the total variance, which reflects how much information the ith index provides and how much comprehensive capacity it has.

$$E_{\mathrm{m}} = \frac{\sum_{i=1}^{m} \lambda_i}{\sum_{i=1}^{p} \lambda_i} \quad (5)$$

Formula (5) represents the cumulative contribution rate, that is, the total comprehensive capacity of the first m principal components, the variance of these m principal components and their proportion in the total variance.

4.2.5 Computational principal component

$$\mathrm{z}_m = a_{mj} x_j \quad (6)$$

4.2.6 extracted the number of principal components

To judge the number of principal components, it is necessary to observe the cumulative variance contribution rate obtained. Generally, all principal components >85% are selected (SPSS extracts >90% by default), so as to complete the extraction of principal components. Finally, according to the indicators obtained, the index system of influence factors of low-carbon economy in Beijing is constructed.

4.3 An empirical study of principal component analysis

The SPSS27.0 software was used to conduct the principal component analysis with the following steps of "analysis-dimensional-reduction - factor", and the total variance interpretation of principal components was shown in Table 4. In addition, a lithotripsy map was drawn, as shown in Figure 1:

Table 4: Explanation of total variance of principal components

Total Variance Explained						
				Extraction Sums of Squared Loadings		
ingredient	ingredient	Initial eigenvalue Percentage of variance	accumulation %	total	Percentage of variance	accumulation %
1	9.258	92.582	92.582	9.258	92.582	92.582
2	0.355	3.547	96.129			
3	0.207	2.067	98.196			
4	0.094	0.942	99.138			
5	0.062	0.620	99.757			
6	0.012	0.118	99.875			
7	0.008	0.076	99.952			
8	0.003	0.034	99.986			
9	0.001	0.009	99.994			
10	0.001	0.006	100			

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Extraction method: principal component analysis

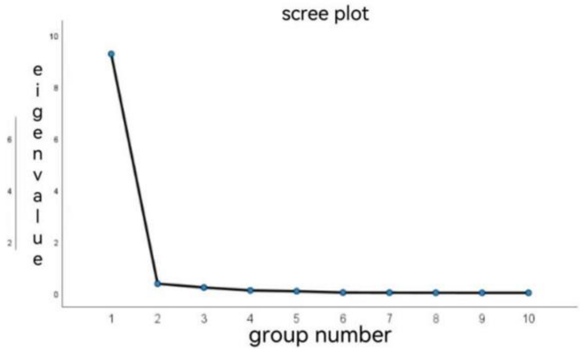

Table 1: Scree plot

The eigenvalue of the first principal component (component No. 1) is up to 92.582%. The slope between the first principal component and the second principal component is very large, which means that the contribution rate of the first principal component is already well enough to satisfy the requirement of data dimensionality reduction. Therefore, one principal component is selected in this paper.

Table 5：Component score coefficient table

	Component score coefficient table	
variate	variable name	principal component 1
X1	gdp per capita	-0.988
X2	Proportion of tertiary industry	-0.958
X4	coal consumption	0.990
X5	Fertilizer application amount per unit planting area	-0.928
X7	forest coverage rate	-0.949
X8	daily urban sewage treatment capacity	-0.978
X10	Conversion amount of agricultural fertilizer application	0.957
X11	total sown area of crops	0.976
X12	Per capita carbon dioxide emissions	0.949
X13	Carbon dioxide emission intensity	0.948

Extraction method: principal component analysis
One component was extracted

After the extraction of principal components, the expression of principal components can be obtained based on Table 5:

$$F1=-0.988X1-0.958X2+0.99X4-0.928X5-0.949X7-0.978X8+0.957X10+0.976X11+0.949X12+0.948X13 \quad (7)$$

Coal consumption load (0.99) and per capita GDP (-0.988) have the greatest impact on low-carbon economy.

The daily treatment capacity of urban sewage (-0.978) and the total sown area of crops (0.976) had great influence on low-carbon economy.

Proportion of tertiary industry (-0.958) conversion amount of agricultural chemical fertilizer application (0.957) Forest coverage rate (-0.949) per capita carbon dioxide emission (0.949) Carbon dioxide emission intensity (0.948) factors have moderate influence on low-carbon economy.

The influence of fertilizer application amount per unit planting area (-0.928) on low-carbon economy is small.

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5. Conclusion

Based on the results in Table 5 and combined with the literature, it can be known that:

（1）The biggest explanations for the influence of coal consumption and per capita GDP on low-carbon economy are as follows:

Economic growth cannot be separated from energy consumption, which will lead to the emission of greenhouse gases, thus causing environmental pollution. In energy consumption, coal has the largest carbon emission coefficient [4], that is, coal consumption affects carbon emissions to the greatest extent, so coal consumption exerts the greatest load on low-carbon economy.

The dependent variable selected in this paper is green GDP= traditional GDP- (all resource depletion in production process + all environmental pollution in production process + all resource depletion in resource restoration process + all environmental pollution in resource restoration process + all resource depletion in pollution treatment process + all resource depletion in final use + all environmental pollution in final use) + (All newly created value of resource restoration department + all newly created value of environmental protection department), per capita GDP is the per capita value of traditional GDP, which symbolizes economic development. As an important term in the calculation formula of green GDP, the load on the dependent variable is very large.

（2）The factors of daily sewage treatment capacity and total sown area of crops have great influence on low-carbon economy:

Daily treatment capacity of municipal sewage refers to the designed capacity of sewage treatment plant to treat sewage day and night. Sewage treatment is considered to be an energy-intensive industry. The adverse impact of urban sewage treatment on low-carbon economy is not only the simple energy consumption, but also the conversion of water pollutants into CO_2, CH_4, N_2O, NH_3, H_2S and other greenhouse gases caused by the energy consumption process. In particular, if the standard of sewage treatment is raised, the energy consumption will be higher and higher, and such conversion will become more prominent. According to the data published by the United Nations, the carbon emissions of the global water treatment industry, such as sewage treatment, account for about 2% of the global carbon emissions. In the United States, about 2% of energy consumption in 2017 was used in drinking water and sewage systems, generating about 41 million tons of greenhouse gases [11]. The energy consumption caused by sewage treatment and the conversion of greenhouse gases have a great impact on low-carbon economy.

The total sown area factor is used to characterize the impact of agriculture on low-carbon economy in this paper. Agriculture is an important source of greenhouse gas emissions. According to statistics, carbon emissions from agriculture account for 7%-8% of the total national emissions. Combined with emissions from coal for production and living, greenhouse gas emissions from agriculture and rural areas account for about 15% of the total national emissions [12]. Methane and nitrogen oxide emissions from agriculture, especially carbon emissions from crop production, have a greater impact on low-carbon economy.

（3）Explanations of moderate impacts of tertiary industry proportion, conversion amount of agricultural fertilizer application, forest coverage rate, per capita carbon dioxide emission and carbon dioxide emission intensity on low-carbon economy:

The higher the value added of the tertiary industry accounts for the gross regional product, the smaller the proportion of the primary and secondary industries with relatively low pollution and energy consumption, and the smaller the relative pollution. Therefore, it can be considered that the proportion of the tertiary industry has a certain impact on the low-carbon economy. From the perspective of industrial structure, Beijing's industrial structure has gradually been in line with western developed countries. Therefore, although the proportion of three industries has a certain impact on the low-carbon economy, in the case of Beijing, the impact is relatively moderate;

Nearly one-fifth of global carbon emissions come from agriculture and land use, and fertilizer industry is one of the important sources of agricultural carbon emissions [13]. Therefore, it can be

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considered that the conversion amount of agricultural fertilizer application has a certain impact on low-carbon economy.

Forest is the largest carbon pool resource in nature, with strong functions of carbon absorption, carbon storage and biodiversity maintenance [14]. Forests participate in atmospheric cycle, water cycle and biological cycle to regulate temperature and humidity. Their carbon sink function is mainly to absorb carbon dioxide, adsorb other pollutants and release oxygen through photosynpaper, which contributes to the low-carbon economy to a certain extent.

Undoubtedly, the emission and intensity of carbon dioxide have a crucial impact on low-carbon economy. As 10 different indicators are finally screened out in this paper to describe the impact on low-carbon economy, most of these indicators are inseparable from the intensity and emission of carbon dioxide, so there is collinearity among the indicators. In the process of principal component analysis, collinearity is reduced in this paper. The impact of the more fundamental per capita carbon dioxide emissions and carbon dioxide intensity is reduced, which is reflected in the conclusion of data processing as moderate impact.

The effect of fertilizer application rate per unit planting area on low carbon economy is small:

The impact of this index on low-carbon economy is less than the conversion amount of agricultural fertilizer application, which indicates that precise fertilization is more important for the development of low-carbon agriculture. Precise fertilization can not only increase crop yield, but also avoid excessive fertilizer application. Only by achieving precise soil fertilization can we contribute to the development of low-carbon agriculture.

6. Suggestion

Based on the above analysis, this paper will further explore how to promote the development of low-carbon economy in Beijing from the following four aspects.

6.1 Optimize the energy mix

In conclusion, coal consumption has the greatest impact on low-carbon economy. Therefore, if the structure of energy production and consumption is optimized, the proportion of coal consumption will be reduced, so as to vigorously develop the low-carbon economy of Beijing. Local electricity demand can be met by increasing the development and utilization of local renewable energy, introducing relevant policies to support the development of clean energy, and actively carrying out high-end demonstration applications of renewable energy, such as promoting the use of clean energy in key areas such as the sub-center of Beijing City, Daxing International Airport and the Winter Olympic Games area. Strengthen and improve urban and rural power supply capacity, form a "multi-direction, multi-source, diversified" electricity distribution pattern and "ring network support, multi-point injection, local consumption" grid structure, can meet the local demand for electricity; The multi-source and multi-direction gas supply system can be improved to form the outward transmission pattern of "three gas sources and seven channels", which can guarantee the natural gas supply [15]. We will actively yet prudently promote the conversion of clean energy from coal to electricity and from coal to gas, and the combination of various energy sources and various heating methods will promote the formation of a comprehensive clean heating system, reduce reliance on coal consumption to a certain extent, and ensure energy demand. Guided by the goal of "double carbon", the green Beijing strategy will be further implemented, the green and low-carbon transformation of industrial structure and energy structure will be further intensified, and the high-quality development of low-carbon economy will be continuously promoted by the construction of eco-city with blue sky, clear water and forest ring [16].

6.2 Strengthen innovation in low-carbon technologies

Low carbon economy is a green economy developed under the premise of low pollution, emission and energy consumption, which determines that the development of low carbon economy

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is inseparable from the innovation of energy technology and emission reduction technology, as well as the innovation of industrial structure and system. Research on low-carbon technologies, development of low-carbon products and utilization of low-carbon energy can help minimize emissions and pollution of energy and other natural resources [5]. Low-carbon technology involves all aspects of national economic development, covering almost all pillar industries of national economic development. Generally speaking, whoever has mastered the development of low-carbon core technology will have the right to speak and win business opportunities. For example, the index of daily treatment capacity of urban sewage selected in this paper, after analysis, has a great impact on low-carbon economy. The cost of improving sewage treatment standards is to increase energy consumption of sewage treatment. If sewage treatment technology is improved, efficient treatment of sewage can be realized under the premise of low pollution, low emission and low energy consumption. By giving full play to the scientific research advantages of Beijing, vigorously supporting the research of universities and research institutes on low-carbon industry, and building a platform for continuing education of researchers, it plays a positive role in the development of low-carbon industry [17].

6.3 Focus on the coordinated development of low-carbon economy in the Beijing-Tianjin-Hebei region

The study shows that the proportion of tertiary industry has a moderate impact on the development of low-carbon economy in Beijing. The reason is that Beijing's industrial structure has been more reasonable. However, the industrial structure of the Beijing-Tianjin-Hebei region is not reasonable. The industrial structure of the Beijing-Tianjin-Hebei region is heavily weighted, especially the heavy industries in Tianjin and Hebei, which mainly relies on high-carbon fossil energy for economic growth and produces large carbon dioxide emissions [18]. Therefore, we can gradually focus on the coordinated development of regional low-carbon economy. Due to the differences in the industrial structure, energy structure, scientific and technological innovation level, management level and so on, the three regions of Beijing, Tianjin and Hebei have caused the imbalance of low-carbon development. Therefore, improving the low-carbon development level of Tianjin and Hebei (especially Hebei) with the help of low-carbon economy should become an important focus to promote the low-carbon development of Beijing-Tianjin-Hebei. The coordinated development of low-carbon economy in Beijing, Tianjin and Hebei will be the focus of low-carbon economic development in the future. We can give full play to the power of the Xiongan New Area, a centennial project, and solve the problem of the gradient gap in the intensity of low-carbon economic links between the Beijing-Tianjin-Hebei city cluster. According to existing studies [19], the role of the construction of Xiongan New Area in bridging the uncoordinated development of low-carbon economy in the Beijing-Tianjin-Hebei region will gradually increase over time after 2025, which is conducive to the coordinated development of low-carbon economy in the urban agglomeration as a whole.

6.4 Guide the carbon behavior of farmers

This study shows that the total sown area of crops has a greater impact on low-carbon economy, indicating that agriculture has a greater impact on low-carbon economy. Agriculture is an important source of carbon emission and a major way of carbon sequestration, playing a crucial role in the development of low-carbon economy. Therefore, it is necessary to guide the carbon behavior of farmers and explore the internal mechanism of the carbon behavior of farmers and its derivation. As for how to guide farmers to abandon the traditional development thinking and mode, develop good carbon behavior habits, and accelerate the promotion of low-carbon planting, the adjustment of farmers' carbon behavior pattern and its optimization incentive mechanism should be discussed from the level of micro-policy system and forward-looking carbon trading [12]. In addition, the vocational education of farmers should be strengthened, the education platform of the whole period should be perfected, the technical awareness of farmers should be enhanced, the field teaching

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should be strengthened, the agricultural technology extension personnel should be encouraged to teach farmers on the spot, and the understanding of farmers on modern agricultural technology and low-carbon agriculture should be gradually improved. In addition, the help of new technologies, professional institutions and personnel to help farmers can also effectively develop low-carbon agriculture. For example, for chemical fertilizer, one of the important sources of agricultural carbon emissions, we can actively guide the development of satellite positioning, remote sensing and other technologies to assist agricultural activities, and make full use of information technology to accelerate the promotion of precision fertilization technology [20], which can lead farmers' low-carbon awareness and implement greener and more efficient low-carbon agricultural technologies.

References

[1] The State Council. Guidelines on Accelerating the Establishment of a Sound Green Low-carbon Circular Development Economic System [Z].2021-02-22.

[2] Xinhua News Agency. Beijing: More than 200 local standards for energy conservation, low-carbon and circular economy promote energy conservation and consumption reduction. Central government portal www.gov.cn 2015-11-04.

[3] Sun Jingshui, Chen Zhirui, Li Zhijian. Research on the Influencing Factors of low-carbon Economy Development in China: Based on the Extended STIRPAT Model [J]. Audit & Economics Research,2011,26(04):85-93.

[4] Xu Guangyue. Study on the Influence Factors and Regional Comparison of Chinese carbon emission: Based on provincial panel data [J]. Business review, 2011 (02) : 14 to 18, DOI: 10.13762 / j.carol carroll nki CJLC. 2011.02.002.

[5] Li Xiaoyan. Evaluation of provincial low-carbon economy based on Fuzzy Analytic Hierarchy Process [J]. East China Economic Management,2010,24(02):24-28. (in Chinese)

[6] Chen Y. Evaluation and analysis of low-carbon economy development in Jiangxi Province based on principal component analysis. Journal of Nanchang University (Humanities and Social Sciences Edition),2012,43(06):7.

[7] Yoichi Kaya"Impact of carbon dioxide emissions on GNP growth: interpretation of proposed scenarios", presentation to the energy and industry subgroup, response strategies working group. IPCC, Paris (1989).

[8] Feng, K., Davis, S., Sun, L. et al. Drivers of the US CO2 emissions 1997–2013. Nat Commun 6, 7714 (2015). https://doi.org/10.1038/ncomms8714.

[9] Jiang et al., 2010, B. Jiang, Z.-Q. Sun, M.-Q. Liu. China's energy development strategy under the low-carbon economy. Energy, 35 (2010), pp. 4257-4264.

[10] Yan Li, Yigang Wei, Siqing Shan, Yuan Tao, Pathways to a low-carbon economy: Estimations on macroeconomic costs and potential of carbon emission abatement in Beijing, Journal of Cleaner Production, Volume 199, 2018, Pages 603-615, ISSN 0959-6526, https://doi.org/10.1016/j.jclepro.2018.07.093.

[11] Chen Weiguo, Sun Xiaohang. How to build a new pattern of sewage treatment in the low-carbon era? China Water Network.2021-03-15.https://www.h2o-china.com/news/321723.html.

[12] Hu Weiying. Current situation and countermeasures of planting carbon emission in China [J]. Chinese and Foreign Entrepreneurs,2014(21):33-34. (in Chinese)

[13] Xinhua Net. Chemical fertilizer industry, agriculture an important source of carbon emissions. http://china.chemnet.com/, 2022-08-23.

[14] The Zhou Fate. A Brief discussion on the role and Strategy of forest low-carbon economic development [J]. Protection Engineering, 16th issue,2018.

[15] CCTV News. Beijing's energy structure has basically realized clean transformation. CCTV news. https://finance.sina.com.cn, 2022-01-05.

ISSN:2790-1661 DOI: 10.56028/aemr.4.1.35.2023

[16] Chen Hang. China News,2022-9-28. Beijing's energy structure transformation has achieved a breakthrough in the remarkable improvement of ecological environment quality [N].

[17] Baoling Jin, Ying Han, Po Kou, Dynamically evaluating the comprehensive efficiency of technological innovation and low-carbon economy in China's industrial sectors, Socio-Economic Planning Sciences, 2022, 101480, ISSN 0038-0121, https://doi.org/10.1016/j.seps.2022.101480.

[18] Wu Yiqing, Yao Lianxiao. Low-carbon economy and high-quality development in the Beijing-Tianjin-Hebei region [A].0529-1445 (2022),F124.5,F292,08-0059-04.

[19] Zhang Xuehua, Xu Wenbo, Zhang Baoan. Pre-evaluation of Xiongan New Area in promoting low-carbon coordinated development of Beijing-Tianjin-Hebei Urban Agglomeration [J]. Economic Geography, 2020, 40(3):9.

[20] Shan Zheng, Keqing Yin, Lianghong Yu, Factors influencing the farmer's chemical fertilizer reduction behavior from the perspective of farmer differentiation, Heliyon, Volume 8, Issue 12,2022,e11918,ISSN 2405-8440, https://doi.org/10.1016/j.heliyon.2022.e11918.