Research on the Prediction and Implementation Path of Carbon Peaking in Daqing City

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Abstract: This study selects carbon emission data from Daqing City from 2001 to 2023 as the subject of analysis, employs the STIRPAT model and ridge regression method to decompose the key factors affecting carbon emissions, and combines scenario analysis to construct 32 different combined scenarios to predict the carbon emissions and peak time of Daqing City from 2024 to 2035. the study results show that the factors affecting carbon emissions are generally positively correlated with Daqing City; Under the baseline scenario, Daqing City is expected to reach its carbon emission peak in 2030, while under single and combined pathway scenarios, Daqing is likely to achieve carbon peak as early as 2025. Based on the analysis and prediction results, propose suggestions in both industry and technology aspects, to take the lead in achieving carbon peak.

Key words: Daqing City; Ridge Regression; STIRPAT Model; Scenario Analysis Method; Carbon Peak

Against the backdrop of global climate change, China has set forth ambitious goals: to strive to achieve carbon peak by 2030 and to reach carbon neutrality by 2060. In 2021, the State Council further issued the "14th Five-Year Plan for Promoting High-Quality Development in Resource-Dependent Regions, " elevating the transformation of resource-based cities to a national strategic level. In this context, local governments, in their efforts to achieve carbon peak targets, prioritize seeking the best pathways for carbon emission reduction. Daqing City, as one of the Northeast oil and gas resource-based cities, faces significant ecological challenges and immense pressure on its natural environment due to over-exploitation and high energy consumption, pollution, and emissions resulting from energy processing and production, while also promoting urban development. Conducting carbon emission accounting and predicting the carbon peak pathway for Daqing City not only holds significant practical importance for Daqing's green and low-carbon high-quality development but also provides data and theoretical support for the Northeast region to achieve the carbon peak target at an early date.

Scholars both domestically and internationally have conducted research on carbon emissions and carbon peaking from multiple perspectives, focusing primarily on two main aspects:first, in terms of influencing factors of carbon emissions, Shuai et al. [1] explored the key factors affecting China's carbon emissions from 43 potential influences, identifying per capita GDP, urbanization rate, the ratio of tertiary to secondary industries, the share of renewable energy, and fixed asset investment as the most significant factors affecting carbon emissions. Wu Jiansheng et al. [2] analyzed the factors of China's carbon emissions, proposing that the sensitivity of per capita carbon emissions to various factors decreases in the following order: per capita construction land area, per capita GDP, permanent population urbanization rate, land development degree, the proportion of the secondary industry, and the share of non-fossil energy. Rao et al. [3] suggested that the main factors influencing carbon emissions in Hubei Province are, in order, total population, energy structure, industrial structure, urbanization rate, per capita GDP, and energy intensity. Domestic scholars have studied the impact of changes in factors such as per capita GDP, population size, and industrial structure on mega-city clusters and the peak of China's carbon emissions [5-7]. Secondly, in terms of predicting carbon peak, domestic and foreign experts use models such as STIRPAT model [8-9], LEAP model [10-11], BP neural network [12-14], LMDI [15-16], among which the more mature and commonly used are LEAP model and STIRPAT model. These methods and models each have their own characteristics, analyzing carbon emission trends from different perspectives and focuses, usually combined with scenario analysis to simulate the path of carbon peak.

Although previous studies have made predictions on carbon peaking for various provinces, cities, and industries and have achieved certain results, there is still a relative lack of research on carbon peaking for oil and gas resource cities like Daqing at a more detailed level. Therefore, this study focuses on Daqing City, aiming to analyze the timing and peak value of carbon emissions in Daqing City, and further provide valuable references and guidance for oil and gas resource cities in the Northeast region to achieve the goal of carbon peaking.

1. Research Methods and Data Sources

1.1 Calculation of Carbon Dioxide Emissions

This paper employs the carbon emission coefficient method provided by the IPCC to estimate the CO2 emissions of Daqing City. In conjunction with existing research, the consumption of 10 common energy sources, including raw coal, coke, crude oil, and gasoline, is selected to calculate the CO2 emissions of oil and gas resource cities in the Northeast region. the calculation formula is as follows:

$$q = CEF_i \times COF_i \times NCV_i \times 44/12 \quad (1)$$

$$C_t = \sum_{i=1}^{10} E_{it} \times CEF_i \times COF_i \times NCV_i \times 44/12 (2)$$

In the formula: CtCt represents the carbon emissions in the tt-th year, EitEit represents the consumption of the ii-th type of energy in the tt-th year, CEFi$CEFi$ represents the carbon content per unit calorific value of the ii-th type of energy, COFi$COFi$ denotes the carbon oxidation rate of the ii-th type of energy, NCVi$NCVi$ indicates the average lower heating value of the ii-th type of energy, and 44/12 represents the coefficient for converting carbon to carbon dioxide, as detailed in **Table 1.**

Table 1. CO2 Emission Coefficients for Various Types of Energy

Energy Type	CO2 emission coefficient	Energy Type	CO2 emission coefficient
Raw coal	1.900 3	Fuel oil	3.170 5
Coke	2.860 4	liquefied petroleum gas	3.101 3
Crude	3.020 2	Refinery gas	3.011 9
Gasoline	2.925 1	Natural gas	2.162 2
Diesel oil	3.095 9	Electric power	1.096 0

Note: The units of carbon dioxide emission coefficients for natural gas and electricity are kg/ m3, kg/kW, the remaining energy units are in kg/kg.

1.2 STIRPAT Model

The STIRPAT model is an extension of the traditional IPAC model developed by Dietz et al. [17]· and has become more mature in carbon emission prediction in recent years. Its traditional basic expression is:

$$I = \mathrm{a}P^bA^cT^d \quad (3)$$

In the formula, I represents environmental pressure, P, A, and T respectively represent population size, wealth level, and technological level, a is the model coefficient, b, c and d coefficients of the corresponding variables, and e is the model error term.

Based on the factors affecting carbon emissions listed in the "Guidelines for Compilation of Greenhouse Gas Inventories (Trial)" and combined with literature analysis, literature [5, 18-23] was selected to apply population size, per capita GDP, urbanization rate, industrial structure, energy structure, and energy intensity to the carbon emission impact factor model. There is a direct correlation between population growth and energy consumption, especially when the population shifts from rural to urban areas, energy consumption patterns will also change accordingly. Given the serious problem of population loss faced by Daqing City in recent years, this study will explore its potential impact on carbon emissions by analyzing the total population and urban population. In addition, this study also uses per capita GDP and industrial structure as key indicators to measure economic output, which not only reflects the level of economic development, but also reveals the economic development model dominated by the secondary industry in Daqing City.

The energy consumption in Daqing City is mainly composed of crude oil and coal, accounting for over 90%. the ratio of total energy consumption to regional GDP and the ratio of coal to total energy consumption are used as technical level variables to reflect the degree of dependence of Daqing's economic development on energy and the level of production technology development. After sorting and summarizing, population size (including year-end population and urbanization rate), wealth level (including per capita GDP and industrial structure), and technological level (including energy intensity and energy structure) were finally selected as factors affecting carbon emissions. This article introduces the above factors into the model and processes the variables. To reduce model heteroscedasticity, the logarithm of the STIRPAT model equation is taken on both sides, and the model is further expanded to:

$$\ln C = a + b\ln P + c\ln A + d\ln U + f\ln IS + g\ln EI + h\ln ES + \ln e \qquad (4)$$

In the formula: a is the model coefficient, b, c, d, f, g, h are the coefficients of the corresponding variables, e is the model error term, and other specific variables are described in **Table 2**.

Table 2. Main Variables and Explanatory Notes

Variable	Indicator Description	Unit
Carbon emissions C	The total amount of carbon dioxide emissions in the region that year	Ten thousand tons
Population size P	Year-end population of the region	Ten thousand people
Per capita GDP A	Regional Gross Domestic Product/Year end Population	Ten thousand yuan/Person
Urbanization rate U	Urban resident population/total population	%
Industrial Structure IS	Secondary industry/regional gross domestic product	%
Energy intensity EI	Total energy consumption/regional GDP	Ton of standard coal/Ten thousand yuan
Energy Structure ES	Coal consumption/total energy consumption	%

1.3 Data Source and Preprocessing

The population, per capita GDP, primary, secondary, and tertiary industries, raw coal, coking coal, crude oil, gasoline, etc. are sourced from the "China Urban Statistical Yearbook" and "Daqing Statistical Yearbook". the CO2 emission coefficient refers to the values in the IPCC CO2 emission coefficient tables for various fuels adjusted based on China's calorific value in the "IPCC 2006 National Greenhouse Gas Inventory Guidelines". the per capita GDP remains unchanged in 2000. For missing data, search for the Statistical Bulletin on National Economic and Social Development of Daqing City and supplement it with the annual government work report of Daqing City. Interpolation method is used to fill in rare data.

2 STIRPAT Model Regression Fitting Results Analysis

2.1 Stationarity Test

Using Stata 15 software for stationarity testing on the data, it was found that the first-order differenced series of the explanatory and explained variables reject the null hypothesis of the presence of a unit root, and are determined to be first-order integrated series. the results are shown in **Table 3**.

Table 3. Unit Root Test

variable	Da Qing	
	DF-GLS value	First-order stationarity
lnC	-5.027	stable
lnP	-4.781	stable
lnA	-3.158	stable
lnU	-5.039	stable
lnIS	-3.696	stable
lnEI	-4.678	stable
lnES	-3.601	stable

Note: respectively indicate significance at 10%, 5%, and 1%.

2.2 Multicollinearity Test

By using the variance inflation factor to determine whether there is multicollinearity between variables, the specific results are shown in **Table 4**. The VIF value of the variable is greater than 50, indicating the presence of collinearity between independent variables.

Table 4. Multicollinearity Test

City	lnP	lnA	lnU	lnIS	lnEI	lnES	Mean VIF
Daqing	7.61	488.2	182.16	38.2	322.61	18.63	176.23

2.3 Ridge Regression

The above analysis shows that there is a problem of multicollinearity in the explanatory variables. Therefore, this article ultimately chooses ridge regression analysis to deal with the problem of multicollinearity. the results obtained through SPSS26 software are shown in Table 5.

Table 5. Ridge Regression Results

City	lnP	lnA	lnU	lnIS	lnEI	lnES	Cons	*k*	*R2*	*p*
Daqing	0.09	0.16	1.08	0.22	0.16	0.10	0.72	*0.01*	*0.97*	*0*

Note: respectively indicate significance at 10%, 5%, and 1%.

According to Table 5, using lnP, lnA, lnU, lnIS, lnEI, and lnES as explanatory variables and lnC as the dependent variable for ridge regression analysis, the results showed that the R2 of Daqing City was above 95%, and the p-value in the F-test was less than 0.05, indicating that the model is meaningful.

Compiled the ridge regression equation for Daqing:

$$\ln C = 1.00 + 0.09\ln P + 0.16\ln A + 1.08\ln U + 0.22\ln IS + 0.16\ln EI + 0.10\ln ES \quad (5)$$

The regression fitting results of carbon emissions in Daqing City reveal that among the factors influencing carbon emissions, the urbanization rate has the greatest impact on Daqing. As the urbanization rate in Daqing City increases, agglomeration effects are produced, leading to an increase in carbon emissions. the industrial structure of Daqing City has a positive promoting effect on carbon emissions, and its impact is second only to the urbanization rate. In the economic development of Daqing City, the development of the secondary industry directly affects the increase in carbon emissions, indicating that Daqing's current low-carbon transformation should focus on adjusting the industrial structure. By developing high-tech, low-energy-consuming tertiary industries and gradually reducing the proportion of the secondary industry in the economy, a long-term reduction in carbon emissions can be achieved. For every 1% increase in energy intensity, Daqing's carbon emissions increase by 0.16%. Energy intensity represents the level of technology, and technological progress is the main factor in curbing carbon emissions. the impact of population size on Daqing's carbon emissions is the smallest. This is because Daqing City has experienced significant population outflow in recent years, which may reduce energy demand and carbon emissions to some extent. Additionally, the severe aging of the population in Daqing City also has a restraining effect on carbon emissions. At the same time, the impact of the energy structure on Daqing's carbon emissions is also relatively small, since coal consumption accounts for a small proportion of primary energy consumption in Daqing, with a primary reliance on crude oil consumption. Based on the regression analysis results, the fitted values of carbon emissions in Daqing City were calculated and compared with the actual values, as shown in Table 6.

Table 6. Comparison of Actual and Fitted Carbon Emissions in Daqing City from 2001 to 2023

Year	Daqing		
	True value/Ten thousand tons	Fitted value/Ten thousand tons	Error rate/%
2001	5572.23	5681.92	1.97
2002	5464.91	5705.74	4.41
2003	5787.02	5872.35	1.47
2004	6006.47	6058.74	0.87
2005	6363.80	6323.83	-0.63
2006	6414.55	6393.76	-0.32
2007	6379.50	6503.03	1.94
2008	6432.32	6665.73	3.63
2009	6656.15	6765.31	1.64
2010	6973.52	7086.13	1.61
2011	7158.24	7171.74	0.19
2012	7032.89	7178.00	2.06
2013	7183.31	7256.69	1.02
2014	7428.76	7385.12	-0.59
2015	7050.26	7129.10	1.12
2016	7085.28	7028.51	-0.80
2017	7266.61	7280.17	0.19
2018	6819.29	7165.84	5.08
2019	7005.29	7418.64	5.90
2020	7400.47	7462.42	0.84
2021	7801.46	7674.93	-1.62
2022	8076.86	7924.14	-1.89
2023	8400.22	7985.63	-4.94

From the figure below, the average absolute error between the actual and fitted values of Daqing's carbon emissions is 1.01%, which is within an acceptable range, indicating that the carbon emission prediction model has certain practical significance. To better demonstrate the error between the actual and fitted values of carbon emissions in Daqing City, the actual and fitted values are plotted in Figure 1.

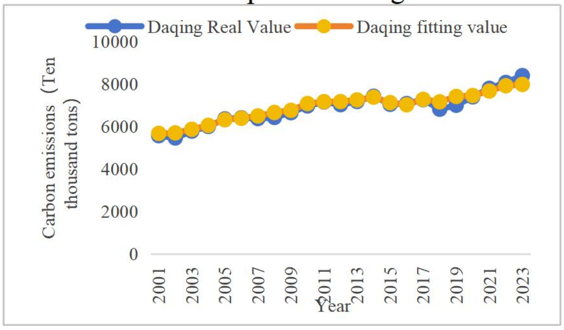

Figure 1. Comparison between Actual and Fitted Carbon Emissions in Daqing City

3 Prediction of Carbon Peak in Daqing City

3.1 Scenario Design of Factors Influencing Carbon Emissions

This paper primarily refers to the average annual growth rate from 2016 to 2020, and takes the average annual growth rates from 2006 to 2010 and 2011 to 2015 as supplementary references. Considering the "five-year" plans of Daqing City and the lag in carbon peaking results for regions dependent on high-carbon development [23], the forecast period is extended to 2035.

3.1.1 Scenario design for population size

In 2021, China's policy to allow up to three children per family was implemented, in conjunction with the two-child policy, which will lead to a certain degree of population growth in the short term [20]. However, the rise in mortality rates due to population aging and multiple pressures mean that the highest average annual growth rate of the population during the "Twelfth Five-Year Plan, " "Thirteenth Five-Year Plan, " and the past decade is set as the medium-speed development scenario for the "Fourteenth Five-Year Plan. " the difference in the average annual growth rate of the population between the "Thirteenth Five-Year Plan" and the "Twelfth Five-Year Plan" for each city is taken as the change in the average annual growth rate of the population for subsequent periods, with medium and high-speed fluctuations of ±0.1% [18].

3.1.2 Scenario design for per capita GDP

Referring to the research of Li Li et al. [25], the actual average annual growth rate of per capita GDP over the past decade is used as the growth rate under the high-speed development scenario of each city during the 14th Five Year Plan period, and the difference between the average annual growth rate of per capita GDP during the 12th Five Year Plan period is used as the change value of the growth rate from 2026 to 2030. Due to the downward trend in China's actual economic growth rate after 2012, which is expected to continue until 2040, but the rate of decline may slow down from 2030 onwards, the average annual growth rate will decrease by 0.5% on this basis, and the parameters for low and medium speed will be set at a rate of 1% difference.

3.1.3 Scenario design for urbanization rate

According to the 14th Five Year Plan report, the urbanization rate of Daqing will reach 76% by 2025. Based on the trend prediction of China's urbanization rate by Du Xiuli et al. [24], it is shown that the urbanization rate can maintain a growth trend from 2023 to 2035. Based on this, the expected annual growth rate of the 14th Five Year Plan is set as a medium speed development scenario, with fluctuations of ± 0.2% between high and low speeds. After that, the annual growth rate of future cycles gradually decreases.

3.1.4 Scenario design for industrial structure

The research team of the Macroeconomic Research Center of the Chinese Academy of Social Sciences has shown that the proportion of the secondary industry will decrease year by year, reaching about 31.69% by 2035 [[21]]· In view of this, Daqing has set this average annual growth rate as a medium speed development scenario during the 14th Five Year Plan period, and the difference in average annual growth rate from previous periods will be taken as the change value compared to the 15th Five Year Plan period.

3.1.5 Scenario design for energy intensity

During the 14th Five Year Plan period in Daqing, the expected cumulative decrease is 14.5%. the expected annual growth rate of the 14th Five Year Plan is set as a medium speed development scenario, and the difference between the average annual growth rate of the three periods of 12th Five Year Plan, 13th Five Year Plan, and 14th Five Year Plan and the medium speed is taken as the fluctuation value of high and low speed, and then each period is reduced by 0.2% on this basis[22] .

3.1.6 Scenario design of energy structure

According to the "China Energy Outlook 2030", the proportion of coal consumption is estimated to be 49% by 2030, with an average annual change rate of nearly ten years set as a high-speed reduction rate. the average annual growth rate of Daqing in the past ten years is set as a medium speed change rate during the "14th Five Year Plan" period, with fluctuations of ± 0.5% between low and high speeds, and then a decrease of 0.2% in each period based on this[22]. the change rates of carbon emission influencing factors in different time periods from 2024 to 2035 are shown in Table 7.

3.2 Scenario Combinations of Factors Influencing Carbon Emissions

Based on the research of numerous scholars, considering the emission reduction situation of each city during the 13th Five Year Plan period and the development goals and growth constraints formulated in policy documents such as the 14th Five Year Plan outline, and based on the rate of change of influencing factors in each city, comprehensively recombine each rate of each factor.

Table7. Setting the Change Rate of Various Factors in Daqing City %

City	Change rate	Time	P	A	U	IS	EI	ES
Daqing	Low speed	2024—2025	-0.53	2.30	0.75	-2.38	-3.63	1.80
		2026—2030	-0.62	0.74	0.10	-1.03	-3.43	1.60
		2031—2035	-0.91	0.24	0.00	-0.83	-3.23	1.40
	Medium speed	2024—2025	-0.43	3.30	0.95	-1.98	-2.90	2.30
		2026—2030	-0.62	1.74	0.20	-0.63	-2.70	2.10
		2031—2035	-0.81	1.24	0.00	-0.43	-2.50	1.90
	High speed	2024—2025	-0.33	4.30	1.15	-1.58	-2.17	2.80
		2026—2030	-0.52	2.74	0.40	-0.23	-1.97	2.60
		2031—2035	-0.71	2.24	0.10	-0.03	-1.77	2.40

3.2.1 Baseline Path Scenario

The setting of the change rate of each influencing factor is medium speed. This scenario is an economic development and carbon emission scenario guided by its own laws and basic energy-saving and emission reduction policies, reflecting the carbon emission development scenarios of each city according to relevant policy goals such as the 14th Five Year Plan, aiming to explore the future trends of carbon emission changes under policy planning.

3.2.2 Single Path Scenario

Under this path, various scenarios are manifested as controlling the change rate of other influencing factors to remain consistent and unchanged, only changing the change rate of one influencing factor, so that each influencing factor change rate is adjusted to low and high speed in sequence, aiming to explore the impact of changing the change rate of a single factor on the carbon peak time and peak value of Daqing City.

3.2.3 Combination path scenario

Based on the effects of various influencing factors on carbon emissions, it can be concluded that industrial structure, energy intensity, and energy structure are carbon reduction factors. the rate of change of carbon reduction factors is set at a low speed, and the rates of change of other influencing factors are selected as low speeds. the aim is to further optimize the industrial structure, improve energy utilization efficiency, and adjust the carbon emission trend when adjusting the energy structure based on the baseline scenario. Set the carbon emission scenario combinations in this article as shown in Table 8.

Table 8. Explanation of Carbon Emission Combination Scenarios

Scenario	Scenario setting
Baseline Path(Scenario 1)	Medium - Medium - Medium - Medium - Medium - Medium
Single Path(Scenario 2~ Scenario 25)	Low- Medium - Medium - Medium - Medium - Medium, Low-High-High-High-High-High, High- Medium - Medium - Medium - Medium - Medium, High-Low-Low-Low-Low-Low, Medium -Low- Medium - Medium - Medium - Medium, High-Low-High-High-High-High, Medium -High- Medium - Medium - Medium - Medium - Medium, Low-High-Low-Low-Low-Low, Medium - Medium -Low- Medium - Medium - Medium, High-High-Low-High-High-High, Medium - Medium -High- Medium - Medium - Medium, Low-Low-High-Low-Low-Low, Medium - Medium - Medium -Low-Medium - Medium, High-High-High-Low-High-High, Medium - Medium - Medium - High- Medium - Medium, Low-Low-Low-High-Low-Low, Medium - Medium - Medium - Medium -Low- Medium, High-High-High-High-Low-High, Medium - Medium - Medium - Medium -High- Medium, Low-Low-Low-Low-High-Low, Medium - Medium - Medium - Medium - Medium -Low, High-High-High-High-High-Low, Medium - Medium - Medium - Medium - Medium -High, Low-Low-Low-Low-Low-High
Combination path(Scenario 26~ Scenario 32)	Medium - Medium - Medium -Low-Low-Low, Low- Medium - Medium -Low-Low-Low, Medium -Low- Medium -Low-Low-Low, Medium - Medium -Low-Low-Low-Low, Medium -Low-Low-Low-Low-Low, Low-Medium -Low-Low-Low-Low, Low-Low-Medium -Low-Low-Low

Note: the six combination values set in the scenario represent population size, per capita GDP, urbanization rate, industrial structure, energy intensity, and growth rate of energy structure in sequence.

3.3 Carbon Peak Prediction Results and Analysis

Input the predicted values of the change rates of various influencing factors in the 32 composite scenarios into the STIRPAT model to calculate the forecasted carbon emissions for Daqing City, and determine the peaking time and peak value of Daqing City under different scenarios.

3.3.1 Baseline path scenario carbon peak prediction results

Under the development of the baseline path scenario based on the actual change rate of carbon emission influencing factors in Daqing City, it can be concluded that Daqing will achieve carbon peak by 2030. the predicted trend of carbon emissions for the baseline path scenario of Daqing City from 2024 to 2035 is shown in Figure 2.

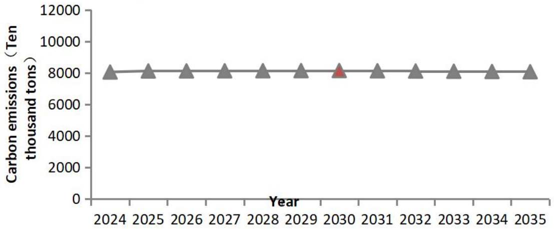

Figure 2. Trend of Carbon Emissions Forecast for the Baseline Path Scenario from 2024 to 2035

3.3.2 Single path scenario carbon peak prediction results

In the single-path scenarios 2 to 25, Daqing City is able to achieve carbon peaking before 2030 in 18 out of the scenarios., including scenario 2 with a peak of 81.39505 million tons, scenario 4 with a peak of 81.4968 million tons, scenario 5 with a peak of 80.173 million tons, scenario 6 with a peak of 80.922 million tons, scenario 8 with a peak of 82.3384 million tons, scenario 9 with a peak of 80.6436 million tons, scenario 10 with a peak of 80.8272 million tons, scenario 12 with a peak of 82.6796 million tons, scenario 13 with a peak of 80.8344 million tons, and scenario 14 with a peak of 81.0283 million tons. Scenario 16, with a peak value of 81.9526 million tons, Scenario 17, with a peak value of 80.4339 million tons, Scenario 18, with a peak value of 80.9784 million tons, Scenario 20, with a peak value of 82.1302 million tons, Scenario 21, with a peak value of 80.5321 million tons, Scenario 22, with a peak value of 81.166 million tons, Scenario 24, Its peak is 81.724 million tons, and in scenario 25, its peak is 80.3024 million tons. Under the scenario of changing the low-speed change rate of only one influencing factor and controlling for the medium speed change rate of other influencing factors, it was found that scenarios 5, 10, 13, 14, 17, 18, 21, and 25 achieved carbon peak five years earlier than other scenarios that changed the rate of change of a single influencing factor, that is, by 2025.

3.3.3 Prediction results of carbon peak in combination path scenario

Based on the carbon peak prediction results under 32 combined scenarios, Daqing City will achieve carbon peak before 2035 under 27 scenarios. In scenarios 26 to 32 of the combined path, Daqing achieved carbon peak in 2025 in all seven scenarios. Under scenario 26, the peak carbon peak in Daqing City in 2025 was 80.7536 million tons, scenario 27 was 80.7405 million tons, scenario 28 was 80.5027 million tons, scenario 29 was 80.4085 million tons, scenario 30 was 80.1586 million tons, scenario 31 was 80.3954 million tons, and scenario 32 was 80.4896 million tons. the lowest scenario is scenario 30, with a peak of 80.1586 million tons, and the highest scenario is scenario 26, with a peak of 80.7536 million tons.

4. Conclusions and Recommendations

4.1 Conclusions

Based on the STIRPAT model and scenario analysis method, 32 scenario combinations were set to predict the carbon emissions of Daqing City from 2024 to 2035, and the following conclusions were drawn:

(1) Ridge regression analysis revealed significant differences in the impact of various influencing factors on carbon emissions in Daqing City, and all of them have a positive driving effect. Among numerous influencing factors, the urbanization rate has the most significant impact on the carbon emissions of Daqing City, followed closely by the industrial structure, followed by energy intensity and per capita GDP. These two influencing factors have similar effects on the carbon emissions of Daqing City, but compared to other influencing factors, the impact of population size and energy structure on the carbon emissions of Daqing City is relatively small.

(2) This study simulated 32 different carbon emission scenarios based on the current socio-economic situation and future policy planning of Daqing City, and predicted the years 2024-2035. the results showed that under different development paths, Daqing City is expected to achieve carbon peak before 2035. Specifically, in the baseline scenario, Daqing is expected to

reach its peak carbon emissions by 2030; In a single path scenario, 19 scenarios show that Daqing can achieve carbon peak before 2030; In the combination path scenario, Daqing can achieve carbon peak in 7 scenarios.

4.2 Recommendations

Based on the above research conclusions, this article proposes the following three suggestions for Daqing City to achieve its carbon peak target as soon as possible, starting from the two key areas of optimizing industrial structure and reducing energy intensity:

(1) Promote the green transformation of manufacturing industry

On the one hand, Daqing City should deeply implement the concept of green development, actively support traditional industries such as petroleum and petrochemicals to move towards the mid to high end, and include industries with high technological content, low resource consumption, and relatively less environmental pollution such as automobiles, new materials, and modern agriculture in the city's key industrial planning.

On the other hand, Daqing should increase financial support for green manufacturing industry, and provide fixed assets investment incentives and economic contribution incentives for new industrial projects that conform to the development direction of petrochemical, automobile, new energy equipment and strategic emerging industries in the high-tech zone.

(2) Cultivate emerging industries

On the one hand, Daqing City should focus on developing the deep processing industry of agricultural and animal husbandry products. Given that Daqing City has abundant arable land and grassland resources, it can implement the strategy of "transforming agriculture into animal husbandry" according to market demand and actively promote the development of animal husbandry. At the same time, we will strengthen support for deep processing enterprises of agricultural products, develop green, low-carbon and circular agriculture, create a green and low-carbon agricultural industry chain, build an integrated comprehensive information service platform covering the agricultural product industry chain, improve the comprehensive capabilities of the smart agriculture information service platform, strengthen policy finance support for green agriculture, and promote the prosperity of green agriculture.

On the other hand, actively expanding the tertiary industry. For example, in the service and information industries, measures such as increasing industrial investment incentives and providing financial support can be taken to break the single dominant situation of oil and gas resource-based industries. the government can provide fiscal subsidies and tax incentives to support the introduction and development of non oil industries, agricultural and animal husbandry industries, biotechnology industries, service industries, and new energy industries, promoting industrial transformation and upgrading of industrial structure. In terms of tourism, Daqing City can make full use of its rich tourism resources, such as the Iron Man Wang Jinxi Memorial Hall, Daqing Longfeng Wetland Nature Reserve, Lianhuan Lake, Lianhua Lake, Duerbote Mountain Grassland and other famous scenic spots, to develop characteristic tourism routes such as petroleum culture tourism, wetland landscape tourism, and urban scenery tourism, to expand the scale of characteristic tourism industry. Only by promoting the diversification of industrial structure can Daqing City achieve the optimization and upgrading of urban industrial structure.

(3) Intensify technological research and development efforts

The development technology of clean and low-carbon energy such as wind power, solar energy, and geothermal energy in Daqing City is increasingly improving. At the same time, the widespread application of digital technology and artificial intelligence provides solid technical support for building a diversified, collaborative, efficient, and highly complementary clean energy system. To further accelerate energy technology innovation, it is recommended that relevant teams increase their investment in technology research and development, actively attract industry elites, integrate technological resources, and build innovation platforms. We can use the National Key Laboratory of Energy and major energy engineering projects as a basis to strengthen the research and development of key core technologies and the transformation of achievements, thereby improving the efficiency and safety of energy transformation and ensuring the smooth progress of the energy transformation process. Through these measures, Daqing City will be able to make greater breakthroughs in the field of clean energy, providing strong support for the city's green development and optimization of energy structure.

Acknowledgments

Fund Project: Northeast Petroleum University Campus Cultivation Fund Project "Research on Carbon Peak Prediction and Implementation Path of Oil and Gas Resource based Cities" (2022QYDL) ; Daqing Philosophy and Social Sciences Planning Research Project “Research on Carbon Peak Prediction and Implementation Path in Daqing City”(DSGB2024183).

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