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Carbon Emission Forecast of Construction Industry based on G(1,1) Grey Forecasting Model

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Abstract

At present, global climate change, the greenhouse effect is an indisputable fact. Carbon emissions are affecting people's lives and polluting the environment. In the late 18th century, the content of greenhouse gases such as carbon dioxide in the atmosphere began to increase. Since the Industrial Revolution, human activities have increased the amount of carbon emissions in the atmosphere by about 25% to 30%. "According to the data of the United Nations Environment Program, the culprit of environmental damage caused by industrial pollution." "The impact of human activities on the concentration of carbon dioxide mainly comes from three aspects: consumption of mineral burning, deforestation and other land use changes, Cement industry production." Among them, the construction industry is a major carbon emitter, so this article predicts future carbon emissions based on G (1,1) gray prediction and matlab curve fitting, hoping to get more accurate data and make corresponding countermeasures.

Keywords

G(1,1); Building Composition; Carbon Emissions; Fitting Prediction.

1. Introduction

Scientific research shows that the increase in carbon emissions is the direct cause of global warming [1-2], the greenhouse effect, and the occurrence of extreme weather, such as typhoons, high temperatures, heavy rains, mudslides, droughts and other natural disasters. The trend of temperature warming is intensifying, the melting of ice and snow in the Arctic and Antarctica is accelerating, and the sea level is rising year by year, which has severely damaged the ecological environment. In 2009, the US Environmental Protection Agency also admitted for the first time that greenhouse gases caused by increased carbon emissions would directly harm the environment. People's physical health and quality of life. The main factor for the increase in carbon emissions is due to the massive use of fossil energy by mankind. High energy consumption means high carbon emissions. Since China's reform and opening up, my country's economy has developed rapidly, population and human income have continued to increase, and the demand for energy and resources has also increased sharply. Therefore, carbon emissions have continued to increase, so study Carbon emissions play a vital role. The construction industry has always been a large carbon emitter, so carbon emissions forecasts are made on this basis, and more advanced algorithms are used to calculate carbon emissions.

2. Concepts and Principles of Grey Forecasting

2.1. Overview

Regarding the so-called "color" prediction or detection, it can be roughly divided into three colors: black, white, and gray. Here we take prediction as an example. Among them, white

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prediction means that the internal characteristics of the system are completely known, and the system information is completely sufficient; black prediction means that the internal characteristics of the system are unknown, and can only be studied by observing its connection with the outside world; gray prediction is between A prediction between black and white, part is known, part is unknown, and there is an uncertain relationship between system factors. Comparison of fineness: white>black>grey. Gray prediction is to identify the degree of difference in the development trend between the factors of the system by calculating the correlation between the factors. Its core system is the Grey Model (GM), that is, the method of generating approximate exponential laws by accumulating the original data (or accumulating, subtracting, and means, etc.) in the modeling method (because of the research on related carbon emission data , It does not follow a very regular linear growth model, but to a certain extent follows an exponential growth model).

2.2. Specific Steps

First we have to enter the original sequence:

$$x^{(0)} = \left(x^{(0)}(1), x^{(0)}(2), \dots, x^{(0)}(n)\right)$$

Then we perform a simple accumulation operation on the model in the initial sequence:

$$x^{(1)} = \left(x^{(1)}(1), x^{(1)}(1) + x^{(1)}(2), \dots, x^{(1)}(1) + x^{(1)}(2) + \cdots + x^{(1)}(n)\right)$$

Then through formula:

$$\left[x(2) - x(1), x\left(3 - x(2), \dots, x(n) - x(n-1)\right)\right]$$

Summarize the above formula:

$$\partial^{(1)} x^{(0)} = \left(\partial^{(1)} x^{(0)}(2), \dots, \partial^{(1)} x^{(0)}(n)\right)$$

Finally, you can get the mean generation sequence:

$$z^{(1)} = \left(z^{(1)}(2), z^{(1)}(3), \dots, z^{(1)}(n)\right)$$

In the specific release process of carbon emissions, there are not only fixed processes, such as fixed carbon emissions per unit of lime cement production, but also carbon emissions that we cannot estimate, such as carbon emissions from machinery consumption during use. A very regular use and consumption cannot be guaranteed during use, which will lead to many disturbance factors in the calculation of carbon emission sub-projects. Therefore, the gray prediction model is used to predict the carbon emissions of the overall construction industry to avoid its possible consequences. The equation is disturbed, which leads to estimation errors. [3]

3. The Overall Carbon Emission Data of the Specific Construction Industry

3.1. Analysis of Specific Carbon Emissions in Recent Years

According to the National Bureau of Statistics, we can get the construction area data of the relevant construction industry more clearly, as shown in the figure below:

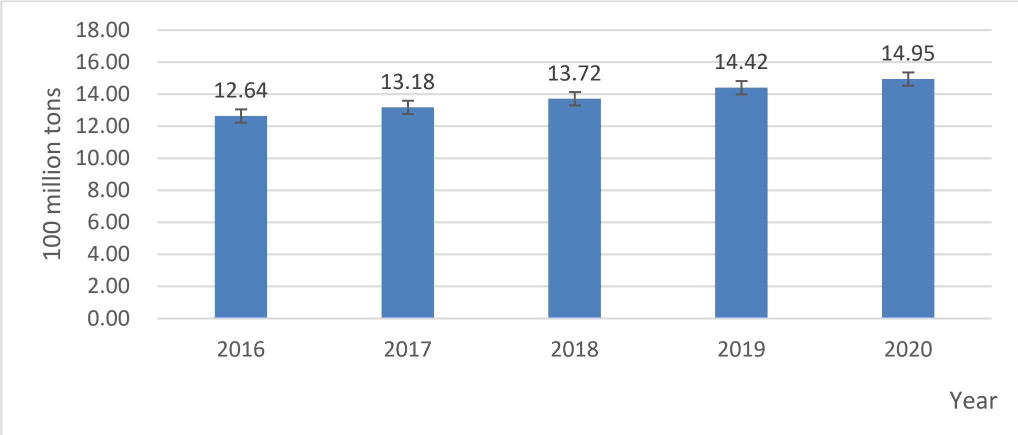

Figure 1. Construction industry area

However, there is no overall carbon emission data or related data for the specific construction industry in each relevant webpage or database. By studying the carbon emission process, it is not difficult to see the law, because the overall carbon emission can be divided into its consumption during the construction process. The basic carbon emissions of, the carbon emissions of natural gas consumption in the production and use process, and the diesel consumption in the production and use process. Therefore, we propose a relevant model for the analysis and calculation of the carbon emissions of a single project:

$$C = S * P$$

$$\mathrm{CO}_2 = \sum_{i=1}^{3} (K_i \times C)$$

Among them, CO2 represents the carbon emissions of a single item, and Ki represents three carbon emission factors (K1 represents the basic carbon emissions of the constituents, K2 represents the basic natural gas consumption of the constituents, and K3 represents the basic diesel consumption of the constituents. Mechanical consumption is different. Separate analysis according to Ki below), C represents the specific consumption, S represents the building area, and P represents the corresponding proportion.(we can get from the chart 1).

3.2. Display of the Specific Proportion of TS and the Proportion of P

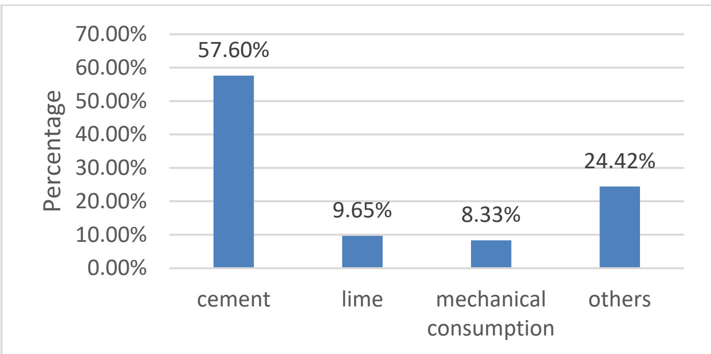

Figure 2. Percentage of related carbon emissions

According to the proportion of various consumption in the above chart2, it is not difficult to conclude that the cement industry is the largest energy-consuming unit. Energy consumption accounts for about 57.6% of the total energy consumption in the building materials industry.

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The industry's energy consumption accounted for 9.65%, and finally the carbon emissions from machinery consumption (others), which accounted for about 8.33% of the carbon emissions

Therefore, we can get the total proportion TS of related cement, lime and machinery consumption:

$$TS = 75.58\%$$

3.3. K_i Factor Consumption

During the use of building materials, there is nothing more than basic carbon emissions, carbon emissions from natural gas use, and carbon emissions from diesel use. The remaining emissions account for a small number. Therefore, we may wish to use these three as the main factors and calculate them based on the specific consumption in 2020. Correspondingly, the basic carbon emission of cement is $596.7\text{kgCO}_2/t$, the consumption of diesel and natural gas is 0; the basic carbon emission of lime is $85.14\text{kgCO}_2/t$, and the consumption of natural gas is $13.15\text{kgCO}_2/t$, Diesel consumption is $1.436\text{kgCO}_2/t$.

According to the calculation of the "China Greenhouse Gas Inventory Study" issued by the Climate Change Department of the National Development and Reform Commission in 2005, the emission factors of China's diesel and gasoline can be obtained as 3.1451 kgCO_2e /kg and 3. 0425 kgCO_2e /kg, and the calculated electricity emission coefficient is 0.6101 kgCO_2e /kWh.

3.4. Yearly Adjustment Factor T

If we get the future carbon emission forecast based only on the building area multiplied by the carbon emission per unit area, we will ignore the important factors such as technological progress, material replacement, and so on. Therefore, we set T as the annual adjustment coefficient. The calculation coefficients of we through fitting adjustments, we can get the nearly 5 T scale coefficients as follows:

$$T = 0.86, 0.74, 0.82, 0.84, 0.93$$

3.5. Calculation and Display of Overall Carbon Emissions

Therefore, we might as well establish relevant prediction models based on the above equations to carry out the overall carbon emissions of the construction industry. We propose related models by studying the specific processes of the specific carbon emissions of the construction industry:

$$T\text{CO}_2 = \frac{\text{CO}_2 c + \text{CO}_2 s + CE_{\text{T}}}{TS} * T$$

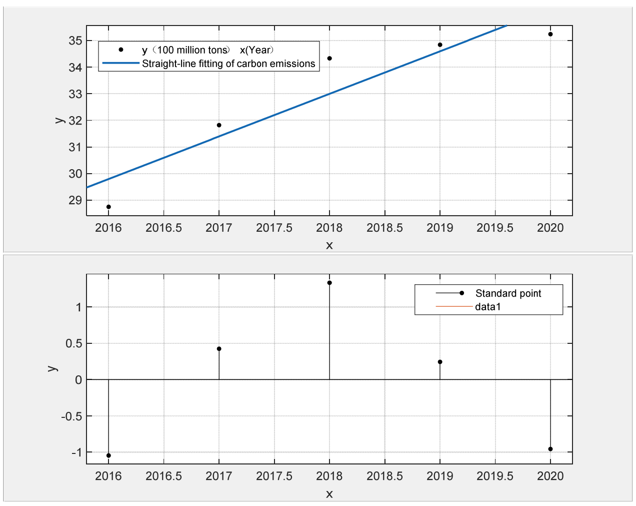

Figure 3. Straight line fitting model

TCO2 represents the overall carbon emissions of the construction industry, CO2c represents the carbon emissions of specific cement in the construction industry, CO2s represents the carbon emissions of specific lime in the construction industry, CET represents the carbon emissions of mechanical construction in the construction industry, T is the time adjustment factor, and TS represents cement, lime , The ratio of machinery consumption to carbon emissions.

After relevant calculations, we might as well use X as the year and Y as the specific carbon emission (100 million tons) of the construction industry to make a corresponding line segment, as shown in Fig 3.

We use Matlab to perform a simple linear linear fitting, and the data obtained are as follows:

Linear model Poly1:

f(x) = p1*x + p2
where x is normalized by mean 2018 and std 1.581
Coefficients (with 95% confidence bounds):
p1 = 2.53 (0.6863, 4.373)
p2 = 33 (31.35, 34.64)

Goodness of fit refers to how well the regression equation fits the observations. The statistic that measures the goodness of fit is the coefficient of determination (also known as the coefficient of determination) R^2. The maximum value of R^2 is 1. The closer the value of R^2 is to 1, the better the fit of the regression line to the observed value; on the contrary, the smaller the value of R^2, the worse the fit of the regression line to the observed value. In this example, the value of R^2 is relatively close to 1, which means that the collected examples can be fitted with linearity to find the future trend of relevant changes.

$$R^2 = 0.7941$$

It is found that if it uses simple fitting, the value of R^2 is relatively small, indicating that the fitting effect is not good, and the predicted value will deviate greatly from the actual value, and to a certain extent, the five years The overall carbon emission trend of the construction industry shows an exponential function trend, so the gray prediction model is used to predict, in order to obtain a better fitting model and accurate carbon emission prediction.

4. Actual Forecast Establishment and Analysis

4.1. Preparation Parameters

In the actual integration process, we use Matlab to calculate and fit the model [4].

First of all, we might as well set x0 as the initial data group:

$$x0 = [28.7500 \quad 31.8200 \quad 34.3300 \quad 34.8400 \quad 35.2400]$$

If the abscissa is set as a year, the relevant calculation results will be too large, which is not conducive to data analysis, so it is better to set the data as an arithmetic series starting from 1 with a tolerance of 1. First, let n = length(x0)

Then we calculate the level ratio and its range:

$$lamda = x0(1{:}n-1)/x0(2{:}n)$$
$$\text{range} = \text{minmax}(\text{lamda}')$$

Then we set x1 = cumsum(x0) and set the data vector Y = x0 (2:n).
hen we pass the constructed data matrix B:

$$B = [-0.5*(x1(1{:}n-1)+x1(2{:}n)),ones(n-1,1)]$$

Fitting parameters $u(1) = a, u(2) = b$, make $u = B\backslash Y$.

4.2. Concrete Solution

Establish related models[5] to solve:

$$x = dsolve(diff(x) + u(1) * x == u(2), x(0) == x0(1))$$

The final prediction result is:

$$\text{xt} = 1023.79 * \exp(0.0312293 * \text{t}) - 995.042$$

We import the data into Matlab to solve:

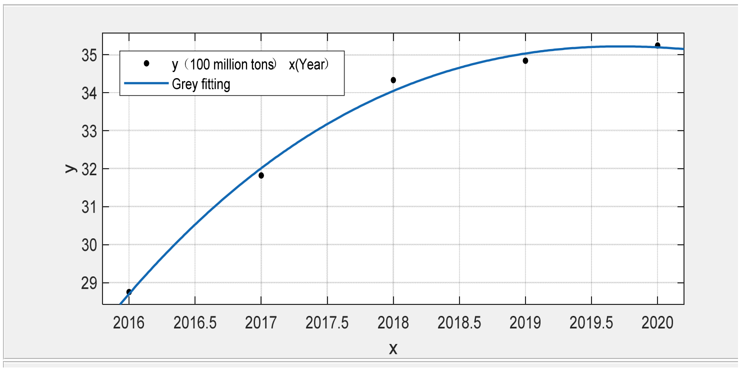

Figure 4. Gray model fitting display

It is not difficult for us to see from the image that after using the gray model curve prediction, the data are all around the curve we simulated. The deviation is better than the straight line fitting, and it can better reflect the specific predicted value. According to the G(1,1) model Predictive analysis is performed because of the following characteristics: 1. It does not require a large number of samples. 2. The sample does not need to have a regular distribution. 3. The calculation workload is small. 4. The results of quantitative analysis and qualitative analysis will not be inconsistent. 5. Can be used for recent, short-term, medium- and long-term forecasts. 6. The gray prediction accuracy is high. Use residual test and posterior test to check the GM (1,1) model Test. The residual test is based on the average relative error between the predicted value and the actual value φ to test the accuracy of the model. If φ<0. 05. Explain that GM (1,1) is connected After the residual test, the model is credible and reliable, with high prediction accuracy, and can be used for Line forecast. The posterior error test uses the mean square error S2 of the absolute error and the original sequence of numbers The ratio C of the mean square error S1 and the probability of the point with the smaller absolute error P The size of the method to test the accuracy of the model. The smaller the test index C, the smaller the index P

The larger the value, the higher the prediction accuracy of the GM (1,1) model. Then we choose P to test, we can get:

Table 1. Test coefficient P ($P = 0.9547$)

Forecast accuracy level	Probability of small error P
Good	>0.95
Qualified	>0.80
Barely qualified	>0.70
Failed	≤0.70

From the table 1, By comparison we can get: its value is Higher than 0.95, which proves that our fitting curve fits well within this spatial range. Therefore, using this data to predict carbon emissions in the next five years, we can get:

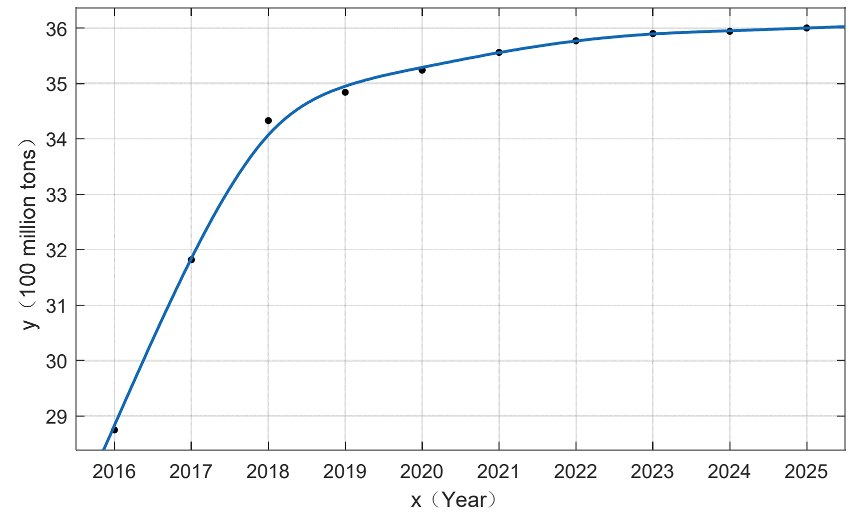

Figure 5. Showcase of future carbon emissions gray forecast

4.3. Corresponding Measures

4.3.1. Enterprise is the Key Subject of the "Dual Carbon" Goal

My country's "dual-carbon" goal is not only a conscious action to promote high-quality development and achieve green transformation, but also a responsibility to deeply participate in global environmental governance. The proposal of the "dual carbon" goal means that sustainable development is no longer a plus for the company's own "high standards and strict requirements", but a "pass line" for survival and development. As a key group enterprise that bears and realizes the "dual carbon" goal, it will be the main force in the carbon reduction movement of the whole society.

4.3.2. Development of Renewable Energy Utilization with Buildings as Carriers

Use renewable energy such as wind energy near the building complex to reduce dependence on fossil energy, use various scattered renewable energy through buildings, and greatly reduce carbon dioxide emissions in the energy use process, and avoid the use of renewable energy on-site in order to achieve remote energy transportation and power conversion.

4.3.3. Forced Corporate Transformation with Low-carbon Construction Industry Policies

The industrial policy of low-carbon buildings mainly promotes the transformation of the construction industry with energy conservation and emission reduction. Use new lightweight building materials, especially heat-insulating building materials that use waste, such as:

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composite materials made of agricultural waste straw as raw materials; standardize the construction industry to fully absorb sustainable design elements, save land as much as possible, and maintain a compact development model; Pay attention to the recyclability of building components and materials.

5. Conclusion

From the data, we can see that from 2016 to 2018, the carbon emissions of my country's construction industry showed a rapid upward trend, and the upward trend was more obvious, from 2.8 billion tons of carbon emissions to nearly 3.45 billion tons of carbon in just two or two years. Emissions, the situation is not optimistic, so my country has pioneered the "dual carbon target" and has made initial achievements in 2019 and 2020, and has played a pioneering and exemplary role in low emissions in the future. At the same time, we can see that my country’s construction industry carbon emissions have approached saturation in 2025, which is a good sign, but we still need to continue to persist and continue to adopt the above to reduce carbon emissions in the hope of getting better results. The contribution to the reduction of world carbon emissions belongs to one's own power.

References

[1] IPCC. Climate Change 2014: Impacts, Adaptation, and Vulnerability[Z], 2014.

[2] IPCC. Contribution of working groups I,II and III to the fourth assessment report of the inter-governmental panel on climate change[Z]. Geneva,2007.

[3] QIU Shujuan, LIU Jianfeng,WU Ming,et al.Grey prediction model of the regular of wax deposition incrude oil pipeline [J]. Journal of Liaoning University of Petroleum & Chemical Technology,2005 (4): 42-44.

[4] Deng Julong. The basic method of grey system[M]. Wuhan: Huazhong Institute of Technology Press, 1987.

[5] Liu Sifeng. Grey system theory and its application[M]. 8th edition. Beijing: Science Press, 2017.