Construction of dual-carbon goal realization path based on fractal theory

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Abstract: The amount of CO_2 emissions is related to people's life, social progress and national development. To seek a balance between environmental protection and social progress is a problem that scholars have paid close attention to. This paper firstly studies the data of carbon emissions from 1997 to 2019, and conducts relevant processing on the data. Using fractal theory to predict the processed data, the prediction results show that my country's carbon emissions will continue to grow. Finally, corresponding countermeasures are put forward for the realization of the dual-carbon goal.

Key words: Dual-carbon; fractal; realization path.

1. Introduction:

Since the Industrial Revolution, the process of industrialization and modernization in the world has been accelerating, and environmental problems arising from production and life have gradually emerged. In recent years, the global economic growth and ecological environment have faced major challenges, and there is an urgent need to reach an international consensus on environmental protection and green development [1]. As early as 2015, President Xi proposed five development concepts of "innovation, coordination, greenness, openness and sharing", and announced at the United Nations General Assembly in 2020 that China will strive to achieve "carbon peak" by 2020 and "carbon peak" by 2060. carbon neutrality" goal. At present, we are in a critical period of realizing the "Dual-Carbon Goal", and it is of great practical significance to study the realization path of the "Dual-Carbon Goal". Many scholars have studied the realization path of the "two-carbon goal" from different perspectives [2-4], and have achieved rich research results. The term Fractal was first proposed by American mathematician Mandelbrot to describe the more complex, irregular and unstable phenomena in nature [5]. In Euclidean geometry, the dimensions are all integers, that is, points are 0-dimensional, lines are 1-dimensional, finite planes are 2-dimensional, and solid geometry is 3-dimensional. But it was later found that this geometry could not explain many irregular graphic laws in life. Mandelbrot explained this: the whole can be regarded as the enlargement of the part in a certain proportion, that is, the part and the whole have a similar shape in a certain proportion. In 1975, Mandelbrot proposed fractal geometry and fractal theory successively, he believed that the dimension is continuous, not necessarily an integer. Dimension is an important feature quantity of geometric objects, which contains many information and properties of graphics. Fractal dimension is a very important concept in fractal theory and application. It is the most important parameter to measure the complexity and irregularity of fractal graphics, objects or fractal bodies. rules and vice versa. Fractal dimension shows that the fractal body has self-similarity between the part and the whole in one aspect of shape, structure, information, function, time, energy, etc., and quantitatively describes the degree of self-similarity. In geometric mathematics, the fractal dimension reflects the effectiveness of the space occupied by the fractal body. Fractal dimension expands the meaning of dimension, and the change of space dimension can be either discrete or continuous. Fractal dimension has a wide range of applications in data prediction [6], information recognition [7] and other fields.

This study uses fractal dimension to forecast the national energy consumption, and according to the forecast results, proposes the realization path of the "dual carbon goal".

2. Fractal model and prediction results

A fractal distribution can be defined by the following power exponential distribution:

$$N = \frac{C}{r^D} \tag{1}$$

Among them, r is the characteristic length such as time, length, etc.; N represents the number of observation targets related to r, which can be price, speed, $C0_2$ emission, etc.; C is the undetermined coefficient, which can be calculated by other values; D represents with fractal dimension. In this study, r represents the year, such as the first year, r1=1; the second year, r2=2. N is the national $C0_2$ emissions in the year. D can be calculated from any two data (N_a, r_a) and (N_b, r_b) on a straight line,

$$D = [\ln(N_a) - \ln(N_b)] / [\ln(r_b) - \ln(r_a)] \quad (2)$$

we can get (3) from (1)

$$C = N_a r^D \quad (3)$$

It should be pointed out that in the research of this paper, all variables involved in the formula are positive numbers. Due to the nonlinear relationship between the data in this study, it is necessary to use the concept of variable dimension fractal for calculation, so as to predict the emission of $C0_2$, and then put forward corresponding suggestions for the realization of the "dual carbon goal".

This study uses the series transformation of cumulative sum proposed by Fu [6] to process the data, so that the processed data is more in line with the fractal distribution model, so that the future data can be reasonably predicted. The method is as follows:

The first step is to plot the original data in the double log coordinate axis. Obviously, these data without obvious regularity generally do not satisfy the fractal distribution. N can form a basic sequence, namely:

$$N_a = \{N_1, N_2, N_3, ...\} (a = 1,2,3.....) \quad (4)$$

Other sequences can be constructed based on the basic sequence, the first-order cumulative sum sequence S_1, where S_{11}=N_1, S_{12}=N_1+N_2, S_{13}=N_1+N_2+N_3. By analogy, higher-order cumulative sum sequences can be constructed.

$$S1a = \{N_1, N_1 + N_2, N_1 + N_2 + N_3, ...\} (a = 1,2,3, ...a) \quad (5)$$

$$S2a = \{S_{11}, S_{11} + S_{12}, S_{11} + S_{12} + S_{13}, ...\} (a = 1,2,3, ...a) \quad (6)$$

$$S3a = \{S_{21}, S_{21} + S_{22}, S_{21} + S_{22} + S_{23}, ...\} (a = 1,2,3, ...a) \quad (7)$$

The processed data are shown in Table 1:

Table 1 original data and processed data

Year	Original	First-order	Two-order	Three-order
1997	**2923.85556**	**2923.85556**	**2923.86**	**2923.86**
1998	**2886.345645**	**5810.201206**	**8734.056766**	**11657.92**
1999	**2878.639872**	**8688.841078**	**17422.89784**	**29080.81**
2000	**3003.426725**	**11692.2678**	**29115.16565**	**58195.98**
2001	**3250.146167**	**14942.41397**	**44057.57962**	**102253.6**
2002	**3472.133954**	**18414.54792**	**62472.12754**	**164725.7**
2003	**4084.320775**	**22498.8687**	**84970.99624**	**249696.7**
2004	**4695.809704**	**27194.6784**	**112165.6746**	**361862.4**
2005	**5398.279906**	**32592.95831**	**144758.633**	**506621**
2006	**6008.710384**	**38601.66869**	**183360.3016**	**689981.3**
2007	**6546.296649**	**45147.96534**	**228508.267**	**918489.6**
2008	**6761.019282**	**51908.98462**	**280417.2516**	**1198907**
2009	**7333.675089**	**59242.65971**	**339659.9113**	**1538567**
2010	**7904.547464**	**67147.20718**	**406807.1185**	**1945374**
2011	**8741.562054**	**75888.76923**	**482695.8877**	**2428070**
2012	**9080.54839**	**84969.31762**	**567665.2054**	**2995735**
2013	**9534.235131**	**94503.55275**	**662168.7581**	**3657904**
2014	**9451.281631**	**103954.8344**	**766123.5925**	**4424027**
2015	**9253.502801**	**113208.3372**	**879331.9297**	**5303359**
2016	**9256.251069**	**122464.5883**	**1001796.518**	**6305156**
2017	**9408.170796**	**131872.7591**	**1133669.277**	**7438825**
2018	**9621.119877**	**141493.8789**	**1275163.156**	**8713988**
2019	**9794.756397**	**151288.6353**	**1426451.791**	**10140440**

The second step is to establish a fractal model according to the data of the selected order.

Each data point is plotted in the double log coordinates, and compared with the fractal distribution model, the sequence with the best fitting degree is selected, and the corresponding fractal dimension is calculated. Then make predictions about the next data.

Table 2 Fractal dimension of C02 emissions in each year

Year	$C0_2$Emissions	D	D1	D2	D3
1997	2923.85556	-0.0186	-0.9907	-1.5788	-1.9954
1998	2886.345645	-0.0066	-0.9925	-1.7031	-2.2544
1999	2878.639872	-0.1475	-1.032	-1.7849	-2.4115
2000	3003.426725	-0.3538	-1.0992	-1.8564	-2.5259
2001	3250.146167	-0.3624	-1.146	-1.9154	-2.6153
2002	3472.133954	-1.0534	-1.2995	-1.9954	-2.6984
2003	4084.320775	-1.0448	-1.4196	-2.0794	-2.7785
2004	4695.809704	-1.1836	-1.5374	-2.1658	-2.8569
2005	5398.279906	-1.0168	-1.6059	-2.2436	-2.9319
2006	6008.710384	-0.8991	-1.6436	-2.3095	-3.0014
2007	6546.296649	-0.3709	-1.6038	-2.3526	-3.0621
2008	6761.019282	-1.0157	-1.651	-2.3945	-3.1164
2009	7333.675089	-1.0115	-1.69	-2.4342	-3.1657
2010	7904.547464	-1.4589	-1.7738	-2.4792	-3.2125
2011	8741.562054	-0.5895	-1.7512	-2.5124	-3.2553
2012	9080.54839	-0.8042	-1.7542	-2.54	-3.2941
2013	9534.235131	0.15289	-1.6676	-2.5512	-3.3269
2014	9451.281631	0.39115	-1.5772	-2.549	-3.353
2015	9253.502801	-0.0058	-1.5322	-2.542	-3.3733
2016	9256.251069	-0.3337	-1.517	-2.5346	-3.3889
2017	9408.170796	-0.4811	-1.5137	-2.5283	-3.401
2018	9621.119877	-0.4024	-1.5057	-2.5222	-3.4105
2019	9794.756397				

In Table 2, D represents the fractal dimension of the original data, and D1, D2, and D3 represent the fractal dimension of the 1st, 2nd, and 3rd order accumulation and processing, respectively. It can be seen that the fractal dimension of the unprocessed data is positive or negative, and fluctuates greatly, and the fractal dimension of the processed data tends to be more stable. In the case of the first-order cumulative sum, we choose D=-1.5057 and C=88.1815. According to the formula, in 2019, the national carbon emissions N=9902.2; in the case of the second-order cumulative sum, D=-2.5222, C=3.9570, then N=10763; in the case of the third-order cumulative sum, D=-3.4105, C=0.254, N=11195. The prediction result of the first-order cumulative sum is closer to the real data, so in the following research, we choose the data after

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the first-order cumulative sum to predict the national CO2 emissions. The prediction results are shown in Table 3:

Table 3 Carbon emissions projections for the next few years

Year	$C0_2$ emission	C	D
2019	**9902.2**	**88.1816**	**-1.5057**
2020	**10558**	**87.8778**	**-1.5068**
2021	**11228**		

Figure 1 shows the changing trend of national $C0_2$ emissions (including forecasts) from 1997 to 2021. It can be clearly seen from Figure 1 that with the development of my country's economy, CO_2 emissions show an upward trend year by year.

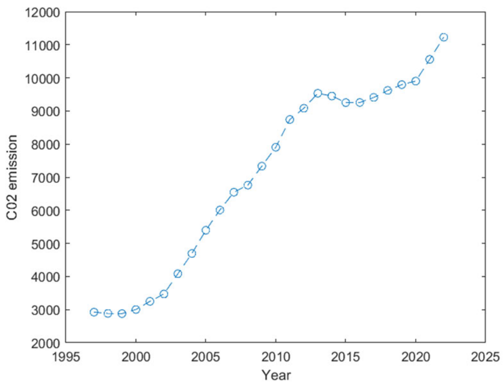

Figure 1 National CO_2 emissions

3. Paths to achieve the "two-carbon" goal

According to the forecast results in the previous section, my country's C02 emissions will continue to grow and remain at a relatively high level for a long time. In order to successfully achieve the "carbon peak" goal in 2030, it is imperative to take measures to reduce carbon emissions.

(1) Vigorously develop clean energy

According to the relevant data of the National Bureau of Statistics, the main fossil fuels in my country are coal, oil and natural gas [3]. In order to reduce our dependence on these highly polluting energy sources, we need to vigorously develop clean energy, for example, support the development of new energy electric vehicles, which can reduce the use of oil. However, the popularity of electric vehicles will also bring new problems. For example, the main power generation method in my country is thermal power generation, and the main fuel used in thermal power generation is coal. Therefore, the new energy electric vehicle reduces the consumption of oil on the surface, but it increases the demand for coal. Therefore, we should increase the proportion of other power generation methods. Our country has abundant water sources and vast land, so we should increase investment in hydropower and wind power.

(2) Transformation and upgrading of key enterprises

In addition to vigorously developing clean energy and reducing people's dependence on coal and oil in their daily lives, it is also an important measure to achieve the goal of "double carbon" by rectifying the phenomenon that some high-polluting enterprises do not meet the pollutant discharge standards. Industry is the cornerstone of a country's prosperity, but the environmental pollution caused by the production process of industrial enterprises does not conform to the principle of sustainable development. Therefore, it is necessary to promote the transformation and upgrading of these enterprises, so that the product skills produced by industrial enterprises can meet the needs of social development and conform to the principle of sustainable development.

(3) Develop high-tech energy-saving technologies

The research and development of energy-saving technology mainly has two aspects, one is independent research and development, and the other is imported from abroad. Introducing technology from abroad is simple, convenient and economical, but in the long run, it is not in our national interest. Therefore, we need to set up our own R&D team, which can not only drive industrial upgrading, but also increase domestic demand and promote the realization of domestic circulation. Energy-saving technologies can be manifested in improving energy utilization, for example, the same coal can generate more electricity; it can also be manifested in energy substitution, developing new energy sources to replace traditional fossil fuels, thereby reducing CO2 emissions and achieving the "double carbon" goal. .

4. Summary

This study uses fractal theory to predict my country's C02 emissions, and according to the prediction results, analyzes the current situation of my country's C02 emissions. In order to successfully achieve the goal of "carbon peaking" in 2030, it is imperative to save energy and reduce emissions, transform the energy structure, and promote the transformation and upgrading of related industries. At the end of the article, this study proposes measures to achieve the "two-carbon" goal.

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