Research on the Performance Evaluation of Green and Low-Carbon Industrial Development in Gansu Province

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Abstract: Having rich natural resources and important strategic location, Gansu province was deployed with a large number of key industries after the liberation of the country. However, most of these industries have high-carbon and high-emission, which not only cause more serious damage to the already fragile ecological environment, but also restrict the green and low-carbon development of industry in Gansu province. Based on the analysis of the status quo of industrial green and low-carbon development in Gansu province, this paper evaluates the performance of industrial green and low-carbon development in recent 10 years, and then puts forward the countermeasures for green and low-carbon development.

1. Status analysis of green and low-carbon industrial development in Gansu province

1.1. Evolution characteristics of industrial development in Gansu province

Industry is the main pillar of the national economy and an important force to promote economic development. From the course of industrial development in Gansu province, it can be clearly seen that from 1952 to 1959, the industry in Gansu province continued to develop rapidly, during which the output value of the secondary industry, which was mainly industrial, rose rapidly from 13% to 50% of GDP. The period from 1960 to 1963 was a backward period for the industrial development of Gansu province, which led to the rapid decline of the share of the secondary industry in the GDP, and the development of the secondary industry lagged behind the primary industry again. From 1964 to 1971 was the adjustment period of Gansu's industrial development. Although there are fluctuations in the middle, but the upward trend is obvious. During the adjustment period of industrial development in Gansu from 1972 to 1982, the proportion of the output value of the secondary industry in the GDP kept above 50%. After 1982, it entered the stable period of industrial development in Gansu, and the total industrial output value increased continuously. However, after 2000, with the rapid development of the tertiary industry, the share of the secondary industry in GDP decreased, and it was overtaken by the tertiary industry from 2014.

In this development process, the industrial development of Gansu province shows the following characteristics. Firstly, the establishment of a number of heavy and chemical industries in the early
years of the founding of the People's Republic of China, makes it play a leading role in the industrial economy of Gansu province, while light industry is seriously insufficient. Secondly, as the heavy and chemical industries in Gansu province is based on its resources, the resource-dependent industries, mainly metallurgy, coal, petrochemical and metal products manufacturing, occupy a large proportion in the industry of Gansu province. Thirdly, in the industry of Gansu province, the output value of petrochemical industry, metallurgical industry, nonferrous industry and other pillar industries accounted for a significant proportion of the total output value of the industry. In addition, since the industrial system of Gansu province is not established based on its own industrial foundation, but is the result of the implementation of the national macro strategy, the industrial industry of Gansu province has not formed a reasonable relationship with other local industries for a long time and cannot fully adapt to the needs of economic and social development [1].

1.2. Overview of industrial energy consumption in Gansu province in recent 10 years
The total industrial energy consumption in Gansu province can reflect the energy demand and dependence of industrial enterprises in the development process. In the past decade, the total industrial energy consumption of Gansu province increased from 29.885 million tons of standard coal in 2008 to 55.1683 million tons of standard coal in 2014, followed by a slight decrease in energy consumption to 51.929 million tons of standard coal in 2017. In terms of energy consumption per unit added value of industrial enterprises above the scale, it was 3.51 tons of standard coal per 10,000 yuan in 2008, and slightly increased to 3.54 tons of standard coal per 10,000 yuan in 2009, and over the next few years it went down. In 2013, it was 2.62 tons of standard coal per 10,000 yuan, the lowest energy consumption per unit added value of industrial enterprises in recent 10 years. It started to rebound in 2014 and reached 3.24 tons of standard coal per 10,000 yuan in 2017. It can be seen that the overall energy consumption of industry in Gansu province is still relatively large. Therefore, in order to improve the green development level of industry in Gansu province, it is necessary to start with the energy-intensive industrial enterprises and promote their effective use of energy.

1.3. Industrial pollution emission in Gansu province in recent 10 years
The industrial pollution emission in Gansu province mainly include waste water, waste gas and general solid waste. In terms of the pollutant emission in the past 10 years, the trend of the emission of the three pollutants is basically the same. Since 2008, emissions of all three pollutants have tended to rise and then fall. Industrial wastewater emissions peaked at 20.71 million tons in 2013 and have been declining ever since, with emissions of 104.26 million tons in 2017, significantly lower than in 2008. Emissions of industrial waste gas and general solid waste both peaked in 2012 at 1.390 billion cubic meters and 66.71 million tons respectively, and have been falling ever since, but emissions in 2017 were both higher than in 2008. From the perspective of pollutant discharge per unit value added of industrial enterprises above the scale, the discharge of industrial wastewater per unit value added has fluctuated since 2008, but the overall trend is downward, from 14.45 tons / 10,000 yuan in 2008 to 6.50 tons / 10,000 yuan in 2017. It shows that the industrial enterprises in Gansu province have achieved remarkable results in water resource recycling and sewage treatment. Industrial emissions per unit of added value rose from 5.01 cubic meters per yuan in 2008 to a peak of 7.99 cubic meters per yuan in 2015. In the past two years, they have declined to 5.62 cubic meters per yuan in 2017, which is still higher than that in 2008. The output of general solid waste per unit of added value was 2.82 tons / 10,000 yuan in 2008, and then fluctuated greatly, reaching a peak of 3.66 tons / 10,000 yuan in 2011, and decreasing to 3.15 tons / 10,000 yuan in 2017, but still higher than the emissions in 2008.

2. Performance evaluation of green and low-carbon industrial development in Gansu province in recent 10 years

2.1. Establishment of index system
To evaluate the performance of industrial green and low-carbon development, we must grasp two key points, namely "green and low-carbon" and "development". Only by organically combining the two can we achieve the goal of industrial green and low-carbon development. "Green and low-carbon" is mainly reflected in the rational allocation of resources and the full use of energy, while "development" mainly considers the economic factors, that is, to realize the improvement of the production efficiency of industrial enterprises on the basis of considering "green".

The selection of the index system for the performance evaluation of green and low-carbon industrial development in Gansu province follows the principles of systematicness, accuracy, representativeness and operability. On the basis of referring to the existing evaluation results of industrial green and low-carbon development, 7 indicators [2] [3] [4] were selected from the two aspects of industrial growth index and energy and environment index according to the actual situation of Gansu province to reflect the level of industrial green and low-carbon development in Gansu province (see table 1).

2.2. Determination of index weight
In this paper, the entropy value method of objective assignment is used to determine the weight. This method uses information entropy to calculate the entropy value of each index according to the variation degree of the observed value of each index, and then modifies the weight of each index through the entropy value, so as to obtain a more objective index weight [5]. The specific steps are as follows.

2.3. Non-negative data processing
Since the entropy method adopts the ratio of one index of each scheme to the sum of the same index value, there is no dimensional influence and no need for standardization. If there are negative numbers in the data, the data needs to be processed in a non-negative way. In addition, in order to avoid meaningless logarithm in entropy calculation, data translation is needed.

1) Calculate the proportion of the ith plan in the index of item j

\[ R_{ij} = \frac{X_{ij}}{\sum_{i=1}^{m} X_{ij}} \quad (i = 1, 2 ... m; \ j = 1, 2 ... n) \]

2) Calculate the entropy value of the j-th index

\[ e_j = -K \times \sum_{i=1}^{m} \ln (R_{ij}) \]

Where, K > 0, ln is the natural logarithm, \( e_j \geq 0 \), the constant K in the formula is related to m in the sample, and in general, K=1/ln(m).

3) Calculate the difference coefficient of item j

For the j-th index, the greater the difference of index value \( X_{ij} \), the greater the effect on scheme evaluation, and the smaller the entropy value. \( g_j = 1 - e_j \), the larger the \( g_j \), the more important the index.

4) Calculate the weight value of each index

\[ W_j = \frac{g_j}{\sum_{j=1}^{n} g_j}, \ j = 1, 2 ... n \]
This method is used to calculate 8 indicators and 80 original data of the assessment of the industrial green and low-carbon development level in Gansu province from 2008 to 2017. The weight value of the three indicators is shown in Table 1.

Table 1 Evaluation index system of industrial green and low-carbon development level

| The first grade indicators | The second grade indicators | No | The third grade indicators | weight |
|---------------------------|-----------------------------|----|---------------------------|--------|
| industrial green and low-carbon development level | industrial growth index | 1 | value-added of industry (100 million yuan) | 0.1303 |
|                           |                             | 2 | investment in industrial fixed assets (100 million yuan) | 0.1045 |
|                           |                             | 3 | average annual employed persons of industry (1000 person) | 0.1397 |
|                           | energy and environment index | 4 | industrial wastewater per unit value added (tons/10000 yuan) | 0.1113 |
|                           |                             | 5 | industrial emissions per unit of added value (cubic meters/ yuan) | 0.1077 |
|                           |                             | 6 | The output of general solid waste per unit of added value (tons/10000 yuan) | 0.1404 |
|                           |                             | 7 | The total industrial energy consumption (tons of standard coal /10000 yuan) | 0.1341 |
|                           |                             | 8 | Water use of added value (cubic meters/10000 yuan) | 0.1321 |

2.4. Performance evaluation of green and low-carbon industrial development in Gansu province

The evaluation formula of industrial green and low-carbon development level is as follows:

\[ S_i = \sum_{j=1}^{n} W_j \times P_{ij} (i = 1, 2 \ldots m) \]

The calculated weight value and the processing value of the original data are calculated according to the above formula to obtain the values of the secondary index and the primary index, that is, the values of the industrial growth index, the energy and environment index and the industrial green and low-carbon development level. The results are shown in Table 2.

Table 2 industrial green and low-carbon development level, subsystem scores and relative growth rate of Gansu province

| year | industrial green and low-carbon development level | industrial growth index | energy and environment index |
|------|--------------------------------------------------|-------------------------|------------------------------|
|      | score | growth rate | score | growth rate | score | growth rate |
| 2008 | 0.7217 | 0.2317 | 0.4901 |
| 2009 | 0.7249 | 0.43% | 0.2421 | 4.49% | 0.5064 | -1.49% |
| 2010 | 0.8002 | 10.39% | 0.2739 | 13.15% | 0.5263 | 9.01% |
| 2011 | 0.7894 | -1.35% | 0.2888 | 5.43% | 0.5006 | -1.46% |
| 2012 | 0.8274 | 4.82% | 0.3198 | 10.74% | 0.5076 | 1.40% |
| 2013 | 0.9105 | 10.05% | 0.3411 | 6.64% | 0.5695 | 12.19% |
| 2014 | 0.9289 | 2.02% | 0.3613 | 5.93% | 0.5676 | -0.33% |
| 2015 | 0.8072 | -13.10% | 0.3151 | -12.77% | 0.4921 | -13.31% |
| 2016 | 0.8139 | 0.82% | 0.2999 | -4.82% | 0.5139 | 4.44% |
| 2017 | 0.7992 | -1.79% | 0.2454 | -18.18% | 0.5538 | 7.77% |

As can be seen from Table 2, the performance of green and low-carbon industrial development in Gansu province has shown a trend of rising first and then falling in the past 10 years. In 2008, the score of industrial green and low-carbon development performance was 0.7217. Although there were
fluctuations in 2009, the overall trend was on the rise. The highest growth rate was 10.39% in 2010, followed by 10.05% in 2013. In 2014, the performance of green and low-carbon industrial development reached the highest value, with a score of 0.9289. After that, it gradually declined. Among them, the biggest decline was in 2015, when the negative growth rate reached 13.10%. The 2017 industrial green and low-carbon development performance score was 0.7992. The reason for this phenomenon is that the industrial structure of Gansu province is single, and the raw material industries such as petrochemical industry, nonferrous metal industry, metallurgy industry, coal industry and electric power industry are major, and most of them are at the bottom of the industrial chain. Under the new normal of the economy, the deep-seated problems in the industrial structure are prominent and have been severely impacted. The number of enterprises above the existing scale is not large and the scale is not strong. Competitive projects are lacking, thus no new growth point. Small, medium, micro and non-public enterprises are small in scale and low in proportion, which do not effectively support the industry of the whole province.

The change trend of industrial growth index in the past 10 years is consistent with the performance of green and low-carbon development, which also shows a trend of rising first and then falling. The industrial growth index scored 0.2317 in 2008, and then gradually increased, reaching a peak of 0.3613 in 2014. The highest growth rate was in 2012, which reached 10.74%. From 2015, the index score of industrial growth continued to decline, falling to 0.2454 in 2017. The year with the largest decline was 2015, when the negative growth rate reached 12.77%. The reason is that in recent years, the industry in Gansu province has been affected by such factors as insufficient effective demand, intensified market competition, and limited transformation and development. The growth of the petrochemical, building materials, coal, metallurgy and power industries, which account for 56% of the total, is sluggish, and the operation difficulties of resource-intensive industries are further increased. At the same time, the development of new industries, new products and new forms of business is restricted by talents, technologies and modes, and new growth points have not yet been formed, resulting in the continuous decline of the score of industrial growth index.

The changes of the energy environment index in the past 10 years are relatively complex. Although the energy environment index fluctuated from 2008 to 2012, it was generally stable. In 2008, the score was 0.4901, which decreased slightly in 2009, and increased to 0.5263 in 2010, with an increase rate of 9.01%. In the following two years, there was a downward trend, with a score of 0.5076 in 2012. 2013 saw a rapid rise, the highest growth rate in nearly a decade, to 12.19 percent. In 2014 and 2015, there was another downward trend, and in 2016 and 2017, there was an increase, with the score of 0.5538 in 2017. The reason lies in the weak foundation of green industrial development in Gansu province, the heavy chemical industry structure dominated by raw material industry, and the difficulty of energy conservation and consumption reduction. The energy consumption per unit product of some key energy-consuming enterprises has reached or approached the international and domestic advanced level through continuous technical transformation in the early stage, and the space for further energy conservation through management and technology is very limited.

3. Countermeasures for industrial green and low-carbon development in Gansu province

3.1. Promoting coordinated development of green industries

According to the natural endowment, ecological environment and industrial development foundation of Gansu province, industries with comparative advantages and characteristics should be developed, and the transfer of production factors to more efficient regions and enterprises should be promoted. We should strengthen the foundation and supporting role of traditional heavy chemical industry to the economy of Gansu province. We will take leading enterprises as the leading role and put the development of technology-intensive industries such as green manufacturing in a strategic position, promoting energy conservation, emission reduction and green manufacturing technology. We will develop profound processing industries, extend industrial chains, and improve the degree of industrial aggregation and the utilization of resources. Taking the "one belt and one road" strategy as an
opportunity, with the "Internet plus" as the driving force and the heavy and chemical industry as the focus, we will encourage different industries to interpenetrate each other and promote cross-border integration of enterprises to maximize the effective use of different elements.

3.2. Promoting green industrial design
Taking into account such factors as resource consumption, environmental impact and the level of clean production technology, in the manufacturing industry with high resource consumption, heavy environmental pollution, large industrial correlation and extensive product influence, we should select a number of enterprises with strong representativeness, great product market influence, good design and development foundation, high management level and strong economic strength, carrying out trials of eco-design demonstration enterprises. We will support enterprises in developing green products, promoting green design, significantly improving the energy conservation, environmental protection and low-carbon levels of their products, guiding green production and consumption, and enhancing the added value of their products and their core competitiveness.

3.3. Implementing green transformation of traditional industries
We will encourage industrial enterprises in key industries and key areas of traditional manufacturing, such as metallurgy, nonferrous metals, chemicals and building materials, to upgrade their clean production technologies, promote the recycling of wastes and energy during production, and reduce the consumption of resources and energy and the production of pollutants during industrial production. With enterprises as the main body, green products, green industrial parks, green supply chain as the focus, green manufacturing standards and evaluation as the support, we will push forward the implementation of green management, strengthen the demonstration and guidance, and comprehensively promote the construction of green manufacturing system.

3.4. Improving the utilization of resources and energy
In accordance with the measures for the administration of energy conservation in industry, we will guide industrial enterprises in strengthening energy auditing, energy metering, energy management system construction, and energy utilization reports. We will step up oversight of energy conservation, organize special inspections of energy conservation, explore new mechanisms for energy conservation oversight, encourage key enterprises to develop energy control center projects, and carry out special renovation of energy-saving technologies for process industries and energy-intensive general technologies. We will support the comprehensive extraction of primary and symbiotic rare and precious metal minerals and the efficient separation and purification technology and technology integration, improve the comprehensive utilization of slag, metallurgical slag, coal gangue and other resources.

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