



# Analysis of the Sustainable Development of the Energy Industry in Shaanxi under the Constraints of “Dual Carbon Targets”

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**Abstract.** Shaanxi is rich in coal, oil and natural gas resources, and its unique resource endowment makes the development of energy industry in Shaanxi have a decisive impact on China's energy security. On the other hand, a series of problems occur during regional development, such as the extreme imbalance of industrial breeding, economic development mode and residents' living habits are closely "tied" with the traditional energy industry, which increases the vulnerability of regional economy. After the "carbon peaking and carbon neutrality" goal was proposed, all provinces and cities across the country have set their own carbon reduction targets. Shaanxi Province proposed in the comprehensive work plan of the "14th Five-Year Plan" energy-saving and emission reduction work plan that by 2025, the proportion of non-fossil energy consumption will reach 16%, which has a severe challenge to the long-term coal-based energy industry pattern. By sorting out the yearbook data of Shaanxi energy industry from 2012 to 2021, this paper points out the problems such as energy structure, energy production efficiency, energy industry layout and negative impact of energy industry on ecological environment under the constraint of “dual carbon targets”.

**Keywords:** dual carbon targets; energy industry; sustainable development

## 1 Introduction

As the blood and food of modern industrial society, the importance of energy to economic life has long been self-evident<sup>[1]</sup>. The report of the 20th National Congress of the Communist Party of China pointed out that high-quality development requires a green transformation of the mode of economic development. In order to achieve the green and low-carbon goal of social operation, it is necessary to promote the upgrading of industrial structure and the optimization of energy structure.

Since China put forward the goal of "carbon peak" and "carbon neutrality" in 2020, all regions of the country have formulated their own plans to achieve the goal. In the "14th Five-Year Plan" comprehensive work plan for energy conservation and emission reduction, Shaanxi Province proposed that by 2025, the total energy consumption should be reasonably controlled, the indicators such as energy consumption per unit of

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Y. Jiao et al. (eds.), *Proceedings of the 3rd International Conference on Internet Finance and Digital Economy (ICIFDE 2023)*, Atlantis Highlights in Economics, Business and Management 1, [https://doi.org/10.2991/978-94-6463-270-5\\_26](https://doi.org/10.2991/978-94-6463-270-5_26)

GDP in the province reach the national goals and tasks, and the proportion of non-fossil energy consumption reaches 16%<sup>[2]</sup>. Therefore, it is of great practical significance to sort out the problems existing in the development of energy industry in Shaanxi Province and put forward corresponding solutions for the completion of the goals and tasks of the 14th Five-Year Plan.

All data in this paper are from Shaanxi Statistical Yearbook (2022) and China Energy Statistical Yearbook (2022).

## **2 Development status of Shaanxi's energy industry**

### **2.1 Energy production**

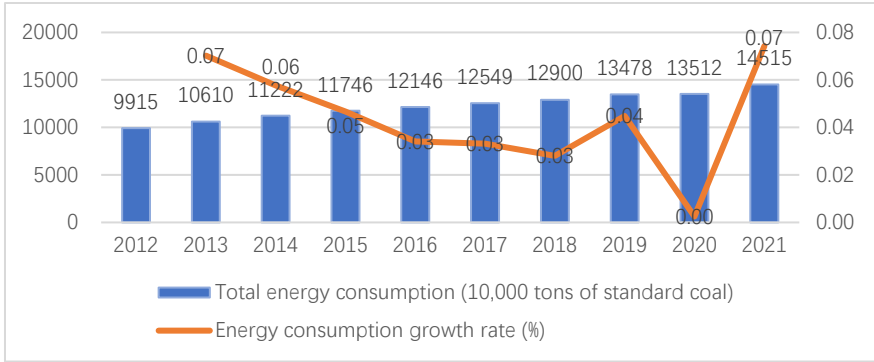
Shaanxi Province is rich in energy resources, and the reserves of main energy varieties ranking among the top in China. The province's coal, oil and natural gas resources are mainly distributed in Yulin City and Yan 'an City, two cities in northern Shaanxi.

In terms of coal resources, the reserves of coal resources rank fourth in China. In 2021, the output of raw coal will reach 701.92 million tons, an increase of 36.1% over 515.66 million tons in 2016. Both raw coal and coke production rank third in the country, with raw coal production accounting for 24.6% of the country's total output and coke production accounting for 9.3% of the country's total output. In the state key construction of 13 large coal bases, Shaanxi Province occupies Shendong, northern Shaanxi and Huanglong three bases.

In terms of oil and natural gas resources, by the end of 2021, the predicted total amount of oil resources ranks fifth in the country, and the accumulated proved technical recoverable reserves of 325 million tons, ranking sixth in the country. In 2021, Shaanxi's crude oil output of 25.528 million tons, ranking fourth in the country, accounting for 12.8% of the national output. The estimated natural gas resources are 11.7 trillion cubic meters, and the cumulative proven geological reserves rank third in China. In 2021, Shaanxi's natural gas output is 29.413 billion cubic meters, ranking third among major regions in the country and accounting for 14.2 percent of the country's total output.

In terms of new energy resources, the high value area of solar energy resources in the province is also concentrated in the northern region. The area receives more than 5,040 megajoules of solar radiation per square meter throughout the year. It belongs to three categories of solar energy resources in China, which is suitable for the construction of large-scale photovoltaic power stations. A considerable part of northern Shaanxi province belongs to the first class wind energy resource area, with a stable prevailing wind direction, which is conducive to the construction of large-scale wind farms. In addition, the province is rich in year-round available biomass energy resources, including straw, forestry waste, livestock and poultry manure, fruit residue, potato, urban garbage, etc., the total amount is about 20.71 million tons of standard coal.

## 2.2 Energy consumption



**Fig. 1.** Total energy consumption and growth rate of Shaanxi from 2012 to 2021

As can be seen from Fig.1, with the development of economy, the total energy consumption of Shaanxi increased steadily from 2012 to 2021. At the same time, with the promotion of energy conservation and consumption reduction in the province, the growth rate of energy consumption has shown a downward trend year by year. According to the change characteristics of energy consumption growth rate, this period can be roughly divided into two periods: the first period is 2012-2018, the growth rate of energy consumption steadily declined; the second period is 2019-2021. During this period, due to the epidemic, international instability and other factors, the economic and social operation was abnormally disrupted, and the growth rate of total energy consumption in Shaanxi Province fluctuated greatly. In 2012, the total energy consumption was 99.1453 million tons of standard coal, and in 2021, the total energy consumption was 145.1523 million tons of standard coal, an increase of 46.4% in ten years, with an average annual growth rate of 4.6%. Total consumption of coal increased by 47 percent, natural gas by 88 percent, and hydropower, wind and other energy generation by 409 percent.

### 3 The problems in the development of Shaanxi's energy industry

#### 3.1 Unreasonable energy structure

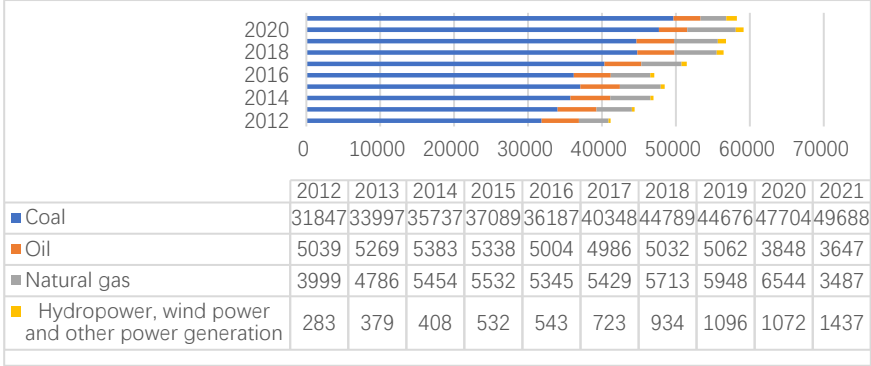


Fig. 2. Energy production in Shaanxi, 2012-2021 (10,000 tons of standard coal)

For a long time, the energy industry has been the pillar industry of Shaanxi Province, and the local economy has developed rapidly relying on the energy industry. Constrained by their own resource endowment, both energy production and energy consumption are dominated by coal resources, which results in unreasonable energy structure<sup>[3]</sup>. From the perspective of energy production, as the data shown in the Fig.2, the production of raw coal accounts for more than 76% of the total energy production, and the proportion shows an increasing trend year by year, the proportion of crude oil has steadily declined, the proportion of natural gas has increased slightly every year after the "eleventh Five-Year Plan", and the production proportion of the three fossil energy has been maintained at an ultra-high level of about 97%.

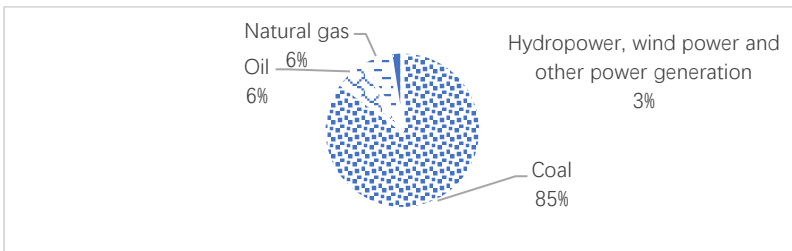
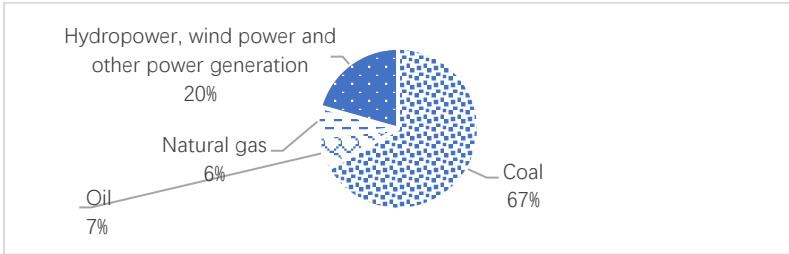
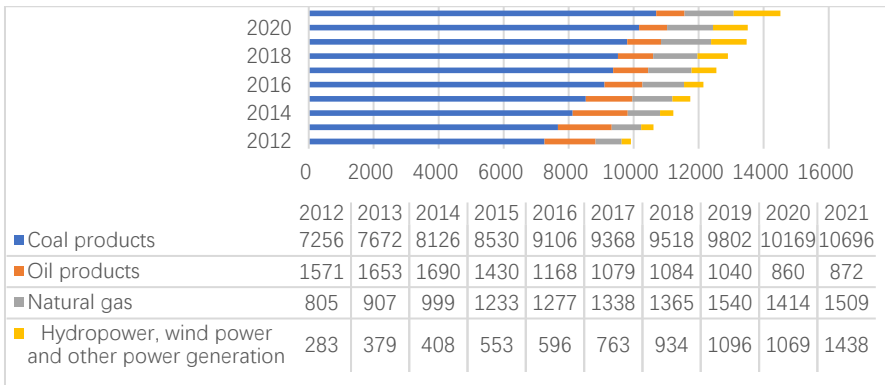


Fig. 3. Shaanxi energy production structure in 2021



**Fig. 4.** National energy production structure in 2021

Comparing Fig.3 and Fig.4 can find that, in 2021, coal, oil and natural gas production in Shaanxi province accounted for 85.3%, 6.3% and 6% respectively, and primary electricity and other power generation will account for 2.5%. In the total energy production in China, coal, oil and natural gas will account for 66.7%, 6.7% and 6% respectively. Primary electricity and other energy sources accounted for 20.6% of the total primary energy production. There is a big gap between Shaanxi and the whole country in the proportion of non-fossil energy production. From the perspective of energy production, in 2021, coal, oil and natural gas in Shaanxi Province will account for 85.3%, 6.3% and 6% respectively, and primary electricity and other power generation will account for 2.5%. In the total energy production in China, coal, oil and natural gas will account for 66.7%, 6.7% and 6% respectively. Primary electricity and other energy sources accounted for 20.6% of the total primary energy production. There is a big gap between Shaanxi and the whole country in the proportion of non-fossil energy production.



**Fig. 5.** Energy consumption in Shaanxi from 2012 to 2021 (10,000 tons of standard coal)

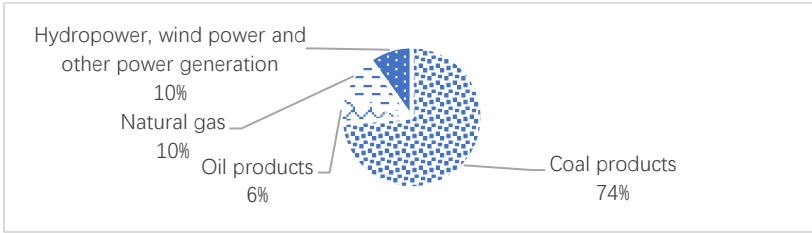


Fig. 6. Shaanxi energy consumption structure in 2021

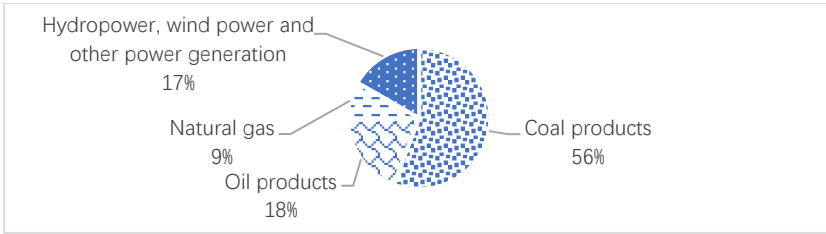


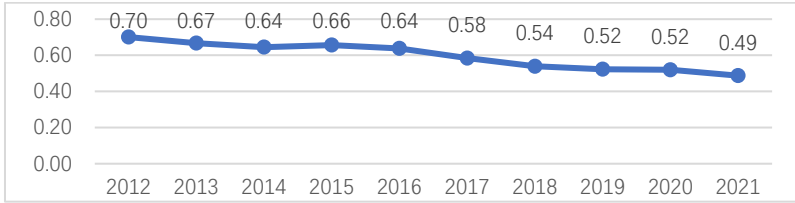
Fig. 7. National energy consumption structure in 2021

From the perspective of energy consumption, as can be seen from Fig.5, influenced by the energy supply structure, Shaanxi's energy consumption structure also shows an obvious "coal preference" phenomenon. In 2021, the figures shown in Fig.6 and Fig .7, coal, oil and natural gas in Shaanxi will account for 73.7%, 6% and 10.4% respectively, while hydropower, wind power and other power generation will account for 9.9%. while the national energy consumption will account for 56%, 18%, 9% and 17% respectively. In the "14th Five-Year Plan" comprehensive work plan for energy conservation and emission reduction, Shaanxi Province proposed that the proportion of non-fossil energy consumption in the province should reach 16% by 2025. It can be seen that in recent years, Shaanxi's energy consumption structure adjustment pressure is relatively large.

### 3.2 Energy efficiency needs to be improved

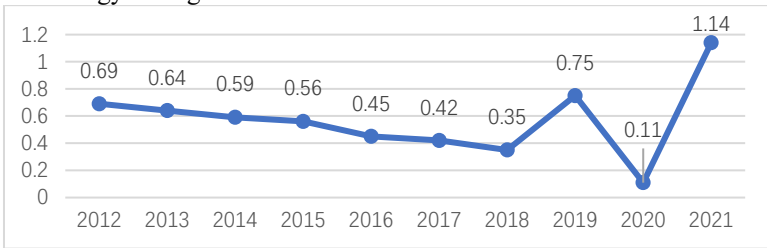
The indicators commonly used to evaluate energy efficiency from an economic point of view are energy consumption per unit of GDP (energy intensity), energy productivity (inverse of energy intensity) and energy elasticity coefficient.

Energy consumption per unit GDP, also known as energy intensity, refers to the amount of energy consumed per unit output value of a country or region, sector or industry in a certain period of time. The lower this value, the higher the energy efficiency. It reflects the degree of economic dependence on energy and the efficiency of energy utilization.



**Fig. 8.** Changes in energy intensity in Shaanxi Province from 2012 to 2021

The data in Fig.8 illustrates that since 2012, energy consumption per unit of GDP in Shaanxi Province has continued to decline, from 0.7 in 2012 to 0.49 in 2021, with an average annual growth rate of -2.1%, reflecting the steady improvement of energy utilization efficiency. However, the 14th Five-Year Plan pays more attention to the management of energy intensity reduction. The basic target of energy intensity in the 14th Five-Year Plan of Shaanxi Province is 0.13, and the incentive target is 0.145. However, according to the actual development of energy consumption intensity in the province from 2012 to 2021, there is still a large distance from the target, and there is great pressure to energy saving.

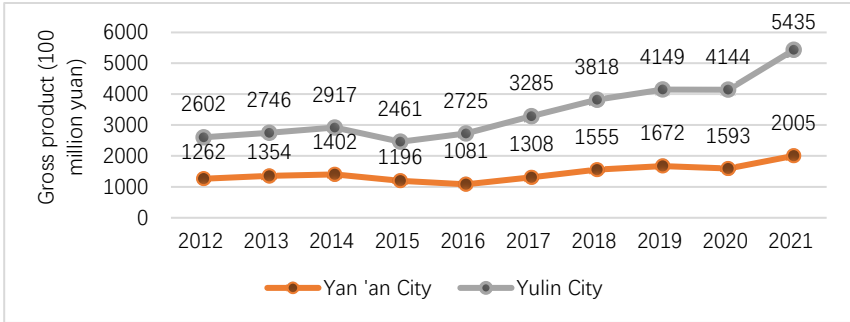


**Fig. 9.** Elasticity coefficient of energy consumption in Shaanxi from 2012 to 2021

Energy consumption elasticity coefficient is an index reflecting the correlation between economic growth and energy consumption. When the parameter values greater than 1, the energy consumption growth rate more than economic growth, parameter values less than 1, the opposite. Higher values in this series indicate lower energy efficiency.

The data in Fig.9 shows that from 2012 to 2018, the elasticity coefficient of energy consumption in Shaanxi decreased year by year, reflecting the initial achievements in energy conservation and consumption reduction in Shaanxi. In 2019, affected by the production of Yan 'an energy and chemical industry, the growth rate of industrial energy consumption in Shaanxi increased compared with previous years. In 2021, the comprehensive energy consumption of the six energy-intensive industries showed a trend of "four increases and two decreases". Resulting in an increase in overall energy consumption.

### 3.3 Unbalanced regional distribution of energy industry



**Fig. 10.** Changes in GDP of Yan'an and Yulin from 2012 to 2021

The energy industry in Shaanxi Province is mainly concentrated in Yulin City and Yan'an City in northern Shaanxi, and a small amount is located in north of the Wei river. In 2021, Yulin's GDP ranked second in Shaanxi, and its per capita GDP ranked first, reaching 149,899 yuan per person. Yan'an's per capita GDP ranks second in the province, reaching 88,127 yuan per person. The output value of the secondary industry in these two cities accounts for more than 60%, and the economic development is "tied" by the energy industry to a certain extent. From 2015 to 2016, when the international energy price was low, the GDP of the two cities declined, and after 2017, as the international energy price rose, the GDP of the two cities increased. Regional economic stability is affected by energy prices, and the uncertainty of development increases, which reflects the vulnerability of regional economy. The data in Fig.10 illustrates this phenomenon.

### 3.4 Fragile ecological environment

In recent years, with the continuous development of energy industry, the ecological environment of Shaanxi continues to deteriorate, and the frequency of haze weather increases, especially in the winter heating period, haze weather almost becomes normal, affecting people's life and health.

The occurrence of haze days is directly related to the use of coal products. From January to December 2021, the provincial urban ambient air quality composite index averaged 4.13, down 7.0% year on year. The average number of excellent days was 79.6% (290.5 days). Shaanxi is located in the middle reaches of the Yellow River, and the water environment quality of the cities (districts) within its jurisdiction ranks lower than the middle in China. Some energy and chemical enterprises discharge pollution along the river from time to time.



## **4 Countermeasures for sustainable development of Shaanxi energy industry under the background of "dual carbon targets"**

### **4.1 Continuously optimize the energy structure under the premise of "ensuring supply"**

Energy is the food of industry and the lifeblood of the national economy. As a major energy province in China, Shaanxi needs to help guard the bottom line of China's energy security and stable supply. Therefore, when optimizing the energy structure, we should not blindly reduce the production and supply of traditional fossil energy, but rely on rich energy resources and solid industrial foundation to strengthen the energy industry<sup>[4]</sup>.

First of all, we should comply with the general principle of the country's work of "six stability" and "six guarantees" to ensure the total energy supply. Secondly, actively optimize the energy production structure, maximize geographical advantages, increase investment in the development of wind, solar, biomass and other new energy, and constantly expand the proportion of clean energy and low-carbon energy in the total energy production. Thirdly, we should adjust the energy consumption structure and strive to control the consumption of coal and oil<sup>[5]</sup>. Make full use of the geographical advantage of being located at the node of west-east gas transmission to increase the proportion of natural gas and new energy consumption.

### **4.2 Improve the clean and efficient utilization of coal and promote the achievement of carbon reduction goals**

On the premise of stable energy production, we will strive to achieve the goals of high efficiency, high quality and high circulation in the utilization of coal resources, as well as low consumption, low pollution and low carbon emissions. In view of the characteristics of energy and resource endowment in the province, clean and efficient utilization of coal is taken as the cornerstone to realize energy transformation, ensure energy security and achieve the goal of "dual carbon targets" in the province. While vigorously promoting the installed scale of wind, light and other renewable energy, the stability of clean coal-fired power generation will be used to smooth the fluctuation of new energy power generation<sup>[6]</sup>. Relying on the currently built Yulin Energy and Chemical Base, by expanding and strengthening the energy and chemical industry, increase the application of coal as a raw material in the production of modern coal chemical industry (indirect coal liquefaction, coal-to-oil, coal-to-olefin) and coal-based high-end materials<sup>[7]</sup> (carbon fiber, high-end activated carbon, graphene, carbon-based reducing agent, etc.), improve the efficiency of energy processing and conversion of coal in situ. We will increase the added value of products and extend the coal industry chain, so as to force coal to eliminate backward production capacity and transform and upgrade, and assume the responsibility of basic supply guarantee in the process of energy transformation. Through the clean and efficient utilization of coal, we can promote the economy to embark on the development path of resource conservation and ecological and

environment-friendly, which is a key step to crack the "reduction of quantity" and "quality" of coal.

### **4.3 Overall layout of the province's energy industry types**

When implementing the national "dual carbon targets", the relevant departments should give full play to the advantages of Shaanxi province's energy industry and carry out a reasonable layout of industrial development. On the one hand, it is necessary to make long-term plans from the perspective of time, taking into account both the actual needs of current economic and social development and the direction of future development. On the other hand, the rational layout of energy production pattern from the perspective of space, including how to give full play to the advantages of resources, industrial base, industrial technology and other issues<sup>[8]</sup>. At present, Shaanxi has formed a pattern of coordinated development of coal, electricity, coal chemical industry and new energy in the three regions of northern Shaanxi, Guanzhong area and southern Shaanxi. In the future, it is still necessary to continue to play the guiding role of policy to guide the sustainable development of energy industry in the province.

### **4.4 Standardize the development of the energy industry and improve the ecological compensation mechanism**

To achieve sustainable development of the energy industry, it is necessary to pay attention to both the current economic benefits of enterprises and the long-term development of the whole industry. First of all, relevant departments should formulate access and evaluation standards for the energy industry. To standardize energy products, in addition to the evaluation of economic benefits, it is necessary to evaluate them from multiple perspectives including efficiency, energy consumption and environmental impact<sup>[9]</sup>. Secondly, the corresponding ecological compensation system should be established. Establish an initial allocation system for water rights, pollutant discharge rights and carbon emission rights, give full play to the regulating function of fiscal and tax policies<sup>[10]</sup>, regulate enterprise production behavior through resource tax, environmental protection tax and other taxes related to ecological and environmental protection, as well as the asset income management system of mineral resources, effectively guide the low-carbon transformation of the whole society, and help achieve the goal of "dual carbon targets".

## **5 Conclusions**

In order to achieve the new requirements for Shaanxi's energy industry under the "dual carbon targets" as soon as possible, it is necessary to make full use of Shaanxi's geographical advantages and current industrial advantages, and work out the future energy utilization and industrial development direction from the comprehensive consideration of planning, system, market, national security and other aspects. Combined with the national development plan, guide the energy consumption habits of enterprises and

social residents, and reasonably learn from the latest technological achievements, so as to promote the energy industry in Shaanxi to achieve high-quality and sustainable development in the new era.

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