



Research on the promotion Pathway of Cascade Ordered Carbon Peak and Carbon Neutrality in Sichuan Province

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Article History

Received: 19/05/2024

Accepted: 01/06/2024

Published: 03/06/2024

Vol – 3 Issue –6

PP: - 01-07

Abstract

China's goal of achieving peak carbon neutrality is a major initiative to coordinate the green transformation of the economy and society. At present, Sichuan province is constrained by energy and industrial structure and faces certain challenges to achieve the goal of peak carbon neutrality on schedule. Therefore, this study is based on the carbon emission, energy structure, and the current situation of industrial structure, with the overall goal of achieving peak carbon neutrality as scheduled, reasonable suggestions are made in three stages: breaking, leading, and deepening, and exploring the path of achieving peak carbon neutrality in line with Sichuan province's orderly carbon ladder.

Keywords: carbon peak; carbon neutrality; implementation path

1. Introduction

The proposal of China's carbon peak carbon neutral goal not only promotes the transformation of China's green and low-carbon development but also brings certain challenges. In order to promote the early realization of the "double carbon" goal, we must adhere to the "national" and "Sichuan" overall planning, but Sichuan Province is currently subject to the multiple constraints of economy, energy, and industrial structure, to achieve carbon peak carbon neutrality is still facing many difficulties. Therefore, it is necessary to clarify the underlying thinking of carbon emissions and analyze the relationship between industrial structure and carbon emissions in Sichuan Province from the perspective of deeper industrial structure. What are the remaining problems? What is the future direction and focus of the dual-carbon goal?

2. The urgency and theoretical basis of peaking carbon neutrality in Sichuan Province

2.1 Urgency of reaching peak carbon neutrality in Sichuan Province

In recent years, the frequent occurrence of global climate problems has seriously hindered the construction and development of ecological civilization. In order to deal with global warming and other issues, all over the world began to implement energy conservation and carbon reduction measures. As the world's largest carbon emitter, China should

actively promote energy conservation and emission reduction, and promote high-quality social and economic development and green and low-carbon development. To achieve the goal of peak carbon neutrality across the country, it is necessary for all regions to play their strengths and roles. Sichuan Province, as a large province of population, resources, and economy, still faces many challenges to achieve the goal of "double carbon".

First of all, Sichuan Province is still in the stage of industrial development, and there is a problem of unbalanced development. From the perspective of the province, except for Chengdu and Panzhihua, the development of other cities is still insufficient, and it is difficult to take into account the reality of energy conservation and emission reduction, and high-quality economic development. Secondly, during July and August 2022, Sichuan faced the "three most" superposition of extreme high temperature, minimum rainfall, and highest power load, which led to severe challenges in power security, and also exposed the outstanding weaknesses of its power system. Finally, the supply of clean energy in Sichuan Province is unstable due to seasonal influences, and there is still a phenomenon of abandoning water and electricity. However, China's "3060" carbon peak carbon neutral target deadline is imminent, according to the "national" and "Sichuan" overall concept, which undoubtedly put forward more urgent requirements for Sichuan Province to achieve energy conservation and emission reduction.

2.2 Theoretical basis of peak carbon neutrality in Sichuan Province

The realization of the "double carbon" goal emphasizes the concept of "sustainable development", which is the concrete embodiment of the modernization of the ecological environment governance system and governance capacity. As the disseminator and practitioner of ecological civilization, the concept of "sustainable development" advocates a green development model of "coordinated promotion, carbon reduction and pollution reduction", and accelerates the promotion of ecological priority and conservation and intensive.

The implementation of the "double carbon" goal needs to adhere to the "national chess", and adhere to the "national" is "Sichuan" overall planning and coordination. The commonality of pursuing green development and sustainable development requires the coordinated development among various environmental subjects and the construction of a coordinated and interconnected development model. Therefore, the goal of achieving peak carbon neutrality must be coordinated development, and the overall concept of "national" and "Sichuan" must be implemented. Based on the concept of green development and sustainable development, service and integration into the new development pattern, with the optimization and adjustment of industrial structure as the key, with green and low-carbon development as the focus, improve the ecological carbon sink capacity, accelerate the promotion of resource conservation and environmental protection of the industrial structure, to ensure that the "double carbon" goal can be achieved on schedule.

3. Status and analysis of carbon emission in Sichuan Province

Indicators are the core content of assessing carbon peaking carbon neutrality, and indicators such as carbon emission intensity and energy consumption are the quantitative refinement of the overall requirements of carbon peaking carbon neutrality. But at present, Sichuan Province is subject to the multiple constraints of economy, energy, and industrial structure, and it is still facing many difficulties to achieve the goal of "double carbon" as scheduled. Therefore, this paper mainly analyzes the status quo of carbon emissions, energy structure, and industrial structure, trying to accelerate the formation of resource-saving, green, and low-carbon industrial structure and energy system through the analysis of the above indicators, and realize carbon peak carbon neutrality as soon as possible.

3.1 Status of carbon emissions

Since the country has not yet developed a unified carbon emission calculation system, it is preliminarily estimated that the total annual CO2 emission in Sichuan Province is about

270-300 million tons, and the carbon emission per unit GDP and per capita is much lower than that of other economies, but the road to low-carbon industrial transformation is very difficult. At present, the added value of the six high-energy-consuming industries in Sichuan Province only accounts for 30% of the industrial added value, but the proportion of energy is as high as 77.3%, and the carbon emissions of the six high-energy-consuming industries account for 43.3% of the total carbon emissions in the province (data source: Sichuan Provincial Bureau of Statistics). Based on the above situation, the province is required to continue to promote the optimization and adjustment of the structure of high-energy products and rely on leading enterprises to carry out "chain extension, chain supplement, and strong chain" actions to enhance the added value of the industry.

3.2 Current situation of energy structure

As a major energy province, Sichuan is endowed with renewable energy and natural gas (shale gas) endowments. Its hydropower generation capacity is about 148 million kilowatts, accounting for more than 20% of the country's total, and its installed hydropower capacity reaches 89.47 million kilowatts. At the same time, it is the largest natural gas (shale gas) production base in China, with a large proportion of natural gas and electricity transmission every year, with natural gas (shale gas) output reaching 52.22 billion cubic meters in 2021 and natural gas consumption reaching 26.8 billion cubic meters (data source: Sichuan Provincial Bureau of Statistics). In terms of industry, the advantages of green low-carbon industries such as photovoltaic crystalline silicon and power batteries are more prominent, and they have and will continue to contribute to the national carbon reduction.

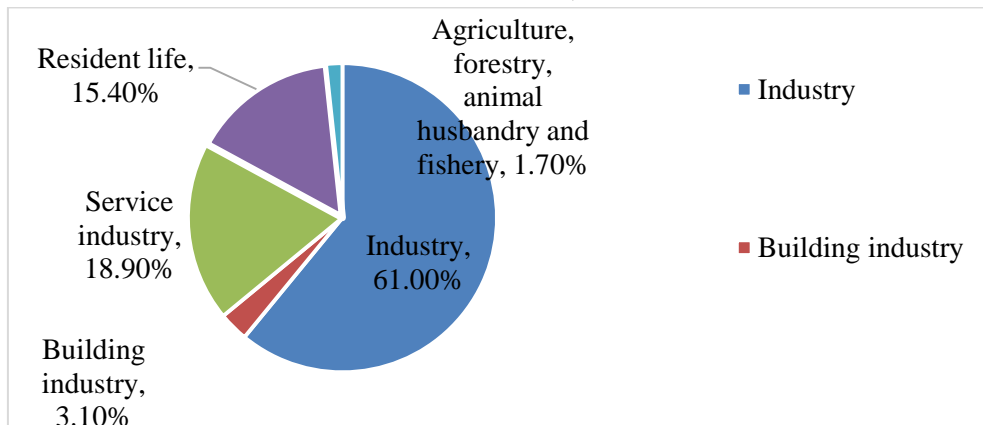
In 2021, the total consumption of coal, raw coal, and other coal fuels in Sichuan Province is about 230 million tons, accounting for 25.9% of the total energy consumption, down 8 percentage points compared with 2016. Natural gas consumption accounted for 16.7%, an increase of about 2.3%. Oil, kerosene, and other oil fuel consumption accounted for 17%, down 2 percentage points. Primary electricity and other energy consumption accounted for 40.4%, an increase of nearly 8 percentage points (Table 1). Raw coal, primary power, other energy sources, and natural gas accounted for 6.8%, 61.1%, and 32.1% of the total energy production, respectively. The energy consumption of industry and service industry accounted for 61.0% and 18.9% of total energy consumption respectively (as shown in Figure 1), and the overall proportion of energy consumption in economic development has declined to a certain extent. Based on the above data, it can be found that the energy structure of Sichuan Province needs to be further optimized, and the energy structure is "not clean enough", and there is a large energy gap.

Table 1 Energy consumption Structure of Sichuan Province, 2016-2021 (unit: %)

index	The year	The year	The year	The year	The year	The year
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	2016	2017	2018	2019	2020	2021
Total energy consumption	100	100	100	100	100	100
Coal fuel	33.9	31.6	29.5	28.3	27.0	25.9
Oil fuel	19.0	19.3	18.5	18.7	17.6	17.0
Natural gas	14.4	15.0	15.8	16.3	16.5	16.7
Primary power and other energy sources	32.7	34.1	36.2	36.7	38.9	40.4

Data sources: Sichuan Provincial Statistical Yearbook 2021, Sichuan Provincial Statistical Yearbook 2022



Data Source: Sichuan Provincial Statistical Yearbook 2022

Figure 1 Energy consumption structure by industry in Sichuan Province in 2021

3.3 Status quo of industrial structure

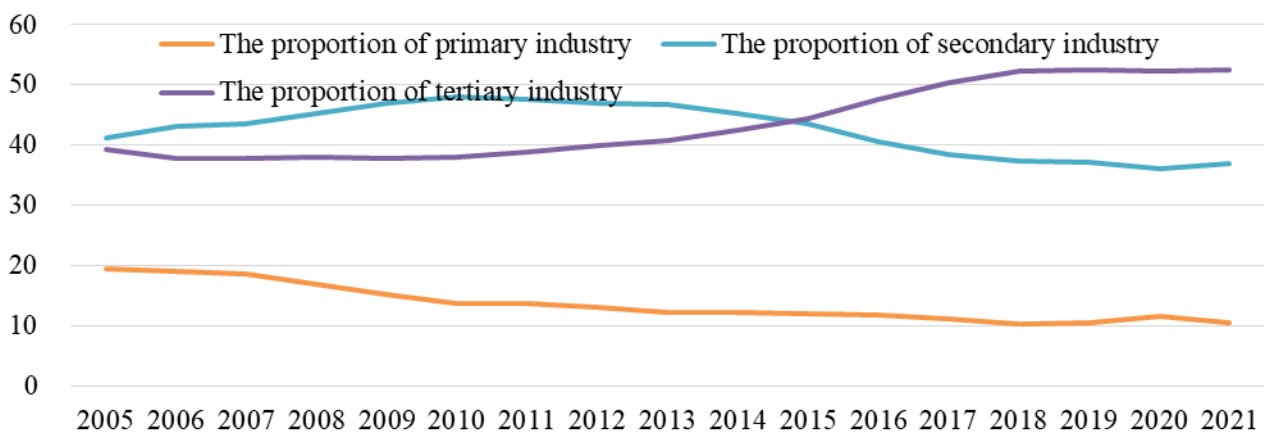
With the development of industrialization, the pillar industry in Sichuan Province has gradually changed into the second industry, which shows the trend of first increase and then decrease. According to the chart, during 2005-2021, the proportion of the three major industries changed from 19.5:41.2:39.3 to 10.5:37.0:52.5, and the contribution of the tertiary industry to the gross domestic product showed a steady growth trend. The "shrinkage" of the primary industry is more obvious, falling by about 8 percentage points. In the stage of industrialization, the rapid development of resource-intensive and capital-intensive industries such as petrochemical industry and manufacturing industry, and the continuous increase of carbon emissions have led to frequent environmental pollution problems. Continuous optimization and upgrading of industrial internal structure is the key to reducing carbon emissions, and the industrial structure of Sichuan Province needs to be further adjusted to speed up the formation of an industrial structure that saves resources and protects the environment. Ensure peak carbon neutrality is achieved on schedule.

Table 2 Three industrial structures of Sichuan Province from 2005 to 2021

A given year	Gross product	Industrial output value (100 million yuan)			Proportion of output value (%)		
		Primary industry	Secondary industry	Tertiary industry	Primary industry	Secondary industry	Tertiary industry
2005	7195.88	1403.24	2961.19	2831.45	19.5	41.2	39.3
2006	8494.68	1613.99	3658.07	3222.62	19.0	43.1	37.9
2007	10562.10	1966.53	4607.73	3987.84	18.6	43.6	37.8
2008	12756.21	2138.96	5766.49	4850.76	16.8	45.2	38.0
2009	14190.60	2160.37	6653.24	5376.99	15.2	46.9	37.9
2010	17224.78	2384.89	8283.21	6556.68	13.8	48.1	38.1
2011	21050.87	2854.62	10014.39	8181.86	13.6	47.6	38.8
2012	23922.41	3142.55	11231.06	9548.80	13.1	46.9	40.0

2013	26518.02	3257.42	12418.94	10841.66	12.3	46.8	40.9
2014	28891.33	3524.74	13082.69	12283.90	12.2	45.3	42.5
2015	30342.01	3660.96	13192.45	13488.60	12.1	43.5	44.4
2016	33138.48	3900.60	13450.13	15787.75	11.8	40.6	47.6
2017	37905.14	4262.51	14569.17	19073.46	11.2	38.4	50.4
2018	42902.10	4427.43	16056.94	22417.73	10.3	37.4	52.3
2019	46615.82	4807.24	17365.33	24443.25	10.4	37.1	52.5
2020	48598.76	5556.58	17505.11	25471.07	11.5	36.1	52.4
2021	53850.79	5661.86	19901.38	28287.55	10.5	37.0	52.5

Data Source: Sichuan Provincial Statistical Yearbook 2022



Data Source: Sichuan Provincial Statistical Yearbook 2022

Figure 2 Evolution of industrial structure in Sichuan Province from 2005 to 2021

4. steps ordered carbon peak carbon neutral path

To achieve the goal of reaching the peak of carbon neutrality is a long-term and arduous systematic project, not a simple and crude "sports" carbon reduction, nor is it unrealistic to "rush to the peak", but the need for overall development, emission reduction and safety overall planning, to promote the province's orderly and gradual low-carbon transformation. Adhere to the ideological path of "one game of chess in the whole province", grasp the main contradictions and the main aspects of contradictions, and focus on the three stages of solving the problem, deepening and leading.

4.1 First level problem-solving stage

4.1.1 Optimize the industrial structure

Overall planning of traditional industrial structure transformation, from the source, process, end of the three links to build the whole process of carbon reduction green industrial chain. We will build an industrial system for green, low-carbon, and circular development, accelerate the transformation of extensive industrial models with high energy consumption and high emissions, promote the in-depth adjustment of industrial structure, comprehensively improve the "green" development level of traditional industries, and strive to build Sichuan Province into an important strategic support area for achieving the goal of carbon peak and carbon neutrality in the country.

4.1.2 Focus on developing green energy

On the one hand, based on the advantages of clean energy and strategic resources endowment, vigorously develop clean energy industry, clean energy support industry, and clean energy application industry. The development and application of new fields of clean energy and the development of new green energy have always required the advantages of clean energy to be transformed into the direction of sustainable development. On the other hand, overall planning and construction of reservoir power stations with more than seasonal adjustment capacity, constantly optimize the main grid frame and make up for the shortcomings of its power system.

4.1.3 Building a multi-component collaborative energy storage system

Give full play to the advantages of various energy storage technologies, accelerate the construction of a strong chain and technological iteration of green low-carbon industries such as new energy storage and pumped energy storage, and proportionally plan the allocation of new energy storage. In addition, it is also necessary to further scientifically plan pumped storage in combination with water conservancy projects to achieve water resource reuse. In-depth research and development and application of electrochemical energy storage, photothermal energy storage, hydrogen energy storage, and actively carry out pilot work of compressed air

energy storage projects. We will coordinate the coordinated development of new energy and energy storage, and build a diversified, coordinated, and efficient energy storage system.

4.2 Secondary deepening stage

4.2.1 Deepen research and development and demonstration of green technologies

We will promote research and development and demonstration application of new clean energy technologies such as hydrogen energy, biomass, photovoltaic, multi-energy coupling, and carbon capture, utilization, and storage. Especially carbon capture utilization and storage technology, for this emission reduction technology, Sichuan Province is still in the initial stage, need to further research and development of technology. In addition, it is also necessary to gradually promote the green and intelligent development of coal, fossil, and other resources and the application of new technologies such as low-carbon resource utilization. At the same time, various regions in the province should also provide certain credit support for green technology research and development and innovation, and accelerate green technology research and development and demonstration.

4.2.2 Strengthen carbon market construction and carbon finance development

At present, Sichuan Province is still in the development stage in the fields of carbon finance and carbon trading. In order to base on the concept of green and low-carbon development, Sichuan Province needs to further establish and improve the carbon market system, promote carbon trading and carbon tax legislation, and improve the review system. Encourage financial institutions to actively participate in carbon finance related businesses and increase investment in carbon emission reduction projects. Guide energy enterprises to empower upstream and downstream carbon emission reduction areas under the application of carbon financial instruments, and provide long-term and low-cost funds for green and low-carbon industry projects. We will vigorously develop green financial derivatives such as green credit, green bonds, and green funds.

4.2.3 Building a green and efficient transportation system

We will speed up the building of a low-carbon transport system, encourage green travel, and promote energy-efficient and environmentally friendly transport. In addition, increase the technology research and development of new energy and clean energy power automobile industry, and promote the coordinated development of automobile manufacturing and green low-carbon industries such as photovoltaic crystalline silicon, power batteries, and green hydrogen energy. Increase the cultivation and introduction of new energy vehicle enterprises, support the transformation and upgrading of traditional fuel vehicle enterprises, form a development model with mass production capacity, and strengthen the whole industry chain of new energy enterprises.

4.3 Level three lead stage

4.3.1 Strong promotion, sound carbon peak carbon neutral supporting measures

In order to achieve the target of peaking carbon neutrality on time, it is necessary to clarify the timetable of peaking carbon neutrality and develop a reasonable road map, so as to provide guidance and framework for building a peaking carbon-neutral society. At the same time, it is necessary to increase investment in the research and development, and innovation of carbon emission reduction technologies, promote the breakthrough and application of key technologies, and improve the efficiency and effect of carbon emission reduction. Actively advocate the concept of green and low-carbon life, pay attention to strengthening publicity and education to the public, improve environmental awareness, and encourage energy conservation and carbon emission reduction behavior. We will support the development of low-carbon industries and promote industrial restructuring, transformation, and upgrading by encouraging the growth of low-carbon industries such as green manufacturing, clean energy, and circular economy.

4.3.2 Promote the construction of ecological civilization and promote coordinated development among regions

By optimizing the energy supply structure, improving the efficiency of energy utilization, promoting the energy interconnection between urban and rural areas, and realizing the rational allocation and utilization of energy resources. To accelerate the green transformation of cities, reduce urban carbon emissions, and improve environmental quality by promoting the use of clean energy, improving energy efficiency, improving urban transportation systems, developing rural clean energy utilization, green agricultural production, and rural household waste disposal. Strengthen cooperation and coordination with neighboring provinces and cities, promote the cross-regional flow and sharing of resources, industries, and talents, and realize regional coordinated development and the overall promotion of carbon emission reduction work.

4.3.3 Continue to promote cooperation and exchanges at home and abroad

Actively participate in international carbon emission reduction cooperation and exchange, exchange and cooperate with international institutions, international organizations, and other countries and regions on carbon emission reduction technology and relevant experience, learn from advanced technology and experience to promote carbon emission reduction work in Sichuan Province. In addition, Sichuan Province is actively promoting the establishment of partnerships with other provinces and cities, enterprises, institutions of higher learning, and research institutions to carry out cooperative research, project cooperation, and technological innovation in the field of carbon emission reduction, and jointly promote the realization of carbon emission reduction targets. Set up a special carbon emission reduction organization or institution, responsible for overall coordination of carbon emission reduction work, strengthen internal and external cooperation and exchanges, and provide policy guidance and technical support

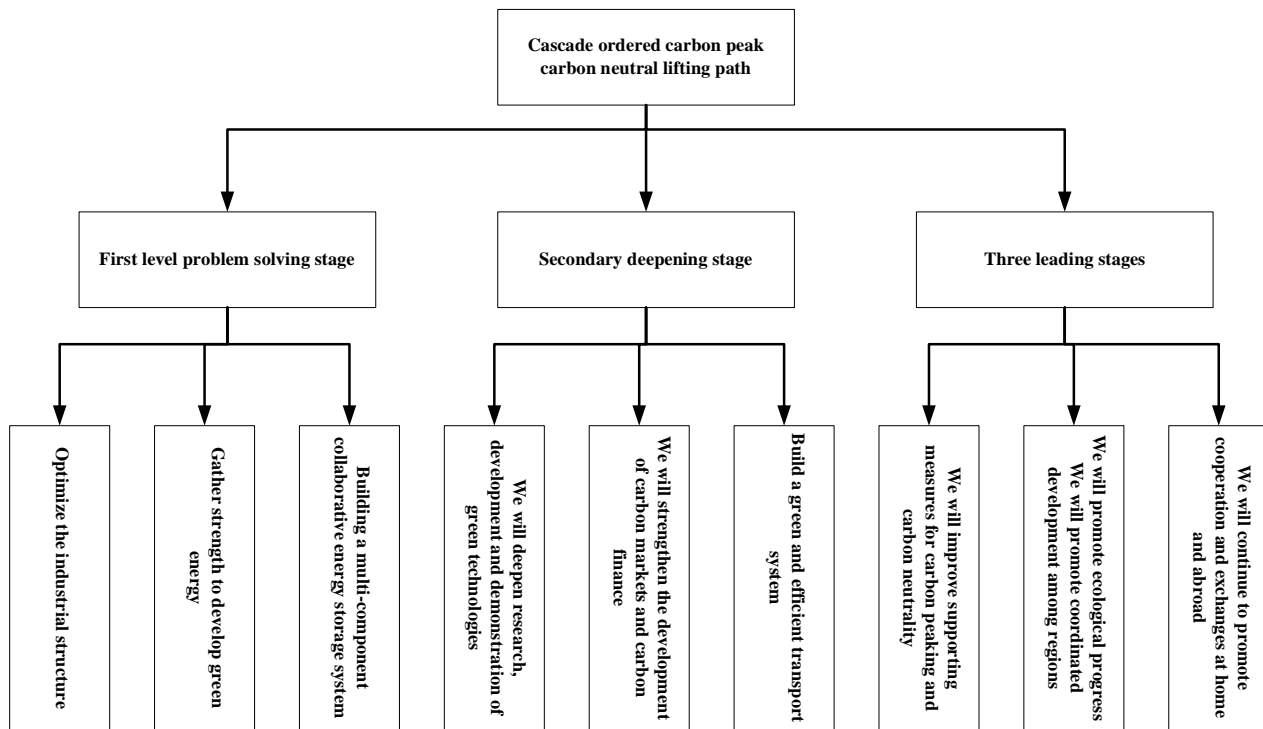


Figure 3 Frame of ascending path for cascade ordered carbon to peak carbon neutrality

5. steps orderly carbon peak carbon neutral safeguard measures

5.1 Policy Guarantee

Achieving peak carbon neutrality requires policy support to drive it forward. In terms of policy guarantee, the province's carbon emission data are unified management, and the "carbon footprint" certification of exported industrial products is carried out. Establish and improve the formation of the price system and mechanism to promote the "scale" development of renewable energy; Encourage qualified financial institutions and relevant enterprises to establish low-carbon transformation foundations, set up funds, support local governments at all levels in Sichuan to establish and improve the carbon market system, actively promote the construction of carbon market, improve the carbon emission trading mechanism and carbon financial market, and provide carbon emission reduction incentives and support for enterprises; We will improve the carbon emission reporting and information disclosure system for enterprises, and promote "carbon disclosure" and "carbon labeling" in an innovative way.

5.2 Organizational Support

In order to ensure the smooth development and effective implementation of the goal of peaking carbon neutrality in Sichuan Province, it is necessary to start from the organizational structure and ensure the organization mode of smooth information and comprehensive development. First, the goal of peaking carbon neutrality requires the support of provincial governments. Second, the implementation of the carbon peak carbon neutral goal needs to be led by provincial committees and hire expert advisers to jointly set up carbon reduction management committees. The Committee is fully

responsible for carbon reduction and carbon neutrality work, responsible for the formulation of carbon reduction policies and work programs, the evaluation and supervision of emission reduction projects, and the guidance and decision-making of carbon reduction work. Finally, the organizational guarantee for the implementation of the goal of peaking carbon neutrality is, in the final analysis, to implement the responsibility system for carbon emission reduction, clarify the work objectives and assessment basis of management and functional departments at all levels, supervise and manage all aspects of carbon emission reduction, and hold relevant responsible departments accountable.

6. Closing remarks

By combing and analyzing the carbon emissions, energy structure, and industrial structure of Sichuan Province, this paper proposes the path to achieve the goal of peaking carbon neutrality. The main conclusions are as follows:

First of all, although the carbon emissions of the province rank low compared with other economically large provinces, the low-carbon transformation of the industry is not easy. At the same time, Sichuan Province is in the period of industrialization development, and there are problems such as unbalanced development. Therefore, it is one of the important means to continue to promote the optimization and adjustment of the structure of high-energy products to achieve the goal of "double carbon" on schedule. Secondly, the dependence on coal fuel is large, the overall energy structure is not clean enough, and there is still an energy gap problem, which needs to be further optimized. In terms of industrial structure, it also needs to be continuously optimized and upgraded.

Finally, the author puts forward the ascending path of cascade ordered carbon peaking carbon neutrality. In the breakthrough stage, the construction of green low-carbon circular development of the industrial system, based on clean energy and strategic resources endowment advantages, vigorously develop clean energy. At the same time, we will build a multi-component collaborative energy storage system and accelerate the construction of a strong chain and technological iteration of green and low-carbon industries such as new energy storage. In the deepening stage, on the basis of the first stage, we will strengthen research and development and demonstration of green technologies, promote clean energy and low-carbon transportation, increase technological research and development of new energy and clean energy power vehicles, strengthen the construction of carbon markets and the development of carbon finance, and promote the upgrading, transformation, and upgrading of industrial structure; On the basis of the second stage, further promote scientific and technological innovation and system integration, promote energy revolution and industrial upgrading, promote urban-rural integration and regional coordinated development, comprehensively build a carbon-neutral society, and accelerate the realization of carbon peak and carbon neutral goals.

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