

Research Hotspot and Development Trend of New Energy Industry Cluster under the Background of "Double Carbon" -- Based on Citespace Visual Analysis

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Abstract: The new energy industry cluster is an important direction for the future development of China's new energy industry. At present, the scale of domestic research on new energy industrial clusters has been issued, but there are still some research directions that are not clear, and there are few research results on new energy industrial clusters using visual means. This paper analyzes the relevant research literature of the new energy industry cluster under the "double carbon" background from 2006 to February 2023 by visual atlas, and combs the research hotspots and evolution trends. The research shows that: (1) domestic research on the new energy industry began in 2006, and then the number of papers proposed under the "double carbon" background increased sharply; (2) The research progress of new energy industry cluster shows the trend of refining the focus; (3) Under the background of "double carbon", the research on new energy industry cluster is still in the initial stage of development, and the indicator system needs to be improved. It is expected to enrich the perspective of the review of new energy industrial clusters and provide some reference for the research and design practice of new energy industrial clusters under the background of "double carbon" in China in the future.

Keywords: New Energy Industry Cluster; Double Carbon; Cite Space; Development Trend

1. Introduction

The development of the energy industry has gradually become the focus of most countries in the world, and the development of the new energy industry has also become one of the important bases to measure the level of high-tech in a country or region. As a high-tech industry in the new era, the cluster development of new energy industry can increase the proportion of new energy consumption and supply, thus optimizing the energy structure and reducing the dependence on traditional fossil energy, which is an effective way for China to achieve the "double carbon" goal and green economic development.

Although the existing research on the new energy industry is relatively rich, the relevant research on the development of the new energy industry cluster is not comprehensive and detailed, and few scholars use visual tools to explain the overall situation and knowledge structure of this sector. In view of the existing shortcomings, this paper uses the literature metrological analysis method and knowledge map visualization to comprehensively sort out the relevant literature of the new energy industry cluster^[1], and uses the data visualization method to clearly display the literature changes, hot spot evolution trend and future development direction of this sector, with a view to providing some reference for the development of China's new energy industry cluster^[2].

The specific analysis process of this study is as follows: First, data screening. Through the keyword search and subject search of CNKI, the research field of new energy industry cluster will be fully covered as far as possible, as the basic data

source for relevant analysis. Second, research the key words of the literature. Analyze the relationship between research hotspots and keywords, so as to analyze the theme of the research field, and explore the intensity of hot spots and the centrality of keywords. Thirdly, on the basis of the above analysis, explore the research hotspots of new energy industrial clusters in the future, and put forward reference suggestions for the development of new energy industrial clusters in China.

2. Manuscript Preparation

According to the requirements of cite space for data, the basic data of this study comes from CNKI database [3]. The selected articles cover the words "double carbon", "new energy industry", "new energy industry cluster", "new energy industry cluster", etc. The source categories include authoritative journals such as Chinese journals, Chinese core journals, CSSCI journals, and CSCD journals. Excluding newspapers, meeting minutes and articles inconsistent with the theme, 1271 relevant documents were finally selected as the basic data for this analysis.

3. Research methodology for scale development

3.1 Feature analysis

The number of annual papers issued in a research field and its change trend can directly reflect the degree of concern of the research field. According to the statistics of the obtained literature release, there was basically no research on "double carbon" and new energy industry before 2006, so the follow-up research and analysis will be based on the literature results of 2006-2023. On the whole, China's attention to the research of new energy industry has been growing slowly until 2020, and the research on new energy industry has increased rapidly since 2021. It is expected that the number of documents issued in 2023 will also maintain the growth trend (Figure 1). The research on the new energy industry began to grow in 2020 and grew rapidly in 2021 (174 articles). In May of that year, the first plenary meeting of the leading group of China's "double carbon" work was held in Beijing. In October, the CPC Central Committee and the State Council issued the "Opinions on Completely and Accurately Implementing the New Development Concept and Doing a Good Job of Carbon Peak and Carbon Neutralization", which is a systematic plan for the development of China's "double carbon" work. Since then, the number of papers (721 papers) issued in 2022 has shown a straight upward trend. In August of that year, the National Development and Reform Commission, the Ministry of Science and Technology, the Ministry of Industry and Information Technology and other nine departments issued the "Implementation Plan for Carbon Neutralization in the Peak of Science and Technology Support" (2022-2030), which further explains that the number of papers issued in the research field of new energy industry cluster will continue to grow under the "double carbon" background.

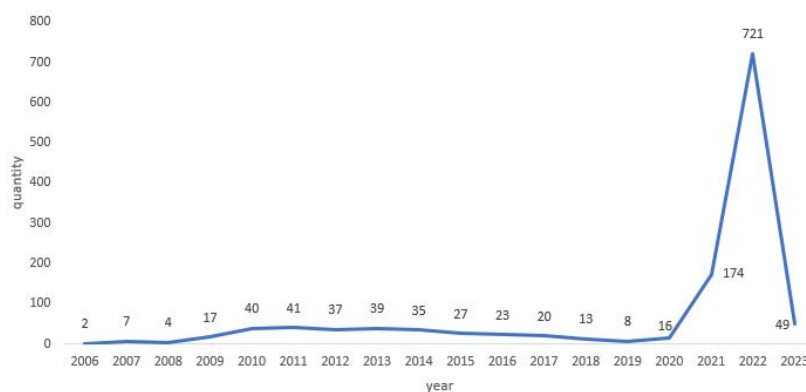


Figure 1 Changes in the number of literatures on the research of new energy industry cluster under the background of "double carbon" (2006-2023)

3.2 Research field

Research clustering is to form research topics through refining and summarizing on the basis of hot network atlas, and clearly display the main research fields. In this paper, the keyword clustering knowledge map is obtained by clustering analysis of keywords in the literature, as shown in Figure 2. Modularity Q is the evaluation index of network modularity. The larger the value, the better the clustering effect of the network. The Modularity Q value obtained by this clustering analysis=0.6031 > 0.3, which means that the network community structure is significant. The Silhouette value is an index used to measure the network homogeneity. Its value range is from - 1 to 1. The larger the value is, the higher the matching relationship between the target and its own cluster is, the higher the network homogeneity is. The average value of network homogeneity obtained by this clustering=0.8387 > 0.5, indicating that the clustering result is reasonable. The nine units of this document analysis cluster are carbon peak (# 0), new energy (# 1), low carbon transformation (# 2), photovoltaic industry (# 3), double carbon (# 4), double carbon target (# 5), low carbon economy (# 6), influencing factors (# 7), and industrial cluster (# 8).

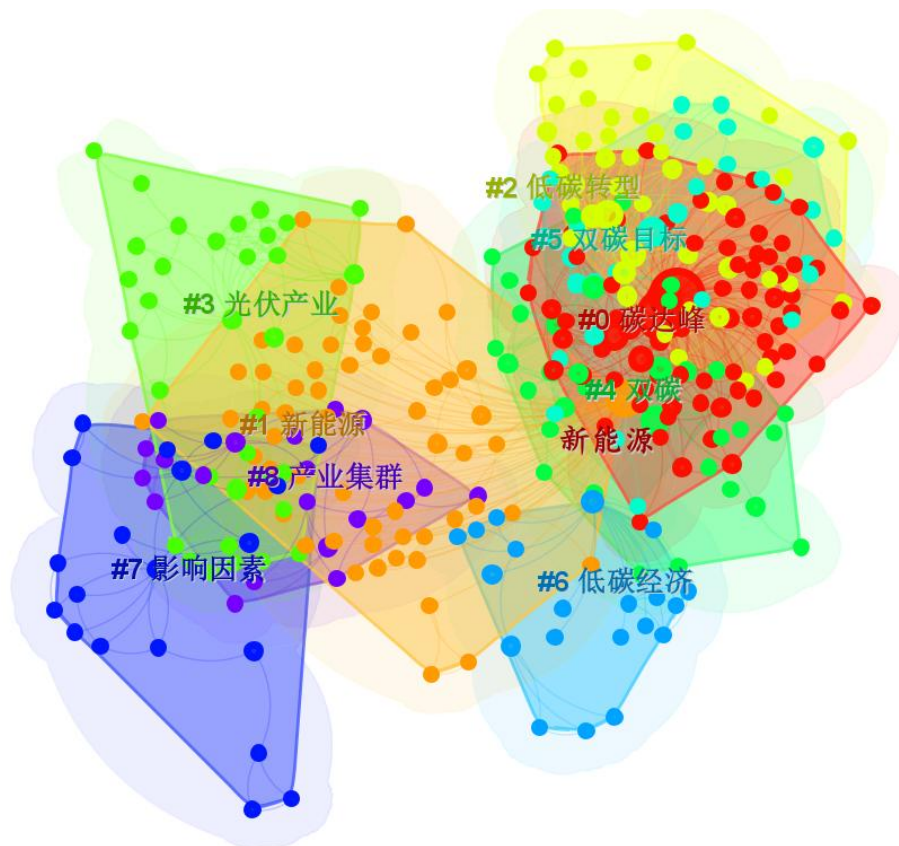


Figure 2 Cluster atlas of new energy industry cluster research under the background of "double carbon"

3.3 Research hotspots

Document keywords are the essence of the core idea and content of the document. The co-word characteristics of high-frequency keywords can reflect the hot research areas. Use Cite Space software to draw the knowledge map of relevant literature keywords, explore the connection network between keywords, and the centrality of different keywords in the network, so as to summarize the hot topics in the research field.

The analysis results show that the research topics of the new energy industry under the domestic "double carbon"

background have a certain degree of concentration, and some key words show a relatively close relationship, which is reflected by the frequency and centrality of key words. In terms of keyword co-occurrence frequency, in addition to "carbon peak", "carbon neutral" and "new energy", the key words of "green finance", "energy transformation" and "industrial cluster" also showed a certain degree of enthusiasm. In terms of keyword centrality, "carbon neutral", "carbon peak" and "new energy" have high centrality and have great influence in the research, and are important nodes in the research of network map.

Table1 The centrality and co-occurrence frequency of hot words in the research of new energy industry cluster under the background of "double carbon"

Number	Count	Centrality	Year	Keywords	Number	Count	Centrality	Year	Keywords
1	267	0.23	2021	Carbon neutralization	16	15	0.01	2022	Green and low-carbon
2	195	0.14	2021	Carbon peak	17	13	0.03	2012	influence factor
3	97	0.47	2006	new energy	18	12	0.01	2016	Green credit
4	45	0.05	2021	Double carbon target	19	11	0.06	2011	Fossil energy
5	43	0.06	2021	carbon emission	20	11	0.02	2021	Energy transformation
6	41	0.04	2021	Bicarbon	21	11	0.01	2021	Carbon market
7	41	0.04	2021	Green finance	22	10	0.01	2011	energy-resource structure
8	26	0.04	2021	Low-carbon transformation	23	10	0.03	2004	solar energy
9	25	0.01	2021	Green development	24	9	0.01	2021	China
10	24	0.03	2021	Green transformation	25	9	0.03	2010	technological innovation
11	23	0.01	2021	climate change	26	9	0.03	2011	New energy industry cluster
12	23	0.02	2021	Carbon emission reduction	27	9	0.01	2021	Carbon tax
13	21	0.06	2010	low-carbon economy	28	9	0.05	2011	Photovoltaic industry
14	19	0.01	2011	Low carbon	29	8	0.01	2022	Carbon sink
15	19	0.01	2022	"Double carbon"	30	7	0.02	2013	Financial support

4. Analysis of main research contents

Domestic research on new energy industrial clusters began in 2006. During this period, a number of articles summarizing foreign experience emerged in the development of domestic new energy industrial clusters^[4-9]. Although not all industries are suitable for industrial clusters, many foreign industries have industrial cluster practices. Kim et al took the

photovoltaic industry cluster in Jeonnam Region, South Korea, as an example, and discussed the importance of the material value chain and government support of the photovoltaic industry. The results showed that the development of the photovoltaic industry cluster is related to the interests of local governments and relevant government-enterprise cooperation. Building a reasonable industrial cluster system can promote better relations between civil society and the government ^[10]. Varela-Vázquez et al taking the wind energy industrial cluster in Galicia, northwest Spain, as an example, discussed the difficulties in the surrounding environment that the wind energy industry will face in the process of clustering. A reasonable and effective wind energy industrial cluster can promote industrial diversification and employment ^[11]. These industrial cluster practices have greatly promoted the development of local economy and employment, and provided support for the theoretical research on the development of new energy industrial clusters.

At the end of 2011 and the beginning of 2012, China's photovoltaic products and wind power products have successively encountered anti-dumping and countervailing investigations ("double anti-dumping" investigations) from the United States and the European Union, resulting in heavy damage to China's new energy industry. In addition, due to the lack of relevant theories on the development of China's new energy industry cluster during this period, the society began to question the development model of the new energy industry cluster. Based on SWOT analysis, Yang Ling and others demonstrated that China's new energy industry cluster development model is justifiable, and the development of the cluster has been frustrated, mainly because of the lack of investment in core technology research and development, the dependence on imports of cutting-edge technology and key equipment, and the high dependence of new energy products on foreign countries in the development process of the new energy industry cluster ^[12]. Through this "double counter" investigation, China's new energy industry has turned the corner, providing a lesson for the development of new energy industrial clusters, and strengthening the public's understanding of the development model of new energy industrial clusters. Now, the "double carbon" goal has put forward new requirements for the development of new energy industrial clusters. The subsequent development path research and strategy issuance should be combined with the requirements of the "double carbon" goal.

5. Conclusion

This paper uses Cite Space to excavate the number, hotspots and trends of the research on the new energy industry cluster under the background of "double carbon", and systematically sort out the relevant research literature. Combining the analysis results of the literature knowledge map in the above research with the main contents of the literature, the relevant research work on the new energy industry cluster in China is being gradually promoted, and some achievements and practical experience have been accumulated. However, in general, the research on the new energy industry cluster under the "double carbon" background is still at the initial stage, lacking mature and solid theoretical support and sufficient practical experience. At the same time, the combination of theory and practice is insufficient, and interdisciplinary research is scarce. It still needs the joint participation of multidisciplinary researchers and scholars to deeply integrate the research of various disciplines and break through the limitations of current research. This paper will make suggestions from the following aspects:

Improving the theoretical framework. Build more theoretical framework of new energy industrial clusters consistent with the "double carbon" goal, and better integrate new requirements into the theoretical framework; At the same time, the institutional framework for cluster development should be formulated according to local conditions in combination with its own actual situation.

Strengthening the research on risk management of new energy industrial clusters. There are problems in the development of new energy industrial clusters, such as insufficient research and development, weak venture capital, and weak industrial linkages. Whether the new energy industrial cluster is in the early, growing or mature stage, cluster risk management is very necessary for the sustainable development of the new energy industrial cluster.

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