Analysis of China's offshore wind power development trend based on bibliometrics

Xin Li[1,a], Haoxian Dong[2,b], Zhi Li[1,c], Changlei Ma[1,d], Qingnan Kong[3,e], Zihan Sun[4,f], Weijia Ma[5,h]*,

[1]National Ocean Technology Center
[2]Tianjin aerospace Data system Technology Co., LTD
[3]Inner Mongolia University of Science and Technology
[4]Tianjin Normal University
[5]Industry Development and Promotion Center Ministry of Industry and Information Technology of the People's Republic of China

[a]Lixin_t@126.com;[b]donghaoxian@163.com
[c]hjlz2008@163.com;[d]notcmachanglei@163.com
[e]kqn1993@163.com;[f]sunzihan081@163.com
[h]*maweijia@idpc.org.cn;* Corresponding author

Abstract. From the perspective of scientific measurement, this paper makes an exploratory analysis of the research status and development trend in the field of offshore wind power. CNKI database is used as the data source to retrieve relevant literature in the field of offshore wind power during 2002-2022, and CiteSpace software is used to analyze the data and visualize the results. By mining and analyzing the number of published papers, institutional cooperation, authors' published papers and distribution of hot spots in the offshore wind power field in the data set, the development trend of the offshore wind power field is analyzed. The results show that the number of published papers in the offshore wind power field is on the rise. The research process can be divided into four stages: starting stage, scale utilization stage, industrialization development stage and commercialization stage. In terms of institutional cooperation, there is closer cooperation among institutions and more emphasis on intra-institutional cooperation. Research hotspots mainly focus on offshore wind power technology research, technology development, application basic research, engineering research and other aspects. Based on the analysis results of this paper, the future direction of offshore wind power field is put forward, which provides a certain reference for future offshore wind power research.

Keywords: offshore wind power, Scientific metrology, Trend analysis, Literature analysis

1 Introduction

In the context of climate change and global energy crisis, countries have accelerated the pace of energy transformation[1,2]. Wind energy, ocean energy, solar energy and

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other renewable energy have attracted wide attention around the world [3-7]. Due to the wide distribution of wind energy resources, early research and development period, and high technical maturity, wind energy has certain development advantages compared with other renewable energy [8,9]. Due to its abundant resource reserves, high annual utilization rate, non-occupation of land resources, and large-scale development, offshore wind power has become an important development direction of global energy transition[10]. According to the International Energy Agency (IEA), offshore wind can provide 11 times the global electricity demand by 2040, and offshore wind power is a key path to achieving the global net zero carbon emissions target by 2050. In the Global Wind Energy Report 2023 (Global Wind Energy Report 2023), the Global Wind Energy Council (GWEC) proposed [11] that the global offshore wind power installed capacity will reach 25 GW by 2025, and the new global wind power grid connected capacity will reach 680 GW in the next five years.

The development of onshore wind resources in China is limited by many factors such as environmental protection, land occupation area and power consumption, and cannot sustain large-scale development, while offshore wind power has huge exploable resource potential and is close to China's power load center, which will be an important strategic choice for China's energy development in the future[12]. China has more than 3 million square kilometers of sea area, rich offshore wind power resources can be developed, according to relevant data statistical analysis, within 200 kilometers offshore, China's offshore and far-reaching sea wind energy resources technology development potential of about 2.25 billion kilowatts [13], has an inherent advantage in the field of offshore wind power development [14]. Since the two-carbon goal was proposed, China has accelerated the energy revolution, accelerated the planning and construction of new energy development and utilization [15]. Due to the development advantages of offshore wind power itself, as well as China's objective environmental conditions and energy needs, the development of offshore wind power will become an inevitable choice for China to vigorously develop new energy. It has become an important strategic support for promoting China's energy structure transformation and ensuring energy security [16].

In 2022, the National Development and Reform Commission and the Energy Administration jointly issued the "14th Five Year Plan for Modern Energy System", proposing to encourage the construction of offshore wind power bases and promote the layout of offshore wind power in deep and distant sea regions [17]; In the same year, the National Energy Administration and the Ministry of Science and Technology issued the "14th Five Year Plan for Science and Technology Innovation in the Energy Field", proposing to carry out research on new efficient and low-cost wind power technologies, develop 15 MW and above Shanghai wind turbines, and develop floating wind turbines in deep sea and deep water areas [18]. In recent years, multiple policy plans have been issued in China to encourage and support the development and utilization of offshore wind power. Whether from the perspective of resource environment, policy environment, and technological development level, offshore wind power has become one of the important hotspots in China today and even in the future. Therefore, it is necessary to study the development process and trend of offshore wind power in China. This study conducts qualitative and quantitative analysis of the knowledge development background of offshore wind power, that is, mining and analyzing the co-occurrence keywords, research scholars, institutions, and other contents of literature in this field. It can comprehensively and completely explain the knowledge development background of this field [19,20], provide a new and unique perspective, and combine visual charts to systematically describe the knowledge development background of offshore wind power research. Scientific publications such as literature are the fundamental units of knowledge structure in all research fields, generated by the joint efforts of a large number of researchers. This study has important reference value for researchers and can help scholars engaged in the field of offshore wind power to better understand the overview and cutting-edge developments in this field.

2 Data sources and research methods

2.1 Data sources

The literature for this study mainly comes from the China National Knowledge Infrastructure (CNKI) database. CNKI database is currently the largest full-text database of continuously and dynamically updated Chinese academic journals in the world, and the most authoritative Document retrieval tool and network publishing platform in China. It contains almost all domestic academic journals, master's and doctoral theses, conference papers, etc. This study uses the CNKI database as the data source and adopts an advanced search method. The search formula is set as TS="Marine Wind Energy" or "Offshore Wind Power" or "Offshore Wind Power" or "Offshore Wind Power" or "Offshore Wind Power". The search time span is limited to January 1st, 2002 to December 31st, 2022. A total of 7393 results were obtained, excluding newspapers, yearbooks, and other classifications, and 6054 articles were ultimately obtained.

2.2 Research Methods

Based on Bibliometrics [21,22], this study analyzes the development process and trend of domestic offshore wind power field, and presents them visually [23]. Literature is a reliable source of knowledge through Peer review [24,25], while Bibliometrics is a method to analyze the distribution characteristics of literature in a certain field through comprehensive mathematical, statistical, linguistic and other methods, which can be used to deeply explore the development law and direction of this field. Commonly used software for bibliometric analysis include CiteSpace [26], VOSviewer [27], Histcity [28], and others. CiteSpace software is an analysis tool of Information visualization developed by Professor Chen Chaomei's team based on the Java language. CiteSpace can intuitively reflect the research progress and research frontiers of a certain discipline and field [29,30] and the development process and laws of this field [31] by analyzing the characteristics, laws, mining research trends and the form of visualization atlas in the literature. Due to the fact that CiteSpace has been proven by numerous scholars and multiple experimental studies to be scientific and feasible for bibliometric analysis [32-36], and Excel [37-39] is also a multifunctional data processing and chart analysis software that has been repeatedly validated in research and analysis, CiteSpace and Excel software were selected for data analysis and result visualization in this study. This research draws the Knowledge graph of offshore wind power field through the visualization tool CiteSpace, and further analyzes the number of papers, author cooperation, institutions, keywords, etc., to obtain the relevant hot spots and future development trends of offshore wind power field from January 1st, 2002 to December 31st, 2022.

3 Analysis of the Development Trend of Offshore Wind Power

3.1 Annual Document Volume Trend

The annual publication volume of scientific research papers can to some extent reflect the research heat in a certain field [40], and the annual publication distribution of literature is an important indicator to measure the scientific research achievements and disciplinary development level in a certain field, which can to some extent explain the development trend of scientific research in that field [41]. From Figure 1, it can be seen that the overall number of papers in the field of offshore wind power in China is increasing. Based on bibliometric analysis and relevant national policies, this article divides the research in the field of offshore wind power from 2002 to 2022 into four development stages, as shown in Table 1.

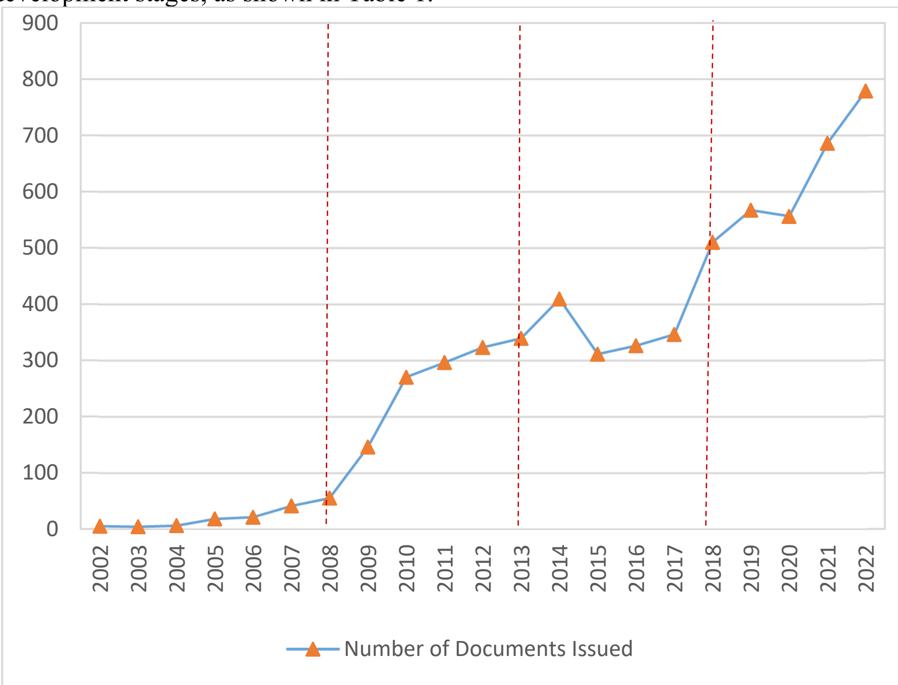

Fig. 1. Trends in publications related to offshore wind power from 2002 to 2022

Table 1. Analysis of Development Stages of Offshore Wind Power

Stage Name	Starting Time	Number of Publications	Duration	Stage Characteristics
Initial Stage	2002-2008	5-55	7 years	Slow Growth
Scale Utilization Stage	2008-2014	55-409	7 years	Rapid Growth
Industrialization Development Stage	2014-2018	409-510	5 years	Fluctuating Growth
Commercialization stage	Since 2018	510-779	5 years	Leap Growth

The first stage: the initial stage (from 2002 to 2008). With the introduction and improvement of theories related to offshore wind power, the number of publications in this stage shows a slow increasing trend. This stage mainly focuses on the research and development of offshore wind power technology, equipment introduction and absorption, and exploration of demonstration wind farm construction. In terms of the approval policy for wind farm construction, in July 2005, the National Development and Reform Commission issued a notice on the relevant requirements for wind power construction management. The localization rate of wind power equipment must reach over 70%, and wind farms that do not meet the requirements for equipment localization rate are not allowed to be built. Imported equipment customs must pay taxes according to regulations. This policy has played a certain role in protecting and promoting the development of wind power technology research and development and unit manufacturers in China in the initial stage. In 2007, China's first offshore wind farm was approved and the country's first trial operation offshore wind turbine unit was installed. It can be seen that at this stage, China's offshore wind power technology is generally in a critical technological breakthrough period, and domestic wind turbines have entered the era of megawatts. In order to accelerate the improvement of technological maturity, the country has provided policy support from wind farm development approval, support for offshore testing, and project approval.

The second stage is the large-scale utilization stage (from 2008 to 2014). With the first release of management measures for offshore wind power development by relevant ministries and commissions, the initiation and completion of multiple offshore wind farm demonstration projects under policy incentives, and the formation of offshore wind turbine design and manufacturing technology with independent intellectual property rights, the large-scale utilization of offshore wind power in China has begun. The number of research papers published during this stage also showed a rapid growth trend, from 55 in 2008 to 323 in 2013, with a maximum annual growth rate of over 165%. In terms of planning and management of offshore wind power development, in 2009, the National Energy Administration issued a notice on the issuance of the Outline of Work for Offshore Wind Farm Engineering Planning, which comprehensively planned and laid out offshore wind farms in coastal provinces and cities in China. In 2010, the National Energy Administration and the National Oceanic Administration jointly issued the "Interim Measures for the Management of Offshore Wind Power Development and Construction", proposing the "Double Ten Principles" for the construction of offshore wind farms, becoming the first management method in the field of offshore wind power development in China, and playing an important role in promoting the standardized utilization of China's offshore wind power industry. During this period, China's offshore wind power incentive policies mainly included wind turbine cost subsidies, approved electricity prices, taxation, franchise bidding, financial subsidies, and other aspects.

The third stage is the industrialization development stage (from 2014 to 2018). The number of publications in this stage shows a fluctuating growth trend. With the accumulation of experience in technological innovation, introduction and absorption, exploration of development models, and construction of demonstration projects, China's offshore wind power industry has gradually matured and entered the stage of industrial development. The sign of entering this stage is that the goal of offshore wind power development and utilization has entered the national level planning. Relevant ministries and commissions have issued benchmark grid electricity pricing policies and guidance pricing policies for offshore wind power. The scale of offshore wind power utilization in China has rapidly increased, and the development and construction costs have rapidly decreased.

The fourth stage is the commercialization stage (since 2018). At this stage, the number of papers published in the field of offshore wind power in China has entered a rapid growth mode. In 2019, the National Development and Reform Commission issued a notice on improving the policy of wind power grid electricity pricing. The bidding grid electricity price of newly built offshore wind farms in China is close to 0.8 yuan/kWh, which means that the subsidy for kilowatt hour electricity is still as high as 0.4 yuan. To promote the offshore wind power industry to break free from subsidy dependence and achieve rapid development through market-oriented methods. In 2020, the National Development and Reform Commission, the Ministry of Finance, and the Energy Administration jointly issued the "Several Opinions on Promoting the Healthy Development of Non aqueous Renewable Energy Power Generation", which proposed that offshore wind farms that have not completed the grid connection of all units before the end of 2021 will no longer be included in the scope of central financial subsidies. The proposal of the policy schedule for offshore wind power parity online marks the official entry of China's offshore wind power into the commercialization stage.

3.2 Analysis of Main Research Forces

Analysis of Research Institutions.

The number of papers published by research institutions can to some extent reflect their institutional level and academic influence in a certain field [42-43]. According to the analysis of the publication status of institutions(see Figure 2)，the top ten institutions include Tianjin University, North China Electric Power University, East China Survey and Design Institute, Guangdong Electric Power Design and Research Institute, Shanghai Jiao Tong University, etc.

Through analysis and research, it is found that Tianjin University mainly focuses on technical research and application basic research in the field of offshore wind power. Its main research directions include tubular foundation, jacket foundation, numerical simulation, model test, single Pile foundation, etc., focusing on the development of basic innovative research. In 2012, Tianjin University carried out research on large-scale tubular foundation of offshore wind power. In order to optimize the force transfer performance and anti-corrosion performance of large-scale tubular foundation transition section, Hongyan Ding, Puyang Zhang and other scholars used finite element software ABAQUS to apply prestress to the arc transition structure on the upper part of the foundation, and carried out numerical simulation analysis on the prestressed large-scale tubular foundation structure [44]. In 2013, Tianjin University used ABAQUS finite element software to analyze the response of foundation and soil under load, compared the contribution of other factors such as wind load and vortex induced vibration of tower to the actual load, and investigated the response of bucket foundation under load in different soil properties by studying the development of settlement and the change of foundation and surrounding soil stress in different time histories. The research results show that:, The stress value in the soil gradually increases, and the soil around the foundation will experience saddle shaped settlement. The equivalent plastic zone in the soil will occur at a height about 2 times higher from the bottom of the foundation to the bottom of the cylinder. The greater the strength of the soil, the smaller the settlement of the cylinder, and the smaller its impact on the surrounding soil [45]. In the same year, relevant researchers of Tianjin University, relying on a wind power foundation project in Fujian offshore, used the large-scale finite element software ABAQUS to carry out three-dimensional finite element numerical analysis on the bearing characteristics of offshore wind turbine single drum foundation [46], and used ABAQUS finite element software to analyze the response of large-scale offshore wind turbine foundation under wind load [47]. In 2022, Tianjin University will carry out research on the stability [48,49], bearing capacity [50], drag reduction and vibration reduction [51,52] of bucket foundation. The research on tubular foundation of offshore wind power in Tianjin University reached a small peak in 2013, and then tended to be flat. In 2022, the number of research papers published reached a peak in nearly 20 years.

North China Electric Power University mainly focuses on technical research and engineering research, and its main research directions include research on offshore wind turbines and offshore wind farms. In 2013, North China Electric Power University conducted analysis and research on the heat dissipation arrangement of offshore wind turbines. By analyzing the radiator space layout form, heat dissipation channel structure design and fan performance of the cooling system of megawatt offshore wind turbines, and conducting three-dimensional numerical simulation, it was concluded that the layout form of the radiator directly affects the system resistance of the heat dissipation channel, and thus affects the characteristic matching between the fan and the system of the radiator [53]. In the following years, North China Electric Power University carried out research on the dynamic characteristics analysis [54], control strategy [55], maintenance optimization [56] and other contents of offshore wind turbines. In 2019, the number of research papers published by North China Electric Power University on offshore wind turbines reached a peak, mainly focusing on the analysis and research of the support structure response of offshore wind turbines. Tian De and other scholars considered the support structure response of offshore wind turbines under the conditions of local scour [57], soil damping [58, 59], etc.

East China Survey and Design Institute mainly focuses on technical research and development, and its main research directions include single Pile foundation, numerical simulation, and offshore wind power foundation. In 2014, East China Survey and Design Institute carried out model tests under axial static load with the grouting connection section of large-diameter single Pile foundation of offshore wind turbine as the research object through the method of model test, and studied the influence of various design parameters on the bearing performance of the grouting connection section [60]. In 2022, the research paper on single Pile foundation of East China Survey and Design Institute will reach its peak, focusing on anti-corrosion technology [61-63] and protection technology [64,65].

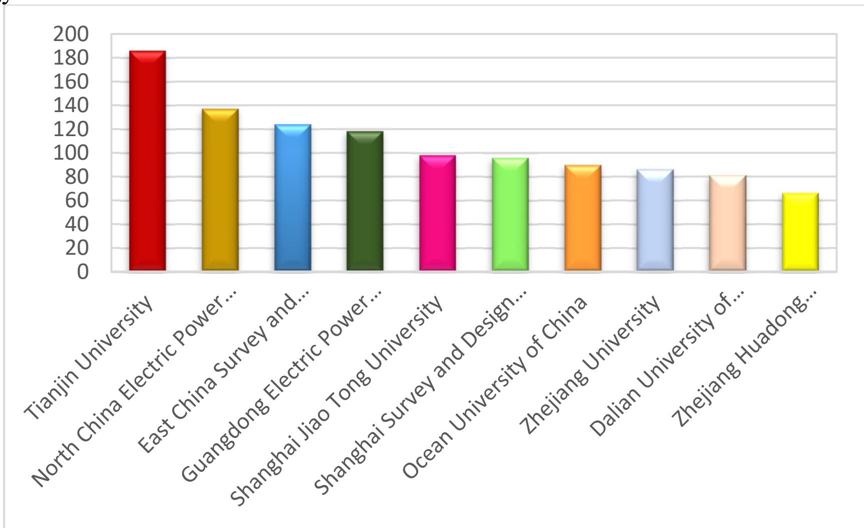

Fig. 2. Top 10 research institutions in the field of offshore wind power

Institutional cooperation analysis can analyze the information of high contributing organizations or groups in a certain field [66]. This study used Citespace to analyze its cooperation network. In the institutional cooperation network diagram (see Figure 3), the number of connections between nodes is directly proportional to the cooperation situation, and the thickness of the lines is directly proportional to the degree of cooperation between authors [67]. The research results indicate that research institutions in the field of offshore wind power often collaborate in the form of teams, forming influential research groups. Among them, Tianjin University, East China Survey and Design Institute and Guangdong Electric Power Design and Research Institute are at the center of cooperation. In addition, many institutions have less external cooperation and pay more attention to internal cooperative research. Since offshore wind power is strategically important for achieving China's goal of "carbon peaking and carbon neutrality", and in terms of science and technology, the technologies of various industrial chains of wind power are the commanding heights of international competition, technical exchanges between experts and scholars and Cooperative learning between institutions are crucial to the development of offshore wind power, and cooperation in fields should be strengthened to jointly explore the innovative development direction of future offshore wind power.

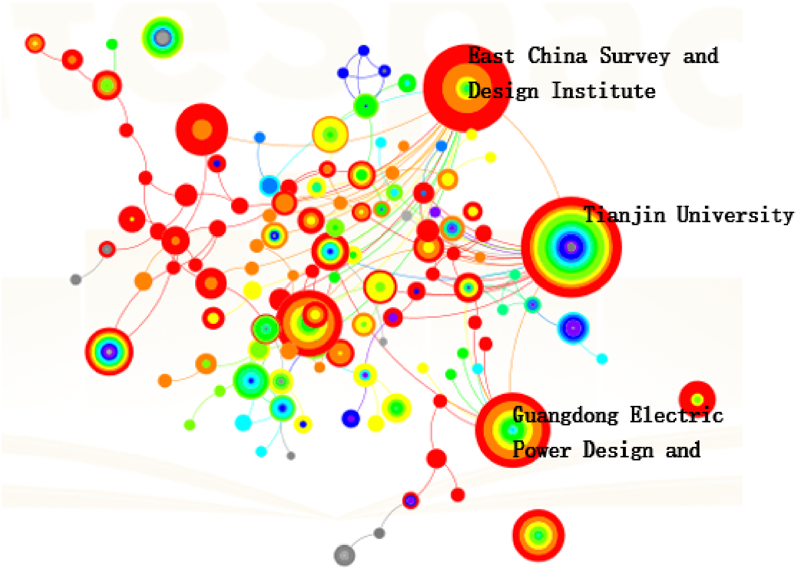

Fig. 3. Cooperation Network of Domestic Offshore Wind Power Issuing Institutions

Analysis of research authors.

The number of research papers produced by an author in a certain field is one of the important indicators determining their influence in that field [68]. From the analysis results of the authors (see Figure 4), the top ten authors include Yang Fu of Shanghai University of Electric Power, Jijian Lian of Tianjin University, Puyang Zhang, Hongyan Ding, Haijun Wang, Xu Cai of Shanghai Jiaotong University, etc. Among them, Yang Fu and Jijian Lian, two scholars, conducted research on the field of offshore wind power earlier and published a large number of papers, playing an important role in consolidating the theoretical foundation of offshore wind power research. Among the top ten authors, there are four scholars from Tianjin University. It can be seen that Tianjin University plays an important role in the basic theoretical research in the field of offshore wind power, and has formed a research team with strong influence in cooperation, focusing on cooperation and exchange inside and outside the institution.

Yang Fu scholars and his team mainly focus on power prediction [69-71], unit failure prediction [72,73], unit operation and maintenance strategy [74], Preventive maintenance [75-78] and other aspects of offshore wind power. Jijian Lian, Puyang Zhang, Hongyan Ding, Haijun Wang and other scholars belong to Tianjin University, which also corresponds to the analysis results of the above main research institutions. These scholars have formed a close research team relationship, mainly focusing on the stability, bearing capacity, drag reduction and shock absorption of tubular foundation of offshore wind power. Scholar Xu Cai and his research team mainly focus on the grid connection system of offshore wind power, DC series connection, and offshore wind power converters.

Through the analysis of the research fields of the main researchers, we can see that each researcher has its own internal research team, and the research focus of each team is different, laying a solid theoretical and technical foundation for the development of offshore wind power in China.

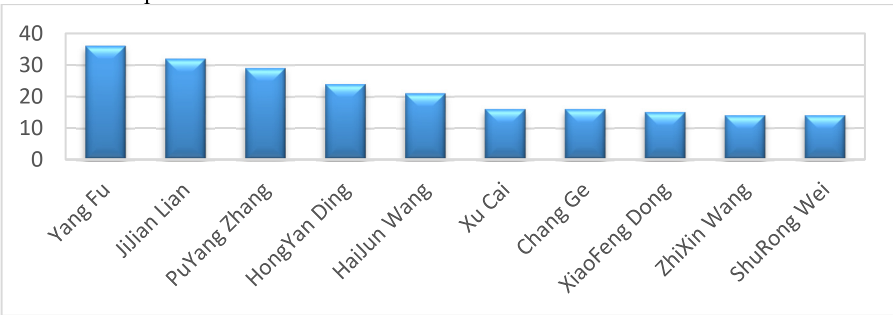

Fig. 4. Top 10 Authors in the Domestic Offshore Wind Power Field with Published Papers

Analysis of funding situation.

This article analyzes the funding situation of research papers on offshore wind power (see Figure 5), and it can be found that the National Natural Science Foundation of China is the largest offshore wind power funding institution in China, with a much higher number of supported and published papers than other funding institutions. There are also many research papers supporting the offshore wind power field, such as the National Key R&D Plan, the National High tech Research and Development Plan (863 Plan), the National Science and Technology Support Plan, and the National Key Basic Research and Development Plan (973 Plan). This also indicates to some extent that offshore wind power research has been included in multiple national key plans and is an important field of technology, science and basic research in China.

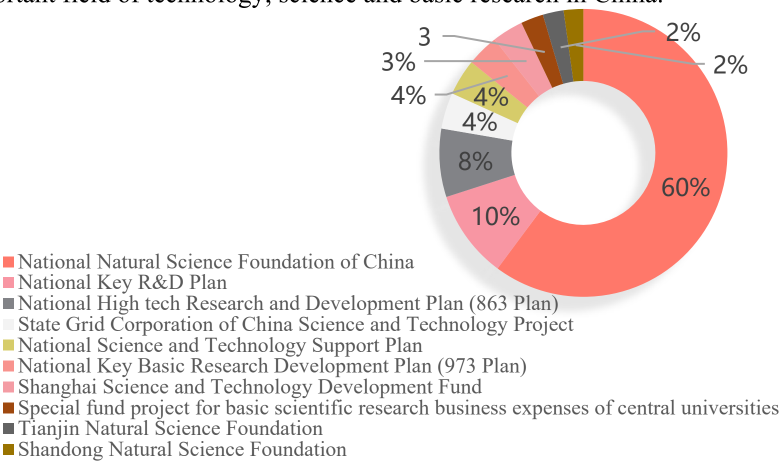

Fig. 5. Main funding institutions in the field of offshore wind power in China

3.3 Analysis of research hotspots

This article uses Citespace software to draw a co-occurrence network diagram of keywords in the offshore wind power field (see Figure 6). From the analysis results, the research hotspots in this field mainly focus on technical research, technology development, application basic research, engineering research, and other aspects. According to the ranking of intermediary centrality, the order is: offshore wind power, wind turbines, wind power industry, power generation, Goldwind Technology, Vestas, wind turbine blades, wind power bases, year-on-year growth, wind power equipment, grid electricity prices, wind power planning, wind curtailment and power restrictions, etc.

(1) Wind turbines, wind power industry, power generation, wind curtailment and power limitation

Through this set of keywords, it can be seen that the current focus in China is on the assembly and generation of wind turbines, and the development of wind power towards industrialization. At present, China's wind power grid connected installed capacity has consistently ranked first in the world for 12 consecutive years[13]. However, compared to other countries with advanced offshore wind power technology, China's offshore wind power still faces problems such as small single unit capacity and individual scale, insufficient reserves of key technologies for far-reaching offshore development, and relatively lagging construction, operation, and maintenance equipment and technology[1]. Therefore, improving the installed capacity and scale of offshore wind power units, breaking through key core technology bottlenecks, is currently the top priority in the research field of offshore wind power in China. Abandoning wind power and limiting power refers to the phenomenon where wind turbines can operate normally, but they stop operating due to insufficient grid capacity, unstable wind power generation, and mismatched construction schedules. It can be seen that improving the maturity and stability of offshore wind power generation technology is still a hot research issue in China.

(2) Goldwind Technology, Vestas

Goldwind Technology and Vestas are leading companies engaged in the development, production, sales, and installation of wind turbines both domestically and internationally. This group of hotspots can be seen as a high level of attention in the domestic research field to the entire industrial chain of offshore wind power equipment from research and development to installation. Encouraged by national policies, China's offshore wind power industry has experienced over 10 years of explosive development[4], with over a hundred enterprises participating in the entire production process of wind power. However, each enterprise has its own way of fighting and technology is difficult to share. Therefore, the overall manufacturing capacity of the industry is weak and lacks technological competitiveness. Some key technologies of offshore wind power rely on imports, which to some extent restricts the development of domestic offshore wind power.

(3) Wind turbine blades, wind power bases, and wind power equipment

This set of keywords indicates that domestic offshore wind power research still focuses on the research and development and upgrading of wind power technology, wind power installation infrastructure, etc. At present, domestic offshore wind turbines are developing towards the trend of "large capacity, lightweight, and high reliability"[6]. Blades are a key component that affects the performance and cost of wind turbines, and are also a symbol of national technological strength[14]. Currently, China is still constrained by foreign countries in terms of flexible blade bending and torsion coupling, stability of coupling with pitch systems, and dynamic testing of blade deformation. Relevant components still need to be imported[6]. Therefore, reducing blade costs, improving blade reliability, stability, and ensuring unit power generation are urgent issues that need to be addressed in the current domestic offshore wind power industry.

(4) Year-on-year growth, grid electricity prices, and wind power planning

From this set of keywords, it can be seen that domestic research focuses on the online electricity price of offshore wind power, as well as the support and future planning of policies for the offshore wind power field, and focuses on the medium to long-term development of the offshore wind power field. The entire development process of offshore wind power in China from the initial stage to the commercialization stage has played a crucial role in policies such as incentive grid electricity prices and financial subsidies issued by the government. These incentive policies have effectively promoted the process of large-scale utilization of offshore wind power in China.

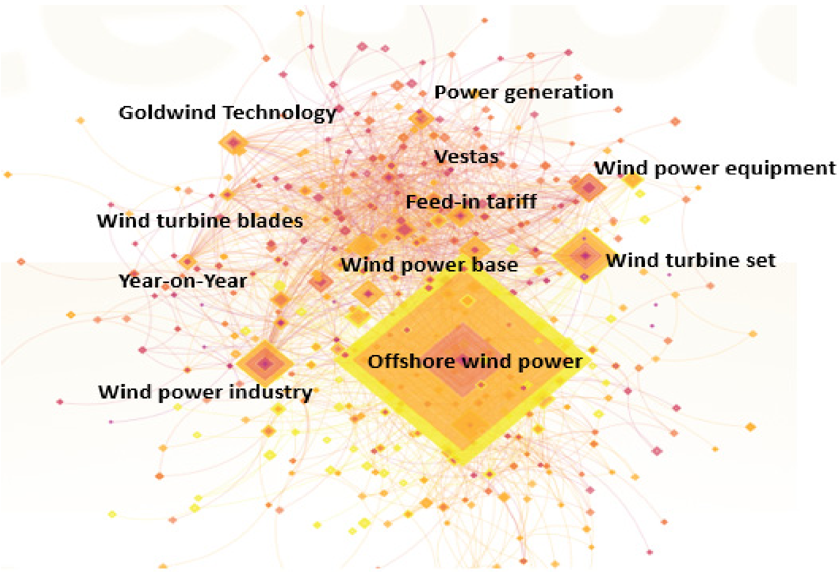

Fig. 6. Co-occurrence map of keywords in offshore wind power field

4 Discussion

Based on the results of scientific econometric analysis in the field of offshore wind power in China, the following conclusions can be drawn:

From the perspective of the number of publications, the overall development trend of offshore wind power in China is rapid, and it is currently a hot research field of concern for domestic scholars. Although China's offshore wind power started relatively late, with the support of national financial subsidies, incentive electricity prices, and other policies, its development has been unstoppable in the past decade, and it is also in a leading position in the international offshore wind power field. As of 2022, the cumulative grid connected installed capacity of offshore wind power in China has exceeded 30 million kilowatts, continuously maintaining the world's largest offshore wind power installed capacity[15], and is expected to become the world's largest offshore wind power market in the future[1]. Based on current data, it is expected that the future development prospects of offshore wind power in China are still broad[16],[17].

From the perspective of research force distribution, the research force in China's offshore wind power field mainly comes from universities and research institutes, and in terms of funding support, it comes from the National Natural Science Foundation and key research and development plans, fully demonstrating that the offshore wind power field is currently an important research field in domestic technology, science and technology, and basic research. In addition, the cooperation between internal and external institutions in the field of offshore wind power is relatively optimistic. In solving the key technical issues of China's current "bottleneck" in the field of offshore wind power, various institutions should brainstorm, save resources, and collaborate for win-win results, which is an inevitable choice to overcome difficulties.

From the perspective of research hotspots, the research hotspots in this field mainly focus on technical research, technological development, applied basic research, engineering research, and other aspects. At present, the development industry chain of offshore wind power is still incomplete, and there are still shortcomings in key technologies, especially in terms of single unit capacity and scale of offshore wind power, core construction equipment, far-reaching offshore development, and relatively lagging construction and operation equipment and technology. Therefore, in future development, there should be a plan with ideas, standards, steps, goals, and layout for the development and utilization of offshore wind power, and efforts should be made to break through technological bottlenecks[1].

5 Conclusion

This article analyzes the development of offshore wind power from the perspective of scientific metrology. Through visual methods, it systematically sorts out relevant literature in the field of offshore wind power from 2002 to 2022, in order to clarify the development context, research hotspots, and trends of offshore wind power, and provide some reference for offshore wind power research. However, there are still some shortcomings in the results of this study. On the one hand, this article only selected literature from the CNKI database as the data source, and the collected data has certain limitations; On the other hand, the collection, analysis, and interpretation of data are to some extent influenced by the knowledge background of researchers, and need to be improved and improved in future research.

The offshore wind power industry is a commanding point for future international competition and an important part of China's energy transformation to achieve the "dual carbon" goal. The support of relevant national policies provides a solid foundation for the sustainable development of offshore wind power. In the future, we will accurately conquer key technologies in China's offshore wind power field, actively explore new directions for the future development of offshore wind power, and make offshore wind power an important strategic force in China's energy and technology fields.

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