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A bibliometric review of China's new energy in 2017

Wenjing Yang ^{1,*}, Xiaoning Zhang ¹, Xiaofu Zhang ²

¹Institute of Scientific & Technology Information of Gansu, Gansu Key Laboratory of Scientific & Technology Evaluation and Monitoring, Lanzhou, China

² Lanzhou Institute of Animal and Veterinary Pharmaceutics Sciences, CAAS, Lanzhou, China

*Corresponding author e-mail: yangwjzh@126.com

Abstract. As new energy grows rapidly in China, this paper presents a review of the research status of China's new energy in 2017 by using bibliometric techniques analysis. The objective is to identify current research fronts, and analysed some aspects of constraints. Moreover, here the content is presented, keywords enabled entries to be assigned to categories in five areas: new energy automobiles, energy internet, renewable energy, energy structure and carbon emission in order to explore research hot spots of new energy research field. Finally the future research trends of new energy were presented. All in all, the deep investigation into China's new energy development status in this paper is aimed at promoting the reform of new energy resources production and utilization, improving the policy system continuously, and providing the reference and advice for the China's new energy development.

1. Introduction

The new energy has aroused more and more attention. The world energy development is entering a new historical period, when clean and low-carbon energy is inevitably required [1]. After the 18th National Congress of the Communist Party of China, as the core leader, President Xi Jinping has addressed a series of important initiatives on energy development. Today, rational development and efficiently use of energy in relation to the future of the world, the world is facing the challenge of resources, social development and environmental protection and other multiple pressures, but the traditional energy reserves are getting fewer, therefore, the national government have focus on the development of new energy [2]. Governments are actively leading the development of alternative energy sources; energy problem is increasingly becoming the focus of international attention [2]. In the past decade, England have achieved the largest increases in renewable energy share [3], the usage of renewable energy resources is increasing in U.S. energy production, and reductions in coal usage through cheaper, cleaner-burning natural gas assuming its share of energy production, and it's in the process of meeting energy efficiency targets to reduce CO₂ emissions by 30 percent utility sector by 2030[4].

China constrained by the level and stage of its economic development, it still practices a rough-edged economic growth model, characters of high energy and resources consumption and high environmental costs, it also has suffered a lot from climate change, so it is necessary to take some attention to new energy. In this paper, we aimed to statistically analyze published articles of new energy research field in 2017 by using bibliometric techniques analysis and explain the main hot topic areas of current



research, explored for the keyword category in future trends, attempts to giving crucial evidence support required to researchers and decision- makers.

2. Data and Methods

Bibliometric is a set of special research methods, which can be used to quantify the documents, authors, words and co-citation by employing statistics and mathematics, and to analyze research directions and hot spots based on a count of scientific papers published [5-6]. Bibliometric analysis aims to quantitatively characterize the literature. Moreover, it can also to evaluate the institutions, universities and countries to decide their influence in a particular research field. Co-word analysis is one of methods which can count and analyze the high frequency of keywords [7], and reveal the theme of the article, estimate the co-occurrence frequency of two words, then form a co-word network by these relevant words, and the distance between the network nodes can reflect the relationship of theme. Therefore, bibliometric are very important to construct a general picture of a research field. In this research, the main goal is to provide a new perspective for the theme, in order to promote more effective review of the literature by others, and to recognize the more significant to the advancement of new energy research field.

In the present study, the data for the new energy research overview is collected from the China National Knowledge Internet (CNKI). For searching the articles published related to new energy, the keyword of “new energy” was used in the “topic” tab of the CNKI. However, there some papers could be collected that are not related to new energy research during the data collection process. To avoid this situation, the search results are carefully checked and cleaned to omit the articles that are not related to new energy. The research hotspots of new energy in 2017 were explored based on the bibliometrics analysis and Pajek software. The results also reflected the frontiers in the area of new energy to a certain extent.

3. Results

3.1 Number of communications in new energy research field

The current search contains more than 9000 articles were found by using the selected keywords in the search tab of CNKI since 1992. During the past 25 years, the number of scientific research articles on new energy has risen substantially. As show in Fig. 1, the number of articles identified per year on new energy-related topics increased steadily from 23 in 1992 to 969 in 2017, a more than fortyfold increase. New energy research is steadily increasing over the past 25 years as evident which shows a consistent increase in the number of publications reported on new energy particularly in the recent few years, the increase in numbers of paper was steepest, there appears to have been a sharply increase in 2010. 4683 articles were published in the last 5 years, approximately 50% of the total. This shows that the research in the new energy is getting more and more importance. According to CNKI records the average number of papers published per year is more than 349 in the new energy field, and with the highest number of yearly publications recorded in 2011 and 2016 as 1040 and 1011 articles respectively. There 969 articles have published in 2017, and approximately 20.69% of the last 5 years. Thus, more scholars have conducted extensive research on the new energy industry.

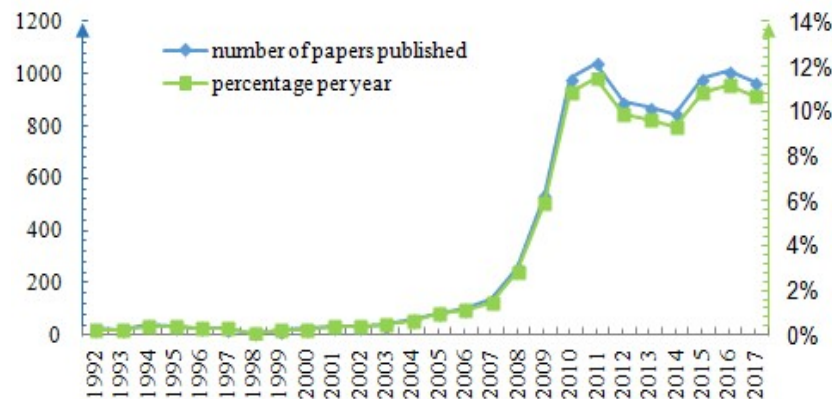


Figure 1. Number of papers on new energy by year.

3.2 Research direction and hot spots of new energy research in 2017

As the conventional energy resources are limited and environmental problems are becoming increasingly prominent, while being environmentally friendly and renewable, new energy resources are paid more and more attention by all the countries. When new energy was selected as the key word, we collected 969 papers included on CNKI on new energy in 2017. After data cleaned, 810 records remained and after screening, 500 was included in the analysis. The 500 unique papers were published in 219 separate academic journals in the CNKI database, most commonly ‘Automation of Electric Power Systems’ (N = 24), ‘Proceedings of the CSEE’ (N = 18) and the ‘Electric Power Construction’ (N = 18).

Fig. 2 shows the keywords number of new energy by topic area. For nine areas at least 10 papers were identified: out of 500 papers, a large number focused on new energy automobiles topic 68 (14%), 27 (5%) were conducted on energy internet specific topics, 19 (4%) concentrated on renewable energy area, 14 (3%) conducted on energy structure, 13 (3%) focused on new energy automobile industry, 11 (2%) focused on carbon emission, 11 (2%) concentrated on renewable energy consumption, 10 (2%) concentrated on new energy industry, 10 (2%) focused on energy transition, respectively.

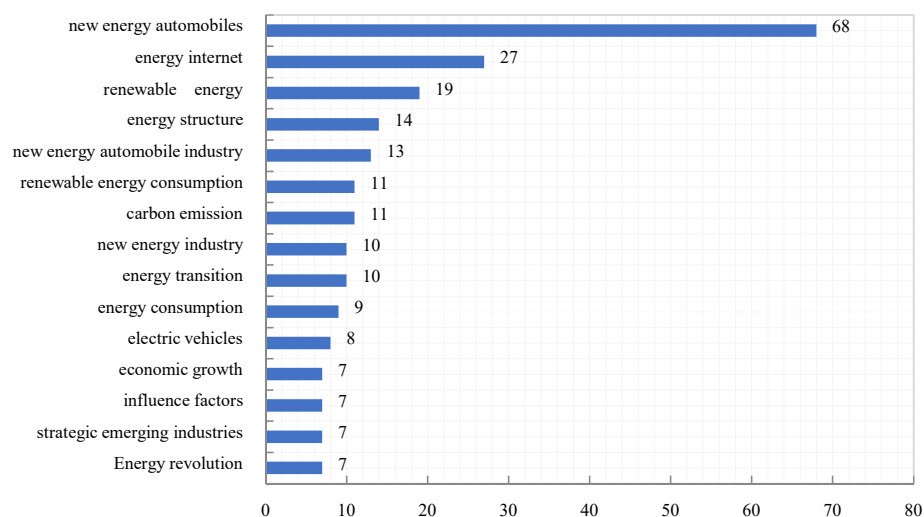


Figure 2. Number of keywords by topic area

The keywords matrix were imported into the Pajek software, and the keyword common map was calculated and analyzed. To highlight some of them, Fig. 3 shows the keyword map for the research

orientations of the new energy in the year 2017, full characteristics of the studies are presented in the map, all of which can be divided into 5 clusters, including new energy automobiles, energy internet, renewable energy, energy structure and carbon emission.



Figure 3. The keyword map for the new energy areas in 2017

3.2.1. New energy automobiles. Preliminary analysis of the key words shows that a total of 68 articles played a role in the new energy automobiles. New energy automotive industry is one of the strategic emerging industries in China, which shows a critical way to solve environmental pollution and energy [8]. Fig. 3 shows the relationship of new energy automobiles with each research topics, different researchers looked at new energy automobile among the policies, charging infrastructure, technology innovation and commercialization, the formation mechanism of patent pool [9-12]. They found that problems exist in the policies for promoting new energy in China, including too many subsidies, unreasonable design of subsidy policies, rough policies of government procurement, and lack of coerciveness [9], Lu (2017) suggested the new public policy of new energy automobiles needs to be redesigned based on the ethics of freedom, rights and happiness [13]. The Chinese charging infrastructure has made some achievements; however, the overall development of charging infrastructure is lagging behind the growth of new energy automobiles, there are still some problems which makes a constraint to sustainable development of the new energy automobiles industry [10]. From the perspective of platform efficiency analysis, the environment induction characteristic of “finished-components” is a key factor of determining the platform supportive level of new energy automobiles technology innovation [11]. At the same time, Sun et al. (2017) reported that if constitute a patent pool, both the vertical integration of enterprises or pure upstream R&D enterprises will get more ideal profits, they found that the formation of the patent pool will also increase the total output of the downstream market and decrease the prices of goods, so as to promote the development and stable operation of the patent pool [12]. Different scholars have put forward the development path of China’s new energy automobile in terms of policy, technology and patent, and so on, which has made great contributions to accelerating the development of China’s new energy.

3.2.2. Energy internet. It has produced a strong response after the strategic concept of global energy internet constructed in the world. Among 27 papers looked at energy internet, including energy transition,

internet+, energy revolution and energy security. China's energy transition is of great significance as a country with the highest energy consumption in the world, the emerging energy internet under external pressure provides a new space for institutional innovation[13], Hong et al. (2017) reported that urban energy internet can be used to realize the efficient conversion among multiple energy sources within urban area, the prospect of urban energy internet is discussed in the aspects of equipment morphology, system planning, operational control, commercial mode and coordinated development[14]. Mao et al. (2017) reported that microgrids have "cell" functions to facilitate the future energy interconnection system, including deployment localization, source/load diversification, structural diversity, operational flexibility, controllability, and interactivity [15]. Energy interconnection is one of the overall visions of energy supply and demand system in the future, making a reasonable electricity purchase plan can reduced the cost of electricity purchasing and the pollution to environment with the large-scale integration of renewable generation [16]. Meanwhile, Liu et al. (2017) by put forward a multi-objective optimization model considering the constraints of the security, found the problems of resources and environment bring an urgent necessary for the transformation and upgrading of energy production, transmission and utilization, which can be effectively solved through development of the smart grid [2].

3.2.3. Renewable energy. A high proportion of renewable energy integration will be one of the basic characteristics of clean in the future. Different scholars looked at renewable energy among the smart grids, renewable energy policy, renewable energy certificates, integrated energy system [17-21]. Chen et al. (2017) studied the future situation and existing problems for the power grids for supporting development of renewable energy, including construction of future power system, improvement of simulation capability for large-scale power grid, and solutions for new stability issues [17]. Meanwhile, energy storages system plays a vital role in mitigating effect of intermittent wind power and loads [18]. Yu et al. (2017) compared the dispatch scheme and the market design associated with the renewable energy unconditional priority policy and the renewable energy market competitive policy, the renewable energy unconditional priority policy will distorting the price signal and incentives of the carbon tax [19], and the ratio of the wholesale price of the renewable energy certificates and the government fine will have impact on the electricity companies' procurement strategies [20]. Power to gas facility can be applied to realize the energy conversion, for this purpose, Du et al. (2017) proposed an optimization model that is for the electricity-gas combination system, studied the impacts application on the energy acceptance rate of loads and the excess rate of renewable energy, found that the integrated energy system improves the rate of energy-supply to loads and reduces the level of wind-power curtailment [21].

3.2.4. Energy structure. China's oil dependency had reached above 63% in 2013 and 2014, and natural gas developed relatively late and has a great growth potential in the future [22]. Different researchers looked at energy structure among energy consumption, influence factor, co-integration relationship and energy efficiency [22-24]. Fan & Wang, (2017) reported that the inflow and outflow of coal and electricity among different provinces in China, energy supply had increased by 1.52%, and coal fired thermal power accounted for 75% of total power generation capacity in China, however, gas electricity was much less than 24% of that in OECD countries [22]. Meanwhile, Xiao et al. (2017) by researched three main energy as well as coal, electricity and fuel wood consumption and its influence factors in 13 district of Beijing, found that the main energy were electricity, coal and liquefied, however, the clean energy proportion of solar energy and biogas is low [23]. Energy structure has a negative impact on energy efficiency in the long term verified with Johansen co-integration test, for this, Wang and Fan (2017) suggested to optimize the energy structure and gradually reduce the dependence of economic growth on fossil fuels, the state should formulate a clean energy policy to promote the rapidly development of the clean energy industry [24]. He et al. (2017) reported that produce a significant inhibition of carbon emissions through the energy structure path[25].

3.2.5. Carbon emission. At present, carbon emissions reduction is a very important challenge all over the world. Many scholars looked at carbon emission among effects, driving factors, intensity and

emission reduction mechanisms in China [26-29]. The industrial sectors of cities are among the largest consumers of energy and the largest source of emissions. Li and Hong (2017) explored the spatial pattern and spatial effects of energy-related carbon emissions and air pollution, they found that energy carbon emissions and air pollution have positive spatial correlation and spatial agglomeration effect, spatial spillover effects of energy intensity [26]. Meanwhile, Sun & Zhou (2017) analyzed the decoupling relationship between energy carbon emission and economic growth and driving factors in China during 1996-2014 used the combination of the Tapio decoupling index method, the Kaya equation and the LMDI factor decomposition, they found that the energy intensity and economic development are the main driving factors influencing the decoupling of carbon emissions [27]. Wang & Li (2017) researched the influencing factors and the intensity of regional carbon emission provides some scientific basis for the development of regional carbon emission management and carbon emission reduction policies, showed that the energy consumption structure is the key factor promoting the growth of carbon emissions, followed by energy utilization efficiency, and population size and the scale of economies also play a certain role in promoting the growth of carbon emissions. In addition to the mentioned above, Yang (2017) establishing a vector autoregressive model for three variables economic growth, found that neither economic growth nor energy consumption had a significant long-term causal relationship with carbon emissions, so suggested to promote the development of new energy technologies, and establish long-term emission reduction mechanisms [29].

4. Conclusion and Discussion

There have pays more and more attention to new energy research in China, the published scientific research articles of new energy research field is grows rapidly. The analyses presented in this paper show the substantial growth of the number of articles on new energy during the past 25 years, with annual growth rate more than 30% from 1992 to 2017. Over the past five years, approximately 50% of the total published articles has developed. As more papers are being published, the potential for duplication and overlap rises, it seems that the research field of new energy has a richer prospect in China.

By using bibliometric techniques analysis, we found keywords of new energy research field enabled entries to categories in five areas: new energy automobiles, energy internet, renewable energy, energy structure and carbon emission. Currently, there seldom have analysis categories of new energy research field, resources did not be used efficiently in the researchers or decision-making process. Analyzing hot topics and main contents among the research field by using bibliometric techniques will increase efficiency of information, promoting the reform of new energy resources production and utilization modes, and improving the policy system continuously.

With the above analysis, it is essential to increasing attention into policy, charging infrastructure, energy security, clean energy in China. Since 2010, the Chinese government has introduced numerous policies to accelerate the development of the new energy. Due to several complex factors of timing, regional economies, and other demands on the government's attention, the policies have various effects on new energy industry. Therefore, in order to effectively promote the development of new energy industries, the government should develop differentiated policies at different stages, strengthen the coordination mechanisms of central and local governments, the policy implementation consisted of a "plan-pilot-promotion-subsidy-development" process, and focus on infrastructure construction, research and development (R&D), the recycling of batteries, and private purchase regulations in future [30]. Secondly, As the world's largest carbon dioxide (CO₂) emitter, China is facing increasing international pressure to reduce emissions. Developing new energy vehicles has become an important measure to cope with the challenges in conserving energy, upgrading the automotive industry and the key stakeholders[31]. Battery electric vehicles powered with renewable energy can reduce greenhouse gas emissions, but the limited range with current batteries becomes a barrier of battery electric vehicles to the market diffusion. For this reason, potential users of electric vehicles often ask for public charging facilities before buying vehicles, so it should increase attentions on battery sizes and power rates in the future[32], developing new business models of charging infrastructures, and the charging price should

be considered more carefully at the same time[33]. Thirdly, cities are responsible for more than 60 percent of the total global energy consumption and approximately 70 percent of greenhouse gas emissions [4]. Faced with energy contradictions caused by increasing need for resources but with severe deficiency, the use of clean resources should be upgraded within the national security strategies. In recent years, countries around the world are actively promoting energy transformation and have developed clean energy development goals and plans. He et al.(2018) compared the level of clean energy development between in many countries by evaluation clean energy development level, they suggested that considering policies and regulations, energy supply, environmental impact, energy consumption, technology, economy and so on when constructs comprehensive evaluation index system[34]. Finally, energy security is one of key parameters for assuring a stable development of countries and regions, making energy security is an integral part of national security. On a household level, energy prices influence energy security, because a rise in energy price places stress on the family budget [35]. On a nation level, energy security concepts underlie International Relations debates and policy-making, Proskuryakova (2018) reported that the existed concepts do not account for the latest technology changes[36], therefore, Raghoo et al. (2018) recommends selected strategies and actions to improve energy security[35]. This finding is in line with evidence that actively developing new energy has become a fundamental means to solve the dilemma between environmental pollution and energy consumption growth. It is hoped that this work can provide some help for subsequent relevant research work.

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