

3

BIBLIOGRAPHIC ANALYSIS FOR CARBON NEUTRALITY (CN) IN THE ENERGY SECTOR

Dipen Solanki
GAIL (INDIA) LTD.

ABSTRACT: Research is an integral part of any development and provides a base it for future growth. Hence, the direction of research matters as a lot of time, resources and effort have been involved already during the process. In such a case bibliographical analysis plays a very crucial role as it gives a brief idea about the work done by different persons, countries, institutions, areas etc. which gives a direction to new researchers to concentrate their efforts in the right direction. Carbon Neutrality is a relatively new but very important concept because humans can't progress at the cost of the environment and this topic is directly connected with the environment of the earth. We have to move ahead in harmony with the nature. Hence, this topic becomes very critical to understand as it gives the idea about the research work done by various scholars, institutions, and countries in this or its relative areas. The backbone of this paper is technology. Scientometric evaluation is been carried out with the help of the VOSviewer (Van Eck and Waltman, 2010) software for visual representation and better understanding. By this paper, we come to know the scope of research in this area for the future. Further deliberation of the methodology and findings are mentioned in the respective heads.

KEYWORDS

Renewable energy, PV-T, heating, clean energy

Introduction

Greenhouse gases absorb the sun's heat that radiates from the Earth's surface, trap it in the atmosphere and prevent from escaping into space. In this way, it creates Greenhouse effect which keeps Earth's temperature warmer than it should be. This effect can cause the changes in climate activities i.e. shift in snow and rainfall patterns, a rise in average temperature and more extreme climate events such as heatwave or floods etc. The goal was set to limit global warming to well below 2 Degree Celsius as preferred to 1.5 Degree Celsius in COP 26 in order to reduce/control the effect. Out of all other Green House Gases, Carbon Dioxide and Methane are contributing the most and hence attracted the attention at globe level. Function of any research is to create the base for the future development which helps to prove direction to take better decision and increase the efficiency. This is true for this research as well. This research focuses on the finding the research gap on the proposed topic "Carbon Neutrality (CN)" in India and at global level in the energy sector where Carbon Neutrality refers to net-zero CO₂ emissions - a balance between all anthropogenic emissions from fossil fuel combustion, industrial production processes, land-use changes and CO₂ removals from land, ocean and human society (such as carbon capture, utilization and storage (CCUS)) (Liu, 2022). This research also helps to identify the contributions of different authors, countries, sectors, institutions, etc. in the CN. Availability of the documents in the proposed area is (407) which can be consider as low availability of documents in the given field. Majority of the documents are in the form of articles followed by the research papers which shows the research gap (Figure 2). China is contributing more than half which leads to the opportunity lies for the other countries to contribute to the sector (Figure 3). Energy and engineering are two major contributing sectors following by environment and mathematics sector. IT sector can contribute more here in terms of implementing new technologies in the given are. Overall, this paper gives broader aspects to align research gap of various sectors toward one very important topic i.e. CN.

Literature Review

The achievement of carbon neutrality, which refers to achieving net-zero carbon dioxide emissions, is of significant interest among the researchers, policymakers, and various environmental departments in developed and developing economies (Shan, 2021). In response to the worsening global climate change, achieving carbon neutrality by 2050 is the most pressing task on the planet (Wang, 2021). As of February 2021, 124 countries had pledged to achieve carbon neutrality by 2050 or 2060 and the goal is to limit the temperature increase by 2100 to 1.5°C - 2.0°C from its preindustrial level by 2050 (Chen, 2021). Carbon neutrality would be a giant first step of humankind in stopping the accelerated damage to our living environment (Chen, 2021). Challenges toward achieving carbon neutrality for developing countries like China are energy consumption and CO₂ emissions increases constantly, the transition period allowed for the country to transition from its carbon peak to carbon neutrality is shorter than that of developed countries, reliant on high-carbon fossil energy fuels and low-carbon and zero-carbon technologies are not mature (Zhao, 2022). 32 developed countries that have proposed carbon neutrality targets as the research objects where how to achieve carbon neutrality targets while ensuring economic growth has become an urgent issue for academics and politicians (Dong, 2022). New technologies (solar, Wind, Hydropower, Nuclear, Green Hydrogen, Artificial carbon conversion) play leading role to transform the future of carbon neutrality (Caineng, 2021).

Methodology

The study follows the established procedures of scientometric evaluation to analyze the global trend of research publications in Carbon Neutrality. The Scopus, an Elsevier product, is a popular and most prominent abstract and citation database in terms of content, including bibliographic and citation information for all traditional, transdisciplinary, and interdisciplinary areas. Scopus is considered to be the best database for investigating the goal of this study. Because of its extensive and updated coverage, data from this source is regarded as the most reliable for a bibliometric investigation to expect precise and accurate results. Moreover, numerous studies have been done using the data from this database. The search strategy was developed by using the following key terms in the "Article Title" field of the database: "Carbon Neutrality" initially. Later, it was found that many irrelevant papers were encountered that were not related to the subject.

So, these unrelated topics are filtered by excluding subject Energy. The search keywords are designed to include the subject Carbon Neutrality in the Energy Sector. The following search string was used to retrieve the data: (TITLE ("Carbon Neutrality") AND (LIMIT-TO (SUBJAREA, "ENER"))). The total number of documents retrieved using the search strategy was 407 (Retrieved on 15 March 2023). The refined results were extracted in an MS-Excel spreadsheet for further analysis using VOSviewer (Van Eck and Waltman, 2010) which facilitate analysis of data for network visualization. The retrieved data were analyzed based on the following attributes:

- Chronological Growth.
- Highly cited publications.
- Prolific Countries.
- Contributing Authors and Institutions.
- Author and Country Co-authorship network.
- Keyword analysis.

The graph shows the chronological growth (Figure 1). To provide a network visualization of the global research on Carbon Neutrality for author and country co-authorship perspective and keyword co-occurrence (density, network, overlay and frequency of occurrence), VOSviewer was used (Figures 4,6, 10-14). To get transparent network maps, the normalization method used is "Association Strength." In the network analysis, the connection within the various publication titles, citations received, and document type is depicted through nodes and edges. Here, Fruchterman Reingold and layout and modularity network overview algorithms were used to visualize the clusters properly.

Results and Discussion:

Descriptive Analysis:

Evolution and Tendency of publications

Over the past decade, the results of about 407 documents on this topic have been made available in the Scopus database. It is observed that extensive research work has been carried out only in the last five years, which has accelerated compared to the last three years (2020 - 2023). This might be because the industry needs a research base to meet its various international obligations, and this is a whole new area to enter with high investment costs and little progress in technology. Before this period of time, there is not much research documents are available. Out of these documents, articles on the subject accounted for 66.1%, followed by conference papers (12.8%), Review (11.5%) and other types of documents shown in the fig.2. Based on this we can infer that the awareness was spread by the articles

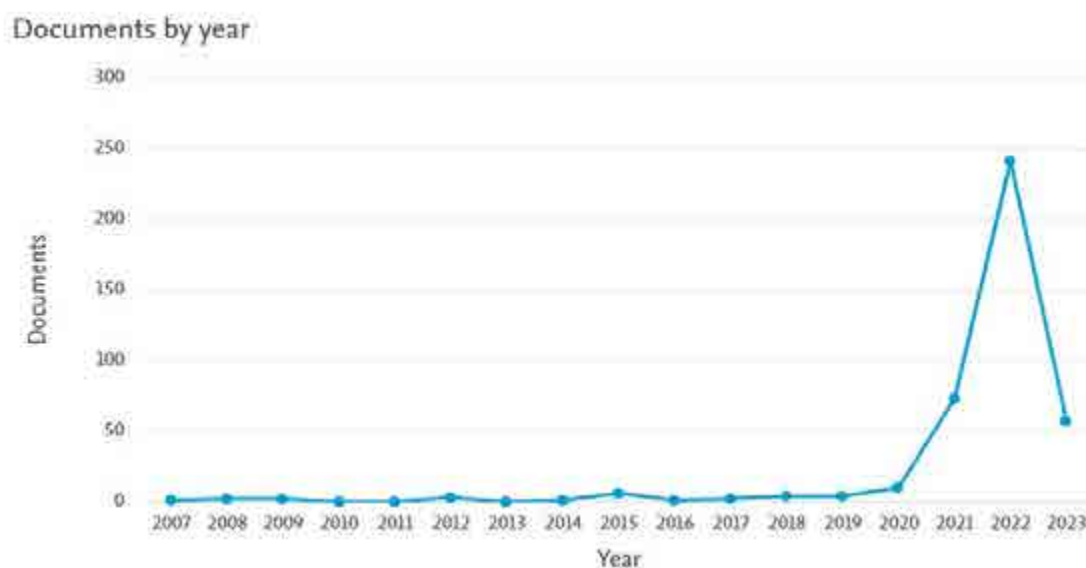


Figure 1: Document Analysis - Year Wise

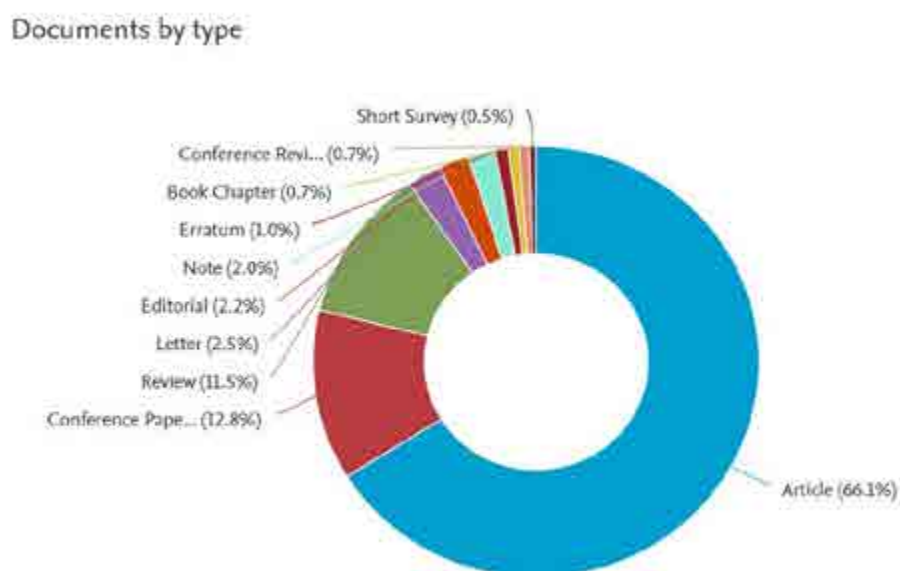


Figure 2: Document Analysis - Type Wise

and even dedicated research was not taken place till 2021 but after COP 21 was also held in 2021, research shoot up in the year 2022. Even before that, short surveys were also very less.

Evolution and tendency of citations:

Research boundaries to check the tendency of citations are mentioned below:

- I. Maximum number of authors per documents are 25
- II. Minimum number of authors per documents are 2
- III. Minimum number of citations of an author are 2
- IV. Number of authors selected are 194
- V. Minimum numbers of documents published by a country are 6
- VI. Minimum number of citations of a country are 6
- VII. Number of countries selected are 19

As a result of the above boundaries, we could be able to map authors who met the above criteria in the VOSviewer software. Results are mentioned and discussed below.

Contributing sectors in Carbon neutrality:

Energy sector is the highest contributor in the research with 35.3% followed by Engineering 17.6%, Environmental science 16.4%, Computer and Social Science 10.5% together and so on. In this analysis, it is observed that the gap between first two sectors are more than the remaining sectors and drastically decline after 3rd sector i.e., Environmental science. This research gap also represents the gap in new technology development in engineering, gap in new theories development in environmental science, gap in new IT applications or future technology implementation via Computer, gap in new policy and framework development in social science and so on for all the presented sectors which effects to CN.

Citation analysis

a. Number of publications per year

Figure 1 clearly shows that there was no significant progress in research work from 2007 to 2015. From 2016 to 2020, the growth rate was as usual as it was in the previous year. Starting from 2020, dramatic exponential growth can be observed, peaking so far in 2022 (241 documents) and accounting for more than half of research work from 2007 to 2023.

b. The most frequently cited articles

From the Fig.4 we can see that the article written by the Lin b. is the most frequently cited article followed by Shahbaz m., Gou j., and tian z., etc.

Documents by subject area

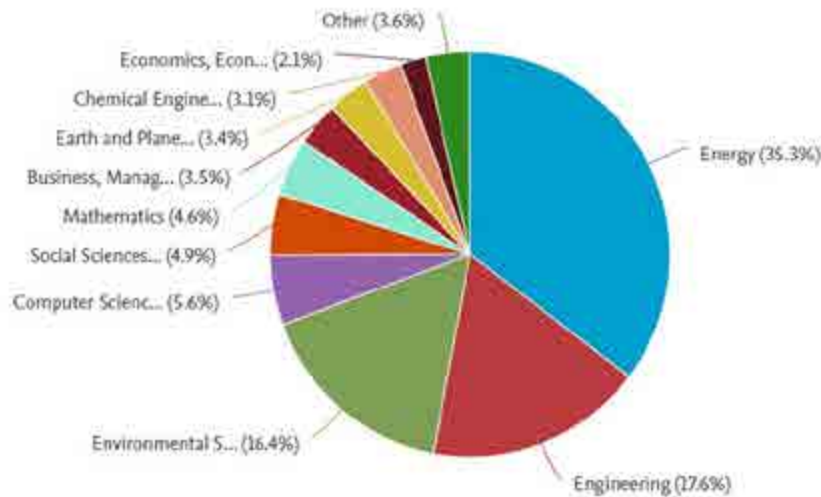


Figure 3: Document Analysis - Sector Wise

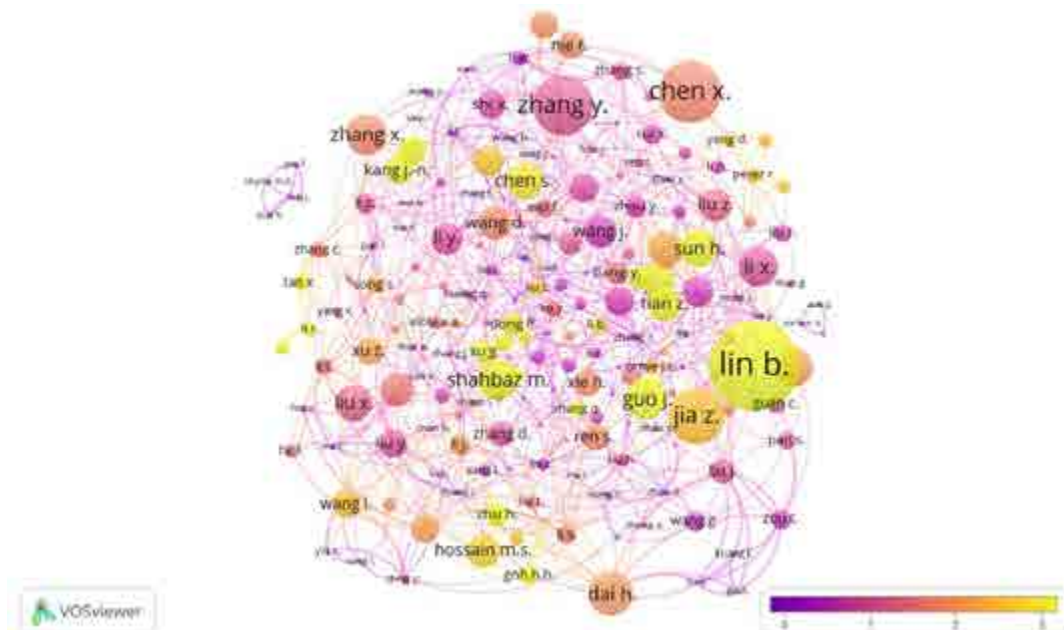


Figure 4: Document Citation Analysis

c. Most contributing and most influential authors

Maximum number of the documents published by the author is Four by Adebayo, T.S., Alola, A.A., Jia, Z. and others. However, despite of this contribution of their work; they were not cited the most. So, we can say that they contribute the most but not the influencers. The authors mentioned are the most cited ones and hence can be considered as the most influential authors.

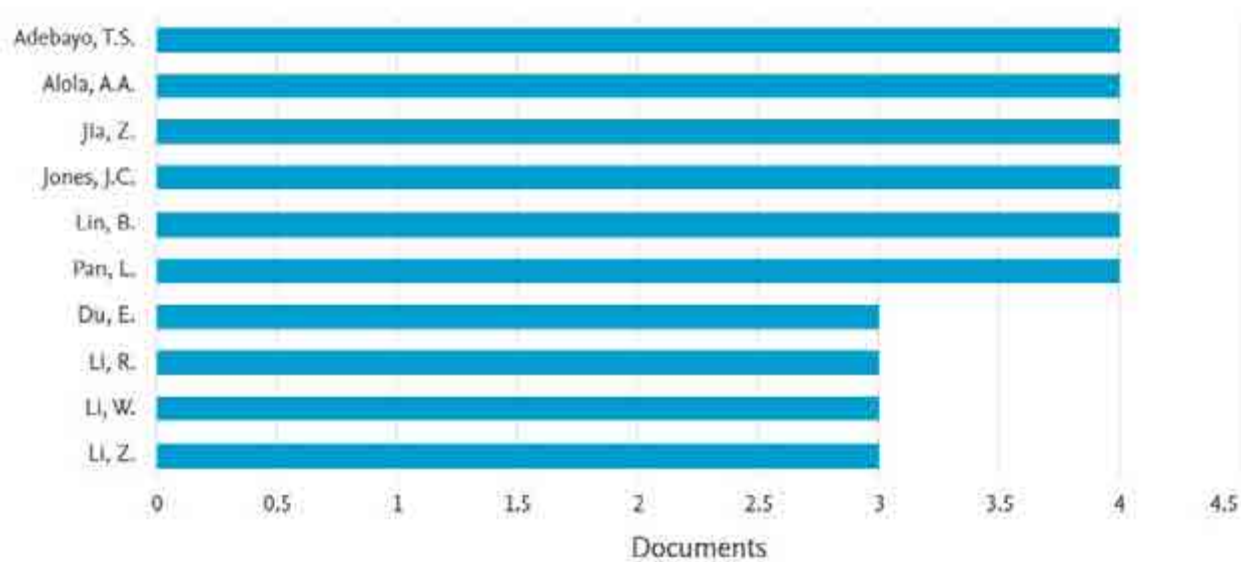


Figure 5: Most Contributing Author

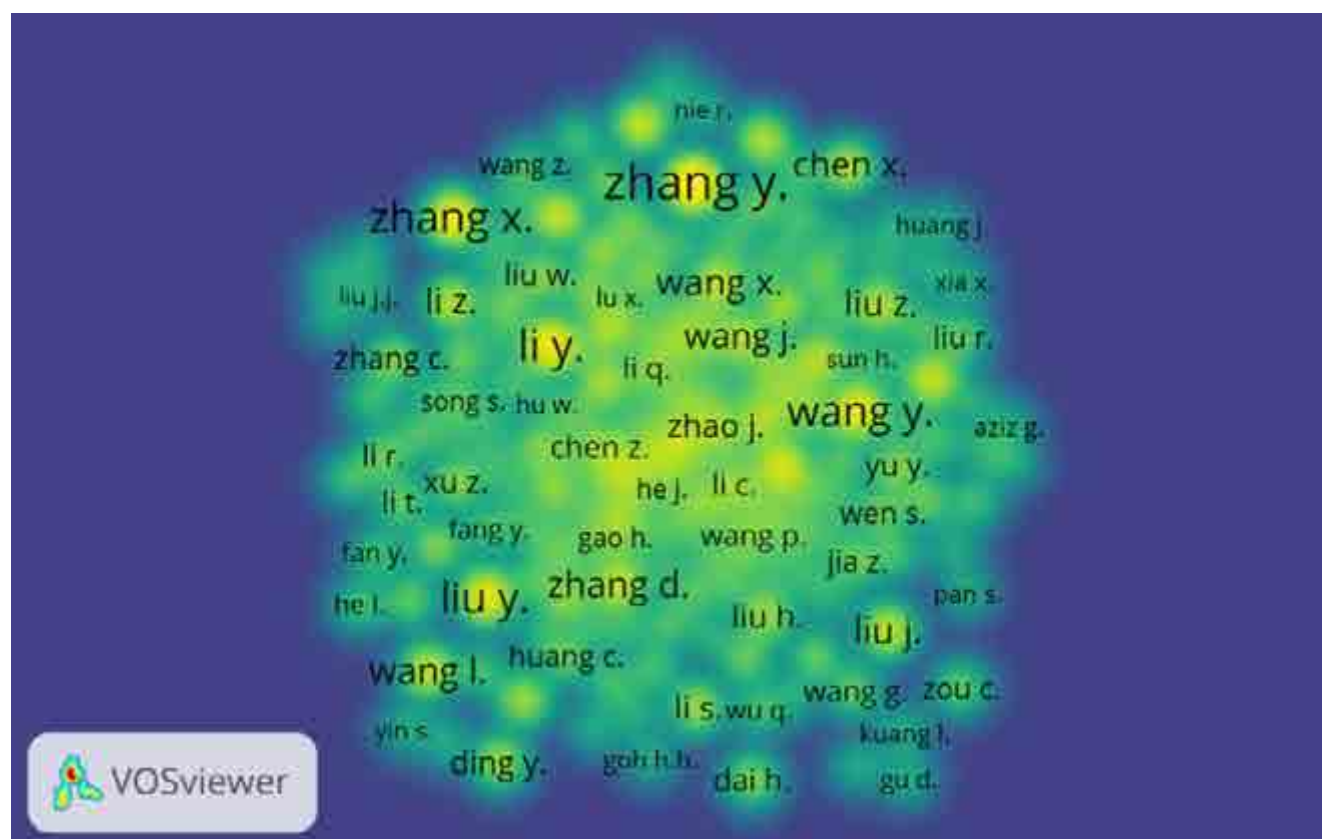


Figure 6: Most Document Publishing Author (most influential authors)

Analysis of institutions by publications

As per the Fig.6, the Tsinghua University contributes the most 27 Documents. Followed by the Chinese Academy of Science 21, Beijing Institute of Technology 18, North China Electric Power University 15 and so on. It shows that chines institutions are on the top in the research of this topic.

China also continues to be the largest funding sponsor of documents, with 100 documents funded by National Natural Science Foundation of China, followed by National Office for Philosophy and Social Science (22), Fundamental Research Funds for the Central University (20), National Key R&D Programs (17), and so on. Ministry of Education, India funded only 1 document so far from the Scopus database.

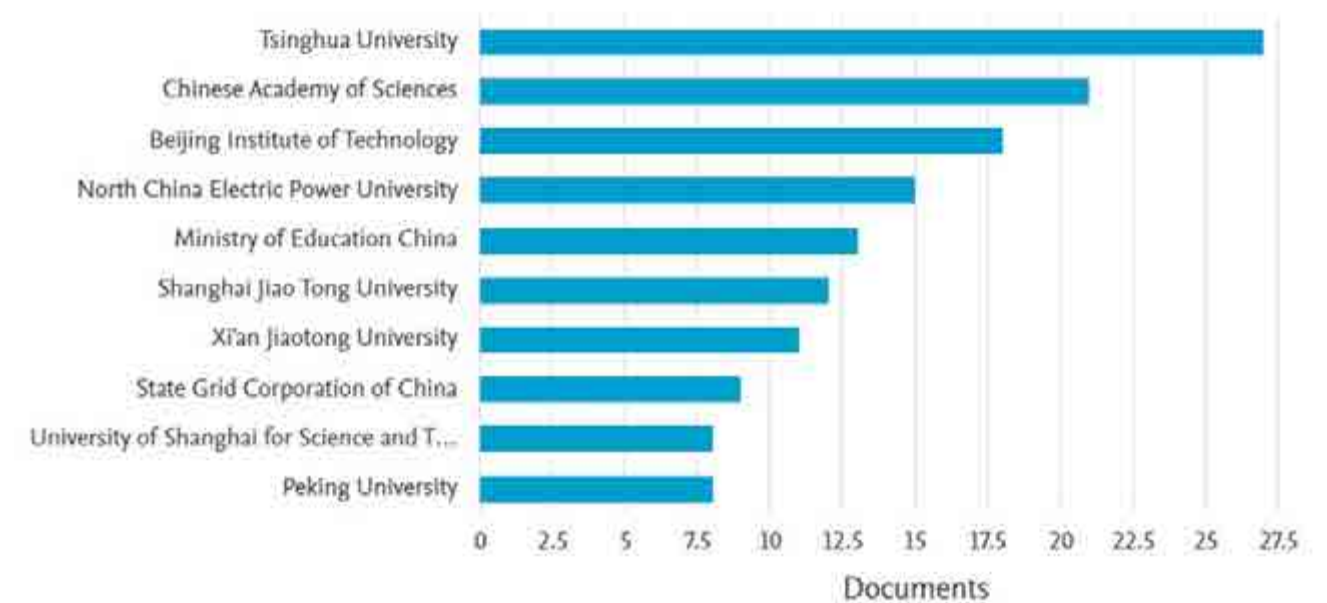


Figure 7: Institution Wise Publication Analysis

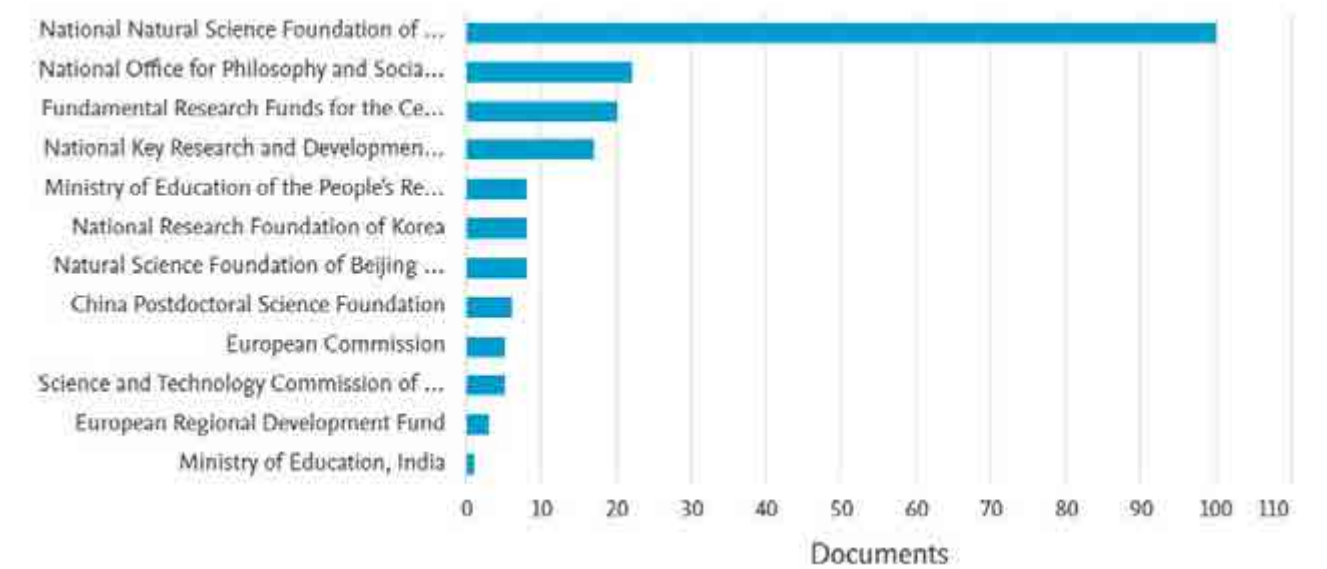


Figure 8: Documents by Funding Sponsors

Analysis of countries by publications

China provided 289 documents, accounting for more than half of the research work, followed by the US at 42, the UK at 22, Australia at 19, and so on. India only accounts for 7 documents in the list.

Analysis of countries by citation

China got maximum documents and citation (289,2159). Remaining countries who got maximum citation are UK, Australia, South Korea etc. India got 7 documents with 32 citations.

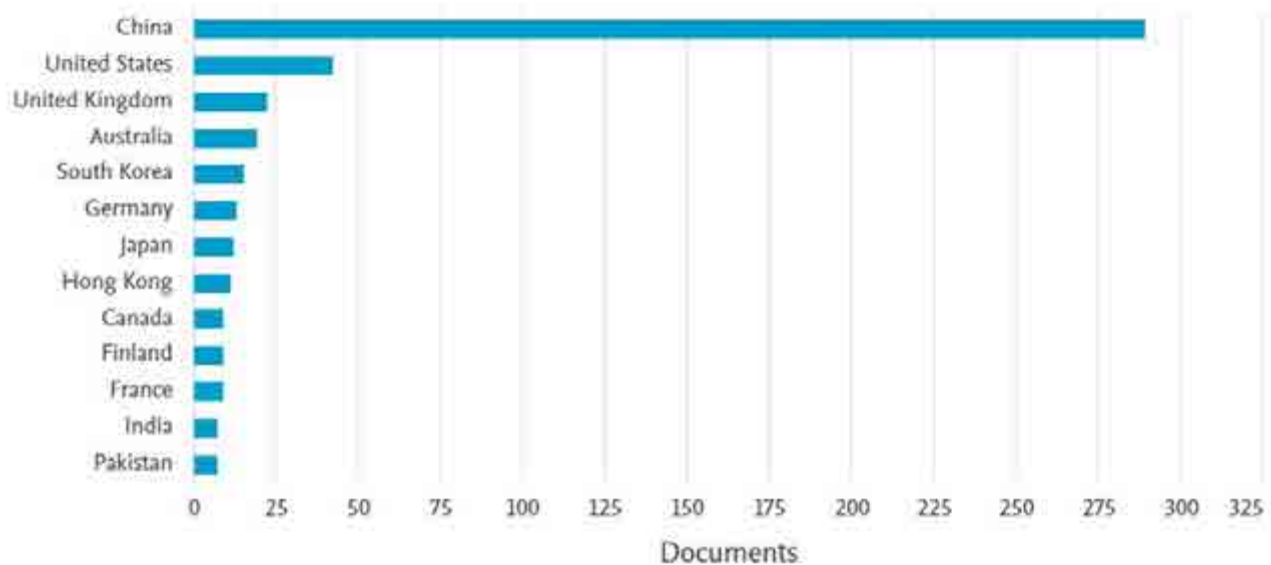


Figure 9: Country Wise Document Published

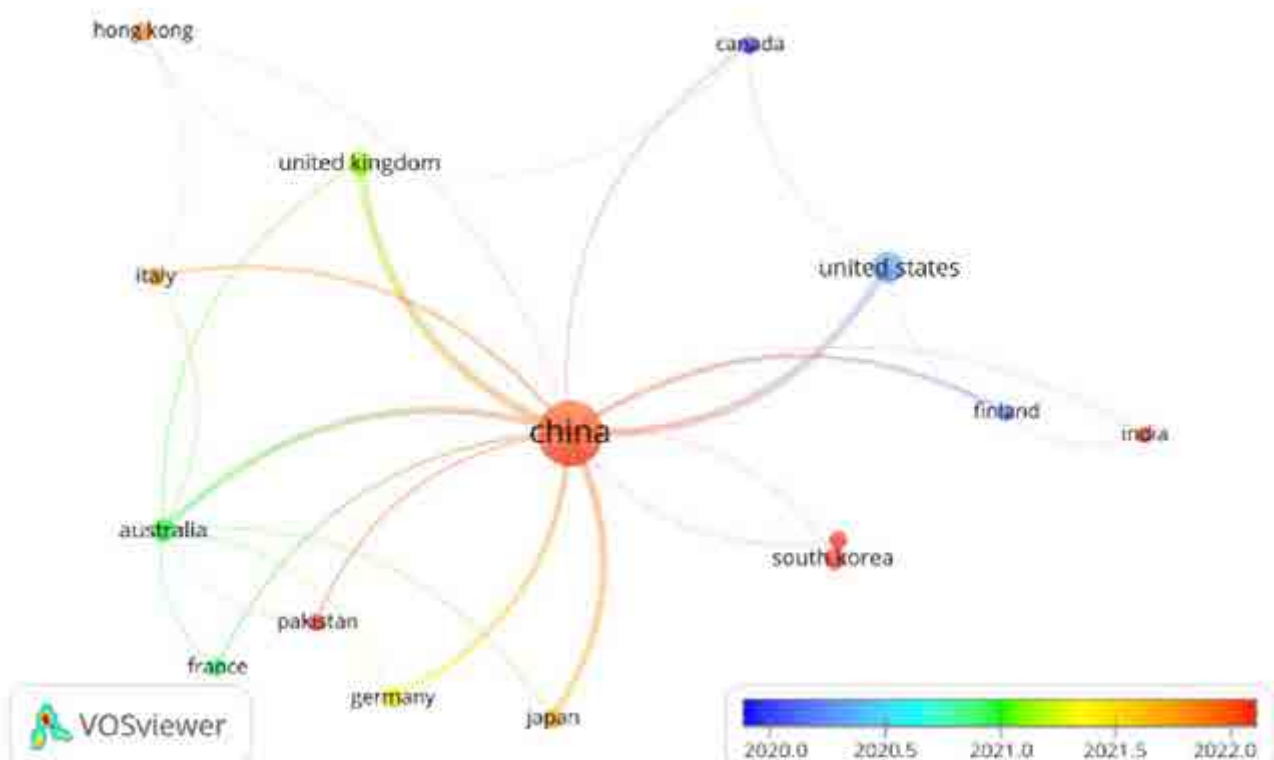


Figure 10: Country Wise Document Cited

Co-citation analysis

Co-authorship analysis for frequently cited authors

Based on the Fig.10, it is observed that wang, x., wang, y., liu, h., liu, z. etc. are the most cited co-others.

Co-occurrence of author's keywords

Carbon Neutrality is highly connected with climate change, CCUS, end energy transition areas from the co-occurrence author's keywords.

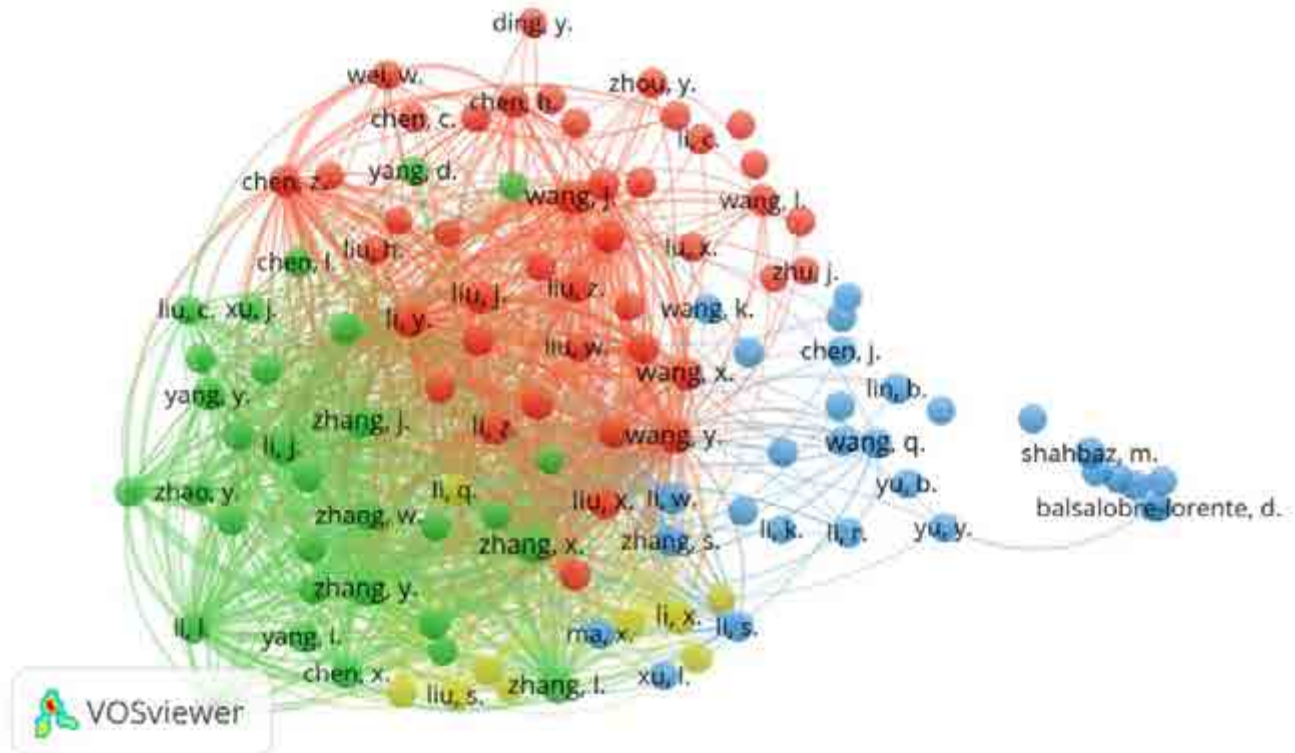


Figure 11: Frequently Co-Cited Authors

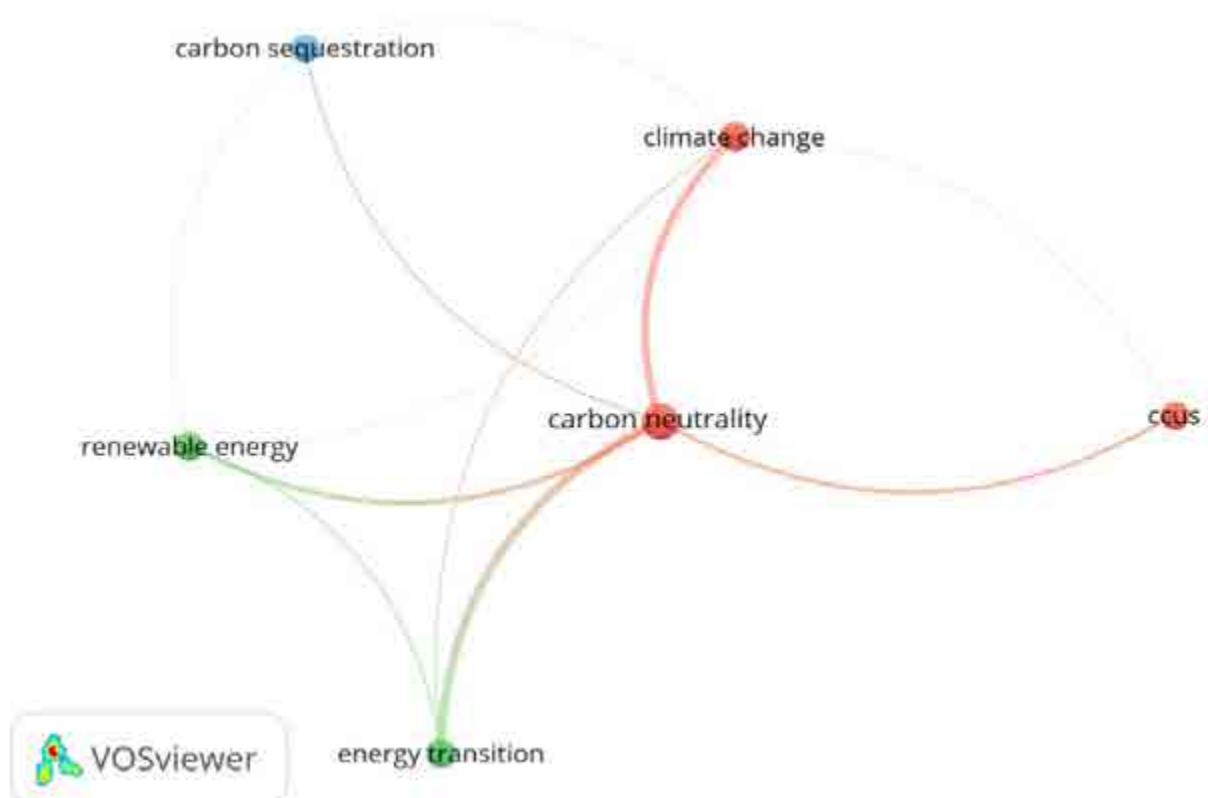


Figure 12: Co-Occurrence of Author's Keywords

Country-wise co-authorship analysis

China has maximum co-authors cited. Followed by United state, UK, Australia etc.

Future Scope analysis

- As of now, the major work on carbon Neutrality is linked with the emission control and Carbon emissions. Other areas are energy utilization and climate change.
- From the analysis it can be derived that work in the carbon capture area, sustainability development, energy efficiency, energy policy and, global warming. These are important areas and it'll be fruitful to do research in these areas with putting CN in the center.
- Research in these areas can help the governments to form policies for fulfilling the international commitments and provide stable, easy, and competitive market for the business. Industries can implement technological solutions to increase efficiency in the energy sector.



Figure 13: Country Wise Co-Author Relationship

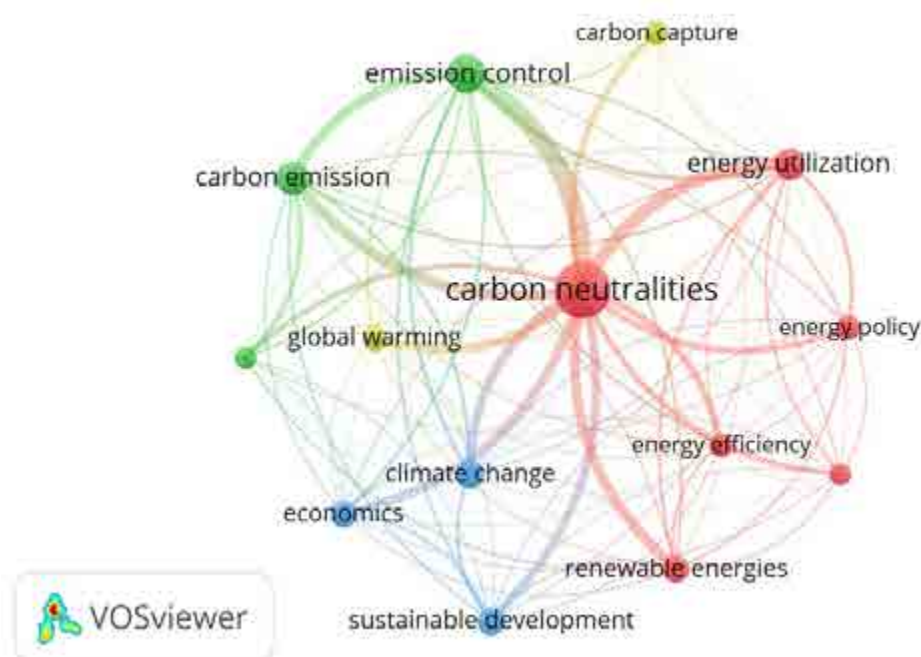


Figure 14: Relation Between Carbon Neutrality and Other Sectors

Implications for Research in India

1. Funding support:

a. It's observed during the analysis that India is not much active in the funding to the research scholars to conduct research in the area and hence not able to contribute more.

b. Compared to India, China is funding a lot of scholars by various means and therefor have strong research base for the development in the sector and fulfil the commitments by applying various technological solutions as well.

2. White paper:

a. Out of 407 documents, there are only 52 documents are papers. It only contributes 12.8% to the sector of overall documents.

b. Major contribution is from articles (269) which contributes 66.1% of total document set.

c. For India, opportunity lies around various papers i.e., research paper, white paper, conference paper etc. which can become strong primary research contribution at global level. This can be achieved with the help of the collaboration of government and industry with the academia.

Limitations and Points for Future Research

1. Only SCOPUS database and so future research can be conducted considered other database such as web of science.

2. Most of the research has been conducted using secondary data. Future research can be conducted using primary data.

Bibliography

Caineng, Z. O. (2021). The role of new energy in carbon neutrality. *Petroleum exploration and development*, 48(2), 480-491.

Chen, J. (2021). Carbon neutrality: Toward a sustainable future. *The Innovation*, 2(3).

Dong, F. L. (2022). Energy Transition and carbon neutrality: Exploring the non-linear impact of renewable energy development on carbon efficiency in developed countries. *Resources, Conservation and Recycling*, 177, 106002.

Liu, Z. D. (2022). Challenges and opportunities for carbon neutrality in China. *Nature Reviews Earth & Environment*, 3(2), 141-155.

Shan, S. G. (2021). A sustainable investigation from Turkey. *Journal of Environmental Management*, 294, 113004.

Wang, F. H. (2021). Technologies and Perspectives for achieving carbon neutrality. *The Innovation*, 2(4), 100180.

Zhao, X. M. (2022). Challenges toward carbon neutrality in China: Strategies and countermeasures. *Resources, Conservation and Recycling*, 176, 105959.

Dipen Solanki

GAIL (INDIA) LTD.

