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# Examining the Research Trends in Energy Resources: A Bibliometric Mapping Technique

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**Abstract:** *Energy resources are materials or systems that store energy that can be converted into useful forms, like electricity, heat, or mechanical power. They're the powerhouses that drive our modern world, powering our homes, industries, and transportation. This study aims to explore energy resources research-related publishing patterns and rank the most used author keywords in the Scopus and Web of Science (WoS) databases. The eminent software, ScientoPy and VOSviewer, are used to run and execute relevant publication data retrieved from Scopus and WoS. The results showed a positive trend in the growth of energy resources literature in both databases since 2010. The top three research areas that dominate this topic are "engineering", "energy & fuels", and "science & technology - other topics". Based on the country analysis, China has become an active publisher, followed by India and United States. Importantly, this study emphasised the scholarly practices prevalent in energy resources research have impressively propagated. The trends will assist researchers in recognising the various fields in identifying the core areas, proactive institutions, and productive authors published in this knowledge for supplementary investigation. Besides, by examining the most popular keywords, the results of this study enable researchers to discover the possibility for future research that may be conducted, particularly concerning the annual growth rates, which have been trending in the last five years.*

**Keywords:** Renewable Energy, Energy Resources, Power Sources, Energy Sector, Research

## 1. Introduction

The energy sector refers to the operational activities of systems, infrastructures or industries relating to productions, distributions, and energy use. It is responsible for producing crucial energy resources for energy productions for national community use. Energy resources are the most fundamental materials required for today's energy production. According to Michaelides (2012), energy resources is defined as the production of power on a large scale for human use globally. The four categories of energy resources are the primary energy resources, the secondary energy resources, the renewable energy resources and the non-renewable energy resources. All these categories are of high-priority for people's sustainable survival.

At present, energy resources are scarce and onerous to renew. Efficient distribution of energy resources is a vital process to avoid excessive use of its conservation. According to Mohamad et. al. (2018), the efficiency towards energy resource conservation will not only reduce excessive energy consumption, nevertheless will also create a better future sustainable environment. Therefore, the success of these efforts will gradually determine the growth rate of energy saving, the increase in our revenue, and reducing a short-term greenhouse effect.

Efficient use of energy resources is of high priority and can minimize some harmful effects, especially on the environment. Energy production from transport and industry is perilous for the environment. Gases such as sulfur dioxide can cause the anomaly of acid rain that is hazardous to plants and aquatic life while disrupting the existing ecosystems. However, green energy can reduce the release of these gases and minimize these anomalies. According to Hussain et. al. (2013), energy efficiency know-how is crucial to the communities on how to apply green technology in their daily lives to ensure sustainable future generation's environment.

One of the current challenges faced by the energy supplier sectors is identifying the most effective methods and mechanisms to develop more sustainable and environmentally friendly energy sources to meet the growing energy generation demand. The cost of energy generation needs to be equally balanced with the environmental preservation, and to achieve this, the latest environmentally friendly technologies such as Carbon Capture and Storage (CCS), Integrated Gasification Combined Cycle (IGCC), and nuclear energy must be studied and implemented. All challenges faced are to become a catalyst for the problem of renewing energy sources (Bhattacharyya, 2007). However, all efforts and methods developed must not pose a risk to the local community. This is because, environmentally friendly energy generation is more important than that which can lead to disaster.

The local community safety must also be a top priority and not at risk in all efforts and methods developed. It is vital not to overlook the importance of environmentally friendly energy generation while avoiding disastrous methods at all costs. Ample opportunities are available to improve energy efficiency in urban and rural areas. Some of them are various cost-effective investments such as diesel to natural gas transition, petrochemicals use in the rubber industry, hybrid cars revolutions, adopting green building standards and introducing energy performance standards for equipment such as air conditioners. In the meantime, the shift to the clean energy sector can also reduce carbon emissions in the environment (Naeem et. al., 2023). This investment opportunity will certainly attract investors to invest in the industry in the country thus creating a new and better ecosystem.

The need for an urgent transition to a low-carbon world can also raise the expectations of shareholders and stakeholders. Therefore, all parties especially the policy makers and the private sectors, are urged to on the benefit of the country's energy change from fossil fuels and gas to cleaner energy and create new ecosystems and job opportunities based on new energy, This change will provide the betterment of our future generations. However, there has been a lack of exploration conducted to analyze the research trends in the field of energy sector within challenges and opportunities, particularly in identifying specific domains within this field that have received limited attention. Hence, the present study employs bibliometric analysis to discern research trends within the realm of energy resources research. This focus remains strong despite increasing interest in this field of study (Iyer et al., 2020; Shankar et al., 2021). As a result, it has been noted that most research has focused on managing and delivering records supporting materials and documentation (Farooq et al., 2021).

In order to address the issue of excessive information availability and the breadth of different research topics, bibliometric analysis assist scholars and researchers in gaining a broad or even microscopic view of the overall progress and steady and continuous flow status (Gazali et al., 2021). Information retrieval is crucial to the cross-disciplinary field; this process can analyse aspects of information science and publication trend analysis. The bibliometric technique visualises vast publishing outputs necessary for deriving valid conclusions, such as the evolution of publications, study fields, and influential authors (Sofyan & Abdullah, 2022).

## 2. Data and Methods

Bibliometrics made it easier for researchers to identify research gaps, emerging research prospects, and significant research areas (Abdullah & Othman, 2022). It indirectly enables them to summarise the significant trends of a particular study field. The current study's primary goal was to identify patterns in energy sector-focused publications. In this study, two software programmes were utilised: ScientoPy and VOSviewer to accomplish bibliometric analysis. ScientoPy is a free and an open-source scientometric analysis program built on Python software developed by Ruiz-Rosero et al. (2017) that sorts data according to the most well-liked, specific, and trending topics and subsequently tested for usability and effectiveness in a later study by Ruiz-Rosero et al. (2019). Pabon et al. (2020) demonstrated that this software helps detect and eliminate duplicate datasets and clean up non-standard data formats. ScientoPy, as demonstrated by Ruiz-Rosero et al. (2019), can automatically categorise and report on the top themes based on author or index keywords, as well as identify the most prolific authors and countries involved in the research, using bibliographical information. VOSviewer is another piece of software used to map the co-occurrence of authors' keywords. VOSviewer is a software application that assists in constructing and visualising bibliometric networks (Abdullah et al., 2020; Roslan et al., 2023).

Figure 1 depicts the data processing sequence in this analysis and it consists of a systematic strategy that has been divided into three primary parts. First, the title should be determined, and the datasets be developed and gathered. The second phase involves integrating the databases and obtaining the ScientoPy-analysable parameters. In the last stage, ScientoPy and VOSviewer parameters are used to evaluate and analyse the results.

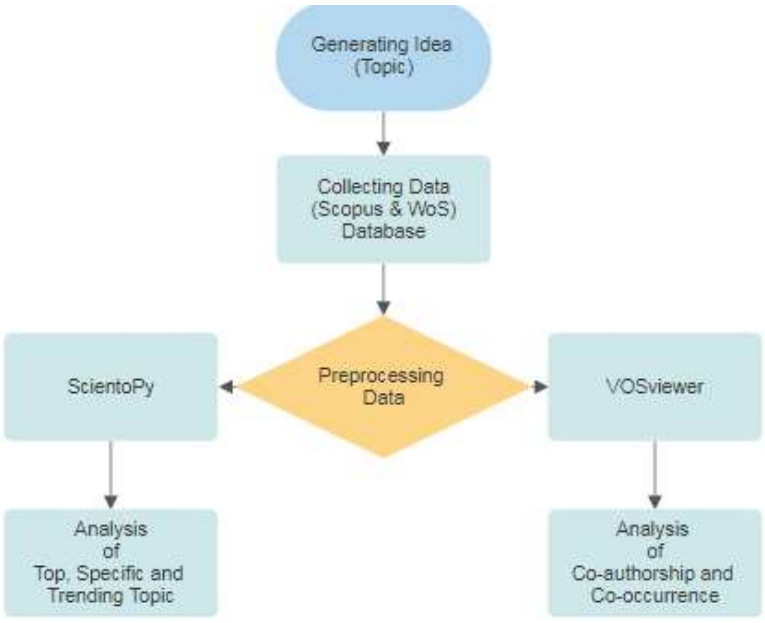


**Figure 1: Selection strategy and research protocol**

Given the multifaceted nature of the studied topic, the literature on energy sector study is spread across many different fields. As a result, it was necessary to use accessible and numerous bibliographic databases to search for and find pertinent material on this subject. Two primary databases, Scopus and Web of Science (WoS), were used to collect the data for this study. The Scopus and WoS database is preferred since it is a multidisciplinary database with more articles in social science, education-related journals, management and other documents in various academic disciplines (Sweileh, 2022; Visser et al., 2021). The Scopus and WoS databases also attract most scholars to obtain publications for their review purposes (Abdullah et al., 2023). These databases span multiple fields (Martín-Martín et al., 2021), and searching them would aid researchers in locating the most significant number of citations on primary sources for bibliometric studies (Pranckutė, 2021). After defining the databases, the search query “renewable energy" OR "energy sources" AND "power sources” was chosen. The following fields were scanned for topic-related terms: article title, abstract, keywords. This inquiry was completed on January 16, 2024.

During the second stage, ScientoPy was used to preprocess the data. The secondary dataset is then established for the following analysis stage. ScientoPy uses the following criteria during the pre-processing steps; (i) normalising the author’s name: it is replaced with a semicolon for metadata retrieved from the Scopus database, it is stripped of dots, commas, and special characters for metadata retrieved from both databases, and (ii) removing duplicate samples with the same title and authors (Ruiz-Rosero et al., 2019). The pre-processing information is recorded in Table 1. Based on Table 1, the ScientoPy pre-processing script has shown that WoS databases are more than Scopus and after duplicate removal, there are more papers in WoS papers than in Scopus. This study used a raw source dataset of 11840 papers from the WoS and Scopus databases. In this study, 860 of the 11840 loaded papers were eliminated due to ScientoPy’s analysis. Following data reconciliation, this study examined 9733 papers from both databases, containing 6103 papers from WoS and 3630 papers from Scopus, removing 1202 from Scopus and 45 duplicate papers from WoS. Finally, the 9733-piece data set was analysed, and the necessary statistical reports, graphs, and tables were generated using bibliometric data visualisation tools, ScientoPy and VOSviewer.

**Table 1: Information on pre-processed data analysis**

| Information | Number | Percentage (%) |
|---|---|---|
| Loaded papers | 11840 | |
| Omitted papers by document type | 860 | 7.30 |
| Total papers after omitted papers removed | 10980 | |
| Loaded papers from WoS | 6148 | 56.00 |
| Loaded papers from Scopus | 4832 | 44.00 |
| Duplicated papers found | 1247 | 11.40 |
| Removed duplicated papers from WoS | 45 | 0.70 |
| Removed duplicated papers from Scopus | 1202 | 24.90 |
| Duplicated documents with different cited by | 181 | 14.50 |
| Total papers after duplicate removal | 9733 | |
| Papers from WoS | 6103 | 62.70 |
| Papers from Scopus | 3630 | 37.30 |

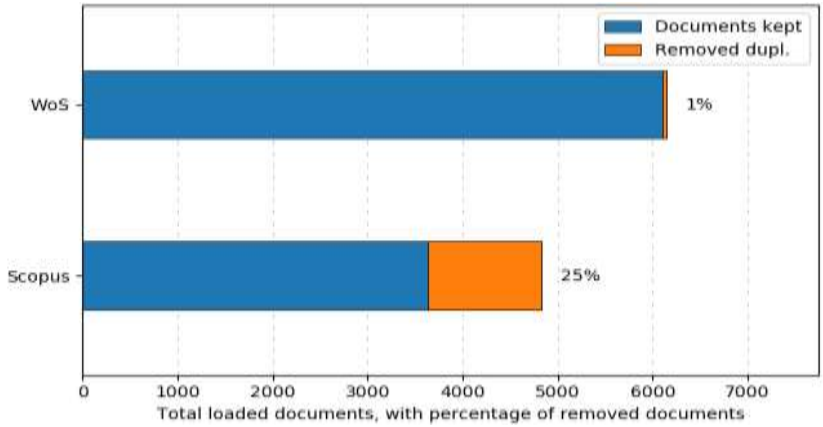


**Figure 2: Pre-processing of metadata from Scopus and WoS databases**

Scholars around the world use many bibliometric software programmes intending to provide information to readers with various interesting infographics and graphical visualisations (Roslan et al., 2023). Even if several software programmes are available for conducting bibliometric analysis, choosing a solution that corresponds to the study objectives and questions is essential. This emphasises assessing the research questions before selecting a software application. The success of software in bibliometric analysis ultimately depends on the researcher's capacity to answer the research questions posed in the study (Abdullah et al., 2023; Roslan et al., 2023).

## 3. Result and Discussion

### Publication Growth

The number of peer-reviewed publications is an excellent indicator of a scientific topic's growth. Since 2012, Figure 3 demonstrates a significant increase in articles on energy resources research. Compared to WoS, Scopus publications have grown steadily, with a sharp rise after 2020. Based on its recognition in scientific publications for a wide range of research fields, WoS has been identified as a leading data source. Also, Scopus is constantly updated and is favoured by many researchers in various research domains. From the data in Table 2, it shows the latest five years for publications in WoS and Scopus. From 2019 to 2023, it was discovered that WoS produced 429.6 publications in average, whereas Scopus produced 458.2 publications in average. The year 2022 shows the highest number of publications for WoS which is 450 papers, while for Scopus, the year 2023 has shown the highest achievement of publications which is 582 papers.

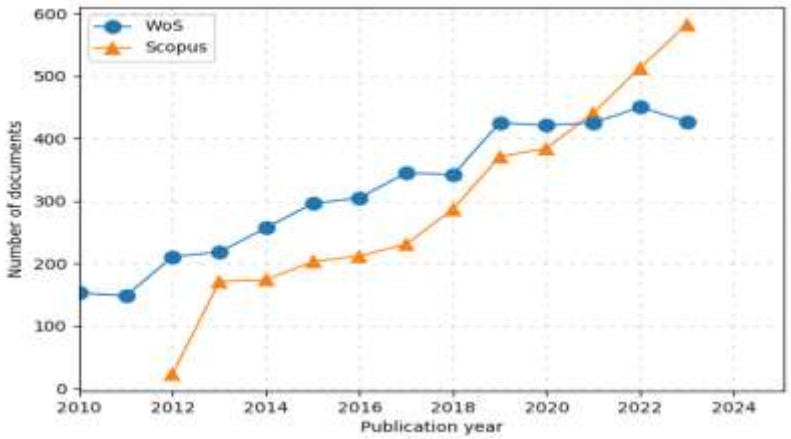


**Figure 3: Timeline graph**

**Table 2: Five years publication trends**

| Publication | 2019 | 2020 | 2021 | 2022 | 2023 |
|---|---|---|---|---|---|
| **WoS** | 425 | 421 | 425 | 450 | 427 |
| **Scopus** | 371 | 384 | 441 | 513 | 582 |

This study also sought to determine where energy resources documents were published by analysing document types and language data. Table 3 shows the different types of documents where publications on energy resources have been published. As can be seen, the majority of the publications are journal articles, with 4541 articles (55.24% of the total documents). Following the articles is a conference paper (n = 1582, 19.24%), a proceedings paper (n = 1454, 17.69%), and a review (n = 499, 6.07%). For other publications (book chapter, early access, data paper and retracted publication), for each document, it is less than 1%.

| **Document Type** | **Total Publications** | **Percentage (%)** |
|---|---|---|
| Article | 4541 | 55.24 |
| Conference Paper | 1582 | 19.24 |
| Proceedings Paper | 1454 | 17.69 |
| Review | 499 | 6.07 |
| Book Chapter | 79 | 0.96 |
| Early Access | 59 | 0.72 |
| Data Paper | 4 | 0.05 |
| Retracted Publication | 3 | 0.03 |
| **Total** | 8221 | 100.00 |

**Table 3. Document type**

## Subject Areas

Likewise, it is critical to conduct a review of relevant research articles. This strategy enables the essential disciplines in which research on energy resources has been undertaken to be identified. Figure 4 depicts an evolution graph of the top ten subject areas that can be used to categorise energy resources research in the Scopus and WoS databases. Engineering has been identified as the most extensively investigated field, with over 2000 publications. Another fascinating subject is Energy & Fuels, and the third-ranked subject area is Science & Technology - Other Topics. From the data in Table 4, showing the latest five years for publication trends from 2019 to 2023, it was found that Engineering produced with an average of 181.4 publications, while for Energy & Fuels with an average of 170.4 publications produced, and for Science & Technology - Other Topics just produced an average of 79.8 publications. According to the data in Table 4, the year 2020 shows the highest number of documents for Engineering which is 201 publications, while for Energy & Fuels, the year 2022 has shown the highest among other years with 187 publications, followed by Science & Technology - Other Topics, showing that the year 2023 was the highest, with 98 publications.

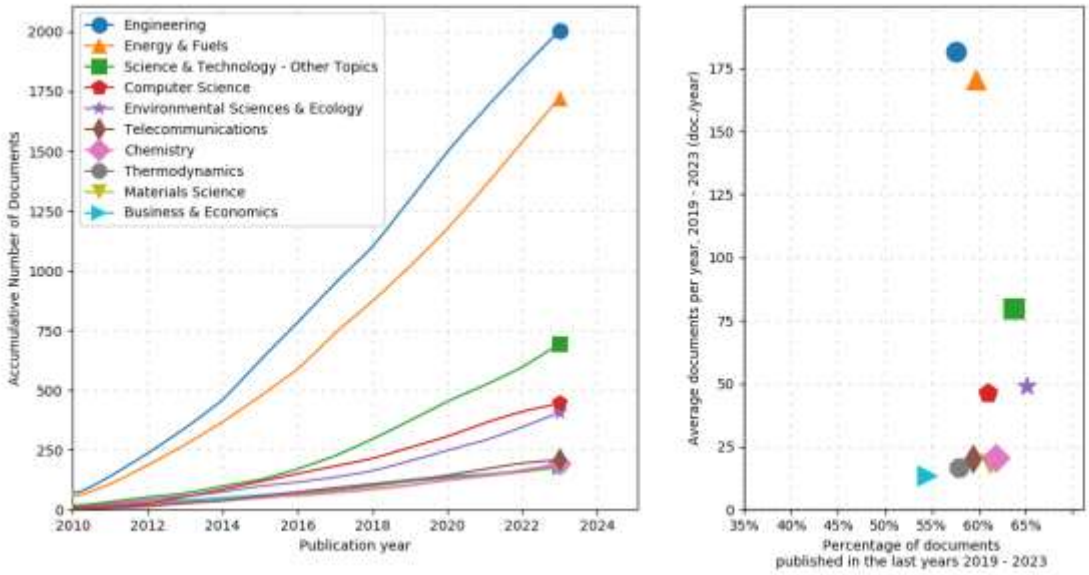


**Figure 4: Subject evolution graph**

| Publication | 2019 | 2020 | 2021 | 2022 | 2023 | Average |
|---|---|---|---|---|---|---|
| **Engineering** | 199 | 201 | 177 | 169 | 161 | 181.4 |
| **Energy & Fuels** | 146 | 157 | 177 | 187 | 185 | 170.4 |
| **Science & Technology** | 78 | 80 | 68 | 75 | 98 | 79.8 |

**Table 4: Five years on top three subject areas**

## Publishing Countries

Since 2010, research on energy resources has been conducted in various countries. Figure 5 shows the country network visualisation of energy resources research. Based on Figure 5, Norway in the middle, has more connections than other countries. In addition, China and India also show a lot of connection after the country of Norway. Next, in Figure 6, China, India and United States were identified as the top three publishing countries in energy resources research. While, the three lowest-ranked countries are Italy, South Korea and Iran. China is at the top of the first chart in this study about energy resources. This is because China has proven to be the leading researcher in this field. However, there are still not many countries that contribute towards the publication of energy resources research. Thus, the study of energy resources should be explored deeper and further in many countries.

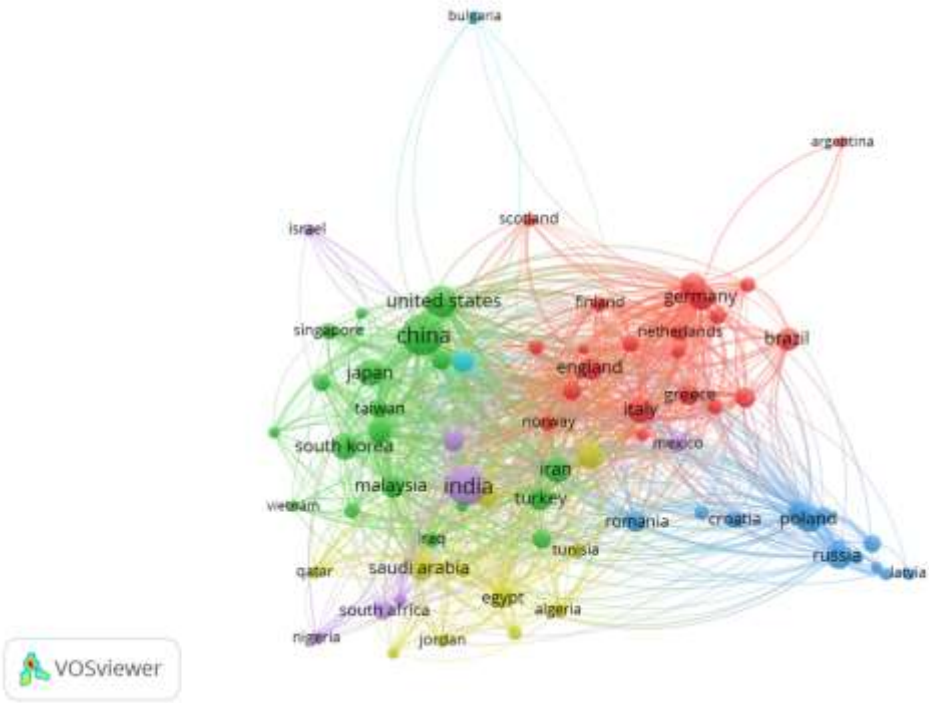


**Figure 5: Network visualisation for publishing countries**

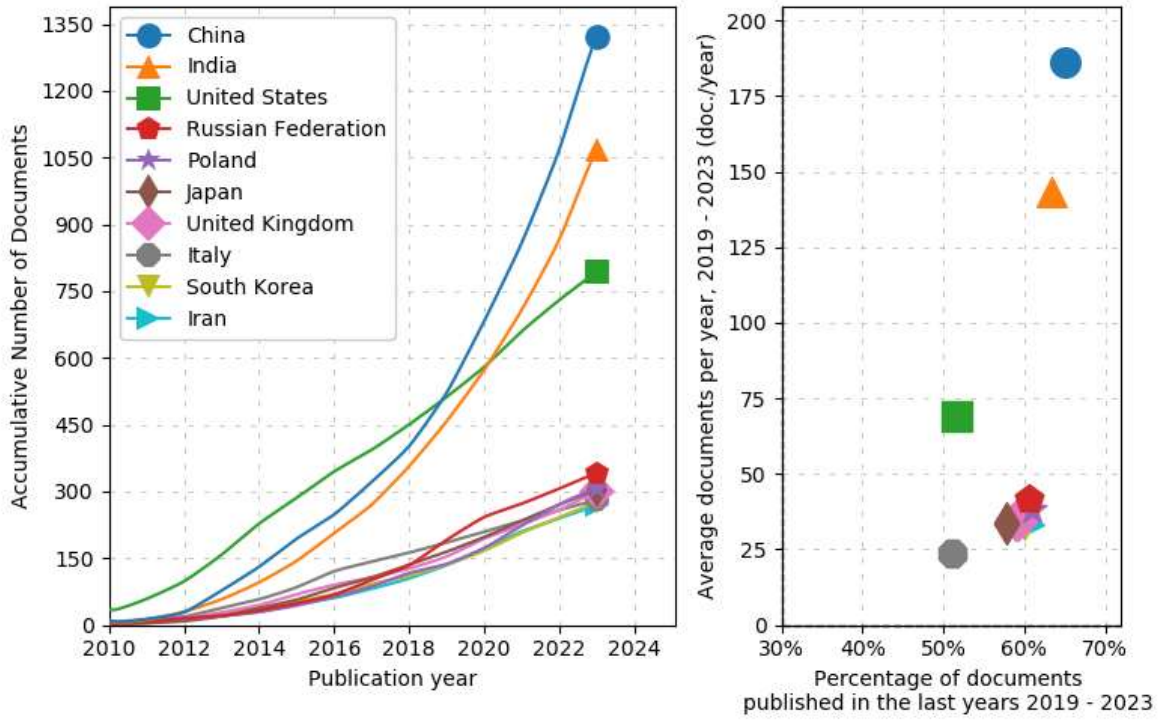


**Figure 6: Country evolution graph**

## Productive Authors

The information in Figure 7 pertains to the most productive authors in energy resources research, which are ranked according to the number of publications. A list of ten authors is included, along with the 13 years and the last five years' trending percentages.

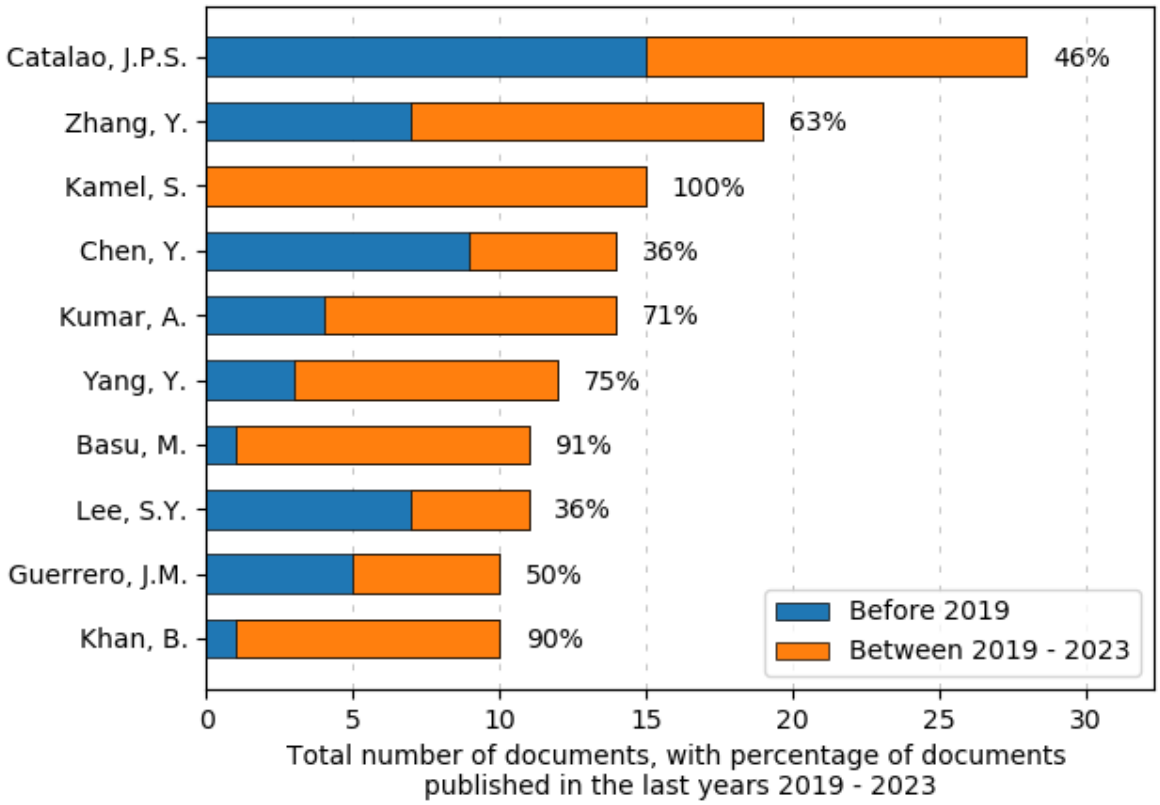


**Figure 7: Productive authors bar trends**

According to Figure 7, Catalao, J.P.S. was ranked first with 28 publications, followed by Zhang, Y. with 19 publications and Kamel, S. with 15 publications. All three authors was the most productive writting journal and remained the most influential in energy resources research, with the possibility plans to maintain further publications for the future. Remarkably, Kamel, S. has been the proactive author in the last five years, with 100% of publications released from 2019 to 2023. Also, the compelling authors in the previous five years is Basu, M., with 91% of publications and Khan, B. with 90% of publications. This authors data is the most up-to-date information for future readers and researchers who want to know which authors are most active in this study of energy resources research.

## Institutional Analysis

Figure 8 pertains to the top ten institutions that publish academic works on energy resources research. The scholars from Russian Academy of Sciences in Russian Federation were credited with the most publications, with 59 publications. The second institution is Islamic Azad University in Iran (n=52 publications), and National Institutes of Technology in India (n=39 publications) is ranked third in this study. An intriguing feature of the top ten institutions in 13 years is that two institutions are from India and China. Thus, Aswan University is the most active for the last 5 years with 97% of publications in energy resources study. This shows that publications related to energy resources research are still growing over time.

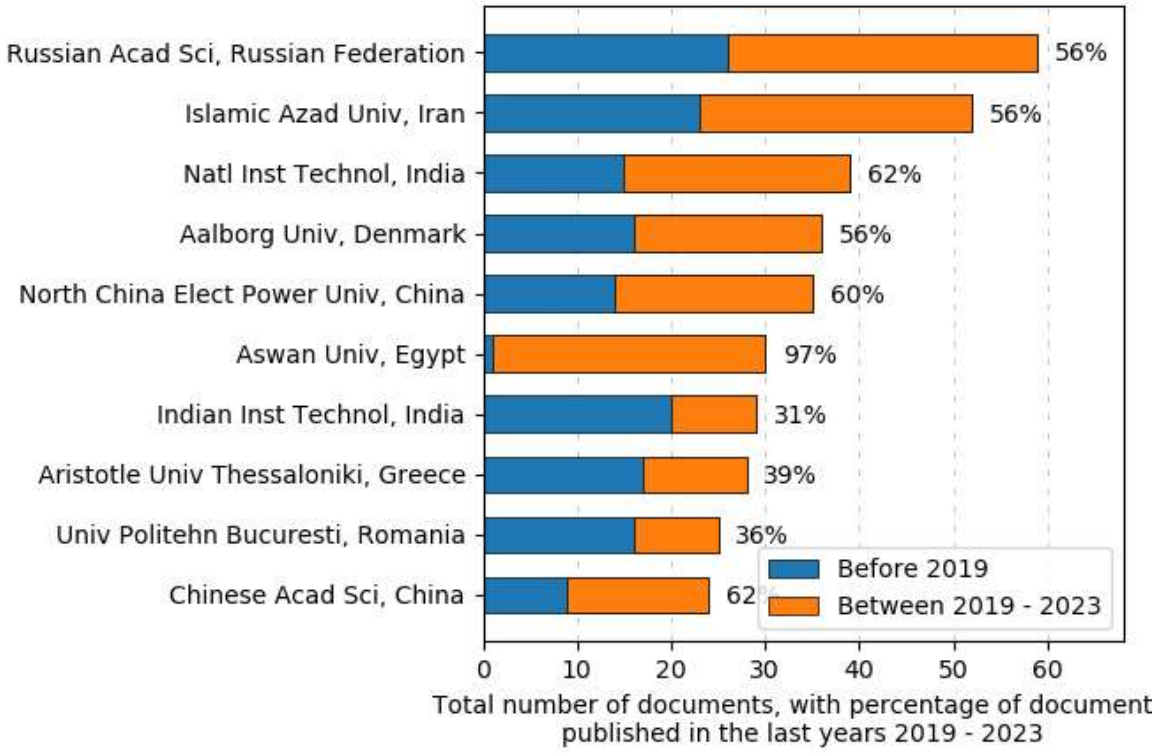


**Figure 8: Institutional bar trends**

## Author Keywords

Analysis Author keywords refer to the terms used by authors to represent the content of their documents accurately. Most authors mention their study topic as a keyword in their document. The authors' keywords aided readers and future researchers in identifying the publications' significant ideas and arguments (Roslan et al., 2023). Numerous electronic search engines, databases, and journal websites use author keywords to identify and deliver relevant articles to prospective readers. Readers need to understand that keywords produce links to other relevant publications (Abdullah et al., 2022). In this case, Scientopy might track the evolution or trends of a study topic or search argument using the authors' keywords. This section analyses the authors' top keywords in previous research on energy resources. In order to complete the procedure, the authors' keywords were used to find research trends. It has been suggested to use an appropriate term, such as "renewable energy" OR "energy sources" AND "power sources". These manual tasks assist in organising data and eliminating term duplication, resulting in more robust results.

Figure 9 exhibits 10 previously researched keywords. As illustrated in Figure 9, the top three used term is "renewable energy," followed by "renewable energy sources" and "microgrid". Data processing was given importance to this broad phrase directly related to the subject. Important keywords are made available to assist readers and future researchers in determining which ones to employ while conducting document analysis (Abdullah et al., 2022). While Figure 9 illustrates the first 10 keywords, ScientoPy enables us to view an infinite number of keywords (Ruiz-Rosero et al., 2019). Also, Figure 9 displays the percentage of documents published in the preceding five years (2019– 2023) to illustrate a relative increase. We can observe from this indicator that "optimization" has the highest proportion (67%) publication between 2019-2023. It is self-evident that the issue has increased significantly over the last five years compared to other keywords. Additionally, "renewable energy" itself has

been a hot topic, with 628 (59%) publications published from 2019 to 2023. Thus, this study depicted that renewable energy and optimization has sparked scholars' curiosity.

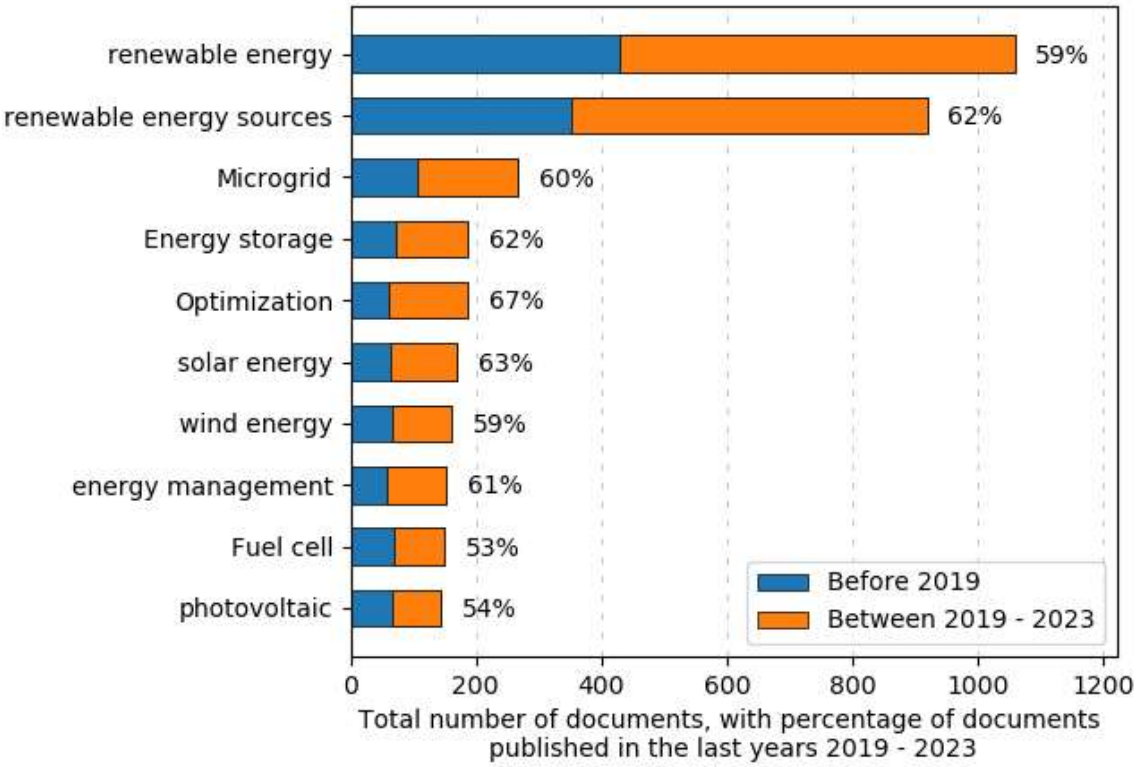


**Figure 9: Author keywords bar trends**

Furthermore, this study used cluster mapping to ascertain the co-occurrence of the authors' keywords to denote themes or issues relevant to energy resources reasearch (see Figure 10). Before using the VOSViewer to generate a network map, the dataset was pre-processed with SientoPy (a combination of Scopus and WoS metadata). Additionally, this study used a thesaurus file to map the co-occurrence of the authors' terms before mapping them. Concatenating related terms, spelling variants, and singular or plural terms requires the use of the thesaurus file.

Based on Figure 10, it can be deduced that the most frequently used keywords were "renewable energy", "renewable energy sources", "microgrid", "distributed generation", and "smart grid". These keywords are inextricably linked. The keyword "renewable energy" was grouped in the same clusters (green colours) with "energy sources", and "solar energy". "renewable energy" is also closely linked to "energy storage".

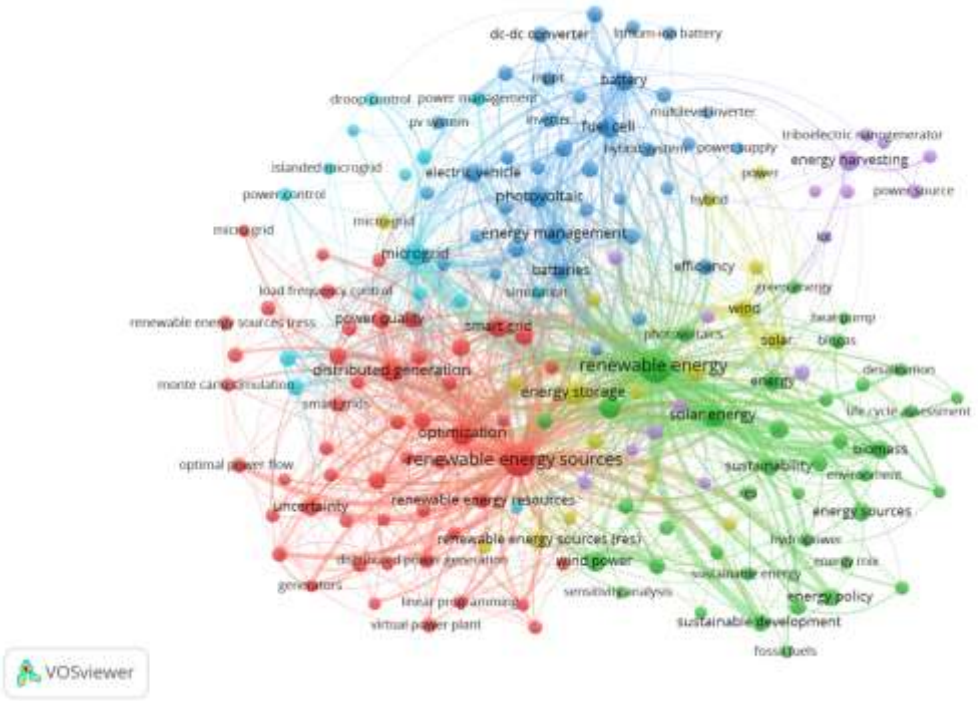


**Figure 10: Network Visualisation of The Co-occurrence**

## 4. Conclusion

The energy sector holds a high-priority responsibility in supporting its economic growth and national development. The government has allocated operations to increase the use of the new energy sector and its efficiency. However, all parties are required to identify opportunities and fully utilise the current situation in creating platforms for new green-technology-based job opportunities with high human capital for our future generations. in an effort to create a platform so that new jobs with more green energy characteristics, as well as high incomes can be generated for future generations. Therefore, it is crucial to know the trends of this study and the importance of using energy resources by learning more deeply about this study as a whole.

This research looks at how often specific articles are published and how often they use certain keywords to determine energy resources research. In the meantime, this study can yield some results from its analysis. The results indicated that publications on energy resources research have increased significantly since 2012. Notably, WoS publications have expanded consistently compared to Scopus, with a sharp increase following 2013. With over 2000 publications, Engineering has been identified as the most thoroughly explored research area. China, India, and United States have been designated as the research area's top three publishing countries. Catalao, J.P.S. was the most productive authors and often published in energy resources research, followed by Zhang, Y. and Kamel, S.. With 59 publications, scholars from Russian Academy of Sciences in Russian Federation were credited with the most active institution. The keyword "renewable energy" is the most frequently used by previous researchers, followed by "renewable energy sources" and "microgrid". Renewable energy was clustered in the same group with "energy sources" and "solar energy". Remarkably, "renewable energy" and "energy storage" are inextricably intertwined.

Certain limitations to this study may help direct future studies. Publications in the Scopus and WoS databases were analysed and mapped for this research. As a result, the findings of this study were limited to deducing the most critical themes or keywords associated with energy resources research found in those databases. Therefore, if future research wishes to expand on the foundation or address broad subjects, a systematic literature review or meta-analysis is recommended to provide the most relevant evidence synthesis possible. Nonetheless, scholarly dissemination in the energy resources research field is provided to potential readers and future researchers keen on this topic.

This study provides a novel perspective by demonstrating that research on energy resources is not restricted to the use of energy resources alone but has drawn scholars to explore energy resources within the framework of challenges and opportunities from research results beyond the research field. Therefore, the study will aid researchers from various fields in identifying essential publication trend factors for systematically disseminating energy resources research. In addition, this study's findings motivate researchers to collaborate and develop new research paradigms for evaluating energy resources research by analysing the most often-used terms through empirical studies.

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