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Analyzing Factors Influencing Renewable Energy Utilization: A Bibliometric Review

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Abstract.

The purpose of this study is to analyze the factors influencing the utilization of renewable energy through a bibliometric approach. The data used in this research consist of articles published over the past 23 years, from 2001 to 2024. Bibliometric analysis was employed, which quantitatively examines publication trends, co-authorship networks, and keyword occurrences related to renewable energy. The findings of this research indicate a growing body of literature on renewable energy each year, utilizing various research approaches, including quantitative, qualitative, and mixed methods. This highlights the continued relevance of renewable energy research over the past two decades. Furthermore, the findings indicate that the terms "use of renewable energies," "renewable energy resources," "renewable energy," "alternative energy," "renewable energy sources," "energy efficiency," "sustainable development," and "carbon dioxide" are commonly used and are applicable in the literature.

Keywords: bibliometrics, publish or perish, renewable energy, VOSviewer

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1. Introduction

From sustaining economic activity [1] to meeting basic requirements, energy is essential to human existence. Many nations, like Indonesia, continue to rely on fossil fuels including coal, oil, and natural gas despite their significance [2]. Ecological footprints have grown in many nations as a result of extensive environmental harm caused by the large-scale mining and use of fossil energy resources [3]. The environment and the availability of natural resources are negatively impacted by this dependence.

Increased renewable energy utilization can serve as an option to reducing negative environmental impacts and dependency on imported fossil fuel sources [4]. Renewable energy is becoming increasingly significant as people become more aware of the environmental damage caused by fossil fuels and the scarcity of natural resources. Renewable energy sources include solar, hydropower, biofuel, geothermal, wind, and

ocean energy [5]. Renewable energy can improve the environment by emitting little or no greenhouse gases [6].

Utilizing renewable energy in companies and organizations can have societal benefits like sustainability, better air quality, and local economic development in addition to reducing adverse effects on the environment (planet) [2]. Businesses can attain long-term sustainable performance by implementing Triple Bottom Line (TBL) principles and embracing renewable energy. Here, monetary success is paired with socially beneficial contributions and environmental sustainability. The Resource-Based View (RBV) Theory is another way to look at how companies and organizations use renewable energy. In order to achieve a lasting competitive advantage, RBV theory highlights the significance of a company's distinct resources and competencies [7]. Competencies, strategic assets [8], skills [9], assets, and stocks [10] are examples of company resources.

Based on several previous studies, there are several variables that can influence renewable energy. According to Aryanti [11], the variables affecting renewable energy are economic growth, foreign direct investment (FDI), trade openness, and carbon dioxide emissions. Meanwhile, according to Akandy [12], the variables affecting renewable energy are consumption of non-renewable energy resources. Additionally, according to Afriyanti et al. [13], and Khansa and Widiastuti [14], the variables affecting renewable energy are corporate governance.

Based on the explanation above, further analysis is needed to understand the factors influenc-ing the utilization of renewable energy. Therefore, the author is interested in conducting research entitled "Analyzing Factors Influencing Renewable Energy Utilization: A Bibliometric Review" The purpose of this study is to use the bibliometric method to determine the factors influencing the renewable energy utilization.

2. Literature Review

2.1. RBV theory

The RBV theory presents a firm as a combination of resources and capabilities that give a lasting competitive advantage over competitors and generate superior performance for the organization [15-17]. If a corporation aspires to reach durable competitive advantage status, it must acquire and hold resources and competencies that are valuable, rare, inimitable, and non-substitutable (VRIN), as well as have an organization in place to absorb and deploy them [7]. The resources required for a corporation to attain a

sustainable competitive advantage are determined by its interactions with the natural environment [18] and social welfare [19].

Many strategic studies have placed minimal attention on the impact of a company's distinctive characteristics on its competitive position while analyzing its environmental impact [20]. The RBV hypothesis highlights the relevance of a company's distinct resources and capabilities in gaining a durable competitive advantage [7]. Company resources include competences, strategic assets [8], skills [9], assets, and stocks [10].

2.2. Renewable energy

Two factors prevent fossil fuels from dominating the energy supply for more than a few decades [21]. First, it is predicted that by 2030, the amount of readily mined coal, gas, and oil reserves would have peaked [21-25]. Second, over 74% of all CO2 emissions come from fossil fuels [21, 26].

The best chance to combat climate change and replace fossil fuels is through renewable energy [27]. Renewable energy is "energy derived from natural processes that are replenished at a faster rate than they are consumed," according to the International Energy Agency (IEA), which also lists biomass, geothermal, hydro, solar, and wind as examples [28]. In its statistical accounting, the European Union counts geothermal energy, wind, solar, hydro, tidal power, biofuels, and the renewable portion of trash as renewable energy [29].

Renewable energy is predicted to become an increasingly important primary energy source with the rising investment and efforts by various countries, including Japan, to replace fossil fuels with renewable energy sources [30]. To evaluate the future potential of each type of renewable energy, factors that may increase or decrease their production in the future need to be considered. These aspects include the environmental repercussions of renewable energy production, land use impacts, climatic and other environmental changes, technical possibilities, and energy return on energy input [31].

3. Material and Methods

This study employs the bibliometric approach developed in 2024. The programs Bibliometrics, VOSviewer, and Publish or Perish are utilized in this investigation. Publish or Perish assesses renewable energy publications. Meanwhile, VOSviewer is used to evaluate data from a variety of sources, including bibliographic databases and scientific

publications. By revealing relationships between publications, citations, authors, and specialized research topics, bibliometrics makes it easier to visualize and analyze bibliographic data. The bibliometric function is essential for supporting strategic planning, academic performance evaluation, and research development decision-making.

3.1. Data resources

The researcher searched the Scopus academic database, which is considered one of the largest and includes a wide variety of peer-reviewed journal papers [32]. The articles used in this study were released between 2001 and 2024, or within the last 23 years. The Eligibility Criteria (EC) guiding the analysis method include:

- Original articles that have undergone peer-review processes in English.
- Research aimed at exploring the impacts of renewable energy variables.

3.2. Research questions

The Research Question (RQ) in this study is designed to identify the development and growth of scholarly articles on renewable energy. The following is the RQ for this study.

1) RQ1: According to their degree of importance to the topic of renewable energy utilization, how many research articles are published by each journal?

2) RQ2: How does the publication of articles in each journal affect the topic of renewable energy utilization?

3) RQ3: Which authors are best suited to study the topic of renewable energy utilization?

4) RQ4: How does each author's publication of publications affect the topic of renewable energy utilization?

5) RQ5: How many nations are involved in research on the use of renewable energy?

6) RQ6: Regarding the topic of renewable energy utilization, which nation has the most citations in the international scientific literature?

7) RQ7: From 2001 to 2024, what are the trends in the scientific literature on the use of renewable energy?

8) RQ8: Which terms are most pertinent to the use of renewable energy in scientific literature?

9) RQ9: Which terms are most frequently used in studies on the use of renewable energy?

3.3. Research steps

This study used RStudio and Scopus in a sequence of organized procedures. Initially, the search terms were established, with “Renewable Energy” serving as the main phrase. Using the phrase (“Renewable AND Energy”), a search for this term was performed on Scopus across titles, abstracts, and keywords. In this research, the keywords “Renewable Energy” were used to initiate a search across titles, abstracts, and keywords on Scopus. The results were further refined to ensure specificity by applying several filters: open access publications, final publication stage, source type restricted to journals, and English language. The results were refined and then exported in.bib format for further processing.

The data was then arranged using RStudio in accordance with the research questions (RQ). The following statements were run in RStudio with the syntax: install.packages (“bibliometrix”), library(bibliometrix), and biblioshiny(). As a result, the previously saved file was transferred to a bibliometric analysis link, enabling thorough data analysis.

Other tools like VOSviewer and Publish or Perish were used to answer different RQs. First, the “Renewable Energy” keyword was utilized in titles, abstracts, and keywords to search Scopus between 2001 and 2024 using the Publish or Perish method. To find trends and patterns in the data, the retrieved articles were first saved in.RIS file format before being displayed and examined in VOSviewer.

4. Results and Discussion

The data search for this study was conducted in 2024 using relevant search phrases, including “Renewable Energy,” collected from article titles, abstracts, and keywords. These keywords were employed to query electronic databases for articles, resulting in the acquisition of information. This inquiry employed the Scopus database as the electronic resource.

4.1. Research results

Issues pertaining to renewable energy are discussed in several journals each year. These periodicals use a range of methodologies, such as mixed, qualitative, and quantitative approaches. This suggests that studies on renewable energy have remained pertinent in recent years. The information is recorded in Table 1 below.

TABLE 1: Research articles related to Renewable Energy Utilization.

No	Author	Source	Publication Year
1	Bull [33]	IEEE	2001
2	Bilgen et al. [34]	Energy sources	2004
3	Lund [35]	Energy	2007
4	Panwar et al. [36]	Renewable and Sustainable Energy Reviews	2011
5	Shahzad [37]	Energy	2012
6	Ellabban et al. [38]	Renewable and Sustainable Energy Reviews	2014
7	Harjanne and Korhonen [39]	Energy policy	2019
8	Guo et al. [40]	Renewable and Sustainable Energy Reviews	2018
9	Güney [41]	International Journal of Sustainable Development & World Ecology	2019
10	Østergaard et al. [42]	Renewable Energy	2022

4.2. Data compilation and visualization

In this study, analysis was conducted using RStudio and leveraging the “bibliometrix” library. Data collection was carried out according to the established RQ. Here are the main findings obtained based on the bibliometrix analysis.

Figure 1: Main information. Source: Author’s own work.

Figure 1 shows various major conclusions. The bibliometric data ranges from 2001 to 2024, demonstrating a thorough investigation that incorporates contemporary sources. This analysis was based on 2,193 sources, suggesting a diverse range of references, and the study included 520 documents for examination, such as articles and papers. The annual growth rate for research in this topic is 6.21%, indicating a significant increase in relevant publications over time. In addition, 2,031 authors contributed to the studied texts, demonstrating authorship variety. Among these, 38 documents were created by single writers, demonstrating individual contributions to the discipline.

International collaboration is important, with a rate of 36.54%, indicating that a large proportion of these documents include authors from several countries. Each document has an average of 4.24 co-authors, demonstrating the collaborative nature of this study subject. A total of 1,784 keywords are utilized across the texts, indicating common topics investigated by the authors. Interestingly, the documents typically include only one reference, indicating an emphasis on primary data analysis or a novel approach to study. The average age of the documents is 4.44 years, indicating that the study depends on relatively recent publications. Each document received an average of 20.28 citations, indicating significant academic recognition and impact.

RQ1: According to their degree of importance to the topic of renewable energy utilization, how many research articles are published by each journal?

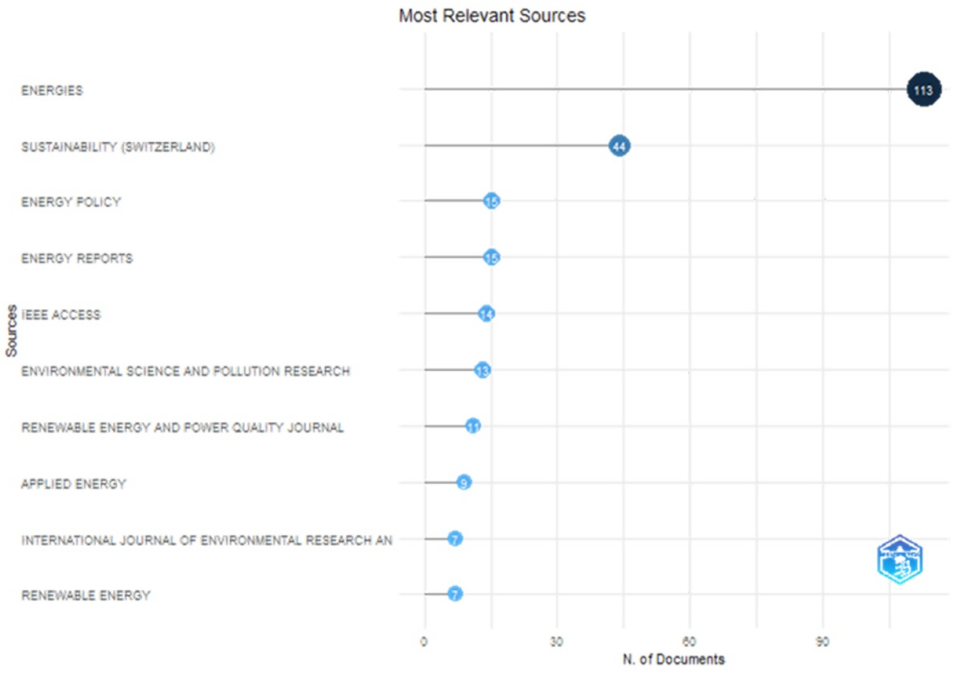

Figure 2: Most relevant sources. Source: Author's own work.

Based on Figure 2, it can be observed that there are several journals contributing to research on renewable energy utilization, with the number of research articles published varying across each journal. The journal “Energies” has the highest contribution with 113 research articles related to the theme, followed by “Sustainability (Switzerland)” with 44 articles, and “Energy Policy” and “Energy Report” with 15 articles each.

The data shows that “Energies” significantly publishes more research articles compared to other journals related to renewable energy utilization. The significant number of publications from this journal may indicate a strong focus or high interest in supporting research on renewable energy utilization. Meanwhile, other journals have lower contributions but still play a role in disseminating information related to this theme. Based on the findings of this research, it can be said that “Energies” and “Sustainability (Switzerland)” appear to be the primary sources for information related to renewable energy utilization.

RQ2: How does the publication of articles in each journal affect the topic of renewable energy utilization?

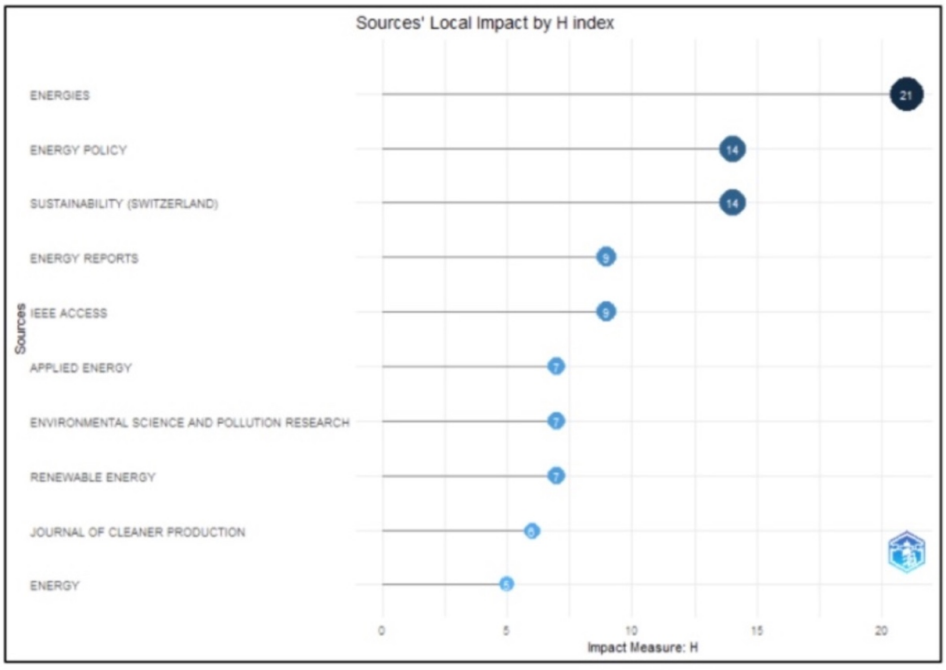

Figure 3: Sources’ local by H index. Source: Author’s own work.

The H-index data of each journal related to renewable energy utilization provides an over-view of the impact generated by these journals in the context of the theme. Based on Figure 3, “Sustainability (Switzerland)” stands out as the journal with the highest impact, indicated by an H-index of 16, which places it at the top in terms of its

impact on the scholarly literature related to renewable energy utilization. This journal demonstrates significant impact in disseminating knowledge and information relevant to the theme.

Followed by journals such as “Energy Policy” and “Energy Report” with H-indices of 14 and 9 respectively, indicating that they also have significant impact in the literature related to renewable energy utilization. Although other journals like “IEEE Access”, “Applied Energy”, “Environmental Science and Pollution Research”, and “Renewable Energy” have lower H-indices, they also contribute in terms of impact on the scholarly literature in the field of renewable energy, albeit to varying degrees. The importance of the H-index lies in serving as a quantitative indicator of how often articles from a journal are cited, which in turn measures the impact and relevance of the journal within the scholarly community. Based on this research, it can be seen that journals like “Sustainability (Switzerland)” have a greater impact in the scholarly literature related to renewable energy utilization compared to other journals.

RQ3: Which authors are best suited to study the topic of renewable energy utilization?

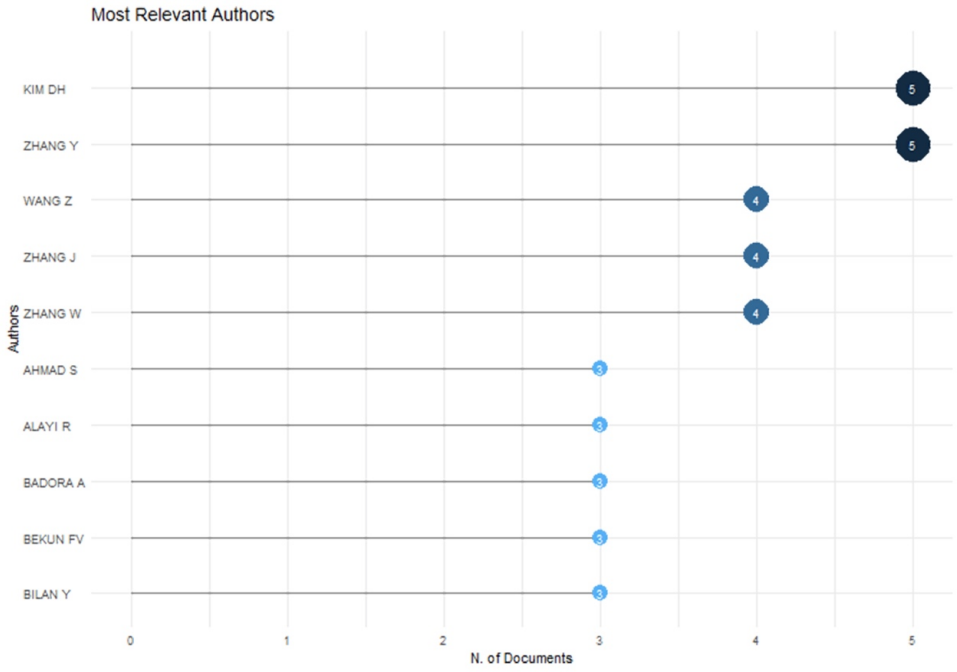

Figure 4: Most relevant authors. Source: Author’s own work.

Figure 4 illustrates the publication contributions of several highly relevant authors in the re-search on renewable energy utilization. Based on Figure 4, there are several authors who stand out in terms of relevance and their publication contributions related to the theme of renewable energy utilization. In this data, authors Kim DH and Zhang Y are the most prolific, each with 5 articles related to this theme. Additionally, there are

several other authors such as Wang Z, Zhang J, and Zhang W who also have significant contributions with 4 publications each related to renewable energy utilization.

The findings of this research indicate that several authors have consistently contributed to the scholarly literature on renewable energy, with their publication numbers being quite high. Although no single author dominantly dominates the number of publications, this group of authors collectively has a significant impact in terms of disseminating knowledge and information about renewable energy utilization. This demonstrates the diversity of authors' contributions to the scholarly literature in this field.

RQ4: How does each author's publication of publications affect the topic of renewable energy utilization?

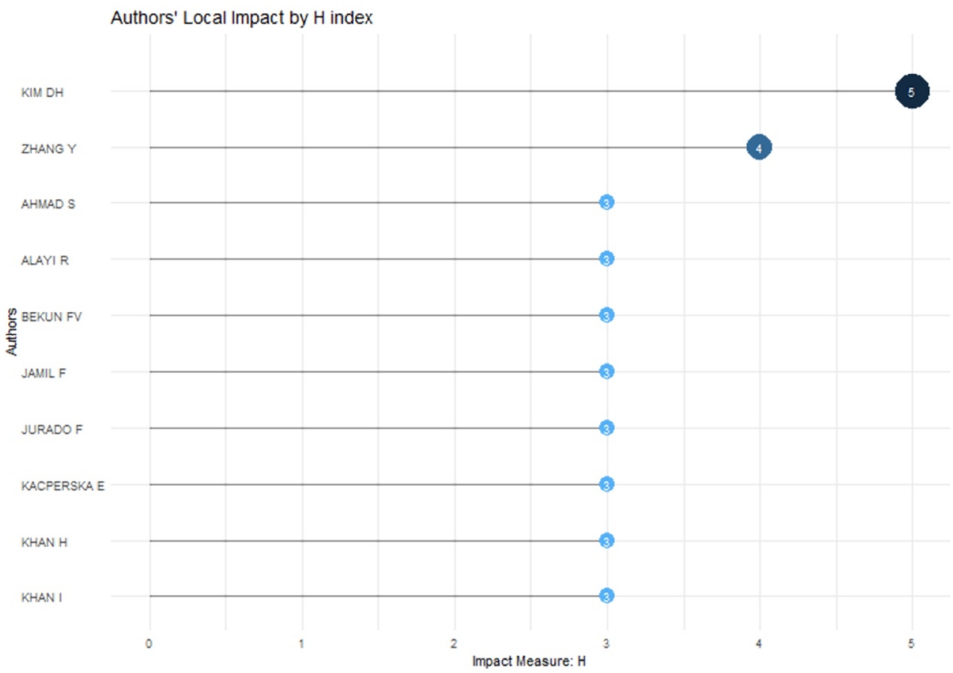

Figure 5: Authors' local impact by H index. Source: Author's own work.

Figure 5 depicts the H-index of each author related to the theme of renewable energy utili-zation, providing information about the impact of their publications in scientific literature. Based on the presented Figure 5, author Kim DH shows the highest impact with an H-index of 5, indicating that their publications in the theme of renewable energy utilization have been frequently cited in scientific literature. This is followed by Zhang Y with an H-index of 4, and Ahmad S, Alayi R, Bekun FV, Jamil F, Jurado F, Kacperska E, Khan H, and Khan I with respective H-indexes of 3, indicating that their publication contributions are also recognized in literature related to renewable energy.

The importance of the H-index lies in its role as a quantitative indicator of how often an au-thor's publications are cited, which in turn measures the impact and relevance of the author within the scientific community. From this data, it can be seen that some authors such as Kim DH and Zhang Y have a greater impact in scientific literature related to renewable energy utilization compared to other authors. This indicates the significant contributions of these authors in enriching knowledge in the field of renewable energy.

RQ5: How many nations are involved in research on the use of renewable energy?

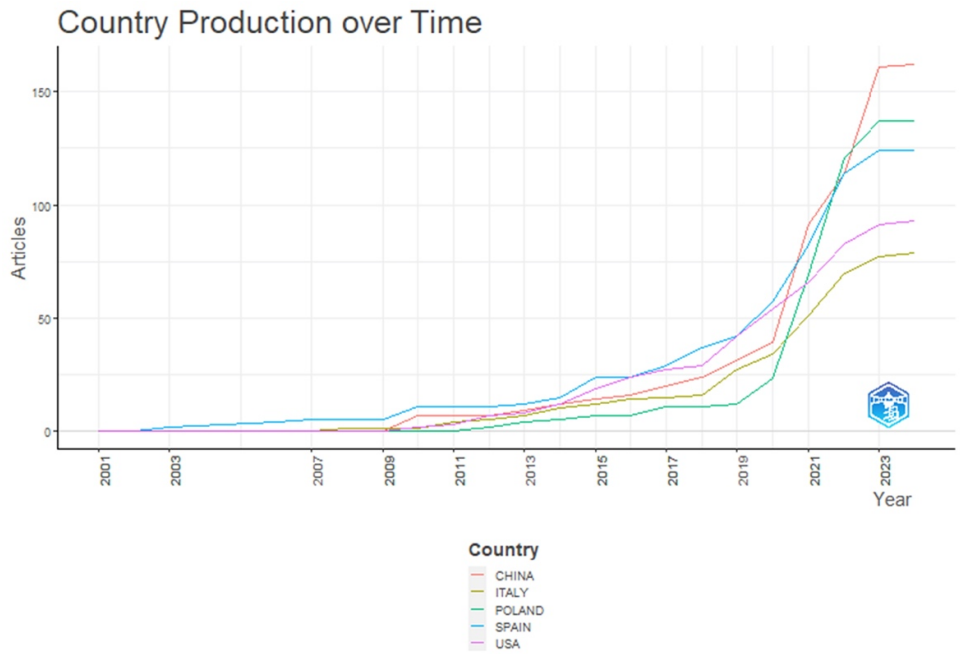

Figure 6: Country production over time. Source: Author's own work.

Figure 6 illustrates the graph depicting the development of countries producing articles on the theme of renewable energy utilization from 2001 to 2024. Based on the graph above, it can be observed how the publication activities from various countries have shown a trend of increasing throughout the research period. In 2023, it is evident that China has the highest number of journals with a total of more than 150 articles, followed by Poland in second place and Spain in third place with totals of more than 100 articles each. Following them are the USA and Italy, respectively, in fourth and fifth positions. This highlights the significant role played by several countries in generating literature related to renewable energy, underscoring global attention to this topic.

RQ6: Regarding the topic of renewable energy utilization, which nation has the most citations in the international scientific literature?

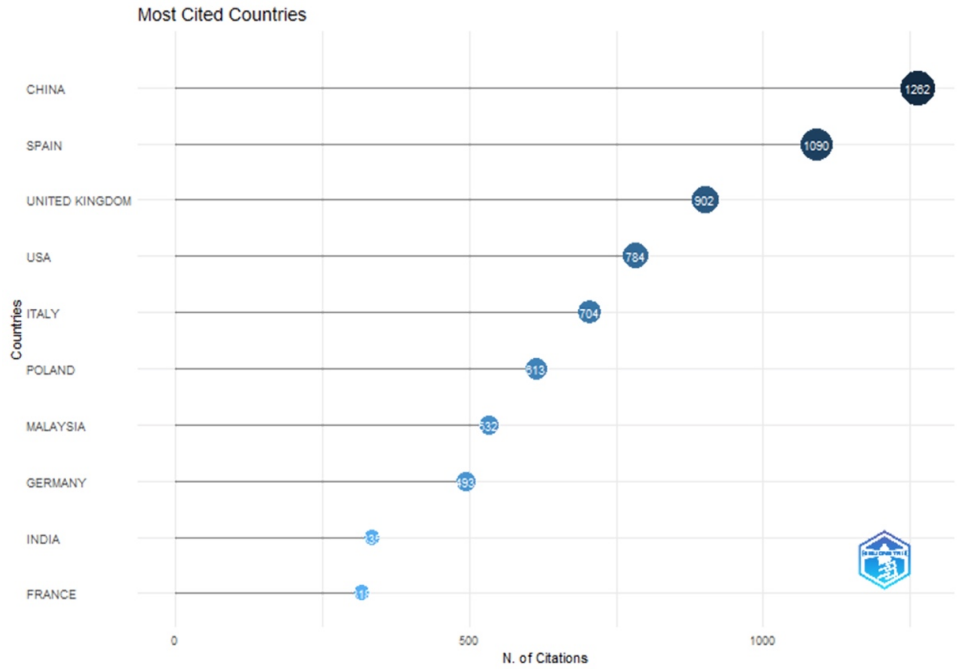

Figure 7: Most cited countries. Source: Author's own work.

The term "most cited countries" denotes the ranking of nations according to the volume of citations garnered by research conducted by their scholars in the scientific literature pertaining to renewable energy usage. This ranking reflects the significant contribution of these countries to global research on renewable energy. It can be seen that China, Spain, and the UK occupy the top three rankings with significant number of citations. A substantial number of citations signifies that the research generated by these countries is esteemed and extensively utilized by global academics, reflecting the prestige and influence of their contributions to the international scientific discourse on renewable energy.

RQ7: From 2001 to 2024, what are the trends in the scientific literature on the use of renewable energy?

Figure 8 above depicts the evolution of the predominant and frequently examined subjects in the scientific literature about renewable energy utilization from 2001 to 2024. This data illustrates the temporal shifts in research focus within the renewable energy sector by emphasizing alterations in trends and the progression of issues that receive predominant attention in the scientific community. In the last three years, various subjects related to renewable energy have been investigated, including electricity quality, Pakistan, alternative fuels, investments, economic development, carbon footprint, renewable energy resources, and alternative energy. Consequently, acquiring further knowledge on these subjects is captivating.

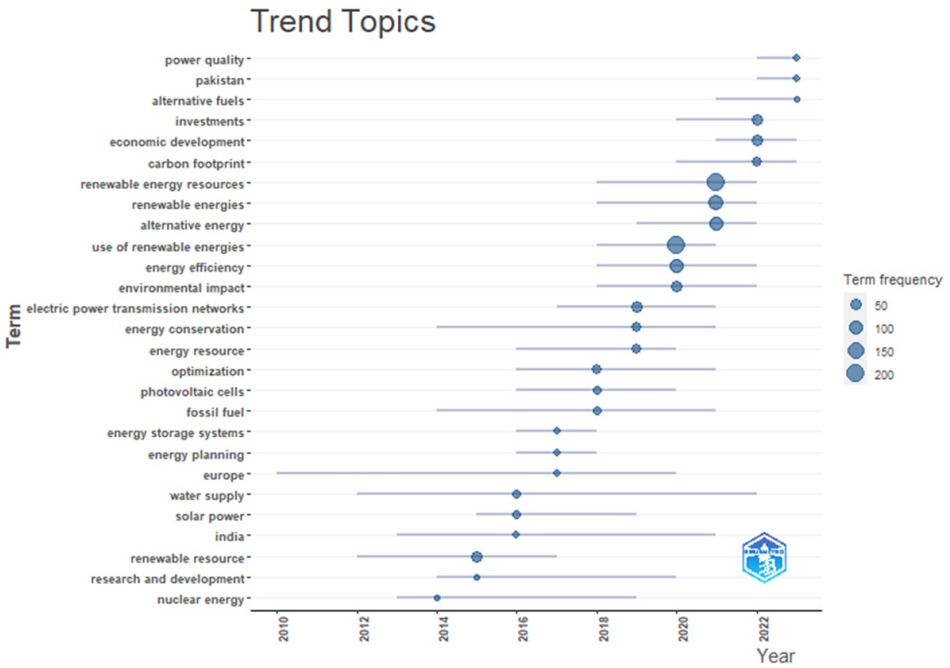

Figure 8: Trend topics about renewable energy utilization. Source: Author's own work.

RQ8: Which terms are most pertinent to the use of renewable energy in scientific literature?

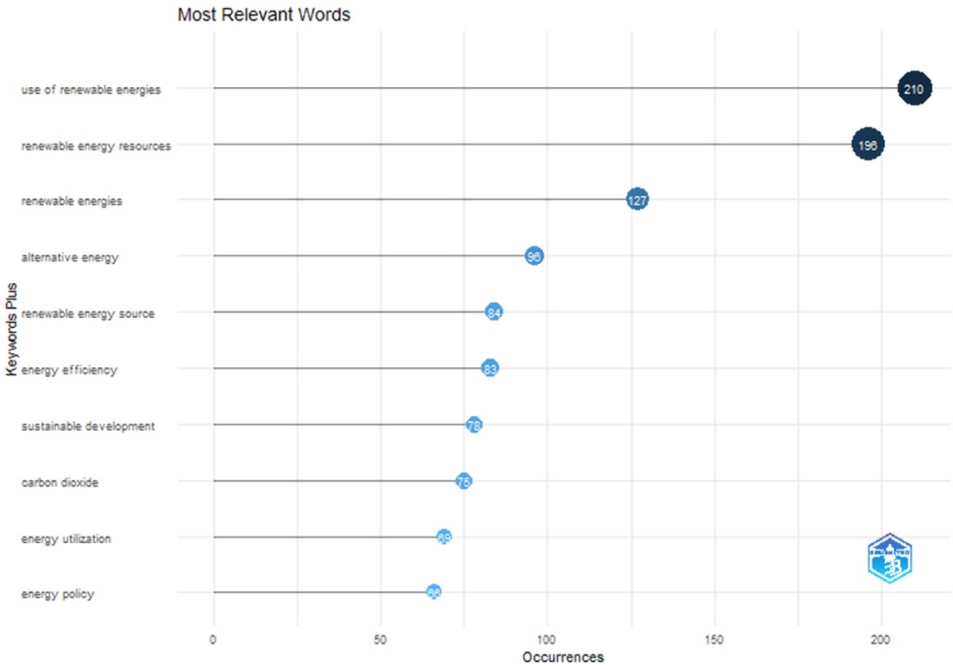

Figure 9: Most relevant word. Source: Author's own work.

Figure 9 illustrates the most relevant terminology utilized in the scientific literature regarding renewable energy. The primary emphasis of research and discourse in renewable energy is encapsulated in these terms. Terms such as "Use of Renewable

Energies," "Renewable Energy Resources," "Renewable Energies," "Alternative Energy," "Renewable Energy Sources," "Energy Efficiency," "Sustainable Development," and "Carbon Dioxide" are the most frequently employed and considered most relevant in the context of renewable energy utilization, as indicated by the figure.

The increase in these phrases indicates that the scientific literature about renewable energies, renewable energy resources, alternative energy, and energy efficiency is garnering heightened attention. This elucidates the primary concepts and research focal points of renewable energy emphasized in scientific literature.

RQ9: Which terms are most frequently used in studies on the use of renewable energy?

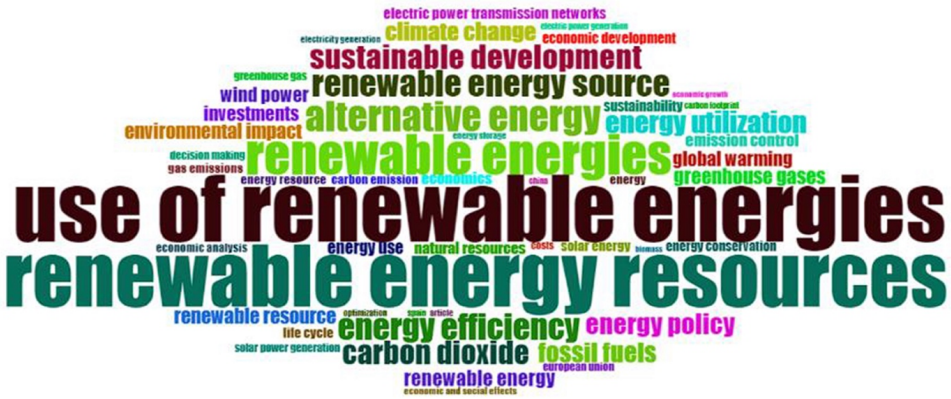

Figure 10: Word cloud. Source: Author's own work.

A graphical representation of frequently occurring terms within a dataset of articles related to a particular issue is termed a word cloud. The most common terms are visually scattered across the word cloud and displayed in larger sizes. According to Figure 10, the most commonly utilized terms related to renewable energy include "Use of Renewable Energies," "Renewable Energy Resources," "Renewable Energies," "Alternative Energy," "Renewable Energy Sources," "Sustainable Development," "Energy Efficiency," and "Carbon Dioxide." The primary focus of study and discourse in the scientific literature around renewable energy is encapsulated by these terms. The magnitude of words in the word cloud correlates with their frequency in the collection of articles, indicating the relevance of these concepts in the literature on renewable energy utilization.

4.3. Discussion

The bibliometric analysis results provide a comprehensive overview of renewable energy utilization in scientific literature. With a time range of analysis from 2001 to 2024, significant growth in the number of relevant articles is evident, indicating sustained interest in this topic. The involvement of over 2,000 authors from various countries also underscores the diversity of perspectives in this domain, reflected in the international collaboration rate of 36.54%. Although the average document only refers to one source, an average of 20.28 citations per document indicates high acceptance within the scientific community. However, the average age of documents used is 4.44 years, suggesting the use of relatively recent literature.

The growing demand and environmental problems brought on by the usage of fossil fuels have made the use of renewable energy sources essential [42]. Future energy demands will be satisfied by sustainable energy sources as a result of the growing usage of renewable energy [43]. The present state, future potential, and enabling technologies of renewable energy sources were examined by Ellabban et al. [38]. They outline the usage of renewable energy sources, scientific advancements that have improved their application, potential futures, and their distribution.

Since existing energy sources are no longer enough to meet global energy demands, leading to an energy crisis, the usage of renewable energy is essential for the world [40]. The generation of renewable energy is increasing annually, and by 2020, the majority of nations hope to produce over 15% of their energy from renewable sources [40, 44]. Space heating, cooling, and hot water production can be accomplished with ease using solar energy, the most accessible renewable energy source [45, 46].

The abundance of renewable energy is its most significant feature. It is not depletable. Compared to conventional fossil fuel technologies, renewable energy sources are clean energy sources with a far smaller adverse environmental impact. Most investments in renewable energy are not in expensive energy imports, but in personnel and materials for building and maintaining facilities [37]. Higher levels of sustainable development will result from advanced nations' emphasis on renewable energy. To increase renewable energy output by 2030, renewable energy projects must be promoted. Additionally, taxation and regulatory measures that enable and lower the cost of renewable energy investments are necessary, especially in poor countries [41].

Strategies for integrating renewable energy sources into a cohesive energy system that is impacted by efficiency and energy-saving measures should be included in the

large-scale renewable energy implementation plan [35]. Integrating a sizable amount of intermittent resources, especially the supply of electricity, into the energy system is one strategy [47]. Incorporating the transportation industry into these plans is an additional strategy [48].

A key finding of this analysis is the abundance of keywords reflecting primary focuses, such as renewable energy utilization, alternative energy sources, sustainable development, and energy efficiency. This reflects the central attention and primary areas in renewable energy utilization research, which continue to evolve over time with enriched and expanding concepts.

There has been a steady increase in publications on renewable energy, particularly solar power generation, reflecting growing academic interest [49]. Optimization, renewable energy, biomass, CO2 emissions, models, and desalination are some of the main research clusters [50]. Bibliometric analysis can indicate future research directions in the literature, such as the application of relatively untested technologies and the identification of potential barriers to their adequate implementation [51].

5. Conclusion

Based on the results of the bibliometric analysis, several conclusions can be drawn regarding research on renewable energy utilization. The journal Energies stands out as the most prolific publisher in this field, significantly contributing more articles compared to other journals. However, Sustainability (Switzerland) emerges as the journal with the highest impact, making it a key source of influence in the scientific literature on renewable energy utilization.

Among the most productive authors, Kim DH and Zhang Y have each published five articles on the theme, with Kim DH being the most impactful author, as indicated by an H-index of 5, showing frequent citations in this research area. The trend of scientific publications on renewable energy from 2001 to 2024 shows a consistent increase, reflecting growing global interest in this field. China, Spain, and the United Kingdom lead in the number of citations related to renewable energy utilization, occupying the top three positions.

Furthermore, frequently used and relevant terms in these articles include “Use of Renewable Energies,” “Renewable Energy Resources,” “Renewable Energies,” “Alternative Energy,” “Renewable Energy Sources,” “Energy Efficiency,” “Sustainable Development,” and “Carbon dioxide.” The dominant terms appearing in word clouds similarly emphasize these areas, reinforcing their importance in the ongoing research on renewable energy utilization.

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