

# A Bibliometric Analysis of the “NetZero” Process in the Energy Knowledge Domain

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**Abstract:** This work aimed to elucidate the key research findings within the realm of NetZero, specifically within the energy field. Employing advanced data visualization tools, particularly VOSviewer, scientific maps were meticulously crafted to explain the evolving landscape of research in this domain. The results showed that the nations that most vigorously committed to the NetZero endeavor are the United Kingdom, United States, China, Australia, and Canada, signaling a global consensus on the urgency of addressing climate change. Furthermore, this study reveals pivotal trends in the field and keywords such as “renewable energy”, “decarbonization”, “netzero”, and “sustainability” have gained remarkable prominence, especially in recent research. In conclusion, this work offers a comprehensive overview of the NetZero landscape within the energy field, emphasizing the urgency of international collaboration, and identifies key trends that will likely shape the future of sustainable energy research and policymaking.

**Key words:** Netzero, renewable energy, decarbonization, sustainability.

## 1. Introduction

The concept of “NetZero” has garnered substantial attention in recent years, amid the escalating climate crisis that looms over the world. In the context of this work, a robust bibliometric analysis was employed to furnish a comprehensive retrospective view of the intricate research landscape that envelops “NetZero” energy strategies. Notably, the urgency of addressing NetZero strategies is underscored by the sobering projections delineated by the Intergovernmental Panel on Climate Change [1]. These projections portend dire consequences should GHG (Greenhouse Gas) emissions persist at their current trajectory. By 2030, a 0.4 °C increase in temperature could unleash profound ecological and societal disruptions, including heightened extreme weather events, sea-level rise, and an existential threat to food security.

For instance, Mouallem et al. [2] conducted a meta-analysis focusing on carbon capture storage and its implications for emissions reduction. Meanwhile, McPherson et al. [3] conducted a comprehensive review of energy system models across diverse domains, evaluating their potential in shaping future NetZero strategies. Lastly, Alves et al. [4] undertook a bibliometric analysis of the energy matrix in countries such as Brazil, Germany, France, and the United Kingdom, assessing their contributions to GHG emissions reduction. Their findings illuminated that significant progress remains necessary, particularly among developed nations.

The objective of this work was to analyze publications spanning from 2004 to 2023, scrutinizing the quality and quantity of NetZero studies within the energy field over this period. To fulfill this aim, a comprehensive bibliometric keyword analysis was deployed, utilizing

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the Scopus bibliographic database in conjunction with the powerful VOSviewer software to construct intricate scientific maps that unveil the evolving contours of this dynamic research domain.

## 2. Methodology

### 2.1 Bibliometric Analysis

Bibliometric analysis examines bibliographic material from an objective and quantitative perspective, organizing information within specific knowledge domains [5-7]. Thus, a bibliometric analysis using keywords enables the examination of information on key research topics within a subject of interest [8]. The current research followed the following stages, as outlined by Castillo-Vergara et al. [9]: (a) definition of the study area; (b) selection of the research database; (c) refinement of search criteria; (d) coding of publications; (e) analysis of the generated information.

### 2.2 Choice of Database

This investigation spanned the timeframe from 2004, marking the inception of term occurrence, through 2023 [10]. The search string, meticulously crafted for precision, was formulated within the advanced search field of Scopus as follows:

(TITLE-ABS-KEY (netzero) OR TITLE-ABS-KEY (“net zero”)) AND (LIMIT-TO (SUBJAREA, “ENER”)) AND (LIMIT-TO (PUBSTAGE, “final”)) AND (LIMIT-TO (SRCTYPE, “j”)) AND (LIMIT-TO (LANGUAGE, “English”)) AND (LIMIT-TO (DOCTYPE, “ar”) OR LIMIT-TO (DOCTYPE, “re”)).

### 2.3 Used Indicators

In accordance with the indicator definitions proposed by Zupic and Čater [11], this work employs quantity-based metrics to assess research productivity at both individual and national levels, focusing on the number of publications and citations. The analysis encompasses three primary units of analysis: countries, authors, and keywords. To evaluate the research impact

of countries, citation indicators are utilized, which gauge the prominence and influence of nations in the research landscape. In the case of authors, a combination of citation and co-authorship indicators is applied. Co-authorship analysis, on the other hand, unveils the intricate social fabric of research, revealing collaborative networks among countries and authors. For the analysis of keywords, co-occurrence analysis is employed.

### 2.4 Software

VOSviewer, an open-source information technology software developed by van Eck and Waltman [12], was employed. Within the operational environment of VOSviewer, the initial configurations were established as follows: the creation of a map based on bibliographic data and the extraction of data from bibliographic database files, specifically the CSV file sourced from Scopus.

## 3. Results and Discussion

The number of publications identified in the literature amounted to 1,948 articles. The distribution of publications from 2004 until 2023 is illustrated in Fig. 1. Remarkably, in the initial year of our analysis, 2004, merely two articles were published on the subject. This relatively low output persisted until 2010. However, a notable shift occurred in the following decade, spanning from 2011 to 2019, where the average annual number of publications surged to 36 articles. This growth trajectory reached its zenith in the most recent period, from 2020 to 2023, with over 400 publications. International agreements and commitments made during this period, notably the Paris Agreement, have underscored the urgency of NetZero initiatives as a crucial component of climate action. The emergence of the COVID-19 pandemic brought renewed attention to society and the economy’s vulnerability to global threats, further emphasizing the need for sustainable and resilient solutions [13-15] (Fig. 1).

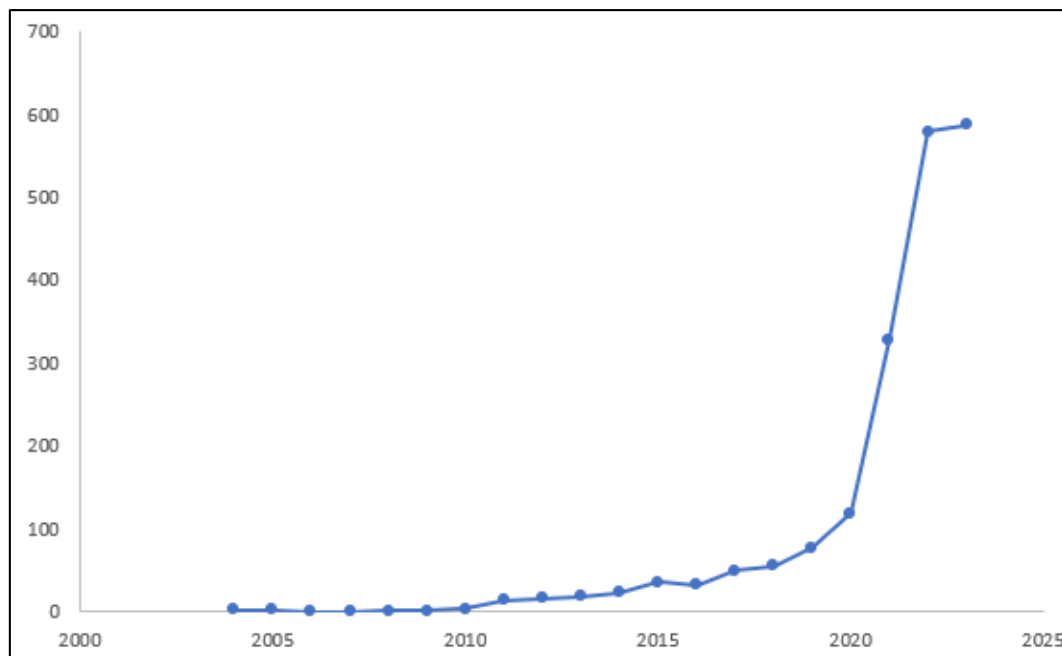


Fig. 1 Annual distribution of publications.

The leading country in terms of publications and citations within the energy field concerning NetZero is the United Kingdom, boasting an impressive tally of 500 articles and 5,678 citations. Following closely is the United States, with 334 publications and 5,595 citations. China secures the third position with 254 articles, although it garners fewer citations compared to Canada, which occupies the fifth spot of citation numbers, just behind Australia. China accumulates 4,061 citations, while Canada edges ahead with 4,079. The specific publication and citation figures for these countries demonstrate their substantial contributions to the discourse surrounding NetZero strategies within the energy domain. To provide a visual representation Fig. 2 illustrates the countries most engaged in the subject of interest.

Based on the information analysis, it is notable that the author with the highest number of published articles on NetZero is B. K. Savacool, having published a total of 16 works. These studies are recent, from 2021 to 2023, and primarily focus on decarbonization strategies within specific industry sectors [16, 17]. This demonstrates his ongoing contributions to the evolving discourse in this critical domain. In contrast, the distinction of being the author with the highest number

of citations, totaling 360, goes to Y. Lu. His research, conducted between 2015 and 2022, predominantly revolves around the development of energy efficiency models aimed at promoting NetZero initiatives [18, 19]. Lu’s work has evidently garnered significant attention within the academic community and beyond, emphasizing its relevance and impact.

The most highly cited article in this research domain is titled “A Global Review of Energy Consumption, CO<sub>2</sub> Emissions, and Policy in the Residential Sector (with an Overview of the Top Ten CO<sub>2</sub> Emitting Countries)”, published in 2015 in the journal *Renewable and Sustainable Energy Reviews*. In this seminal article, the authors provide a comprehensive overview of global GHG emissions originating from the residential sector, offering valuable insights into this critical aspect of the energy landscape. Turning the attention to the social dynamics within the research field, characterized by the necessity for effective collaborations among authors, it is evident that such collaborations remain limited. Employing stringent criteria, requiring a minimum of two documents and a minimum of 20 citations per author within the VOSviewer environment, our analysis revealed the presence of 43 authors

dispersed across 30 distinct clusters. This configuration results in an average of merely 1.4 authors per cluster, signifying that despite the substantial volume of publications on NetZero within the energy field, a significant proportion of authors continue to operate in relative isolation, even when their research themes

exhibit noteworthy similarities. Fig. 3 shows the collaborative landscape within this field of research.

The most frequently employed terms in this research landscape are “Renewable Energies”, “Decarbonization”, “Net-Zero”, and “Sustainability”. These keywords have gained prominence relatively recently, with their

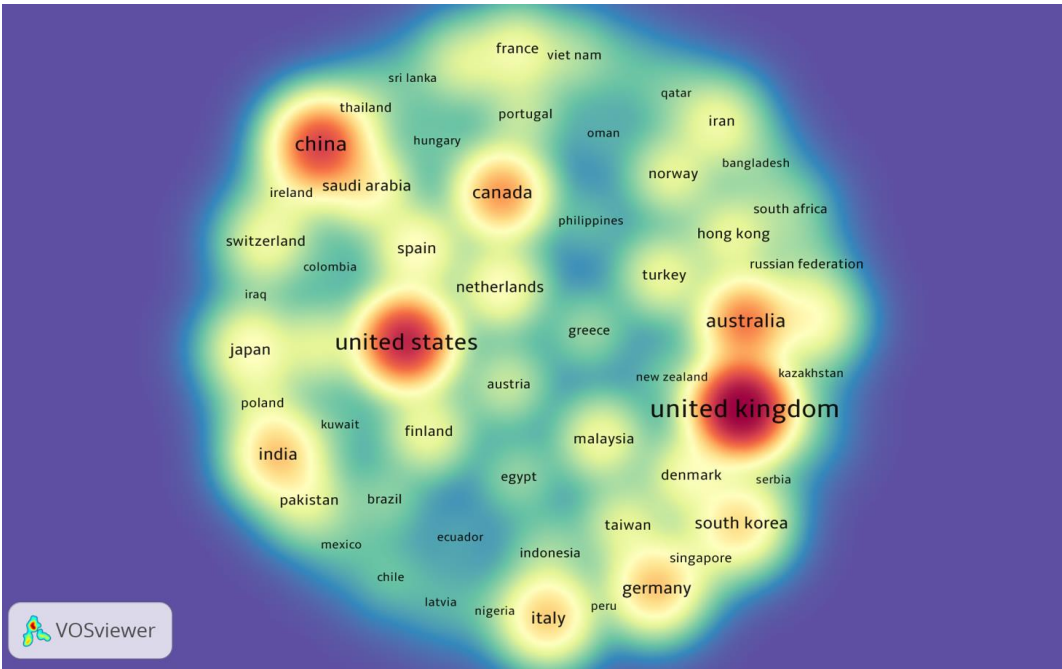


Fig. 2 Intensity of publications and citations by country.

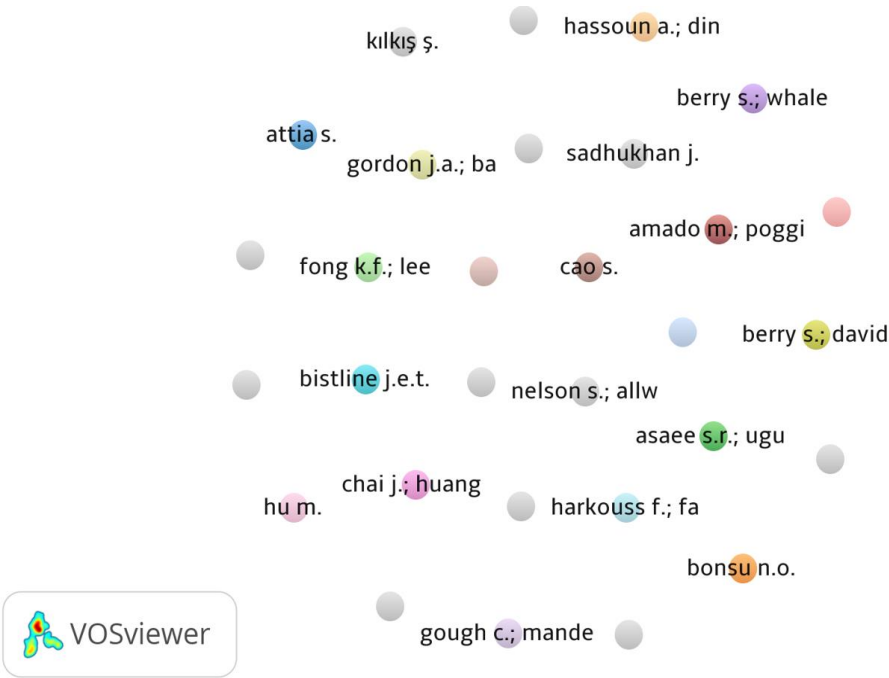
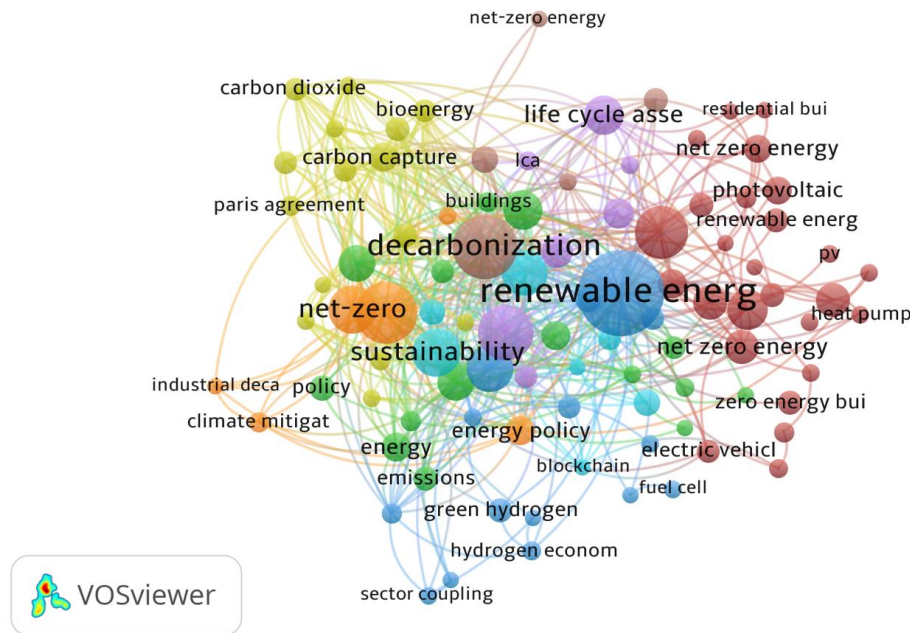


Fig. 3 Social structure of NetZero research in the energy area.



**Fig. 4** Keyword co-occurrence analysis.

usage becoming prominent since 2019, indicating their status as emerging areas of interest. From 2019 to 2023, the selected sample of articles for this study garnered a total of 26,417 citations, representing a substantial 86% share of the citations received throughout the broader period spanning from 2004 to 2023. It is noteworthy that among the most highly cited articles from 2019 to 2023, all of them incorporated at least some of these commonly used terms. For instance, in 2019, the article titled “Daily-Seasonal Operation in a Net-Zero Energy Building Powered by Hybrid Renewable Energies and Hydrogen Storage Systems” not only featured the term “net-zero” in its title but also prominently included it in the keywords and abstract. Similarly, the article “The Role of the Power Sector in Net-Zero Energy Systems”, published in 2021 and cited 32 times, along with the 2023 article “Exquisite Workmanship through Net-Zero Emissions? The Effects of Carbon Emission Trading Policy on Firms’ Export Product Quality”, which received 10 citations, all prominently incorporated these crucial terms. This substantial alignment between highly cited articles and the identified common terms underscores the vibrant research landscape in the field of NetZero within the energy domain. It also provides valuable insights into potential avenues for future

research endeavors on this subject. Fig. 4 illustrates the prevalence of these terms in the research, offering a visual representation of their significance and prominence within the scholarly discourse.

#### 4. Conclusions

The bibliometric research has unveiled a thriving and diverse field of study closely linked to the NetZero process within the Energy sector. Over the course of just two decades, a substantial body of work has emerged, comprising 1,948 works and garnering more than 30,700 citations, all dedicated to exploring various facets of this critical subject. Significantly, most of these studies are notably recent, with an astonishing 96% of both publications and citations originating from 2015 onwards. This timeline underscores the growing urgency and scholarly attention directed towards NetZero initiatives. In terms of geographical involvement, the research spotlights the primary countries that have been at the forefront of this subject matter. The United Kingdom, United States, China, Australia, and Canada emerge as the most prominent contributors, collectively accounting for approximately 45% of all publications and 40% of the total citations.

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## Conflicts of Interest

The authors confirm that there are no conflicts of interest.

## Data Availability

On behalf of all authors, the corresponding author states that there is no conflict of interest.

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