



Global Knowledge Structure of Energy Policy in the Sustainable Development Goals Era: A Bibliometric Analysis of Studies Indexed in Scopus

Toan-VU Le¹, Huy Pham Canh¹, Tran Nhat Minh^{1*}, Nguyen Cam Tu¹

¹ Faculty of Management, School of Economics and Management, Hanoi University of Science and Technology, Hanoi, Vietnam

*Corresponding author: Trannhatminh1204@gmail.com

Abstract

The narrative of energy policy constantly being renewed to adapt to our ever-changing society is not new in the modern era, but the challenges posed by the demand for sustainable development have introduced new perspectives and rendered this issue more urgent, giving ways to newer strategies for policymakers to prioritize. This study employs a bibliometric analysis from 1992 to 2024, using Scopus data and the VOSviewer tool with a total of 536 articles, to assess the general landscape and the evolution of scientific researches on energy policy and the SDGs. Notably, the data indicates that research emphasizing economic/financial aspects is generating greater scientific impact. Deeper bibliometric analysis, evidenced by data visualization, also reveals that traditional topics such as “renewable energy” and “CO2 emissions” are now being approached with fresh perspectives, integrating additional economic, policy, and financial elements. This is further emphasized by the rise of terms such as “green finance” and “economic growth”, “financial development”, shifting this field from a technical dominated field to be economically driven, displaying the importance of developing both simultaneously. The study particularly calls attention to the role of geopolitical factors, revealing their significant impact on how nations formulate energy and sustainability strategies, while also highlighting a gap in previous research, which has historically focused less on the geopolitical aspects of renewable energy compared to fossil fuels. Future research directions are also discussed, emphasizing the necessity of comprehensive assessments and enhanced strategic coordination to respond to the complex geopolitical landscape.

Research purpose:

The purpose of this research is to provide a systematic, bibliometric overview of scientific research connecting energy policy and SDGs. It specifically investigates the shift in focus among scholars and nations to green finance and economic growth within this field and discusses how geopolitics affect a nation’s approach to sustainable energy policy.

Research motivation:

With the urgent global need to achieve the SDGs given by the UN along with the importance of the transition to renewable energies for a sustainable future of each nation, scholars have produced an extensive library of work throughout the years. The research discourse is rapidly evolving, shifting from a primarily technical focus to one increasingly dominated by economic and financial considerations. A comprehensive analysis is necessary to map this change, signifying the rise of themes like “green finance”, and understand how this shift reflects the change in real-world policy.

Research design, approach, and method:

This study uses bibliometric analysis to identify the pattern and development of research regarding energy policies and Sustainable Development Goals (SDGs). This approach allows us to thoroughly analyze publication trends, citation networks, and keyword co-occurrence to provide an overview of the topic and its shift towards economic, finance and how geopolitics affects policymakers.

Main findings:

This bibliometric analysis identifies a definitive shift in energy policy and SDGs research, where economic and financial topics have become a central focus as the field continues to develop, surpassing the technical research of earlier years. China, India, and the EU stood out as the leading research nations and regions, with their distinct geopolitical and economic needs to shape their unique approaches to energy policy and achieving SDGs. Furthermore, the data is represented to have a highly intertwined collaboration between countries, yet there is still a gap in addressing how geopolitics affects the transition to renewables.

Practical/managerial implications:

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For policymakers, this paper serves as an indicator for the necessity of integration between energy policies and economic and financial development. The demonstrated importance of green finance and economic growth suggests future policies should prioritize not just technical but also economical and financially viable options for success. Furthermore, strategies must be geopolitically informed and locally relevant because there is no universal solution to achieving a transition to sustainable energy. This paper also signifies the importance of shifting beyond just technical focus research to embrace inclusive pathways that strike a balance between affordability, economic development, and energy security to ensure success.

Keywords: SDGs, Energy Policy, Bibliometric, Geopolitics, Sustainable Development.

1. INTRODUCTION

As the population and economy gradually expand from the early 20th, the demand for limited resources has increased at a constant rate, including energy. For instance, increase demand for oil and gas production by the United States' government has contributed to the long-term expansion of fossil fuel extraction - an approach increasingly viewed as unsustainable considering climate commitments and environmental goals (Achakulwisut et al., 2021). Therefore, the main objectives for policymakers, governments worldwide have shifted to utilizing renewable energies, to ensure a sustainable future and development. With the increasing awareness of negative environmental and social impacts and for countries to achieve sustainable development goals, the shift to renewable energy sources has never been as crucial as it is in today's world (Xue et al., 2023).

Concurrently, the notion of sustainable development experienced a gradual transformation into a worldwide framework, which resulted in the release of the 17 Sustainable Development Goals (SDGs) (Xin et al., 2024). The Sustainable Development Goals (SDGs), were established by the United Nations and are regarded as a worldwide call to action to eliminate poverty, safeguard the planet, and promote peace and prosperity across all nations. Among these, energy policy is regarded as a primary goal, particularly in reaching goal 7 (SDG 7) and goal 13 (SDG 13), which calls for universal access to modern, affordable, dependable, sustainable energy and take urgent action to combat climate change and its impacts (Marco-Lajara et al., 2023).

Since 1992, journals and academics have been interested in the relationship between energy policy and sustainable development goals. This article offers a bibliometric analysis of research on energy policy and sustainable development goals, considering green energy development continues to be a global trend. This essay focuses on analyzing prior evaluations of SDGs and energy policy towards sustainable development to contribute to the continuing conversation, reflecting the importance of SDGs and their potential to improve the world.

Overall, the field has significantly evolved, with earliest papers mainly focused on national-level strategies for energy efficiency and renewable energy investments with the goal of achieving sustainable development and reductions of greenhouse (Van Buskirk, 2006). Over time, the scope expands to analyze multiple countries in one region, studying the relationship between environmental indicators like the ecological footprint and diverse socio-economic factors such as trade policy, economic growth, and fertility rates in EU countries (Alola et al., 2019). In a more recent paper, scholars have integrated sophisticated policy instruments and financial mechanisms, investigating the role of environmental taxes and economic complexity in reducing carbon emissions for G7 countries (Doğan et al., 2022). Furthermore a new term green finance, particularly green bonds, has appeared, and scholars have been examining how they enhance energy efficiency and renewable energy development among "Green Leaders" to meet Sustainable Development Goals in the context of global challenges (Rasoulinezhad & Taghizadeh-Hesary, 2022).

In this study, a fundamental synopsis and overview of research activities, journals, authors, publications, and common research goals in relation to energy policy and sustainable development will be provided. Using bibliometric data from VOSviewer based on the Scopus database, statistically analyzed from 1992 to 2024, the bibliometric analysis method in this field looks at the number of publications, the keywords used by authors, the frequency of citations of articles, the co-citation relationships between research works, and related journals. This method will be able to help identify prominent research topics and the how field has evolved over time (T.-V. Le & Tran, 2021; T. Le et al., 2025).

The current state of energy policy research is also summarized in this article, which also identifies possible future study directions. In order to raise awareness and encourage action to incorporate energy policy within the SDGs framework for a more sustainable future, this study helps provide a broad perspective. The final part of this article concludes with the research findings, presenting contributions to the analysis of current research trends and identifying existing gaps or issues, shaping further research efforts to promote sustainable development in the energy sector. This research aims to answer the following questions:

- (1) What are the emerging trends for energy policies and sustainable development? Furthermore, how have discussions around these topics changed?
- (2) How has the role of economy in sustainable development changed in the 21st century based on new publications?

(3) How are the sustainable energy policies of respective countries influenced by geopolitical aspects?

The study seeks to offer a thorough review of the topic while identifying innovative avenues that may stimulate further progress energy policy and SDGs research.

2. METHODOLOGY

2.1 Bibliometric analysis

Bibliometric analysis is a quantitative research method that systematically evaluates the body of scholarly literature through statistical and mathematical approaches. It enables researchers to identify patterns of publication, citation structures, and knowledge dissemination within specific fields. By employing tools such as citation analysis, co-authorship mapping, and keyword co-occurrence, bibliometrics offers helpful information regarding intellectual structures, research trends, and emerging topics.

This research employed a bibliometric methodology to analyze trends in the scholarly discourse around energy policy and SDGs. The study utilized data obtained from the Scopus database, focusing on published articles related to energy policy and SDGs from 1992 to 2024.

2.2 Data collection

Scopus and Web of Science are two widely recognized databases frequently employed in bibliometric research (Singh et al., 2021). For this study, Scopus was selected as the data source owing to its broad application in bibliometric investigations and its extensive coverage across the social sciences (Baluku et al., 2018; T.-V. Le et al., 2022; T. Le et al., 2025). Data collection followed the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) protocol (Moher et al., 2009).

The initial keywords employed for data retrieval comprised the combination of “Energy Policy” AND “sustainable development goal*,” with variations such as “SDG” and “SDGs” also incorporated to ensure comprehensive coverage of relevant records. Furthermore, retrieval parameters, including time span, language, research domain, and publication type, were applied to refine the dataset and maintain focus on the study’s objectives.

The query used to extract data from the Scopus database is shown as follows:

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TITLE-ABS-KEY("Energy Policy" AND ( "sustainable development Goal*" OR sdg OR sdgs )) AND ( EXCLUDE ( PUBYEAR,2025) ) AND ( LIMIT-TO ( DOCTYPE,"ar" ) OR LIMIT-TO ( DOCTYPE,"cp" ) ) AND ( LIMIT-TO ( LANGUAGE,"English" ) ) AND ( LIMIT-TO ( SUBJAREA,"ENER" ) OR LIMIT-TO ( SUBJAREA,"ENVI" ) OR LIMIT-TO ( SUBJAREA,"SOCI" ) OR LIMIT-TO ( SUBJAREA,"ECON" ) OR LIMIT-TO ( SUBJAREA,"BUSI" ) OR LIMIT-TO ( SUBJAREA,"EART" ) OR LIMIT-TO ( SUBJAREA,"DECI" ) OR LIMIT-TO ( SUBJAREA,"MULT" ) OR LIMIT-TO ( SSUBJAREA,"AGRI" ) ) )
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Following this stage, 557 records were excluded. In the next stage, three authors jointly assessed the titles, abstracts, and, when necessary, the full texts of the remaining articles to evaluate their relevance. Any discrepancies in judgment were resolved through collaborative discussion until consensus was achieved. This stage resulted in the elimination of 21 additional documents. Ultimately, 536 publications were retained for bibliometric analysis in the final stage. Figure 1 illustrates the overall four-step PRISMA process that this study employed.

2.3 Data analysis

This study employed a bibliometric and science-mapping approach to analyze research on energy policy and sustainable development. Descriptive bibliometric indicators were first used to examine publication and citation trends, capturing the historical trajectory of the field. Performance analysis was then applied to identify the most productive authors, journals, institutions, and countries, alongside their scholarly influence measured through citation counts. To uncover structural and thematic patterns, science-mapping techniques—including co-authorship, co-citation, and keyword co-occurrence analyses—were conducted. These methods enabled the visualization of collaboration networks, intellectual foundations, and research frontiers, while country-level mapping highlighted the global distribution of contributions. Keyword analysis revealed emerging topics and thematic clusters within the field. All procedures were implemented with established bibliometric software tools, ensuring rigor and reproducibility. Together, these methods offered a comprehensive perspective on both the knowledge base and the evolving directions of the research domain.

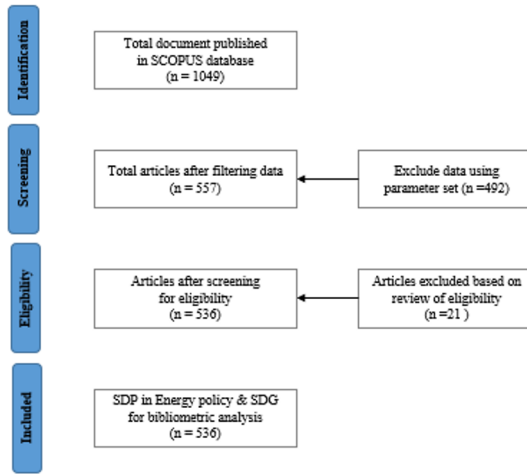


Fig. 1. Data collect based on the PRISMA guidelines

3. RESULTS

3.1 Overview of research data

Table 1 presents the dataset analyzed in this study, which covers publications on energy policy and sustainable development spanning the period 1992–2024. A total of 536 documents were retrieved from 187 distinct sources, including journals, books, and conference proceedings, supported by 32,688 references. The corpus reflects contributions from 1,687 unique authors, of whom 61 produced single-authored works, resulting in 61 stand-alone publications. On average, each document involved 3.62 co-authors, indicating a strong tendency toward collaborative research within this field. In terms of document types, peer-reviewed journal articles account for the overwhelming majority (482 items, 89.9%), while conference papers represent a smaller share (54 items, 10.1%). This distribution highlights the centrality of journal publications in disseminating knowledge and advancing discourse on energy policy and sustainable development. Collectively, these descriptive statistics provide a robust foundation for subsequent bibliometric and science-mapping analyses, enabling insights into the field’s structural characteristics and intellectual evolution.

Table 1. Overview of research data

Description	Results
MAIN INFORMATION ABOUT DATA	
Timespan	1992:2024
Sources (Journals, Books, etc)	187
Documents	536
References	32688
Authors	1687
Authors of single-authored docs	61
Single-authored docs	61
Co-Authors per Doc	3.62
DOCUMENT TYPES	
article	482
conference paper	54

3.2 Number of publications

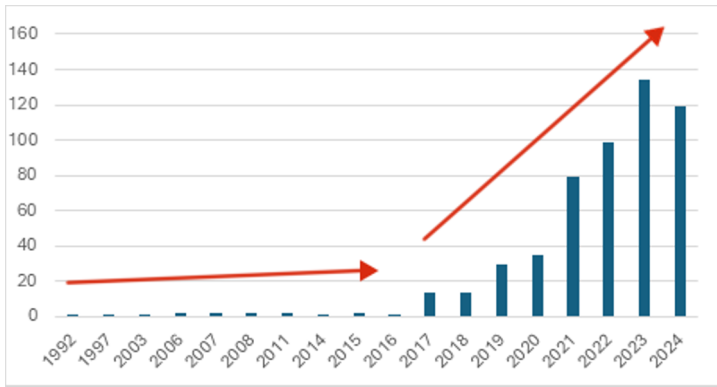


Fig. 2. Expansion trend of sustainable development and energy policies

Figure 2 presents the timeline of article publications through the research span, starting from 1992 up to 2024, over this 32-year period, a total of 536 articles were published on the topic. The development of the publications can be divided into 2 main periods. The first period (1992–2015), accounts for 15 publications, representing only 2.8% of the total dataset. In the second period, from 2016 to 2024, is when research output increased significantly. During this period, 521 articles, 91.2% were published, in 2015, the United Nations put out the 17 Sustainable Development Goals (SDGs), this rapidly increased the annual publications significantly, dividing the period into 2 clear groups. Starting on June 3rd of 1992, the United Nations Conference on Environment and Development, held at Rio de Janeiro, has given out the basics for sustainable development on a global scale. The event has since become the foundation for many discussions surrounding this topic. The foundation period (from 1992 to 2016), when publications by scholars, averaging one article in around 2 or 3 years. This shows that the topic has not garnered much of the public’s attention, preventing scholars from looking deeper into it. But, since 2015, as SDGs became the focus of many countries, demand for more research and knowledge surrounding both said SDGs and energy policies has become increasingly important. To meet that demand, scholars, all around the world, from different institutions have worked together and published their findings and ideas, this is the beginning of the second period, progression. During 2017 and 2024, the volume of published articles increased markedly, further expanding to other related fields. The majority of articles delved deep into two main goals out of the 17 SDG set by the UN, which are SDG7 and SDG13. These two goals’ focus are energy policies, ensuring society functions properly with the changes in integrating clean energy into its system.

3.3. Analysis of leading countries

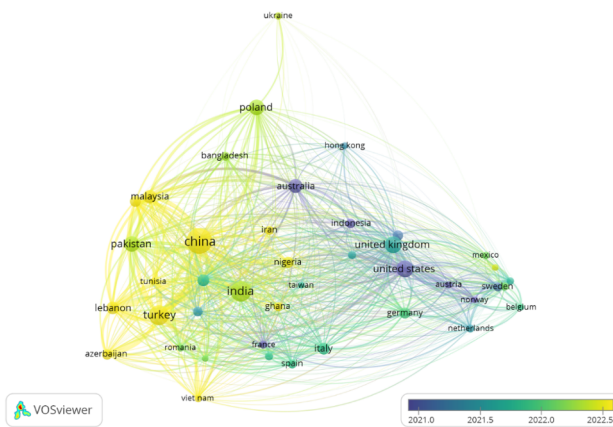


Fig. 3. Collaboration of countries throughout the time period, showing 42 countries with at least 3 published documents.

Table 2. Top 10 countries in publications

No	Label	Documents	Avg. pub. year
1	China	105	2022.6
2	India	69	2022.2
3	Turkey	66	2022.5
4	United States	49	2019.7
5	United Kingdom	48	2021.6
6	Poland	41	2022.2
7	Pakistan	39	2022.2
8	Australia	33	2021
9	Malaysia	30	2022.7
10	Lebanon	27	2023.5

Data analysis reveals significant differences in the contributions of various countries to research output on energy policy and the SDGs. Table 2 presents an overview of the top 10 leading countries in terms of the scientific publications’ quantity from 1992 to 2024. With the three published articles per country threshold, Figure 3 of the study focuses on showcasing the impressive collaborative network of 42 countries, signifying a highly engaged global research system.

Figure 3 illustrates the structure of the global collaborative network, which is densely interconnected, showing close collaboration within national publishing systems. The breadth of the network indicates a trend indicating many countries’ approaches to the development and implementation of energy policies and the achievement of sustainable development goals. Furthermore, the color variation in the figure reflects the average publication year for each country.

Figure 3 and Table 2 show that China is leading the research effort with 105 articles, despite its relatively recent engagement on this topic India ranks second with 69 publications, followed by Turkey with 66 articles. Other countries such as the United States, the United Kingdom, and Poland have also made significant contributions to the research field, with approximately 41 and 49 articles, respectively. The collaboration network of these countries is extremely extensive and complex; for scholars, the topic of energy policy is a highly essential and engaging subject of discussion.

Data indicates that in recent years, Eurasian nations (such as China, Turkey, Vietnam, Lebanon, Malaysia, and Iran) and certain African nations (such as Tunisia and Nigeria) have become more involved in the research flow on this subject. It can be observed that the colors representing these countries are brighter than those for countries that have been involved in this topic for a longer time, such as Australia, the United States, Indonesia, etc. This increase suggests that scholarly interest in this subject has spread geographically. What is noteworthy here is that countries with bright yellow colors are developing economies (Vietnam, Iran, Tunisia, China, ...), while countries with darker colors are developed economies (Australia, the United States, etc.). This demonstrates that it is not only developed economies that are interested in research, but also countries on the path to development are participating in the discussion on energy policy for sustainable development.

3.4. Analysis of impact sources

Table 3. Top 10 active journals published in Energy policies and sustainable development, 1992-2024

No	Source	Publisher	Country	Quality	h-index	TC	NP	PY_start
1	Energies	Multidisciplinary Digital Publishing Institute (MDPI)	Switzerland	Q1	175	728	50	2008
2	Energy policy	Elsevier Ltd	United Kingdom	Q1	292	1756	41	1973
3	Renewable energy	Elsevier Ltd	United Kingdom	Q1	464	1415	28	1997
4	Sustainability (Switzerland)	Multidisciplinary Digital Publishing Institute (MDPI)	Switzerland	Q1	207	149	21	2009

No	Source	Publisher	Country	Quality	h-index	TC	NP	PY_start
5	Journal of cleaner production	Elsevier Ltd	United Kingdom	Q1	354	1241	18	1993
6	Environmental science and pollution research	Springer Science and Business Media Deutschland GmbH	German	Q1	212	395	17	1994
7	Energy	Elsevier Ltd	United Kingdom	Q1	274	893	14	1976
8	Resources policy	Elsevier Ltd	United Kingdom	Q1	138	442	14	1974
9	Applied energy	Elsevier B.V.	United Kingdom	Q1	323	586	11	1975
10	Renewable and sustainable energy reviews	Elsevier Ltd	United Kingdom	Q1	464	359	11	197

During 2005 and 2016, the exploration period, most of the mentioned journals have started to publish their research, with others soon to follow. This shows a clear interest from scholars in this field, slowly drawing in more attention. Taking up to 34% of the entire timeline, the journal “Energy policy” took the lead, further developing the research scene.

Starting from 2017 to 2024, the growth has only accelerated. The number of publications over the years has increased significantly in spite of taking only 26% of the entire timeline, the majority of the publications are in this period. This indicates the sustainable development and energy policies field has finally taken off as a main choice surrounding research topics. Notably, *Energies*, a journal which has demonstrated an exceptionally high research output within a single year (around 40 publications in 2020), has managed to take over as the journal with the most publications from Energy policy, which held the title for 15 years straight.

3.5. Analysis of top authors

Table 4. Top 10 author regarding citations and publications, 1992-2024

Most citations				Most publications			
Authors	No publication	No citation	PY start	Authors	No publication	No citation	PY start
Alola, Andrew Adewale	5	1173	2020.6	Bekun, Festus Victor	13	1023	2022.5
Bekun, Festus victor	13	1023	2022.5	Sinha, Avik	12	930	2022
Sinha, Avik	12	930	2022	Adebayo, Tomiwa Sunday	8	524	2023
Shahbaz, Muhammad	4	899	2021.25	Adebayo, Tomiwa Sunday	6	198	2022.5
Sarkodie, Samuel Asumadu	2	811	2019.5	Gyamfi, Bright Akwasi	6	179	2022.8
Balsalobre-Lorente, Daniel	3	780	2020.6	Alola, Andrew Adewale	5	1173	2020.6
Adebayo, Tomiwa Sunday	8	524	2023	Usman, Muhammad	5	273	2023.2
Doğan, Buhari	4	450	2022.5	Anwar, Ahsan	5	222	2022.8
Ghosh, Sudeshna	4	443	2023	Simsek, Yeliz	5	211	2019.8
Chu, Lan Khanh	3	442	2022.6	Urmee, Tania	5	211	2019.8

Table 4 shows that the co-author with the most publications (Bekun, Festus Victor) at 13 publications and 1023 citations, was different from the co-author that had the most citations (Alola, Andrew Adewale) at only 5 publications while achieving 1023 citations. This indicates the relevancy of Alola, Andrew Adewale’s works are to the general scholars of this topic. Another interesting note from the co-authorship Bekun, Festus Victor, despite having the most published, their work average at 2022.5, being one of the most recent compared to other co-authors, which can also explain the slightly less citations compared to Alola, Andrew Adewale. This trend also carries over to other co-authors, only 3 of the top 10

most publication co-authors in Table 4 are listed in the top 10 most cited co-authors. This includes Bekun, Festus Victor and Alola, Andrew Adewale as mentioned, and Sinha, Avik at 12 publications and 930 citations.

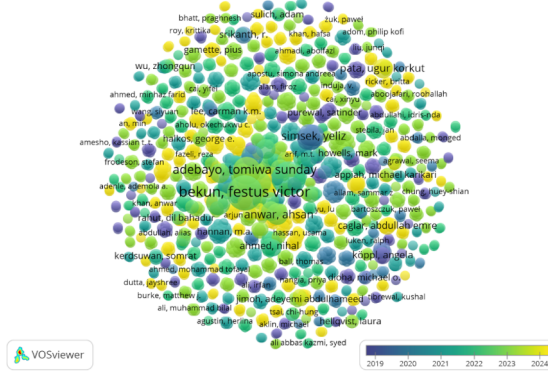


Fig. 4. Co-author mapping of energy policies and sustainable development between 1992 and 2024

Analyzing figure 4, out of the 1,727 authors in the dataset, only 125 published more than two papers. This number drops sharply to 36 for those with more than three publications, 19 for four, and just 10 authors with five or more. These figures show that while the field of energy policy and sustainable development has attracted wide interest, most scholars have only contributed occasionally, rather than establishing a consistent publishing presence.

Figure 4 displays the co-author network and highlights the timeline of contributions using a color gradient. Most nodes are shaded in dark blue to green, representing an average publication period between 2019 and 2021. More recent authors, shown in yellow, make up only about 30–40% of the graph. This suggests that although research on this topic remains active, there hasn't been a strong wave of new scholars entering the field in recent years.

The map also gives a good sense of how collaboration between scholars has taken shape in this field. Larger nodes from authors like “Adebayo, Tomiwa Sunday” and “Bekun, Festus Victor” are placed near the center, showing that they are not only among the most active authors, but have also collaborated with many others. The center of the network is densely packed, indicating repeated co-authorship among a small group of scholars. In contrast, the outer parts of the map are made up of smaller and more scattered nodes, likely representing one-time contributors or authors with fewer connections. The variety of names and how they're spread across the map suggest that researchers from different countries have taken part in the topic, even though many seem to work independently or in smaller groups. Overall, the co-author network shows consistent interest in the field, but with collaboration mostly happening within a limited circle of recurring contributors.

3.6. Analysis of influential publications

Table 5. Top 10 influential publications

No	Title	Author	PY	Journal	Total citation	TC per year
1	Dynamic impact of trade policy, economic growth, fertility rate, renewable and non-renewable energy consumption on ecological footprint in Europe	Alola A.A.; Bekun F.V.; Sarkodie S.A.	2019	Science of the Total Environment	620	103.3
2	Foreign Direct Investment–CO2 Emissions Nexus in Middle East and North African countries: Importance of Biomass Energy Consumption	Shahbaz M.; Balsalobre-Lorente D.; Sinha A.	2019	Journal of Cleaner Production	462	77

No	Title	Author	PY	Journal	Total citation	TC per year
3	Role of green finance in improving energy efficiency and renewable energy development	Rasoulinezhad E.; Taghizadeh-Hesary F.	2022	Energy Efficiency	370	123.3
4	Energy indicators for sustainable development	Vera I.; Langlois L.	2007	Energy	346	19.2
5	Green technological innovation, green finance, and financial development and their role in green total factor productivity: Empirical insights from China	Jiakui C.; Abbas J.; Najam H.; Liu J.; Abbas J.	2023	Journal of Cleaner Production	330	165
6	Renewable energy consumption in EU-28 countries: Policy toward pollution mitigation and economic sustainability	Saint Akadiri S.; Alola A.A.; Akadiri A.C.; Alola U.V.	2019	Energy Policy	279	46.5
7	Economic policy uncertainty (EPU) and firm carbon emissions: Evidence using a China provincial EPU index	Yu J.; Shi X.; Guo D.; Yang L.	2021	Energy Economics	272	90.6
8	How environmental taxes and carbon emissions are related in the G7 economies?	Doğan B.; Chu L.K.; Ghosh S.; Diep Truong H.H.; Balsalobre-Lorente D.	2022	Renewable Energy	269	89.6
9	The effect of financial development on renewable energy demand: The case of developing countries	Shahbaz M.; Topcu B.A.; Sargül S.S.; Vo X.V.	2021	Renewable Energy	239	59.75
10	The dynamic impact of biomass and natural resources on ecological footprint in BRICS economies: A quantile regression evidence	Awosusi A.A.; Adebayo T.S.; Altuntaş M.; Agyekum E.B.; Zawbaa H.M.; Kamel S.	2022	Energy Reports	217	72.3

As seen from Table 5, these top 10 influential publications signify the trend in research in each time period. Notably, “Dynamic impact of trade policy, economic growth, fertility rate, renewable and non-renewable energy consumption on ecological footprint in Europe (2019)” has garnered the most attention, with a total of 630 citations and an average of 103.3 per year. Similarly, 2 publications “Foreign direct Investment CO2 emissions nexus in Middle East and North African countries: Importance of biomass energy consumption (2019)” and “Role of green finance in improving energy efficiency and renewable energy development” at number 2 and 3 with 462 and 370 total citations respectively, all have themes relating to economy. This indicates a clear focus on the economic side for this research topic.

Furthermore, “Energy indicators for sustainable development (2007)”, the earliest publication for this list has set a foundation for this research, earning itself at top 4 with 346 citations. Delving more at top 3, “Role of green finance in improving energy efficiency and renewable energy development”, this was one of the most interested by scholars in the “green finance” topic as the citations number exceeds those with similar publication dates (2022,2023), signaling the growing importance of green finance and its role for new research as time progresses. This is also backed up by number 5 “Green technological innovation, green finance, and financial development and their role in green total factor productivity: Empirical insights from China”, a publish with a main emphasis on “green finance”, now at a more confined geographical area, China, has clearly shown the trend is continuing across continents.

Overall, from the lists of publications from Table 5, it is clear that policies in economy and finance, for a sustainable future has become the main focus for this topic. Not only about engineering or management, economy and finance has integrated into the path of sustainability, putting itself as a crucial step forward for any country.

3.7. Analysis of keywords

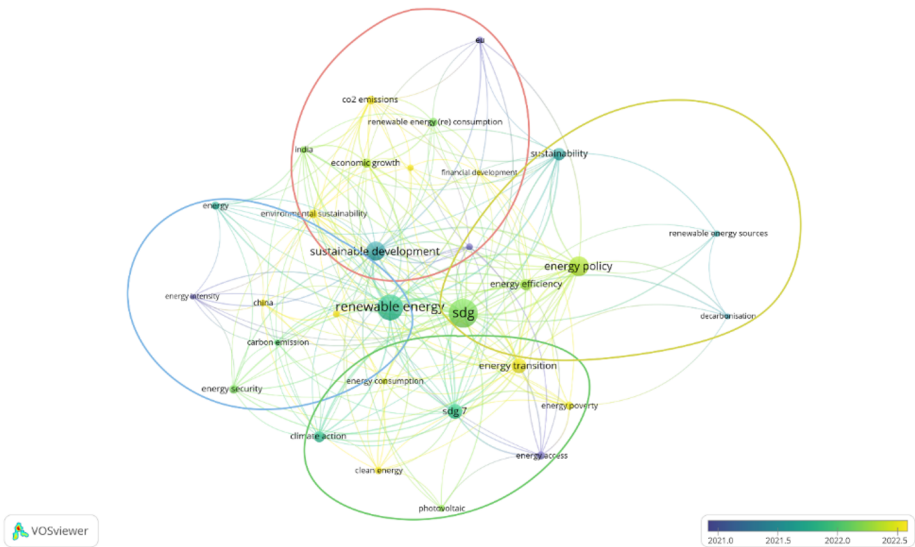


Fig. 6. Co-occurrence keyword in time period analysis, 1992-2024.

This figure shows that all author keywords have remained relevant throughout the years; the first article of this set was published in 1992, while the figure's earliest year is 2021. This indicates how many of the mentioned keywords have been revisited recently. Notably, keywords such as “clean energy”, “energy poverty”, “energy transition”, “environmental sustainability” ... especially “renewable energy”, “sdg”, “sustainable development”, despite showing up a lot in different documents throughout multiple periods, their color remains yellow, indicating that it has recently gotten a lot more attention, turning their average year up to 2022.5. The countries keywords that are shown in the figure also indicate when they start to research the topic. The EU was the first, having the darkest color (averaging at 2021), then followed by India (2022), and finally, most recently is China (2022.5). This could indicate the EU is slowly stepping off from the research, meanwhile, China will start to take the lead in researching, along with other newer topics such as “environmental sustainability”, “energy”.

A significant insight derived from this figure is the author keyword “co2 emission”, despite it has been the key to sustainability development from the beginning, the color of the node in this instance is in fact yellow (2022.6). This is probably due to the new, more recent policy about CO₂ credit, this encouraging a lot more scholars to dive deeper into researching co2 emissions and policies surrounding it, making the node appear brighter in color despite its relevance throughout. Similarly, terms that include “green” are also emerging such as “green energy” (2022.8) and “green finance” (2022.6) are both keywords that are only showing up recently. All three of these keywords mentioned are linked together, notifying a new term and new research starting to go back to an old topic “co2 emission”. Furthermore, dominating the lighter colored nodes are economy and finances related keywords: “economic growth” (2022.2), “financial development” (2023), “green finance” (2022.6), signifying is a shift from the usual technical-focused field into a more economical-focused field. This is a clear sign of how far our energy development has come and the importance of sustainability or “green” in this case is for various fields.

Table 6. Typical trends based on 31 keywords with at least nine occurrences

Cluster color	Name of cluster	Keyword (Occurrences) (Avg.Pub.Year) (Avg.Cited)	Total keywords
Red	Sustainability and Energy-Economy	Sustainable development (64) (2021.5) (20.6), economic growth (19) (2022.2) (94.8), co2 emissions (18) (2022.6) (70.7)	10

Cluster color	Name of cluster	Keyword (Occurrences) (Avg.Pub. Year) (Avg.Cited)	Total keywords
		Environmental sustainability (17) (2022.7) (41), renewable energy (re) consumption (17) (2022.1) (94.7), Sub – Sahara Africa (13) (2020.6) (25.1), eu (12) (2020.4) (37), India(12) (2022.1) (17.1), financial development (9) (2023) (72.4), green energy (10) (2022.8) (33.9)	
Green/ purple	Affordable and Clean Energy	Energy transition (44) (2022.4) (13.9), sdg 7 (43) (2021.8) (25.9), climate action (26) (2021.8) (10.6) Energy poverty (16) (2022.4) (16.9), energy access (15) (2020.8) (23.4) , clean energy (14) (2022.6) (18.4), photovoltaic (12) (2022.1) (25.9)	8
Blue	Global Energy and Environmental Issues	Renewable energy (108) (2021.8) (26.3), Energy security (18) (2022.1) (23.5), energy (16) (2021.6) (19.6), green finance (13) (2022.6) (103.3), China (12) (2022.5) (51.8), carbon emission (11) (2022) (95.6), energy intensity (9) (2020.7) (91.5)	7
Yellow	Sustainability and Policies	SDG (131) (2022.1) (23.3) , energy policy (67) (2022.2) (16.8) Sustainability (31) (2021.5) (20.7), Energy efficiency (28) (2022.2) (30.5), renewable energy source (11) (2021.5) (14.9), decarbonization (9) (2021.4) (23.8)	6

Sustainability and Energy-Economy (Red Cluster)

Sustainability and Energy-Economy cluster is dominated by “Sustainable development” (64) (2021.5) (20.6), taking up the majority of the cluster’s occurrence (64), significantly exceeding the occurrence of the second and third most occurred “economic growth” (19) (2022.2) (94.8), “CO₂ emissions” (18) (2022.6) (70.7). But, despite occurring the most, “Sustainable development” only have an averaging citing of 20.6, pale in comparison to the aforementioned keywords “economic growth” (94.8) and “co₂ emissions” (70.7). Similarly, “financial development” (9) (2023) (72.4) also supports this trend. With only 9 occurrences, it has 72.4 average citations. This proves the high number of occurrences does not correlate with reliability and shows how relevant research in economic and finance has become in energy.

Affordable and Clean Energy (Green/purple cluster)

The Affordable and Clean Energy cluster’s keywords are almost all referring to the 7th goal from the 17 different United Nation’s sustainable development goals “sdg 7” (43) (2021.8) (25.9). Keywords such as “Energy transition” (44) (2022.4) (13.9), “Energy poverty” (16) (2022.4) (16.9), “energy access” (15) (2020.8) (23.4), all underline the affordable aspect of the cluster. The articles mentioning these keywords all focused on how to make energy more accessible and affordable to a wider population—an essential step toward achieving SDG 7. For example, Koster et al. (2024) demonstrated how mapping solar potential with socio-economic data can help identify where solar investments would most benefit low-income communities(Koster et al., 2024). Additionally, not far behind in “clean energy”(14) occurrence amount, “photovoltaic” appeared 12 times. This indicate out of the various ways to make energy more accessible and affordable, solar energy is what this cluster focuses on.

Global Energy and Environmental Issues (Blue cluster)

The Global Energy and Environmental Issues cluster is dominated by “Renewable energy” (108)(2021.8) (26.3), making all the other keywords stand obsolete in comparison with the keywords standing right after “Energy security” (18) (2022.1) (23.5), “energy” (16) (2021.6) (19.6), “green finance” (13) (2022.6) (103.3), “China” (12) (2022.5) (51.8), “carbon emission” (11) (2022) (95.6), “energy intensity” (9) (2020.7) (91.5). But, seemingly in the same trend as the red cluster, the high occurrence amount does not correlate to a high number of citations. Seeing how “carbon emission” and “energy intensity” both have the lowest occurrence, yet the highest average citation rate in the cluster.

Sustainability and Policies (Yellow cluster)

The Sustainability and Policies cluster centers around “SDG” (131) (2022.1) (23.3), and “energy policy” (67) (2022.2) (16.8). This cluster includes various articles in discovering ways to achieve the goals set by the United Nations through improvement or changes in policies or proposing new ones. Under the 2 main keywords, “sustainability” stood far behind at 31 occurrences, along with the other keywords surrounding the same theme of ways to achieve said goals “Energy

efficiency” (28) (2022.2) (30.5), “renewable energy source” (11) (2021.5) (14.9), “decarbonization” (9) (2021.4) (23.8).

4. DISCUSSION

4.1 Discussion of RQ1: Emerging Trends

The co-author keyword analysis reveals major changes in the trends that scholars follow, similarly, old topics remerge in new contexts for energy and sustainability discourse. While terms such as “renewable energy” and “CO₂ emissions” have remained relevant throughout, recent papers have further paired energy policy and ways to achieve SDGs with financial and economic considerations, giving both fields a fresh take, showing how important both needed to be developed consecutively. For instance, Adebayo *et al* has highlighted the role that solar energy holds for innovations and economy towards a quality environment, while Bruke and Melgar emphasize the importance of energy sufficiency in the pursuit for Sustainable Development Goal 7 (Adebayo *et al.*, 2024; Burke & Melgar, 2022). Additionally, S. Voitko examine the relationship between economic development and CO₂ emissions, emphasizing the importance of integrating economic to the effort of sustaining a clean, low emission development (Voitko *et al.*, 2021).

These findings point to increasingly diversified research in energy, where economic, technological, and environmental themes are becoming more prominent and increasingly important. This trend is reflected in the increased focus on concepts such as green finance, carbon pricing, energy system digitalization, and energy efficiency across multiple articles, which traditionally far separated from the energy field (Alola *et al.*, 2019; Numan *et al.*, 2023). This diversification of focus not only reflects the evolution of research priorities but also enables a deepened understanding of energy systems - one that acknowledge the relationship between technological feasibility, financial viability, and environmental impact. Consequently, areas including economics, finance, data analytics are rapidly being incorporated into energy studies and policies. As such, methods which involve economic evaluation, cost of living assessment, and multi-criteria decision analysis (MCDA) have been adopted in addition to conventional technical development (Davidsdottir *et al.*, 2024). The objectives of sustainable development are closely linked with such scientific integration, especially when it comes to making sure that clean energy transitions are environmentally responsible, economically feasible, and socially acceptable (Patrizio *et al.*, 2020).

4.2 Discussion of RQ2: Economy & Sustainability

When considered together with the co-author keyword analysis, these findings give a clearer view of how current research surrounding energy and sustainability is shifting. As shown earlier, the most connected and frequently mentioned keywords - like “renewable energy”, “CO₂ emissions”, and “SDG” - highlight their continued importance across different clusters. The recent appearance of finance-related keywords such as “green finance”, “economic growth”, and “financial development” alongside the more traditional terms referring to technical marks a clear shift in direction in this period. This change, supported by both the connection strength in the science mapping from figure 6 and the average year of appearance, indicated by the colors of figure 6, shows that energy policy research is starting to lean more toward economic, financial, and policy-focused topics. It reflects a broader trend where discussions around energy are no longer just about technology, but are becoming more integrative, shaped by wider global sustainability goals (Ahmed *et al.*, 2022).

Building upon this, another clear pattern can be seen in how older, familiar keywords are starting to reappear in new research contexts. Keywords like “CO₂ emissions”, “renewable energy”, and “SDG” have long been central to energy and sustainability discussions, but their appearance in figure 6 - especially with average years clustering around 2022 - shows that these topics are gaining attention. This suggests that while these themes have remained relevant, they are now being revisited more frequently due to shifts in policy, finance, and global development goals. Furthermore, due to said policy changes and a growing focus toward finance-based solutions for sustainability from many governments, the term “CO₂ emissions”, which has been used regularly in earlier studies which scholars were focusing more onto technicality, is now often seen alongside “green finance”, suggesting that the discussion is moving toward market-based approaches like green bonds. Additionally, “CO₂ emissions”, which has long been a core topic in sustainability discussions, is now more frequently associated with market-based mechanisms such as carbon credits. One example is Brazil’s CBIOS program, where carbon emission reductions are quantified and traded as certificates, encouraging both environmental responsibility and financial participation in the decarbonization effort (Palazzi *et al.*, 2024). In a separate study, Rasoulnezhad and Taghizadeh-Hesary found that green bond issuance, used as an indicator of green finance, has a positive effect on promoting green energy use and lowering CO₂ emissions. Their results suggest that a 1% increase in green bonds is associated with roughly a 1% reduction in per capita emissions (Rasoulnezhad & Taghizadeh-Hesary, 2022). Likewise, “renewable energy” continues to play a central role in energy research, but now it’s more often discussed in relation to financial development, investment planning, and branching out to economic progressions. One study points out that economic efficiency in renewable energy projects is no longer assessed solely through financial returns, but instead through a broader approach that also takes into account social, environmental, legal, and technical factors, showing that financial frameworks are now an essential part of how renewable energy projects are planned and evaluated (Dębicka *et al.*, 2024). These links point to a shift in how scholars are framing their work, bringing older terms back into focus, but with new meanings that align more closely with today’s interdisciplinary and policy-driven approach to energy research.

Once combined, the results from both the keyword clusters and the timeline visualization offer a comprehensive understanding of how energy policy and sustainability research have changed over the years. Notably, in the 2020s, studies have increasingly emphasized the role of green finance, or “green bonds”, in helping to reduce CO₂ emissions, proving how economics, finance, and policy have taken a more prominent role in achieving SDGs (Ahmed et al., 2022). The four keyword clusters show that while familiar terms such as “renewable energy”, “SDGs” and “sustainable development” remain central to the discussion, while the surrounding research focus has evolved. In particular, the red and blue clusters indicate an increasing focus on financial and economic topics. Keywords such as “economic growth” “green finance” “financial development” and “CO₂ emissions” appear less frequently than the key sustainability terms, but they have a much higher average citation rate. This suggests that while these topics are not mentioned as frequently, articles focusing on them are making a greater impact. Figure 5 also demonstrates this, showing that these keywords - particularly “green finance” (2022.6), “financial development” (2023), and “economic growth” (2022.2) - appear in brighter colors, meaning they have only recently started to receive more attention. It is worth noting that while “CO₂ emissions” has had a steady presence in articles over the years, Figure 5 illustrates that it has a similarly vibrant node color to more recent terms such as “green finance” and “financial development”, suggesting that it has attracted increased attention in recent publications. This suggests that rather than declining in importance, “CO₂ emissions” is regaining prominence alongside scholars, signifying a resurgence of academic interest that may be influenced by recent legislative developments and sustainable development goals. Rather than being displaced, fundamental sustainability topics are now being revisited within the broader context of today’s changing research priorities. This change reflects a broader shift in the conversation - in which the economy has gone from a supporting role (measuring costs/returns) to a leading driver (green bonds, financial frameworks, carbon markets) in sustainable development.

4.3 Discussion of RQ3: Geopolitics & Policy

The results above indicate that nations exhibit differences in their research, implementation, and policy orientation due to varying geographical locations and political institutions. Therefore, this study posits that geopolitical factors significantly influence the strategic plans of nations, particularly in policymaking and the pursuit of sustainability. These differences in political, economic, and geographical landscapes shape a nation's access to resources and international cooperation, directly impacting its energy choices and environmental commitments (Zhao & Huang, 2024). Local factors, such as societal needs and socioeconomic conditions, play a crucial role in shaping effective and sustainable energy policies. Tailoring strategies to these local factors is essential for the success of these policies (Elkhatat & Al-Muhtaseb, 2024). Nations possessing strategic locations and stable economies, especially those with control over resources, often have a greater influence on the international stage (Yu & Wang, 2023). This influence is evident in the energy and sustainability policies of major economies like China, the European Union, and India, where distinct geopolitical circumstances exert strong influence, leading to differentiated policy making approaches towards a green and economically sound future.

Geopolitics plays a potent role in shaping the energy policies and sustainable development plans of major economies such as China, the European Union, and India, resulting in distinct strategic policies in pursuit of a green economy. China's energy policy is significantly intertwined with its geopolitical objectives, particularly concerning energy security, given its substantial reliance on external energy sources and escalating geopolitical competition (Zhao & Huang, 2024). Indeed, as indicated by research findings in Table 6 and Figure 5, there is a strong association between the keywords “energy security” and “renewable energy” with “China.” Furthermore, data presented in Figure 3 show China's large volume of scientific publications and dense cooperation network with other countries. The period with the highest number of scientific publications also coincides with the period of related keywords, as can be observed in Table 5 and Table 6. This suggests that Chinese policymakers are focusing on energy security goals and the nation's transition to sustainable energy (Huang et al., 2025).

Turning to another key region, in the context of the European Union (EU), energy challenges, particularly those arising from the conflict in Ukraine, have further highlighted the importance of energy security alongside climate objectives. The EU seeks to enhance its energy autonomy by reducing dependence on potentially unstable energy suppliers, while simultaneously accelerating the transition to renewable energy sources (Atstāja, 2025). This urgent geopolitical imperative is driving the EU to strengthen its clean energy market and diversify its external energy partnerships (Proedrou, 2023). As a pioneering region in developing the concept of a sustainable economy, member states have collaboratively established appropriate and comprehensive policy frameworks in stages, aiming to ensure regulatory transparency for investors and effectiveness for each member state. This lays the groundwork for the transition to a low-carbon economic model and the creation of a modern, sustainable energy system for the European Union bloc (Brodny & Tutak, 2023)(Brdulak et al., 2020).

Similarly, in the case of India, a major energy-consuming nation, with its urban population projected to increase from 31.6% to 57.7% by 2050, the country faces significant environmental challenges, energy security concerns, meeting consumption demands and reducing carbon emissions (Yenneti et al., 2019). The Indian government has also acknowledged the importance of harnessing clean, green energy resources such as wind, solar, bioenergy, and small hydropower. Despite significant potential in clean energy, current trends indicate that these resources remain largely untapped (Dubey et al., 2023). Facing these challenges and recognizing the opportunities from clean energy, India is

pursuing a multi-pronged strategy, integrating renewable energy transition and sustainable development goals into national programs such as poverty reduction, digital connectivity, healthcare improvement, infrastructure development, and educational reform (Melethil et al., 2024). However, India's commitment to meeting a significant portion of its energy needs from renewable sources by 2030 demonstrates its strategic approach to balancing energy demand, environmental sustainability, economic development, and geopolitical realities (Melethil et al., 2024). A key finding of the research is that both EU member states and India demonstrate a common approach, focusing on sustainable development and economic growth while addressing carbon emissions.

The economic, institutional, and especially geopolitical contexts – which shape overall development policy – create differences in the pathways, priorities, and progress of each nation towards achieving the Sustainable Development Goals (SDGs). Despite global progress, a significant gap persists in policies and SDG achievements between developed and developing or less developed countries. In particular, less developed countries, especially in Sub-Saharan Africa and South Asia, face severe difficulties, even struggling to implement and monitor SDGs, as geopolitical challenges hinder their long-term development policies (Cheng et al., 2021). Therefore, a core requirement is that policies must be formulated based on careful consideration of the specific local factors at various levels, including environmental, social, economic, and cultural aspects. Furthermore, policies need to highlight the core nexus between energy, society, and the environment. International cooperation must play a guiding role in energy policy, promoting the sharing of experiences and knowledge to support equitable development among nations towards achieving the established global sustainable development goals (Eras-Almeida & Egidio-Aguilera, 2020).

Finally, this study also points out that the discussion on the relationship between energy and geopolitics is not new, but the majority of prior scholarships have predominantly focused on fossil fuels, specifically oil and gas, in discourses concerning energy security and geopolitics. Conversely, experts and research pertaining to clean and renewable energy have largely concentrated on the development and market proliferation of novel technologies, without extensively investigating the energy security and geopolitical dimensions inherent to renewable energy sources (Vakulchuk et al., 2020). Energy security, resource competition, technological innovation, and international commitments are all key factors in shaping how global nations, including China, India, and the EU, respond to the changing world landscape while endeavoring to achieve their sustainable development objectives. Consequently, in the context of increasing and complex geopolitical challenges and international confrontations, policymakers need a comprehensive perspective and close collaboration to formulate a common plan. This plan can only be effective with the participation of the entire society and all relevant stakeholders (Borge-Diez, 2022).

5. CONCLUSION

Over the past three decades, research on energy policies and sustainable development has steadily grown, with a noticeable rise in volume after the Sustainable Development Goals were introduced in 2015, aiming for completion by 2030. Through co-author and keyword analyses, this paper has shown how the direction of research has shifted over time. What used to focus mostly on technical aspects has now moved toward a more interdisciplinary approach, with financial and economic considerations becoming a major driving force.

The co-author keyword mapping reflects this shift clearly. Older keywords like “renewable energy” and “CO₂ emissions” still appear frequently, but they're now part of different conversations. Newer keywords such as “green finance”, “financial development”, and “economic growth” don't show up as often, but they tend to be linked to more highly cited studies - suggesting they're shaping some of the more impactful work in the field. Figure 6 also supports this, where the bright colors of these finance-related terms—alongside long-standing ones like “CO₂ emissions” - show how older topics are being revisited through new lenses, with economic relevance pushing them back into focus.

When looking at authorship, most researchers only contributed once or twice, while a smaller group continued publishing over time. A few names form the core of the network, especially between 2019 and 2021, showing strong collaboration among recurring contributors. While the research comes from all over the world, new authors have joined gradually rather than all at once, pointing to stable but slow growth. More recently, countries like China and India have become more involved, suggesting that the leadership in this research space may be shifting toward emerging economies.

Looking ahead, future studies should place greater focus on the role of economy and finance in shaping clean energy transitions - particularly in developing countries, where affordability, access, and investment risks remain key challenges. As shown in the recent emergence of keywords such as “green finance” and “financial development”, these factors are not just supporting elements but now act as central forces in both research and implementation. Strengthening these areas of study could provide valuable insights for decision-makers in the Global South, where the gap between sustainability goals and practical progress remains wide. The gradual transition of global energy leadership, highlighted by the increasing contributions from China, India, and other emerging economies, necessitates research that examines clean energy technologies alongside financial mechanisms, policy instruments, and regional investment strategies. Incorporating these elements will be essential for guaranteeing that the clean energy transition is economically feasible and geopolitically inclusive, particularly as emerging nations strive to comply with long-term environmental goals while addressing local growth requirements.

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