



Global Scholars' Interest In Energy Demand And Sustainable Development Goals: A Bibliometric Analysis From The Scopus Database For The Period 1997 To 2024

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Energy demand is always present in each country's development policies. In the context of sustainable development, the approach to energy demand also needs to be consistent with sustainable development goals. The purpose of this study is to investigate the interest of scholars in this topic, based on their research findings from the Scopus database. The study uses the bibliometric analysis method for 224 articles and conference papers found in the Scopus database from 1997 to the end of June 2024. The results show that this topic has been of particular interest from 2018 to present. The most influential authors, sources, documents, and countries are explored. The co-authorship analysis reveals the research collaboration network on energy demand that aligns with sustainable development goals, while the co-word analysis pinpoints the interests of scholars over time. VOSviewer and the bibliometrix R-package tools support the data processing.

Research purpose:

The purpose of this study is to investigate the interest of scholars in this topic, based on their research findings from the Scopus database in the following aspects: the number of publications over time, the key countries, the main authors.

Research motivation:

This study, driven by the pressing need for sustainable energy solutions to power development across sectors while mitigating environmental impacts, aims to provide a comprehensive overview of research on energy demand and sustainable development goals through bibliometric analysis, bridging existing gaps and inspiring future research directions.

Research design, approach, and method:

The study uses the bibliometric analysis method for 224 articles and conference papers found in the Scopus database from 1997 to the end of June 2024. VOSviewer and the bibliometrix R-package tools support the data processing..

Main findings:

The results show that this topic has been of particular interest from 2018 to present. The most influential authors, sources, documents, and countries are explored. The co-authorship analysis reveals the research collaboration network on energy demand that aligns with sustainable development goals, while the co-word analysis pinpoints the interests of scholars over time.

Practical/managerial implications:

This study offers actionable insights for policymakers, energy corporations, and academics by delineating research trends, deficiencies, and promising domains in energy demand and sustainable development objectives. It underscores prospects for new solutions, efficient policies, and collaborations to advance sustainable energy practices and attain long-term sustainability objectives.

Keywords: Energy demand, Sustainable development goals, SDG, Energy policy, Bibliometric

1. INTRODUCTION

The demand for energy is constantly highlighted throughout the early phases of development in all sectors (Akikur et al. 2014) (Baah et al. 2024; Luty et al. 2023; Maduabuchi and Okoli 2024; Samatar et al. 2024). Indeed, no industry runs without energy. Energy is critical to the development of production, healthcare, education, cultural training, and society. As a result, the impact will be seen directly in the economy, finance, and monetary systems. In addition to meeting energy demands, there is a focus on sustainable development. These two subjects are inextricably linked, aiming for a world that uses energy efficiently, effectively, and sustainably. The focus on energy efficiency in present times has led us to select the topic of "Energy Demand & SDGs" for our research (Feng et al. 2023).

We calculated the scope of 1997 to the present using data from 234 articles extracted from the reliable Scopus database.

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Following the study procedure, it became clear that the number of publications was divided into two distinct phases: before and after 2016, indicating two opposing tendencies. While publications published before 2016 accounted for less than 2% or 1.78%, research published after 2016 surged considerably, accounting for 98.22% of the total 233 articles. This clearly illustrates the authors' growing interest and focus on the topic of energy consumption in the context of sustainable development.

Since 1997, authors have studied energy demand in connection with familiar issues and fields such as population growth, the oil and gas industry (Sykes, Depraz, and Buckley 2008), and nuclear energy (Lewis 2008). From 2015 to after 2016, following the introduction of the 17 United Nations Sustainable Development Goals, more research emerged, with topics becoming increasingly diverse and in-depth. Articles on this subject appeared more frequently, and studies on goal programming models (Jayaraman et al. 2017) or research on carbon footprints as a substitute for biomass energy (Okoko et al. 2017) were among the ideas proposed during this period. The focus on sustainable development goals in residential cooling needs (Mastrucci et al. 2019) and the construction sector (Wall and Hofstadler 2019) shows that sustainability goals must be applied across all aspects of society. Promoting a low-carbon urban development (Ali et al. 2019), accessing clean technology, energy, finance, and food (Hishan et al. 2019) were also prominent topics. In addition to theoretical and comprehensive studies, authors actively applied many models or quantitative methods to produce highly convincing results (Arnz and Krumm 2023; Modibbo, Ali, and Ahmed 2021; Nyeche and Diemuodeke 2020). Investigations into the impacts of using energy access scenarios in specific regions (Dioha and Emodi 2019) and research on balancing clean water with climate change mitigation (Parkinson et al. 2019) are trends that have garnered much attention from researchers.

Before the global outbreak of COVID-19, more studies were published. Models continued to gain attention, such as the SWOT model (Madurai Elavarasan et al. 2020), energy transition models (Taghizadeh-Hesary and Rasoulnejad 2020) or modeling project implementation in agriculture and crop production (Makai, Chowdhury, and Popoola 2020). In 2021, during the sensitive period of the pandemic, articles highlighted the pandemic's impact on sustainable development goals (Yoshino, Taghizadeh-Hesary, and Otsuka 2021). Both fossil fuel energy (Islam et al. 2021) and renewable energy (Li et al. 2021; Medam, Kavitha, and Chandrashekar 2021; Shahbaz et al. 2021) were subjects of interest and were included in research topics.

After this period, from 2022 to the present, as the economy gradually recovers from the heavy impacts and losses caused by the pandemic, articles have consistently emphasized and prioritized sustainable development goals (Schislyaeva and Saychenko 2022; Yang et al. 2022; Yu et al. 2022). Authors have outlined research objectives focused on reducing carbon emissions (Wong et al. 2022), lowering environmental pollution (Wang et al. 2023) and promoting clean energy consumption (Arshed 2023). The number of articles in 2022 surged, reflecting society's response to the challenges posed by the pandemic. As a result, more ideas, solutions, and models were proposed to address ongoing issues.

This trend continues to be developed and sustained in the following years, aiming for sustainable development with a focus on the green hydrogen economy. Various positive trends are proposed to promote the green economy, enhance sustainability, and ensure environmental safety as well as energy security (Luty et al. 2023). Strategies are even put forward to eradicate poverty and reduce environmental pressure (Liu et al. 2023). The authors fully utilize technological advancements to research and propose very modern solutions, suited to the digital technology era (Ajieh et al. 2023; Naranjo et al. 2023). Building on previous research, studies in 2024 are further developed, resolving the remaining issues of older research. Models are compared to find the most effective solutions for energy demand forecasting (Serrano et al. 2024). There is also a combination of science and human awareness training to enable intelligent and efficient energy use (Cabeza et al. 2024). In-depth exploration of algorithms (Xu and Wang 2024), comprehensive evaluation of anaerobic digestion processes (Dhull et al. 2024), performance assessment (Alma'asfa et al. 2024) and spatial evaluation (Ryali et al. 2024) all contribute towards a sustainable society. Matlab is also used in solar energy research (Ryali et al. 2024). India, China, the UK, and several countries in Southwest Asia are selected as the primary research subjects (Alma'asfa et al. 2024; Mukherjee et al. 2024; Shivanna and Rangappa 2024; Zhong, Ali, and Zhang 2024).

Some scholars point up limitations in addition to positive, contemporary, and progressive developments. These open questions are brought up for discussion. What impact will too stringent and tight enforcement of environmental policy mechanisms (EPS) have on the demand for renewable energy consumption (REC)? Can the relationship between the global economy and REC be influenced and moderated by EPS (Athari 2024)? By highlighting these drawbacks, the author will be better able to resolve the conflict between renewable energy and the global economy. Alternatively, resolving urgent, significant problems endangering energy sources will lay the groundwork for developing a sustainable energy system (Sedaoui 2023). Using a more representative example for the G-7 and E-7 countries, which are leading nations with a variety and plenty of export items, another specific and macro-level feature is examining the varied effects of exports on the consumption of renewable energy (Shahzad et al. 2021). What about the need for energy use in areas without extensive electrical networks? There may be a lot of surprises in this new field of study (Pandyaswargo et al. 2020).

In the scope of research from 1997 to 2024, with 224 documents on energy and sustainable development, there has been a

significant upward trend. Regarding the scope of the study, most of the influential research so far has focused on countries like the United Kingdom, China, Turkey, and the Netherlands, which have relatively developed economies.

It is observed that no research has been conducted to provide a comprehensive picture of issues related to energy demand and sustainable development. Therefore, this study aims to fill that gap. Bibliometric analysis is used to provide an overview of the research topic, including keywords, major themes, and the interests of authors in certain countries or key topics. Specifically, renewable energy (Gudlaugsson et al. 2023), green finance (Zhong et al. 2024), sustainable development (Luty et al. 2023), energy demand (Serrano et al. 2024). Additionally, bibliometric analysis helps scholars identify existing gaps and propose new ideas for the future.

Specifically, the study aims to address the following research questions (RQs):

RQ1: Research productivity on energy demand and sustainable development goals.

RQ2: The total number and geographical distribution of publications on energy demand and sustainable development goals

RQ3: The most important sources of information (journals, books, book series, or conferences), authors, research groups, and publications related to energy demand and sustainable development

RQ4: The most important themes in the literature on energy demand and sustainable development goals

By answering these four questions, readers will notice some shortcomings and gaps, as well as new ideas and directions for relevant and innovative research in this field.

2. METHODOLOGY

Bibliometric analysis can reveal research patterns and anticipate future directions in several subjects. Bibliometric studies can indicate scientific discipline evolution, significant works and authors, and rising areas of interest by evaluating publishing statistics, citation patterns, and collaboration networks. Many fields use this strategy to understand existing research and guide future studies. Bibliometrics examines the relationships between scientific publications based on data extracted from databases such as Web of Science, Scopus, or other databases (Zupic and Čater 2015).

Bibliometric analysis enables the identification of contemporary trends in specific study domains by examining publication volume and growth. For instance, a study on green innovation and sustainable development indicates a notable increase in publications, with China and the USA at the forefront of productivity (Le, Pham, and Tran 2022). Bibliometric studies can forecast future research trajectories by examining citation networks and keyword trends. Bibliometric analysis also reveals deficiencies in the literature, presenting opportunities for novel research. Bibliometric analysis utilizes many tools and approaches, such as VOSviewer and the bibliometrix R-package, to enable the display of networks pertaining to authors, countries, and keywords (Ha et al. 2022). These instruments help to map a discipline's intellectual framework and identify seminal publications and writers.

Bibliometric analysis generally comprises multiple stages, such as formulating research questions, choosing databases, refining data, and employing suitable analytical techniques. These procedures adhere to the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) recommendations (Figure 1).

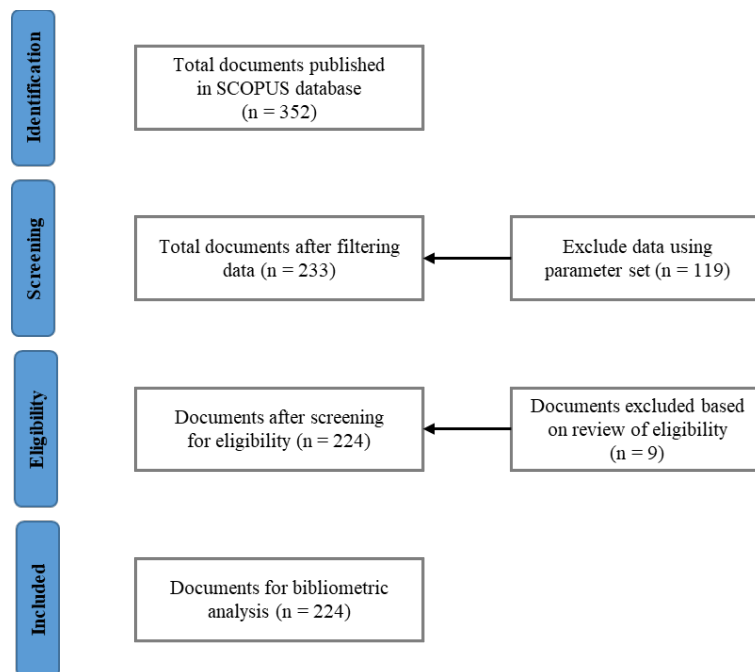


Figure 1: PRISMA Guide to data searching

The topic of the research paper is “energy demand in line with sustainable development goals. Therefore, the keywords chosen for simultaneous data searching are “energy demand” and “sustainable development goals”. Variants of keyword “sustainable development goals” (SDGs) are also used to avoid omission. Publications, including journal articles and conference papers, are limited to English. Data extraction was performed in July 2024. No limit was set on the search. However, regarding the latest publications, we allowed Scopus to search until the end of June 2024.

Specifically, the command to query data on the Scopus database is as follows:

TITLE-ABS-KEY("ENERGY DEMAND" AND ("SUSTAINABLE DEVELOPMENT GOALS" OR SDG)) AND (LIMIT-TO (DOCTYPE,"AR") OR LIMIT-TO (DOCTYPE,"CP")) AND (LIMIT-TO (SUBJAREA,"ENER") OR LIMIT-TO (SUBJAREA,"ENVI") OR LIMIT-TO (SUBJAREA,"SOCI") OR LIMIT-TO (SUBJAREA,"ENGI") OR LIMIT-TO (SUBJAREA,"ECON"))

The Scopus database contained 233 scientific publications, including articles in journals and conferences. The authors also checked 233 publications to eliminate those that were not suitable for the research objectives, resulting in 9 publications being eliminated; 224 articles and conferences were retained for further analysis.

3. RESULTS

3.1 Number of publications

Based on the analysis of the data file, we present the results and findings regarding energy demand and sustainable development, in line with the three initial research questions.

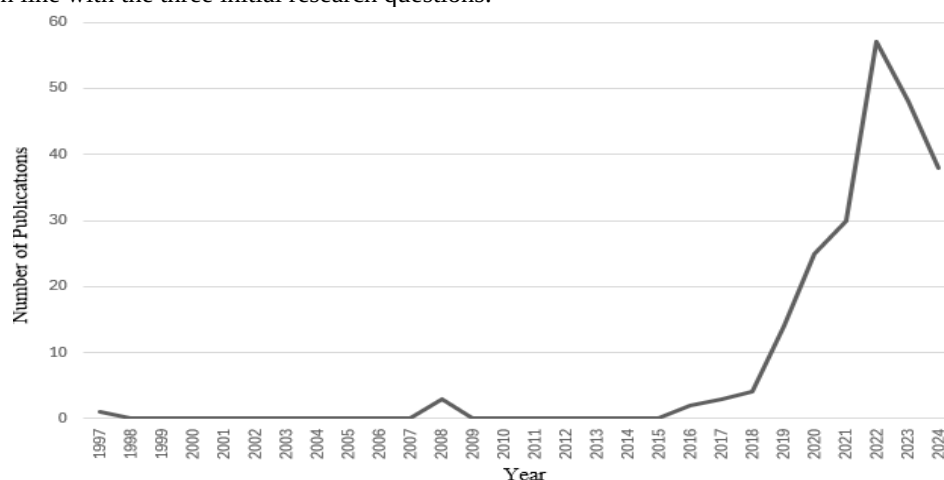


Figure 2: Expansion trend of energy demand and SDGs in Scopus between 1997-2024

In this section, studies on energy demand and the Sustainable Development Goals are analyzed through three key dimensions: total volume, growth trajectory, and geographical distribution. As mentioned earlier, we collected a dataset of 224 documents for the final analysis, with 100% of the materials being in the form of articles.

Figure 2 illustrates the progression of publications related to energy demand and the Sustainable Development Goals, beginning with the first study published in 1997 and concluding with the final research conducted in 2024. A longitudinal analysis indicates that the knowledge base on this topic can be divided into two main phases: the period before the 17 United Nations Sustainable Development Goals were introduced and the period after.

- **Phase 1997-2016:** Spanning from 1997 to 2016, this initial phase saw only 3 publications. It seems that during this period, energy demand had not yet garnered significant attention, likely because people were still confident in the availability of existing energy reserves. Only after the 17 United Nations Sustainable Development Goals were introduced did research publications on energy demand and the pursuit of sustainable development begin to emerge. The average annual publication rate was approximately 9.03 documents, but the total number of articles during this phase was still below the average rate.
- **Phase 2016-2024:** This phase witnessed an explosion in the number of publications, with 221 documents. This phase accounted for the remaining percentage, with a growing focus on topics such as energy demand, clean energy, green finance, and development goals. There were numerous topics to explore and research during this period. The year with the highest number of publications in this phase was 2022, with 57 documents published.

3.2 Analysis of country scientific production

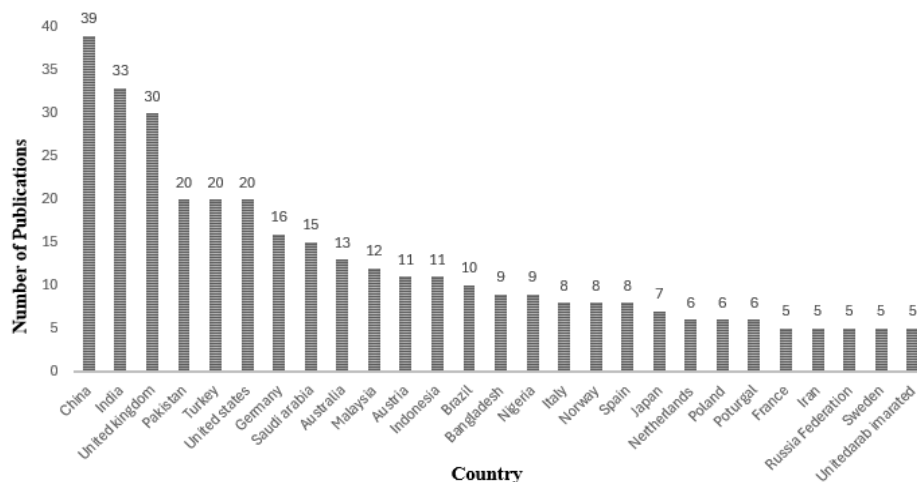


Figure 3: Geographical distribution of energy demand and SDGs literature in scopus between 1997-2024

As Figure 3, the number of publications surged after 2016. Based on geographical distribution, a total of 75 countries contributed research on the topic of energy demand and sustainable development goals. However, this concentration was not evenly distributed across all 75 countries. Developed countries and those with large populations were emphasized, as evidenced by the number of publications by scholars from China and India, with 39 and 33 articles, respectively. Developed countries and European nations consistently led in the number of publications. Additionally, countries in West Asia and South Asia, which possess abundant fuel reserves, were also represented in the publications. There were 24 countries that published only one article during the 2016-2024 period.

3.3 Analysis of important authors

From the data results, it indicates that there is a relatively large number of authors, 924 in total, but 891 of them (about 96.43%) have only 1 publication. Authors with more than 1 publication (up to 3 publications) include 20 authors (2.16%) with 2 publications and only 7 authors (0.07%) with 3 publications. To identify the most influential scholars, h-index, number of publications, and total citations are used.

Table 1: Authors' scientific production and performance

Authors with the most citations	Authors with the most publications
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Authors	No. Citation	No. Publications	PY_Start	Authors	No. Citation	No. Publications	PY_Start
Riahi, Keywan	968	3	2016	Shahzad, Umer	449	5	2021
Rao, Narasimha D.	917	3	2018	Santika, Wayan G.	236	5	2018
Shahzad, Umer	449	5	2021	Urmee, Tania	236	5	2018
Doğan, Buhari	416	4	2021	Zaman, Khalid	162	5	2019
Santika, Wayan G.	236	5	2018	Doğan, Buhari	416	4	2021
Urmee, Tania	236	5	2018	Riahi, Keywan	968	3	2016
Shafiullah, G.M.	180	3	2018	Rao, Narasimha D.	917	3	2018
Zaman, Khalid	162	5	2019	Shafiullah, G.M.	180	3	2018
Simsek, Yeliz	98	3	2020	Simsek, Yeliz	98	3	2020
Nassani, Abdelmohsen A.	78	3	2020	Nassani, Abdelmohsen A.	78	3	2020

Table 1 shows the authors with the highest number of citations and publications. Based on Table 2, the key findings are: The authors with the highest number of citations and publications are Keywan Riahi and Narasimha D. Rao. Keywan Riahi has received 968 citations from 3 publications, while Narasimha D. Rao, with the same number of publications, has received 917 citations. However, the results show that authors with a greater number of publications do not necessarily have the highest number of citations. Specifically, Shahzad Umer, with 5 publications, has 449 citations.

3.4 Analysis of important journals

Table 3 illustrates the top 10 journals with the greatest influence on energy demand issues and sustainable development goals. It can be observed that over 90% of the journals are in Q1. As of now, the journal with the highest number of publications is Renewable Energy, with 336 articles, indicating a high publication frequency and widespread attention. Journals with relatively fewer articles, such as Sustainable Cities and Society (60) and International Journal of Green Energy (83), may reflect a stronger focus on quality over quantity.

Diving deeper into the analysis, it is clear that the starting point for these leading journals is quite recent within the scope of the research. Although Nature Energy has the highest citation count, reaching 769 with just 1 publication, its h-index stands at 229 — still reflecting long-term influence, but not surpassing Renewable and Sustainable Energy Reviews.

From the results obtained, we can conclude that the number of publications plays an important role in determining the citation count. Specifically, International Journal of Green Energy has 83 citations with just 1 article, while Environmental Science and Pollution Research has 178 citations from 12 publications, averaging 14.8 citations per article. These results confirm that publishing more does not necessarily guarantee the quality of the articles. The credibility of a journal depends on various factors, as illustrated in Table 3.

Table 2: Top 10 Active Journals Published energy demand and SDGs in Literature, 1997–2024

No	Source	Publisher	Country	Quartile	h-index	NP	TC	PY_start
1	Nature energy	Nature Publishing Group	United Kingdom	Q1	229	1	769	2018
2	Renewable energy	Elsevier Ltd	United	Q1	35	8	336	2021

			Kingdom					
3	Renewable and sustainable energy reviews	Elsevier Ltd	United Kingdom	Q1	421	4	310	2020
4	Sustainable development	John Wiley and Sons Ltd	United Kingdom	Q2	91	3	284	2019
5	Resources policy	Elsevier Ltd	United Kingdom	Q1	114	4	247	2020
6	Environmental research letters	Institute of Physics Publishing	United Kingdom	Q1	183	4	218	2016
7	Environmental science and pollution research	Springer	Germany	Q1	179	12	178	2022
8	Energy and buildings	Elsevier Ltd	Netherlands	Q1	232	2	134	2019
9	International journal of green energy	Bellwether Publishing, Ltd.	United States	Q2	54	1	83	2021
10	Sustainable cities and society	Elsevier Ltd	Netherlands	Q1	120	2	60	2019

3.5 Analysis of important articles

We employ citation count and annual citation rate measures to assess the articles' impact. The results demonstrate that we ranked the top 20 most cited papers, as shown in Table 3. However, only a few names with significant total citation counts from Table 1 appear in Table 3.

The findings suggest that not all highly cited publications are written by scholars with high overall citation metrics, as indicated in Table 1. For example, Riahi, Keywan, and Rao, Narasimha D. are at the top of Table 1, but do not appear in Table 3. Meanwhile, Shahzad is fourth in Table 1 and third in Table 4. Regarding the influence of research articles, it is uncertain if later-published articles will obtain more citations. This is determined by the writers' research topic. The earliest published and most cited article is "A low energy demand scenario for meeting the 1.5 °c target and sustainable development goals without negative emission technologies" by Glubler, which receives 128.17 citations each year. This is substantially greater than the article "The contradiction of the sustainable development goals: Growth versus ecology on a finite planet" by Hickel, which has been mentioned 54.8 times per year since its publication in 2019. From 1997 to 2024, the 20 most cited publications were published in a variety of renowned journals focusing on energy consumption and sustainable development goals.

Table 3: Top 20 publications in Energy Demand & SDGs 1997-2024

No	Title	PY_Start	Journal	Total Citations
1	A low energy demand scenario for meeting the 1.5 °c target and sustainable development goals without negative emission technologies	2018	Nature Energy	769
2	The contradiction of the sustainable development goals: Growth versus ecology on a finite planet	2019	Sustainable Development	274
3	The role of environmental technology for energy demand and energy efficiency: Evidence from OECD countries	2022	Renewable and Sustainable Energy Reviews	254
4	The effect of financial development on renewable energy demand: The case of developing countries	2021	Renewable Energy	213
5	Covid-19 and Optimal Portfolio Selection for Investment in Sustainable Development Goals	2021	Finance Research Letters	164

6	2°C and SDGs: United they stand, divided they fall?	2016	Environmental Research Letters	152
7	SWOT analysis: A framework for comprehensive evaluation of drivers and barriers for renewable energy development in significant countries	2020	Energy Reports	140
8	Implications of the Sustainable Development Goals on national energy demand: The case of Indonesia	2019	Energy	130
9	Renewable energy resources investment and green finance: Evidence from China	2021	Resources Policy	124
10	Modelling and optimisation of a hybrid PV-wind turbine-pumped hydro storage energy system for mini-grid application in coastline communities	2020	Journal of Cleaner Production	118
11	Improving the SDG energy poverty targets: Residential cooling needs in the Global South	2019	Energy and Buildings	101
12	Role of economic complexity to induce renewable energy: contextual evidence from G7 and E7 countries	2021	International Journal of Green Energy	83
13	Role of economic complexity to induce renewable energy: contextual evidence from G7 and E7 countries	2021	Renewable Energy	71
14	Renewable energy resources and sustainable development goals: Evidence based on green finance, clean energy and environmentally friendly investment	2023	Resources Policy	68
15	Access to clean technologies, energy, finance, and food: environmental sustainability agenda and its implications on Sub-Saharan African countries	2019	Environmental Science and Pollution Research	63
16	The benefits of geospatial planning in energy access - A case study on Ethiopia	2016	Applied Geography	63
17	Urban environment dynamics and low carbon society: Multi-criteria decision analysis modeling for policy makers	2019	Sustainable Cities and Society	60
18	A Weighted Goal Programming model for planning sustainable development applied to Gulf Cooperation Council Countries	2017	Applied Energy	60
19	Critical review on technological advancements for effective waste management of municipal solid waste “ Updates and way forward: Advancements in Municipal Solid Waste Management	2021	Environmental Technology and Innovation	53
20	A snapshot of coal-fired power generation in Bangladesh: A demand“supply outlook	2021	Natural Resources Forum	52

3.6 Collaborative research analysis

Figure 4 shows that countries represented by the majority of light nodes have recently been researching and concerning about the topic of energy demand and SDGs, especially countries in Asia such as: China, India, Pakistan... In the Southeast Asian region, Thai Lan represented by a small light node just begun to show interest in this topic. Meanwhile, also in the southeast Asian region, Indonesia has been researching this topic for a longer time. Jordan is represented by a small dark node, which is the first country to research the energy sector but is still not grow and has not many published articles. Developed countries such as the United State, Austria and Canada have been paticipating in the energy and sustainable development community for a long time. Although Countries such as China, India, etc., have only recently joined the research, they have thick connections between the nodes in this country and other countries, showing a significant number of co-authored publications.

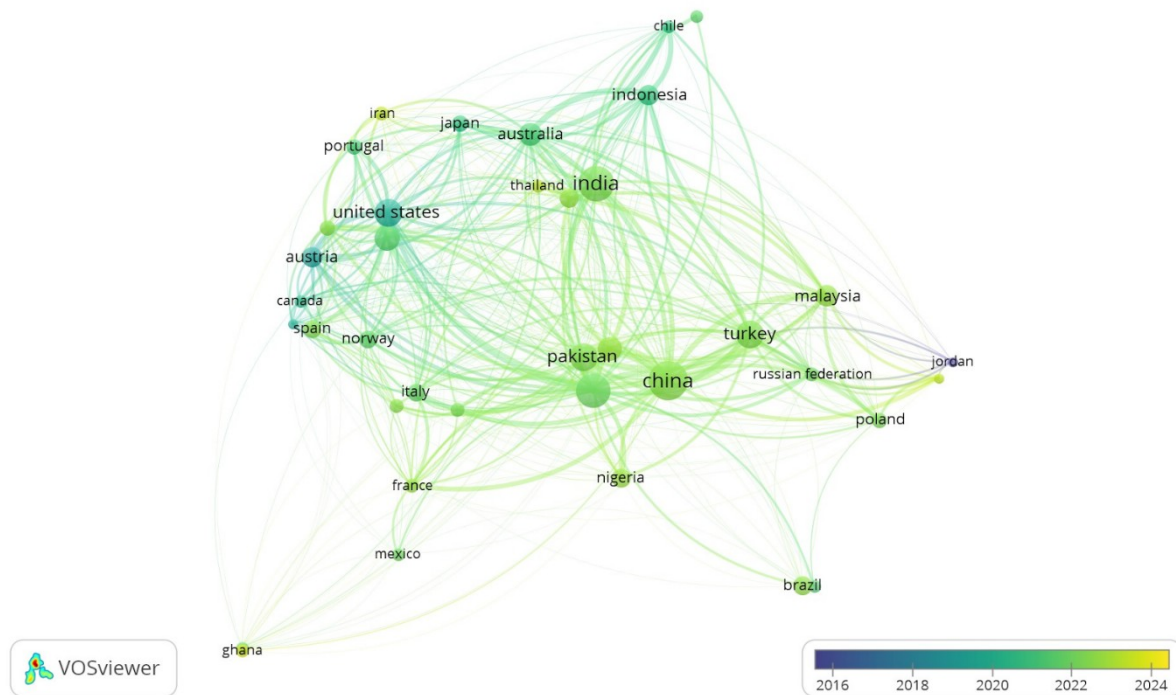


Figure 4: Co-author collaboration network by country from energy demand and sustainable development goals literature in Scopus between 1997-2024.

Note: Science mapping showed a collaboration network of 75 countries with at least three published documents in a period of time between 1997 – 2024.

3.7 Analysis of co-author

The network in Figure 5 represent 924 authors. Among them, 4 authors have 5 articles, and none of the authors have 5 or more works. There are 33 authors with 2 works and 13 authors with 3 works.. Different research groups on energy demand and SDGs over time were shown figure 5. Each circle represents an author. The size of the node reflect the number of publications on energy demand and SDGs of respective Figure. On the other hand, based on the color of nodes, it could be determined experience of the respective Figure in energy demand and SDGs study:

The purple colour indicates that the respective author had the first publication on energy demand and SDGs prior to 2017. The yellow colour indicates that respective author joined the studies of energy demand and SDGs in recent year since 2020. The green colour indicates that respective author published the publication for the first time between 2018 and 2020. From the result of Figure 5, It is clear that the research groups are relatively fragmented, with only three groups exhibiting close and strong collaborations: the Santika, Wayang group, the Riahi, Keywan group, and the Zaman, Khalid group. These groups are aligned in pursuing similar research topics. Among them, the Riahi, Keywan group is the most complex, featuring a large number of participants contributing across various time periods.

The Santika, Wayang group, represented by bright nodes from 2019 onwards, suggests a pattern of continuity and progression, building upon prior research. The increasing presence of yellow nodes in Figure 4 highlights that this topic is emergent and has garnered significant attention from recent researchers. This indicates that it is a novel area of inquiry, attracting growing interest and engagement from contemporary scholars.

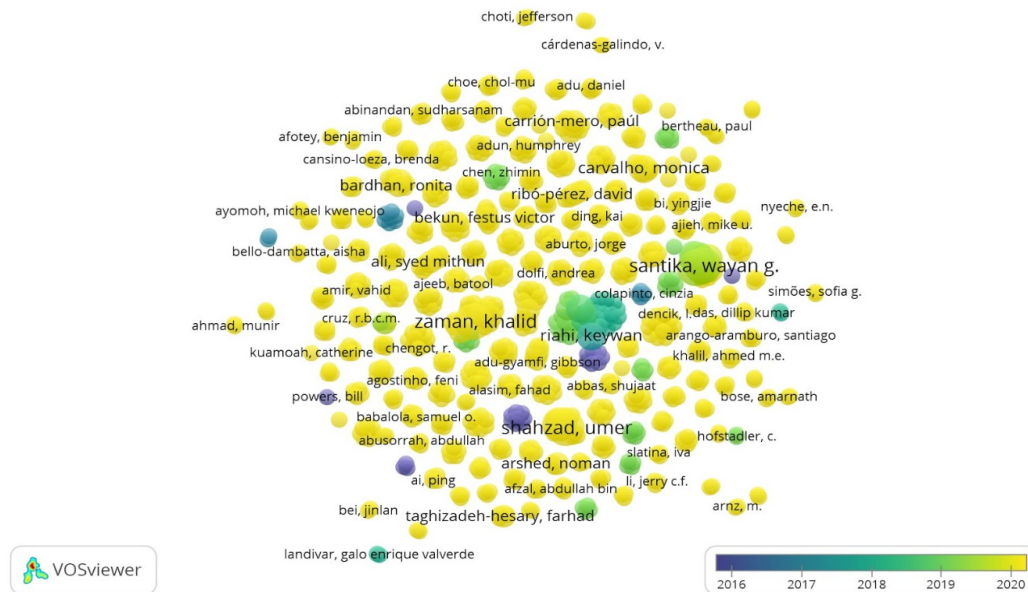


Figure 5: Co-authorship map of scholars between 1997 and 2024

3.7 Analysis co-author keyword

As illustrated in Figure 6, the color of the nodes reflects distinct research topics over time. During the period from 2018 to 2020, nodes represented in blue predominantly correspond to research on topics such as energy demand, energy efficiency, and energy policy. Moving into the period from 2020 to 2022, represented by green nodes, the research focus shifts towards sustainable development goals, sustainability, and life cycle assessment. In the more recent period of 2022 to 2024, indicated by light green and yellow nodes, the prominent research topics have transitioned to renewable energy, solar energy, and China.

The size of the nodes signifies the frequency of keyword occurrence. For instance, the large size of the sustainable development goal node suggests that this keyword has appeared frequently. Following this, keywords such as renewable energy, climate change, and carbon emissions are also noteworthy in their recurrence.

The thick link between the keywords energy demand and sustainable development goal indicates that these terms often co-occur. This thick link also suggests that energy demand serves as a foundational topic, playing a significant role in the development and expansion of research on sustainable development goals. Furthermore, the connection between these two topics is noticeably stronger and more prominent than other linkages, such as those between climate change, energy poverty, and other topics. This indicates a closer and more robust relationship, implying that energy demand and sustainable development goals complement and reinforce each other more effectively compared to other research areas.

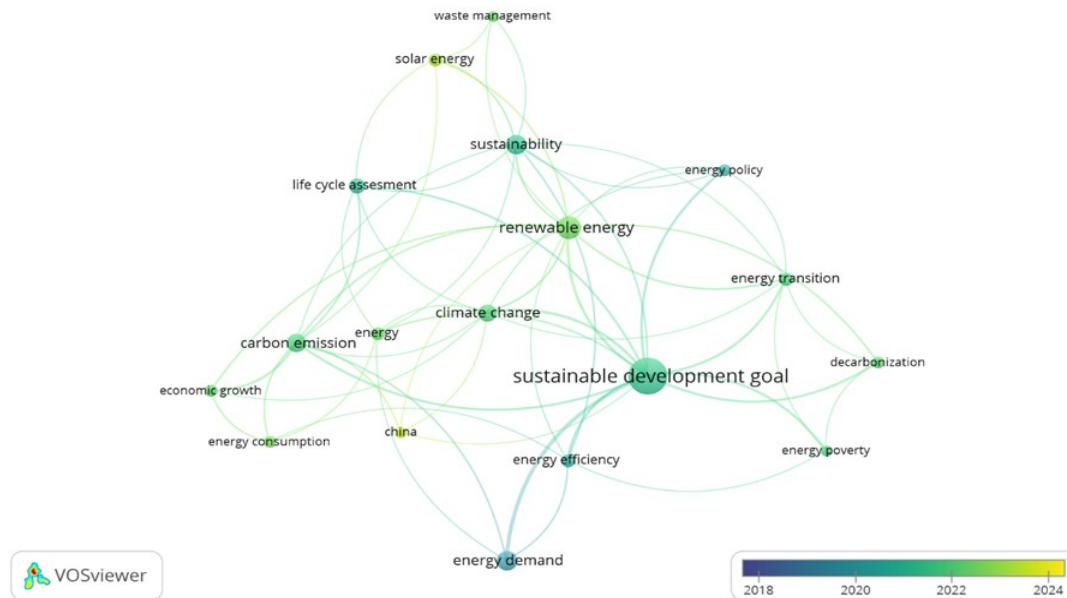


Figure 6: Keyword co-occurrence, 2018-2024.

4. DISCUSSION AND CONCLUSION

Noticing the growing academic interest in the issue of energy demand, nearly every article ultimately aligns with the Sustainable Development Goals. However, a comprehensive understanding of the overall policy landscape remains unclear. To address this research gap, we applied bibliometric analysis to explore the existing literature on energy demand and the Sustainable Development Goals. Specifically, our investigation focused on three key aspects: (i) Research productivity on energy demand and sustainable development goals, (ii) The total number and geographical distribution of publications on energy demand and sustainable development goals, (iii) The most important sources of information (journals, books, book series, or conferences), authors, research groups, and publications related to energy demand and sustainable development, (iv) The most important themes in the literature on energy demand and sustainable development goals. This study employs bibliometric analysis to provide an overview of energy demand and Sustainable Development Goals (SDGs) from 1997 to 2024, using a dataset comprising 224 publications gathered from the Scopus database. Additionally, tools such as Rstudio and VOSviewer were used to analyze and present clear and specific results on the increasing number of publications, countries contributing actively to the topic, influential scholars, journals, and co-authorship, cited author and co-occurrence maps.

RQ1: Research productivity on energy demand and sustainable development goals.

According to the results of the publication analysis, 2019 marked a significant milestone in terms of the number of published papers. From 1997 to 2018, only 14 articles were published, accounting for 6% of the total 224. From 2019 to 2022, there was a remarkable surge in research on energy and sustainable development topics. This can be explained by the impact of the COVID-19 pandemic, which led to a significant shift in thinking about sustainable energy development, greenhouse gas emission reduction, and green economic recovery. Furthermore, the Russia-Ukraine war has affected the global energy supply chain, strongly driving the need for research into sustainable development systems and energy demand (Sun et al. 2024). Although the number of papers on energy and SDGs for 2024 only stopped in June, the growth is expected to remain substantial. This is explained by the global trend towards energy transition from fossil fuels to renewable energy sources such as wind (Kularni et al. 2023), solar energy (Imam, Abusorrah, and Marzband 2024) and biomass energy (Shivanna and Rangappa 2024)). Additionally, global policies on sustainable energy development (Santarius et al. 2023) including clean and accessible energy further support this trend.

RQ2: The total number and geographical distribution of publications on energy demand and sustainable development goals

The evaluation of contributions by countries on a global scale, particularly in Asia, highlights the region's importance in energy research. Among the top 10 contributing countries, six Asian nations—China, India, Pakistan, Turkey, Saudi Arabia and Malaysia—are prominent. Notably, China and India, although still classified as developing countries, are the largest contributors to energy research, surpassing developed nations like the United Kingdom and Germany. Furthermore, within Southeast Asia, Malaysia plays a crucial role in energy research, which signifies the country's pioneering contribution in the ASEAN region. This has the potential to drive countries like Indonesia, Thailand, and Vietnam to further engage in energy research. Moreover, this fosters competition and collaboration among nations in the

region in this field. China plays an important role in the context of research and time series data from 2000 to 2020. Based on the findings from investigating the causal relationship between investment in renewable energy and green finance, researchers recommend that the government should increase investment in green finance and renewable energy sectors to achieve sustainable growth as well as environmental sustainability (Bei and Wang 2023). India is one of the leading countries in the world in biomass and coal energy consumption, therefore there are many concerns about ecological sustainability. By investigating the impact of economic globalization, coal energy, and biomass energy, the authors indicate that biomass energy and economic globalization improve ecological quality in India (Ding et al. 2023). Cities in the Southern Hemisphere are warming due to climate change and the impact of urbanization. With research based on the concept of India's future smart city - Amaravati, it emphasizes the importance of designing and implementing cooling plans that meet sustainable development goals (Bardhan et al. 2020).

RQ3: The most important sources of information (journals, books, book series, or conferences), authors, research groups, and publications related to energy demand and sustainable development

In the field of energy demand and sustainable development, the journal's *Nature energy* is the most productive journal, publishing the highest number of productions, with a total of 12 publications. It is closely followed by the renewable energy published with 8 productions. This field has significant contributions from several institutions. Renewable and sustainable energy reviews, resource policy and environmental research letter publish the same number of productions with a total of 4 published papers. Among them renewable and sustainable energy reviews have the most citation so that it is the most effective. Overall, these findings show that these institutions have many important and active contributions. Among the 20 authors have up to 3 publications, Riahi, Keywan is author that has the highest number of citations with a total of 968 citations. These works have attracted much interest and influence over the world. Rao, Narashimha is closely follows with 917 citations while Shahzad, Umer has 449 citations and Dogan, Buhari has 416 citations. The group authors of Santika, Wayan G and Umee, Tania have the same of 236 citations, 5 publications and published year start. They have demonstrated that these authors research the same topic (Santika et al. 2020). These influential authors provide insight into the topic of energy demand and sustainable development goals.

Analysis of important articles indicate that the publication "A low energy demand scenario for meeting the 1.5 °C target and sustainable development goals without negative emission technologies" of the *Nature Energy* journal is the most influential with a total of 769 citations. It was published in the first year in 2018 by the group of authors Grubler. Flowing that is "The contradiction of the sustainable development goals: Growth versus ecology on a finite planet" of the *Sustainable Development* journal with 274 citations. This article emphasizes the theme of sustainable development goals. Through experimental data, the article proposes specific changes to the SDG goals addressing the issue of CO2 emission reduction as well as setting quantitative targets for per capita resource use. The article also presents alternative approaches to achieving human development goals (Hickel 2019). The number of citations shows that these publications have important contributions and dedication of authors to this area of study.

RQ4: The most important themes in the literature on energy demand and sustainable development goals

The keyword co-occurrence analysis uses node size, edge thickness and color timing provides insight into relationships of themes within the analyzed data of each stage. It allows for an insightful understanding of the connection between different keywords highlighting field of research each period. Based on the figure of analysis Timepans of Keyword co-occurrence shows that the topics in the research on energy demand and sustainable development have changed in different periods. The color of timepans indicate that in the past the most commonly appeared phrase is "energy efficiency" and "demand management". Then 2020-2022 phase shows a significant increase in research on "Sustainable development and policy". The phase from 2022 to now has seen growing concern topics related to "Renewable energy", "Negative impact on the environment". Figure 6 of keyword co-occurrence indicates that these hot topics are "Sustainable development goals", "sustainability", "carbon emission" "renewable energy" and "climate change". This shows that the demand for energy is now greater than ever and is expected to increase, so researchers have been constantly looking for zero emission alternative solutions such as renewables to meet energy demand. The sudden increase in energy demand is not the only cause, but the underlying cause is the price of raw materials, and global warming has contributed significantly to this decision (Madurai Elavarasan et al. 2020). Every country in the world is aiming for solutions to achieve sustainable development goals to cope with extreme weather phenomena such as climate change, greenhouse effect, global warming (Hafner, Slabik, and Storck 2020). Currently, topics such as "solar energy" and "China" are concerned by authors around the world. This is explained by the gradually increasing issues of climate change or global warming. To reduce the negative impact from this problem, a transition to using renewable energy is necessary and one of which is solar energy (Mukherjee et al. 2024).

5. LIMITATIONS

This study possesses certain drawbacks. The author has exclusively gathered and examined English documents. This may result in the exclusion of studies not published in English. Subsequent research should also augment other reputable worldwide databases, such as PubMed or Web of Science (WoS), to achieve a more thorough comprehension of the research subject.

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