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Mapping renewable energy publications: A bibliometric analysis using RSTUDIO bibliometrix

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Abstract

The rapid expansion of renewable energy research has generated a vast body of scientific literature, yet comprehensive analyses of publication trends and thematic emphases remain limited. This study addresses this gap by conducting a bibliometric analysis of renewable energy and related subfields, using publications retrieved from a major scientific database. A total of 2237 publications authored by 2787 researchers were examined using advanced bibliometric tools to identify influential journals, organizations, research themes, and collaborative networks. Publications were classified according to primary focus areas, revealing that studies on potential assessment and policy development dominate the field, followed by mathematical modeling and theoretical approaches, with experimental research and new material and design development being less represented. The findings highlight both the strengths and underexplored areas within renewable energy research, providing a detailed overview of thematic trends and knowledge gaps. This analysis offers valuable insights for researchers and policymakers by revealing areas requiring further investigation and collaboration. Overall, the study demonstrates the growing scholarly interest in renewable energy and underscores the need for multifaceted, interdisciplinary approaches to advance the field effectively.

Keywords: Bibliometric analysis; renewable energy; research trends; scientific publications; thematic mapping.

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1. INTRODUCTION

In recent years, increasing environmental degradation and pollution have raised serious concerns. There are various ways pollution affects the ecosystem, such as air, water, and soil levels (Swain, 2024). It is also impossible to deny the existence of climate change, which comes with environmental pollution, and especially air pollution. The primary cause of global warming is humankind's excessive use of fossil fuels, which releases greenhouse gases into the atmosphere. The international community has long agreed that addressing climate change and reducing greenhouse gas emissions globally, particularly carbon dioxide, are priorities (Gan et al., 2024). Industry and services consumed five and nine times more energy in 2020 than in 1991, respectively. In addition, the possibility of reducing emissions from these two sectors seems low (Guo et al., 2024). In the modern world, energy is vital to achieve the required rate of economic growth, in other words, to grow industry. This is because the production of goods and services is impossible without energy, which is a necessary component of all economic activity (Saidi & Omri, 2020).

Due to factors including resource scarcity, social progress, and environmental preservation, smart energy use becomes essential for keeping global sustainability, highlighting the necessity of transitioning to green energy as conventional products run out (Xu et al., 2024). Therefore, cleaner renewable energy sources must take the place of ongoing energy production from fossil fuels that release greenhouse gases to prevent climate change. Since climate change and its impacts are a global phenomenon, all governments must work together to address them (Obada et al., 2024).

The energy industry is currently undergoing a major shift across the world. The transition to renewable energy, which is increasingly viewed as a crucial component in radically altering our connection with the environment, our economy, and larger cultural ideals, is at the core of this discussion (Hassan et al., 2024). The composition of the world's energy consumption scenario has changed significantly in recent years, favoring renewable sources. The overall usage of fossil fuels has not dropped despite this positive trend, showing difficulties in preventing climate change (Zou, 2024; Peng et al., 2025). Turkey is a developing country with a population of approximately 85.4 million (TÜİK, 2024).

Over the next few decades, it is expected that energy demand will rise significantly in developing countries such as Turkey. Turkey now ranks among the top 20 countries in the world for energy consumption, and among OECD members, its energy market is expanding at the quickest rate. Over the past 20 years, Turkey's power consumption has nearly tripled, and in the years to come, this growth is anticipated to continue (Aktekin et al., 2024). Based on the Turkey power Statistics for 2024, the Turkey Electricity Transmission Corporation (TEİAŞ) reported that the total amount of power consumed was 326301 GW (TEİAŞ, 2025). Turkey's National Energy Plan figures indicate that the country's projected final energy consumption, which was 105.5 Mtoe in 2020, will reach 148.5 by 2035 (ETKB, 2023). Interest in renewable energies will increase due to the high energy demand forecasts. Therefore, guidance for scientometric studies is essential.

Quantitative Analysis studies have been used to measure the progress of scientific publications within a particular subject or country and to obtain statistics (Zhang et al., 2024; Ng, 2025). Scientometrics, one of the quantitative analysis studies, is the study of the quantitative characteristics and attributes of science, academic research, technologies, and innovation. The scientific discipline of bibliometrics, sometimes referred to as "scientometrics," focuses on the statistical assessment of publications, including books, journals, and other scientific study types (Żarczyńska, 2012). The use of the bibliometric analysis method is also common as part of scientometric studies, in other words, as a subset of them. With this method, it is possible to identify distinct trends in the literature, although certain approaches and views are clearly widespread. The bibliometric approach has been used in numerous fields.

All disciplines are lightning-fast in adopting bibliometrics. This makes it especially appropriate for science mapping at a time when the focus on empirical contributions is creating large, chaotic, and argumentative research streams (Bergougui & Ben-Salha, 2025). Because science mapping involves multiple steps and frequently calls for a wide range of software tools, it can be complicated and unmanageable (Aria & Cuccurullo, 2017). Bibliometric methods are used as a quantitative approach to describe, evaluate, and track research studies, together with the complex network theory of published studies. These methods have the potential to

provide a systematic, transparent, and reproducible review process, thereby improving the quality of reviews (Duan & Guan, 2021).

Bibliometric methods map the study field objectively and point the researcher toward the most prominent papers; they are helpful tools for literature reviews even before reading (Kemeç et al., 2023). Some tools are required to carry out bibliometric analysis. Between these is the R package. R is a robust open-source program that can be used for free to analyze data and create graphs that are ready for publication (Kronthaler & Zöllner, 2020). The bibliometrix package in R Studio. We used the R Studio (bibliometrix package), created by Aria and Cuccurullo (2017), which is one of the tools that helps facilitate the comprehensive conduct of bibliometric analysis by applying particular tools to accomplish quantitative bibliometric research and scientific study. Thus, in addition to being regarded as one of the most potent and adaptable statistical tools available, R Studio is also known as an open-source program that is freely shared and utilized.

A large and cohesive collection of software tools for a range of data processing, computation, and graphical representations is represented by R Studio. The most popular terms are mapped and shown in this review using R Studio (Cai et al., 2024). Software such as Bibliometrix, developed as part of the Bibliometrix package, and VOSviewer, developed by the Center for Science and Technology Studies (CWTS), are used as research aids (Van Eck & Waltman, 2010). The steps involved in bibliometric citation analysis are data collecting, knowledge structure, analyzing the data, tendency and spectrum observation, and data presentation through the development of a Science Mapping Workflow (thematic network study) (Adamczak et al., 2024). The R programming language and the Biblioshiny program were important in this manuscript.

A general framework and overview of the analyzed publications emerged using the Biblioshiny program. Changes in the field of renewable energy significantly influence academic publications, as demonstrated by the growing interest in topics identified through a systematic literature review conducted within this study. This underscores the importance of monitoring literature trends to identify effective renewable energy developments and assess progress toward strategic investments. The findings of this study provide valuable insights for researchers, academics, and students seeking a comprehensive overview of renewable energy research. Furthermore, the results offer a detailed understanding of the bibliometric characteristics of energy-related studies and enhance awareness of the current state of renewable energy research in Turkey.

1.1. Purpose of study

The objective of this paper is to perform a scientometric analysis of renewable energy studies in Turkey using the R software and the Biblioshiny application.

2. METHOD AND MATERIALS

The analysis is based on the Scopus database of peer-reviewed scientific publications. Large volumes of bibliometric data are now comparatively easy to access thanks to the development of scientific databases like SCOPUS. Thanks to bibliometric software programs like VOSviewer, Bibliometrix, and Citespace, which have made data analysis quite practical, there has been a recent increase in scholarly interest in bibliometric analysis (Donthu et al., 2021). SCOPUS 2004 creation by Elsevier is among the most significant citation indexes. Through direct data acquisition from publishers, Scopus compiles a database of 78 million records (Ortega & Delgado-Quirós, 2024). The study begins by selecting literature that meets the search criteria between 2008 and 2024, applying the same criteria as in the study conducted for previous years (Celiktas et al., 2009). Following that, an in-depth examination of the literature takes place, implementing consideration of both quantitative and qualitative factors. This analysis aims to identify significant results and establish appropriate inferences. Collecting data from the SCOPUS database is the initial stage. The phases and criteria used for the literature search and filtering are outlined in Table 1. All studies from the SCOPUS database from the beginning of 2008 until November 23, 2024, are included in the "Time Period". The "TOPIC" search field, which includes title, abstract, and keywords, is used in the "Search Field" section. This selection offers a wide but suitable source collection, providing a thorough method to gather all relevant papers in the field of study. In total, 2237 publications were individually examined, revealing that 1301 studies primarily focused on renewable energy. After that, publications that were relevant to the chosen themes were found. Information such as the

institution where the author works, journals, and citation numbers was analyzed using a bibliometric analysis application called "Biblioshiny", which uses the Shiny package base of the "Bibliometrix". R is a statistical computing and graphics programming language that was used to create the Bibliometrix package. As previously stated, the main research methods used in all of the studies were: comparative analysis, performance research and development, literature based & statistical search, mathematical modelling & theoretical based, potential determination, policy development, new material and design development, new method or process development, comparative study, performance R&D, environmental impact analysis. 11 sub-fields were also conducted using prior research as a basis (Celiktas et al., 2009).

Table 1

Study conditions

SCOPUS	All
Timespan of study	From 2008 up to November 23, 2024
Search field	Article title, Abstract, Keywords
Standardized keywords	"Renewable Energy" AND "Turkey"
Document Type	Abstract report, article, book, book chapter, conference paper, conference review, data paper, letter, review
Number of documents	2237
Languages	English, Turkish
Authors	2789
References	52165
Journals	495

Analysis of the topics identified within the resources obtained through the systematic literature review conducted as part of this study reveals that demographic and political developments significantly influence publication trends.

3. RESULTS

Important data are examined and evaluated in this section of the study, including the connection strength and density of the papers that appeared using the chosen keywords and the dates when the keywords were mentioned the most.

Table 2

Used keywords in the renewable energy fields

No	**A-B**	**C-G**	**H-O**	**P-T**	**W-Z**
1	Agricultural Residue (3)	Clean Energy (26)	Hybrid Energy (15)	PEM (Proton Exchange Membrane) (3)	Waste (25)
2	Alternative Fuel (5)	Cogeneration (2)	Hydrogen Energy (11)	PV (Photo Voltaic) (45)	Wind Energy (128)
3	Anaerobic Digester (1)	Crop Residue (1)	Hydrogen Storage (2)	Pyrolysis (3)	Wood (5)
4	Biodiesel (11)	Energy (7714)	Hydropower (73)	Renewable Energy (1299)	
5	Bioenergy (9)	Energy Policy (146)	Manure Energy (4)	Solar Energy (78)	
6	Bioethanol (4)	Fuel Cell (6)	Methane Production (3)	Solar Thermal (1)	
7	Biofuel (6)	Gasification (4)	Organic Waste Energy (9)	Solid Fuels (3)	
8	Biogas (29)	Geothermal Energy (51)		Thermochemical Conversion (1)	
9	Biomass (32)	Green Energy (24)			

3.1. A general assessment of all reviewed publications

This study aimed to review Turkey's research trend in the field of renewable energy. A total of 2237 publications were analyzed, and the years 2008-2024 were considered for evaluation. 495 different journals were identified. The highest number of publications was recorded in 2022, while the highest number of citations occurred in 2020. To provide an overview, the majority of studies have been published as articles (68.5%), followed by reviews (8.7%), conference papers (14.6%), and book chapters (6.8%). Other types, including letters (0.1%), editorials (0.1%), and data papers (0.1%), constituted smaller proportions. Over a quarter of all publications (27.63%) were published by the top 20 publishers, while the remaining publications were distributed among other publishers. The studies were prepared by researchers affiliated with 751 different institutions, with Ege University ranking 8th among the most relevant affiliations. An average of 26.56 citations per document highlights the impact and relevance of the published studies. The top four countries contributing to collaborative publications are the USA (24.8%), China (12.4%), Pakistan (9.9%), and the United Kingdom (11.5%). The analysis of the publications, categorized according to three key parameters, reveals a dominant 17.14% in potential determination, closely followed by 16.79% in policy development. mathematical modelling & theoretical based accounts for 14.01%, while experimental study makes up 9.57%. New material & design development holds the smallest share at 2.26%, followed by available system analysis at 3.66%, and literature-based & statistical search at 3.75%, marking the lowest percentages in the classification. The publications were published in 494 different sources. The annual growth rate was determined to be -15.57%. A total of 2789 authors contributed to the publications, with 228 single-authored documents. The international co-authorship rate was found to be 16.48%. The average number of co-authors per document was 2.72. The authors used 3003 keywords, and 52165 references were cited. The study titled "Experimental evaluation of using various renewable energy sources for heating a greenhouse" by Esen & Yuksel(2013), received the most citations. While 18.98% of the studies received no citations, 9.5% received only one citation. The most frequently used keywords were Turkey and renewable energies.

3.2. Renewable energy

Out of a total of 478 sources, 1299 publications were reviewed, comprising one abstract report, 880 articles, five books, 87 book chapters, 193 conference papers, two letters, one data sheet, and 120 review papers. The annual growth rate was found to be 8.52%. A total of 6202 unique keywords were utilized. Among these publications, 214 were single-authored, with the total number of authors reaching 2647. International co-authorship accounted for 16.76%, while the average citations per document stood at 26.28. The authors used a total of 2829 distinct words. The year 2022 saw the highest number of publications, with 159 papers published.

In contrast, 2020 had the most citations, with 713 different institutions contributing to these studies. Istanbul Technical University ranked first in terms of author affiliations, followed by Yıldız Technical University and Karadeniz Technical University. More than half of the most relevant affiliations were international, and the publications appeared in 478 different journals. The majority of studies were published in the Renewable and Sustainable Energy Reviews journal. The most cited paper is “Experimental Evaluation of Using Various Renewable Energy Sources for Heating a Greenhouse” (Esen & Yuksel, 2013), with 721 total citations. The overall citation count for all studies reached 34194. Notably, 18.9% of the studies were not cited at all, while 16.21% received between one and two citations. The most frequently used terms were “Turkey” and “renewable energies.” Among the 1301 publications, 18.36% focused on policy development, 15.75% on potential determination, and just 2.23% on new material and design development, the least prevalent category.

Figure 1

Thematic Network Approach “Renewable Energy”. The network was created using Biblioshiny.

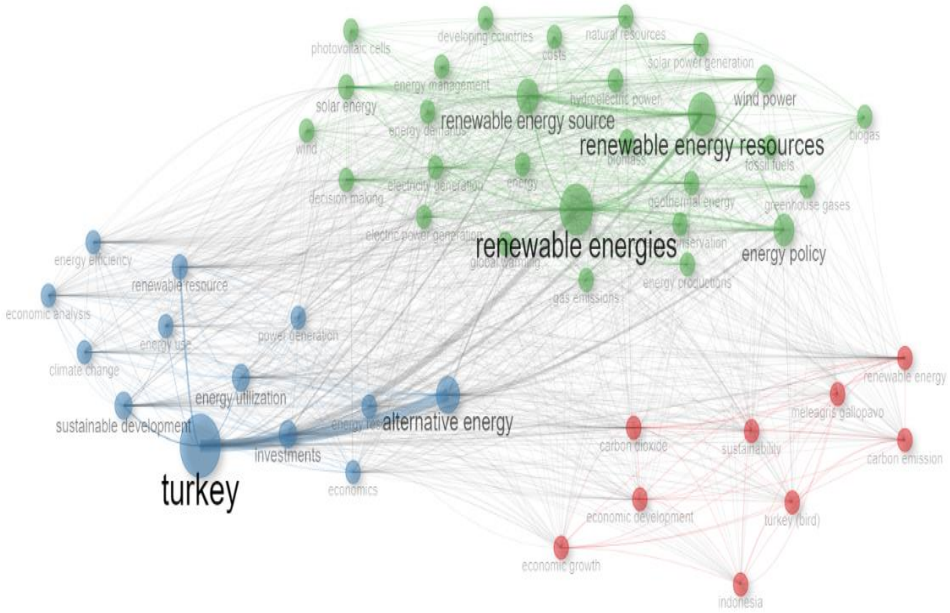

Table 3

Co-occurrence network source data. The data was obtained from Biblioshiny

Node	Cluster	Betweenness	Closeness	PageRank
carbon dioxide	1	3,804	0,02	0,024
renewable energy	1	3,464	0,02	0,019
economic development	1	0,818	0,017	0,015
economic growth	1	0,44	0,016	0,014
sustainability	1	0,407	0,017	0,013
carbon emission	1	0,457	0,017	0,013
turkey (bird)	1	0,547	0,015	0,012
Indonesia	1	0,024	0,014	0,009
meleagris gallopavo	1	0,305	0,017	0,01
turkey	2	41,764	0,02	0,074
alternative energy	2	11,165	0,02	0,04
investments	2	4,051	0,02	0,029
sustainable development	2	3,804	0,02	0,029
energy utilization	2	3,598	0,02	0,029
renewable resource	2	1,799	0,02	0,025
energy efficiency	2	0,704	0,02	0,015
economics	2	2,222	0,02	0,02
climate change	2	0,587	0,019	0,014
economic analysis	2	0,847	0,02	0,014
energy resource	2	1,296	0,02	0,016
energy use	2	0,957	0,019	0,016
wind	2	0,123	0,016	0,009
power generation	2	0,246	0,018	0,011
renewable energies	3	14,335	0,02	0,056
renewable energy resources	3	8,731	0,02	0,047
renewable energy source	3	3,624	0,02	0,038
wind power	3	2,778	0,02	0,028
energy policy	3	4,539	0,02	0,034

solar energy	3	1,723	0,019	0,023
fossil fuels	3	2,058	0,02	0,024
decision making	3	0,847	0,02	0,016
electricity generation	3	1,464	0,02	0,021
geothermal energy	3	0,567	0,019	0,018
greenhouse gases	3	0,978	0,02	0,021
hydroelectric power	3	0,542	0,019	0,015
global warming	3	0,624	0,02	0,017
biomass	3	0,318	0,018	0,012
natural resources	3	0,415	0,019	0,017
Solar power generation	3	0,31	0,018	0,013
electric power generation	3	0,437	0,017	0,014
energy conservation	3	0,596	0,019	0,015
gas emissions	3	0,386	0,019	0,014
energy productions	3	0,432	0,019	0,014
energy management	3	0,308	0,018	0,013
developing countries	3	0,081	0,017	0,01
energy	3	0,111	0,016	0,01
biogas	3	0,095	0,016	0,008
energy demands	3	0,126	0,018	0,012
costs	3	0,054	0,016	0,009
energy resources	3	0,091	0,017	0,01

Table 3 was created with the Biblioshiny application to examine the conceptual organization of articles about renewable energy. It was able to show the conceptual relationships between different research areas. The keywords utilized in the examined articles are represented by a node (Babyr, 2024). Clustering enables the grouping of related or commonly used concepts. A concept known as betweenness, which has a high betweenness value, is essential to the information flow because it serves as a link between various clusters or themes in the network (Klarin, 2024). The concept's average distance from other ideas in the network is measured by its closeness. A concept that has a low proximity value can readily reach other ideas since it is more centrally connected to the network (Donthu et al., 2021).

3.3. Energy Policy

A total of 146 publications, including articles, books, book chapters, conference proceedings, and reviews, were authored by 334 individuals. Of these, 28 were single-authored, and 96 were articles. The international co-authorship rate was 15.07%. The average number of citations per document was 26.32. The year 2022 saw the highest number of publications, and publications from this year also received the most citations. These studies were published across 79 different journals. Renewable Energy Journal led with 15 publications, followed by Energy Policy with 12. The most prominent affiliations were Istanbul Technical University, ranked first, followed by Gazi University in second place. The publications involved 122 different institutions, with 25 international collaborations identified. The most frequently used terms were energy policy and Turkey, followed by renewable energy in third place. A significant number of studies focused on renewable energy sources. The total citation count for these studies reached 3,843. Notably, 17.12% of the studies received no citations. The most cited article addresses Turkey's energy consumption. Among the publications using the keyword energy policy, policy development emerged as the most researched topic, comprising 25.24% of the studies. Both experimental and informational studies represented 7.14%, while new material & design development was the least explored area, accounting for only 0.48%.

Figure 2

Worldcloud of "energy policy". The cloud was created using Biblioshiny.

3.4. Wind Energy

A total of 128 studies, including articles, book chapters, conference papers, and reviews, have been prepared in both Turkish and English. Of these, 30 were single-authored. The international co-authorship rate stands at 10.94%, with an average of 17.33 citations per document. The studies involved 315 authors and utilized 299 distinct keywords. The year 2021 was the most productive, with 16 publications. Renewable and Sustainable Energy Reviews was the journal with the highest number of publications. Yıldız Technical University was the leading affiliation. The most frequently used keyword group was "wind power." These studies were published across 90 different journals, and a total of 90 institutions collaborated on the research. The most cited study is titled "GIS-based environmental assessment of wind energy systems for spatial planning: A case study from Western Turkey" (Aydin et al., 2010). A total of 28 international collaborations have been identified. Most of the studies have primarily focused on the potential of wind energy. These works have received a total of 2218 citations. Additionally, 15.62% of the studies have received no citations. Potential determination is, in the first place, with a rate of 16.85%. No study was found on new material & design between the specified years.

3.5. Solar Energy

A total of 78 studies, including articles, book chapters, conference papers, and reviews, were published in both English and Turkish. Thirteen of these studies were single-authored. The research involved 200 authors, with an international co-authorship rate of 12.82%. The average number of citations per document was 27.04, and the authors used 245 distinct keywords. The most productive year was 2022, with 12 publications. Renewable Energy and Sustainable Energy Reviews was the journal with the highest number of studies. The leading affiliation was Yıldız Technical University. The most frequently used keyword group was "solar energy."

These studies were published across 56 different journals, with contributions from 64 institutions. A total of 13 international collaborations took place. The studies have been cited 2109 times, with 17.94% of the studies not receiving any citations. The study "GIS-based solar farms site selection using analytic hierarchy process (AHP) in Karapinar region, Konya/Turkey" was the most cited (Uyan, 2013). Research on mathematical modelling & theoretical based was leading to improvements in solar energy (11.88%). Potential determination publications came after that (10.64%), but there wasn't an informational study.

3.6. Hydropower

A total of 73 documents were prepared by 140 authors. The studies published in the types of articles, books, book chapters, conference papers, and reviews are in English and Turkish. There are 15 single-authored documents, each written by one author. The average citations per document was determined as 32.12. The year in which the most studies were produced was 2009. The authors used 188 different keywords. Most of the studies were published in the journal Renewable and Sustainable Energy Reviews. Yildiz Technical University is in the first place as the most relevant affiliation. As can be seen from the figure, hydroelectric power was the most used keyword group. The studies were published in 39 different journals. 58 different institutions contributed to the studies, 20 of which were international organizations. "Renewable energy consumption, urbanization, financial development, income, and CO2 emissions in Turkey: Testing EKC hypothesis with structural breaks" by Pata (2018) was the most cited study. 16.43 of the studies cited 2345 times were not cited at all. Regarding hydropower, policy development and potential determination research were of equal weight (13.79%). However, experimental studies and new material & design studies were not identified in this field during the years specified.

Figure 3

World tree of "hydropower". The tree was created using Biblioshiny.

3.7. Geothermal Energy

51 studies have been published as articles, books, book chapters, conference papers, data papers, and reviews. There are nine authors of single-authored documents. The international co-authorship rate is 11.76%. Average citations per document is 14.06. The highest number of publications was made in 2009. The studies were cited the most in 2017. The journal with the most studies was Renewable Energy. The most relevant affiliations, Istanbul Technical University and Karadeniz Technical University, are in the first place with an equal number of studies. The most frequently used word was geothermal energy. 45 different institutions contributed to the studies published in 36 different journals, and 28.88% of international cooperation was achieved. "Geothermal energy in Turkey and around the World: A review of the literature and an analysis based on Turkey's Vision 2024 energy targets" by Melikoglu (2017) is the most cited study. The total number of citations is 717, and 15.68 of the studies have not received any citations. First place was taken by potential determination publications addressing geothermal energy, with a rate of 20%. It was observed that further study remains important in this area. Nevertheless, there wasn't a publication on new material & design.

3.8. PV

A total of 45 articles, book chapters, conference proceedings, and compilations have been published in English and Turkish. Eight authors have written single-authored documents. A total of 116 authors have contributed to the preparation of the studies. The international co-authorship rate has been determined as 15.56%. While the average citations per document was 15.38, the author's keywords were 179. The years 2018, 2022, and 2024 were the years in which the most studies were published. The year with the most citations was 2018. The studies were published in 40 different fields. There was no preferred institution among the publishing organizations. Contributions to the studies were provided by 40 different institutions. There are nine international institutions among them. The most relevant affiliation was Istanbul Technical University. Pamukkale University and Ege University are in second and third place, respectively. All studies received a total of 632 citations, and the most cited publication was "Integration of hybrid power (wind-photovoltaic-diesel battery) and seawater reverse osmosis systems for small-scale desalination applications" (Gökçek, 2018). 15.5% of the publications did not receive any citations. Solar energy was the most frequently used keyword. It was determined that the most mathematical modelling & theoretical based publications, which rank first with a rate of 23.08%, were conducted on PV. Even though there were mathematical modelling & theoretical based publications, it was observed that no research based on literature & statistical analysis has been conducted in the identified years.

3.9. Biomass

A total of 32 studies have been published. 10 of these papers were prepared by a single author. 59 authors contributed to the remaining 22 publications. The international co-authorship rate was determined as 9.375%. 22.81 citations were averaged per document. The year with the most publications was 2021, and the year with the most citations was 2018. The year in which the studies were cited the most was 2017. The studies were published in 28 different publishers. The largest number of publications was published in the journal Energy Sources, Part B: Economics, Planning and Policy. The authors who prepared the studies work in 35 different institutions, six of which are international. Yildiz Technical University is in first place, and Istanbul Technical University is in second place in the most relevant affiliations of the authors who contributed to the preparation of the publications. The studies have received 730 citations in total. The publication, which is "Biomass energy potential and utilization in Turkey" (Toklu, 2017), that received the most citations in this category was one that was published in the Renewable Energy journal and was cited 149 times. Another study published in the Renewable Sustainable Energy Reviews journal ranks second with 148 citations. 21.87% of the publications have not received any citations. Biomass and Turkey were the most frequently used keywords. 46.67% of biomass publications are about potential determination. This shows that there are still shortages in this area and that academic research is focused on this.

3.10. Biogas

Biogas: 29 publications, which genres article (26), book chapters (one), conference proceedings (one), and reviews (one), have been prepared on behalf of the biogas keyword. The annual publication growth rate is observed as 9.68%. While a total number of authors is 69, six publications have been prepared by a single author. The international co-authorship rate was determined as 6.897%. The years with the most work were 2019, 2022, and 2024. The average number of citations per document was 12. 2020 is the most cited year. The studies were published in 23 different journals, and Biomass Conversion and Biorefinery and Energy journals were ranked first two. The authors are affiliated with 23 different institutions, three of which are international institutions. Most of the studies are affiliated with Istanbul Technical University. There are a total of 348 citations to publications. The percentage of uncited publications is 13.79%. The most cited publication has 70 citations and is titled "Integrated fuzzy QFD and TOPSIS methodology for selecting ideal gas fuel in WATs" (Akbaş & Bilgen, 2017). The most frequently used words are renewable energy sources, biogas, and Turkey. Among the 29 publications, as with the biomass, the percentage of potential determination was 36.67%.

3.11. Others

All remaining publications were distributed as follows: available system analysis 2.11%, comparative case study 4.93%, environmental impact analysis 11.97%, experimental study 14.08%, informational study 3.52%, literature & statistical analysis 4.23%, mathematical modelling & theoretical based 5.63%, new material & design development 2.11%, new method or process development 6.34%, performance R&D, 3.52%, policy development 14.07%, and potential determination 21.13%.

Agricultural Residue: Three publications prepared by eight authors were identified, including one experimental study and two potential determinations. All publications are of the "article" type. Two of these articles were published in 2008, and the other in 2019. The number of co-authors per document is 2.67, and there is no article with a single author. Each of the articles was published in different journals. These are the journals: Bioresource Technology, Energy Policy, Energy Sources, Part A: Recovery, Utilization and Environmental Effects. It was seen that the authors worked in five different organizations, but there was no international cooperation. 80 keywords were used in the papers. The most frequently used keywords were biomass, crops, and turkey. The average number of citations per publication was determined as 45.33%.

Alternative Fuel: In total, five scientific studies were identified in the types of articles and conference proceedings prepared by 17 authors. Two of these studies were experimental studies, one was a potential determination, one was a literature & statistical analysis, and one was a potential determination. There is no international consensus. The authors used 16 keywords. The average citations per document was determined as 10. The highest cited year was 2009. No studies were published between 2014 and 2020. Both studies were published in different sizes. Yıldız Technical University and Karadeniz Technical University are the first two most relevant affiliated institutions. The most cited document was the study titled "Perspectives on Pilot Scale Study of RDF in Istanbul, Turkey" by Kara et al. (2009) with 32 citations. The most frequently used words were alternative fuels, municipal solid waste, and recycling.

Anaerobic Digester: Just one publication was conducted between 2008 and 2022; a total of three authors took part in the preparation of the publication, and this was an experimental study. The study was patterned around 15 different keywords. One study is from Ege University, while the other is from Ataturk University. The first one was published in the Energy Sources Journal, while the other was published in the Water, Air, and Soil Pollution. The first three most frequently used keywords were anaerobic digestion, chemical oxygen demand, and solubility. While the average citation per document was 8.5, there is no international co-authority.

Biodiesel: When the general distribution of studies is examined, experimental study 36.36%, informational study 9.09%, literature & statistical analysis 9.09%, mathematical modelling & theoretical based 9.09%, new material & design development 18.18%, and potential determination 18.18%. A total of 26 authors prepared 11 papers during the relevant year periods. The publication category is just an article. Publications were promoted with 31 different keywords. Most of the publications are associated with Dicle University (19). The average number of citations per document was determined as 37.36. With three publications, 2022 was the year with the most publications. All remaining publications were published in different journals. Biodiesel (18), renewable energy resources (11), and turkey (8) are the first three most frequently used words.

Bioenergy: in the timespan of 2008 and 2022, nine studies were prepared by 22 authors with 31 keywords. Among these nine publications, two were published as potential determination studies, two as mathematical & statistical studies, and the remaining ones as performance R&D, new material & design development, new method or process development, literature based & statistical search, and informational studies, respectively. Only two of the articles were prepared by a single author, of which the international co-authorship rate is 17.24%. Publication types are eight articles and one conference paper. Most of the studies are associated with Bulent Ecevit University and Dokuz Eylul University. The year with the highest number of citations was 2020. All the studies were published in different journals. The most frequently used words were biomass and bioenergy.

Bioethanol: There were four publications related to this keyword, three of which were potential determinations, and one was an informational study. There is only a single author in one of these publications. Three additional studies contain the contributions of ten co-authors. The percentage of international students is 25%. All publications have been published in various journals. First in terms of affiliation is Sirnak University. Ethanol and bioethanol are the most often used terms.

There are no publications on biomethanol that match these requirements.

Biofuel: There were six publications in total, the last one being in 2018. Three of them were identified as policy development, two as literature & statistical research, and one as an experimental study. One author created two of the publications, while nine authors contributed to the remaining ones. International co-authorship does not exist. Every publication was released in a unique journal. The National Research Institute of Animal Production is the most relevant affiliation. The word biofuel appeared the most.

Clean Energy: 26 studies were prepared. The annual growth rate was determined as 14.91%. The number of authors of single-authored documents was nine. The international co-authorship rate was 19.23%. The average citations per document was determined as 30.27. With an increasing trend since 2020, 2024 became the year in which the most publications were prepared. 2021 became the year in which the most citations were received. The Environmental Science and Pollution Research journal is the most preferred journal for publications. Cyprus International University is in the first place with the most relevant affiliation. Turkey, renewable energy, and carbon dioxide were the most frequently used words. The studies were distributed as follows: two available system analyses, two comparative case studies, three environmental impact analyses, one experimental study, three informational studies, four literature & statistical analyses, three mathematical modelling & theoretical-based studies, one new method or process development, one performance R&D, five policy development, and one potential determination.

Cogeneration: 14 authors worked on two conference papers prepared in 2019. One of them was about available system analysis; the other one was about performance R&D. International co-authorship was determined to be 100%. The average citations per document was 1.5.

Crop Residue: In 2019, one article was prepared on the potential determination by three authors. The average citations per document was 86. The article was published in the journal Renewable Energy. All authors are from Ankara University.

Energy: One by one, the publications related to this title were reviewed, and those associated with renewable energy were divided. Following the division, 7714 papers in all had been determined to be unrelated to the topic of renewable energy but related to energy. These studies have not been reviewed in this manuscript.

Fuel Cell: Of the 6 studies prepared, one is on mathematical modelling & theoretical based, one is on new material & design development, one is on environmental impact analysis, two are on experimental study, and one is on policy development. Publications were found in the conference paper and article categories. One publication was single-authored, and 12 authors contributed to the preparation of the remaining five publications. International co-authorship was found at 33.33%. Average citations per document was 31.83. The average citations per year was the most cited year, with 41 citations in 2024. The International Journal of

Hydrogen Energy was the journal in which two of these studies were published. Indonesia and Nigeria were the two most frequently used words.

Gasification: Four scientific studies were found in an article and a conference paper. There was one scientific study prepared for each of the following topics: environmental impact analysis, literature based & statistical search, potential determination, and performance R&D. International co-authorship rate is 25%; there is no single-author publication. Each study was shared in different conferences and journals. Most of the studies were conducted by Dokuz Eylul University. Biomass, gasification, turkey, and yeast were the most used words.

Green Energy: There are 24 publications, including articles, book chapters, conference papers, and reviews. Three of the publications are single-authored. The remaining 62 authors prepared collaborative works. The international co-authorship rate is 33.33%. The average number of citations of the documents was determined to be 7,042. 2024 was the year in which the most studies were prepared, with nine publications. Environmental Science and Pollution Research is the journal in which most studies were published. Jiangsu University, Anadolu University, and Vilnius University are in the first two places with the most relevant affiliation. Turkey, carbon dioxide, and economic development are the three most used keywords. The categorization of the studies is as follows: two comparative case studies, four environmental impact analyses, one experimental study, two informational studies, one literature & statistical analysis, four mathematical modelling & theoretical-based, one performance R&D, seven policy development, and two potential determination.

Hybrid Energy: In Turkish and English, 15 articles and conference papers were prepared. 40 authors worked while preparing the studies. Two of the studies were single-authored. International co-authorship is 25%. The average number of citations per document is 23.56. The authors used 70 different keywords. 2024 was the year with the most publications. The first three places are Energy, Sources, Part A: Recovery, Utilization and Environmental Effects, International Journal of Hydrogen Energy, and Sustainable Cities and Society journals, with two publications each. Pamukkale University is in the first place as the most relevant affiliation. Hybrid systems are the most frequently used word group. The studies belong to the following categories: three of them are mathematical modelling & theoretical based, five of them are new material & design development. One study was conducted in the new method or process development category, four studies were prepared in the performance R&D and two studies were prepared in the potential determination category.

Hydrogen Energy: 11 studies were prepared with 18 different authors and published in six different sources. The studies are in the article and conference paper types. All of the documents are in English. Two studies have a single author. The average citations per document is 26. 38 different keywords were used. Four studies were published in 2012. It is the year in which the most studies were published, according to the years. The International Journal of Hydrogen Energy was the journal in which most studies were published. Yildiz Technical University is in the first place as the most relevant affiliation. The most frequently used word was hydrogen. The studies are distributed in terms of their categories as follows: One comparative case study, two new methods or process development, four policy development, and four potential determinations.

Hydrogen Storage: Two scientific studies, one on policy development and the other on potential determination, were prepared by seven authors. The average citations per document is 120. The authors preferred 10 different keywords. Both studies are in English and in the article type. Studies were prepared in 2015 and 2024 and published in the IEEE Access and International Journal of Hydrogen Energy journals. The most relevant affiliation to which the authors are affiliated is the World Bank. Electric energy storage, hydrogen storage, and renewable energy sources are the most used keyword groups.

Manure Energy: Four studies were prepared by nine authors. All are in English. The average citations per document is 0.5, and authors used 16 different keywords. Three of the studies were prepared in 2024, and two of them were published in the International Journal of Agricultural and Biological Engineering. Isparta University of Applied Sciences stands out as the most relevant affiliation. The category distinctions within the four studies are as follows: one comparative case study, one environmental impact analysis, and two experimental studies.

Methane Production: Three publications, one of which is a comparative case study and the other two are experimental studies, were prepared by 10 authors. The average citations per document is four. 16 keywords were used in the prepared studies. Two of the studies were published in 2022. Each was published in a different journal. Akdeniz University and Ataturk University share the first place as the most relevant affiliation.

Organic Waste Energy: There are nine studies written in English in the article and conference paper genres. Two of the studies have a single author. Three of the studies were identified as environmental impact analysis, four as experimental studies, and two as new methods or process development. While the average citations per document is 13, 31 different keywords were used in the publications. All the studies were published by different publishers. Bursa Uludag University is in the first place as the most relevant affiliation. Anaerobic digestion and biogas are the most frequently used words.

PEM: There were three studies written in English as articles and conference proceedings, one of which was performance R&D, and two of which were new method or process development. Six authors worked on the studies. While the average citations per document was 34.67, the author's keywords were determined as 15. No studies were conducted between 2017 and 2020. All studies were published in different journals. Proton exchange membrane fuel cells were the most frequently used word groups.

Pyrolysis: There are three studies published in the article type, in English. One of them is a single author. Two studies were prepared by the other eight authors. While the average citation per document is 21, there is no international co-authorship. The authors used 17 different keywords. The studies were published by different publishers in 2008, 2019, and 2022. Yildiz Technical University is in first place in the most related affiliates. Pyrolysis was the most frequently used word. Three studies prepared on pyrolysis are in the experimental study category.

Solar Thermal: There is one article published in 2017 in the Applied Thermal Engineering journal, prepared by two authors in English, which was about a new method or process development.

Solid Fuels: These scientific studies were related to experimental study, environmental impact analysis, and potential determination, respectively**.** There are three studies in English prepared as article types. One of them has a single author. The other two studies were prepared by eight authors. Average citations per document is 124.7. International co-authorship is 33.33%. The authors preferred 15 keywords while preparing their studies. Each of the studies was published in different journals. Ege University and Istanbul Technical University share the first place as the most relevant affiliation. The most frequently used keyword group was climate change.

Thermochemical Conversion: There was one English article prepared as a comparative case study by two authors. The article was published in the International Journal of Hydrogen Energy. While the average citations per document was 601, six different keywords were used while publishing the study.

Waste: There were 25 studies prepared as articles, book chapters, conference papers, and reviews. All the scientific studies were prepared in English. Two of them were available system analysis, five were environmental impact analysis, three were experimental study, two were mathematical modelling & theoretical based, two were performance R&D, three were policy development, and eight were potential determination. Seven authors wrote single-authored documents, and the international co-authorship rate is 8%. Average citations per document is 21, and 96 different keywords were used while preparing the studies. 2013 and 2021 were the years in which the most studies were produced. Renewable and Sustainable Energy Reviews is the journal in which the most studies were published. Burdur Mehmet Akif University is in the first place as the most relevant affiliation. Turkey is the most frequently used word, while the waste management keyword group is in the second place.

Wood: There are five studies published as articles in English. There is just one author of single-authored documents. One of these five articles is about environmental impact analysis. Another one is about new method or process development; one is about policy development, and the remaining two are prepared for potential determination. International co-authorship is 40%. The average citations per document is determined as 5.8, and 25 different keywords were used while preparing the studies. Two of the studies were published in the Fresenius Environmental Bulletin journal. Biomass was the most used word in the studies.

As shown in Table 2, the majority of studies are aimed at determining the potential of renewable energy sources. Since renewable energy is a rapidly developing field, many of the research studies are likely focused on assessing the potential of these resources. Determining potential is particularly important in sectors like energy, which require significant investments. Identifying the potential of renewable energy sources is also a critical step in strategic planning processes. Moreover, this process is essential for minimizing environmental impacts and designing sustainable energy systems. With the development of technologies in renewable energy, potential assessment studies offer opportunities for new methods and innovative solutions. Following that, the prominence of the policy development category in publications can be interpreted as renewable energy developments often being driven by government regulations and policies. Energy policies are critical for accelerating the transition from fossil fuels to renewable energy, reducing carbon emissions, and promoting sustainable energy production. Governments are developing policies to encourage the use of renewable energy to achieve climate goals. Global climate agreements and international collaborations guide countries in developing their renewable energy policies, making policy development research highly significant. In this regard, the bibliometric study is consistent with the observed trends. The new material & design development category emerges as the least studied category, as research on new materials and designs in renewable energy often requires longer and more complex development processes. These studies often require resources for experimental work, prototype production, and long-term testing, and face challenges such as cost-effectiveness and scalability. Similarly, the Literature and Statistical Analysis category is the least researched area. The extensive literature reviews in renewable energy research in previous years may have encouraged researchers to seek more innovative approaches in this area.

Table 4

Renewable energy research: distribution by keywords and categories

	Available System Analysis	Comparative Case Study	Environmental Impact Analysis	Experimental Study	Informational Study	Literature & Statistical Analysis	Mathematical Modeling & Theoretically Based	New Material & Design Development	New Method or Process Development	Performance R&D	Policy Development	Potential Determination
1. Renewable energy (1301)	44 3.38	92 7.07	130 9.98	110 8.45	82 6.30	49 3.76	173 13.29	29 2.23	73 5.61	76 5.84	239 18.36	205 15.75
2. Energy policy (146)	9 4.29	14 6.67	12 5.71	15 7.14	15 7.14	8 3.81	14 6.67	1 0.48	3 1.43	3 1.43	53 25.24	14 6.67
3. Wind energy (128)	7 3.80	15 8.06	7 3.80	7 3.80	10 5.35	2 1.07	26 14.13	0 0	7 3.80	3 1.62	13 7.07	31 16.85
4. Solar energy (78)	5 3.30	2 1.32	1 0.66	13 8.60	0 0	4 2.65	18 11.88	5 3.30	7 4.63	5 3.30	1 0.66	16 10.64
5. Hydropower (73)	2 1.72	4 3.45	9 7.76	0 0	8 6.90	3 2.59	11 9.48	0 0	2 1.72	2 1.72	16 13.79	16 13.79
6. Geothermal energy (51)	3 6	5 10	5 10	2 4	3 6	2 4	8 16	0 0	1 2	3 6	9 18	10 20
7. PV (45)	5 12.82	4 10.26	1 2.56	8 20.51	1 2.56	0 0	9 23.08	3 7.69	2 5.13	5 12.82	3 7.69	3 7.69
8. Biomass (32)	0 0	1 3.33	4 13.33	5 16.67	2 6.67	0 0	1 3.33	1 3.33	0 0	1 3.33	2 6.67	14 46.67
9. Biogas (29)	1 3.33	3 10	2 6.67	6 20	1 3.33	0 0	1 3.33	0 0	2 6.67	1 3.33	1 3.33	11 36.67
10. Others (142)	3 2.11	7 4.93	17 11.97	20 14.08	5 3.52	6 4.23	8 5.63	3 2.11	9 6.34	5 3.52	20 14.08	30 21.13

Sub-categories

The sub-categories were determined based on the study prepared by (Celiktas et al., 2009). Each study has been examined within only one keyword or sub-category keyword. Consequently, no study is classified under multiple categories. At the outset, scientific studies classified within the sub-categories were analyzed. If they were not included in these groups, they were evaluated based on the primary keyword groups.

Biomass Conversion & Biofuel: There is one publication prepared by a single author in 2009. It has received 21 citations. It was published in the journal Energy Sources, Part A: Recovery, Utilization and Environmental Effect. The author is affiliated with Karadeniz Technical University. The most frequently used words are biogas, biomass, developing countries, ethanol, forestry, fossil fuels, heating, and solid wastes.

Biomass Conversion & Biodiesel: Two articles were published, and one of the publications has a single author, while the other has three authors. The average number of citations per document is 14, and six different keywords were used by authors. One of the studies was prepared in 2009, and the other in 2021. The studies were published in the journals Current Microbiology and Energy Sources, Part A: Recovery, Utilization and Environmental Effects. The two authors who contributed to the studies are also affiliated with Nevsehir Haci Bektasi Veli University. Biomass was the most used word. One of the studies is an experimental study, while the other is an informational study.

Biomass Conversion & Bioethanol: In 2009 and 2012, two studies were prepared for each of the article and review types. Average citations per document is 12.5, and both are single-authored. Studies have been published in Energy Sources, Part A: Recovery, Utilization and Environmental Effects, and Journal of Renewable and Sustainable Energy. It has been determined that the most relevant affiliations are Ankara University and Karadeniz Technical University. Biomass and ethanol were the most frequently used words. One of the studies is an informational study; the other is a study about potential determination.

Biomass Conversion & Biogas: It was determined that six studies were prepared as articles and reviews. International co-authorship rate is 16.67%. Only one of the studies is single-authored. The authors used 28 keywords. The average citations per document is 13.5. Two of the studies were prepared in 2024, and each was published in different journals. Lodz University of Technology and Afyon Kocatepe University are in the first two places in terms of affiliation. Biogas was the most frequently used word. The distribution of studies according to their subjects is as follows: two potential determination, one comparative case study, one informational study, one new method or process development, and one performance R&D.

Biomass Conversion & Biooil: Published three studies in the article genre by five authors, one of which was published by a single author. Average citations per document is 160.3, while the author's keywords are 15. The studies were published in different journals at two-year intervals since 2008. The most relevant affiliations are with Istanbul Technical University, while the most frequently used word is biomass. The other most frequently used words were biofuel and pyrolysis. Studies were conducted in the following three categories: environmental impact analysis, experimental study, and literature & statistical analysis.

Biomass Conversion & Hydrogen Production: A total of four studies in the English language in the genres of article and conference paper were published. A total of 16 authors worked on the preparation of these studies. The international co-authorship is 50%, while the average citations per document is 23.25, and the author's keywords are 16. 2011 was the year in which most studies (4.7) were cited. Two of the studies were published in the International Journal of Hydrogen Energy, with the most relevant affiliations being Yildiz Technical University. Bio-hydrogen is the most frequently used word. The studies are distributed within their categories as follows: one experimental study, two new methods or process development, and one potential determination.

Biomass Conversion & Hydrogen Storage: Two articles and a book chapter were published in 2022 and 2024, both of which are in English. Five authors worked on the preparation of the studies, and they used 16 different keywords. The authors work in four different institutions. Renewable energies and solar power generation

were the most frequently used words. One of the studies was prepared in accordance with the mathematical modelling & theoretical based category. The other one is about policy development.

Hybrid Systems & Hydrogen & Hydropower: Three articles, two of which were single-authored, were prepared in English. The remaining study had three authors, and the average citations per document is 115.7, while the author's keywords are 16. Two of the studies were published in the International Journal of Hydrogen Energy. The most relevant affiliations were with Yildiz Technical University. Hydroelectric power, hydropower energy, renewable energy, and solar power generation were the most frequently used keyword groups. Each of the prepared publications belongs to a different category. These categories are literature & statistical analysis, policy development, and potential determination.

Hybrid Systems & Hydrogen & Geothermal: Six English studies have been published in the genres of articles and conference papers. One of the studies has a single author, while 10 authors worked on the preparation of the other five studies. Average citations per document is 23.67, while the author's keywords are 28. All the studies have been published through different publishers. Ontario Technical University and Yildiz Technical University share the first place for the most relevant affiliation. Geothermal energy is the most frequently used keyword group, followed by energy policy. One study belongs to the comparative case study category. Another study is in the environmental impact analysis category. Two publications were identified in the literature & statistical analysis category. There is also one study in the performance R&D category. Finally, there is one publication in the policy development category.

Hybrid Systems & Fuel Cell: 23 studies have been published in the English language as articles, book chapters, conference papers, and review genres. Four of the studies have a single author. The remaining 19 studies have been prepared by 45 authors. The international co-authorship is 13.04%. Average citations per document is 57.3, and the authors' keywords are 77. 2018 was the year with the most studies (5) produced. The International Journal of Hydrogen Energy was the journal with the most studies published. The most relevant affiliation was with Pamukkale University. Fuel cells were the most frequently used keyword group, while photovoltaic cells came in second. When examining the categories, eight publications were identified in the comparative case study category. Three publications were prepared as an experimental study. Eight publications were in the mathematical modelling & theoretical based category. One study was about new method or process development, while three publications were evaluating performance R&D.

Hybrid Systems & Cofiring + Biomass: In 2013, a study that was about new method or process development was prepared as an article in English. The average citations per document is 14, and the article was prepared by two authors. The authors used five keywords to describe the study. The article was published in the International Journal of Environmental Research. Gazi University and the University of Ulster are the institutions to which the authors are affiliated.

Hybrid Systems & Solar & Geothermal; Six studies were published in English. Document genres were article and review. One of the studies is single-authored. There is no international co-authorship. Average citations per document is 37.67, while the author's keywords are 30. 2016 was the year with the most studies (2), and 2011 was the year with the most citations. Renewable Energy is the preferred journal for the publication of these studies. Turkey is the most frequently used keyword group. The numbers in the publication categories are as follows: one publication is related to a comparative case study, the other one is about an experimental study, one publication is on literature & statistical analysis, and one publication is about mathematical modelling & theory based. Finally, one study was conducted in the performance R&D and policy development categories.

Hybrid Systems & Solar: Three studies were prepared in English and Turkish in the genre of an article. The average citations per document is 29, and the authors' keywords are 14. The number of citations was the highest in 2013. Energy Conversion and Management, Journal of the Faculty of Engineering and Architecture of Gazi University, and Thermal Science journals are preferred for the publication of the studies. Atilim University is the university with the most relevant affiliation. Solar energy was the most frequently used keyword group. Two of the studies are experimental studies, while the remaining belong to the mathematical modelling & theoretical based category.

Hybrid Systems & Solar & Biogas: Two studies in the English language were prepared in the form of articles. All studies were prepared with the contribution of four authors. Average citations per document is 395.5, while the author's keywords are 11. 2013 is the year with the most citations. Each of the studies was published in a different medium. Ege University has the most relevant affiliations. Biogas and solar energy were the most frequently used keyword groups. Both publications are experimental studies.

Hybrid Systems & Solar & Hydrogen: Five studies have been prepared in English in the genres of article, book chapter, and conference paper. One of the studies has a single author, and 15 authors have worked on the studies in total. The international co-authorship rate has been determined as 20%. While preparing the studies, the authors used 21 keywords. Average citations per document was 105.6, and the year in which the most studies were produced was 2011. The International Journal of Hydrogen Energy has been the most preferred institution for the publication of studies. Middle East Technical University was the first one to which the authors working on the preparation of the studies are affiliated. The most used keywords were solar energy production, hydrogen, and solar energy. Three of the publications are in the experimental study category; the others are in the mathematical modelling & theoretical based and new method or process development category.

Hybrid Systems & Solar & Wind; 10 studies have been published in English in the types of articles, conference papers, and reviews. In total, two of the studies in which 19 authors worked have a single author. International co-authorship was 20%, the average citations per document was 70.2, and the authors used 39 keywords while preparing the studies. 2013 was the year in which the most studies were prepared. The Energy and Buildings journal is the first preferred journal, while Istanbul Technical University and Ege University Solar Energy Institute are the most relevant affiliates. Hybrid systems are the most frequently used keyword groups. When the categories of publications are examined numerically, the following results emerge: one experimental study, two mathematical modelling & theoretical based, two new method or process development, one performance R&D, and four potential determinations.

Hybrid Systems & PV & Wind: 13 English studies were prepared in the genres of article, book chapter, conference paper, and review. The international co-authorship was 7.69%, while average citations per document were determined as 20, and the studies were prepared using 39 different keywords, with the most published in 2021. Istanbul Technical University and the University of Science and Technology of China were the most linked institutions in the studies. The most frequently used keyword groups were renewable energy resources. If the publications are evaluated according to categories, the results are as follows: there are six publications in the mathematical modelling & theoretical-based category, one in the new material & design development category, two in the performance R&D category, two in the policy development category, and two in the potential determination categories.

Hybrid Systems & PV: Five English studies were prepared in the genres of article, book chapter, and conference paper. There is no international co-authorship or single-authored publication. Nine authors in total took part in the studies. Average citations per document were 12.6, while 17 keywords were used while preparing the studies. The most contributions to the studies came from Yildiz Technical University. Economic analysis was the most frequently used keyword group. The categories of publications are distributed as follows: one comparative case study, two new methods or process developments, one performance R&D, and one potential determination.

Hybrid Systems & Wind: Nine English studies were prepared in the genres of article and conference paper. The international co-authorship was determined as 11.11%, and the average citations per document was determined as 52.89, while 39 keywords were used. 20 authors took part in the preparation of the studies, while only two of the studies were single-authored. The years in which the most studies were produced were 2010 and 2013. Ege University is in first place among the most relevant affiliations. The Energy Journal was the most preferred. Wind power was the most frequently used word group, while Turkey followed it. Among the nine studies, four were prepared in the mathematical modelling & theoretical based, two in the new method or process development categories. One study was prepared in the performance, R&D, policy development, and potential determination categories.

Hybrid Systems & CHP: Three studies were published in the English language as articles and conference papers. One of the studies was single-authored, while the other six authors contributed to the preparation of the remaining two studies. There is no international co-authorship, and the average citations per document are five. The number of keywords used by the authors. The most citations were received in 2014. The studies were published in three different media, and the authors who took part in the preparation of the studies worked in three different institutions. Biomass, lignite, renewable energy, and Turkey were the most frequently used keyword groups. The studies were prepared in the categories of literature & statistical analysis, mathematical modelling & theoretical-based, and new method or process development.

Solar Energy Systems & ANN: Four studies in the genres of articles were accessed. One of the studies has a single author, while there is no international collaboration. Average citations per document is 65.75, and the author's keywords used are 16 in total. Most studies (2) were published in 2014. 2012 was the year with the most citations. Four different media were preferred for the publication of the studies. Istanbul Technical University is the first with the most relevant affiliation, while four different institutions contributed to these studies. The most frequently used keyword groups were neural networks and Turkey. One of the studies belongs to the two new method and process development categories. The others are prepared in accordance with the experimental study and mathematical modelling & theoretical based categories.

Solar Energy Systems & Solar Collector: Nine English studies in the genres of articles and conference papers were accessed. The international co-authorship rate is 11.11%, while the authors of a single-authored document are just one, and the remaining eight studies were prepared by 29 authors. The average citation per document is 105. The authors used 37 keywords while preparing the studies. 2015 was the year in which the most studies (3) were produced, while 2013 was the year with the highest number of citations (66.1). The studies were published in nine different media forms. The authors who worked on the studies were from nine different institutions, among which Université Abdelmalek Essaâdi Tanger contributed the most. Exergy was the most frequently repeated keyword group. Seven publications were prepared as experimental studies. The remaining ones are suitable for the environmental impact analysis and new material & design development categories.

Solar Energy Systems & Energy Storage: 10 different studies were identified in English. These studies are in the types of articles, book chapters, conference papers, and reviews. 26 authors were involved. There is just one author of a single-authored document. The international co-authorship rate is 10%. Average citations per document is 13.8, and the author's keyword number is 41. The most citations were received in 2016 (6.8). Different media were preferred for releasing the studies. In the most relevant affiliations category, Istanbul Technical University and New Mexico State University share first place. Solar energy and energy were the most frequently used words. The categories of publications are as follows: three new method & process development, one mathematical modelling & theoretical based, five experimental studies, and one comparative case study.

Solar Energy Systems & PV: 23 documents were identified. These documents are in English, in the types of articles, book chapters, conference papers, and reviews. Three of them are single-authored. A total of 62 authors worked. The international co-authorship rate was determined as 13.04%, and the co-author rate per document was 3.04. The authors used a total of 90 keywords. The average citations per document is 30.22. 2021 was the year with the most citations (11.4). Renewable and Sustainable Energy Reviews was the most preferred journal. Istanbul Technical University is in first place, and Duzce University is in second place. Solar energy and solar power generation are the most frequently used word groups. The category distribution of publications is as follows: one comparative case study, eight experimental studies, two informational studies, one literature-based & statistical search, two mathematical modelling & theoretical-based, two new material & design development, four performance R&D, one policy development, and two potential determinations.

Solar Energy Systems & Radiation: 12 different studies were published in various types of articles and book chapters. Two of the studies have a single author. The total number of authors is 25. The international co-authorship rate is 8.33%. The average citations per document is 12.92. The authors used 45 keywords. The year in which the most studies (3) were produced was 2020. The most citations were received in 2024. International

Journal of Green Energy was given priority. In the most relevant affiliation category, Karabuk University ranks first, and solar radiation and solar energy are the most frequently used words. While only one of the studies is in the comparative case study category, four of them are in the experimental study category, two of them are in the mathematical modelling & theoretical-based category, one of them is in the new method & process development category, and four of them are in the potential determination category.

Solar Energy Systems & Solar Cell; In English, four documents were identified in the types of articles and conference papers. In total, the studies were prepared by 11 authors. The authors used 252 different keywords. The average citations per document is 23.75. 2017 was the year in which the most citations (9) were received. The most frequently used keyword groups are photovoltaic cells. Two publications were prepared in the comparative case study category. The other two publications were prepared in the experimental study and performance R&D categories, respectively.

Solar Energy Systems & Solar Thermal; In English, two documents were identified as being of the type of article. Both studies are single-authored. There is no international co-authorship. The authors used nine different keywords. The average citations per document is 60. 2013 was the year in which the most citations (6.2) were received. One study is in the informational study category, while the other study is in the policy development category.

4. CONCLUSION

Using the Biblioshiny tool for a thorough assessment of publications from the Scopus database, this study successfully conducted a bibliometric analysis of the scientific literature on renewable energy. Important trends, difficulties, and gaps in the subject were emphasized by focusing on articles published between 2008 and 2024. According to the study, interest in renewable energy has increased dramatically in recent years, with a primary focus on determining potential and developing policies, followed by experimental research and mathematical modelling. The results show that the development of novel materials and designs accounts for a lesser percentage of the studies, indicating a potential field for more research.

A more precise comparison of trends in the renewable energy industry was made possible by the combination of a manual literature review and meta-analysis using the Biblioshiny tool. It is significant to remember that the study only covered the years 2008–2024, excluding 2024. Nevertheless, it is evident from the patterns that research on renewable energy is becoming increasingly important. This analysis, which was carried out using the Biblioshiny program and R software, provides insightful information about the developing field of renewable energy. Additionally, it contributes to a sustained increase in publications, offering a more comprehensive and nuanced view of the industry. To further strengthen the field of renewable energy, future research can build on these findings by extending studies in areas like design development and new materials.

Conflict of Interest: The authors declare no competing interests.

Ethical Approval: Ethical approval was not required for this study as it is literature-based research with no involvement of human or animal subjects.

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REFERENCES

Adamczak, M., Broda, M., Kurzyńska, K., Łucka, K., & Graczyk-Kucharska, M. (2024). Sustainable marketing: A scientometric analysis using Biblioshiny and the R package. *Annales Universitatis Mariae Curie-Skłodowska, sectio H–Oeconomia*, *58*(3), 31-49. https://www.ceeol.com/search/article-detail?id=1264818

Akbaş, H., & Bilgen, B. (2017). An integrated fuzzy QFD and TOPSIS methodology for choosing the ideal gas fuel at WWTPs. *Energy*, *125*, 484-497. https://www.sciencedirect.com/science/article/pii/S0360544217303365

Aktekin, M., Genç, M. S., Azgın, S. T., & Genç, G. (2024). Assessment of techno-economic analyses of grid-connected nuclear and PV/wind/battery/hydrogen renewable hybrid system for sustainable and clean energy production in Mersin-Türkiye. *Process Safety and Environmental Protection*, *190*, 340-353. https://www.sciencedirect.com/science/article/pii/S0957582024008607

Aria, M., & Cuccurullo, C. (2017). Bibliometrix: An R-tool for comprehensive science mapping analysis. *Journal of informetrics*, *11*(4), 959-975. https://www.sciencedirect.com/science/article/pii/S1751157717300500

Aydin, N. Y., Kentel, E., & Duzgun, S. (2010). GIS-based environmental assessment of wind energy systems for spatial planning: A case study from Western Turkey. *Renewable and Sustainable Energy Reviews*, *14*(1), 364-373. https://www.sciencedirect.com/science/article/pii/S1364032109001610

Babyr, N. V. (2024). Topical themes and new trends in the mining industry: Scientometric analysis and research visualization. https://www.sid.ir/paper/1500719/en

Bergougui, B., & Ben-Salha, O. (2025). The Impact of Environmental Governance on Energy Transitions: Evidence from a Global Perspective. *Sustainability*, *17*(19), 8759. https://www.mdpi.com/2071-1050/17/19/8759

Cai, C., Hazaea, S. A., Hael, M., Al-Matari, E. M., Alhebri, A., & Alfadhli, A. M. H. (2024). Mapping the landscape of the literature on environmental, social, governance disclosure and firm value: a bibliometric analysis and systematic review. *Sustainability*, *16*(10), 4239. https://www.mdpi.com/2071-1050/16/10/4239

Celiktas, M. S., Sevgili, T., & Kocar, G. (2009). A snapshot of renewable energy research in Turkey. *Renewable energy*, *34*(6), 1479-1486. https://www.sciencedirect.com/science/article/pii/S0960148108003972

Donthu, N., Kumar, S., Mukherjee, D., Pandey, N., & Lim, W. M. (2021). How to conduct a bibliometric analysis: An overview and guidelines. *Journal of Business Research*, *133*, 285-296. https://www.sciencedirect.com/science/article/pii/S0148296321003155

Duan, Y., & Guan, Q. (2021). Predicting potential knowledge convergence of solar energy: bibliometric analysis based on link prediction model. *Scientometrics*, *126*(5), 3749-3773. https://link.springer.com/article/10.1007/s11192-021-03901-6

Esen, M., & Yuksel, T. (2013). Experimental evaluation of using various renewable energy sources for heating a greenhouse. *Energy and Buildings*, *65*, 340-351. https://www.sciencedirect.com/science/article/pii/S0378778813003563

ETKB. (2023). *TÜRKİYE ULUSAL ENERJİ PLANI 2022*. ETKB.

Gan, T., Zhou, Z., Li, S., & Tu, Z. (2024). Carbon emission trading, technological progress, and synergetic control of environmental pollution and carbon emissions in China. *Journal of Cleaner Production*, *442*, 141059. https://www.sciencedirect.com/science/article/pii/S0959652624005067

Gökçek, M. (2018). Integration of hybrid power (wind-photovoltaic-diesel-battery) and seawater reverse osmosis systems for small-scale desalination applications. *Desalination*, *435*, 210-220. https://www.sciencedirect.com/science/article/pii/S0011916417308305

Guo, K., Cao, Y., He, S., & Li, Z. (2024). Evaluating the efficiency of green economic production and environmental pollution control in China. *Environmental Impact Assessment Review*, *104*, 107294. https://www.sciencedirect.com/science/article/pii/S0195925523002603

Hassan, Q., Viktor, P., Al-Musawi, T. J., Ali, B. M., Algburi, S., Alzoubi, H. M., ... & Jaszczur, M. (2024). The renewable energy role in the global energy Transformations. *Renewable Energy Focus*, *48*, 100545. https://www.sciencedirect.com/science/article/pii/S1755008424000097

Kara, M., Günay, E., Tabak, Y., & Yıldız, Ş. (2009). Perspectives for pilot-scale study of RDF in Istanbul, Turkey. *Waste management*, *29*(12), 2976-2982. https://www.sciencedirect.com/science/article/pii/S0956053X09003110

Kemeç, A., & Altınay, A. T. (2023). Sustainable energy research trend: A bibliometric analysis using VOSviewer, RStudio bibliometrix, and CiteSpace software tools. *Sustainability*, *15*(4), 3618. https://www.mdpi.com/2071-1050/15/4/3618

Klarin, A. (2024). How to conduct a bibliometric content analysis: Guidelines and contributions of content co-occurrence or co-word literature reviews. *International Journal of Consumer Studies*, *48*(2), e13031. https://onlinelibrary.wiley.com/doi/abs/10.1111/ijcs.13031

Kronthaler, F., & Zöllner, S. (2020). R and RStudio. In *Data Analysis with RStudio: An Easygoing Introduction* (pp. 1-12). Berlin, Heidelberg: Springer Berlin Heidelberg. https://link.springer.com/chapter/10.1007/978-3-662-62518-7_1

Melikoglu, M. (2017). Geothermal energy in Turkey and around the World: A review of the literature and an analysis based on Turkey's Vision 2023 energy targets. *Renewable and Sustainable Energy Reviews*, *76*, 485-492. https://www.sciencedirect.com/science/article/pii/S1364032117304227

Ng, S. L. (2025). A global bibliometric review of climate change and energy policy research: insights for sustainable development and international collaboration. *Discover Sustainability*. https://link.springer.com/content/pdf/10.1007/s43621-025-02343-x_reference.pdf

Obada, D. O., Muhammad, M., Tajiri, S. B., Kekung, M. O., Abolade, S. A., Akinpelu, S. B., & Akande, A. (2024). A review of renewable energy resources in Nigeria for climate change mitigation. *Case Studies in Chemical and Environmental Engineering*, *9*, 100669. https://www.sciencedirect.com/science/article/pii/S266601642400063X

Ortega, J. L., & Delgado-Quirós, L. (2024). The indexation of retracted literature in seven principal scholarly databases: a coverage comparison of dimensions, OpenAlex, PubMed, Scilit, Scopus, The Lens, and Web of Science. *Scientometrics*, *129*(7), 3769-3785. https://link.springer.com/article/10.1007/s11192-024-05034-y

Pata, U. K. (2018). Renewable energy consumption, urbanization, financial development, income, and CO2 emissions in Turkey: testing EKC hypothesis with structural breaks. *Journal of Cleaner Production*, *187*, 770-779. https://www.sciencedirect.com/science/article/pii/S0959652618309132

Peng, W., Morales, C. C., Shiwang, J., Luo, H., Iyer, G., Budolfson, M., & Scovronick, N. (2025). Effects of the low-carbon energy transition on air pollution and health. *Nature Reviews Clean Technology*, 1-14. https://www.nature.com/articles/s44359-025-00070-0

Saidi, K., & Omri, A. (2020). Reducing CO2 emissions in OECD countries: do renewable and nuclear energy matter?. *Progress in Nuclear Energy*, *126*, 103425. https://www.sciencedirect.com/science/article/pii/S0149197020301773

Swain, C. K. (2024). Environmental pollution indices: a review on concentration of heavy metals in air, water, and soil near industrialization and urbanisation. *Discover Environment*, *2*(1), 5. https://link.springer.com/article/10.1007/s44274-024-00030-8

TEİAŞ. (2025). *TEİAŞ*. https://www.teias.gov.tr/

Toklu, E. (2017). Biomass energy potential and utilization in Turkey. *Renewable Energy*, *107*, 235-244. https://www.sciencedirect.com/science/article/pii/S0960148117300861

TÜİK. (2024). *TÜİK Kurumsal*. TÜİK. https://data.tuik.gov.tr/Bulten/Index?p=Dunya-Nufus-Gunu-2024-53680

Uyan, M. (2013). GIS-based solar farm site selection using analytic hierarchy process (AHP) in Karapinar region, Konya/Turkey. *Renewable and Sustainable Energy Reviews*, *28*, 11-17. https://www.sciencedirect.com/science/article/pii/S1364032113004875

Van Eck, N., & Waltman, L. (2010). Software survey: VOSviewer, a computer program for bibliometric mapping. *scientometrics*, *84*(2), 523-538. https://akjournals.com/view/journals/11192/84/2/article-p523.xml

Xu, J., Liu, Q., Wider, W., Zhang, S., Fauzi, M. A., Jiang, L., ... & An, Z. (2024). Research landscape of energy transition and green finance: a bibliometric analysis. *Heliyon*, *10*(3). https://www.cell.com/heliyon/fulltext/S2405-8440(24)00814-4

Ozliman, Y. & Celiktas, M. S. (2025). Mapping renewable energy publications: A bibliometric analysis using RSTUDIO bibliometrix. *World Journal of Environmental Research, 15*(2), 156-180. https://doi.org/10.18844/wjer.v15i2.9923

Żarczyńska, A. (2012). Nicola De Bellis: bibliometrics and citation analysis, from the science citation index to cybermetrics, Lanham, Toronto, Plymouth 2009. *Toruńskie Studia Bibliologiczne*, *8*(1), 155-157. https://www.ceeol.com/search/article-detail?id=264198

Zhang, K., Tao, M., & Hao, J. (2024). Analysis and prediction of factors influencing carbon emissions of energy consumption under climate change. *Strategic Planning for Energy and the Environment*, 81-112. https://journals.riverpublishers.com/index.php/SPEE/article/view/21841

Zou, Z. (2024). Powering the future: application of machine learning to analyze the global renewable energy consumption. In *Proceedings of the 2024 3rd International Conference on Cyber Security, Artificial Intelligence and Digital Economy* (pp. 643-649).