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ARTIFICIAL INTELLIGENCE AND ENERGY TRANSITIONS: A BIBLIOMETRIC AND THEMATIC ANALYSIS OF RESEARCH ON ENERGY MARKETS, POLICY, AND REGULATION

1. Michael Yao-Ping Peng
1. School of Economics and Management, Fujian Polytechnic of Water Conservancy and Electric Power
2. School of Management, Foshan university
s91370001@mail2000.com.tw

2. Malik Shahzad Shabbir (Corresponding Author)
Faculty of Business and Communication, INTI International University, Nilai, Malaysia
malikshahzad.shabbir@newinti.edu.my

3. Aysha Zamir
Sunway Business School, Sunway University, Selangor, Malaysia
aysha.z@imail.sunway.edu.my

4. Andrei Octavian Paraschivescu
Faculty of Economics, Law and Administrative Sciences, George Bacovia University, Bacău, Romania
andrei.paraschivescu@ugb.ro

5. Florin Radu
Faculty of Economics, Law and Administrative Sciences, George Bacovia University, Bacău, Romania
florin.radu@ugb.ro

6. Gabriela Daniela Bordeianu
Faculty of Economics, Law and Administrative Sciences, George Bacovia University, Bacău, Romania
gabriela.bordeianu@ugb.ro

7. Violeta Hazaparu
Faculty of Economics, Law and Administrative Sciences, George Bacovia University, Bacău, Romania
violeta.hazaparu@ugb.ro

8. Gabriela Fotache
Faculty of Economics, Law and Administrative Sciences, George Bacovia University, Bacău, Romania
gabriela.fotache@ugb.ro

9. Adeeb Alhebri
Applied College at Muhayil, King Khalid University, Muhayil, Saudi Arabia

aalhebri@kku.edu.sa

10. Bălan Leonard Sergiu
Aurel Vlaicu University of Arad, Arad, Romania
leonard.balan@uav.ro

11. Iancu Dorin
Valahia University of Târgoviște, Târgoviște, Romania
dorin_iancu04@yahoo.com

12. BONCIU Cătălina-Ioana
Faculty of Administration and Business, Bucharest University
catalina.bonciu@faa.unibuc.ro

13. Ramona Lile
Aurel Vlaicu University of Arad, Arad, Romania
Romanian Academy of Scientists
Ramona.lile@uav.ro

Abstract:

This study looks at how scientific research connects AI, energy markets, and energy policy, focusing on oil, gas, coal, and low-carbon energy systems. It uses Scopus-indexed papers to spot trends, top researchers, leading institutions, and new themes. They follow PRISMA 2020 guidelines for picking studies in a clear, methodical way. However, it does not stop there. The study digs into how tech changes, geopolitics, and moves towards renewable energy shape work in this field. As research grows, it's becoming more interdisciplinary too, pulling in folks from developed and developing countries alike. Much of the focus is on using machine learning and other AI methods for energy forecasting, making optimizations, and crafting policy models. Furthermore, study results show that a lot of research in AI-energy stuff is coming from just a few countries and places. This means big differences in who knows what about this topic still exist. The study helps us see how AI is changing how energy markets work, how policies are made, and the shift towards greener energy systems overall.

Keywords: Bibliometric analysis; Artificial intelligence; Energy markets; Energy transition; Machine learning

JEL Classification: Q40; Q47; O33; O30

1. Introduction

The energy system is undergoing a crucial transformation. The drivers of this transformation are increasing demand, technological innovation, geopolitical shifts, and environmental issues (Pasqualetto et al., 2024; International Energy Agency, 2023, Sadiq et al 2026; Shabbir et al 2026; World Energy Council, 2020; and Aslam et al., 2026). There have always been transitions in energy systems but the present one is highly significant as the consumption of energy has increased many folds. The Intergovernmental panel on climate change has issued a particular report in 2018 that stated that up till 2050 carbon emissions will have to be reduced to net zero globally. It's essential to "restrict temperature increase below 1.5°C above pre-industrial levels". Energy systems are producing two-thirds of carbon emissions globally. To reduce these emissions is not an easy task given the architecture and size of the current energy system and decision-making factors (IEA, 2024; Peng et al 2025; Nawaz et al 2025; Zupic & Čater, 2015; Page et al., 2021; Veith et al., 2026). Transitioning to a lower-carbon energy system is complex. Electrification is necessary for de-carbonization but it accounts for only 19% of the total final consumption of energy whereas the share of fossil fuels is 81%. These trends underscore the need to accelerate the process of transition to clean energies. The second edition of the ETI covered 40 indicators from 115 countries. Its findings are summarized in this paper. The common feature among countries that are better prepared for this energy transition is an enabling environment. The Laggards have poor energy system performance. Their readiness for energy system transition is low as their regulatory frameworks are weak. They are having instability of policies, facing geopolitical issues, and are more dependent on fossil fuel to fulfill their energy requirements (Abdalla et al., 2025; Jiao et al., 2025; and Liu et al., 2025).

During the period from 2018 to 2020, electricity has provided to more than 152 million people each year. Developed countries are ranked better on the ETI, despite that finding a balance between sustainability and growth is hard for them (Aslam et al., 2025; Nawaz et al 2024; and Chen et al., 2025). Whereas, Sub-Saharan African countries have gaps in blanket accessibility of electricity and cleaner fuels for cooking. Whereas, Hanna et al. (2018) utilized meetings with 12 incorporated energy service companies (IESCs) to conduct a subjective investigation of energy efficiency, and discovered the hindrances and hinder factors in vitality proficiency. Similarly, Shafi et al. (2023) discussed few notable economies rely heavily on oil subordinate creation and passages, current low-carbon advancement scattering, imperativeness adequacy and air technique may be significantly diminishing overall enthusiasm for non-renewable energy sources. Whereas, Carbonara and Pellegrino (2018) discussed critical economies are reliant on oil subordinate creation and sections; however current low-carbon progression is dissipating; noteworthiness ampleness and air method might be generously diminishing excitement for non-sustainable energy sources.

This work suggested that G7 economies showed resiliency in the reduction of energy consumption while maintaining sustainable economic welfare (Aslam et al., 2026; Nawaz et al 2024; Alsaigh et al., 2023; and Antonopoulos et al., 2020). To pursue sustainability and sustainable welfare, the provision and affordability of renewable energies are essential. Finally, G7 countries should work towards a sustainable welfare future for themselves and the rest of the world. However, several studies have analyzed the impact of ICT on various environmental and socio-economic variables and offered two-sided conclusions. The positive side suggested that ICT pushes forward the industrialization process, which drives economic and social progress. Hence, the current manuscript makes an important scholarly contribution to energy research through its extensive review of energy market analysis, regulatory trends and policy focus pertaining to artificial intelligence, robotics and automation (Donthu et al., 2021; Hou & Wang, 2023). This interdisciplinary field's dynamics must be clearly understood because both climate change challenges and sustainable energy systems creation require such knowledge to support evidence-based decisions along with innovation promotion. This research combines existing knowledge through bibliometric methods while establishing unexplored research areas that direct educators as well as government officials and business leaders towards the goal of sustainable energy systems (IEA, 2021).

Furthermore, the rest of the manuscript is organized as: section 2 explores literature review: section 3 describes Methodology; section 4 inspected research objectives; and finally conclusion is presented in the last section 5.

2. Literature Review

Over the last few years, one of the major areas of “research and development” has been the utilization of air and sunlight as a significant source of energy from renewable sources (RE). The advancement of innovative technology for optimal production from the natural resources already in place, environmental awareness, and improved management and distribution systems make up the majority of the current and future advancements in renewable energy. Similar to other industries (health, food, safety, housing, etc.), artificial intelligence (AI) may help the RE accomplish its long-term objectives. Several projects have used biologically and statistical and inspired AI techniques to accomplish shared and future goals of the RE. The review of evaluations and the most recent results from cutting-edge research on solar, wind, geothermal, ocean, hydro, bioenergy, hybrid energy, hydrogen, and sources are summarized in Jha et al. (2017).
By 2050, a lot of nations hope to be using only renewable energy sources. Due to the current dramatic rise in the use of renewable energy sources (RE) in the "global energy mix" and its ongoing influence on the energy industry, there hasn't been enough analysis and research done on how RE affects the achievement of sustainable development objectives. Additionally, an evaluation of artificial intelligence's growing involvement in the use of renewable energy to meet SDGs is carried out (Aslam et al., 2026; and Cali et al., 2026).

In the beginning of the 2000s, Germany shifted its energy mix away from nuclear power and coal and toward renewables like solar, biomass, and wind power in response to grassroots NIMBY steps against radioactive power and a growing need for independence from fossil fuels (see the conflict in Ukraine). By 2050, the country wants to generate 80% of its power from sources of renewable energy. Thus, Germany's energy mix consists of both conventional energy sources that are being gradually phased out and a variety of renewable sources of energy. Let us now examine the hydroelectric power bundle of Brazil. Brazil's numerous waterfalls and rivers provide an abundance of hydroelectric energy, which accounts for most of the nation's electrical production. But as the frequency of severe droughts increases, the nation is also making investments in natural gas and other sources of clean power like solar and wind electricity. Renewable energy, natural gas, and hydroelectricity make up Brazil's energy mix (Sturm, 2022).

Furthermore, certain nations are privileged to select their energy mix at will, but wealthier nations with better natural resource-endowed funds are not afforded this choice. Limits and regulations can support uncompetitive renewable energy sources, while protective regulations like subsidies for the use of renewable energy can also drive out efficient fossil fuel sectors in emerging nations (IEA, 2021). Similarly, Saudi Arabia energy bundles is diversifying outside its primary oil export. MBS is shifting to wind and solar power in an effort to meet its 2030 target of obtaining 50% of its power from renewable sources after realizing the unpredictability of relying primarily on the cost of oil. As a result, the Saudi energy mix is evolving to match their evolving macroeconomic interests, moving toward a more balanced mix of renewables and oil. The second aspect of this analogy is that nations will select the energy bundle with the lowest feasible cost, just like consumers do. Realizing that the definition of "cost" varies based on a nation's degree of development is vital, though (Aslam et al., 2026).

There is a lack of convergence in the existing literature on the nature of the causality relationship between growth and energy usage. Whereas, G7 is a group of the seven biggest economies in the world. Their policies hugely impact the world economy. This group has distinct characteristics from the rest of the economies. It should be studied separately for energy-growth and sustainability analysis. They also engage in constructive dialogues with the under-developed world to take developmental initiatives.

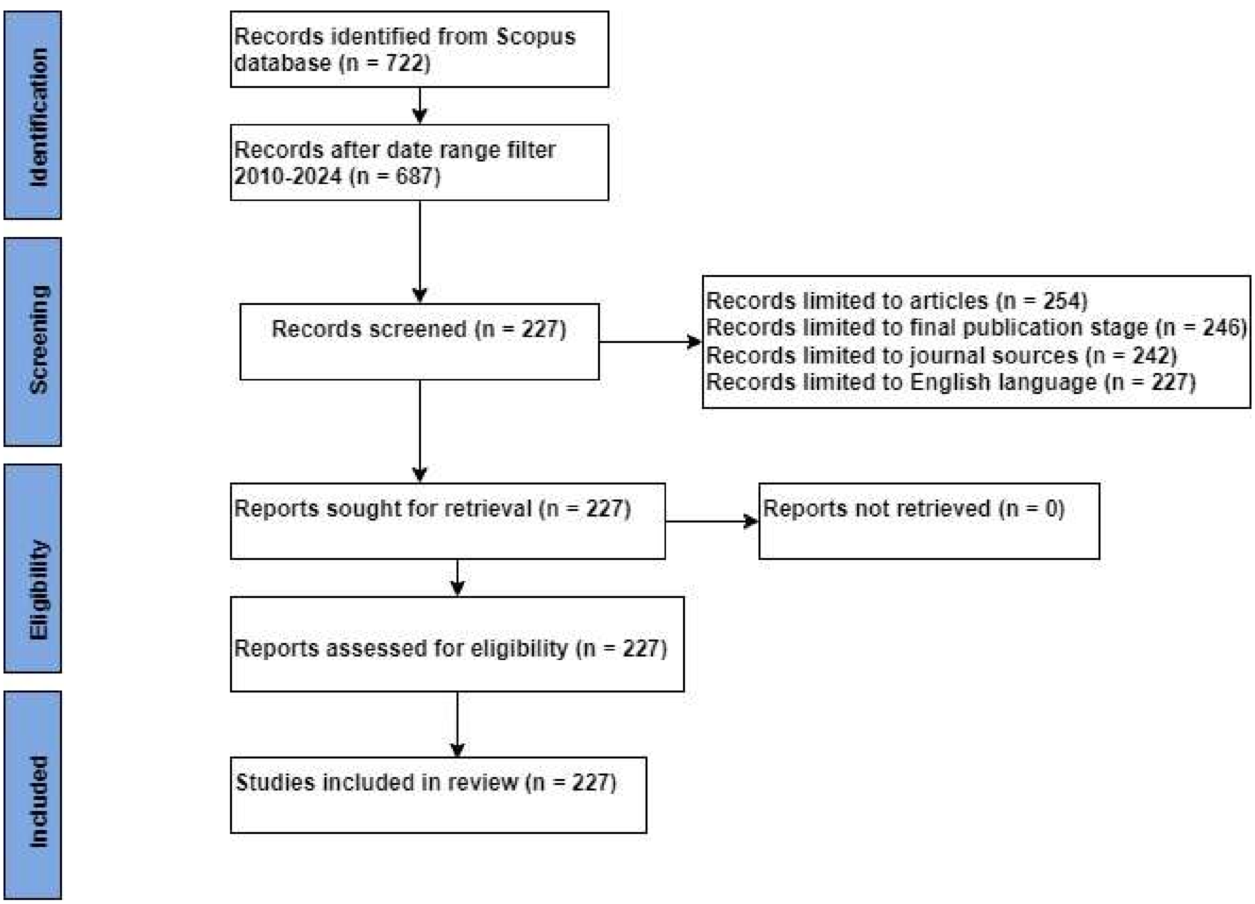
3. Methodology

This study employs a systematic bibliometric analysis to examine the intersection of energy markets, regulations, and policy with artificial intelligence, robotics, and automation. The methodology follows the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) 2020 guidelines to ensure a comprehensive and transparent approach to literature selection and analysis.

3.1.Data Source and Search Strategy

The Scopus database was selected as the main one for this research since it offers an extensive amount of literature in the form of peer-reviewed articles on different topics (Talpur et al., 2023; and Sikandar et al., 2023). The search was conducted using the following string: TITLE-ABS-KEY ("Energy Security*" OR "Energy Regulation*" OR "Energy Markets*" OR "Energy Sector*" AND "Artificial Intelligence*" OR "robotics*" OR "Automations*") AND PUBYEAR > 2009 AND PUBYEAR < 2025 AND (LIMIT-TO (DOCTYPE , "ar")) AND (LIMIT-TO (PUBSTAGE , "final")) AND (LIMIT-TO (SRCTYPE , "j")) AND (LIMIT-TO (LANGUAGE , "English")). This search string was used to find articles related to energy security, regulation, markets, or industry with regard to artificial intelligence, automation, and robotics.

We implemented the PRISMA (Preferred Reporting Items for Systematic Reviews and Meta-Analyses) framework to systematically identify and screen relevant articles from the Scopus database. Initially, we identified a total of 722 records. A date range filter was applied to include only publications from 2010 to 2024, reducing the number of records to 687. We then limited the records to only articles, which further narrowed the pool to 254 entries. To ensure the quality and relevance of the data, we included only articles that had reached the final publication stage, were sourced from journals, and were available in the English language, resulting in 227 records being screened. During the screening phase, no records were excluded, allowing us to proceed with seeking retrieval for all 227 records. Figure 1 presents the PRISMA flow diagram for this research.

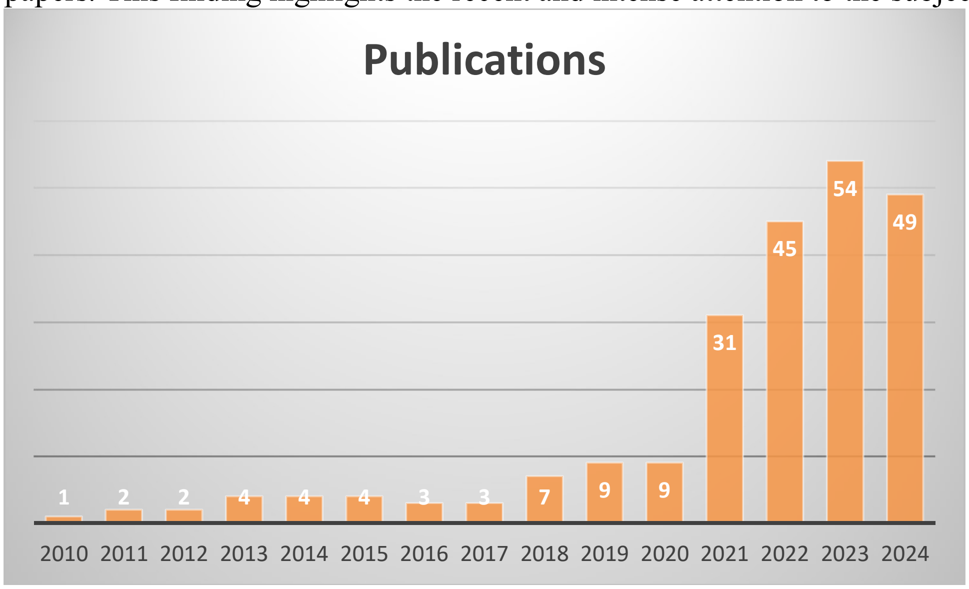


Our preliminary search produced an aggregate of 227 studies that fulfilled all the set-inclusion requirements.

4. Results

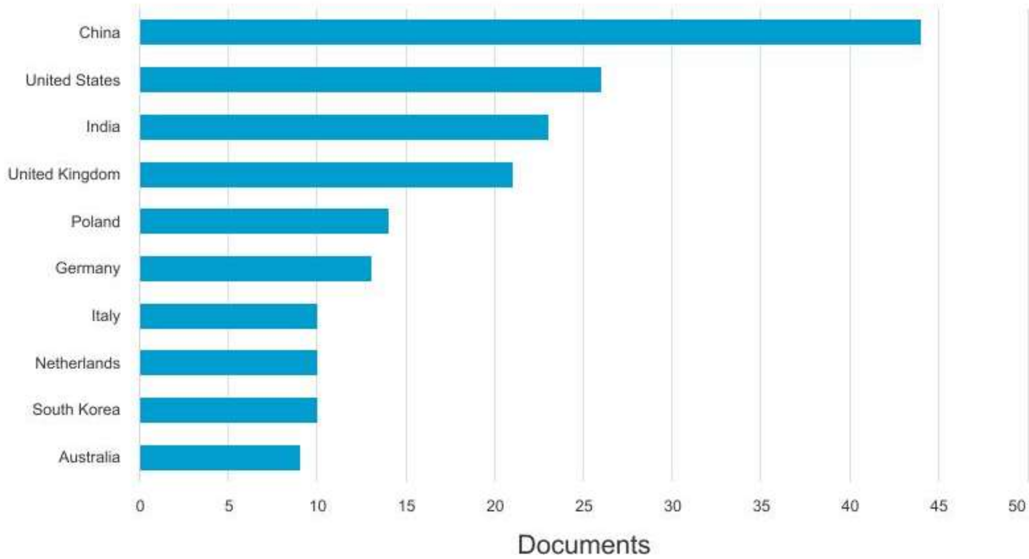
4.1.Publication output

The graph below depicts the pattern of publications in the research domain between 2010 and 2024. A steady increase in scientific outputs is evident during the period under consideration. Low publication productivity is observed in the first seven years (2010-2017). Specifically, the number of published papers varies between 1 and 4 annually. A moderate increase in scientific outputs occurs from 2018 with the production of 7 publications, followed by 9 papers in 2019 and 2020. However, compared to pre-2021 years, there is an extremely high level of publication activity. It should be emphasized that over the last four years (2021-2024), there is the largest volume of scientific outputs accounting for 179 out of 227 papers. This finding highlights the recent and intense attention to the subject under investigation.



4.2.Top contibuting countries

We have also analyzed the top countries contributing to the literature in the chosen field. The figure presents how research documents were allocated across various countries in a certain field, showing clear differences in their scholarly productivity levels. China occupies the first place in the table, having about 44 documents. It is far ahead compared to any other country included in the list. The USA follows with 28 documents, followed by India and the UK which have about 25 and 23 documents respectively. There is quite a large gap between the leading countries and the following group including Poland, Germany, Italy, The Netherlands, and South Korea with about 10-15 documents each. Australia has taken the tenth place on the list with around 8 documents. From this allocation of research participants we can see that our research is conducted globally, as it includes many countries from Asia, North America, and Europe. Furthermore, it highlights China's significant investment in the area and their keen interest therein. As shown by the graph below, there is high activity in terms of research, although it is limited to a select few countries. The above observation is attributed to the varying degrees of involvement in studying energy markets, regulation, and policies related to AI technologies.



4.3.Top authors

The study includes the identification of the top scholars whose research works consist of at least three documents related to the domains of energy markets, regulations, and policy. The chart presents several key details about each author such as number of documents published, institution affiliations, Scopus ID, total number of citations, and H-index. These scholars are Rasikh Tariq from Tecnológico de Monterrey (4 documents, H-index 18), Ameni Boumaiza from Qatar Environment and Energy Research Institute (3 documents, H-index 7), Mir Sayed Shah Danish from University of the Ryukyus (3 documents, H-index 21), Haris Ch Doukas and Vangelis Marinakis from National Technical University of Athens (H-indices 38 and 20 respectively), and Chien-Chiang Lee from Adnan Kassar School of Business (the largest number of citations, 21,700 and H-index 80).

Author	Number of documents	Affiliation	Scopus ID	Citation	H Index
Tariq, Rasikh	4	Tecnológico de Monterrey, Mexico	57200243861890	890	18
Boumaiza, Ameni	3	Qatar Environment and Energy Research Institute , Doha, Qatar	58003466800	121	7
Danish, Mir Sayed Shah	3	University of the Ryukyus, Nishihara, Japan	56432549200	1444	21
Doukas, Haris Ch	3	National Technical University of Athens (NTUA), Athens, Greece	8626662500	5062	38
Lee, Chien-Chiang	3	Adnan Kassar School of Business, Beirut, Lebanon	8601620600	21700	80
Marinakis, Vangelis	3	National Technical University of Athens (NTUA), Athens, Greece	55386639700	1503	20

The next section will explore the findings from the bibliometric analysis, focusing on aspects such as co-authorship patterns among authors, collaboration between countries, and the co-occurrence of keywords.

Analysis that follows will offer us an opportunity to gain knowledge about collaborative networks in the field, geographical distribution of research collaboration, and popular topics in literature

4.4.Bibliometric analysis

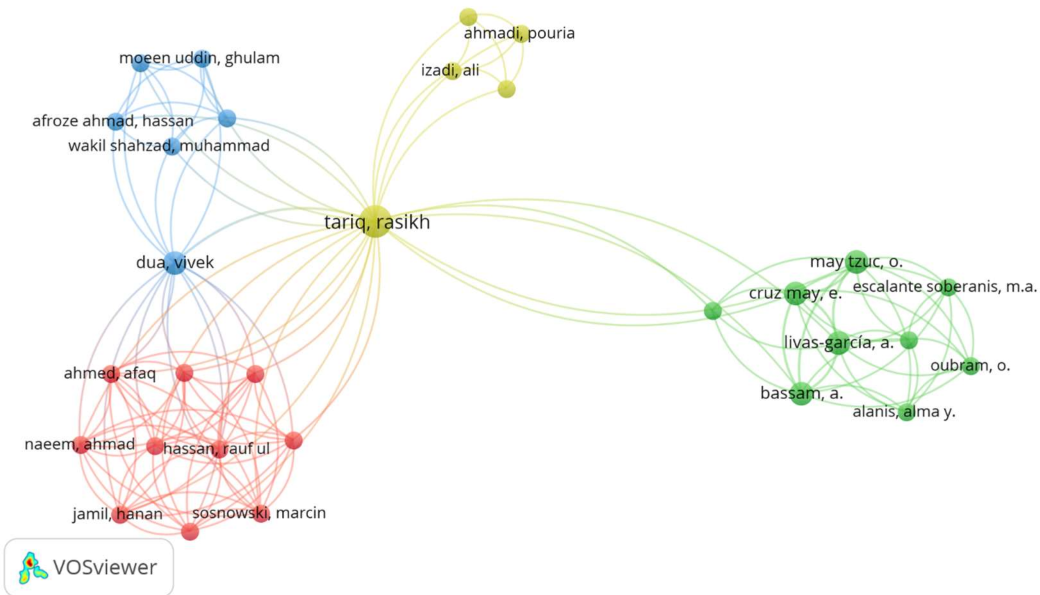
For bibliometric analysis, we used a program called VOSviewer that is dedicated to creating visualizations of bibliometric networks. It enabled us to construct co-authorship, co-citation, and keywords co-occurrence networks that helped us to detect the most influential authors, papers, and clusters of research in the field. Through the use of VOSviewer, we managed to obtain a full picture of the development of research in energy market and policy. Our methodology provides a reliable analysis and offers us some insight into the scholarly debates on the topic. In turn, this will facilitate the identification of research trends, influential works, and possible shortcomings, helping us understand the evolution of this field better.

4.5.**Authorship of co-authors**

For this research, a co-authorship analysis was performed in order to determine the collaborative networks and prominent scholars who worked on issues related to energy markets, regulations, and policies. One of the primary methods that can be applied to studying research collaboration (RC) is the co-authorship analysis. In this particular case, we analyzed the co-authorship network of authors by applying VOSviewer software and choosing such options as at least one paper per author and zero citation per author. Thus, we obtained the full list of authors who participated in this research area regardless of their experience in this field (from beginners to renowned scholars). There were 893 authors who fit this criterion and participated in our co-authorship analysis. Table 1 provides links between authors who worked together. These links show the number of times an author collaborated with his/her colleagues. Total Link Strength (TLS) is the sum of link strengths (Eck and Waltman, 2020).

The results of our study include the following points:

1. Tariq, Rasikh appeared to be the most connected researcher with 25 links, 26 connections strength, 4 documents, and 50 citations. This means that Tariq is a pivotal person in the network of collaboration in this field of study.
2. Another researcher who displayed considerable collaboration level was Dua, Vivek with 16 links, 17 connections strength, 2 documents, and 44 citations.
3. Finally, there was a set of researchers, whose data were absolutely identical: namely, they had 9 links, 12 connections strength, 2 documents, and 25 citations each, which included the following authors: Bassam, A., Cruz May, E., Livas-García, A., and May Tzuc, O.
4. Interestingly, a large group of authors (Ahmed, Afaq; Ashraf, Waqar Muhammad; Farhan, Muhammad; Hassan, Rauf Ul; Jamil, Hanan; Krzywanski, Jaroslaw; Naeem, Ahmad; Nazeer, Muhammad Aarif; Sosnowski, Marcin; Uddin, Ghulam Moeen) all showed identical metrics with 11 links, a total link strength of 11, 1 document, and 11 citations each. This could indicate a single, large collaborative project involving all these researchers.
5. Alanis, Alma Y., Escalante Soberanis, M.A., and Oubram, O. formed another distinct group with 7 links, a total link strength of 7, 1 document, and 19 citations each.



Authors	Links	Total link strength	Documents	Citations
Tariq, Rasikh	25	26	4	50
Dua, Vivek	16	17	2	44
Bassam, A.	9	12	2	25
Cruz May, E.	9	12	2	25
Livas-García, A.	9	12	2	25
May Tzuc, O.	9	12	2	25
Ahmed, Afaq	11	11	1	11
Ashraf, Waqar Muhammad	11	11	1	11
Farhan, Muhammad	11	11	1	11
Hassan, Rauf Ul	11	11	1	11
Jamil, Hanan	11	11	1	11
Krzywanski, Jaroslaw	11	11	1	11
Naeem, Ahmad	11	11	1	11
Nazeer, Muhammad Aarif	11	11	1	11
Sosnowski, Marcin	11	11	1	11
Uddin, Ghulam Moeen	11	11	1	11
Alanis, Alma Y.	7	7	1	19
Escalante Soberanis, M.A.	7	7	1	19
Oubram, O.	7	7	1	19

Analysis of this data (figure 2) using VOSviewer showed clear clusters of researchers, indicating the areas that are centers of collaboration and influence in the studied scientific field. These clusters probably indicate the different fields of research in the general topic of energy markets, regulation and policies. Analysis of co-authorship indicates the need for collaboration in the development of research in the scientific field and gives insight into the possible opportunities for collaboration in other areas. The emergence of clusters of researchers indicates the presence of research groups, while highly linked authors can serve as bridges between the different research groups.

It would be interesting in future research to explore the research topics of each cluster, their relationships with each other, and the flow of knowledge in them. Analysis of co-authorship by time periods would be an informative addition to this analysis.

5. Conclusion

The present bibliometric analysis provides vital information about the development of research related to the dynamics of energy market, regulatory policies, and the incorporation of artificial intelligence and automation in the field. Through the analysis of 227 scholarly papers written during the period from 2010 to 2024, we can conclude that the examined area is quite productive and highly dynamic. The coauthorship pattern indicates the importance of international collaboration as a driving force behind the progress in the research area. Such researchers as Tariq, Rasikh and Dua, Vivek have shown themselves as important contributors to research collaboration.

When considering countries globally, the countries such as India, China, United Kingdom and the United States display high levels of international collaboration. The TLS indices of these countries are extremely high, which shows the importance of the role these nations play in the global network of energy researchers dealing with various challenges in the field.

To sum up, this bibliometric study offers a detailed assessment of modern scientific developments within energy markets, regulations, and policies with a particular emphasis on the increasing role of artificial intelligence technology. In order to overcome existing energy-related problems in the future, it will be essential to involve interdisciplinary cooperation on the international scale and implement advanced technologies effectively. The fluidity of this field makes it evident that this line of research will remain highly significant as it continues to influence the future of global energy systems and policies.

5.1.Limitations

Despite being able to demonstrate the fast development of energy-oriented studies into more technological and environmentally oriented directions, there are certain limitations to this research which should be mentioned. First of all, it is worth noting that only studies written in English and published in the Scopus database were included in this review, which may have caused some papers to be overlooked.

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