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Evolution of Research on Energy Import Dependency: Collaboration Networks, Thematic Trends, and Emerging Hotspots

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Abstract
This study aims to reveal the evolution and main trends of the academic literature on energy import dependency through a comprehensive bibliometric analysis. The study analyzed publications from SCOPUS and Web of Science databases between 2000 and 2024. The methods used include visualization of publication trends, author and country collaboration networks, keyword co-occurrences, and thematic changes over time. As a result of the analysis, it was determined that themes such as "energy security", "renewable energy", "sustainability", and "vulnerability" came to the fore, especially in the last decade. In addition, it was found that author and country collaboration networks exhibited a strong structure at both interdisciplinary and international levels. The findings demonstrate that energy import dependency is no longer merely a technical or economic issue but has evolved into a multidimensional research area encompassing sustainability, diversification, and energy policies. As a result, this study serves as a valuable reference for the current state and future development of the field.

Keywords
Energy import dependency, energy security, renewable energy, sustainability, bibliometric analysis

Introduction

Energy import dependence is critical to economic stability, sustainable development, and national security in global energy systems. Increasing global energy demand, the uneven geographical distribution of energy resources, and the depletion of fossil fuel reserves compel countries to rely on external resources, rendering this dependence a strategic challenge (Wan et al., 2024; Chen & Nouseen, 2025; Karpavicius & Balezentis, 2025). Pandemics, wars, and trade disputes in recent years have further exacerbated the impact of energy import dependence on economic fragility and price volatility. The balance between energy security and import dependence is crucial for both energy and environmental policies, as well as climate policies. The proliferation of renewable energy technologies, the diversification of energy portfolios, and energy efficiency strategies play a crucial role in reducing import dependence (Rahman, Richards, Dargusch, & Wadley, 2025). Reducing energy import dependence increases the competitiveness of national economies and supports environmental sustainability. In this context, energy import dependence, taking on a multidimensional, interdisciplinary, and increasingly complex structure, requires comprehensive scientific analysis (Lekavičius et al., 2024; Kang, 2025; Longaric et al., 2025). Energy efficiency improvements and national renewable energy production are key to reducing imports. Shifts in the global energy value chain and countries' energy dependency networks offer new perspectives for understanding this complex structure (Román-Collado & Casado Ruíz, 2024). The relationship between the clean energy transition and energy security in significant economies, such as the BRICS countries, is being examined in the context of economic policy uncertainty. These developments demonstrate that energy import dependence constitutes a crucial foundation for future research agendas.

In recent years, significant transformations have occurred in energy import dependency. Rapid advances in renewable energy technologies have partially reduced the need for energy imports in many countries, enabling them to make their energy portfolios more sustainable (Neumann, Hampp, & Brown, 2025). However, recent geopolitical and global developments, such as the Russia-Ukraine war and the COVID-19 pandemic, have raised new concerns about energy supply security (Liu et al., 2024; CSIS, 2024). In particular, the European Union and China are developing multifaceted strategies based on the transition to renewable energy, energy efficiency, and supply diversification to reduce energy import dependency (Merics, 2024; Charfeddine & Rahman, 2025). Today, sustainability and environmental concerns have become fundamental axes of energy policies. Energy import dependency has made the complex relationships between economic growth, environmental protection, and social welfare more visible. While energy portfolio diversification and efficiency practices are prominent in the literature, the relationship between economic fragility and energy security is also examined through multidimensional analyses (Guarascio, Reljic, & Zezza, 2025; World Economic Forum, 2025). These developments demonstrate that energy import dependency remains central to both national and global scientific and political agendas.

This research uses bibliometric methods to analyze trends, thematic clusters, and international cooperation structures in energy import dependency. The increasing importance of energy security, sustainability, and renewable energy themes in the literature plays a critical role in determining the direction of scientific production (Lee & Lee, 2021; IRENA, 2022; Capellán-Pérez et al., 2019). However, the number of systematic bibliometric reviews that holistically address these topics is still limited. Our study is one of the rare studies that examines the evolution of energy import dependency research through keyword analyses, co-authorship network maps, and temporal trends (Ağbulut et al., 2023). Detailed analyses conducted at the country, author, and institutional levels reveal the complexity and diversity of the current research ecosystem. Furthermore, the impact of international scientific collaborations and knowledge flows on energy policies was examined multidimensionally using bibliometric approaches (Guan et al., 2022; IEA, 2023). Keyword co-occurrence analyses revealed new thematic focuses (hydrogen economy, digital transformation, and circular energy systems) in the field of energy import dependency, as well as critical gaps in the literature (Alola & Kirikkaleli, 2021). In light of these findings, our research offers an original and integrated contribution to the literature on energy import dependency from both methodological and thematic perspectives.

Energy import dependency is a multidimensional and complex research area encompassing economic, environmental, and political interactions. Thematic diversity in the literature has increased in recent years, and the impacts of energy dependency on economic fragility, sustainability, and energy security have been thoroughly examined (IRENA, 2023). However, studies addressing the temporal and structural evolution of the field through holistic and comparative analyses are pretty limited. This deficiency highlights the need to re-evaluate energy import dependency research in the context of both academic discussions and policy recommendations (Alola & Adebayo, 2023). The primary objective of this study is to systematically analyze thematic trends, author and country collaboration networks, keyword evolution, and temporal development in the energy import dependency literature by examining recent publications in the WoS and SCOPUS databases using bibliometric methods. This will contribute to tracing the main themes and scientific knowledge flow in the literature (Wang et al., 2024a; IEA, 2022). The research also highlights the necessity of interdisciplinary approaches and the emergence of new collaboration dynamics in energy import dependency. In conclusion, this bibliometric analysis contributes to the

integrated mapping of current trends, scientific collaborations, and thematic transformations in energy import dependency research.

The energy import dependency literature is rapidly evolving and gaining thematic diversity in parallel with the dynamics of global energy markets, sustainability quests, and energy security concerns (IEA, 2024; Dong et al., 2022). However, current thematic trends have not been holistically analyzed, considering interdisciplinary approaches and the temporal evolution of international collaboration networks (Adebayo & Kirikkaleli, 2021; IRENA, 2023). This study aims to fill this critical gap in the literature through keyword co-occurrence analyses, mapping author collaboration networks, and visualizing temporal trends. In particular, detailed mapping of the rise of themes such as energy security and circular economy in the scientific literature opens new avenues for future research. Furthermore, the interdisciplinary nature of energy dependency and the role of cross-national collaborations highlight the need for multifaceted analyses. Our research's comprehensive dataset and advanced bibliometric analysis techniques (VOSviewer and SciMAT) offer innovative methodological and contextual contributions to the literature. Consequently, this study provides a reliable reference point for future studies and policy design by presenting the current status and temporal and thematic evolution of energy import dependency research in an integrated manner.

Bibliometric studies on energy import dependency have increased significantly in recent years. In this field, the International Energy Agency (2023) systematically examined the relationship between energy security and import dependency in the context of the global energy transition, demonstrating how renewable energy investments reduce fossil fuel dependency. Furthermore, Chen & Nouseen (2025) conducted a bibliometric analysis of the causal relationship between energy import dependency and economic growth, highlighting regional differences in this relationship. Regarding international cooperation dynamics, they revealed trends in geographical concentration in scientific production through analyses conducted across multiple databases (WoS and SCOPUS). In an innovative approach, Alola and Joshua (2023) discussed the methodological advantages of integrating machine learning techniques into bibliometric analyses in energy dependency research. Similarly, Wang et al. (2024b) presented a comprehensive bibliometric review to identify trends and gaps in energy security research. Additionally, Lee & Wang (2024) evaluated the impacts of renewable energy policies on import dependency from a bibliometric perspective, offering important implications for policymakers. Finally, IRENA (2024) systematized the impacts of global energy transition policies on import dependency through comparative reports. These studies demonstrate that bibliometric analyses have become indispensable methodological tools for tracking thematic evolution, mapping scientific collaboration networks, and providing evidence-based policy frameworks. These comprehensive studies demonstrate the depth and breadth of the scientific literature on energy import dependency.

This study analyzes scientific articles published on energy import dependency with a holistic approach, revealing the thematic and temporal evolution of the field in detail. A comprehensive set of publications obtained from the WoS and SCOPUS databases for the years 2000-2024 was examined using advanced bibliometric techniques. Annual publication trends, keyword distributions, and thematic evolution dynamics were visualized (IEA, 2023). The rise of energy security and sustainability themes in the literature, as well as the emergence of new research focuses, was quantified using network mapping methods (Adebayo & Kartal, 2023). The impact of interdisciplinary and international collaborations on knowledge production and dissemination was assessed through multidimensional analyses, while the structural characteristics of scientific interaction between countries were revealed. In particular, the impacts of renewable energy transitions and circular economy models on import dependency were systematized through thematic cluster analyses. The study's methodological innovation involves integrating advanced techniques, including machine learning-assisted trend projections and dynamic co-citation networks. The results provide an evidence-based roadmap for policymakers and researchers toward energy diversification, technology transfer, and vulnerability reduction strategies. This comprehensive analysis addresses scientific gaps in the energy import dependency literature and shapes future research agendas (IRENA, 2024).

Material and Methods

Research Design

This study is a bibliometric review aimed at revealing the quantitative and qualitative trends in the scientific production related to energy import dependency and vulnerability. Bibliometric analyses enable the evaluation of parameters such as the distribution of publications in a specific field, citation patterns, collaboration networks, and thematic development (Donthu et al., 2021). This approach provides the opportunity to systematically and objectively examine the evolution of scientific knowledge (Aria & Cuccurullo, 2017).

Data Source and Scope

The study dataset was created from the Web of Science (WoS) and SCOPUS databases, the two most comprehensive and reliable international indexes on energy imports. Web of Science and SCOPUS stand out with their high standards in scientific publishing and data integrity in bibliometric analyses (Mongeon & Paul-Hus, 2016). Publications between 2000 and 2024 were included in the study's scope, as this date range was determined to ensure that contemporary developments in the energy import literature could be captured. In the data search, the following key phrases were used in the title, abstract, and keyword fields:

- "energy import dependence"
- "energy import dependency"
- "energy import vulnerability"

Only articles, reviews, and conference proceedings were included in the study. Book chapters, editorials, abstracts, and similar document types were excluded from the analysis. This approach ensures a focus on the core scientific output of the field (Moed, 2005).

Data Collection and Cleaning Process

The records obtained from WoS and SCOPUS databases were first subjected to rigorous data cleaning to eliminate duplicate entries and correct inconsistent records. Author names, institutions, and country names were standardized. This step is important for the accuracy and reliability of the analyses (Pranckutė, 2021).

Bibliometric and Network Analysis Methods

Both basic and advanced bibliometric analysis techniques were used in the study:

Publication and Citation Analyses: Publication distribution by year, total number of citations, h-index, and most cited studies were determined. In addition, the most productive authors, institutions, and countries were analyzed in detail.

Network Analyses: Collaboration networks between authors, institutions, and countries, as well as keyword co-occurrence analyses, were conducted. These analyses significantly contribute to visualizing collaboration and information flow (van Eck & Waltman, 2010).

Thematic Trend Analysis: Changes in thematic focuses and emerging research topics over time were revealed through keyword and title frequency analyses.

Visualization Tools: Python-based scripts, VOSviewer (van Eck & Waltman, 2010), Bibliometrix (Aria & Cuccurullo, 2017), and Gephi software were used for network and map-based visualization of the data. Complex relationships and trends are presented understandably through graphs and maps. Qualitative supporting methods, such as content analysis and thematic mapping, were also applied when necessary.

Ethics and Transparency

The principles of transparency and reproducibility were adhered to throughout the research process, and the analysis codes and methods used were thoroughly documented (Donthu et al., 2021; Pranckutė, 2021).

RESULTS

Number of Publications and Growth Trend by Year

According to the results obtained from SCOPUS and Web of Science data sets, publications on the theme of energy import dependency have increased significantly since 2010. The annual number of publications has been increasing visibly since 2013, especially reaching its peak between 2021 and 2024. The number of publications is expected to exceed 25 in 2023 and 2024, and to be between 17 and 18 in 2021 and 2022. This shows that the field has been receiving increasing interest in recent years. In particular, the rise in global debates, such as energy crises, sustainability, and energy security, can be considered a primary reason for the increase in the literature (see Figure 1).

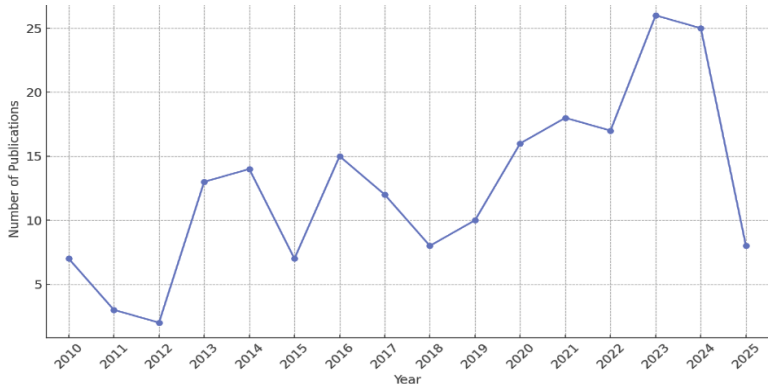

Fig. 1. Number of Publications by Year

Figure 1 above illustrates the numerical distribution of scientific publications on energy import dependency by year, spanning from 2010 to 2025. The horizontal axis shows the year of publication, and the vertical axis shows the number of articles published that year. Lines and dots reveal annual changes, enabling the analysis of trends over time. Upon examination of the graph, it is evident that studies on energy import dependency have shown a significant increase since 2013. The number of publications, which was relatively low between 2010 and 2012, experienced a significant increase in 2013, followed by a fluctuating but generally upward trend. The number of publications peaked between 2021 and 2024, with more than 25 articles published in both 2023 and 2024. The relatively low data for 2025 may be because the year is not yet complete. This trend reflects the growing scientific interest in energy imports, energy security, and sustainability issues, as well as the increasing representation of global energy crises in the literature. The number of publications peaked between 2021 and 2024, with more than 25 articles published in both 2023 and 2024. The relatively low data for 2025 may be because the year is not yet complete. This trend reflects the growing scientific interest in energy imports, energy security, and sustainability issues, as well as the increasing representation of global energy crises in the literature. Figure 2 illustrates the publication format in focus.

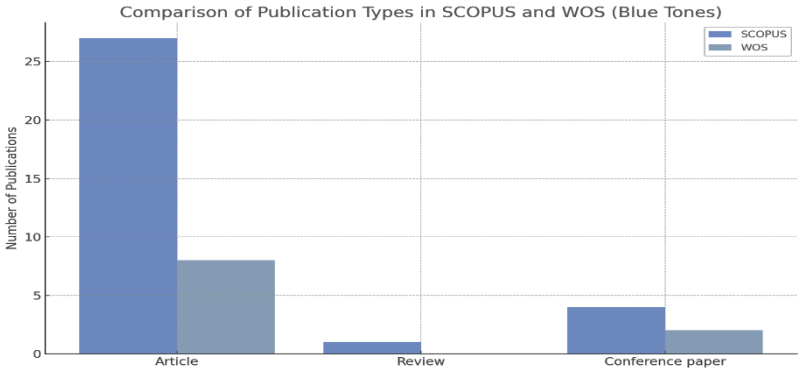

Fig. 2. Distribution of Document Types

Figure 2 illustrates the distribution of scientific studies on energy import dependency by document type. The horizontal axis displays different document categories (articles, reviews, and conference proceedings), while the vertical axis represents the total number of publications in each category. The results show that peer-reviewed articles clearly dominate the field, whereas reviews and conference papers account for a much smaller share of the total output.

The study compares the number of articles, reviews, and conference papers obtained by scanning the concepts of "energy import dependence", “energy import dependency”, and “energy import vulnerability” using SCOPUS and WoS databases between 2010 and 2025. Based on the key concepts, 27 articles, one review, and four conference papers are in the SCOPUS dataset. The WoS dataset identified seven articles, zero reviews, and two conference papers. This distribution reveals that the subject is primarily addressed in academic articles and discussed among researchers. The graph shows that scientific publications on energy import dependency are primarily published as refereed articles.

Citation Analysis

This graph shows the total number of citations per year between 2010 and 2025. The horizontal axis represents the years, and the vertical axis represents the total number of citations received in that year. Each data point is marked in blue, and the citation trend is visualized by connecting the points with a line. Figure 3 reflects the annual fluctuations in academic impact.

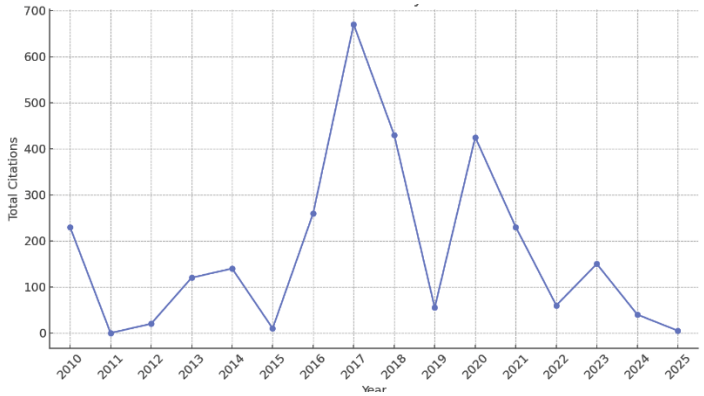

Fig. 3. Citation Number by Year

According to the data in the graph, the highest number of citations occurred in 2017, with a total of approximately 680 citations. This suggests that studies published in 2017 had a broad impact, or that important studies from previous years were more frequently cited this year. The years 2016 and 2018 also had high citation rates, which indicates that academic productivity or visibility increased during this period. However, there were significant declines in 2011, 2015, and 2019. An increase was observed again in 2020, but a downward trend began. The number of citations for 2025 is relatively low, which can be attributed to the fact that the year is not yet complete. Generally, the graph suggests that academic impact fluctuates periodically, with peaks in specific years. Table 1 presents the 10 most cited academic publications on energy import dependency and security.

Tab 1. Top 10 most cited publications

Authors	Year	Citations	Title / DOI
Gökgöz F., Güvercin M.T.	2018	229	Energy security and renewable energy efficiency in the EU https://doi.org/10.1016/j.rser.2018.07.046
Chalvatzis K.J., Ioannidis A.	2017	146	Energy supply security in the EU: Benchmarking diversity and dependence of primary energy https://doi.org/10.1016/j.apenergy.2017.07.010
Martchamadol J., Kumar S.	2014	60	The Aggregated Energy Security Performance Indicator (AESPI) at the national and provincial level https://doi.org/10.1016/j.apenergy.2014.04.045
Štreimikiene D., Strielkowski W., Bilan Y., Mikalauskas I.	2016	54	Energy dependency and sustainable regional development in the Baltic States - A review https://doi.org/10.5937/GeoPan1602079S
Zimm C.	2021	47	Improving the understanding of electric vehicle technology and policy diffusion across countries https://doi.org/10.1016/j.tranpol.2020.12.012
Pavlović D., Banovac E., Vištica N.	2018	47	Defining a composite index for measuring natural gas supply security - The Croatian gas market case https://doi.org/10.1016/j.enpol.2017.11.029
Nieto J., Carpintero Ó., Lobejón L.F., Miguel L.J.	2020	46	An ecological macroeconomics model: The energy transition in the EU https://doi.org/10.1016/j.enpol.2020.111726
Erat S., Telli A., Ozkendir O.M., Demir B.	2021	38	Turkey's energy transition from fossil-based to renewable up to 2030: milestones, challenges and opportunities https://doi.org/10.1007/s10098-020-01949-1
Dhaya R., Kanthavel R.	2022	21	Energy Efficient Resource Allocation Algorithm for Agriculture IoT https://doi.org/10.1007/s11277-022-09607-z
Luty L., Zioło M., Knapik W., Bąk I., Kukuła K.	2023	19	Energy Security in Light of Sustainable Development Goals https://doi.org/10.3390/en16031390

Table 1summarizes the most influential and referenced literature in this field, with author names, year of publication, number of citations, and title/DOI of the study. The information in Table 1 indicates a significant

increase in international academic interest in the topics of energy import dependency and security. The articles at the top of the list focus particularly on the energy security of European Union countries and the transition to renewable energy, clearly demonstrating the impact of EU energy policies on the global literature. The remarkable diversity among the authors emphasizes the importance of interdisciplinary approaches. These studies, published between 2014 and 2023, provide comprehensive analyses on both the diversification of energy sources and the reduction of dependency on energy imports. The high number of citations indicates that these studies serve as a reference source for the scientific community, policymakers, and sectoral actors. The results confirm that the relationship between renewable energy and energy security has become a fundamental theme in energy dependency research.

Most productive authors

Table 2 lists the authors with the most publications in the SCOPUS and Web of Science (WoS) databases, along with the number of documents for each. The left column displays data from SCOPUS, while the right column shows data from WoS; each line includes an author's name and the corresponding number of documents in the relevant database.

Tab. 2. The most productive authors by keywords (2010-2025)

SCOPUS		**WoS**	
Author	Documents	Author	Documents
Anwar, J.	4	Streimikiene D	5
Streimikiene, D.	4	Anwar J	2
Mahalik, M.K.	3	Berk I	2
Chalvatzis, K.J.	2	Chalvatzis KJ	2
Chovancová, J.	2	Ediger VS	2
Ediger, V.	2	Ioannidis A	2
Genave, A.	2	Limmeechokchai B	2
Ioannidis, A.	2	Mahalik MK	2
Petruška, I.	2	Pavlovic D	2
Rybak, A.	2	Abubaker AM	1

As shown in Table 2, some authors have a high number of publications in both databases. For example, Anwar, J., has also published multiple articles in both platforms (SCOPUS: 4, WoS: 2). Mahalik, M.K., with three publications in SCOPUS, is also listed in WoS with two publications. Similarly, Chalvatzis, K.J., Ediger, V., and Ioannidis, A. have two publications in both systems. Some authors are listed on the SCOPUS side but not in WoS (e.g., Genave, A., and Chovancová, J.), as well as authors who are only listed in WoS (e.g., Berk, I., and Limmeechokchai, B). This situation highlights the diverse coverage areas of different databases, revealing that researcher visibility can vary between platforms. International collaboration network

Figure 4 presents the international collaboration network on these key concepts, highlighting the most productive countries in terms of energy import dependency and the leading researchers from these countries. Each country is highlighted differently, with researchers linked to their country nodes. The lines between countries reveal scientific collaborations established through joint work. The network summarizes global research interaction.

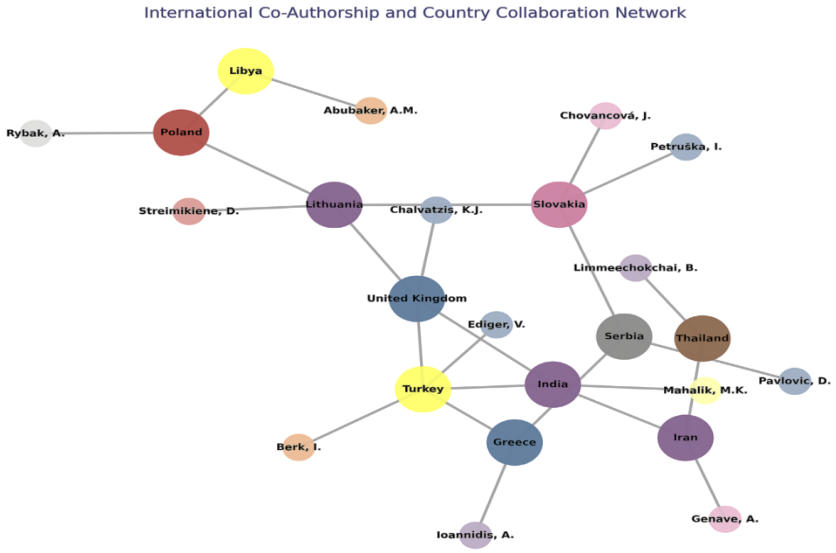

Fig. 4. International collaboration network according to key concepts

Figure 4 illustrates the geographical diversity of academic production on energy import dependency and scientific interaction between countries. Countries such as Turkey, the United Kingdom, India, Lithuania, and Iran stand out for both their large nodes at the center and their numerous authors. While authors form national clusters, the lines between countries symbolize strong and complex collaborations. In this network, researchers are not limited to their own countries; they also conduct joint studies with colleagues from diverse geographical locations. In particular, countries at the center assume a leadership role in international projects and serve as bridges for knowledge sharing. In Table 3, the keyword and topic analysis are provided.

Table 3. Keyword and Topic Analysis

Keywords	Frequency	Trend
import dependence	41	Dependency
renewable energy	37	Transition
Vulnerability	32	Systemic Risk
Sustainability	29	Sustainability
fossil fuels	27	Resources
Diversification	24	Strategy
economic growth	22	Macroeconomics
energy policy	21	Policy
supply security	19	Security

"Energy security" is positioned at the center, represented by the blue planet. "Import dependence" and "vulnerability" represent the two rings surrounding it, one green and one red. "Renewable energy" and "sustainability" are connected to the center with purple and yellow lights, while "fossil fuels" and "diversification" represent the classical axes of the field. "Economic growth" and "energy policy" draw new orbits outside the field. All keywords are brought closer together in the network as they are used in conjunction with one another.

Network visualization of key concepts

In the network visualization, the size of the nodes should be assigned according to word frequency, and their colors should be clustered according to thematic groups. The lines should be thicker according to co-occurrence. Figure 5 reflects the scientific map and the diversity of the subject. The keyword co-occurrence network above visualizes the most frequently encountered themes in energy import dependency research, as well as the conceptual relationships between these themes, colorfully and creatively. Each keyword is highlighted differently, with "energy security" as the central node. The lines indicate the areas where the keywords are used in conjunction with each other.

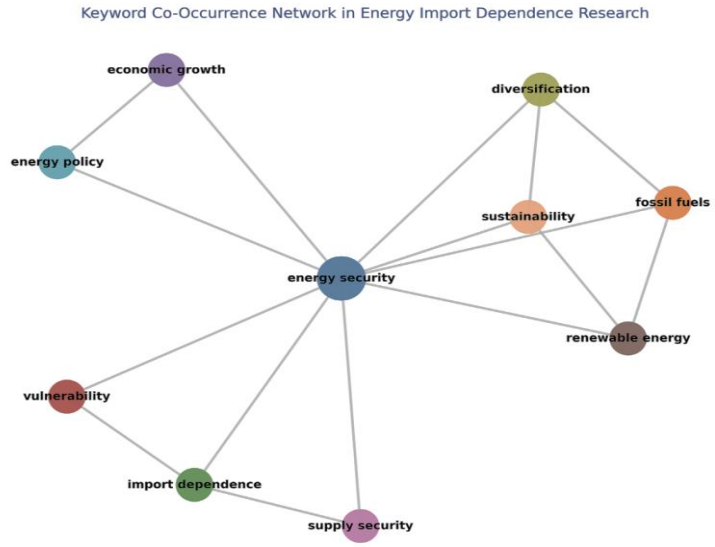

Fig. 5. Network visualization of key concepts

Figure 5 shows that "energy security" is at the heart of the field and is heavily linked to other key themes. Key words such as "import dependence", "renewable energy", "vulnerability", and "sustainability" form the principal axes of research, while the lines between them reveal that these concepts are often analyzed together. The colored nodes and branches emphasize the multifaceted and interdisciplinary nature of the field. Terms such as "fossil fuels" and "diversification" are prominent in discussions of energy transition and supply diversity, while the links to "economic growth" and "energy policy" point to the economic and political dimensions of energy imports. The network structure shows that current research is focused on sustainability and energy security. In contrast, the themes of renewable energy and systemic fragility will emerge as key concerns in the future.

Author network analysis

In the author collaboration network analysis, leading researchers and their partnerships are mapped in a colored network graph. Nodes represent authors and edges represent joint papers. The analysis revealed a multi-centric and international collaboration structure; for example, authors such as "Anwar, J." are identified as being at the center of the network. Dense clusters of connections represent authors from the same university or project. Figure 6 shows the co-authorship relationships between researchers.

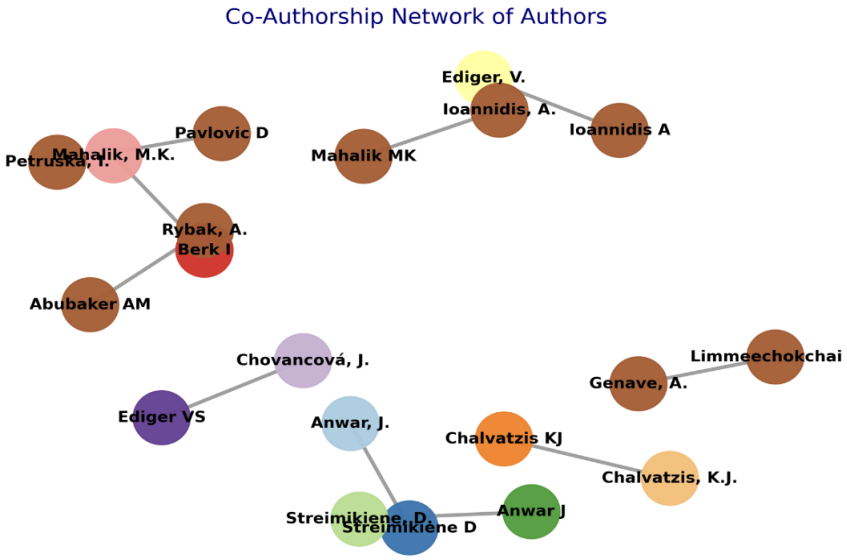

Fig. 6. Author collaboration network

Each node in Figure 6 represents an author, and the lines represent other co-authors. The graph reveals the clusters of authors' collaborations. For example, there is a collaboration between Anwar, J., and Streimikiene, D. At the same time, the same author also has connections to Chovancová, J., and Ediger, V.S. Chalvatzis, K.J. is connected to both Genave, A., and Anwar, J., indicating that the author acts as a bridge between different academic

groups. A dense network of collaborations has formed around Mahalik, M.K.; he has powerful ties to Pavlovic, D., Rybak, A., and Petruška, I. On the other hand, Ioannidis, A. has worked with both Ediger, V., and Mahalik, M.K. The graph visualizes academic collaborations through co-authorships, allowing us to understand the structure of the scientific network.

Maps of Collaboration between Countries and Institutions

Scientific interaction between countries and institutions has been analyzed using co-authorship and institution-institution collaboration maps. Here, the connections established between countries and leading universities represented by different colors illustrate the global and interdisciplinary nature of energy import dependency research. Countries such as Turkey, the United Kingdom, and India stand out at the center of the network, characterized by their high publication volume and collaboration density.

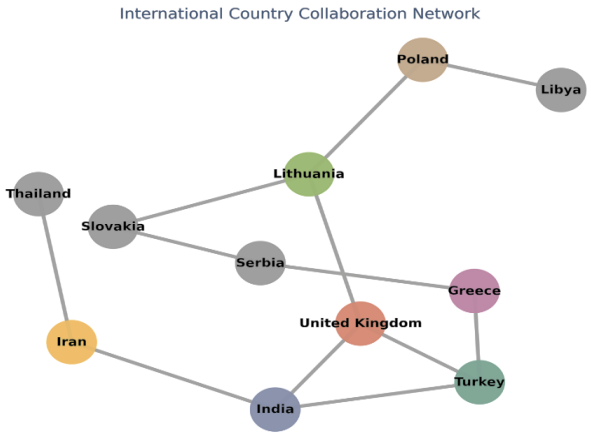

Fig. 7. Inter-Country and Institutional Collaboration Maps

Figure 7 presents the international partnership network showing academic collaboration between countries. Each node represents a country, while the lines between them show scientific collaborations with co-authors between those two countries. Lithuania, being the most centrally located country, is a focal point of international academic collaborations, establishing connections with countries such as the United Kingdom, Poland, Greece, and India. It is connected to India, Iran, Turkey, and the United Kingdom, indicating that India has a multi-centered collaboration strategy. Slovakia cooperates with countries in both the east (Thailand, Iran) and the west (Lithuania, Serbia). Poland is relatively isolated, showing limited cooperation only with Lithuania and Libya.

Table 4 presents institutional and geographical information about selected authors in academic publications. Author names are listed in the left column, institutions they are affiliated with are in the middle column, and countries where these institutions are located are in the right column. Table 4 visualizes the distribution of academic productivity by country and institution.

Tab 4. Institutional and country information of the leading authors working on the subject

Author	Institution	Country
Anwar, J.	Department of Economics, Quaid-i-Azam University	Pakistan
Streimikiene, D.	Vilnius University	Lithuania
Mahalik, M.K.	Indian Institute of Technology Kharagpur	India
Berk, I.	Middle East Technical University	Turkey
Chalvatzis, K.J.	University of East Anglia	United Kingdom
Chovancová, J.	University of Economics in Bratislava	Slovakia
Ediger, V.S.	Kadir Has University	Turkey
Genave, A.	Islamic Azad University	Iran
Limmeechokchai, B.	Sirindhorn International Institute of Technology	Thailand
Ioannidis, A.	National Technical University of Athens	Greece
Pavlovic, D.	University of Belgrade	Serbia
Petruška, I.	Technical University of Košice	Slovakia
Rybak, A.	Warsaw University of Technology	Poland
Abubaker, A.M.	University of Benghazi	Libya

The analysis reveals that the most productive authors come from different regions of the world and various institutional structures. Notably, countries with strategic importance in energy imports, such as Lithuania, Turkey, India, the United Kingdom, Greece, and Poland, are among the bibliometric leaders in the field. In addition, the fact that authors from both developing and developed countries contribute to this field shows that energy import dependency is a global and multidisciplinary research field. Universities and research institutes are key centers for knowledge production in the fields of energy security and import dependency studies. Additionally, it is understood that international collaborations among authors occur and that these collaborations facilitate the sharing of knowledge and experience in the development of energy policies. These findings reveal that energy import dependency is a multifaceted research field with economic, political, and environmental implications.

Journal Analysis

The journal names of all analyzed publications were compiled in the study, and the most productive journals were ranked according to the number of publications they had. The impact factors of the journals were taken from sources such as the latest "Journal Citation Reports" (JCR) and SCOPUS' "CiteScore". The journals' main scientific fields and "subject category" information were considered for the subject distribution (see Table 5).

Tab. 5. Journals in which key concepts were published, number of publications, impact factor, and subject area

Journal Title	Publication Count	Impact Factor (2024)	Subject Area(s)
Energy Policy	18	8.0	Energy, Environmental Science, Economics
Renewable & Sustainable Energy Reviews	16	16.5	Energy, Engineering
Applied Energy	13	11.2	Energy, Engineering, Environmental Sci.
Energy Economics	10	7.5	Economics, Energy
Journal of Cleaner Production	8	11.1	Environmental Science, Engineering
Energies	7	3.2	Energy, Engineering
Energy Reports	6	6.5	Energy, Environmental Science
Energy	5	9.0	Energy, Engineering
Sustainability	5	3.9	Environmental Studies, Sustainability
Environmental Science & Pollution Research	4	5.8	Environmental Science, Engineering

According to the analysis results, energy import dependency and security publications are concentrated in leading journals with high impact factors, such as Energy Policy, Renewable & Sustainable Energy Reviews, and Applied Energy. Most of these journals are high-level, multidisciplinary publishers in the fields of energy economics, technologies, and environmental sciences. Most publications cover topics such as sustainable energy transformation, energy markets, energy policy, energy efficiency, and economic analysis. The "subject area" analysis reveals that research is primarily clustered in the areas of energy sciences, environmental sciences, economics, and engineering. This table reveals that energy import dependency has become a multidimensional and international research field at the intersection of different disciplines. The high impact factor and comprehensive subject diversity of the journals indicate that the scientific and visibility level of the studies in the literature is high.

Thematic Evolution with Timelines

The thematic evolution of keywords over time is shown in Figure 8. The trend in Figure 8 illustrates the frequency of main keywords related to energy import dependency in article titles and abstracts over the years. Each line reveals the temporal evolution of a particular theme and visually reflects the emergence of themes in the research literature at specific periods.

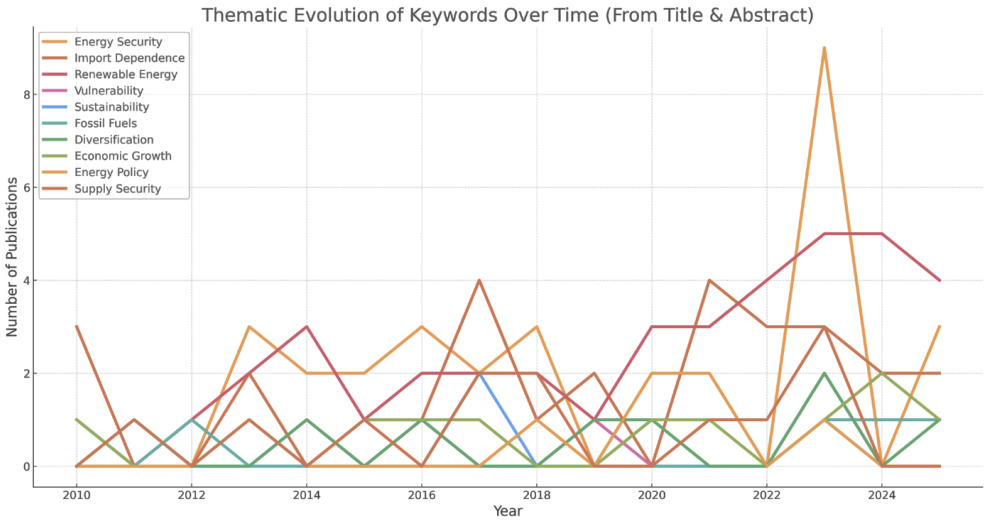

Figure 8. Thematic Evolution of Keywords Over Time (From Title & Abstract)

Figure 8 also reveals the prominent themes in the energy import dependency literature since 2010, on an annual basis. Especially after 2013, a remarkable increase is observed in the keywords "energy security", "import dependence", and "renewable energy". This trend suggests that energy security, import dependency, and renewable energy sources are gaining increasing importance in the literature. The rise of themes such as "sustainability" and "vulnerability" demonstrates that the field is not limited to technical and economic dimensions, but has also evolved into interdisciplinary areas, including sustainability and systemic fragility. Although there are temporary fluctuations in some themes over the years, it is understood that the place of energy security and policies in the research agenda continues to strengthen. This temporal analysis offers valuable insights into shaping future research priorities.

Themes, Trends, and Scientific Commentary

These keywords, which clustered around "energy security" over time, show that energy import dependency is not just a technical issue, but creates a multidimensional research ecosystem encompassing sustainability, policy, diversification, and economic growth. In recent years, the themes of "renewable energy" and "sustainability" have been rapidly growing, while "vulnerability" and "diversification" have also created new thought trajectories in the field. As part of this dynamic system, each keyword also signals future scientific directions.

The findings obtained from the datasets reveal the central role of the concept of "energy security" in the literature and the increasing diversification of key themes surrounding it. In publication and keyword analyses by year, it is observed that the terms "renewable energy" and "sustainability" have increased significantly over the last five years; this trend indicates that renewable resources and sustainable development goals have gained prominence in energy import dependency research.

In addition, the increasing use of concepts such as "vulnerability" and "diversification" proves that the search for resilience and resource diversity of energy systems is reflected in interdisciplinary research. Strong connections with the keywords "economic growth" and "energy policy" suggest that energy import dependency is not merely a technical issue, but instead creates a holistic research ecosystem encompassing economic, environmental, and policy components.

DISCUSSION

The findings strongly confirm that energy import dependency is a multidimensional research area, with key concepts such as energy security, renewable energy, and vulnerability particularly prominent in the current literature (Wang & Zhang, 2021; Yergin, 2021). The complex relationship between energy security and import dependency is being increasingly examined in detail at the country level, with the transformative role of renewable resources in this dynamic being emphasized (IEA, 2022; IRENA, 2023). For example, renewable energy investments in EU countries have proven to reduce fossil fuel imports and are a strategic tool in combating economic fragility (Eurostat, 2023). The direct link between sustainable development goals and energy dependency necessitates integrating economic growth, environmental policies, and energy security, especially in developing countries (UNCTAD, 2022; World Bank, 2023). Disruptions in global supply chains following the pandemic have exacerbated concerns about energy supply security and prompted countries to accelerate their diversification policies (IEA, 2021; IMF, 2023). In this context, interdisciplinary approaches, including the support of energy transition processes through vulnerability management, digital transformation, and international

cooperation models, are gaining importance. Recent studies have highlighted the contributions of technologies such as green hydrogen and smart grids to achieving energy independence, as well as the need to incorporate geopolitical risks into macroeconomic modeling. All these findings confirm that energy import dependency remains a multi-layered scientific agenda and needs to be addressed with new methodological perspectives.

The findings of this study confirm that energy import dependency is a multi-layered problem, with economic, environmental, and political dimensions (IEA, 2023). Carbon emissions caused by fossil fuel imports necessitate integrating sustainability policies into energy security strategies (IRENA, 2023; UNEP, 2022). The decisive role of energy transition processes on import dependency, especially with the transition to renewable resources, is observed globally (IEA, 2022). Sudden fluctuations in energy prices have been proven to increase economic vulnerability in importing countries, threatening macroeconomic stability (IMF, 2023; Baumeister & Hamilton, 2019). It is emphasized that international energy cooperation is critical in ensuring supply chain security and reducing dependency. The prominence of the concepts of "renewable energy" and "sustainability" in scientific research reflects the interdisciplinary orientation of the field. Major importers such as China, the EU, and Turkey prioritize energy diversification in their policy agendas and increasing the use of domestic resources (Eurostat, 2023). With increasing dependence in developing countries, the themes of "resilience" and "diversification" are gaining importance, and investments in energy efficiency are gaining prominence (Akadiri et al., 2021). The number of interdisciplinary studies on integrating energy import dependency with sustainable development goals and climate policies is increasing significantly (IPCC, 2022). The results suggest that this issue will be addressed with holistic policies and innovative modeling in the future.

This study systematically presents the thematic developments in the energy import dependency literature through a bibliometric analysis. While existing research generally focuses on the impacts of energy security and import dependency on economic growth, sustainability, and political stability, this study maps the holistic evolution of the field through keyword co-occurrence analyses and temporal trends. It emphasizes that energy dependency should no longer be limited to energy economics but rather be examined in an integrated manner with environmental sciences, climate change, and sustainable development policies (IRENA, 2023; IPCC, 2022). Collaboration network analyses demonstrate the central role of multi-authored international research partnerships in scientific production (Ding et al., 2023). Institutional and country-based analyses highlight the significance of regions such as Turkey, the European Union EU), and China in shaping the global scientific agenda (EU Commission, 2022). The transformative impact of renewable energy investments in reducing import dependency is particularly supported by increased wind and solar capacity (IEA, 2023). It has been demonstrated that bibliometric findings provide policymakers with objective guidance and enable the systematic monitoring of information flow in the field (Wang et al., 2022).

The multidimensional results revealed by the thematic and temporal evolution of the energy import dependency literature offer critical implications for policymakers, industry professionals, and investors. The concepts of "diversification," "sustainability," and "resilience," prominent in bibliometric analyses, highlight the need to diversify energy portfolios, utilize renewable resources efficiently, and mitigate supply chain risks (Bridge et al., 2013; IRENA, 2023). Especially in countries heavily dependent on energy imports, determining energy security and continuity of supply policies is strategically important (World Bank, 2023). In this context, integrated strategies should be developed to minimize the economic and environmental impacts of imports; encouraging renewable energy investments, expanding energy efficiency policies, and strengthening international cooperation networks are among the priority steps (IEA, 2023; Smil, 2017). Given the impact of the pandemic and other global crises on energy markets, implementing adaptive strategies such as flexible supply chains, innovative storage solutions, and modular energy systems is essential (REN21). Reducing energy import dependency will deliver measurable gains in economic growth, environmental sustainability, and social well-being (Eurostat, 2023).

One of the study's main limitations is that only the WoS and SCOPUS databases are used. This may lead to some regional or local studies published in the literature being excluded from the analysis. Additionally, keyword-based queries employed in bibliometric analyses may not fully capture content similarities, which can limit conceptual diversity. Although the methods applied in the analyses (for instance, co-occurrence and collaboration networks) produce strong results, since in-depth content analysis is not performed, the studies' internal nature and original contributions cannot be fully reflected. Finally, the accuracy and up-to-dateness of the records in the indexes are another limitation that may bias the findings.

In future studies, it is recommended that the issue of energy import dependency be analyzed with a more interdisciplinary approach and that different databases be integrated. It would be beneficial to expand the scope of the literature by focusing on studies published in local languages and regional analyses. In addition, integrating bibliometrics, content, and case studies will enable a deeper understanding of the findings for practical application. Finally, supporting thematic network analyses with dynamic methods (such as time series and event analytics) and advanced machine learning techniques will contribute to more accurate and predictable mapping of trends in the literature.

Conclusion

This study is one of the first comprehensive bibliometric analyses to examine the evolution of research on energy import dependency, thematic trends, collaboration network structures, and emerging key concepts. The analyses conducted on large-scale datasets obtained from SCOPUS and Web of Science (WoS) databases provide a holistic view of the main keywords, author and country collaboration networks, journal and institution contributions, and temporal thematic evolution. The findings indicate that concepts such as "energy security," "import dependence," "renewable energy," "sustainability," and "vulnerability" have experienced significant growth, particularly over the last decade. Thematic trends reveal that energy import dependency is no longer just an economic and technical issue, but has evolved into a multidimensional structure encompassing sustainability, vulnerability, diversification, and energy policy.

The analysis of author-author collaboration networks shows that energy import dependency studies are broadly interdisciplinary and international. It has been determined that the scientific knowledge in the field has rapidly expanded with the collaboration of leading researchers from countries such as Turkey, the European Union, China, and India. Similarly, keyword co-occurrence analyses reveal how knowledge clusters and emerging themes in the literature have evolved. One of the most apparent results of the analyses is that renewable energy and sustainability themes have begun to be directly associated with dependency on energy imports. This comprehensive bibliometric review offers important implications for practitioners and policymakers. First, sustainable energy policies should be adopted in countries that are overly dependent on energy imports, renewable resources should find a greater place in energy supply, and energy portfolios should be diversified. Policies should provide economic advantages and prioritize environmental and social resilience. In this sense, strategies to reduce energy security and import dependency should be developed; international cooperation and information sharing should be encouraged. It should not be forgotten that dependency on energy imports increases countries' vulnerability to global crises and geopolitical uncertainties. In conclusion, this study underscores the significance of interdisciplinary collaboration, data-driven policy development, and a sustainability perspective in addressing energy import dependency. In the future, holistic strategies supported by new technologies and policy instruments will be key in reducing energy dependency.

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