Exploring Recent Global Scholarly Interest in Energy Demand Forecasting: A Bibliometric Analysis of Conference Papers in the Scopus Databas

Toan-VU Le[1], Thao Tran Phuong[1*], Nhung Do Hoai[1], Long Do Duc[1]

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

[*]Corresponding author: thao78038@gmail.com

Abstract

Within the framework of growing concerns about energy security worldwide, energy demand forecasting is pivotal to policy-making and sustainable development strategies. However, systematic analysis of global research trends in this field is still limited, especially in the conference paper data source, which often reflects new scientific achievements and discussions faster than slower publication in journals. To capture the most current picture of the field in the past 5 years, this study selected and conducted bibliometric analysis on 348 conference papers extracted from the Scopus database in the period 2020 - 2024. By employing this methodology, the study elucidates trends in the annual growth of publications, citation patterns, prominent contributors, and international research collaboration. The findings indicate that China is a prominent country in terms of publication volume, academic participation, and the number of authors contributing many works on the topic. Concurrently, the analysis revealed five major research themes and commonly used keywords across numerous conference papers. Based on these findings, we propose future research directions such as applying machine learning to develop energy management models for smart grids integrated with renewable energy. By selecting data from recent conferences, this study not only reflects the most up-to-date state of the art in the field of energy demand forecasting but also lays the foundation for more targeted and impactful research directions in the future.

Research purpose:

The research purpose of this study is to analyze global research trends in energy demand forecasting through a bibliometric analysis of conference papers from 2020 - 2024, aiming to clarify publication patterns, academic collaboration, and key themes to guide future research.

Research motivation:

Growing concerns over energy security have emphasized the importance of energy demand forecasting for policy and sustainable development. However, systematic analyses of global research trends in this area, especially within conference papers, remain limited and call for further investigation.

Research design, approach, and method:

This study adopts a bibliometric research design with a quantitative approach. Data were retrieved from the Scopus database, focusing on 348 conference papers published between 2020 and 2024. Data analysis was conducted using Microsoft Excel and VOSviewer software. Using bibliometric techniques, the analysis examines publication growth, citation patterns, leading contributors, international collaboration, and co-occurrence keyword to identify research trends and emerging themes in energy demand forecasting.

Main findings:

The study reveals a significant growth in research on energy demand forecasting, with a sharp increase in conference papers and contributing authors, particularly between 2022 and 2024. China, India, and the United States emerge as the leading contributors, reflecting a close link between research activity and their large energy consumption needs. Keyword analysis highlights machine learning as a central theme, underscoring its potential to optimize energy management and advance renewable energy integration. Overall, bibliometric analysis proves to be an effective tool in mapping research trends and identifying emerging directions in this field.

Practical/managerial implications:

The findings provide policymakers and energy managers with insights into global research trends, enabling them to better align national strategies with emerging technologies such as machine learning in energy forecasting. Identifying leading contributors and collaboration networks helps decision-makers recognize potential partners and benchmark best practices. Last but not least, understanding the link between research activity and energy consumption patterns can support more effective planning for energy security, sustainable development, and the integration of renewable

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energy sources.

Keywords: Energy, Energy demand, Forecast, Bibliometric.

1. INTRODUCTION

Since ancient times, energy has been an integral part of human life, progressively assuming a vital role in societal development. As global economic and social advancement accelerates, the demand for energy continues to rise, posing significant challenges to resource availability and environmental sustainability. Prolonged exploitation of conventional energy sources - such as coal, petroleum, and natural gas - has led to resource depletion and severe ecological consequences, including climate change and ecosystem degradation. In response to these pressing issues, the scientific community and policymakers have intensified research efforts aimed at identifying and transitioning toward renewable and sustainable energy alternatives.

Given the escalating global energy challenges - including the surge in consumption demand, environmental deterioration, and the imperative shift toward sustainable energy sources - precise energy demand forecasting has emerged as a fundamental pillar for strategic energy system planning and governance (Zhan, 2018). Forecasting energy demand is instrumental in optimizing grid operations (Karunarathne et al., 2024), augmenting energy efficiency, and informing evidence-based policy formulation to safeguard energy security and promote sustainable development within the energy sector (Liu et al., 2024; Rao et al., 2023).

As the global economy continues to expand, fluctuations in energy consumption patterns have become increasingly complex and difficult to manage. Traditional forecasting models, which often rely on linear assumptions and limited input variables, have proven inadequate in capturing the dynamic and nonlinear nature of modern energy systems. This inadequacy has prompted a paradigm shift toward more sophisticated and adaptive forecasting approaches. Over the past decade, the discipline has undergone a profound transformation, transitioning from conventional forecasting methodologies to sophisticated modeling techniques and data-driven approaches, mirroring the increasing intricacy of energy systems in the digital era (Mohammadi et al., 2023). To systematically examine the evolution of this research domain, bibliometric analysis has emerged as a rigorous methodological tool for identifying key contributors, influential institutions, and emergent scholarly trends (Donthu et al., 2021; Zupic & Čater, 2015). By quantitatively evaluating the structural composition, dynamic progressions, and geographical dissemination of the scientific corpus, researchers can attain a more profound comprehension of the epistemological trajectory, prevailing research focal points, and collaborative networks within the realm of energy demand forecasting.

This phenomenon is clearly reflected in previous studies by various scholars. Rehman et al. applied the ARIMA model in Pakistan and found it to be more suitable than the Holt-Winter and LEAP models for forecasting electricity, natural gas, oil, coal, and LPG demand across different sectors (Rehman et al., 2017). Similarly, Neshat et al. introduced a nonlinear ARIMAX model specifically designed for sectoral peak demand forecasting in Iran, highlighting the importance of capturing nonlinearities and exogenous variables in energy demand prediction (Shajalal et al., 2022). In the United States, Portugal, and Iran, studies employing Artificial Neural Networks (ANN) for electricity consumption forecasting have shown that demand is projected to increase by 60% to 130% by 2050 compared to 2020 (Kiani et al., 2024). A comprehensive review of energy forecasting models revealed that machine learning techniques are the most widely used, with hybrid models also gaining popularity (Verwiebe et al., 2021). It is evident that each study, depending on its geographic and contextual characteristics, adopts different forecasting methodologies. Not only are standalone models utilized, but combinations of methods are also employed to enhance prediction accuracy. For instance, Somu et al. proposed a deep learning framework that integrates Convolutional Neural Networks (CNN) and Long Short-Term Memory (LSTM) networks to accurately forecast building energy consumption by analyzing complex patterns and temporal dependencies (Somu et al., 2021). This approach has also been applied to short-term electricity forecasting, yielding superior results compared to standalone LSTM and Seq2Seq-Attention models (Doan et al., 2024).

Although there have been previous studies addressing the topic of "Energy Demand," for example, the study by (Le et al., 2025) examined global scholarly interest in the topic of "Energy Demand and Sustainable Development Goals" during the period 1997-2024. However, this study places energy demand in the context of sustainable development goals and considers published research, including journals and scientific conferences. Including journal publications may limit the topicality of scientific findings, as journal publications are often slower to publish, involving lengthy editorial and peer-review processes (Björk & Solomon, 2013; Nguyen et al., 2015). Consequently, academic conferences serve as preferred outlets for the initial dissemination of novel ideas, advanced methodologies, and exploratory experiments. The focus on conference proceedings, as (Forti et al., 2021) emphasized, often leads researchers to choose to disseminate results quickly. Concentrating on conference publications therefore enables this review to capture pioneering contributions and the most recent research developments in the field of energy demand forecasting. In addition, the scientific and technological landscape changes rapidly, and reviewing recent research trends is necessary to capture the most updated

picture of the research field. New studies often reflect current issues, advanced methods, and practical applications of interest, helping to avoid repeating old directions and locating knowledge gaps. Therefore, this study limits the number of conference papers published between 2020 and 2024.

This study undertakes a comprehensive bibliometric assessment of the conference proceedings from the Scopus database for the period 2020 - 2024, which frequently encapsulate the latest advancements in the field. By scrutinizing publication trajectories, regional scholarly contributions, patterns of scientific collaboration, seminal works, and core thematic domains, the study aspires to provide an integrative perspective on the research activity and intellectual progression of the energy demand forecasting discipline. The findings are anticipated to assist researchers and policymakers in delineating prospective research avenues within this evolving subject.

This study seeks to address three fundamental research questions:

RQ1: How is scientific output and research productivity evolving in the field of energy demand forecasting?

RQ2: What key concepts and knowledge clusters define and support this domain?

RQ3: Which emerging themes are shaping the future direction of energy demand forecasting research?

By addressing these questions, the study aims not only to provide a comprehensive overview of the field but also to identify novel pathways that can catalyze further advancements in green energy policy research.

2. METHODOLOGY

2.1 Bibliometric analysis

Bibliometric analysis is a quantitative methodology that is extensively employed in scientific research, especially suitable to study large scientific datasets (Donthu et al., 2021). This approach centers on quantifying scientific output and efficacy by examining diverse bibliographic data, such as publications, authors, citations, and other relevant factors. Bibliometric techniques enable academics to monitor long-term patterns in a specific discipline, evaluate the influence of scholarly work, and pinpoint prominent contributors in a particular research domain. Moreover, bibliometric analysis can enhance comprehension of the organization and development of scientific fields by delineating relationships among researchers or subjects. The bibliometric approach provides valuable insights into the dynamics of knowledge production and dissemination, contributing to an empirically grounded understanding of scientific activity. Numerous scholars widely employ this approach in comprehensive evaluation studies across various disciplines, including education (Hallinger & Hammad, 2019), entrepreneurship (Le et al., 2022; Rey-Martí et al., 2016) and energy (Mao et al., 2018).

2.2 Data collection

The data collection process followed the PRISMA instruction, the PRISMA framework is a set of guidelines that ensures the process of selecting, evaluating, and synthesizing literature in systematic reviews and meta-analyses is transparent and structured, thereby facilitating accurate communication and improving the accessibility of research findings for the scientific community. Using the Scopus database, 7,717 publications were identified through a search of the title, abstract, and keyword fields.

In the second step, the initial dataset was refined according to the following criteria:

- Publication period: within five years (2020 - 2024)
- Subject: energy demand, forecasting, and prospects
- Document type: conference papers
- Language: English

The query below displays information collected from the Scopus database:

TITLE-ABS-KEY ("energy demand" AND (outlook OR foresighting OR forecasting OR prediction OR predict OR forecast OR foresight)) AND (LIMIT-TO (SUBJAREA , "ENER")) AND (LIMIT-TO (DOCTYPE , "cp")) AND (LIMIT-TO (LANGUAGE , "English")) AND (LIMIT-TO (PUBYEAR , 2020) OR LIMIT-TO (PUBYEAR , 2021) OR LIMIT-TO (PUBYEAR , 2022) OR LIMIT-TO (PUBYEAR , 2023) OR LIMIT-TO (PUBYEAR , 2024))

A total of 6,781 documents were excluded, leaving 390 records in the dataset. In the third step, each record was screened based on its title, abstract, and, where available, full text. Forty conference papers were removed at this stage. In the final step, 348 conference papers meeting the above criteria were retained for bibliometric analysis. The simplified procedure is illustrated in Figure 1.

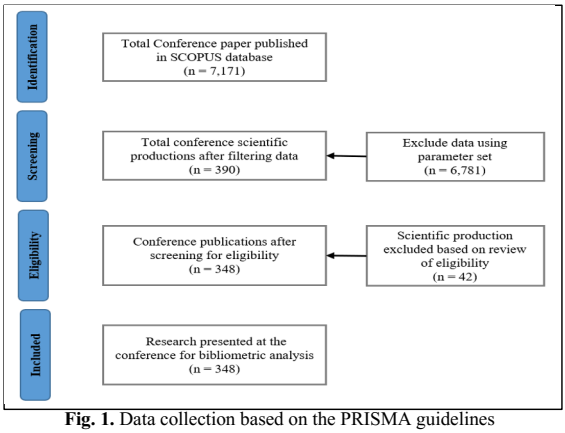

Fig. 1. Data collection based on the PRISMA guidelines

2.3 Data analysis method

This study adopted a bibliometric approach to analyze trends in academic discussions on energy demand forecasting. The research utilized data from the Scopus database, focusing on published conference papers related to energy demand forecasting from 2020 to 2024.

Data analysis was conducted using Excel and VOSviewer. Excel was employed for tabulation, numerical calculations, and performance analysis. Meanwhile, VOSviewer was applied for citation analysis, co-citation analysis, and keyword analysis based on databases such as Scopus. It generates network maps that illustrate relationships among authors, journals, keywords, and documents. The software is capable of handling large datasets and presenting results in intuitive and accessible visualizations. This analysis focused on growth trajectories, geographical distribution, research collaborations, and significant publications. The visual scientific maps facilitate the identification of prominent connections among authors, countries, and keywords.

This model uses keywords and author frequency by year to map trending topics. In addition, information related to current trends serves as a guide for further research in the field. Each node represents an author keyword. The larger the node, the more times the author keyword appears. The links between two nodes represent the relationship between two author keywords based on co-occurrence analysis, while the widths of the lines connecting different nodes represent the number of co-occurrences of the corresponding keywords in the same document on “Energy Demand Forecast”.

3. RESULTS AND DISCUSSION

3.1 Number of conference papers

Fig. 2 provides a detailed view of the recent conference paper trends, which generally show an increasing but uneven tendency. The number of papers presented at conferences in the Scopus database is 348 on the topic of "Energy Demand Forecast" in the 5 years period from 2020 to 2024. In this section, studies on this topic are analyzed from four main perspectives: growth trajectory, geographical distribution, research collaboration, and crucial publications in the field of energy demand forecasting. The conference papers can be divided into two distinct phases: the Incepting period and the Accelerating period.

First, the incepting period from 2020 to 2022 is a period of stable growth, with a slight and steady increase over the years, only rising about 3–5% per year. The annual total of publications does not surpass 60. Because the growth rate is still slow, this period can be considered a stable start, without a major breakthrough.

Second, the growth rate accelerated markedly during the period from 2023 to 2024, with a total of 179 publications within just two years. The number of conference productions increased by approximately 27% from 2022 to 2023 and by nearly 39% from 2023 to 2024, reflecting a substantial surge in research. The peak year in terms of issuances volume during this period was 2024, with 104 conference papers presented, indicating a strong boost in research activity. The rapid increase in the number of research issuances on energy demand forecasting reflects the growing interest in energy transition (Portillo Diaz et al., 2022), the application of new technologies, and the need to ensure energy security in the context of climate change (Gonenc et al., 2022).

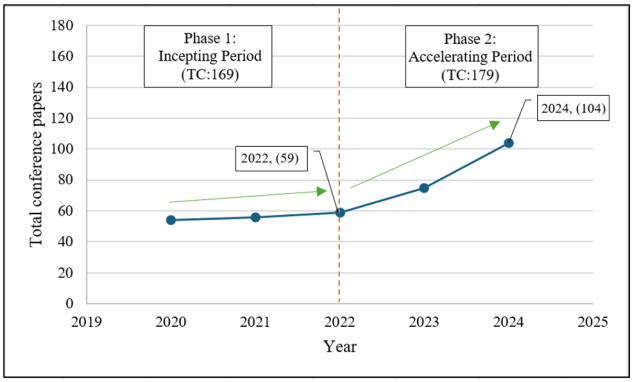

Fig. 2. Total publications by year

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3.2 Analysis of impact sources

Table 1. Top 10 impact sources

No	Source	TC	NP	PY_start	Country
1	E3S Web of Conferences	50	31	2020	France
2	Energy Reports	36	2	2020	Netherlands
3	Proceedings - 2022 IEEE 4th Global Power, Energy and Communication Conference, GPECOM 2022	32	3	2022	Turkey
4	Proceedings - 2021 International Conference on Control, Automation, Power and Signal Processing, CAPS 2021	22	1	2021	India
5	International Conference for Technological Engineering and its Applications in Sustainable Development, ICTEASD 2023	18	1	2023	Iraq
6	2020 8th International Electrical Engineering Congress, iEECON 2020	17	1	2020	Thailand
7	Asia-Pacific Power and Energy Engineering Conference, APPEEC	17	5	2020	China
8	Proceedings - 2020 IEEE International Conference on Environment and Electrical Engineering and 2020 IEEE	16	3	2020	Spain

No	Source	TC	NP	PY_start	Country
	Industrial and Commercial Power Systems Europe, EEEIC / I and CPS Europe 2020				
9	2021 IEEE Electric Ship Technologies Symposium, ESTS 2021	15	1	2021	USA
10	2021 IEEE PES Innovative Smart Grid Technologies - Asia, ISGT Asia 2021	15	3	2021	Australia

Table 1 shows the 10 most publication sources based on the number of citations. As shown in the table, the most prominent is the *E3S Web of Conferences*, with a total of 50 citations and 31 published papers. Although there are numerous publications, only four conference papers received a relatively high number of citations, ranging from 5 to 10. Consequently, when considering the criterion of the average number of citations per paper, this source ranks the lowest, with an average of 1.61 citations per paper, which is 11 times lower than the top-ranked source - *Proceedings of the 2021 International Conference on Control, Automation, Power and Signal Processing*, which has only one paper but received 22 citations. This is a conference proceeding organized by IEEE, similar to 7 out of the 10 top sources in the table, all of which show relatively high citation counts ranging from 15 to 32. This indicates that, when conducting research on energy-related topics, IEEE conference proceedings are among trusted publication venues for scholars. Notably, the fact that each publication source originates from a different country indicates that reputable publication sources are not concentrated in a single region or specific country but are diversely distributed on a global scale, ranging from Asia to Europe.

3.3 Analysis of country scientific production

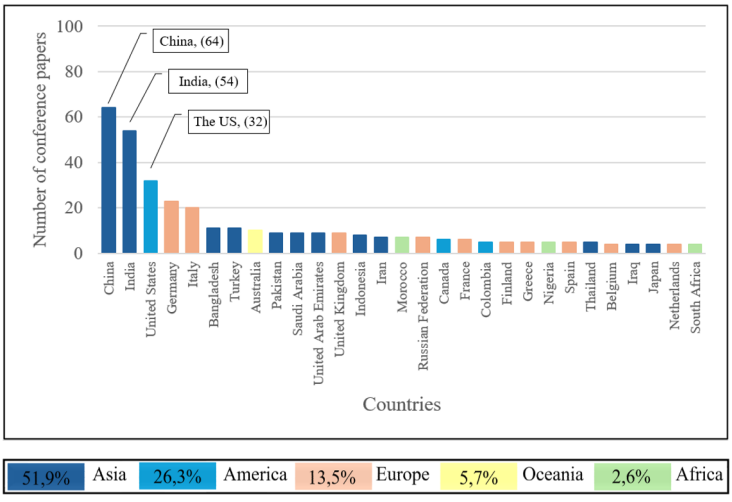

Fig. 3. Geographical distribution of literature on the topic "Energy Demand Forecast" by continent

Fig. 3 focuses on the geographical distribution of conference publications across countries and continents that have made significant contributions to this field from 2020 to 2024. With a total of 348 conference papers promulgated by scholars from 70 countries worldwide, it provides an overview of the academic interest in the topic of "Energy Demand Forecast" across different territories. However, there is a noticeable geographical imbalance in the distribution of these scholars. Specifically, leading the ranking is China, with a total of 64 conference papers featuring an author from this country concentrating on the research, accounting for over 15%, followed by India with approximately 12%. With the active involvement of these two major contributing countries, Asia accounts for 51.9% of the participating scientific productions, demonstrating not only a dominant share in the field but also a diversity of contributing countries. Wang et al. employed Single-linear, Hybrid-linear, and Non-linear Time series forecast techniques to simulate energy consumption in China and India during 1990–2016, demonstrating that these models achieve high accuracy and hold strong potential for application in forecasting energy demand in other countries or regions (Wang et al., 2018). Asia leads this field due to

its rapid economic growth, increasing energy consumption, and strong research promotion policies from countries such as China and India. The Americas, with a significant contribution from the United States accounting for 32 issuance papers, represents a salient proportion of research on energy demand forecasting, attributed to a solid scientific foundation and substantial investments in advanced energy technologies. Suri et al.'s study highlights the need to link academic research with practical applications in microgrid development, implicitly reflecting Europe's comprehensive scientific foundation and large-scale support for advanced energy technology development that supports such integrated innovation (Suri et al., 2020). Beyond the top three countries, the number of conference papers from other nations declines gradually and is relatively evenly distributed. After that, Europe accounts for 13.5% of the total number of publications contributing to the literature on "Energy Demand Forecast" between 2020 and 2024. In contrast, Oceania and Africa represent significantly smaller shares, at 5.7% and 2.6%, respectively. These figures highlight a clear imbalance in regional research contributions, with Asia playing a leading role, followed by the Americas, while Europe holds a moderate position. In contrast, Oceania and Africa remain underrepresented in this field. The geographical imbalance in the number of publications reflects differences in field priorities, research capacity, energy demand, and investment in science and technology across countries and continents (Fu & Waltman, 2022).

While the study "Global Scholars' Interest in Energy Demand and Sustainable Development Goals" provides an important global overview of academic trends from 1997 to 2024, our research advances this discussion by explicitly examining the distinct contributions of scholars from each continent (Le et al., 2025). Specifically, we analyze publication volumes, research themes, and academic impact by citation across six regions: the Americas, Europe, Asia, Africa, South America, and Oceania. This continental breakdown enables us to highlight both regions with strong research development and those with limited engagement, thereby offering insights for more tailored academic development strategies and policy support.

3.4 Analysis of top 20 contributing authors

Table 2. Top 20 authors contributing to the topic "Energy Demand Forecast"

No	Author	NP	PY_start	Author	Citaions	PY_start
1	Arshad N	3	2023	Alam Q	22	2021
2	Brugger H	3	2021	Devi L	22	2021
3	Deb S	3	2022	Khan A.A.	22	2021
4	You G	3	2023	Minai A.F.	22	2021
5	Abbas M	2	2020	Pachauri R.K.	22	2021
6	Aggidis G	2	2023	Chebak A	20	2022
7	Ajibade A.A.	2	2024	Eder L.V.	20	2020
8	Anand P	2	2022	Filimonova I.V.	20	2020
9	Beigh K	2	2021	Hammouch F	20	2022
10	Cao Y	2	2023	Ledmaoui Y	20	2022
11	Chebak A	2	2022	Maghraoui A.E.	20	2022
12	Chen S	2	2023	Nemov V.Y.	20	2020
13	Colombo E	2	2023	Provornaya I.V.	20	2020
14	Das N	2	2022	Zemnukhova E.A.	20	2020
15	Deb C	2	2022	Alzubaidi L.H.	18	2023
16	Eichhammer W	2	2021	Choubey A	18	2023

No	Author	NP	PY_start	Author	Citaions	PY_start
17	Fleiter T	2	2022	Khurramov A	18	2023
18	Golagha O.G.	2	2024	Mahesh B.	18	2023
19	Goswami A.K.	2	2022	Sathiyakala R.	18	2023
20	Gratzfeld P	2	2021	Sravanthi J	18	2023

As presented in Table 2, this is a list of the 20 most influential authors, determined based on two criteria: the number of conference papers published and the total citation counts. The data were extracted from a dataset of 1,399 authors who conducted research on the topic of "Energy Demand Forecast" during the period 2020 - 2024, with conference papers being the primary form of publication. During this period, the number of papers published by most authors was relatively limited, averaging only 2 - 3 conference papers.

Although the publication time is different, there are conference papers published early from 2020, such as *Methods to establish energy performance targets in a gas plant* by Abbas M., to conference papers published late in 2024, such as *An Automated Machine Learning and Analytics Framework for Data-Driven Optimization of Multi-Source Regional Energy Systems* by Ajibade A.A. - these conference papers also received very few citations (1 - 5). This shows that these studies have not received much attention from researchers. In contrast, among the top 20 authors with the highest total citation counts, the majority of citations are concentrated in a single conference paper. Chebak A. is the only exception, having published two papers, although the majority of his citations still originate from one main paper. Notably, the authors in this group are also the contributors of highly cited conference papers published in the sources listed in Table 1 as (Khan et al., 2021; Maghraoui et al., 2022; Provornaya et al., 2020; Udayakumar et al., 2023). Although most of the conference papers published by these authors are single contributions, the high citation counts the authors have received indicate that the research topics they concentrate on - such as energy, energy forecasting, smart building, and machine learning - are attracting considerable attention from the scientific community.

3.5 Analysis of co-author collaborations

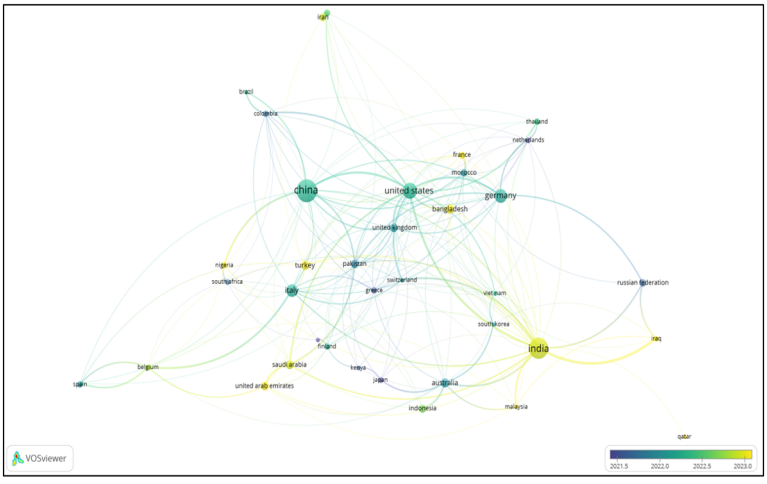

Fig. 4. Co-author collaboration networks by country from the topic "Energy Demand Forecast"

Fig. 4 illustrates the experience of each country documented in the studies and the extent of international collaboration in the field of "Energy Demand Forecast". The width of the lines connecting different nodes represents patterns of co-authorship among scholars from the corresponding countries. The wider the line, the more publications have been co-authored by researchers from the nations. China has the highest number of contributing authors and maintains the most extensive connections with countries across various continents for international research collaboration. However, the

relationship between the United States and the international community seems clearer and stronger, showing a closer and deeper partnership. This may reflect the quality and impact of combining research works, where projects tend to be larger in scale, longer in duration, or focused on complex issues requiring intensive cooperation. This distinction between the number of connections and the amount of combinations is one that needs special attention when evaluating the roles of countries within the global research network.

Notably, although Indian co-authors represent a large contributor base and maintain links with many countries, India is not among the territories with the most experience in this field of scientific inquiry, even though it became the second most productive academic community (after China) in 2024. This indicates that the rapid growth in the number of publications from India could stem from emerging scientists or newly formed research groups entering the field. Recent studies highlight that prominent topics such as the integration of artificial intelligence (AI) into climate change estimation processes (Duklan et al., 2023) have garnered significant attention from Indian scholars, motivating their active engagement in the development of scientific outputs in the field of energy demand forecasting. As these researchers accumulate greater expertise, this progression is expected to substantially enhance both the quality and quantity of academic issuance originating from India in the foreseeable future. In addition, Colombia, Kenya, Japan, Greece, and the Netherlands have contributed co-authors with extensive experience in "Energy Demand Forecast" research, with publications dating back to before 2021. Presented by a Greek author at the International Conference on Energy and Environmental Systems in 2006, it is one of the earliest studies to discuss the application of the modified logistic and the General Modified Exponential (GME) in order to forecast the maximum power demand in Greek (Christodoulou et al., 2006). This can thereby guide future research collaboration strategies, encouraging emerging countries to build experience while strengthening existing partnerships to more effectively address global energy challenges (Bilardi et al., 2023).

3.6 Analysis of important documents

Table 3. Top 10 influential documents in the topic "Energy Demand Forecast"

No	Title	Authors	PY_Start	Conference	Total Citations	TC_Per Year
1	Energy Demand Modelling and ANN Based Forecasting using MATLAB/Simulink	Khan A.A.; Minai A.F.; Devi L.; Alam Q.; Pachauri R.K.	2021	CAPS	22	5.5
2	Smart Energy Management System: A Comparative Study of Energy Consumption Prediction Algorithms for a Hotel Building	Maghraoui A.E.; Hammouch F.-E.; Ledmaoui Y.; Chebak A.	2022	GPECOM	20	6.7
3	Formation of energy policy in Europe, taking into account trends in the global market	Provornaya I.V.; Filimonova I.V.; Eder L.V.; Nemov V.Y.; Zemnukhova E.A.	2020	Energy Reports	20	4
4	An Integrated Deep Learning and Edge Computing Framework for Intelligent Energy Management in IoT-Based Smart Cities	Udayakumar R.; Mahesh B.; Sathiyakala R.; Thandapani K.; Choubey A.; Khurramov A.; Alzubaidi L.H.; Sravanthi J.	2023	IEEE	18	9
5	PV Power Forecasting with Holt-Winters Method	Kanchana W.; Sirisukprasert S.	2020	iEECON	17	3.4
6	Forecasting residential electric power consumption for Bogotá Colombia using	Peña-Guzmán C.; Rey J.	2020	Energy Reports	16	3.2

No	Title	Authors	PY_Start	Conference	Total Citations	TC_Per Year
	regression models					
7	On Estimating the Port Power Demands for Cold Ironing Applications	D'Agostino F.; Schiapparelli G.P.; Dallas S.; Spathis D.; Georgiou V.; Prousalidis J.	2021	ESTS	15	3.8
8	Analyzing the Effects of COVID-19 Pandemic on the Energy Demand: The Case of Northern Italy	Scarabaggio P.; La Scala M.; Carli R.; Dotoli M.	2020	AEIT	14	2.8
9	Forecasting energy time series with profile neural networks	Heidrich B.; Turowski M.; Ludwig N.; Mikut R.; Hagenmeyer V.	2020	ACM	13	2.6
10	Designing Microgrids for Rural Communities: A Practitioner Focused Mini-Review	Suri D.; Shekhar J.; Mukherjee A.; Singh Bajaj A.	2020	EEEIC	12	2.4

Table 3 presents the top 10 documents ranked by citation index to identify the most important publications. The top 10 papers were mostly presented at the top conferences shown in table 1; nevertheless, these significant publications were not authored by the leading researchers listed in table 2. To assess the impact of the scientific issuances presented at the conference, we use the number of citations and the annual citation rate as analytical metrics. The three most cited promulgations have about 26% more citations than the total number of citations. From the 6th literature onwards, the ratio starts to decrease steadily from nearly 6.5% to 3%, a fairly even distribution of percentages reflecting the tight competition among productions in the same field. The publications outside the top 10 accounted for less than 3% of citations, showing that the impact gap between the top 10 documents is quite pronounced. Additionally, half of the scientific productions at conferences held in 2020 ranked among the most cited papers despite being in the early years of the study, demonstrating the importance of these promulgations. The research presented at the conference during this time attracted great attention from the research community by virtue of their in-depth analysis of the impact of the pandemic (Scarabaggio et al., 2020) and the development of modern forecasting methods such as the neural network (Heidrich et al., 2020) or the Holt-Winters method (Kanchana & Sirisukprasert, 2020). Notably, although the scientific paper ranks fourth in terms of total citations, it has a high annual citation rate, averaging nine citations per year despite being published only two years prior to the time of this study, surpassing the citation rate of many earlier published papers. A vital conference paper explored advanced energy management strategies to address growing energy demands and resource depletion (Udayakumar et al., 2023). This not only highlights the topics and approaches receiving the greatest attention from the scientific community but also emphasizes the urgency of developing more accurate and efficient forecasting models. Recent studies, particularly those focusing on advanced energy management strategies, have the potential to provide deep insights and practical tools to address resource scarcity and meet the growing energy demand. Therefore, researchers in this field should continue to concentrate on applying modern methods, exploiting new data, and exploring more flexible forecasting scenarios to adapt to the rapidly changing global energy landscape.

3.7 Analysis of author keyword

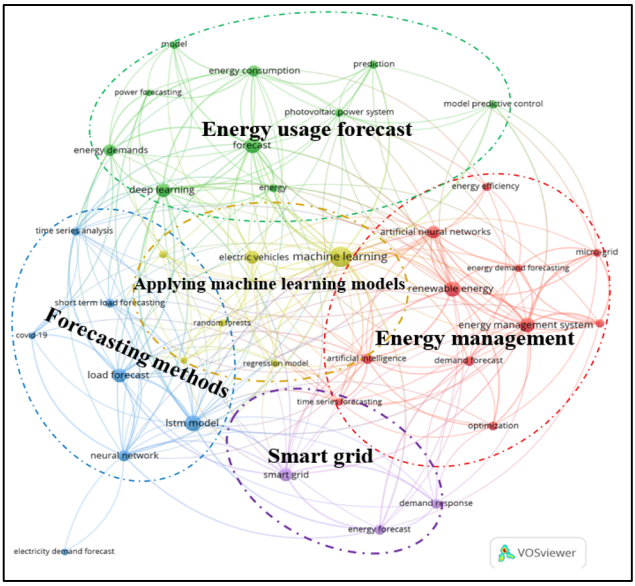

Fig. 5. Science mapping of keywords in the topic "Energy Demand Forecast"

Note: Threshold 37 author keywords with at least 5 occurrences

As shown in Fig. 5, five overlapping clusters represent five topics and are characterized by five colors identified from the co-occurrence analysis: (i) Energy usage forecast, (ii) Applying machine learning models, (iii) Forecasting methods, (iv) Energy management, (v) Smart grid. Combined with the yearly figure, we will determine the era and influence of the keywords. First, the group of keywords that have appeared early, such as forecast, load forecast, short term load forecasting, time series analysis have appeared and been heavily researched early (2022 and before). These are important foundations in electricity load forecasting and energy forecasting. But in recent years, the trend has gradually shifted, not only to research load forecasting but also to apply algorithms to optimize operations and use energy effectively. Therefore, in the period from 2022-2023, keywords such as Machine Learning, LSTM model, smart grid, micro grid, renewable energy, and optimization are the most prominent. And especially Machine learning is the most appearing keyword, showing that this is the center connecting with other keywords in the research papers and with the color being green, it shows that this is a prominent topic, has an influence on other topics and will continue to be mentioned in future research articles.

Table 4. Topical trends based on the 37 most frequent keywords (minimum five occurrences)

Cluster's color	Name of cluster	Keywords (Occurrences) (Avg.Pub.Year)	Total keyword
Green	Energy usage forecast	deep learning (21) (2022.8), energy (8) (2022.8), energy consumption (13) (2022.2), energy demands (15) (2021.1), forecast (24) (2022.0), model (7) (2022.2), model predictive control (8) (2022.4), photovoltaic power system (8) (2022.8), power forecasting (8) (2022.8), prediction (8) (2022.6)	10
Blue	Forecasting method	covid-19 (5) (2021), electricity demand forecast (5) (2023.2), load forecast (21) (2022.2), lstm model (27) (2023), neural network (14) (2022.2), short term load forecasting (9) (2022.4), time series analysis (7) (2022.8)	7

Cluster's color	Name of cluster	Keywords (Occurrences) (Avg.Pub.Year)	Total keyword
Yellow	Applying machine learning models	convolutional neural networks (6) (2023.2), electric vehicles (18) (2022.2), energy consumption forecasting (5) (2021.8), machine learning (46) (2022.8), random forests (6) (2022.2), regression model (6) (2022.8)	6
Red	Energy management	artificial intelligence (11) (2022.6), artificial, neural networks (17) (2022.), demand forecast (10) (2021.), energy demand forecasting (6) (2022.6), energy efficiency (7) (2021.4), energy management system (22) (2022.), internet of things (7) (2023.), micro-grid (8) (2023.2), optimization (9) (2023.0), renewable energy (24) (2023.0), time series forecasting (6) (2022.6)	11
Purple	Smart gird	demand response (10) (2022.0), energy forecast (12) (2022), smart grid (18) (2022.6).	3

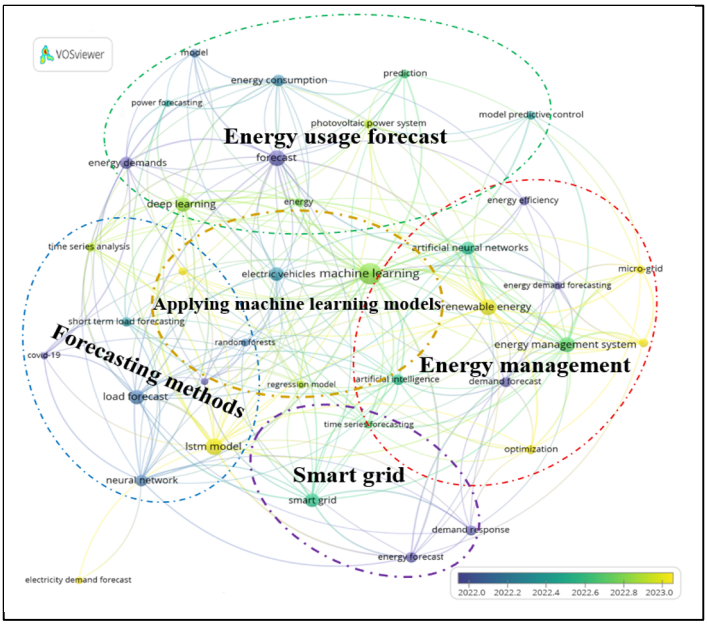

Fig. 6. Temporal co-occurrence network of keywords

Energy usage forecast (Green cluster)

The "energy usage forecast" topic cluster primarily focuses on the application of deep learning (21 occurrences) and forecasting (24 occurrences). Among the keywords of cluster such as energy, energy consumption, energy demands, model, model predictive control, photovoltaic power system, power forecasting, and prediction, the term forecast has the highest frequency (24 occurrences), with an average publication year of 2022, reflecting its central role in recent research. Meanwhile, the notable presence of deep learning (21 occurrences, average publication year 2022.8) highlights a growing trend in employing deep learning techniques to enhance forecasting accuracy, especially in the energy sector. The trend of using deep learning models particularly Bi-LSTM, as illustrated in the study by Wibawa et al. (2024) not only improves the accuracy of hourly energy forecasts but also supports effective management of energy resources in densely populated urban areas with high demand fluctuations. This underscores the potential of deep learning in addressing complex challenges in energy forecasting and contributes to the advancement of smarter and more sustainable energy systems (Wibawa et al., 2024). In addition, deep learning is increasingly used to predict solar power generation, as renewable

energy becomes more common in daily life. Photovoltaic systems now account for about 47.4% of the total share. Recent studies have found the main factors that affect solar power output and suggested future research directions to improve the accuracy of long-term forecasts (Kumar & Picerno, 2023; Zhang et al., 2024).

Forecasting Method (Blue Cluster)

The Forecasting Method topic cluster focuses on techniques for predicting energy demand, with key keywords including LSTM model (27, 2023), neural network (14, 2022.2), short-term load forecasting (9, 2022.4), time series analysis (7, 2022.8), load forecast (21, 2022.2), electricity demand forecast (5, 2023.2), and COVID-19 (5, 2021). Among these, the LSTM model stands out with the highest frequency (27 occurrences) and the most recent average publication year (2023), reflecting the growing trend in utilizing deep learning models particularly LSTM. LSTM has the ability to retain past information, especially long-term information, which allows it to make highly accurate and realistic (Cheelamanthula, 2022; Sau et al., 2024; Zhou et al., 2020). This is a key advantage that sets it apart from other methods and explains why it is widely used in energy demand forecasting. Because energy demand often changes on an hourly, daily, or weekly basis and is influenced by various external factors. While neural networks also show a relatively high frequency of usage (14 occurrences), it appears that researchers are increasingly shifting toward more advanced methods such as LSTM, indicating a progression in the adoption of deep learning techniques in this field (Kaur et al., 2022). Although time series analysis appears less frequently (7 occurrences), it continues to serve as a fundamental approach, often integrated with machine learning models to analyze energy data. As highlighted in the study by Tahir et al., external factors such as the COVID-19 pandemic can significantly reduce the accuracy of short-term forecasting models, necessitating the flexible combination of machine learning and time series analysis to adapt to sudden changes in energy demand (Tahir et al., 2021). These findings underscore the importance of ongoing research and optimization of deep learning models to ensure the reliability and sustainability of future energy systems.

Applying machine learning models (Yellow cluster)

Studies in this theme focus on applying machine learning models on convolutional neural networks (6) (2023.2), electric vehicles (18) (2022.2), energy consumption forecasting (5) (2021.8), machine learning (46) (2022.8), random forests (6) (2022.2), regression model (6) (2022.8). Various machine learning load forecasting methods, including random forest models and explored regression models, are employed to predict the outputs of natural factors, analyze energy consumption, and evaluate performance, serving as an effective foundation for planning, design, and intelligent management to address current challenges in the application of these models. In the context of water scarcity, increasing carbon emissions, climate change and increasing energy demand, advanced models are deployed to address the challenge of accurately forecasting and optimizing both the renewable energy mix for desalination systems and the estimated ultimate recovery (EUR) of shale gas at an early stage, thereby improving operational efficiency, saving energy, reducing emissions and optimizing resource development strategies (Algarhy et al., 2024; Sanan et al., 2024**).** It is noteworthy that "Machine learning" appears 46 times, underscoring its central importance to this group. Furthermore, the application of these models extends beyond energy consumption forecasting to include the analysis of natural factors affecting energy, optimize energy distribution and performance evaluation (Omirgaliyev et al., 2024). This reinforces the role of machine learning as a fundamental tool for the intelligent planning, design, and management of energy systems (Jala et al., 2023; M et al., 2024). Besides, "convolutional neural networks" are not a new keyword, but it appear less in the research on in the context of energy demand forecasting because they are not the most optimal models for time series data, with models such as LSTM and GANs being more commonly preferred (Raju et al., 2024). In summary, this cluster represents a key research frontier, concentrating on the development and deployment of advanced machine learning techniques to address current and future challenges in the energy sector, particularly in the context of the transition to sustainable energy and the growth of renewable energy (Hall et al., 2023).

Energy management (Red cluster)

The Energy Management Group focuses on the governance, operations, and policy aspects of energy efficiency. Keywords with a huge citation count, such as renewable energy (24) (2023.0), energy management system (22) (2022.0), neural networks (17) (2022.0), artificial intelligence (11) (2022.6) reflect a modern prioritization of these critical concerns. At the same time, it reflects the cluster's emphasis on managing energy pools and employing models to promote efficient and optimal energy use. Notably, the presence of the terms "Demand forecast" (10) (2021.0), "Energy demand forecasting" (6) (2022.6) and "Artificial intelligence (11) (2022.6)" is categorized under this group rather than the green cluster because it plays a central role in forecasting and optimizing energy demand through AI-based methods for efficient resource management (Gonenc et al., 2022; Shajalal et al., 2022) It serves as evidence of the necessity to optimize energy system management for future forecasting purposes (Chakma & Das, 2021; Goswami et al., 2023). In summary, the "Energy Management" cluster not only reflects the trend of applying AI technologies and neural networks in energy system management but also emphasizes the indispensable role of energy demand forecasting in achieving efficiency and sustainability goals (Abbas & Saad Bin Saeed, 2024; Popov & Bochkareva, 2022). This suggests that future research should continue to focus on developing intelligent energy management systems, with deeper integration of advanced forecasting methods to address the complex challenges of modern energy systems (Maghraoui et al., 2022; P. et al., 2023;

Safari et al., 2024; Teixeira et al., 2024).

Smart Grid (Purple cluster)

The purple cluster, named “Smart Grid”, comprises three main keywords: smart grid (18 occurrences, 2022.6), energy forecast (12 occurrences, 2022.0), and demand response (10 occurrences, 2022.0). Among these, “smart grid” stands out with the highest frequency, reflecting growing research interest in intelligent electricity grid systems. Characterized by its ability to collect and analyze real-time data through devices such as smart meters, the smart grid facilitates more accurate “Energy forecast”. As noted by (Husnoo et al., 2022), analyzing smart grid data enables the discovery of hidden patterns and critical factors for effective energy consumption prediction, underscoring the pivotal role of energy forecasting in managing energy demand and optimizing grid performance.

“Energy forecast” serves as a core function within the smart grid, enabling the prediction of future energy demand and supporting demand response programs. Demand response programs rely on precise load consumption forecasts to optimize energy distribution planning (Faria et al., 2020). Deep learning models, including “LSTM” and “Random Forest Regressor”, are widely employed to enhance forecasting accuracy, bridging the gap between the vast data generated by smart grids and practical applications in demand response. However, the deployment of these systems faces challenges such as high initial investment costs and data security requirements, necessitating close integration between technological advancements and energy policy frameworks.

Although both our study and (Le et al., 2025) examine the topic of energy through bibliometric analysis, there are notable differences in the findings. (Le et al., 2025) research on the 2020 - 2024 period, with a group of keywords that focus on sustainable development, energy policy, renewable energy, and climate change. In contrast, our research, in addition to the above group of keywords such as forecasting techniques and models including machine learning, deep learning, LSTM models, convolutional neural networks, or smart grids. This divergence suggests that when focusing exclusively on conference papers, the publication trend shifts toward more practical and technology-driven research. These studies tend to emphasize real-world applications and the shaping of future technological directions. It is this characteristic that has given advice to the conference as a place to publish works that can be quickly transferred into practice (Franceschet, 2010), aiming to solve today's urgent problems.

4. CONCLUSION

In conclusion, our exploration of the topic "Energy Demand Forecast" provides a comprehensive overview, shedding light on important aspects different that are highly relevant to this field. These findings underscore the significance of forecasting energy demand across multiple aspects of life and highlight the substantial potential of bibliometric analysis as a powerful tool to understand and advance academic research in this domain. By analyzing data collected from the Scopus database using bibliometric methods, we have observed a significant increase in the number of conference papers contributed to the topic of “Energy Demand Forecast” over the years. Notably, during the period from 2022 - 2024, contributions surged by 27 - 39% annually, compared to a modest 3 - 5% annual growth from 2020 - 2022. Additionally, a country scientific production analysis revealed that China, India, and the United States lead in publication volume. These nations are also among the largest energy consumers for both economic and daily life activities, indicating a strong correlation between research attention and practical energy management needs. Keyword and keyword cluster analysis identified core concepts and foundational knowledge clusters that define the field. From consistently appearing keywords such as energy, forecast, and power forecasting, to emerging terms like renewable energy, optimization, and micro-grid, we observed a shift in research direction. Based on this, proposing future research is applying machine learning to develop algorithms that address stability issues in smart grid management using renewable energy sources, given the variable nature of these resources across regions. In addition, based on the findings of our study, we propose a future research direction focusing on the analysis of the influence of social factors such as mobility behavior, tourism, and trends in the use of electric vehicles on energy demand. This trend aims to optimize energy management and promote the use of renewable energy sources, contributing to environmental sustainability and supporting the energy transition toward a more sustainable future.

Limitation

As with many studies using bibliometric approaches, this research also has certain limitations. First, this research only provides an analysis within a short period of five years (2020 - 2024), which may not fully capture long-term trends, particularly in the current context of energy transition. Second, all data employed in this article are drawn from the Scopus database and consist of conference papers; therefore, limit the representativeness and comprehensiveness of the findings. Finally, the exclusive use of English-language data may reduce the diversity of research perspectives and constrain the ability to reflect the global context adequately.

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