



Applications of Operations Research in Energy Management Optimization

¹Dr Richa Kalpesh Saxena, ²Paakhi Garg, ³Rajashri Iyer, ⁴Raina Goel, ⁵Rian Shah, ⁶Praneel Basu

BBA, NMIMS, Anil Surendra Modi School of Commerce, Mumbai Campus, India

ABSTRACT

Energy systems should meet rising demand while reducing emissions, and operations research (OR) provides many of the decision tools for doing so. This study maps how OR-based research on energy management has developed. A Scopus search on 10 September 2026, screened according to the PRISMA statement, retrieved 614 articles and reviews published since 2016 in 364 sources, which were analysed with bibliometrix (Biblioshiny) and VOSviewer. Annual output grew from 4 documents in 2016 to 194 in 2025, an annual growth rate of 44.97%. Energies, IEEE Access and Applied Energy are the most productive journals, India and China lead by corresponding-author country, and the United Kingdom, Singapore and the United Arab Emirates earn the highest average citations. Thematic analysis identifies energy, machine learning and energy management as motor themes; energy efficiency, data analytics and information management as basic themes; predictive analytics and optimization as niche themes; and the Internet of Things, digital twins and predictive maintenance as emerging ones. Optimization is increasingly embedded in data-driven systems and is less often studied on its own. The study proposes a research agenda built on five gaps: integrated models of interacting assets, links between forecasts and operating decisions, settings with limited infrastructure, the system-wide effects of storage, and long-term planning under policy uncertainty. Implications for academics, managers, society and policymakers are discussed, as well as the limitations of the study.

KEYWORDS: operations research; energy management; optimization; bibliometric analysis; predictive analytics; PRISMA; VOSviewer

1. INTRODUCTION

Energy systems are being asked to deliver more power, from sources that are harder to predict, while releasing less carbon. The scale of that demand is clear from the latest global figures. According to the International Energy Agency (IEA, 2026a), world energy demand grew by 1.3% in 2025, and electricity demand grew by about 3%, more than twice as fast. Energy-related carbon dioxide emissions still reached a record of nearly 38.4 billion tonnes, even though their growth slowed to around 0.4% (IEA, 2026a). The IEA (2026b) expects global electricity demand to keep growing by about 3.6% a year between 2026 and 2030, at least 2.5 times faster than total energy demand, with emerging economies accounting for about 80% of the additional consumption. The authors take the view that this pressure cannot be met by building capacity alone. Generation, storage and consumption also have to be scheduled, controlled and priced with far greater care, and that is the task of energy management.

Operations research (OR) offers the formal means of doing so. Techniques such as linear and mixed-integer programming, stochastic and robust optimization, model predictive control and metaheuristic search allow a decision maker to state an objective, set out technical and economic constraints, and identify the best feasible action. The dataset examined in this study contains clear examples. Tziovani et al. (2021) formulated the peak-shaving operation of a flywheel storage system as a lexicographic optimization problem, solved by linear programming within a model predictive controller and corrected by a secondary controller when forecasts proved wrong. Wang et al. (2026) developed a data-driven stochastic optimization approach that uses observed side information and tested it, among other cases, on a wind energy commitment problem. Pawar et al. (2026)

combined hydraulic simulation, machine learning and a genetic algorithm to plan urban water infrastructure, and reported a 24.3% fall in the energy used to operate the water system. In practice the methods divide by problem type. Deterministic programming handles scheduling and dispatch when inputs are reliable. Stochastic and robust methods are used when demand, prices or renewable output are uncertain. Metaheuristics such as genetic algorithms are applied where a problem is too large or irregular for an exact solution, and model predictive control repeats the optimization at each time step so that decisions adjust as new measurements arrive. The common benefit is that choices once made by rule of thumb or operator experience can be tested against explicit cost, emissions and reliability criteria. The three studies above show where the field currently stands. Optimization is rarely applied alone any more. It is paired with forecasting, sensing and artificial intelligence (AI), so that data indicate what is likely to happen and optimization determines what should be done about it. For managers, this changes the practical question from whether to optimize to how the different methods should be combined.

The motivation for this study came from a mismatch the authors noticed while reading around the subject. Research on energy management is expanding quickly, yet it is scattered across engineering, computing, sustainability and management journals, and few sources show how much of it rests on OR. The applications are broad: dispatch and unit commitment in power systems, battery and storage scheduling, demand response, heating and cooling control in buildings, microgrid coordination, maintenance planning, fuel logistics and long-term investment decisions. Each of these is, at its core, an allocation problem under constraints, which is what OR was built to handle. Most learners meet OR through classroom problems such as transportation, assignment and inventory, and energy management shows how the same logic scales to systems that carry national budgets and emissions. A researcher or practitioner entering this area has no easy way of telling which themes are well established, which are only now forming, and which have been left alone. The authors considered that a bibliometric review, which counts and maps the literature instead of selecting from it, was the most direct way to answer these questions.

The study differs from the reviews cited below in scope and method. Existing reviews usually examine one technology or one sector, such as photovoltaic systems, hybrid renewables or digital twins, and they select the studies they discuss. This study instead takes a defined set of 614 documents, applies stated screening rules to it, and reads the whole set through counts, networks and thematic maps. The authors regard this as a more transparent basis for judging which areas are crowded and which are thin, and it is the reason the paper ends with a research agenda grounded in the data and not in the preferences of the authors.

The literature review that precedes the analysis was organised around ten concepts: energy management optimisation, energy efficiency, predictive analytics and forecasting, AI and machine learning, smart energy management systems, the Internet of Things (IoT), renewable energy integration, hybrid renewable energy systems, smart grids and grid stability, and energy auditing. Recent reviews cover these concepts mostly from the technology side. Rao et al. (2025) survey IoT-enabled energy management for photovoltaic generation, Mhlanga (2023) reviews AI and machine learning for energy consumption and production in emerging markets, and Ahamed et al. (2026) examine machine learning for optimizing hybrid renewable systems in decentralized smart grids. Gopinath et al. (2024) look at energy auditing in hybrid solar and wind systems, and Djebali et al. (2024) at digital twins in smart grids. A second group of studies looks at the setting in which such tools are used, including edge computing policy in the oil and gas sector (Yadav et al., 2026), ICT infrastructure and governance in smart cities (Sunindyo et al., 2025), predictive modelling for urban development (Cina et al., 2025) and the digital transformation of operations in engineering enterprises (Soni & Saini, 2025). The authors found that these works describe tools and settings well but say comparatively little about the decision models that turn data into action. Three patterns recur across the reviewed work. Forecasting and AI studies report high predictive accuracy, such as 91.7% for wind pattern prediction (El-Barbary et al., 2025) and 97.2% for water demand (Pawar et al., 2026), but accuracy is treated as the end point and not as an input to an operating decision. IoT studies concentrate on monitoring and maintenance. Reviews that look at deployment repeatedly name the same barriers: weak data interoperability, cybersecurity risk, fragmented governance, limited financing and limited institutional capacity (Tiwari et al., 2025). This observation shaped the research questions set out below.

The empirical part of the paper follows the guidance of Donthu et al. (2021) on bibliometric analysis and reports sample selection according to the PRISMA statement (Moher et al., 2010). A Scopus search carried out on 10 September 2026 with the keywords “energy management”, “optimization” and “analytics” returned 1,755 records. Restrictions on time span (from 2016), document type (articles and reviews), language (English) and source type (journals) reduced this to 614 documents drawn from 364 sources, of which 499 are

articles and 115 are reviews. The data were analysed with the bibliometrix package and its Biblioshiny interface (Aria & Cuccurullo, 2017), supported by VOSviewer for term and keyword networks. The outputs used include annual production, citation indicators, source, author and country rankings, Bradford's and Lotka's laws, factorial and cluster analysis, trend topics, the thematic map and thematic evolution.

The results describe a field that has grown rapidly from a small base. Annual output rose from 4 documents in 2016 to 194 in 2025, an annual growth rate of 44.97%, and 164 documents are recorded for 2026, a year that is not yet complete. The documents average 25.29 citations each. Energies (31 articles), IEEE Access (24) and Applied Energy (13) are the most productive journals, and WANG Y is the most productive author with 13 articles. Bradford's law places 28 sources in the core zone, and together they account for 206 publications. India (115 articles) and China (111) lead by corresponding-author country, followed by the United States (38), while 31.76% of documents involve international co-authorship. Authorship is widely dispersed, with 92.22% of authors appearing on a single document. The thematic map places energy, machine learning and energy management among the motor themes; energy efficiency, data analytics and information management among the basic themes; predictive analytics and optimization among the niche themes; and the Internet of Things, digital twins and predictive maintenance among the emerging ones. Thematic evolution across three periods (2016–2020, 2021–2023 and 2024–2026) shows early work on AI, big data and optimization giving way to analytics, energy efficiency and energy management, and later to decision making and IoT. The VOSviewer term network separates six clusters, covering technology and governance, analytics and energy efficiency, adoption and property management, smart cities, digital innovation and policy, and the needs and limitations raised by researchers.

The rest of the paper is arranged as follows. It first reviews the literature and describes the research methodology and the screening of records. It then presents the bibliometric results and the thematic analysis, sets out a future research agenda, and closes with a conclusion that covers the implications and limitations of the study.

The study pursues four objectives, each tied to a research question.

RO1. To trace the growth of publications and citations in the OR-based energy management literature, and to identify the journals, authors and countries that have shaped it. RQ1: How has research output developed between 2016 and 2026, and who contributes most to it?

RO2. To describe the conceptual structure of the field and the way its themes have changed over time. RQ2: Which themes are central, specialised or emerging, and how have they shifted across the three periods studied?

RO3. To examine where optimization and other OR methods sit among analytics, AI and IoT in this literature. RQ3: How prominent are optimization and decision-oriented themes compared with data-driven ones?

RO4. To propose a future research agenda. RQ4: Which gaps remain, and which OR approaches could address them?

2. LITERATURE REVIEW

Energy management optimisation: Coordinating generation, storage, and consumption to meet demand at lower cost and with less waste, while respecting technical and operational constraints.

Energy efficiency: Delivering the same service or output with less energy; commonly assessed through consumption, intensity, losses, or system performance.

Predictive analytics and forecasting: Using historical and real-time data, weather information, and statistical or machine-learning models to estimate future demand, renewable generation, or equipment performance.

Artificial intelligence (AI) and machine learning (ML): Data-driven methods that learn patterns and support prediction, fault detection, scheduling, and control decisions in energy systems.

Smart energy management systems (SEMS): Monitoring-and-control platforms that combine measurements, optimisation logic, and automated actions to manage energy use and flows.

Internet of Things (IoT) and real-time monitoring: Connected meters, sensors, and devices that provide timely operating data and enable remote monitoring or control.

Renewable energy integration: Coordinating variable sources such as solar PV and wind with demand, storage, and grid supply to improve utilisation and reliability.

Hybrid renewable energy systems (HRES): Systems that combine two or more energy sources—often solar and wind, sometimes with storage or grid connection—to improve supply flexibility.

Smart grids and grid stability: Digitally enabled electricity networks that coordinate supply and demand; stability concerns the ability to maintain reliable operation despite fluctuations and disturbances.

Suggested search string: (“energy management” OR “energy management system”) AND (optimisation OR optimization OR scheduling OR control) AND (forecasting OR “machine learning” OR IoT OR “renewable energy” OR “smart grid”).



One of the most well-known tools for assessing is systematic literature review (SLR). It is helpful in understanding the previous outcomes for future research (Paul & Rialp, 2020) . SLR provides a structured way to understand the research gaps and the emerging areas of interest. The current study employs Bibliometric Analysis under SLR to get a strong foundation for the topic chosen from the data obtained through keywords search and using citations analysis in peer reviewed journal articles and review papers.(Dr Richa Kalpesh Saxena, Arya Garg, Aryaman Jain, Aryann Mittal, Bhargav Y, 2024). The current investigation utilises an array of assessment techniques to identify and analyse the trends in the application of Operations Research in Energy Management Optimization.

A search was conducted on 10th September 2026 on Scopus database using the search keywords “energy management AND optimization AND analytics”. The inclusion and exclusions of the sample space were based on the Preferred Reporting Items for Systematic reviews and Meta-Analyses (PRISMA) statement. PRISMA has a systematic process that ensures efficiency and effectiveness to the authors in documenting the research methodology.

Following this, a time span filter was set. The publications found were till 2009 but in order to have the adequate data required some exclusion was made. The existence of skip years was taken into consideration and since taking such years would have resulted in a gap in the data which would have disturbed the uniformity, they were excluded from the data set. Keeping all factors in mind data from 2016-2027 was taken into consideration for the further study. This filter left a total of 1717 papers.

Different types of academic publications are available in the Scopus database. However, the author found it essential to excluded Conference papers, Book chapters, Conference review, Book, Retracted, Editorial, Short survey, Erratum and Data paper from the study. This ensured that the sample space was limited to only reviews and articles. This was an important step for the authors as it ensured a great convenience in the bibliometric analysis for the topic. This filter excluded a total of 1088 papers from the data being dealt with.

Subsequently the authors observed that the papers obtained were written in an umbrella of languages. This would have proved to be an obstacle for any further analysis of the data and thus it was decided to exclude languages like Chinese, Russian, and Spanish. It was decided to include only English as it was widely accepted globally. This resulted in an exclusion of 13 papers from the data. This also shows that most of the review and article papers written for the chosen topic are written in English.

The authors then proceeded to add a filter on the source type in the database. There were only two types namely, journal and trade journal. Trade journal publications were excluded because the study focuses on academic research and peer-reviewed scholarly literature. It was decided to include only the journals which left the sample set to 614 documents.

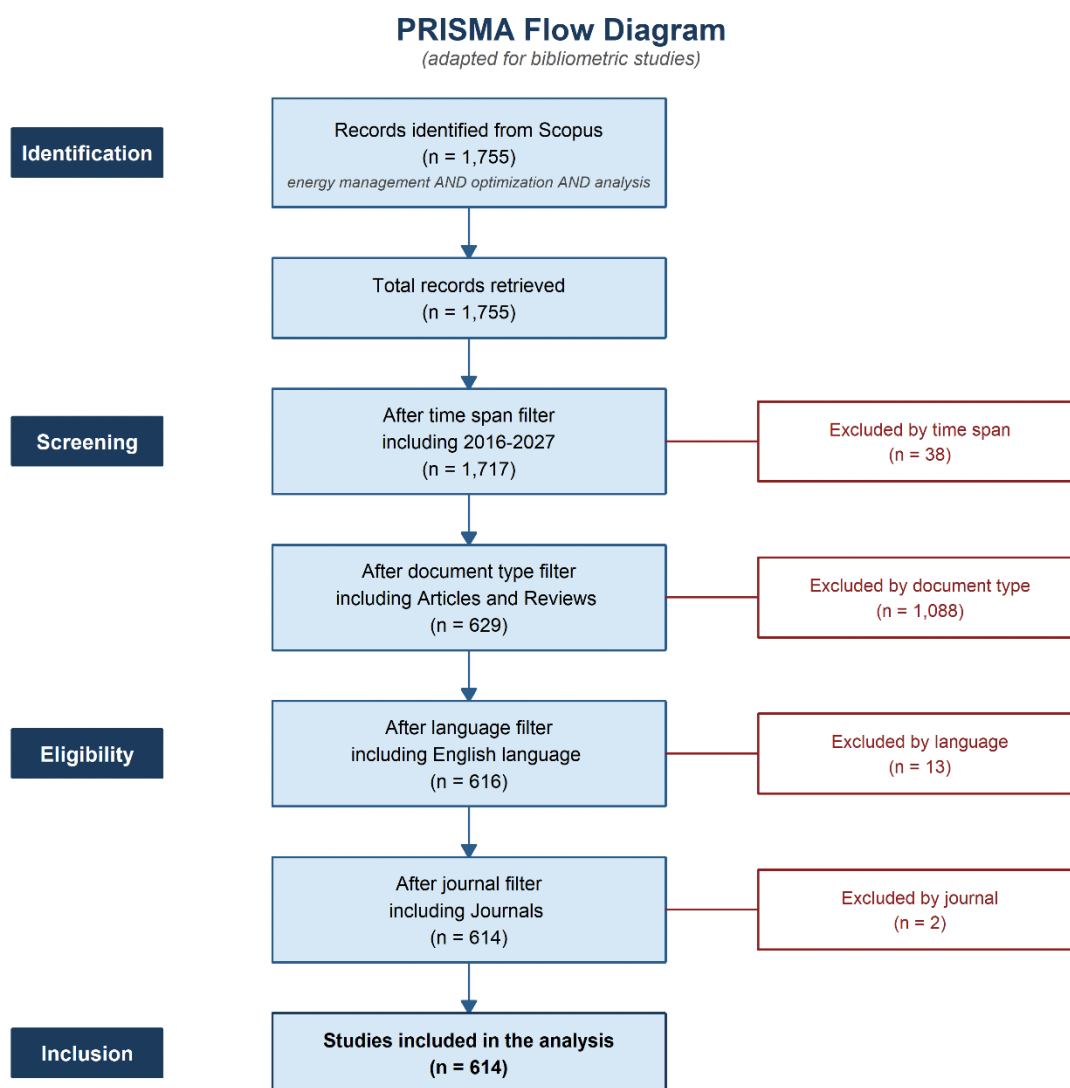


Figure 1: Flowchart of the screening process using Biblioshiny (Aria & Cuccurullo, 2017)

Preferred reporting items for systematic reviews and meta-analyses The authors have created an extensive PRISMA diagram including and documenting for all exclusion and inclusion criteria considered in refining the sample space. Subsequently the authors have used Biblioshiny a package of RStudio to create the PRISMA diagram that is in accordance with the PRISMA 2020 Statement.(Aria & Cuccurullo, 2017).

3.2 Bibliometric Analysis

Bibliometric analysis is a popular and rigorous method for exploring and analysing large volumes of scientific data (Donthu et al., 2021). The authors have used bibliometric analysis and review for the same purpose for the topic chosen in this paper. After employing the keyword search in Elsevier's Scopus database and introducing the above-mentioned filters, the remaining papers were exported in an .ris file from the database and imported into Mendeley Desktop. Furtherly, the papers were then exported from Scopus in a BibTex file (.bib). the reason being this file format is essential for further analysis.

The authors used RStudio to utilise a package inside the library of RStudio called as “bibliometrix”. The authors employed “Biblioshiny” under the bibliometrix package and imported the BibTex file to Biblioshiny. Biblioshiny converted the data into an excel supported file with (.xlsx) format for further analysis in Microsoft Excel. The data was also analysed using analytical software like VOSviewer, Tableau and employed thematic mapping and co-occurrence analysis to obtain or observe a relationship between the keywords searched.

4. DATA ANALYSIS

Report at a Glance

The report covers bibliometric profile, publication growth, sources, authors, countries, citations, collaboration, conceptual structure and thematic development of the selected literature. The main contribution of the report is thematic interpretation. The other bibliometric results serve as the supporting and contextualizing information. Thematic interpretation plays the central role in this report because it helps identify the structure and evolution of the field. The report is based on Biblioshiny dataset.

1. Executive Summary

The report covers bibliometric profile, publication growth, sources, authors, countries, citations, collaboration, conceptual structure and thematic development of the selected literature. The main contribution of the report is thematic interpretation. The other bibliometric results serve as the supporting and contextualizing information. To be more precise, publication growth shows how the field developed over the period of 2016-2026, and containing 614 documents from 364 sources and authors identify the key players and gatekeepers, collaboration reveals the degree and structure of partnerships, and citations indicate the influence and prestige of journals/articles. When it comes to conceptual structure and thematic development, it is possible to suggest that the field is moving towards smart energy management and data-driven decision-making. The thematic map shows that there is strong emphasis on machine learning, data analytics, energy efficiency, optimization, and management as the key themes and areas for investigation. The biggest motor-theme clusters are energy management, machine learning, and energy management, while energy efficiency, data analytics, and information management are the central themes. Predictive analytics and optimization are the specialism, whereas the Internet of Things, digital twin, and predictive maintenance are the declining/emerging areas. According to thematic evolution results, the last three areas might be considered as the most promising ones because they were not present in the earlier years. Therefore, it is possible to conclude that the field evolved from exploring the impacts and role of artificial intelligence, big data analytics, energy consumption, and optimization towards integrated, combined, and holistic approaches to smart decision-making, energy efficiency, and digitalization. All the findings are based on the Biblioshiny database.

2. Dataset and Method

The report is based on Biblioshiny database, which includes articles published between 2016 and 2026. The following bibliometric dimensions were analysed using the dataset: source, author, country, citation, collaboration, Lotka’s law, Bradford’s law, factorial analysis, trend topics and thematic evolution. The study used thematic map as the key analytical tool to reveal the structure of the field, which was aligned with the research question.

The principal dataset indicators are:

Table 1. Principal dataset indicators.

Indicator	Value
Timespan	2016–2026
Documents	614
Sources	364
Annual growth rate	44.97%
Average document age	2.15 years
Average citations per document	25.29
Keywords Plus	4,422
Author keywords	2,265
Authors	2,364
Single-authored documents	34
Co-authors per document	4.3
International co-authorship	31.76%
Articles	499
Reviews	115

Figure 2. Annual publication life- cycle.

3. Annual Scientific Production

There was a significant increase in the number of published articles during the period under review. The output increased from 4 articles in 2016 to 194 articles in 2025. Furthermore, a high level of production was maintained in 2026, with 164 articles published. Overall, the growth rate of the number of publications in the studied period according to Biblioshiny is 44.97% per year.

Table 2. Annual scientific production (articles per year).

Year	Articles
2016	4
2017	10
2018	11
2019	17
2020	29
2021	56
2022	26
2023	28
2024	75
2025	194
2026	164

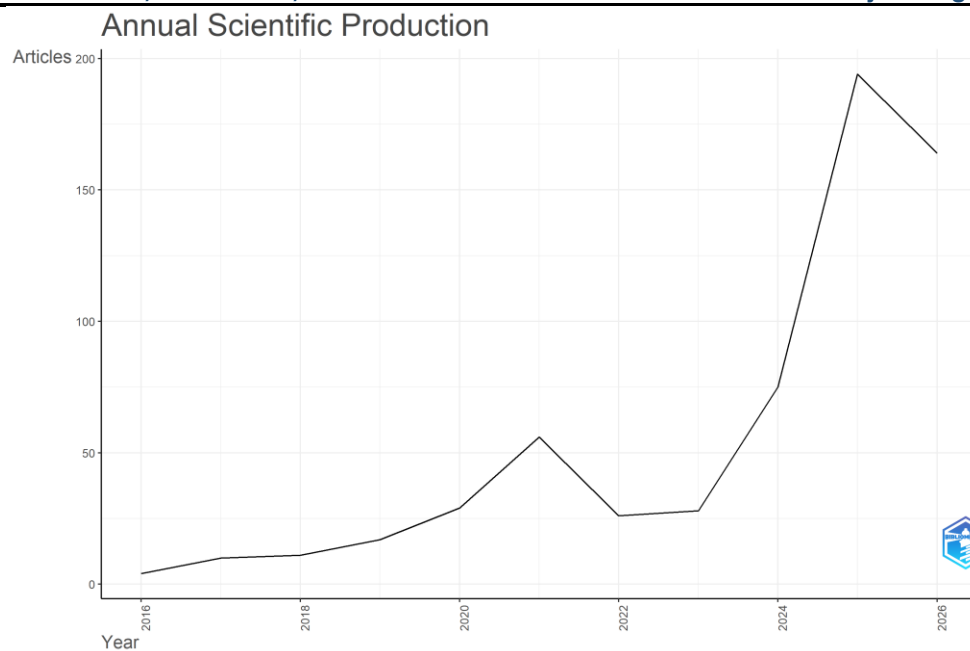


Figure 3. Annual scientific production, 2016–2026.

The number of articles published per year does not grow steadily. It can be seen that before 2021, the growth was consistent from year to year, there was a slight decline in 2022-2023, but then there was a steep rise from 2024 to 2026. This means that the topic went from an emerging one to the mainstream one.

4. Citation Pattern

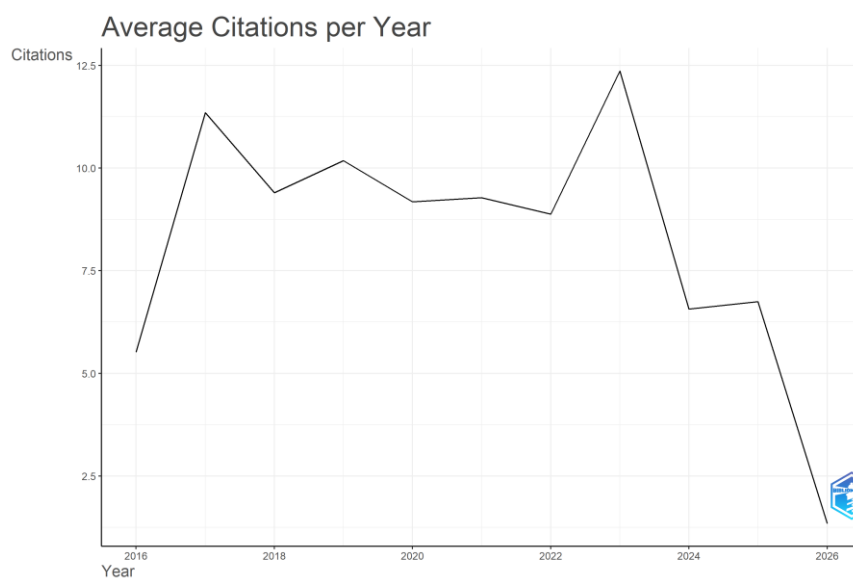


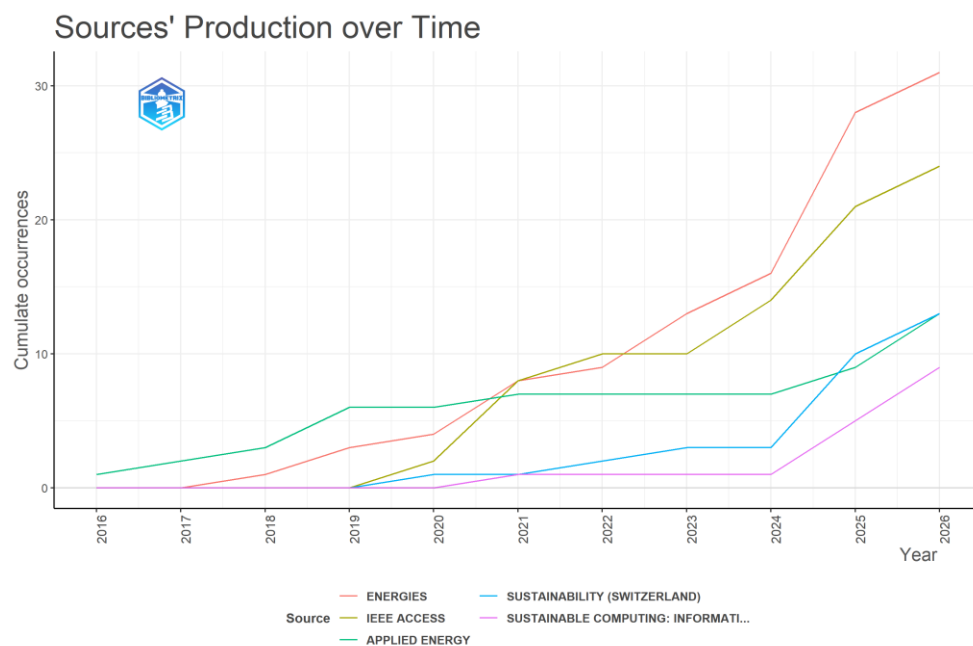
Figure 4. Average article citations per year.

The average citations per article were highest among the earlier publication years, while the number of publications was highest in the most recent years. This trend can be explained by the sheer fact that older works had more time to accrue citations. Hence, the decrease in mean citations from 2024 onwards should not be seen as a decrease in the quality of research.

Table 3. Average citations by publication year.

Year	Mean TC per Article	N	Mean TC per Year
2016	60.75	4	5.52
2017	113.50	10	11.35
2018	84.64	11	9.40
2019	81.41	17	10.18
2020	64.24	29	9.18
2021	55.66	56	9.28
2022	44.38	26	8.88
2023	49.46	28	12.37
2024	19.72	75	6.57
2025	13.50	194	6.75
2026	1.34	164	1.34

5. Most Relevant Sources and Bradford's Law

**Figure 7.** Source dynamics across the study period.

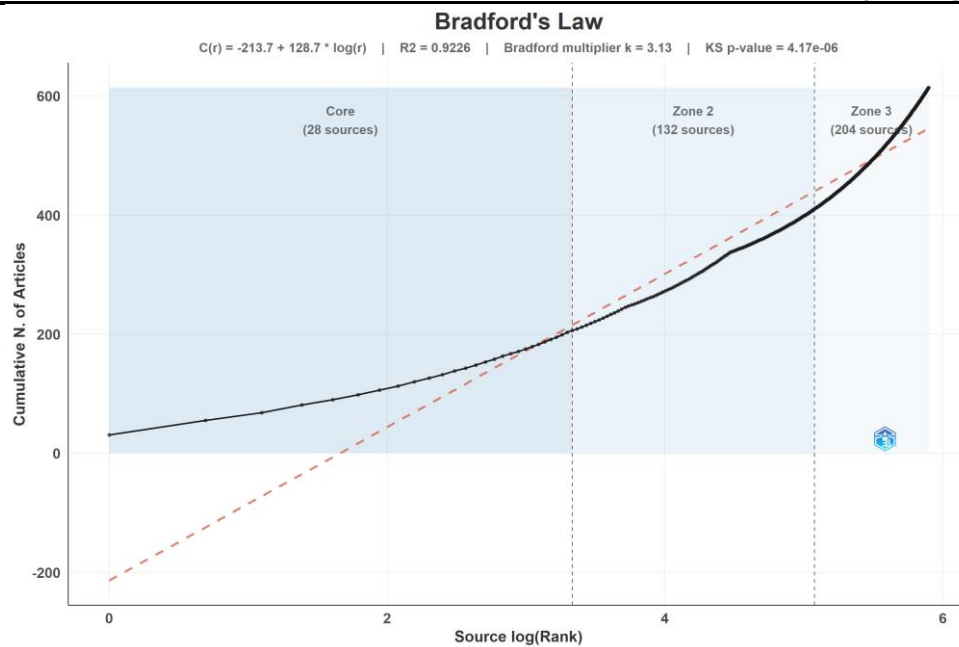


Figure 8. Bradford's Law showing source concentration.

The literature was distributed among 364 sources, most of which are journals, but only a few contain a considerable number of articles. Indeed, the most productive source is ENERGIES yielding 31 articles, followed by IEEE ACCESS with 24 and APPLIED ENERGY with 13 Sustainability (Switzerland) also has 13 articles.

Table 4. Most productive sources.

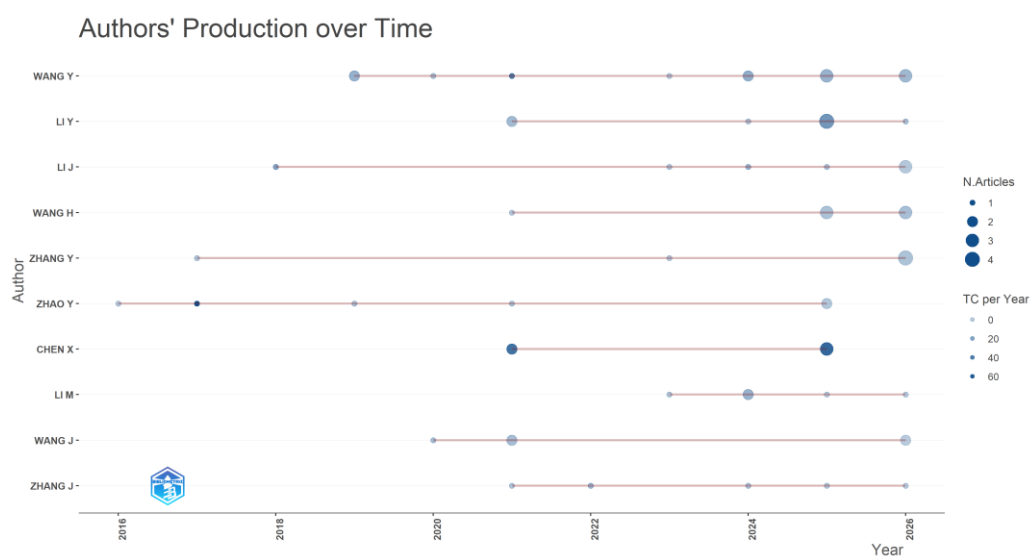
Sources	Articles
ENERGIES	31
IEEE ACCESS	24
APPLIED ENERGY	13
SUSTAINABILITY (SWITZERLAND)	13
SUSTAINABLE COMPUTING: INFORMATICS AND SYSTEMS	9
IEEE TRANSACTIONS ON CONSUMER ELECTRONICS	8
RESULTS IN ENGINEERING	8
ENERGY AND BUILDINGS	7
SCIENTIFIC REPORTS	7
IEEE INTERNET OF THINGS JOURNAL	6
SUSTAINABLE CITIES AND SOCIETY	6
SUSTAINABLE ENERGY TECHNOLOGIES AND ASSESSMENTS	6

The Bradford's Law demonstrates the concentration of the publications in the core journals as well. The first Bradfordian zone contains 28 sources and covers 206 publications in the provided output. Such a value means that the majority of the scholars conducting research in the domain tend to publish their findings in a defined group of energy, sustainability, computing and engineering journals.

Table 5. Bradford's Law: sources in Zone 1.

Source	Rank	Frequency	Cumulative Freq.	Zone
ENERGIES	1	31	31	Zone 1
IEEE ACCESS	2	24	55	Zone 1
APPLIED ENERGY	3	13	68	Zone 1
SUSTAINABILITY (SWITZERLAND)	4	13	81	Zone 1
SUSTAINABLE COMPUTING: INFORMATICS AND SYSTEMS	5	9	90	Zone 1
IEEE TRANSACTIONS ON CONSUMER ELECTRONICS	6	8	98	Zone 1
RESULTS IN ENGINEERING	7	8	106	Zone 1
ENERGY AND BUILDINGS	8	7	113	Zone 1
SCIENTIFIC REPORTS	9	7	120	Zone 1
IEEE INTERNET OF THINGS JOURNAL	10	6	126	Zone 1
SUSTAINABLE CITIES AND SOCIETY	11	6	132	Zone 1
SUSTAINABLE ENERGY TECHNOLOGIES AND ASSESSMENTS	12	6	138	Zone 1

6. Author Productivity and Impact

**Figure 5.** Authors' production over time.

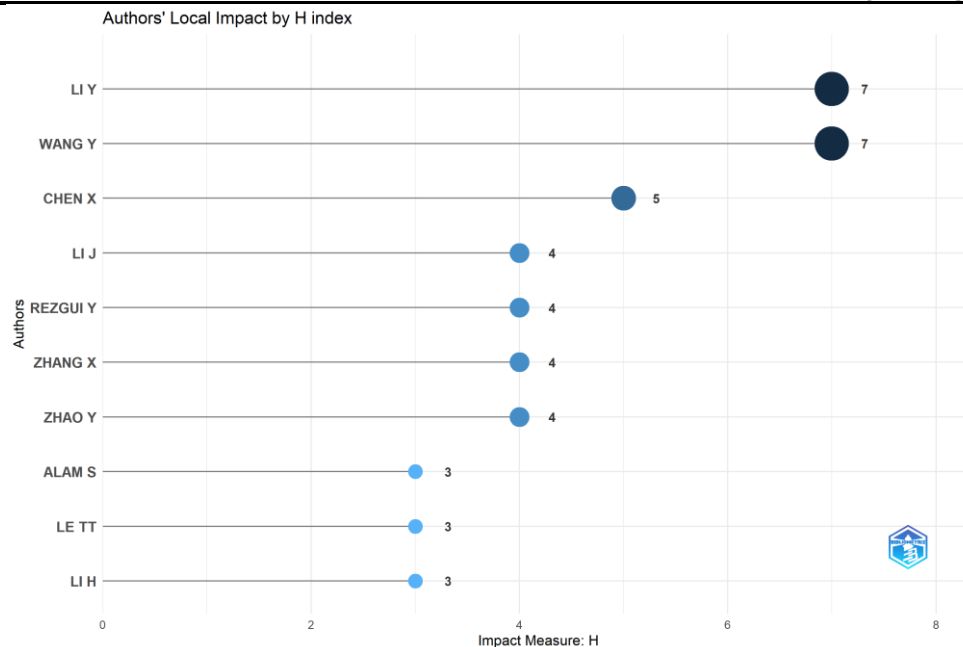


Figure 6. Author impact indicators.

The data base consists of 2364 authors. The most productive author is WANG Y with 13 articles., followed by LI Y with 8,LI J and WangH-7 articles each. In general, the majority of the authors are productive in terms of fractional counts, and their productivity is based on their cooperation with other authors.

Table 4. Most productive authors.

Author	Articles	Articles Fractionalized
WANG Y	13	3.18
LI Y	8	1.84
LI J	7	2.23
WANG H	7	1.43
ZHANG Y	6	0.99
ZHAO Y	6	1.28
CHEN X	5	0.93
LI M	5	1.53
WANG J	5	1.51
ZHANG J	5	1.23
ZHANG X	5	0.88
LI X	4	0.61

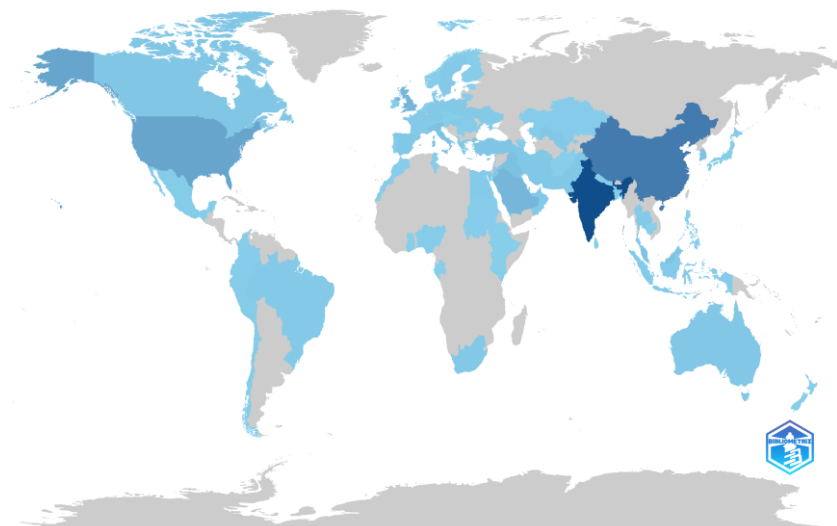
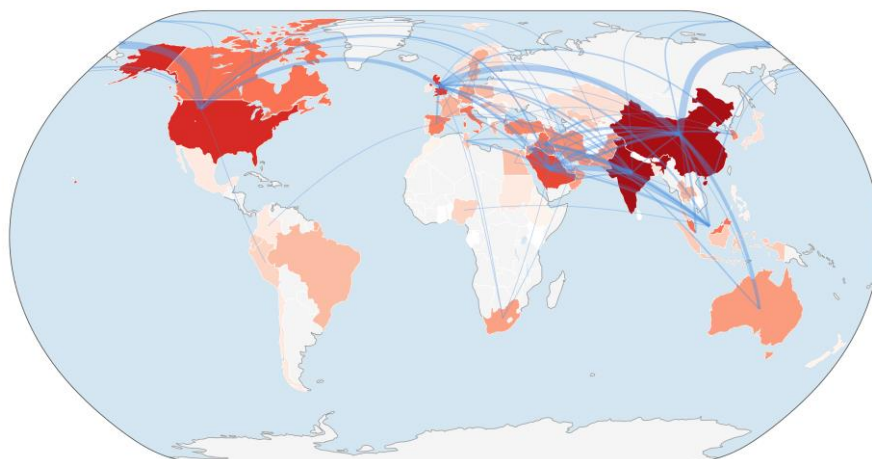
The influence indicators reflect a different perspective on the impact of the authors. WANG Y. And. LI Y, in this case, have the same H index of 7. In the provided author impact output. WANG Y is cited 472 times overall in 13 papers, whereas many authors with the lower number of work have a significant citation impact. The case illustrates why the 2 dimensions should be considered separately.

Table 5. Author impact indicators.

Author	h-index	g-index	m-index	TC	NP
LI Y	7	8	1.17	119	8
WANG Y	7	13	0.88	472	13
CHEN X	5	5	0.83	386	5
LI J	4	7	0.44	231	7
REZGUI Y	4	4	0.40	616	4
ZHANG X	4	5	0.57	90	5
ZHAO Y	4	6	0.36	713	6
ALAM S	3	3	0.75	92	3
LE TT	3	3	1.00	75	3
LI H	3	3	0.43	178	3

7. Country Contribution and Collaboration

Country Scientific Production

**Figure 7.** Country scientific production.**Figure 8.** Country collaboration.

India tops among countries in terms of the number of corresponding-author articles in the supplied output with 115 articles ,followed closely by China with 111.The United states have 28.This data set thus reflects that there is c participation from Asian research paper systems and significant contributions from both North America and Europe.

Table 6. Country production and collaboration (corresponding author).

Country	Articles	Articles %	SCP	MCP	MCP %
INDIA	115	18.73	94	21	18.26
CHINA	111	18.08	81	30	27.03
USA	38	6.19	27	11	28.95
UNITED KINGDOM	25	4.07	13	12	48.00
CANADA	17	2.77	9	8	47.06
ITALY	15	2.44	9	6	40.00
KOREA	15	2.44	8	7	46.67
MALAYSIA	12	1.95	6	6	50.00
SAUDI ARABIA	12	1.95	6	6	50.00
SPAIN	12	1.95	8	4	33.33

In terms of total number of citations, China has 2462 and India has 1874. The United Kingdom has 1377 citations. Some smaller countries in terms of the number of publications have very high number of citations ,which indicated the level of activity and impact are not directly related.

Table 7. Total and average citations by country.

Country	TC	Average Article Citations
CHINA	2,462	22.20
INDIA	1,874	16.30
UNITED KINGDOM	1,377	55.10
USA	910	23.90
SINGAPORE	631	210.30
UNITED ARAB EMIRATES	565	141.20
ITALY	437	29.10
HONG KONG	419	139.70
SAUDI ARABIA	389	32.40
CYPRUS	388	64.70

International co-authorship accounts for 31.76% of the dataset, indicating a meaningful international collaborative component.

8. Most Globally Cited Documents

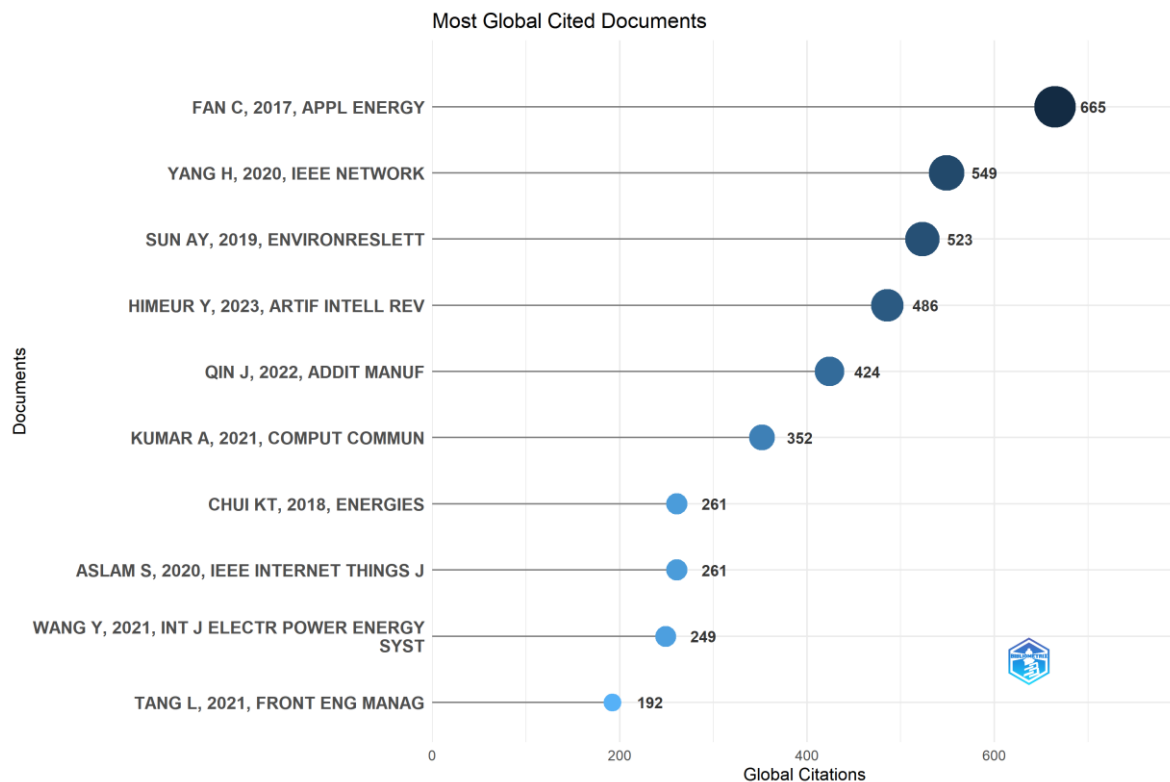


Figure 9. Most globally cited documents.

The most frequently cited document is FAN C (2017) published in Applied Energy journal, which has the largest number of citations (665). The next two are YANG H (2020) with 549 and SUN AY (2019) with 523 citations. The document HIMEUR Y (2023) has the highest number of citations per year, which is also significantly higher than others.

Paper	DOI	Total Citations	TC per Year	Normalized TC
FAN C, 2017, APPL ENERGY	10.1016/j.apenergy.2017.03.064	665	66.50	5.86
YANG H, 2020, IEEE NETWORK	10.1109/MNET.011.2000195	549	78.40	8.55
SUN AY, 2019, ENVIRONRESLETT	10.1088/1748-9326/ab1b7d	523	65.40	6.42
HIMEUR Y, 2023, ARTIF INTELL REV	10.1007/s10462-022-10286-2	486	121.50	9.83
QIN J, 2022, ADDIT MANUF	10.1016/j.addma.2022.102691	424	84.80	9.55
KUMAR A, 2021, COMPUT COMMUN	10.1016/j.comcom.2021.06.003	352	58.70	6.32
CHUI KT, 2018, ENERGIES	10.3390/en11112869	261	29.00	3.08
ASLAM S, 2020, IEEE INTERNET THINGS J	10.1109/JIOT.2020.2993411	261	37.30	4.06
WANG Y, 2021, INT J ELECTR POWER ENERGY SYST	10.1016/j.ijepes.2021.106830	249	41.50	4.47
TANG L, 2021, FRONT ENG MANAG	10.1007/s42524-020-0126-0	192	32.00	3.45
CHEN K, 2019, APPL ENERGY	10.1016/j.apenergy.2019.03.094	188	23.50	2.31
LUO XJ, 2021, ADV ENG INF	10.1016/j.aei.2021.101357	183	30.50	3.29

Table 8. Most globally cited documents.

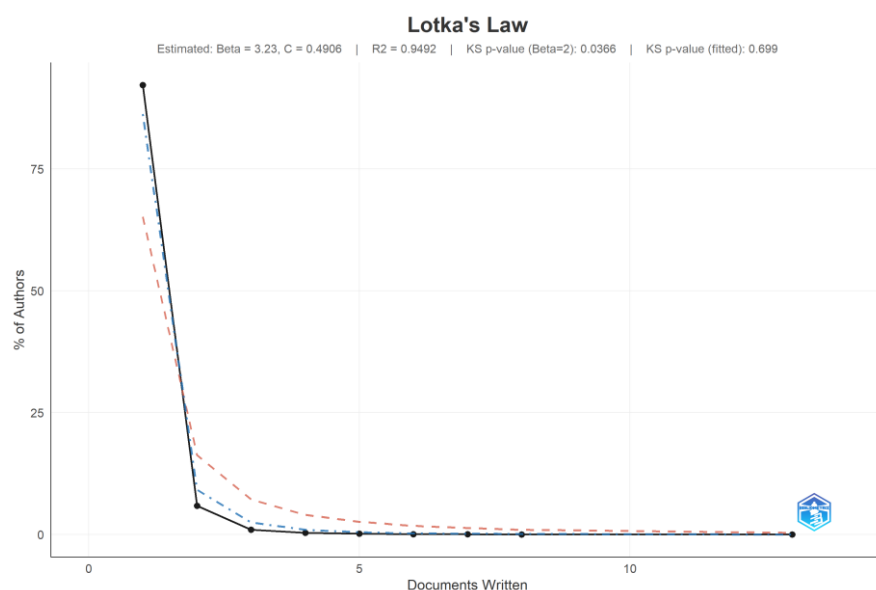


Figure 10. Lotka's Law showing author productivity distribution.

9. Lotka's Law and Author Concentration

The distribution of the number of authors according to the number of works is significantly dominated by authors who wrote only one document. Among the presented authors, 92.22% are represented in the volume by one work, 5.92% – authors of two works. The remaining 1.86% have made more than one contribution to the corpus.

Table 9. Lotka's Law: distribution of author productivity.

Documents written	N. of Authors	Proportion of Authors
1	2180	0.92
2	140	0.06
3	24	0.01
4	9	0.00
5	5	0.00
6	2	0.00
7	2	0.00
8	1	0.00
13	1	0.00

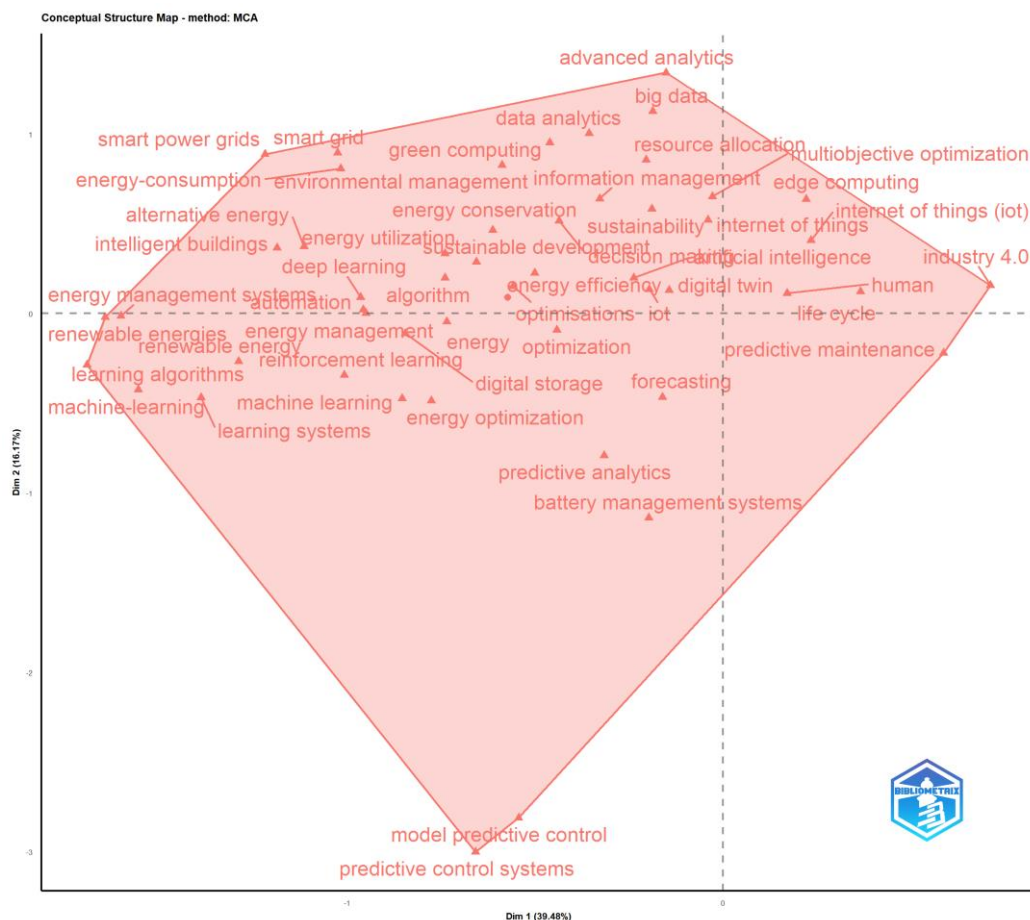


Figure 11. Factorial analysis of the conceptual structure.

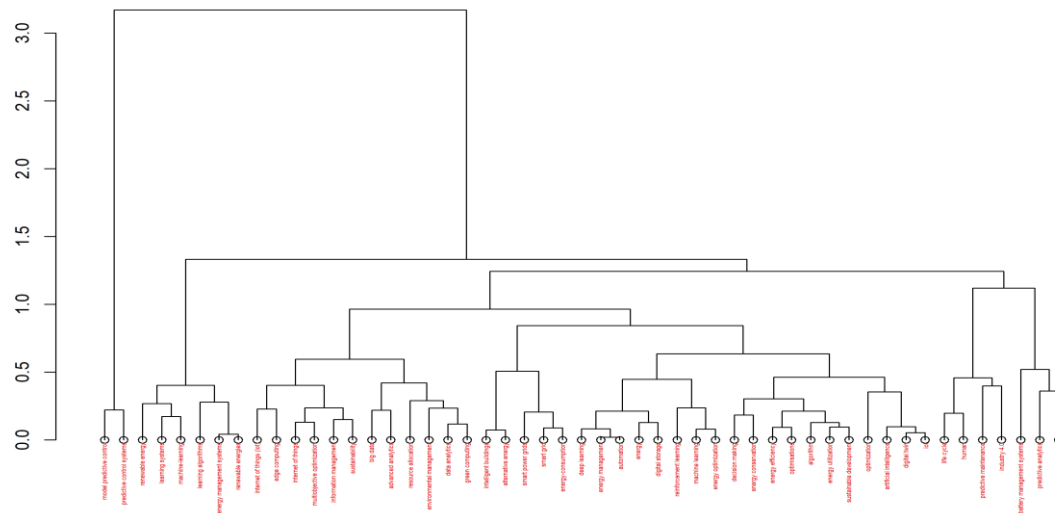


Figure 12. Dendrogram of the conceptual clusters.

10. Thematic Map – Main Analytical Highlight

The thematic map ranks research themes by their centrality (importance to the domain) and density (development within the theme). There are four quadrants, which represent motor themes, niche themes, basic themes, and emerging/declining themes.

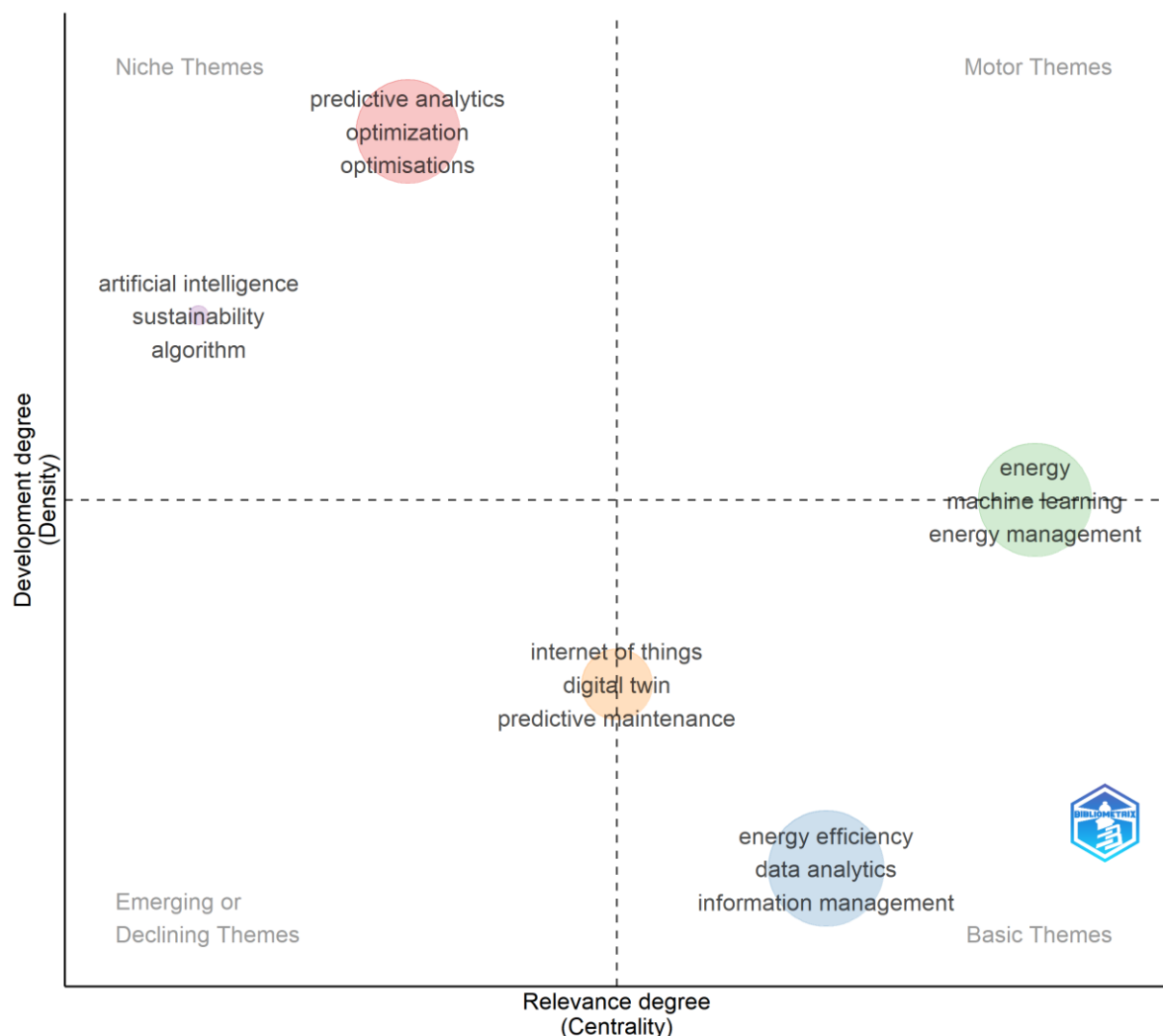


Figure 13. Thematic map of the keyword clusters (centrality–density quadrants).

10.1 Motor Themes

The motor-theme area is where the cluster of energy, machine learning and energy management are found. Their presence in the upper right quadrant reflects the relevance of the research field to the area and its deep internal development. This is the central conceptual framework of the dataset. The combination of energy management with machine learning suggests that recent research is more focused on energy management via data-driven learning algorithms and intelligent control. The trend-topic output supports this hypothesis as energy is more present in the later period of the data. The thematic evolution results show that earlier themes such as optimization and artificial intelligence are connected to later energy management and energy efficiency themes.

10.2 Basic Themes

Energy efficiency, data analytics and information management appear as the basic-theme quadrant research disciplines. Data analytics is a methodology for analyzing energy-related information, while information management is responsible for collecting, organizing and utilizing such data. Energy efficiency is a broad application purpose which links these analytical approaches to real energy outputs. These themes are central and less developed internally so that they could be used to link specialized technological developments with broader energy-management needs.¹⁰ These themes are relatively more central but have a lower density than the motor-theme cluster. Hence, they can be viewed as foundational or transversal themes connecting various.

10.3 Niche Themes

Predictive analytics and optimization are present in the niche theme quadrant. Their high density suggests that the topics are well-established in their own research community, whereas their lower centrality implies that they are more specialized than the general energy management theme. The presence of predictive analytics matches the trend topic output, where predictive analytics is prominent in the later years. Optimization is also related to the thematic evolution results, where earlier optimization research is included in later energy efficiency, energy management, and energy utilization themes. That is to say, optimization is becoming ever more integrated with the practical energy system objectives and not a singular methodological topic.

10.4 Emerging or Declining Themes

Internet of things, digital twin and predictive maintenance appear in the emerging/declining quadrant. However, the relatively low density and centrality of these concepts means that they are not as established as the main motor themes. Yet, the thematic evolution data indicate that the recent literature is tending towards the internet of things and connected intelligent systems. Thus, these themes are more accurately described as emerging directions than as declining ones. It is also essential to be cautious here as the thematic map alone is not informative about whether a topic is emerging or declining. The temporal evidence must be taken into account alongside the quadrant position. The presence of the internet of things in the 2024–2026 thematic evolution in our data is consonant with our new interpretation.

10.5 Artificial Intelligence, Sustainability and Algorithms

Artificial intelligence, sustainability and algorithm-related terms are in the upper-left and hence have high development but low centrality. These are specialised research directions. Their position is consistent with the general development of the field; AI and algorithms were extremely important in the earlier stages, and increasingly so in the later years they are linked to energy efficiency, management and optimization.

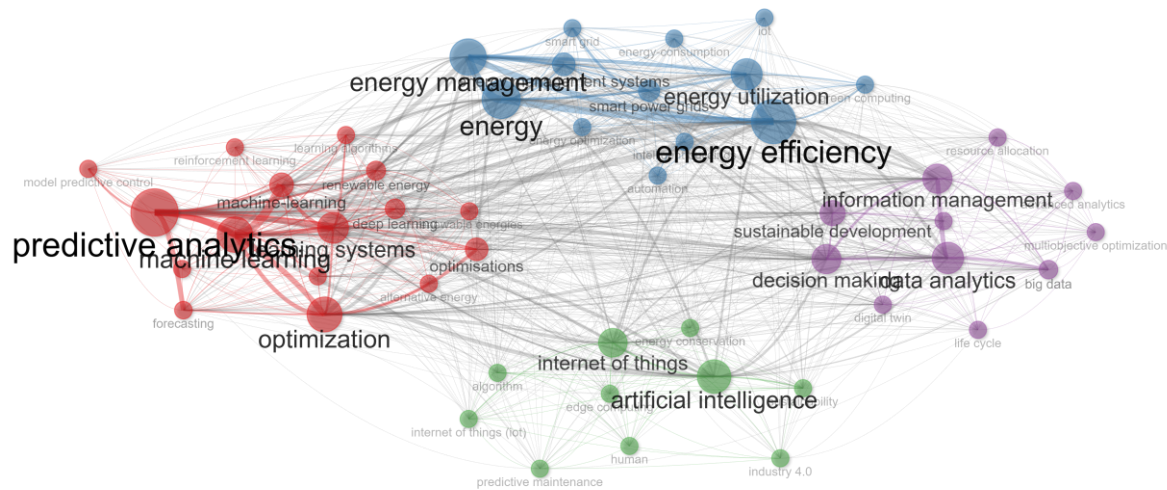


Figure 14. Keyword co-occurrence network supporting the thematic analysis.

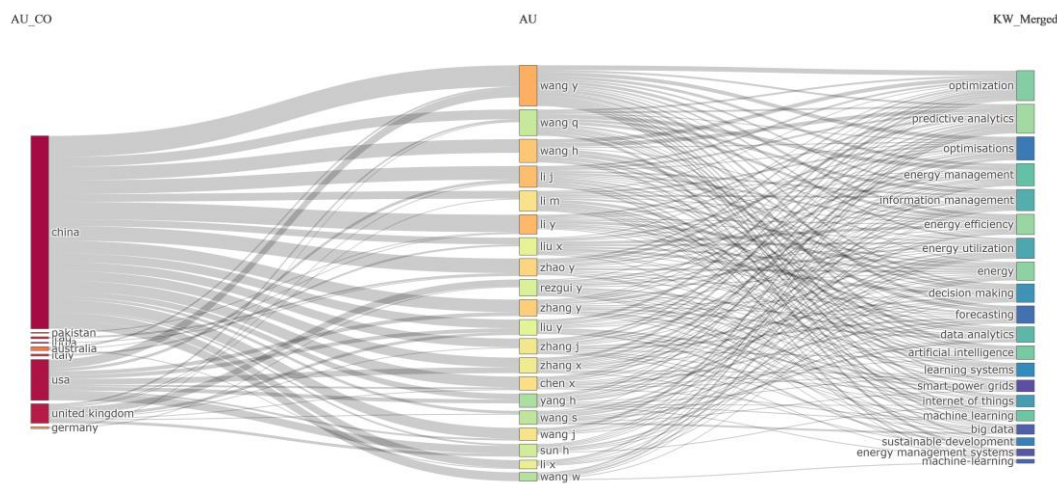


Figure 15. Three-field plot linking countries, authors and keywords.

11. Thematic Evolution

The thematic-evolution analysis explains the time period behind the thematic map. The years 2016-2020 had research themes of artificial intelligence, big data, energy utilization, optimization, predictive analytics and support vector machines. The years 2021-2023 saw the themes evolve into data analytics, energy efficiency, energy management, energy utilization, predictive analytics, quality of service and wind power. The years 2024-2026 will see trends of artificial intelligence, decision making, energy, energy efficiency and internet of things.

This evolution is an indication of a transition from computational techniques and optimization to broader energy related analytics. It is evident from the thematic map that energy is emerging as a focal point for analytics. The evolution path from big data to data analytics, from optimization, to energy management/efficiency and from AI to decision-making and internet of things indicates increased technological convergence.

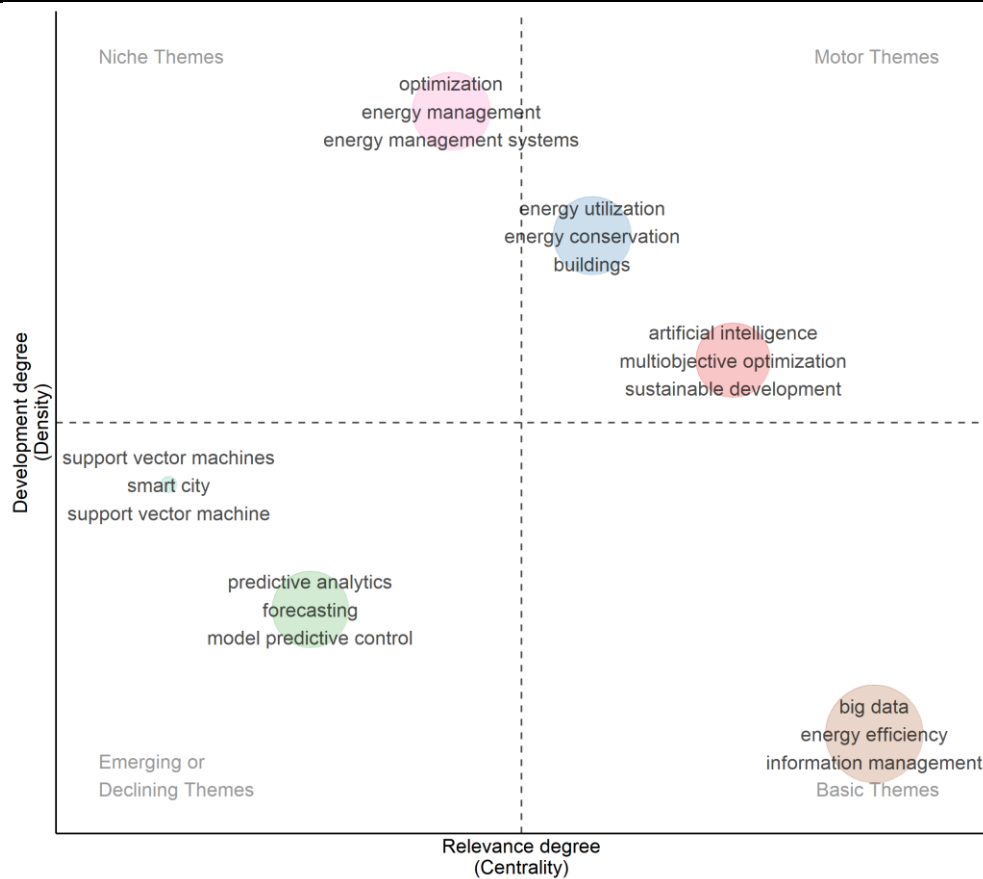


Figure 16. Thematic evolution — first period (2016–2020).

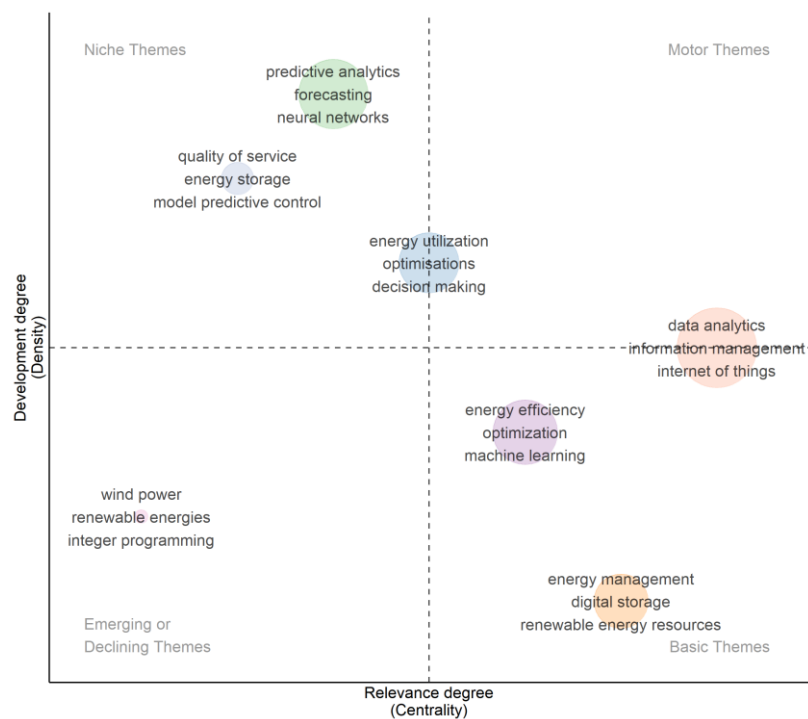


Figure 17. Thematic evolution — second period (2021–2023).



Figure 18. Thematic evolution — third period (2024–2026).

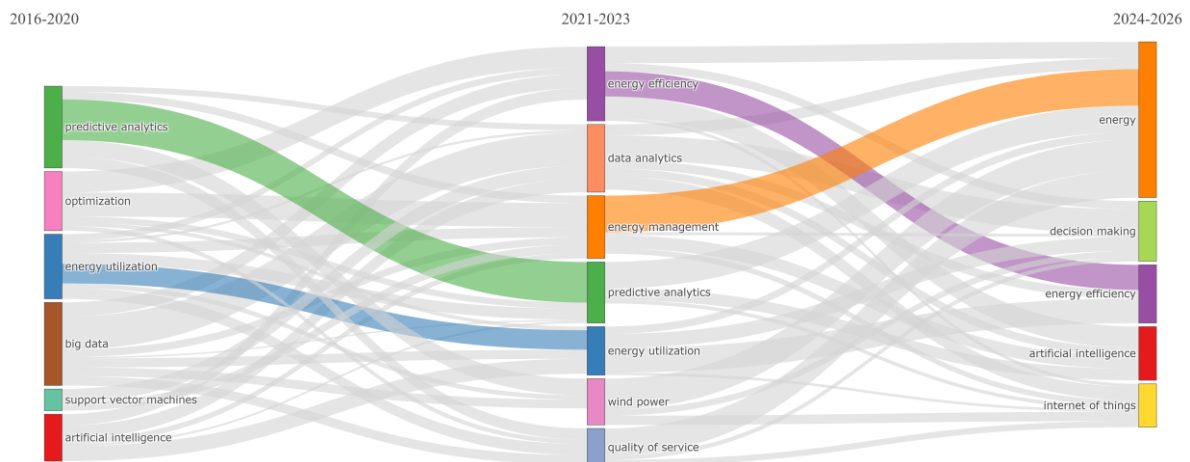


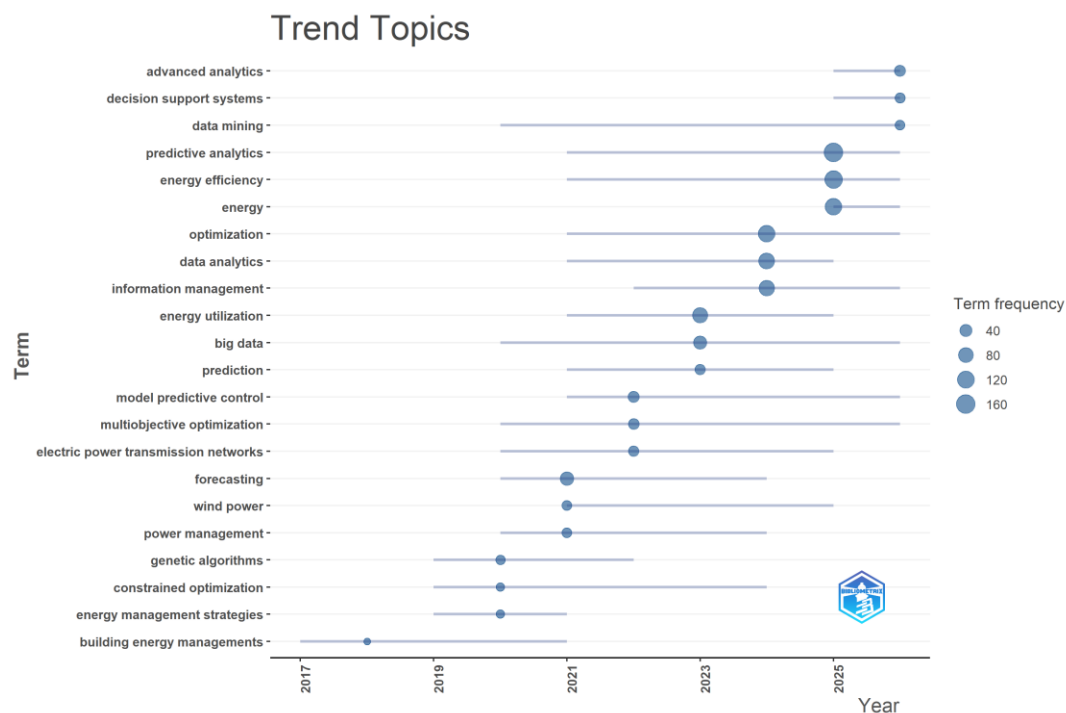
Figure 19. Overall thematic evolution across the three periods.

Table 10. Thematic evolution links between time periods.

From theme	To theme	Occurrences	Weighted Inclusion Index
energy management	energy	17	0.51
predictive analytics	predictive analytics	28	0.48
wind power	energy	6	0.46
big data	data analytics	18	0.42
quality of service	energy	8	0.40
predictive analytics	energy	36	0.35
data analytics	decision making	31	0.28
optimization	energy management	16	0.28
energy utilization	energy efficiency	31	0.28
energy efficiency	artificial intelligence	28	0.25
energy efficiency	energy efficiency	33	0.24
optimization	energy efficiency	23	0.20

12. Trend Topics

The trend-topic output supports the thematic-map interpretation. Later period terms include advanced analytics, decision support systems, data mining, predictive analytics, energy efficiency and energy. Earlier terms such as building energy management, energy management strategies and genetic algorithms occupy earlier parts of the timeline. Thus, the trajectory suggests increasingly sophisticated analytical and decision support applications.

**Figure 20.** Trend topics by term frequency.

13. Integrated Interpretation

In general, the results allow one to conclude that the present research area is emerging, multidisciplinary, and topical. First, the number of publications included in the analysis increased significantly to indicate the presence of a growing interest in the area. Moreover, the source distribution demonstrates that the present topic is actively explored in energy, sustainability, computing, engineering, and smart-system journals.

According to the country analysis, the largest number of contributions were reported from India and China, and the impact of the research topic was confirmed by the citation analysis since the topic attracted the attention of scholars from numerous countries and regions. Finally, the thematic analysis revealed that most of the studies examined have been focused on similar themes for quite a long time. Articles on energy management, machine learning, and energy, data analytics and information management, and predictive analytics and optimization comprise the largest group of the papers on the topic. Therefore, it may be concluded that the current research area integrates topics from diverse fields and promotes the development of new trends related to the Internet of Things, digital twins, predictive maintenance, and connected systems. In general, the reviewed literature highlights the shift from purely computational and optimization-oriented studies to more integrated and data-centric approaches to energy management. Thus, future studies on the topic may be expected to cover various aspects and address diverse interests, including analytics and machine learning for connected systems, energy management, decision support systems, connected devices, and efficiency.

14. Key Findings

The dataset contains 614 documents from 364 sources over 2016–2026.

Annual scientific production increased strongly, reaching 194 articles in 2025.

ENERGIES is the most productive source, with 31 articles.

WANG Y is the most productive author, with 13 articles.

India and China are the leading countries by corresponding-author article count.

FAN C (2017), YANG H (2020) and SUN AY (2019) are among the most globally cited documents.

The authorship structure is highly dispersed: 92.22% of authors contributed to one document.

The motor-theme cluster centres on energy, machine learning and energy management.

Energy efficiency, data analytics and information management act as basic/foundational themes.

Predictive analytics and optimization are specialised niche themes.

Internet of things, digital twin and predictive maintenance appear as newer directions in the thematic landscape.

Thematic evolution shows a shift from AI, big data and optimization toward data analytics, energy efficiency, energy management, decision-making and IoT.

5. FUTURE RESEARCH

The 614 papers in this dataset, drawn from 364 sources across 2016 to 2026, reveal both where OR-based energy management research has concentrated over the past decade and where it has not. Annual output rose from 4 documents in 2016 to 194 in 2025, a growth rate of 44.97% per year, and 164 documents are already recorded for an incomplete 2026. The thematic map places energy, machine learning, and energy management in the motor-theme quadrant, while predictive analytics and optimization appear only as niche themes, and the Internet of Things, digital twins, and predictive maintenance sit in the emerging quadrant. Thematic evolution across three periods—2016–2020, 2021–2023, and 2024–2026—shows the field moving steadily from computational and optimization-based work toward integrated, data-driven energy management. The gaps that follow from this pattern define the agenda set out below.

Integrated Systems Rather Than Isolated Models

Wang et al. (2024) study the thermal management of lithium-ion batteries. Lin et al. (2025) design cooling plates for prismatic energy storage batteries. Each paper addresses a well-defined technical problem in isolation. In a real energy system, however—one with rooftop solar, a battery bank, electric vehicles charging on site, and a dynamic electricity tariff—these decisions interact directly. Solar output affects the battery charging decision. Battery state affects grid purchases. The EV charging schedule depends on both. The present dataset contains very few papers that model this kind of interconnected decision-making within a single formulation.

The motor-theme cluster in the thematic map—energy, machine learning, and energy management—is built largely on single-asset studies of exactly this kind. Raza et al. (2024), in a survey of smart home energy management systems covering research challenges across 83 cited studies, note that most published systems treat the home as a collection of independent loads rather than as a network in which scheduling one asset changes the optimal decision for every other. Yuan et al. (2024) begin to address this directly: they develop a

fully distributed, privacy-preserving energy management system for a networked microgrid cluster and demonstrate that the joint scheduling problem across interconnected microgrids produces materially different outcomes from solving each microgrid's problem in isolation. Mixed-integer programming is suited to problems with multiple interacting variables and binding constraints between them, and future research could apply it to build genuinely integrated models—ones in which generation, storage, demand, and grid purchases are decision variables in the same formulation rather than subjects of separate studies.

Forecasting That Feeds into Decisions

Wen et al. (2024) develop a deep learning-driven hybrid model for short-term electricity load forecasting and smart grid information management, achieving strong predictive accuracy on real grid data. Raza et al. (2024) survey the broader field of smart home energy management, covering AI-based forecasting and control methods across a wide body of published work. Both studies are relevant and well-cited. The gap they share, however, is the step between a forecast and the operating decision it is intended to inform. Demand predictions carry uncertainty, and the question of how that uncertainty should shape real operational choices—when to discharge storage, how much to purchase from the grid, how to sequence consumption—receives little systematic treatment in the dataset.

This pattern holds across the corpus. Predictive analytics appears in the niche-theme quadrant of the thematic map, well developed internally but disconnected from the broader energy management cluster. Lin et al. (2025), reviewing data-driven, mechanism-driven, and hybrid modelling approaches for energy system modelling, identify the same structural feature: the prediction literature and the decision literature have developed largely as separate streams. Thematic evolution data confirm that predictive analytics has been present from the first period (2016–2020) through to the most recent, yet decision making only emerges as a distinct theme in 2024–2026. Stochastic programming was designed for precisely this problem—optimizing a decision under uncertainty about a future state. Future research that links AI-based forecasting to formal optimization under uncertainty would close a gap that has been visible in the literature for at least five years.

A Narrow Geographical Base

Most of the studies in this dataset are set in contexts where electricity supply is reliable, pricing information is available in real time, and smart meters are standard infrastructure. India leads by corresponding-author articles with 115, at 18.73% of the dataset, followed by China with 111 at 18.08% and the United States with 38 at 6.19%. Together, India and China account for more than a third of all documents. Sub-Saharan Africa, Central Asia, and much of Latin America are barely represented. Kaur et al. (2025), reviewing hybrid systems that combine hydrogen, biomass, biogas, and solar PV, take a broader view of deployment contexts, but even that study assumes reasonably developed grid infrastructure.

Energy systems in many parts of the world operate under very different conditions. Intermittent supply, limited metering, the absence of real-time pricing, and community-run generation are standard in large parts of South Asia, Africa, and Latin America. Citation rates point to a related imbalance: the United Kingdom's 25 articles average 55.10 citations each, Singapore averages 210.30, and the United Arab Emirates averages 141.20, while India's 115 articles average 16.30 and China's 111 average 22.20. OR models developed for well-resourced grids may require significant adaptation to perform in constrained settings, and the present dataset offers almost no evidence either way. Testing existing methods in low-infrastructure environments, and developing new formulations where current models fall short, would expand the practical reach of the field and test whether its results are as general as they appear. With 31.76% of the dataset already involving international co-authorship, multi-country teams are well-positioned to run the same model across more than one infrastructure context within a single study.

Storage and System Dynamics

Taabodi et al. (2025) provide a comprehensive review of electrochemical storage technologies for renewable energy integration, covering battery chemistries and grid-scale applications in detail. Yuan et al. (2024) take a more operational perspective, developing a distributed and privacy-preserving energy management system for networked microgrid clusters that coordinates storage decisions across sites without centralizing sensitive data. Both studies address how storage performs as a technology. What receives less attention in both, and across the dataset more broadly, is how storage deployment changes the behaviour of the wider system around it. Internet of Things, digital twins, and predictive maintenance—three of the four emerging themes in the thematic map—are all most developed for storage assets, yet the system-level effects of storage remain understudied.

When significant battery capacity is introduced into a network, the optimization problem changes for every other participant. Users can exploit price differentials by charging during low-cost periods and discharging during high-cost ones, which shifts market prices for others. Aggressive cycling accelerates battery degradation beyond standard specifications. Coordinating storage decisions across household, microgrid, and grid scales introduces coupling constraints that single-asset models cannot represent. Multi-agent optimization offers a natural framework for studying these interactions, with each asset or site represented by an agent with its own constraints and the system-level outcome observed from their joint behaviour. The thematic evolution data show decision making emerging as a theme in 2024–2026 alongside IoT, consistent with growing interest in coordinated, sensor-driven control. Empirical studies that benchmark multi-agent formulations against single-agent baselines on realistic network instances are what is needed to move that interest into demonstrated results.

The Missing Long-term Perspective

Almost everything in this dataset is operational in orientation—concerned with running systems that already exist, with incremental improvements in efficiency or control. The three-period thematic evolution makes this visible: from optimization and big-data analysis in 2016–2020, to energy management and efficiency in 2021–2023, to real-time decision making and IoT control in 2024–2026. Oladosu et al. (2024), a review of energy management strategies, control systems, and AI-based algorithms for hydrogen fuel cell vehicles, is among the few papers in the dataset that engages with a technology not yet fully deployed at scale. Even there, however, the focus is on how to manage the technology once it exists, not on the investment and planning decisions that determine whether and where it gets deployed.

Kaur et al. (2025) identify a parallel gap in hybrid renewable energy systems: the optimization literature concentrates on operational control of installed systems, while the capacity and investment decisions that determine which technologies are installed receive far less attention. Taabodi et al. (2025) note the same at the grid level—investment decisions for grid-scale storage involve uncertain future electricity prices, carbon policy, and technology costs, yet the optimization literature for storage investment rarely models these uncertainties explicitly. These are not peripheral concerns. Tariff structures change. Carbon pricing schemes are introduced, revised, or withdrawn. Subsidies shift. Each of these affects what investments make sense and what it is worth optimizing. Scenario-based and stochastic programming approaches could bring these factors into OR models, connecting energy management research to the longer-run planning decisions that ultimately determine how energy systems are built and operated. That connection is almost entirely absent from the present dataset.

Summary

Taken together, these five directions reflect one underlying pattern in the data: the field has grown rapidly in volume—44.97% per year over the period studied—without fully resolving how prediction connects to decision, how asset-level models scale to system-level outcomes, or how operational research relates to the long-term planning choices that precede it. The next significant contribution is unlikely to be another benchmark on a single well-studied asset in a well-resourced grid. It is more likely to come from a study that models interacting assets together, embeds a forecast within an operating decision model, tests that model under realistic uncertainty, and does so in a setting the current corpus has not yet reached. Combined with stronger bibliometric designs in future reviews—wider database coverage, cited-reference export, and author disambiguation—this kind of work would show where OR has genuinely improved energy management decisions, and not only where it has grown as a field of publication.

6. CONCLUSION

Achievement of objectives

The study aimed to map research on the application of OR to energy management between 2016 and 2026 and to indicate where that research should go next. It pursued four objectives and the authors consider that each has been met within the limits described in Limitations below.

The first objective was about growth and contributors. The 614 documents show rapid and recent expansion, from 4 in 2016 to 194 in 2025, concentrated in a small core of journals led by *Energies*, *IEEE Access* and *Applied Energy*. India and China produce the most documents, yet the United Kingdom, Singapore and the United Arab Emirates earn far higher average citations per article, which indicates that volume and influence do not move together. Collaboration also differs by country: between 40% and 50% of corresponding-author papers from the United Kingdom, Canada, Korea, Malaysia and Saudi Arabia involve multi-country teams, against 18.26% for India. The second objective was about structure and change. The thematic analysis shows

a field built around energy management and machine learning, supported by energy efficiency, data analytics and information management, and moving in the most recent period towards decision making and IoT-based systems. The third objective was about the position of OR. Optimization remains a well-developed but specialised theme. Earlier optimization work has been absorbed into energy management and energy efficiency, so OR now operates as one component of wider data-driven systems and not as a separate stream. The most cited document in the dataset, a study of short-term building cooling load prediction with deep learning (Fan et al., 2017; 665 citations), is a forecasting paper and not a decision model, which is consistent with the authors' reading that prediction has received more attention than the decisions that follow from it. The fourth objective produced a research agenda with five gaps: integrated models of interacting assets, for which mixed-integer programming is suited; the link between forecasts and operating decisions, which calls for stochastic programming; a geographical base that is narrow and tied to well-resourced grids; the effect of storage on the wider system, which multi-agent optimization could study; and the almost complete absence of long-term planning under uncertain policy, which scenario-based and stochastic programming could address.

Implications

Academic implications. The study gives researchers a consolidated, quantified account of a literature that was previously dispersed. It documents the change from computational and optimization-based work to integrated analytics and decision support, separates productivity from impact at the level of journals, authors and countries, and states five concrete gaps together with the OR methods suited to each. These contributions add to knowledge on both the use of bibliometric methods in energy research and the role of OR within it. The finding that optimization is developed but less central than data-driven themes is itself a proposition that later reviews can test. The thematic structure and the three-period evolution can also serve as a reference frame for scholars who wish to position new studies, choose target journals or identify potential collaborators.

Managerial implications. For managers and energy operators, the evidence points to several steps that can improve profitability through lower cost and less downtime. First, forecasting and optimization should be run as one workflow and not as separate projects, since a forecast has value only when it changes a scheduling or purchasing decision. Second, because data analytics and information management appear as foundational themes, firms should invest in metering and data quality before buying more sophisticated models. Third, case studies in the dataset report concrete gains from integrated approaches, for example a 41.5% cost reduction in a hybrid renewable water-sector system (Ramos et al., 2025) and a 41% fall in maintenance costs from AI-driven monitoring of urban wind turbines (El-Barbary et al., 2025). These results belong to their own settings and need local validation. Fourth, phased deployment with site-specific calibration, as Onwong'a et al. (2026) suggest for fuel depots, lets a firm test returns before committing full capital. Fifth, the growth of predictive maintenance and IoT themes suggests that condition-based maintenance is becoming a practical way to protect asset life and revenue. Finally, firms with several sites or energy sources should treat storage, on-site generation and grid purchases as a single optimization problem, because the research shows that these decisions affect one another and are usually studied apart.

Social implications. Better energy management reduces waste and emissions and supports reliability of supply. The studies in the dataset link optimization with lower energy consumption and cleaner operation of water, building and grid systems, which reach households through cost and service quality. Because India and China account for a large share of the research, much of the knowledge is being produced in economies where energy demand is growing fastest, which is where gains in efficiency matter most. The agenda's call to test models under intermittent supply and limited metering would extend these benefits to communities that current research serves least. The work therefore bears on affordable and clean energy (Sustainable Development Goal 7) and climate action (Goal 13). A clearer picture of what is known and unknown also helps universities, funders and public bodies direct limited research money to problems with social value.

Policy implications. The authors suggest four points for policymakers. First, interoperable data standards and wider smart metering are needed, since optimization models cannot work without reliable data. Interoperability and data security are named as barriers in the dataset (Tiwari et al., 2025), and they are regulatory problems as much as technical ones. Second, stable and clearly communicated tariff and carbon pricing frameworks would help, because both operational and investment models depend on them, and frequent reversals make long-term planning unreliable. Third, public research funding could be directed at low-infrastructure settings and at projects that connect forecasting with decision models, the two least covered areas. Fourth, with only 31.76% of documents involving international co-authors, programmes that encourage collaboration across countries would help move methods between well-resourced and constrained systems. Rules on cybersecurity and privacy for connected energy devices should develop alongside these measures, so that wider data sharing does not expose consumers or critical infrastructure to new risks.

Limitations

The findings should be read with the following limitations in mind. The data come from a single database, Scopus. Web of Science, IEEE Xplore and other sources may index additional work, and the exclusion of conference papers, books and non-English publications removes part of the field, notably fast-moving computing research that appears in proceedings. The search used three keywords, so studies that describe the same problems in other terms, such as demand response, unit commitment or microgrid scheduling, may not have been retrieved. The 2026 count covers an incomplete year, and recent papers have had little time to be cited, so the low citation averages for 2024 to 2026 reflect age and not quality. Citation counts and h-indices in any case measure attention more than merit. Author names recorded as a surname and initial, such as Wang Y and Li Y, may combine different individuals, so productivity figures for these authors may be overstated. The thematic interpretation rests on author keywords, indexed terms and abstracts. The authors did not read the full text of every study or assess the mathematical models in detail, which reflects the limits of their technical training in advanced OR methods. Bibliometric software also involves choices on thresholds, term normalisation and clustering that shape the maps, and different settings could yield somewhat different clusters. Future studies could widen the database, add full-text analysis, and complement this mapping with systematic reviews of individual OR techniques, such as stochastic programming or multi-agent optimization, applied to energy systems. Tests of the proposed agenda in settings with intermittent supply and limited metering would show whether current models hold outside well-resourced grids.

In sum, the literature on OR in energy management is large, growing and increasingly integrated with data-driven methods, but the decision models that link forecasts, storage, geography and policy remain thinly studied. The authors hope that the agenda proposed here gives later researchers a clear place to start.

7. REFERENCES

1. Ahamed, A., Fardin, H., Hasan, E., Rimon, S. M. T. H., & Haque, M. M. (2026). A review of machine learning approaches for optimizing hybrid renewable energy systems (HRES) in decentralized smart grids: Enhancing energy efficiency and grid stability. *Iranian Journal of Science and Technology, Transactions of Electrical Engineering*, 50(1), 455–468. <https://doi.org/10.1007/s40998-025-00807-4>
2. Aria, M., & Cuccurullo, C. (2017). bibliometrix: An R-tool for comprehensive science mapping analysis. *Journal of Informetrics*, 11(4), 959–975.
3. Cina, E., Elbasi, E., Elmazi, G., & AlArnaout, Z. (2025). The role of AI in predictive modelling for sustainable urban development: Challenges and opportunities. *Sustainability*, 17(11). <https://doi.org/10.3390/su17115148>
4. Djebali, S., Guerard, G., & Taleb, I. (2024). Survey and insights on digital twins design and smart grid's applications. *Future Generation Computer Systems*, 153, 234–248. <https://doi.org/10.1016/j.future.2023.11.033>
5. Donthu, N., Kumar, S., Mukherjee, D., Pandey, N., & Lim, W. M. (2021). How to conduct a bibliometric analysis: An overview and guidelines. *Journal of Business Research*, 133, 285–296.
6. El-Barbary, Z. M. S., Safarova, L., Atamurotov, F., Alsayah, A. M., & Yadav, B. K. (2025). Artificial intelligence driven internet of things framework for wind energy monitoring and performance enhancement in smart cities. *International Journal of Energy Research*, 2025, Article 7215655. <https://doi.org/10.1155/er/7215655>
7. Fan, C., Xiao, F., & Zhao, Y. (2017). A short-term building cooling load prediction method using deep learning algorithms. *Applied Energy*, 195, 222–233. <https://doi.org/10.1016/j.apenergy.2017.03.064>
8. Gopinath, T., Kesavan, J., Srividhya, P. K., & Ramkumar, P. (2024). Towards greener horizons: A comprehensive review of energy auditing in hybrid solar and wind systems. *Interactions*, 245(1). <https://doi.org/10.1007/s10751-024-02049-y>
9. International Energy Agency. (2026a). Global energy review 2026. IEA. <https://www.iea.org/reports/global-energy-review-2026>
10. International Energy Agency. (2026b). Electricity 2026: Analysis and forecast to 2030. IEA.
11. Mhlana, D. (2023). Artificial intelligence and machine learning for energy consumption and production in emerging markets: A review. *Energies*, 16(2). <https://doi.org/10.3390/en16020745>
12. Moher, D., Liberati, A., Tetzlaff, J., & Altman, D. G. (2010). Preferred reporting items for systematic reviews and meta-analyses: The PRISMA statement. *International Journal of Surgery*, 8(5), 336–341.

13. Onwong'a, D., Kabeyi, M. B., Njoroge, K., & Olanrewaju, O. (2026). Energy optimization in fuel depots: A system-of-systems review of cyber–physical–human–institutional integration. *Energies*, 19(9), 2237. <https://doi.org/10.3390/en19092237>
14. Pawar, P., Nangare, V., Gaurav, G., & Ayarekar, S. (2026). AI-driven urban water infrastructure planning using simulation models for sustainable water resource management. *International Journal of Computer Information Systems and Industrial Management Applications*, 18(3), 665–679. <https://doi.org/10.70917/ijcisim-2026-2388>
15. Ramos, H. M., Pérez-Sánchez, M., Correia, T., Bekçi, E., Besharat, M., Kuriqi, A., & Coronado-Hernandez, O. E. (2025). Contributions toward net-zero carbon in the water sector: Application to a case study. *Aqua – Water Infrastructure, Ecosystems and Society*, 74(9), 579–595. <https://doi.org/10.2166/aqua.2025.031>
16. Rao, C. K., Sahoo, S. K., & Yanine, F. F. (2025). A comprehensive review of smart energy management systems for photovoltaic power generation utilizing the internet of things. *Unconventional Resources*, 7. <https://doi.org/10.1016/j.uncred.2025.100197>
17. Soni, S., & Saini, R. (2025). Digital transformation of project and operations management in smart infrastructure and engineering enterprises. *Archives for Technical Sciences*, 3(34), 372–380. <https://doi.org/10.70102/afts.2025.1834.372>
18. Sunindyo, W. D., Putranda, I. G., Rachmawati, R., & Sensuse, D. I. (2025). Designing a sustainable ICT infrastructure framework for Nusantara: Enabling smart city governance and environmental resilience in Indonesia's new capital. *International Journal of Sustainable Development and Planning*, 20(8), 3239–3251. <https://doi.org/10.18280/ijstdp.200808>
19. Tiwari, S., Botre, B. A., Sridhar, S., & Santos, C. M. (2025). Smart water grids in India: A systematic review of purification, conservation, and emerging digital trends. *Proceedings of the Indian National Science Academy*, 91(4), 1044–1064. <https://doi.org/10.1007/s43538-025-00621-w>
20. Tziovani, L., Hadjidemetriou, L., Charalampous, C., Tziakouri, M., Timotheou, S., & Kyriakides, E. (2021). Energy management and control of a flywheel storage system for peak shaving applications. *IEEE Transactions on Smart Grid*, 12(5), 4195–4207. <https://doi.org/10.1109/TSG.2021.3084814>
21. Wang, Y., Srivastava, P. R., Hanasusanto, G. A., & Ho, C. P. (2026). On data-driven prescriptive analytics with side information: A regularized Nadaraya–Watson approach. *Manufacturing & Service Operations Management*, 28(3), 841–859. <https://doi.org/10.1287/msom.2024.0997>
22. Yadav, P., Ingle, D., & Choudhary, P. (2026). Enabling the energy transition: Policy-driven edge computing innovations for sustainable oil and gas sector management. *Process Integration and Optimization for Sustainability*. <https://doi.org/10.1007/s41660-026-00782-1>
23. Paul, J., & Rialp, A. (2020). The art of writing literature review : What do we know and what do we need to know ? (xxxx).
24. Dr Richa Kalpesh Saxena, Arya Garg, Aryaman Jain, Aryann Mittal, Bhargav Y, D. K. (2024). The Applications of Operations Research in Insurance and Management. *INTERNATIONAL JOURNAL OF MANAGEMENT AND SOCIAL SCIENCES RESEARCH*, 10(02).
25. Aria, M., & Cuccurullo, C. (2017). bibliometrix : An R-tool for comprehensive science mapping analysis. *Journal of Informetrics*, 11(4), 959–975.
26. N, Donthu, S. Kumar, D. Mukherjee (2021). How to conduct a bibliometric analysis: An overview and guidelines
27. Moher, David, Liberati, Alessandro, Tetzlaff, Jennifer, Altman, Douglas G, Prisma, The (2010) Preferred reporting items for systematic reviews and meta-analyses : The PRISMA statement
28. Rao, C. K., Sahoo, S. K., & Yanine, F. F. (2025). A comprehensive review of smart energy management systems for photovoltaic power generation utilizing the internet of things. **Unconventional Resources**, 7. <https://doi.org/10.1016/j.uncred.2025.100197>
29. Mhlanga, D. (2023). Artificial Intelligence and Machine Learning for Energy Consumption and Production in Emerging Markets: A Review. **Energies**, 16(2). <https://doi.org/10.3390/en16020745>

30. Gopinath, T., Kesavan, J., Srividhya, P. K., & Ramkumar, P. (2024). Towards greener horizons: a comprehensive review of energy auditing in hybrid solar and wind systems. **Interactions**, 245(1). <https://doi.org/10.1007/s10751-024-02049-y>
31. Ahamed, A., Fardin, H., Hasan, E., Rimon, S. M. T. H., & Haque, M. M. (2026). A Review of Machine Learning Approaches for Optimizing Hybrid Renewable Energy Systems (HRES) in Decentralized Smart Grids: Enhancing Energy Efficiency and Grid Stability. **Iranian Journal of Science and Technology, Transactions of Electrical Engineering**, 50(1), 455–468. <https://doi.org/10.1007/s40998-025-00807-4>
32. Djebali, S., Guerard, G., & Taleb, I. (2024). Survey and insights on digital twins design and smart grid's applications. **Future Generation Computer Systems**, 153, 234–248. <https://doi.org/10.1016/j.future.2023.11.033>
33. Yadav, P., Ingle, D., & Choudhary, P. (2026). Enabling the Energy Transition: Policy-Driven Edge Computing Innovations for Sustainable Oil and Gas Sector Management. **Process Integration and Optimization for Sustainability**, . <https://doi.org/10.1007/s41660-026-00782-1>
34. Sunindyo, W. D., Putranda, I. G., Rachmawati, R., & Sensuse, D. I. (2025). Designing a Sustainable ICT Infrastructure Framework for Nusantara: Enabling Smart City Governance and Environmental Resilience in Indonesia's New Capital. **International Journal of Sustainable Development and Planning**, 20(8), 3239–3251. <https://doi.org/10.18280/ijstdp.200808>
35. Cina, E., Elbasi, E., Elmazi, G., & AlArnaout, Z. (2025). The Role of AI in Predictive Modelling for Sustainable Urban Development: Challenges and Opportunities. **Sustainability**, 17(11). <https://doi.org/10.3390/su17115148>
36. Soni, S. & Saini, R. (2025). Digital transformation of project and operations management in smart infrastructure and engineering enterprises. **Archives for Technical Sciences**, 3(34), 372–380. <https://doi.org/10.70102/afts.2025.1834.372>