Analysis of the Use of Author Keywords and IEEE Terms in IEEE Xplore Data to Identify Current Research Topics in Energy Technology and Existing Limitations

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Posted Date: 2 October 2025

doi: 10.20944/preprints202510.0086.v1

Keywords: energy technologies; IEEE Xplore; bibliometric records; author keywords and IEEE terms; topic analysis

 doi:10.20944/preprints202510.0086.v1

Article

Analysis of the Use of Author Keywords and IEEE Terms in IEEE Xplore Data to Identify Current Research Topics in Energy Technology and Existing Limitations

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Abstract

The rapid rise in energy consumption by artificial intelligence (AI) systems necessitates advancements in energy technologies. Training large AI models, like GPT, demands considerable computing power, overwhelming data centers and straining energy systems due to the use of energy-intensive hardware. Consequently, high energy usage poses a significant limitation on AI development and scalability. IEEE Xplore has been chosen for bibliometric analysis in energy technologies because of its emphasis on electrical engineering and computer science. The aim of this study is to analyze the limitations in the use of Author Keywords and IEEE terms presented in the corresponding fields of bibliometric records in the IEEE Xplore database on the topic of energy technologies. One of the goals of the study is to propose a format for additional conclusions and recommendations on each issue considered, formulated in a semi-formal but personalized style. The material under study consisted of 12,000 bibliometric records exported from the IEEE Xplore database from 2020 to 2025. Of these records, 6,000 were conference materials and 6,000 were journal articles. The identified research highlights major trends in smart energy systems, emphasizing the integration of IoT, AI, and machine learning for enhanced operation and predictive maintenance. Key focus areas are smart microgrids, hydrogen energy storage, and electric transport/battery systems. The publications reflect a strong emphasis on cybersecurity, data privacy, and addressing economic and accessibility issues. Furthermore, research involves advanced topics like mathematical modeling, innovative components (e.g., varactor diodes), and thermal management to improve energy efficiency and ensure safe, modern energy infrastructure, particularly in applications like smart cities. For further research, it is proposed to use the expandable IEEE thesaurus for analyzing publications, with a particular focus on the frequency of term occurrences in titles and abstracts.

Keywords: energy technologies; IEEE Xplore; bibliometric records; author keywords and IEEE terms; topic analysis

Introduction

Relevance of the Study. Brief Literature Review

Justification for Choosing IEEE Xplore as a Source of Bibliometric Data and the Importance of Technology for the Energy Sector

The explosive growth in energy consumption by artificial intelligence systems requires the development of technologies in the energy sector. Training and launching large artificial intelligence models, such as GPT, requires significant computing resources, which leads to an increased load on data centers. The use of energy-intensive equipment, such as graphics processing units and specialized accelerators, places unprecedented demands on energy systems. As a result, high energy

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consumption has become one of the key constraints on the development and scaling of artificial intelligence technologies.

IEEE Xplore was selected for analyzing bibliometric data in the field of energy technologies due to its focus on relevant disciplines, in particular electrical engineering and computer science, which correspond to energy technologies such as smart grids, converters, renewable energy sources, and energy storage. The high quality of its peer-reviewed publications makes it a benchmark in the field of engineering. In addition, IEEE Xplore provides comprehensive coverage of both journal articles and conference proceedings. Access to the database is open and allows for the export of bibliometric records.

To avoid bias and demonstrate the significance of the issue under consideration, let us cite examples of publications that reflect the importance of IEEE-related technologies and the estimated costs of their implementation.

5G is a transformative technology with superior technical characteristics, supporting innovative services and products across the economy, potentially adding $1 trillion to global GDP by the end of the decade [1].

5G technology can generate millions of jobs across various sectors, requiring a comprehensive study among engineering, business, and economists. Mobile networks can transform from social media to a pillar in economic growth [2].

The Internet of Things (IoT) market in additive and advanced manufacturing is expected to reach USD 1742.8 billion by 2030, growing at a CAGR of 20.47% from 2022 to 2030, enhancing real-time data collection, quality control, predictive maintenance, and efficient inventory management [3].

A IoT, or Internet of Things, is expected to revolutionize various sectors, with an estimated 350 billion devices by 2030, contributing to 14% of global GDP [4].

The research [5] explores the impact of IIoT projects on industrial efficiency and the world economy, focusing on the role of the Internet of Things (IoT) in the Industrial Revolution. It examines the advantages, impact, and projected consequences of IIoT, as well as the implementation of IIoT projects in Russia and foreign markets.

The study [6] evaluates the economic feasibility of three transition strategies - wind and solar power, nuclear power, and fossil fuel power with carbon capture and storage. It reveals that the high wind and solar pathway is the most cost-effective, with cumulative costs ranging between 5.07 and 5.26 trillion USD. The high nuclear and high CCS pathways are significantly more expensive, with costs rising to 6.31 and 8.21 trillion USD, respectively. This study highlights the need for a comprehensive analysis of transition strategies.

The World Economic Forum predicts that blockchain could generate 3.1 trillion in economic value by 2030, but adoption remains low, particularly among small and medium-sized enterprises. High initial costs, regulatory ambiguities, and technical knowledge barriers hinder its adoption. However, overcoming these challenges could improve security, speed up trade, and reduce transaction costs [7].

The study [8] predicts significant shifts in employment patterns, regulatory challenges, and societal structures due to the transformative potential of AI. It predicts AI-induced unemployment reaching 40-50%, outpacing existing governance frameworks, and exacerbates economic inequalities. However, a 10% probability suggests governments and societies are not prepared to manage these risks.

The global economy is vulnerable to macroeconomic disruptions, affecting operations and supply chain management systems. Advanced technologies like blockchain, AI, and quantum computing can enhance transparency but also introduce risks. A systemic approach is needed to integrate these technologies [9].

Generative AI's rapid advancements, driven by potential benefits, have negative environmental impacts. The current focus on efficiency enhancements instead of sustainability is unsustainable. Balancing innovation with sustainability is crucial for businesses, the economy, and the planet.

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Integrating environmental impact assessments, promoting sustainable AI models, and collaborating across diverse stakeholders is essential for advancing sustainable AI practices [10].

The examples above show that energy is fundamental to the electronic systems and devices studied by IEEE in areas such as smart grids, the Internet of Things, and artificial intelligence. This underscores the importance of energy technologies in all areas of IEEE's activities, which serve as an important foundation for digital transformation and sustainable development.

The second objective of this study is to conduct a preliminary analysis of keyword significance. The selection of keywords is essential for accurately and completely describing the subject under study. Keywords act as filters that shape the researcher's understanding of the topic; errors in keyword selection can distort conclusions.

Reasons Why Choosing Keywords for Thematic Analysis Is Important

The topic of keywords, especially author keywords, has been discussed for decades. In my opinion, the issue is discussed most specifically in publication [11], in which the author points out that readers decide to read the article based on the actual keywords in the title, rather than the list of author keywords. To make sure that the article is relevant to their research or of interest to them, they read the abstract.

The examples below illustrate the limited usefulness of author keywords for analyzing publication topics and collecting publications on a given topic.

The study [12] analyzes the role of author keywords in scientific articles and their descriptors in various databases. A comparison of 1080 articles with the descriptors revealed that 64.96% of the authors' keywords in the IME database match the descriptors or do so after normalization, while 60.48% in ISOC and 58.18% in ICYT match the descriptors. Note: An English version of the article is available at https://redc.revistas.csic.es/index.php/redc/article/view/165. Database names are retained as they appear in the abstract. For our research, numerical estimates are important.

The study [13] reveals that author keywords are found in titles, abstracts, and both titles and abstracts at 31%, 52.1%, and 56.7%, respectively. Author-selected keywords are found in references and high-frequency keywords at 41.6% and 56.1%, respectively. Core authors' keywords appear less frequently in titles and abstracts, but more frequently in references and high-frequency keywords. Keywords in high-frequency keywords are positively associated with paper citation counts. Note: This article probably best illustrates the issue of key authorial words.

The study [14] examines the retrievability of author-provided keyphrases from scientific publications' abstracts using phrase-level matching. Results show that author-provided keyphrases are often not present in abstracts, with abstract coverage around 30% in three datasets. Unsupervised methods achieve coverage of less than 20%, indicating limited accuracy in identifying keywords. Note: This article confirms the results of the previous one and points out the limited application of unsupervised methods for keyword extraction.

The article [15] analyzes the presence of scientific article authors keywords in database descriptors. It found that 25% of keywords appeared in the same form as descriptors, and 21%, even after normalization, were still detected in the descriptors, indicating that almost 46% of keywords are present in the descriptors. Note: The result that almost 46% of the keywords are present in the descriptors is not significantly different from the previously announced results. An important addition to this work is the significance of keyword normalization.

Bibliometric analysis using literature from the Web of Science is gaining popularity for understanding scientific field structure [16]. Keywords Plus, a more descriptive term, is as effective as Author Keywords in analyzing knowledge structure, but less comprehensive in representing an article's content. Note: The statement that Keywords Plus are more descriptive but less comprehensive suggests that to increase comprehensiveness, it is advisable to increase the size of the Keywords Plus dictionary.

The study [17] analyzed human-assigned keywords in neurological disorders publications and compared them with unsupervised and machine-algorithm-based extracted terms. It found that

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while author-provided keywords are crucial for readability, they lack specificity for in-depth analysis. The study suggested that machine learning algorithms, which are more compatible with unstructured data, could be a valid alternative to human-generated keywords for more accurate results. Note: machine learning algorithms could be a valid alternative to human-generated keywords. The computational complexity of this approach should be taken into account. It is most rational to consider them as a supplement to the existing glossary of terms.

The paper [18] discusses the increasing availability of author keywords in biomedical journal articles, revealing that over 60% of these keywords can be linked to a closely related indexing term, based on a comparative study of MEDLINE indexers' assignments. Note: 60% is a really good result for such assessments.

The study [19] found that out of 955 keywords, 414 cases were repeated in titles, resulting in a 43% match or overlap. However, the majority of these matches are due to specialized terminologies, with a ratio of 80.7% of specialized keywords in titles to the total number of keywords. This suggests that users need domain-specific background knowledge to find relevant information. Using general terms in queries is unlikely to lead to successful results. Note: It would be useful to expand the results of this work to analyze the role of specialized terminologies in abstract texts.

The study [20] focuses on determining the percentage of keywords in abstracts, with results for three journals being 48.81, 41.59, and 56.84, respectively. Note: It is fairly normal for abstract texts to contain only between 40–60% keywords.

The brief literature review above makes it possible to identify the main limitations of using author keywords for in-depth text analysis.

The Purpose of this Study

This study aims to analyze the limitations of using a dictionary of keywords—including both author-defined terms and IEEE terms—to determine the thematic structure of research in energy technology using the IEEE Xplore database. The paper presents valid examples of publications related to this topic, assesses the limitations associated with keywords from directly exported bibliometric records, and offers a suggestion for improvement to increase the completeness of topic descriptions by compiling a more relevant keyword dictionary.

One of the aims of the study is to propose a format for additional conclusions and recommendations on each issue under investigation, formulated in a semi-formal but personalized style.

Materials and Methods

The material under study consisted of 12,000 bibliometric records from 2020 to 2025, exported from the IEEE Xplore database. Of these, 6,000 were conference materials and 6,000 — journal articles.

The data was obtained upon query: "((("Document Title": energy) OR ("Abstract": energy)) AND (("Document Title": technology) OR ("Abstract": technology))" to ieeexplore.ieee.org. The "Journals" and "Conferences" filters were used accordingly.

This study did not use any special programs; only SQL queries and string processing utilities, such as grep, were applied.

After each table, topical examples of publications on the subject described by the terms contained therein are provided. Following a brief description of the content of the selected publications, comments are provided in a semi-formal but personalized style.

Note: Due to the highly specialized nature of the terminology used in the abstracts of the sample publications, the intention was to preserve the original spelling of the terminology as much as possible. This may trigger a reaction from some anti-plagiarism software. However, altering the terminology could significantly distort the meaning of the referenced text. Therefore, one of the secondary tasks of this work was to practice an informal procedure for summarizing the texts of publication abstracts.

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Results and Discussion

Common Remark for Sections Conferences and Journals Publications

After each Table containing keywords, there are examples of selected publications obtained by analyzing the corresponding abstracts. The search for the publications was focused on publications closely related to the listed keywords and was conducted using three open-access abstract databases: IEEE Xplore, ScienceDirect, and MDPI. The selection criteria for these sample publications included both citation frequency and publication date. The citation frequency of each work was confirmed by searching for the title on Google, which allowed us to accurately identify the most cited recent publications.

Conferences Publications

IEEE Terms

General Characteristics of IEEE Terms in Bibliometric Records of Conference Proceedings

Of the total number of records, 6,000, 304 records do not have IEEE Terms filled in.
The total number of unique IEEE keywords in the IEEE Terms field after lemmatization: 2938.
The total number of times IEEE Terms appeared in abstract texts: 106910.
The total number of unique IEEE Terms found in the abstract texts: 2191.
Percentage of unique IEEE Terms founded in the abstract texts among all unique IEEE Terms: 100*2191/2938=74.6%.
The average number of times a unique IEEE Term appears in all abstracts: 106910/2191=48.8.
To generate new requests for material collection, the most interesting terms are those that appear most frequently in publications, are taken from frequently cited publications, and appear in later publications. Examples of the 20 publications with the highest scores are presented in Tables 1–3.

Table 1. Top 20 IEEE Terms most frequently found in conference materials.

IEEE Terms	Count	IEEE Terms	Count
Renewable energy sources	1372	Power demand	352
Energy consumption	753	Photovoltaic systems	346
Energy efficiency	707	Power system stability	343
Costs	641	Sustainable development	324
Real-time systems	456	Simulation	323
Batteries	448	Internet of Things	302
Production	419	Smart grids	292
Optimization	389	Wireless sensor networks	272
Technological innovation	362	Reliability	271
Wireless communication	361	Stability analysis	270

Query. Find top-3 most cited peer-reviewed scientific publications described by keywords → *Renewable energy sources, Energy consumption, Energy efficiency, Costs, Real-time systems*. Published in 2020–2025 years.

The most frequently occurring terms in the general set of abstract texts reflect the most common and frequently discussed issues. Publications on such issues are not necessarily the most highly cited.

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There are simply many works on them, or they describe the general context of publications, for example, reflecting the relevance of the topic.

The Internet of Things (IoT) can be used to monitor energy consumption in solar-powered buildings. Its purpose is to provide real-time data to support energy efficiency. A Wi-Fi-enabled device is proposed that allows daily and weekly energy consumption studies to be conducted, enabling consumers to implement energy-saving measures. This is an affordable solution, as traditional systems can be costly and complex [21].

The study [22] examines hydrogen energy storage (HES) systems for long-term and large-scale energy storage, focusing on their high energy density, long-term storage, and adaptability to the energy system. It highlights system optimization challenges, energy management strategies, and economic viability, as well as emerging technologies such as artificial intelligence and machine learning. The study also discusses advances in battery technologies and HES methods.

The paper [23] evaluates the technical and economic impacts of a microgrid at the building level. It considers photovoltaic generation, battery energy storage, and electric vehicle use. Using real on-site data, it quantifies system efficiencies and provides insights into microgrid design and implementation. The study found that economic benefits depend on tariff variability, energy storage system costs, degradation, and equipment efficiency. Additionally, the study emphasizes the importance of real on-site data in calculating overall asset efficiencies.

The topic of renewable energy is widely promoted at the political level and supported by incentives for investment. For the effective use of renewable energy, the key issues at present are solutions for large-scale energy storage and optimization of its distribution not only at the national level, but also at the local level. The most discussed solutions to these problems are the use of hydrogen generated by renewable sources and the introduction of smart microgrids capable of implementing efficient energy consumption and distribution in real time. It is assumed that the effective operation of microgrids will be achieved through the use of the Internet of Things. This is reflected in the above publications.

Table 2. Top 20 IEEE Terms related to the most cited conference materials.

IEEE_Terms	AVG	IEEE_Terms	AVG
Phase shifters	90	Bitcoin	22.5
Frequency division multiplexing	80	Metallization	22
Computer crashes	44	Passivation	22
Industrial control	44	Program processors	21
Malware	44	Aerospace control	20
Switched mode power supplies	28	Ground penetrating radar	20
IEEE 802.15 Standard	26	Sidelink	20
Precoding	24.5	Downlink	18.3
Quality of experience	24	Access control	18
Electron accelerators	23	Authorization	18

Note: AVG field is calculated as the average citation count of articles to which this term refers (Article_Citation_Count).

The table shows that terms related to engineering solutions are most frequently used in the most cited publications. The first two terms, *Phase shifters, Frequency division multiplexing*, are more directly related to technical tasks, while the following terms, *Computer crashes, Industrial control and Malware*, refer to the reliability and security of their operation at the system level.

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Below are examples of articles that use the first two terms from the table.

Phase shift spatial multiplexing has recently emerged as an effective multiple-input multiple-output technology with reduced radio frequency chains. The paper [24] proposes a new PSSM system with superposition coded modulation, which introduces a flexible extension of quadrature amplitude modulation (QAM) constellations in the baseband, significantly improving bit error rate performance.

The paper [25] investigates a novel, low RF-chain technique called phase-shifter-aided spatial multiplexing (PSSM) in the context of frequency-selective channels. Based on the concept of single-carrier frequency-domain equalization, the authors developed a message-passing detector tailored specifically for PSSM systems. This detector efficiently leverages prior constraints and handles the linear inverse problem by integrating belief propagation and expectation propagation.

The publications listed above refer to 2025; their citation rates have not yet been established.

The following publication is recommended for the second part of the listed keywords.

In order to ensure the resilience and security of the power grid, it is necessary to identify security vulnerabilities in power electronic devices. Fuzzing is an effective technique for detecting security flaws in software and firmware. It involves subjecting the system under test to a series of unexpected inputs, which can result in unexpected behavior, such as system crashes. However, new methods are needed to detect the unexpected behavior of power electronic devices during fuzzing. In [26] the authors verify the use of electromagnetic waves to detect silent system crashes in power electronic devices, with the aim of advancing fuzzing in this field.

According to IEEE Xplore, this article has been cited three times. This information is current as of September 27, 2025.

Table 3. Top 20 IEEE Terms related to the most recent conference materials.

IEEE Terms	**IEEE Terms**
Electronic packaging thermal management	Superconducting microwave devices
Message services	Switched reluctance motors
Fly ash	Chip scale packaging
Streams	Phase locked loops
Root mean square	Biosensors
Transport protocols	Laser fusion
Space-air-ground integrated networks	Radio spectrum management
Phase change memory	Space missions
Sparse matrices	Space communications
Gravitational waves	Quantum cryptography

Due the highly specific nature of the terms listed in the table, here are some examples of recent publications that mention the term *Electronic packaging thermal management*.

The study [27] focuses on the preparation of high-performance graphite film/aluminum composites and diamond/aluminum composites for in-plane and isotropic high thermal conductivity requirements, exploring the impact of magnesium and silicon elements on thermal conductivity and mechanical characteristics.

Wireless technology and electronic device miniaturization have increased power density, posing challenges to thermal management. Efficient thermal interface materials (TIMs) are needed for stable thermal performance in compact devices. The 2025 review [28] analyzes TIMs used in electronic packaging cooling, focusing on nano-enhanced phase change materials (NePCMs) that combine high latent heat with superior thermal conductivity.

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The article [29] was published on August 20, 2025. Its popularity was assessed based on the number of views it received. Current as of September 6. The use of wide bandgap semiconductors such as SiC and GaN offers effective methods for minimizing thermal losses caused by conduction losses in high-frequency switching topologies. Advancements in high-power density devices and innovative cooling systems like phase change materials and nanofluids show potential for enhanced heat dissipation in power electronics, with improved designs enabling more efficient thermal management.

The topic of electronic packaging thermal management is a classic one, and it can be assumed that *nano-enhanced phase change materials (NePCMs)* may serve as an emerging area of interest for research.

Author Keywords

The author's keywords could be spelled differently, so they had to be converted to lowercase, lemmatized. The text was cleaned up by removing various types of quotation marks, unnecessary punctuation, and symbols, such as copyright symbols. Different types of separators in complex words were converted to hyphens. The abstract texts underwent the same preparation. Some changes had to be made manually, for example, k-mean++ algorithm → k-mean\+\+ algorithm.

General Characteristics of Author Keywords in Bibliometric Records of Conference Proceedings

Of the total number of records, 6,000, 653 records do not have Author Keywords filled in.

The total number of unique Author Keywords in the Author Keywords field after lemmatization: 13249.

The total number of times Author Keywords appeared in abstract texts: 247683.

The total number of unique Author Keywords found in the abstract texts: 7719.

Percentage of unique Author Keywords founded in the abstract texts among all unique Author Keywords: 100* 7719/13249=58.3%.

The average number of times a unique Author Keywords appears in all abstracts: 247683/7719=32.1.

The Author Keywords field is less populated than the IEEE Terms field.

The relative frequency of unique Author Keywords in the abstract texts is lower than that of IEEE Terms.

Note: Without preprocessing the authors' keywords and abstracts texts, the above values would be significantly lower. Therefore, works in which authors' keywords are used to evaluate keyword extraction methods raise doubts. This issue requires further detailed research and is therefore not discussed here.

To generate new queries for collecting materials, it is useful to examine the author keywords that appear most frequently in publications, are related to publications with high citation rates, and appear in more recent publications. This is reflected in Tables 4–6.

Table 4. Top 20 author keywords most frequently found in conference materials.

Author keywords	Count	Author keywords	Count
renewable energy	349	microgrid	119
energy efficiency	273	energy consumption	109
internet of thing	221	machine learn	108
blockchain	201	artificial intelligence	100
smart grid	198	optimization	95
energy storage	188	battery	94

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iot	176	energy storage system	93
electric vehicle	143	renewable energy source	85
energy management	137	energy	82
energy harvest	133	solar energy	82

When selecting keywords for their publications, authors consider not only the content of the article but also its broader relevance. Therefore, the terms *renewable energy*, *energy efficiency*, *internet of things*, *smart grid* and *energy storage* accurately reflect this context for articles presented at conferences and collected in the IEEE Xplore database under the topic "energy AND technology."

One example of a well-cited work published in the IEEE Xplore database is the article [30]. The paper discusses the integration of renewable energy sources into smart grid systems, highlighting the need for a holistic solution that includes real-time energy monitoring, smart algorithms for energy management, and cloud computing for data analysis. Simulation results show that distributed IoT systems can improve smart grid practices by reducing energy transportation losses, ensuring AC grid stability, and integrating renewable energy potential.

An example of a review that reveals a number of aspects related to the keywords listed in Table 4 and indexed in the ScienceDirect database is the work [31]. The integration of blockchain and IoT in smart grids can improve energy management, security, and operational efficiency. Blockchain ensures secure transactions without centralized authorities, while IoT allows real-time data collection and monitoring. These technologies address cybersecurity, data security, and network security challenges. By leveraging smart contracts and consensus algorithms, they enhance grid resilience and privacy, providing robust solutions for distributed energy resources and decentralized energy markets.

The review [32] in the MDPI database addresses this topic. This article analyzes existing research on energy management in smart cities, identifying technological trends and highlighting future directions. It uses a literature review of Scopus and Web of Science databases to evaluate studies. Future research should focus on smart energy grids, energy storage, renewable energy integration, and innovative technologies like the Internet of Things, 5G/6G, artificial intelligence, blockchain, and digital twins.

Table 5. Top 20 author keywords related to the most cited conference materials.

Author Keywords	**AVG**	**Author Keywords**	**AVG**
process in memory	131	heuristic algorithm	34
accelerator	131	client selection	34
proof-of-stake	54	global energy demand	29
climate action	54	plan renewable energy project	29
dram	46.67	target	29
malware	44	bio-mass power plant	29
apt	44	carbon footprint	28
car park	37	amr	28
time save	37	precision farm	28
internet layer	37	reproducibility	28

Even among the author's keywords that appear most frequently in the cited texts, there are many common terms such as *accelerator*, *climate action*, *drama*, *malware*. In order to find more specific and interesting publication topics, let's select the author's keywords: *process in memory and heuristic*

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algorithm. Upon exact request *"process in memory" AND "heuristic algorithm"* to IEEE Xplore no publications were found. However, since heuristic algorithms are used in many engineering solutions, it was decided to examine which highly cited publications containing the term "*heuristic algorithm*" have been indexed in IEEE Xplore in recent years. Interestingly, all three publications selected according to these criteria and published in conference proceedings contained the term "*Meta-Heuristic Algorithm*" in their titles.

The paper [33] introduces a Sine Cosine hybrid optimization algorithm with Modified Whale Optimization Algorithm (SCMWOA) for solving continuous and binary decision variables. The SCMWOA algorithm outperforms other algorithms and offers better accuracy.

The article [34] explores an energy-efficient distributed no-wait flow-shop scheduling problem with sequence-dependent setup time (DNWFSP-SDST) to minimize makespan and total energy consumption. It constructs a mixed-integer linear programming model and proposes a cooperative meta-heuristic algorithm based on Q-learning (CMAQ). The article also proposes an energy-saving strategy based on knowledge to improve makespan and TEC.

The study [35] presents a novel method for detecting oral cancer in medical images using a convolutional neural network and optimized deep belief network. The algorithm, a hybrid of Particle Swarm Optimization (PSO) and Al-Biruni Earth Radius (BER) Optimization, optimizes the design parameters of the CNN and DBN.

Table 6. Top 20 author keywords related to the most recent conference materials.

Author Keywords	**Author Keywords**
programmable delay cell	future grid
multi-resolution	software-define wire sensor network
conversion time	smart energy meter system
energy/ conversion	short message service
accuracy fom	multi-modal technology
high-entropy alloy	ai-drive decision-make
electronic application	real-time feedback
supergrid	ultra-low latency
ac-dc energy node	synchronization
hvdc grid	human-machine interaction

The author's keywords, which characterize more recent publications, reveal many common terms among them: *multi-resolution, conversion time, energy/ conversion, accuracy fom.*

Therefore, as in the previous case, let's limit ourselves to publications in IEEE Xplore that contain the term "*programmable delay cell*" in the title. There were no such publications in 2025, but one publication each was found for 2023 and 2024.

The work [36] introduces an all-digital differential programmable delay circuit for time domain applications, including time-to-digital converters and temperature sensors. The circuit offers eight delay modes and occupies 0.0072 mm2 layout area.

The work [37] presents a 90-nm CMOS programmable delay cell with eight modes, a stable output, and a low power consumption of 0.671 μW at M0 and 3.88 μW at M7, despite occupying only 0.009 mm of space.

A subjective assessment suggests that the author's keywords may not be the most effective for searching for new, specific, and relevant topics. Conducting a separate study to identify key terms from titles and abstracts, followed by a study akin to the current one, could be beneficial.

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Additionally, it has been observed that commonly occurring terms tend to be more general, whereas terms that appear frequently in highly cited, recent publications tend to be more specialized.

Journals

IEEE Terms

General Characteristics of IEEE Terms in Bibliometric Records of Journal Articles

Of the total number of records, 6,000, 22 records do not have IEEE Terms filled in.

The total number of unique IEEE keywords in the IEEE Terms field after lemmatization: 3137.

The total number of times IEEE Terms appeared in abstract texts: 118360.

The total number of unique IEEE Terms found in the abstract texts: 1998.

Percentage of unique IEEE Terms founded in the abstract texts among all unique IEEE Terms: 100*1998/3137=63.7%.

The average number of times a unique IEEE Term appears in all abstracts: 118360/1998=59.2.

Compared to unique IEEE terms in conference proceedings, the percentage of unique IEEE terms found in journal article records in abstract texts is lower, but they occur more frequently.

Tables 7–9 show the top 20 IEEE terms that are most frequently encountered in general, most frequently encountered in highly cited publications, and most frequently encountered in new publications, respectively.

Table 7. Top 20 IEEE terms most frequently encountered in journal articles.

IEEE Terms	Count	IEEE Terms	Count
Optimization	756	Computer architecture	418
Internet of Things	691	Wireless sensor networks	385
Energy consumption	676	Task analysis	382
Wireless communication	595	Computational modeling	346
Resource management	545	Servers	312
Energy efficiency	464	Delays	311
Batteries	459	Logic gates	292
Costs	457	Real-time systems	289
Sensors	455	Security	282
Renewable energy sources	425	Switches	277

By looking at the dominant themes of publications on energy and technology in the IEEE context, it becomes apparent that the optimization of everything listed below this term in the table appears in numerous articles.

Optimization, Internet of Things, Energy consumption, Wireless communication, Resource management, Energy efficiency, since the topic described by these terms is very broad, lets limit ourselves to three examples from the IEEE Xplore database that are most relevant to the interests outlined in this article and related to these terms.

The study [38] explores a resource allocation scheme to reduce energy consumption in relay-assisted IoT networks. A joint optimization problem is formulated, considering scheduling IoT devices, transmit power allocation, and computation frequency allocation. Using graph theory, near-optimal and low-complexity suboptimal solutions are proposed. Simulations show that the near-optimal scheme achieves 6, 4 and 2 times lower energy consumption compared to fixed schemes.

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Intelligent Reflective Surface is a technology that improves the spectral and energy efficiency of wireless networks. By adjusting the phase shifts, it enables high gain passive beamforming, improving spectral efficiency. The research objective [39] was to maximize energy efficiency by optimizing the phase shifters, beamformer, time allocation and transmit power while ensuring minimum rate requirements. An alternating optimization algorithm is proposed to solve the nonlinear fractional programming problem. Simulation results show that IRS can improve the system performance compared with benchmarks.

The integration of autonomous aerial vehicles (UAVs) and low-Earth orbit (LEO) satellites is beneficial for IoT task processing due to the ability to overcome ground network coverage issues [40]. In this paper, energy-efficient resource allocation in LEO-enabled UAV networks is considered. A novel ORHCC optimization algorithm is proposed to optimize trajectories and hover points of UAVs, improving endurance and minimizing energy consumption. Results show 12.5% and 20.76% reduction in energy consumption compared to the proximal policy-based optimization and the greedy baseline algorithm.

Table 8. Top 20 IEEE terms related to the most cited articles in journals.

IEEE Terms	AVG	IEEE Terms	AVG
Resource description framework	769	Dielectric losses	166.75
User interfaces	594	Augmented reality	166
Semiconductor devices	562	Satellite communication	162
Mars	491	Fuel cell vehicles	162
Ubiquitous computing	459	Medical Internet of Things	155
Biology	306	Focusing	153.5
Backhaul	286	Nash equilibrium	153
Rural areas	286	Conductivity measurement	143
Torque control	176	Haptic interfaces	142
Androids	173	Message passing	140.5

The most interesting terms in this table are likely to be: *Resource description framework, Ubiquitous computing*. Below are examples of three publications that reflect some aspects of this topic.

The article [41] presents a new, asymptotically optimal, fully decentralized, real-time framework for IoT networks, integrating wireless computation offloading and fog computing. It addresses challenges in data-intensive applications and provides ubiquitous computing for continuously increasing IoT services.

The paper [42] explores a new ontology-based approach for controlling the behavior of Edge Computing devices. It proposes utilizing ontology reasoning mechanisms on resource-constrained Edge devices, enabling on-the-fly function modifications, ad-hoc monitoring of intermediate data, and interoperability within IoT. The solution is demonstrated through an ontology-driven Smart Home edge device for locating lost items.

The study [43] extends a logic-based methodology for clustering data in Resource Description Frameworks (RDFs) by computing a Common Subsumer structure. The method was tested on two datasets: public procurement and drugs in pharmacology. Both datasets provided concise descriptions of clusters with up to 1800 resources.

Taking into account the terms selected from the table and the summary of the three articles presented above, the following topics for research can be proposed. The development of intelligent frameworks for edge data management focuses on three key areas: 1) Decentralized intelligence, which shifts computation to the network's edge for enhanced efficiency, 2) semantic understanding,

 doi:10.20944/preprints202510.0086.v1

which employs knowledge-based models to give meaning to data, and 3) enhanced IoT capabilities, which are aimed at addressing challenges like data handling, device interoperability, and insightful data extraction.

Table 9. Top 20 IEEE Terms related to the most recent journal articles.

IEEE Terms	**IEEE Terms**
Systematic literature review	Resonance
Cables	Closed box
Smart charging	Digital audio players
Fast Fourier transforms	Petri nets
Torque measurement	IEEE 802.16 Standard
Tracking loops	Curve fitting
Piezoelectric effect	Predictive analytics
Optical mixing	Proof of stake
Silicon dioxide	Nuclear imaging
Lead zirconate titanate	Photosynthesis

In this case, lets try to answer just one question: "Why has the topic of *Systematic literature review* become so popular in recent publications?"

Given that the publication type *Systematic literature review* has a very specific meaning, the search for such reviews in IEEE Xplore was performed based on the exact match of "Systematic literature review" in the publication title and the terms *energy and technology* in the metadata. Publications listed in this database for 2025–2026 were considered. Current as of September 9, 2025. A total of 9 publications were found, which were ranked by number of views. A brief description of three of them is provided below.

Industry 4.0 has accelerated manufacturing by introducing innovative technologies like supervised machine learning to anticipate equipment failures and optimize maintenance schedules. The [44] study presents a systematic literature review of 216 peer-reviewed papers, focusing on a structured taxonomy of predictive maintenance methods in safety-critical industries, highlighting their domain-specific usage.

Source number estimation is crucial in multi-sensor array signal processing, essential for radar, sonar, wireless communication, and astronomy applications. This review [45] outlines traditional methods and recent advancements. Variables like noise background, signal-to-noise ratio, snapshot number, array manifold, and element number significantly impact algorithm performance. The review suggests future research, particularly deep learning techniques, and addresses unresolved challenges and gaps in current studies.

The systematic literature review [46] examines how artificial intelligence (AI) can improve smart grid stability. It evaluates 41 studies using machine learning, deep learning, neural networks, and explainable AI. Findings show AI enhances grid stability through predictive capabilities and adaptive controls. Challenges include scalability, data privacy, model interpretability, while opportunities lie in hybrid models and blockchain integration.

Scientific publications in the systematic literature review (SLR) format are crucial because they provide comprehensive syntheses of research in rapidly evolving fields such as Industry 4.0, multi-sensor signal processing, and AI in smart grids. SLRs systematically summarize complex studies, reveal methodological taxonomies, and identify challenges and research gaps. They also support evidence-based decision-making for technology deployment.

 doi:10.20944/preprints202510.0086.v1

Author Keywords

General Characteristics of Author Keywords in Bibliometric Records of Journal Articles

Of the total number of records, 6,000, 653 records do not have Author Keywords filled in.

The total number of unique Author Keywords in the Author Keywords field after lemmatization: 16677.

The total number of times Author Keywords appeared in abstract texts: 221149.

The total number of unique Author Keywords found in the abstract texts: 6055.

Percentage of unique Author Keywords founded in the abstract texts among all unique Author Keywords: 100*6055/16677=36.3%.

The average number of times a unique Author Keywords appears in all abstracts: 221149/6055=36.5.

It seems that authors of scientific articles are less guided by the frequency of keywords in abstracts than authors of conference proceedings. This is also a topic that deserves separate research.

Tables 10–12 show the top 20 Author Keywords that are most frequently encountered in general, most frequently encountered in highly cited publications, and most frequently encountered in new publications, respectively.

Table 10. Top 20 author keywords most frequently found in journal articles.

Author Keywords	Count	Author Keywords	Count
energy efficiency	366	renewable energy	127
internet of thing	353	edge compute	126
energy harvest	213	mobile edge compute	122
blockchain	202	iot	112
machine learn	174	wire sensor network	110
deep reinforcement learn	156	wire power transfer	109
resource allocation	154	unman aerial vehicle	108
electric vehicle	154	artificial intelligence	106
smart grid	144	reconfigurable intelligent surface	105
deep learn	128	energy consumption	104

As in previous cases, the most frequently occurring author keywords are mainly general in nature: *energy efficiency, internet of thing, energy harvest, blockchain, machine learn.* To find a more interesting option for exploring the topic of technology for energy, consider publications found using keywords *deep reinforcement learn and smart grid* in IEEE Xplore.

The growing reliance on renewable energy and flexible loads in smart grids poses challenges to optimizing power systems due to high levels of uncertainty. While traditional optimization methods require accurate mathematical models, advanced meters allow for data-driven artificial intelligence methods. Deep reinforcement learning (DRL) has gained attention for its performance in solving problems with high uncertainty. The article [47] provides a comprehensive literature review of DRL and its applications in smart grid operations. It identifies challenges and potential solutions and suggests future research directions. It is worth noting that at the time of the database query on September 9, 2025, the publication had 84 Cites in Papers and 19,487 Full Text Views.

The paper [48] presents a deep reinforcement learning framework for enhancing resiliency in smart power grids against cyber-physical disturbances. The framework, based on the Deep Deterministic Policy Gradient algorithm, is optimized using the Root Mean Square Propagation

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method for stable training. It features a two-layered control architecture, a comprehensive reward design, and a resiliency adaptation layer for rapid response to disturbances and cyber-attacks. The framework offers a scalable and intelligent solution for enhancing smart grid resiliency.

Smart meters are crucial for energy management, but fraudulent customers can compromise them, leading to cyber-attacks. To combat this, a deep reinforcement learning (DRL) approach is proposed [49]. This method uses RL's adaptability to dynamic cyber-attacks and consumption patterns, enabling optimal decision-making. Experiments show the DRL approach improves detection of electricity theft cyber-attacks and efficiently defends against new attacks.

The application of deep reinforcement learning (DRL) in smart grid systems is explored, focusing on optimization, resilience, and cybersecurity. Key research areas include data-driven control for renewable energy variability, tailored DRL algorithms for grid operations, enhancing power system resilience against cyber-attacks, and real-time fraud detection in smart metering.

Table 11. Top 20 author keywords related to the most cited articles in journals.

Author Keywords	**AVG**	**Author Keywords**	**AVG**
intelligent communication environment	962	ai/ml drive air interface	594
pervasive artificial intelligence	962	network localization and sense	594
network automation	962	cognitive spectrum share	594
all-spectrum reconfigurable transceiver	962	sub-terahertz	594
internet of nanothings	962	run-core convergence	594
internet of bionanothings	962	subnetwork	594
df relay	769	network as a platform	594
massive connectivity	629	passive array	562
datum rate	621	phase shift model	562
passive array optimization	595	quantum communication	506.5

It should be noted that the topics of the *internet of nanothings* and the *internet of bionanothings* are highly specialized and therefore require separate consideration. Therefore, only one review will be considered [50]. Advances in synthetic biology and nanotechnology have led to the development of tools for manipulating biological cells, allowing for the creation of Bio-Nanothings — small, inconspicuous devices suitable for in-vivo applications such as health monitoring and targeted drug delivery. These nano-scale devices can form a collaborative network (nanonetwork) when connected to external high-bandwidth networks like 5G. This paper reviews bio-cyber interfaces for IoBNT architecture, discussing options such as bio-electronic devices and RFID-enabled implants, while addressing potential vulnerabilities and mitigation strategies for future implementations.

Previously, no publications were reviewed for the query "*all-spectrum reconfigurable transceiver*" thus let us focus on this task.

All-Spectrum Reconfigurable Transceivers are devices capable of operating with any wireless standard through software updates, while covering the entire radio frequency range. This is the idealized solution for wireless communications.

A precise search of databases on the topic "*all-spectrum reconfigurable transceiver*" yielded no results. Therefore, similar publications will be found from all three databases, with an emphasis on semantic similarity and citation frequency.

IEEE Xplore: The paper [51] introduces a reconfigurable bidirectional wireless power and data transceiver (RB-WPDT) for wearable biomedical applications. It supports full-duplex data transmission via a single inductive link, allowing real-time control and monitoring between devices. The full-duplex method uses frequency shift-keying pulse-width modulation for downlink and load

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shift-keying for uplink, ensuring simultaneous bidirectional data transmission with minimal interference.

ScienceDirect: The research [52] introduces a reconfigurable antenna capable of operating in multiple frequency ranges and supporting various wireless communication uses, including 5G sub-6 GHz. The antenna uses strategically placed varactor diodes for frequency changes and pattern reversal, enhancing its ability to adapt to the dynamic needs of wireless networks. The paper investigates and evaluates five operating modes based on varactor diode switching conditions.

MDPI: The paper [53] discusses the use of reconfigurable antennas for IoT applications, focusing on electrical reconfiguration techniques. It reviews various approaches, including PIN diodes, digital tunable capacitors (DTCs), varactor diodes, and RF switches, and categorizes them based on their implementation. These antennas can adapt their frequency, radiation pattern, or polarization to meet changing requirements.

The articles focus on the development of reconfigurable wireless communication systems, emphasizing dynamic reconfigurable antennas for 5G and IoT, bidirectional transceivers for wearable biomedical devices, and electrical reconfiguration techniques such as varactor diodes and RF switches that support adaptive operations in various environments.

Table 12. Top 20 author keywords related to the most recent articles in journals.

Author Keywords	**Author Keywords**
energy-use right trade system	normalize step response matrix
psm-did	discrete map
green technology innovation motivation	power system plan and economic
onboard energy storage system	long-duration storage system
train trajectory	valuation of emergent technology
reversible solid oxide cell	peer-to-peer system
seaport energy-logistic dispatch	peer-to-peer energy resource share
green vehicle	rural community
integrate energy	techno-economic assessment
superposition principle	optimization methodology

Given that many terms in this table are general in nature, such as *train trajectory*, *green vehicle*, *integrate energy*, *superposition principle*, lets choose a term that reflects a relatively new and promising research topic: *onboard energy storage system*.

IEEE Xplore: The article [54] explores the use of onboard energy storage systems (OESS) in modern railway systems to reduce energy consumption. It highlights the lack of intelligent energy management considering regenerative braking energy utilization. The article also explores the stochastic characteristics of regenerative braking power in railway power networks, aiming to optimize train trajectory while utilizing OESS.

IEEE Xplore: The study [55] develops an energy management system for an onboard energy storage system in a railway traction system, aiming to control the state of charge of a supercapacitor for regenerative braking energy. The control strategy is designed using model predictive control (MPC), and simulation results show its effectiveness compared to Proportional Integral and Fuzzy Logic controllers.

ScienceDirect: The study [56] focuses on the China Railways High-Speed 5 Electric Multiple Unit and proposes a mathematical model and capacity optimization method for an on-board energy storage system using lithium batteries and supercapacitors. It establishes a model considering electrical characteristics, weight, and volume, and proposes an energy management strategy to

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address energy consumption and power quality issues. The capacity optimization uses a bi-level programming model, considering constraints like train load and space.

All three studies share the theme of optimizing energy consumption in railway systems.

Conclusions

For this study, the most basic method of selecting IEEE terms and author keywords was used, based on their frequency of occurrence and the average number of citations of articles in which these words appear, as well as the novelty of such publications.

The keywords and examples of publications found clearly reflect well-known trends in the development of energy technologies, focusing on the integration of the Internet of Things (IoT), wireless communications, artificial intelligence (AI), and machine learning to enhance energy systems. Key topics include smart microgrids, energy storage (notably hydrogen), and advanced mathematical modeling. It emphasizes the importance of safe operations, economic issues, and accessibility in energy infrastructure, particularly for electric transport and battery systems. The interdisciplinary field of smart energy systems is highlighted, incorporating renewable sources and innovative technologies like machine learning for predictive maintenance and energy management. Additional components such as varactor diodes and thermal management materials are noted for improving efficiency. It also addresses cybersecurity and data privacy to ensure secure energy solutions in modern applications like smart cities and electric vehicles.

The main issue identified during the study was the low frequency of terms from the Author Keyword and IEEE Terms fields in the abstract texts. Additionally, with a large number of author keywords, their spelling can vary significantly, which requires preliminary lemmatization, removal or replacement of abbreviations, and other text cleaning, such as removing various types of quotation marks and copyright symbols. Author keywords contain many rare terms that can interfere with in-depth text analysis.

The solution lies in the classic approach — using a broad thematic vocabulary. IEEE provides this opportunity. At the same time, it seems appropriate to use IEEE terms not just as keywords, but to evaluate their occurrence in the texts of titles and abstracts. The latter is due to the fact that experts in a given field conduct an initial assessment of the relevance of a publication to their interests by reading the titles and abstracts of publications. The use of a dictionary of terms verified by experts will allow the analysis of bibliometric records that do not have a keyword field but contain titles and abstracts in the exported data. For example, OnePetro.

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