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Perspective

Energy-Related Carbon Emissions in the Residential Sector: A Bibliometric Analysis (2023–2026)

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Abstract

Energy-related carbon emissions in the residential sector have emerged as a critical focal point in global climate change mitigation efforts, given the sector's significant contribution to overall carbon footprints and its close ties to daily human activities. This study presents a systematic bibliometric analysis of energy-related carbon emissions in the residential sector over the last four years (2023–2026), aiming to unravel the latest trends, driving factors, and potential implications for sustainable development, with a particular focus on major carbon-emitting countries and regions, such as China and the United States. By integrating national statistical data, household energy consumption surveys, and relevant policy documents, the analysis first quantifies the temporal and spatial variations in residential carbon emissions across different regions and urban–rural divides. Subsequently, it delves into the key determinants influencing these emissions, including changes in energy consumption patterns (such as the penetration of clean energy sources), household income levels, demographic shifts, and the implementation of energy efficiency measures. Furthermore, this analysis explores the intricate relationships between residential energy choices, carbon emissions, and broader socioeconomic contexts, shedding light on the challenges and opportunities in transitioning toward low-carbon residential lifestyles. The findings are anticipated to provide valuable insights for policymakers, researchers, and stakeholders involved in formulating targeted strategies to curb residential carbon emissions and promote the adoption of sustainable energy practices in the household domain.

Keywords: residential sector; carbon emissions; bibliometric analysis

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1. Introduction

The residential sector, as a cornerstone of human societal functioning, has long been recognized as a significant contributor to global energy consumption and subsequent carbon emissions [1–3]. With the intensification of climate change concerns and the urgent need to achieve global carbon neutrality goals, understanding the dynamics of energy-related carbon emissions within this sector has become increasingly paramount [4–6]. Over the past three decades, rapid urbanization, population growth, and rising living standards worldwide have collectively driven substantial increases in residential energy

demand, particularly in emerging economies undergoing profound socioeconomic transformations [7,8]. This upward trajectory has not only strained energy supply systems but has also exacerbated the environmental burden, making the residential sector a critical target for emission reduction strategies [9,10]. In recent years, however, the landscape has begun to shift, influenced by a confluence of factors, including advancements in clean energy technologies, the implementation of stringent energy efficiency standards, evolving policy frameworks aimed at decarbonization, and growing public awareness of environmental sustainability [11–13]. These developments have introduced new complexities into the analysis of residential carbon emissions, necessitating a fresh and focused examination of the most recent trends and patterns [14,15]. The next four years (2023–2026) in particular represent a period of heightened global attention to climate action, following key international agreements and the ongoing recovery from the COVID-19 pandemic, which itself had temporary yet significant impacts on energy use behaviors [16,17]. It is within this context that this study seeks to conduct a perspective analysis, aiming to capture the post-pandemic emission dynamics, assess the effectiveness of recent policy interventions, and identify emerging drivers and barriers to emission reduction in the residential sector. By focusing on this relatively short but critical time frame, this research endeavors to provide an up-to-date assessment that can inform current and future policy development, technological innovation, and behavioral intervention strategies tailored to the residential domain. Specifically, it aims to address gaps in the existing literature by offering a granular understanding of how residential carbon emissions have evolved in response to the latest global and regional developments, thereby contributing to the broader discourse on sustainable urban living and climate change mitigation [18].

Previous bibliometric analyses of residential carbon emissions have mostly covered broad time spans spanning more than a decade, with limited focus on the distinct shifts that occurred in the post-pandemic period [19]. Earlier reviews captured the gradual growth of interest in residential decarbonization before 2020, but failed to account for the structural changes in residential energy use triggered by pandemic lockdowns, the subsequent acceleration of renewable energy deployment, and the updated global climate commitments rolled out in the years following the COVID-19 pandemic [12]. The 2023–2026 division adopted in this study is designed to explicitly capture this new phase: this period follows the peak of the pandemic and coincides with the full implementation of the Paris Agreement's nationally determined contributions, making it a critical window to observe how national decarbonization strategies have translated into actual changes in residential sector emissions [20]. This focused time framing allows us to track how the temporary shifts in residential energy demand during the pandemic evolved into long-term behavioral and structural changes, filling the gap in existing research that lacks timely analysis of this emerging new normal of residential carbon emissions [21].

Two questions are raised in light of the above objectives: (1) What are the latest spatial distribution patterns and publication trends of research on residential carbon emissions in the post-pandemic period, and what are the core research hotspots in this field during this specific phase? (2) What research gaps and future research directions need to be further addressed to support the deep decarbonization of the residential sector under the global carbon neutrality framework? To answer these two questions, this study adopts a bibliometric analysis approach to systematically sort out the relevant literature published in the 2023–2026 period. This study contributes to two main aspects. First, it aims to systematically synthesize and critically evaluate the existing body of research on residential energy consumption and its associated carbon emissions, with a particular focus on identifying the key determinants, trends, and knowledge gaps [22]. By conducting a comprehensive review and bibliometric analysis, this research seeks to map the intellectual landscape of the

field, highlighting the most influential studies, prominent research themes, and emerging areas of inquiry [23]. This will not only provide a consolidated overview for scholars and policymakers but also reveal under-explored topics or methodological limitations that warrant further investigation. Second, building upon this synthesis, this study intends to propose a holistic analytical framework that integrates the complex interplay of individual, technological, market, and policy factors shaping residential carbon emissions [24,25]. This framework aims to bridge disciplinary divides, offering a more nuanced understanding of how these multiple dimensions interact to influence energy choices and emission outcomes at the household level. By doing so, it seeks to provide actionable insights for the development of targeted and effective policies and interventions that can drive meaningful reductions in residential carbon footprints while considering issues of energy access, affordability, and social equity [26]. In essence, this research aspires to both consolidate existing knowledge and provide a conceptual foundation for future studies and evidence-based decision-making in the pursuit of sustainable residential energy transitions.

The main objective of this work is to analyze the scientific advances made in research on energy-related carbon emissions and residential carbon emissions worldwide that have occurred in the last four years, thus providing an updated and comprehensive overview of the current state of knowledge in this rapidly evolving field [27]. Additionally, this work intends to highlight geographical disparities in research output and focus, shedding light on regions that are underrepresented in the global discourse despite facing unique challenges and opportunities in mitigating residential carbon emissions [28].

2. Methods

This study analyzed 1249 publications retrieved from the Science Citation Index Expanded (SCIE) and the Conference Proceedings Citation Index–Social Sciences and Humanities (CPCI-SSH), using the search terms and parameters summarized in Table 1. The search was conducted in the Web of Science Core Collection to ensure broad coverage of the relevant academic literature [29]. The time span was set from 2023 to 2026 to capture the most recent scientific advances in research on residential energy consumption and carbon emissions. Only English-language publications were included to maintain consistency in data processing and bibliometric analysis. The inclusion criteria were as follows: (1) the publication focuses on household or residential contexts; (2) the publication addresses energy consumption, energy use, energy-related carbon emissions, carbon emissions, or carbon footprint assessment; (3) the publication contains substantive empirical, theoretical, review-based, or methodological content; and (4) the publication provides sufficient bibliographic metadata for bibliometric analysis. The exclusion criteria were as follows: (1) records unrelated to the residential or household sector; (2) records that did not address energy use, energy consumption, or carbon emission-related issues; (3) corrections, editorial materials, data papers, and book chapters; and (4) duplicate records.

Duplicates were removed before relevance screening. Records with identical DOI values were first identified and removed. For records without DOI information, duplicate detection was conducted by comparing title, first author, source title, and publication year. After duplicate removal, the remaining records were screened by title, abstract, and keywords. Records were retained only when they explicitly addressed residential or household energy use and carbon emission-related issues. After this screening process, 1249 publications were retained as the final dataset for subsequent bibliometric analysis and synthesis.

The Web of Science Core Collection was selected as the data source because it provides standardized citation records, author information, institutional affiliations, source titles, subject categories, and cited reference data, which are essential for bibliometric analysis

and visualization. Scopus was not combined with Web of Science in this study in order to maintain consistency in citation indicators and metadata structures. Since Scopus and Web of Science apply different indexing rules and citation-counting systems, merging the two databases would require extensive cross-database harmonization and could introduce inconsistencies into the bibliometric results. Nevertheless, the exclusion of Scopus may have led to the omission of some relevant publications, and this issue has been acknowledged as a limitation of this study.

Table 1. Literature search and screening strategy.

Item	Description
Research topic	Energy-related carbon emissions in the residential sector
Database	Web of Science Core Collection
Citation indexes	Science Citation Index Expanded (SCIE) and Conference Proceedings Citation Index–Social Sciences and Humanities (CPCI-SSH)
Rationale for database selection	The Web of Science Core Collection was selected because it provides standardized bibliographic records, citation data, institutional affiliations, source information, subject categories, and cited reference information, which are suitable for bibliometric analysis and visualization.
Reason for not including Scopus	Scopus was not combined with Web of Science in order to maintain consistency in citation indicators and metadata structures. Because Scopus and Web of Science use different indexing rules, source coverage, affiliation formats, and citation-counting systems, merging records from both databases would require extensive cross-database harmonization and might introduce inconsistencies into the bibliometric results. The omission of Scopus is acknowledged as a limitation of this study.
Search field	Topic search, including title, abstract, author keywords, and Keywords Plus
Search query	(“household” OR “residential”) AND (“carbon emission” OR “carbon footprint” OR “energy-related emission”) AND (“energy consumption” OR “energy use”)
Time span	2023–2026
Language	English
Inclusion criteria	Publications were included when they (1) focused on household or residential contexts; (2) addressed energy consumption, energy use, energy-related carbon emissions, carbon emissions, or carbon footprint assessment; (3) contained substantive empirical, theoretical, review-based, or methodological content; and (4) provided sufficient bibliographic metadata for bibliometric analysis.
Exclusion criteria	Publications were excluded when they (1) were unrelated to the residential or household sector; (2) did not address energy use, energy consumption, or carbon emission-related issues; (3) were corrections, editorial materials, data papers, or book chapters; or (4) were duplicate records.
Document types excluded	Correction; Book Chapter; Data Paper; Editorial Material
Reason for excluding book chapters	Book chapters were excluded because they are heterogeneous in peer-review process, citation structure, and bibliographic completeness, which may affect the comparability of bibliometric indicators.
Reason for retaining conference proceedings	Conference proceedings indexed in CPCI-SSH were retained because they often report recent empirical, theoretical, or methodological findings. Their inclusion is appropriate for this study because the analysis focuses on the recent 2023–2026 period and aims to capture emerging research trends.
Duplicate removal procedure	Duplicate records were removed before relevance screening. Records with identical DOI values were identified first. For records without DOI information, duplicate detection was conducted by comparing title, first author, source title, and publication year.
Relevance screening procedure	After duplicate removal, the remaining records were screened by title, abstract, and keywords. Records were retained only when they explicitly addressed residential or household energy use and carbon emission-related issues.
Final sample size	1249 publications

Book chapters were excluded because they are often heterogeneous in the review process, citation structure, and bibliographic completeness, which may affect the comparability of bibliometric indicators. In contrast, conference proceedings indexed in CPCI-SSH were retained because they often present recent empirical, theoretical, and methodological developments. Their inclusion is particularly relevant to this study because the analysis focuses on the recent 2023–2026 period and aims to capture emerging research trends.

3. Results

3.1. Worldwide Publications on Energy-Related Carbon Emissions in the Residential Sector

Figure 1 presents the worldwide scientific production on energy-related carbon emissions in the residential sector from 2023 to 2026, showing a clear geographical imbalance in research output. North America, Europe, and East Asia are the main contributors, with China, the United States, and several Western European countries producing a relatively large number of publications [30]. This concentration indicates that research activity in this field is closely associated with established academic infrastructure, strong institutional support, and active policy agendas related to energy transition, building decarbonization, and climate change mitigation [31]. In contrast, many countries in Africa, South America, and parts of Asia show relatively limited publication output. This uneven distribution suggests that the current global research landscape does not fully reflect the residential energy and carbon emission challenges faced by underrepresented regions. For example, countries in sub-Saharan Africa face important issues related to energy access, household energy poverty, and low-carbon transitions, yet their contributions to the international literature remain limited. Similarly, small island developing states are highly vulnerable to climate change impacts, but their research output in this field is relatively low compared with that of larger and more economically developed countries [32].

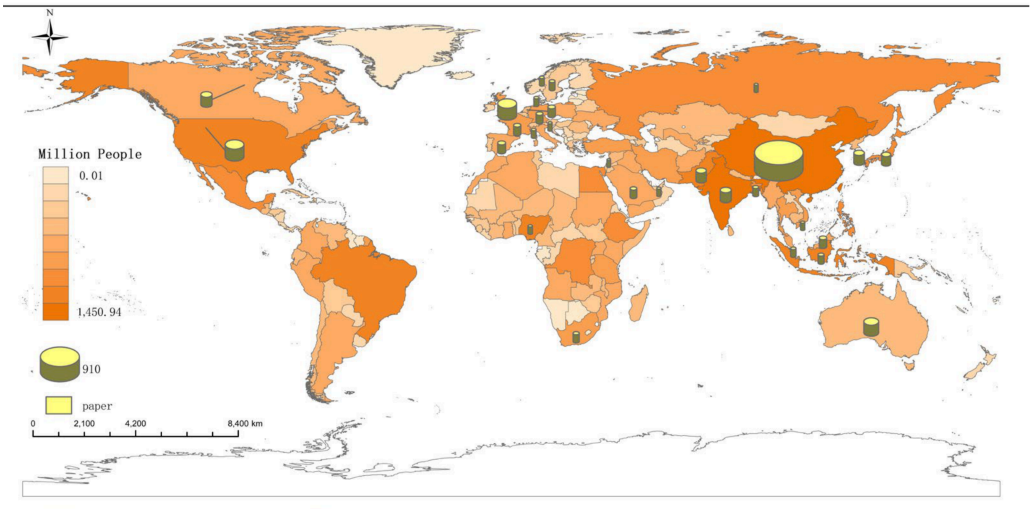


Figure 1. Worldwide scientific production related to energy-related carbon emissions in the residential sector (2023–2026).

3.2. Worldwide Institution Distribution

Table 2 presents the ten most productive institutions in the field of energy-related carbon emissions in the residential sector from 2023 to 2026. Among these, Chongqing University demonstrates remarkable research output, with two of its faculties ranking first and second. The Faculty of Built Environment of Chongqing University leads with 19 papers, followed closely by the School of Management Science and Real Estate of the same university with 18 papers, indicating the university's strong focus and significant

contributions to this research area. Beijing Normal University's School of Environment secures the third position with 12 papers. The State Key Joint Laboratory of Environmental Simulation and Pollution Control and Tsinghua University's School of Architecture both have 10 papers, sharing the fourth and fifth ranks. International institutions also feature prominently, such as University College London's Bartlett Faculty of the Built Environment, the National University of Singapore's College of Design and Engineering, and The University of Tokyo's Graduate School of Engineering Faculty of Engineering, reflecting the strong role of built environment, environmental science, and urban sustainability institutions in carbon emissions and building energy research [33]. Tsinghua University's School of Environment and Beijing Institute of Technology's School of Management and Economics round out the top ten with eight and seven papers, respectively. This distribution highlights the concentration of research efforts in leading academic institutions, particularly those with strengths in built environment, environmental science, and management, and reflects both domestic and international collaboration and the focus on addressing residential carbon emissions [34].

Table 2. The ten most productive institutions in terms of energy-related carbon emissions in the residential sector (2023–2026).

Rank	Institutions	Papers
1	Chongqing University Faculty of Built Environment	19
2	Chongqing University School of Management Science and Real Estate	18
3	Beijing Normal University School of Environment	12
4	State Key Joint Laboratory of Environmental Simulation and Pollution Control	10
5	Tsinghua University School of Architecture	10
6	University College London Bartlett Faculty of the Built Environment	9
7	National University of Singapore College of Design and Engineering	8
8	The University of Tokyo Graduate School of Engineering Faculty of Engineering	8
9	Tsinghua University School of Environment	8
10	Beijing Institute of Technology School of Management and Economics	7

Figure 2 illustrates the cooperation network among the top 30 countries with the highest publication output on energy-related carbon emissions in the residential sector, thereby revealing the pattern of international research collaboration in this field. In the network, nodes represent countries, and their sizes reflect the relative scale of research output, while the links between nodes indicate collaborative relationships, such as co-authored publications, and their strength [35]. The network shows several clearly connected clusters, suggesting that international cooperation is concentrated among a number of major research hubs. A dense collaborative cluster can be observed among European countries, including Germany, the United Kingdom, France, and Italy, reflecting the strong research integration and long-standing cooperation mechanisms within Europe in the areas of climate change and sustainable energy [36]. Another prominent cluster involves the United States and China, indicating their central roles in global research production and international collaboration on residential carbon emissions. In addition, countries such as Japan and South Korea also maintain relatively strong collaborative ties, both within Asia and with Western countries. By contrast, some countries are located on the periphery of the network and are connected by fewer and weaker links, suggesting lower levels of international collaboration [37].

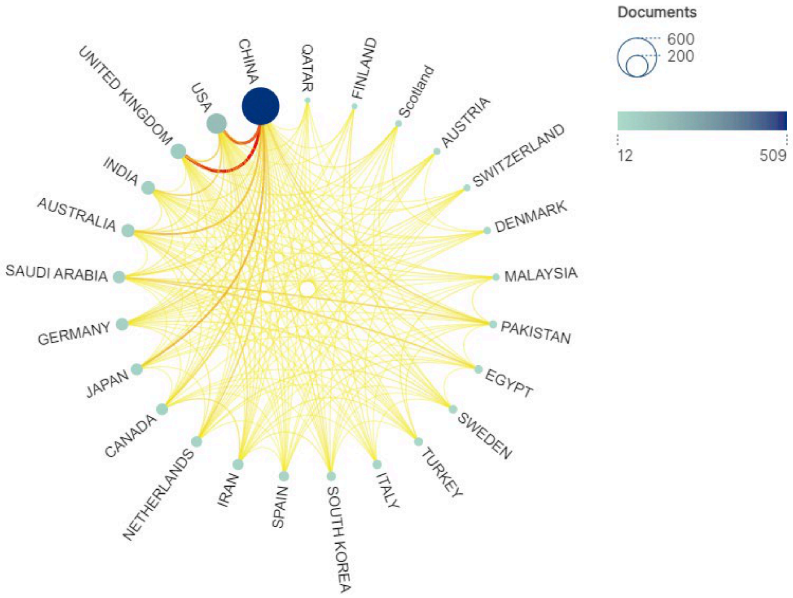


Figure 2. A cooperation network circulation graph of the top 30 countries with the most publications on energy-related carbon emissions in the residential sector.

3.3. Distribution of Publications

The distribution of publications across journals (Table 3) provides insights into the productivity and academic impact within this field. While *Energy and Buildings* ranks first in terms of publication volume (71 papers), a quality assessment based on citation metrics reveals the prominence of other journals. Notably, *Applied Energy* and *Energy* demonstrate superior academic influence, recording the highest total citations (773 and 600, respectively) and H-indices (17 and 14). This indicates that although research output is diverse, the most impactful and frequently cited studies are concentrated in a core set of high-quality energy journals.

Although *Energy* and *Applied Energy* published fewer papers than the top three journals, with 46 and 43 papers, respectively, they show strong citation impact. In particular, *Applied Energy* records the highest H-index among the listed journals, with an H-index of 17 and 773 citations, suggesting that studies published in this journal have had considerable influence in the field. The *Journal of Cleaner Production* and *Building and Environment* also occupy important positions, with 40 and 30 papers, respectively, reflecting the close connection between residential carbon emission research, cleaner production, building performance, and environmental impact assessment. In addition, *Sustainable Cities and Society*, although ranking tenth in publication volume, shows a relatively high citation count and H-index, indicating the growing relevance of urban-scale and community-level perspectives in residential carbon emission studies.

Table 3. Top 10 journals in terms of documents published on energy-related carbon emissions in the residential sector.

Rank	Journal	Papers	Cited	H Index
1	*Energy and Buildings*	71	498	13
2	*Sustainability*	70	345	11
3	*Energies*	52	307	10
4	*Energy*	46	600	14
5	*Applied Energy*	43	773	17

Table 3. *Cont.*

Rank	Journal	Papers	Cited	H Index
6	*Buildings*	43	158	8
7	*Journal of Cleaner Production*	40	298	10
8	*Journal of Building Engineering*	37	316	12
9	*Building and Environment*	30	328	11
10	*Sustainable Cities and Society*	27	369	11

3.4. Most Cited Papers

The top 20 most cited documents (Table 4) serve as the intellectual foundation of current research. Although the most cited paper (Rank 1) appears in *Engineering* (H-index = 75), the majority of highly cited papers are concentrated in journals with substantially higher H-indices (e.g., *Applied Energy* H-index = 245, *Energy* H-index = 232), indicating that while individual papers can achieve a high impact in lower H-index journals, sustained scholarly influence and visibility are more consistently associated with journals that have a strong historical citation track record. The table reports key bibliographic information for each document, including title, authors, publication date, journal, volume, issue, page range, annual citation counts, average citations per year, and total citations. These indicators help identify publications that have received substantial scholarly attention and have shaped recent research development in this field [38], with highly cited documents covering several major research themes. One important theme concerns carbon emission accounting, scenario analysis, and decarbonization pathways, including studies on the Guangdong–Hong Kong–Macao Greater Bay Area, China's building sector, and provincial residential buildings. Another prominent theme relates to building energy modeling and retrofit decision-making, as reflected in studies on urban building energy modeling tools such as AutoBPS, life-cycle carbon emissions of buildings, and the influence of future climatic uncertainty on residential building retrofits. A third theme focuses on household-level drivers, including household structure transitions, income, energy-saving behavior, and urban–rural inequality in residential energy consumption.

The journals represented in Table 4, including *Science of the Total Environment*, *Energy and Buildings*, *Energy*, *Ecological Economics*, *Applied Energy*, and *Sustainable Cities and Society*, further demonstrate the interdisciplinary nature of this field. Overall, the most cited documents suggest that recent research has moved beyond the measurement of residential carbon emissions alone and has increasingly focused on integrated mitigation pathways involving building performance, household behavior, energy technologies, policy scenarios, and socioeconomic conditions [39].

Table 4. Top 20 most cited papers.

Rank	Title	Authors	Date	Journal	Avg./Year	Total Cites	Journal H-Index
1	Life-Cycle Carbon Emissions (LCCE) of Buildings: Implications, Calculations, and Reductions [11]	Huang, ZJ; Zhou, H; (. . .); Zhuang, WM	Apr 2024	*Engineering*	51.5	103	75
2	Toward carbon free by 2060: A decarbonization roadmap of operational residential buildings in China [40]	Zou, CC; Ma, MD; (. . .); Zhang, SF	Aug 2023	*Energy*	31	93	232
3	Driving factors and emission reduction scenarios analysis of CO_2 emissions in Guangdong-Hong Kong-Macao Greater Bay Area and surrounding cities based on LMDI and system dynamics [6]	Luo, XC; Liu, CK; and Zhao, HH	Apr 2023	*Science of the Total Environment*	30.67	92	299
4	AutoBPS: A tool for urban building energy modeling to support energy efficiency improvement at city-scale [18]	Deng, Z; Chen, Y; (. . .); Causone, F	Mar 2023	*Energy and Buildings*	30.67	92	170
5	Timetable and roadmap for achieving carbon peak and carbon neutrality of China's building sector [12]	Huo, TF; Du, QX; (. . .); Cai, WG	Jul 2023	*Energy*	28.33	85	232
6	The impacts of household structure transitions on household carbon emissions in China [8]	Zhang, YM; Wang, F; and Zhang, B	Apr 2023	*Ecological Economics*	28.33	85	208
7	Method and evaluations of the effective gain of artificial intelligence models for reducing CO_2 emissions [37]	Delanöe, P; Tchuente, D; and Colin, G	Apr 2023	*Journal of Environmental Management*	26.33	79	214
8	How does future climatic uncertainty affect multi-objective building energy retrofit decisions? Evidence from residential buildings in subtropical Hong Kong [17]	Liu, S; Wang, Y; (. . .); He, JT	May 2023	*Sustainable Cities and Society*	22	66	128
9	Predictive control and coordination for energy community flexibility with electric vehicles, heat pumps and thermal energy storage [39]	Srithapon, C and Månsson, D	Oct 2023	*Applied Energy*	21.67	65	245
10	A data-driven DRL-based home energy management system optimization framework considering uncertain household parameters [41]	Ren, KZ; Liu, J; (. . .); Xu, HT	Feb 2024	*Applied Energy*	21.33	64	245
11	Carbon peak prediction and emission reduction pathways exploration for provincial residential buildings: Evidence from Fujian Province [16]	Lin, CX and Li, XJ	Mar 2023	*Sustainable Cities and Society*	31.5	63	128

Table 4. *Cont.*

Rank	Title	Authors	Date	Journal	Avg./Year	Total Cites	Journal H-Index
12	Towards COP27: Decarbonization patterns of residential building in China and India [42]	Yan, R; Ma, MD; (. . .); Mao, C	Dec 2023	*Applied Energy*	20.67	62	245
13	Real-time energy scheduling for home energy management systems with an energy storage system and electric vehicle based on a supervised-learning-based strategy [43]	Huy, THB; Dinh, HT; (. . .); Kim, D	Sep 2023	*Energy Conversion and Management*	20.33	61	179
14	DRL-HEMS: Deep Reinforcement Learning Agent for Demand Response in Home Energy Management Systems Considering Customers and Operators Perspectives [44]	Amer, AA; Shaban, K; and Massoud, AM	Jan 2023	*IEEE Transactions on Smart Grid*	20	60	183
15	A Dynamic Peer-to-Peer Electricity Market Model for a Community Microgrid With Price-Based Demand Response [45]	Alfaverh, F; Denai, M; and Sun, YC	Sep 2023	*IEEE Transactions on Smart Grid*	19.67	59	183
16	Using urban building energy modeling to quantify the energy performance of residential buildings under climate change [46]	Deng, Z; Javanroodi, K; (. . .); Chen, YX	Sep 2023	*Building Simulation*	19.33	58	35
17	Environmental reverberations of geopolitical risk and economic policy uncertainty resulting from the Russia-Ukraine conflict: A wavelet based approach for sectoral CO_2 emissions [47]	Pata, UK; Kartal, MT; and Zafar, MW	Aug 2023	*Environmental Research*	19.33	58	192
18	Per capita CO_2 emission inequality of China's urban and rural residential energy consumption: A Kaya-Theil decomposition [7]	Luo, GF; Balezentis, T; and Zeng, SZ	Apr 2023	*Journal of Environmental Management*	19.33	58	214
19	Household energy consumption, energy efficiency, and household income-Evidence from China [48]	Zheng, JJ; Dang, YJ; and Assad, U	Jan 2024	*Applied Energy*	19	57	245
20	Household energy-saving behavior, its consumption, and life satisfaction in 37 countries [10]	Piao, X and Managi, S	Jan 2023	*Scientific Reports*	19	57	212

3.5. Scientific Community and Keyword Analysis

Table 5 lists the top 10 authors in this field, providing an overview of the main contributors to recent research on energy-related carbon emissions in the residential sector. The table reports three key indicators for each author: the number of publications, total citations, and total link strength. In terms of publication output, Salah Kamel and Yin Long are the most productive authors, each with six documents. Mohammad H. Hassan, Heba Youssef, and Sami Ben Slama also show relatively high productivity, each contributing five documents.

Regarding citation impact, Salah Kamel ranks first with 63 citations, followed by Mohammad H. Hassan and Heba Youssef, each with 60 citations. This indicates that these authors have received comparatively strong scholarly attention within the analyzed dataset. Total link strength, which reflects the intensity of collaborative connections among authors, is highest for Ahmad Alferidi, Mohammed Alsolami, Mohammad H. Hassan, Salah Kamel, Badr Lami, and Heba Youssef, each with a value of 11. Sami Ben Slama follows with a total link strength of 9, while Liqiao Huang and Yin Long each record a value of 7, and Yuan Li records a value of 6.

Figure 3 presents the co-citation network of cited references on energy-related carbon emissions in the residential sector, revealing the intellectual structure and knowledge base of this research field. In this network, nodes represent individual cited references, whereas links between nodes indicate co-citation relationships, that is, the frequency with which two references are cited together in later studies. The clustering of nodes into different groups reflects the main thematic areas and research fronts that have shaped the development of the field. Several prominent clusters can be identified in the network. One major cluster is associated with the methods and models used to assess and predict residential carbon emissions, including life-cycle assessment (LCA), input–output analysis, and emission inventory approaches [49]. Another important cluster focuses on energy efficiency in residential buildings, covering topics such as building envelope optimization, energy-efficient appliances, and smart home technologies, as well as their roles in reducing residential carbon footprints. A further cluster is related to behavioral and policy dimensions, including household energy use patterns, energy pricing mechanisms, government subsidies for renewable energy adoption, and building codes and standards designed to reduce emissions. In addition, a distinct cluster concerns the integration of renewable energy technologies into the residential sector, such as solar photovoltaic systems and heat pumps, which are increasingly viewed as key pathways for residential decarbonization [50]. In general, larger nodes represent more highly cited references and therefore indicate studies that have played a more influential role in shaping the field. Different node colors distinguish separate thematic clusters and help reveal the internal structure of the knowledge network.

Figure 4 presents a timeline view of the evolution of key research themes related to energy-related carbon emissions in the residential sector from 2023 to 2026, thereby revealing shifts in research focus and emerging trends over the study period. The figure shows how keywords have changed over time and reflects the thematic development of this field. At the early stage of the timeline, particularly in 2023, foundational keywords such as residential energy consumption, carbon emissions, energy efficiency, and carbon footprint appear prominently, indicating that early studies mainly focused on core concepts, basic assessment frameworks, and the measurement of residential carbon emissions [51]. As the timeline progresses into 2024, more specific themes begin to emerge, including energy savings, gender, and attitude, suggesting that research attention gradually expanded from emission accounting to the social, behavioral, and practical dimensions of household energy use. By 2025, policy- and governance-related topics become more visible, including sustainable construction, smart home management, and building energy efficiency, reflecting

increasing concern with the institutional, regulatory, and technological pathways for reducing residential carbon emissions. In addition, keywords such as electrification of heating, green building standards, and data-driven energy management have gained prominence, indicating a growing interest in targeted and innovative mitigation strategies [52].

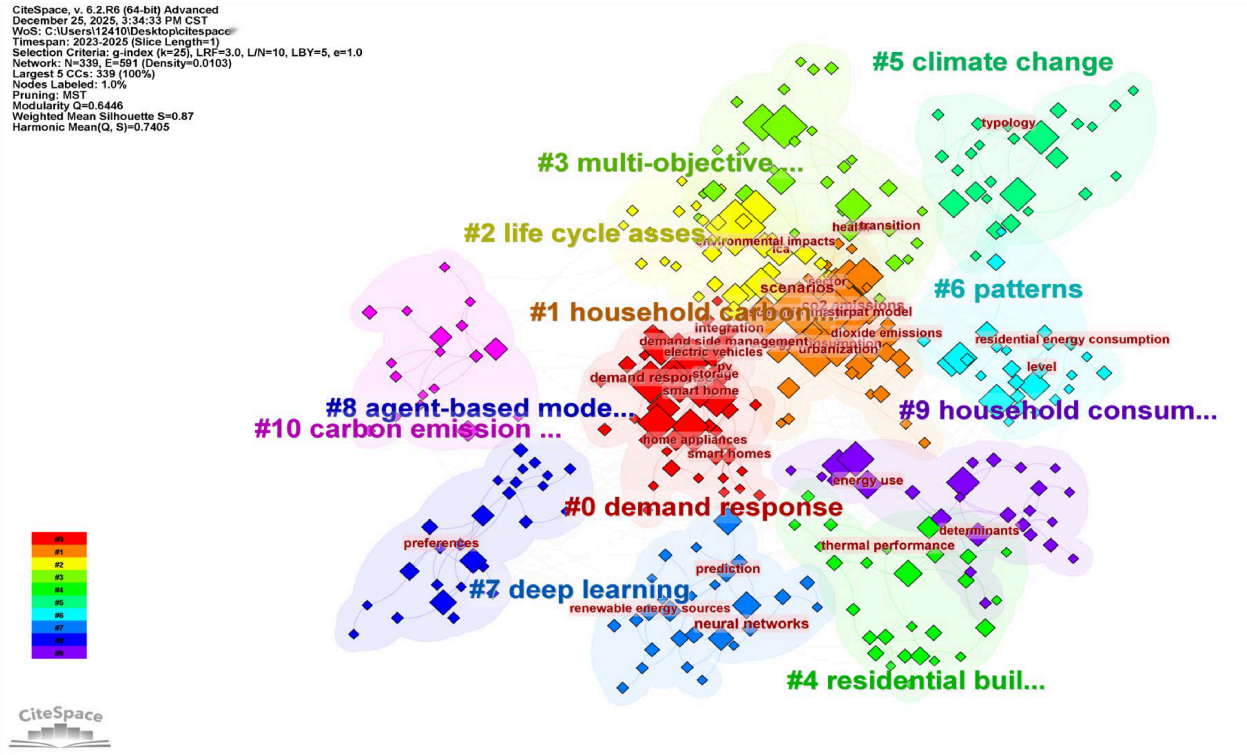


Figure 3. Co-citation network of cited references on energy-related carbon emissions in the residential sector.

Figure 5 presents a keyword co-occurrence and clustering network, showing the relationships among key terms in research on energy-related carbon emissions in the residential sector [51]. In this network, nodes represent individual keywords, with larger nodes indicating higher frequencies of occurrence, while links between nodes represent co-occurrence relationships within the same publications. Different clusters reflect major thematic areas in the field and reveal the internal structure of current research. Several main clusters can be identified. One cluster centers on keywords such as residential energy consumption, household carbon emissions, and building energy efficiency, reflecting the core focus on measuring and understanding household energy use and its associated emissions. Another cluster includes terms such as renewable energy, solar power, heat pumps, and energy transition, indicating strong research interest in low-carbon energy technologies and sustainable residential energy systems [52]. A further cluster is associated with governance and policy, including keywords such as policy instruments, carbon pricing, subsidies, and energy efficiency standards, highlighting the importance of regulatory and institutional mechanisms in promoting emission reduction. Additional clusters relate to behavioral dimensions, including energy behavior, occupant behavior, awareness, and energy conservation, as well as technological themes such as smart homes, energy management systems, and the Internet of Things (IoT). The strength of the links between keywords reflects the closeness of their conceptual relationships, with stronger links indicating more frequent co-occurrence.

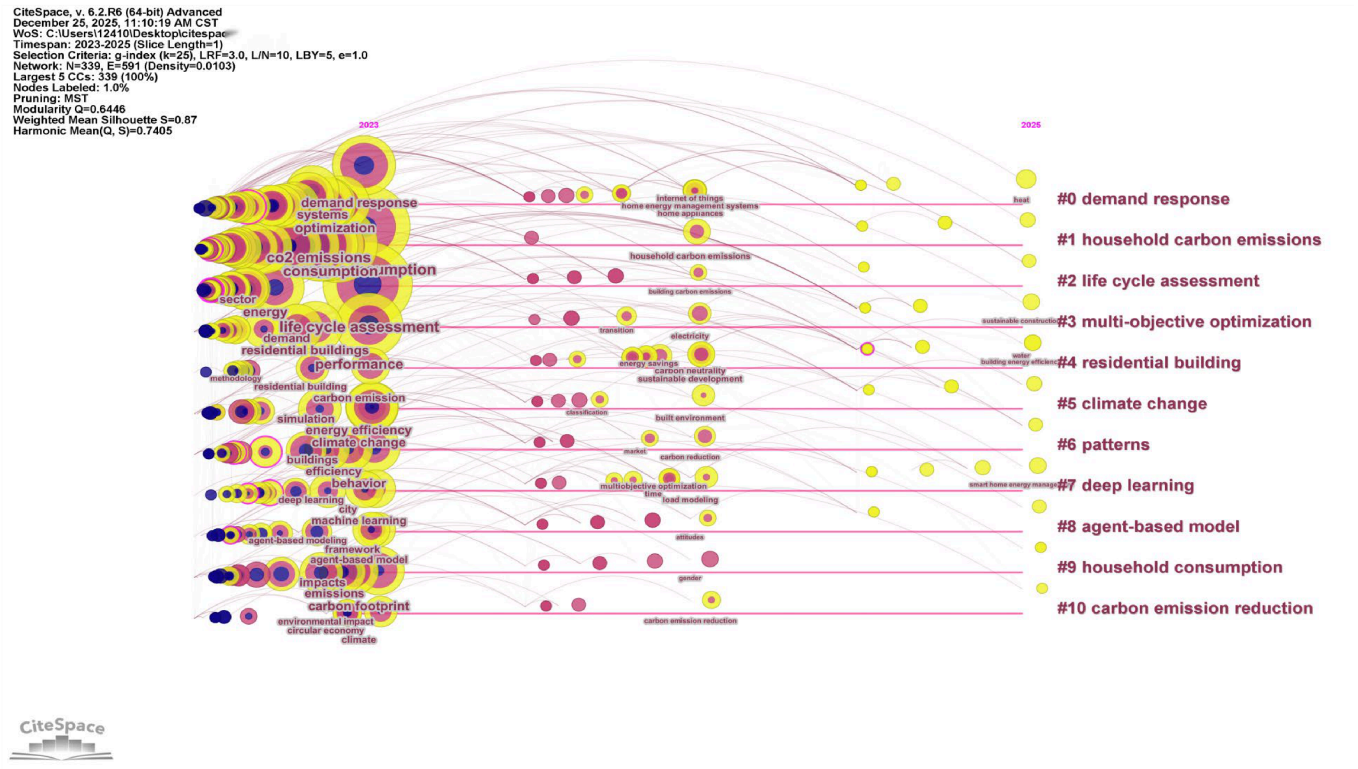


Figure 4. Timeline view of keywords.

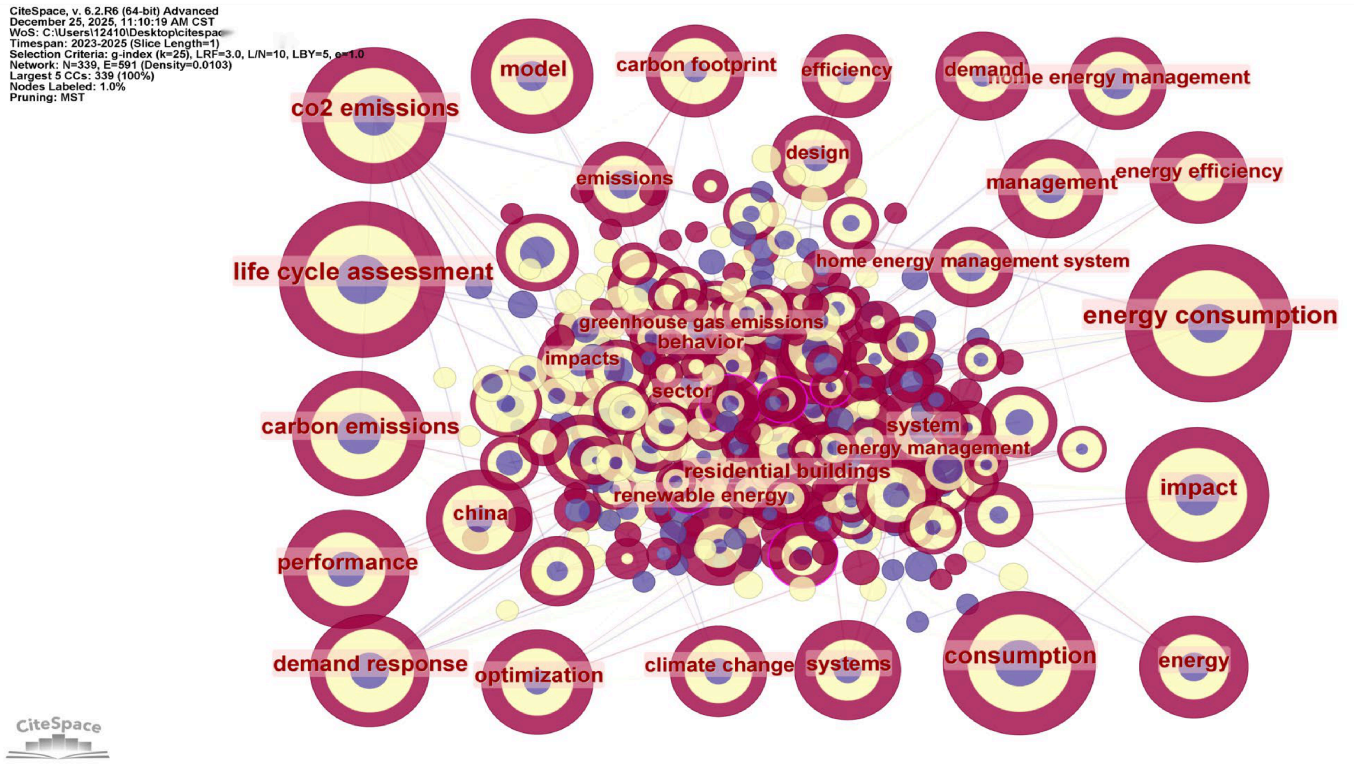


Figure 5. Keyword co-occurrence and clustering network mapping.

Table 5. Information about the top 10 authors.

Selected	Author	Documents	Citations	Total Link Strength
1	Alferidi, Ahmad	4	17	11
2	Alsolami, Mohammed	4	17	11
3	Hassan, Mohammad H.	5	60	11
4	Kamel, Salah	6	63	11
5	Lami, Badr	4	17	11
6	Youssef, Heba	5	60	11
7	Ben Slama, Sami	5	47	9
8	Huang, Liqiao	4	32	7
9	Long, Yin	6	45	7
10	Li, Yuan	4	36	6

4. Discussion

To contextualize our bibliometric findings within the broader evolution of this research field, we compare our results with those of earlier bibliometric reviews covering longer time spans. Our keyword analysis (Figures 4 and 5) reveals that technical and AI-related terms—such as "agent-based model" and "deep learning"—have emerged as prominent research hotspots in the 2023–2026 period. This finding contrasts with earlier studies, which consistently identified foundational themes such as "energy efficiency", "carbon footprint accounting", and "household energy consumption" as the dominant research clusters [22], suggesting that the field has transitioned from descriptive measurement toward predictive modeling and optimization-oriented research [34]. Our citation analysis (Table 4) further reveals that 12 of the top 20 most cited papers focus on modeling or technological interventions, while only three address behavioral or social dimensions. This techno-centric pattern in high-impact publications diverges from earlier reviews that reported a more balanced mix of technical, behavioral, and policy-oriented research [30,49]. We attribute this shift to the recent maturation of artificial intelligence and its increasing application to residential energy systems, coupled with growing policy emphasis on real-time demand-side management. However, this imbalance raises concerns about whether behavioral and social dimensions—such as energy justice and occupant behavior—are receiving adequate attention in the current research agenda.

Our institutional analysis (Table 2) reveals another distinct finding: Chinese institutions now dominate both publication output and citation impact, marking a significant departure from earlier studies that identified a relatively balanced distribution across North America, Europe, and East Asia [30]. This concentration, also confirmed by a recent bibliometric study on building decarbonization [53], likely reflects China's aggressive policy push for building sector decarbonization under its 2060 carbon neutrality goal [12]. Nevertheless, this geographic concentration implies that the knowledge base may be increasingly shaped by research priorities, potentially limiting the generalizability of findings to other regions. Furthermore, our co-citation network (Figure 1) incorporates a substantially higher proportion of very recent papers compared to earlier analyses, allowing us to capture emerging trends such as deep reinforcement learning for home energy management and urban-scale building energy modeling. Overall, our comparison reveals that the 2023–2026 period is characterized by a distinct profile—more technically oriented, more geographically concentrated in China, and more focused on predictive tools than earlier periods. While these shifts reflect genuine scientific progress and policy alignment, they also point to potential gaps in geographic representativeness and behavioral research [54].

It is recognized that the concentration of high-output research in institutions from high-income countries, coupled with the heterogeneity of source quality, implies that the

existing bibliometric results may inadequately represent the context-specific research needs and findings from the Global South. Numerous low- and middle-income countries in the Global South encounter unique residential carbon emission challenges propelled by distinct housing conditions, energy access levels, and consumption patterns. However, these issues have not received adequate attention in the existing literature retrieved from mainstream databases. Most existing models are parameterized based on data from high-income regions, which restricts their capacity to accurately project and address the unique residential emission mitigation challenges that the Global South will confront in the coming decades [55]. It has been clarified that future research should prioritize the integration of more context-specific research from the Global South to enhance the representativeness and policy relevance of both bibliometric findings and climate change modeling outcomes [56].

However, a critical reflection on the methodology reveals inherent limitations that contextualize these results. First, the exclusive reliance on the Web of Science (WoS) Core Collection, chosen to ensure citation consistency, inevitably excludes relevant research indexed in Scopus, potentially biasing the network toward Western-centric publications [29]. Second, the restriction to English-language documents likely underrepresents significant region-specific innovations from non-English speaking countries, limiting the global inclusivity of the identified hotspots [57,58]. Third, the short temporal scope (2023–2026) captures emerging trends but may not yet reflect the long-term citation maturity of these recent works, as citation windows of less than five years are known to have lower reliability for impact assessment [59]. Despite these constraints, this analysis provides a timely baseline for understanding how the field is recalibrating in response to recent global policy shifts.

5. Conclusions

This study analyzed recent scientific publications on energy-related carbon emissions in the residential sector from 2023 to 2026 using bibliometric methods. Based on 1249 records retrieved from the Web of Science Core Collection, the analysis examined publication output, institutional distribution, journal sources, highly cited papers, author contributions, co-citation structures, and keyword co-occurrence patterns. The results indicate that research on residential carbon emissions has become increasingly interdisciplinary, involving energy studies, building science, environmental management, urban sustainability, and policy analysis.

Several limitations should be acknowledged. First, the analysis was limited to English-language publications indexed in selected citation databases, which may exclude relevant studies published in other languages or regional databases. Second, the selected time span captures only recent developments and may not fully represent the long-term evolution of the field. Third, bibliometric indicators such as publication counts and citation numbers cannot fully reflect the practical policy impact or methodological quality of individual studies. Future research could expand the temporal scope, include additional databases, combine bibliometric analysis with systematic content review, and pay greater attention to underrepresented regions and household-level behavioral dimensions. Overall, this study provides an updated overview of recent research trends and offers a reference for future studies on residential energy transition and carbon emission mitigation.

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