

# BUILDING LIFE CYCLE ENERGY ASSESSMENT (LCEA): A BIBLIOMETRIC REVIEW

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## Abstract

Literature on building LCEA has experienced exponential growth globally over the past decades. This study was undertaken to investigate the global research dynamics in building LCEA, shedding light on publication patterns, emerging areas, and hot topics in the expanse literature on building LCEA. The study focuses on building LCEA related literature published in the last decade, from 2015 to 2025. The study adopted bibliometric approach in the analysis, employing both performance analysis and science mapping techniques for the analysis of the bibliometric data retrieved through keyword search from the Scopus database. The keyword search retrieved 4589 publications within the stated timeframe, and of the documents retrieved, 65% were articles published in journals and 20% resulted from conference proceedings. The remaining 15% resulted from reviews, book chapters, conference reviews and many more. Some of the key themes analysed in this article include subject areas, languages, trending topics, countries and the most influential articles in terms of citation count. It is evidenced that publications related to building LCEA has experienced steady growth over these years, with China as the most productive country. The findings inform researchers about the current trend in building LCEA studies and provides a guide for future works.

**Keywords:** Bibliometric analysis, Buildings, Building Energy Assessment, LCA, h-index

## Article history:

Submitted: 06/02/2026; Revised: 26/05/2026; Accepted: 30/06/2026; Online: 30/06/2026

## INTRODUCTION

The building sector remains one of the most important sectors of the world due to its relevance to the everyday lives of all and sundry. Both those who live and operate in supertall skyscrapers in the most advanced cities and economies, and those who live and operate in huts in the hinterlands of emerging economies depend on buildings. There are but a handful of human endeavours that thrives outside of buildings (Cucos & Turcan, 2025). Hence, buildings and the building sector as a whole remain vital to the survival of humanity. Therefore, buildings will continue to form an integral part of global infrastructure, and will continue to exert influence on the globe either positively or negatively. According to United Nations Environment Programme, (2025), the building industry accounted for 32% of global energy demand and about 34% of energy-related carbon dioxide (CO<sub>2</sub>) emissions in 2023. Again, the building sector is notable for the excessive consumption of raw materials globally (Dsilva et al., 2023). This indicates the extent to which the building industry is affecting the globe negatively, notwithstanding its many indispensable contributions to the survival of humanity. This calls for urgent attention.

An elevated standard of living and an increasing global population have led to an increase in the worldwide use of energy in several sectors of the global economy in recent years (Aldhshan et al., 2021). The building sector's demand for energy has consequently hiked in response to these global forces. The building sector, which comprises both residential and commercial end-use, utilizes the most energy when compared to other economic sectors (Dsilva et al., 2023). This has resulted in the increased impact of the building sector on the environment globally. Within buildings, energy use is largely influenced by appliances including dryers, water heaters, freezers, refrigerators, and the like, as well as lighting, ventilation, and air conditioning units (Yeboah & Tseh, 2023). This development has shifted the attention of researchers over the past decades towards life cycle assessment (LCA) of buildings.

Life cycle assessment (LCA), is an innovative approach for evaluating a product's environmental impact over its service life. It involves the process of assembling and estimating the resources needed for inputs, outputs, and any potential environmental effects of a product's system,

including its design and operation, over the course of its life cycle (Moutik et al., 2023). While LCA focuses on every resource input and their associated impact, LCEA focuses on all of the energy needed for a building from the point of manufacture to the point of demolition. Both operational and embodied energy are part of a building's life cycle energy use (Jane, 2025). LCEA studies focus on areas such as understanding operational energy use, embodied energy, comparative analysis of the energy efficiencies of different classes of energy buildings and many more (Jane, 2025).

The growing body of knowledge surrounding LCA and for that matter LCEA has made it imperative to investigate and understand the current trend in LCEA related publications in order to inform researchers about gaps and hot areas for attention. The aim of the study is to investigate the global research landscape of building lifecycle energy assessment, providing insights into publication trends, emerging research areas, trending topics and also identify gaps. The key objectives that drive the study are; (1) To provide insights into publication dynamics and growth patterns of building lifecycle energy assessment literature from 2015-2025. This includes insights into annual outputs, the productivity of journals, countries and institutions and; (2) To determine the dominant thematic areas and research trends in the field of building lifecycle energy assessment.

Hence, a quantitative analysis of the body of knowledge on building LCEA with the aid of bibliometrics was undertaken to understand and appreciate the status of studies on building LCEA from 2015 to 2025. This was intended to paint the current picture regarding building LCEA literature, focusing on publication patterns, language, subject categories, country productivity, most cited articles, and trending topics.

## METHODOLOGY

The main methodological approach chosen for the study is bibliometric analysis. Bibliometric methodology involves the application of quantitative techniques on bibliometric data such as citations (Donthu et al., 2021). It is a systematic study undertaken in an area of study to identify trends, patterns and impact within the scholarly community of the area. Characteristic of bibliometric analysis is its capacity to analyze a large volume of data to provide insight into emerging trends, journal performance, productivity of research constituents and the distribution of studies globally (Passas, 2024).

In carrying out this study, keyword search was conducted in Scopus database in December 2025. The search strings employed for the literature search is "Lifecycle energy assessment" and "Buildings". This resulted in the retrieval of 4589 documents from the Scopus database. The publication period for the retrieved documents spanned from 2015-2025, capturing the characteristics of building LCEA literature in the last decade. The documents were further limited to journal articles and conference since they comprised the largest bulk of all the document types retrieved, representing approximately 86% of all the retrieved documents.

The selected documents were saved as a CSV file with every information necessary for conducting analysis on them. The file was exported, and saved in a folder for further processing. The data was cleaned to remove redundant documents and erroneous entries with the aid of Microsoft Excel. The refined data was then imported into the Biblioshiny website with the help of the RStudio software. The imported file was then processed on the Biblioshiny website to generate results for analysis and discussion.

The analysis techniques employed for the study are two-fold. Both performance analysis and science mapping, which are the common types of analysis techniques for bibliometric studies (Donthu et al., 2021) were adopted for this study. Performance analysis was employed to evaluate the contribution of constituents such as journals, institutions, and countries based on their productivity with reference to building lifecycle energy assessment publications from 2015 to 2025. Within the performance analysis spectrum, one metric for citation adopted in the analysis is H-index. H-index measures the cumulative impact of an author by comparing the number of publications to the number of citations attributed to the author or researcher (Kawimbe, 2024).

In addition, science mapping which focuses on the relationship among research constituents was also adopted. Specifically, the study relied on citation analysis to identify the most influential constituents within the area of building lifecycle energy assessment (e.g. the most influential article based on the number of citations) worldwide. Moreover, co-word analysis was also used to identify the prevalent themes within the available literature of building lifecycle assessment.

The study, regardless of the rigorous process followed, has some limitations associated with it. These include;

- i. The adoption of one scientific database for the study; the study relied on the Scopus database for retrieving the data used for the analysis. This poses the challenge of excluding documents which are not listed in the Scopus database but may be listed within other credible scientific databases.
- ii. Time frame; the study was limited to a specific time frame (2015 – 2025), hence all documents which fall outside the specified period for the study, regardless of their relevance, are excluded from the study.

## RESULTS

### General observations and trends

A total of 4589 documents were retrieved from the Scopus database, of these 3021 were journal articles representing 65.83%, 925 were conference papers, representing 20.16%. These two types of documents made up the largest bulk of all the retrieved documents on building LCEA, with the remainder shared among reviews, book chapters, conference reviews and the likes. Since the largest share of the retrieved LCEA related publications were journal articles and conference papers, these two document types were further investigated. Of the 3946 published articles and conference papers, 3865 were written in English, accounting for 97.95%, this was followed by Chinese, 35 documents accounting for 0.89%. The remainder was distributed among German, Spanish, Polish, French, Japanese, Thai, and Turkish. This indicates that presently English language dominates LCEA related publications even among non-English speaking nations such as China which is currently dominating LCEA publications worldwide.

Figure 1 is an illustration of the annual scientific production related to building LCEA over the past decade; it is clearly evident from the graph that the production rate has grown steadily over the past decade, reaching its peak in 2025 with a total of 527 publications. This is an indicator that building LCEA related studies have drawn the attention of researchers, and rightly so owing to the immense impact of buildings on the environment. Additionally, Table 1 gives a broad overview of the retrieved documents. Building LCEA publications over the past decade has seen an average growth rate of 9.69% per annum. Moreover, the retrieved documents had a total of 11,104 authors, of which 114 are authors of single authored documents.

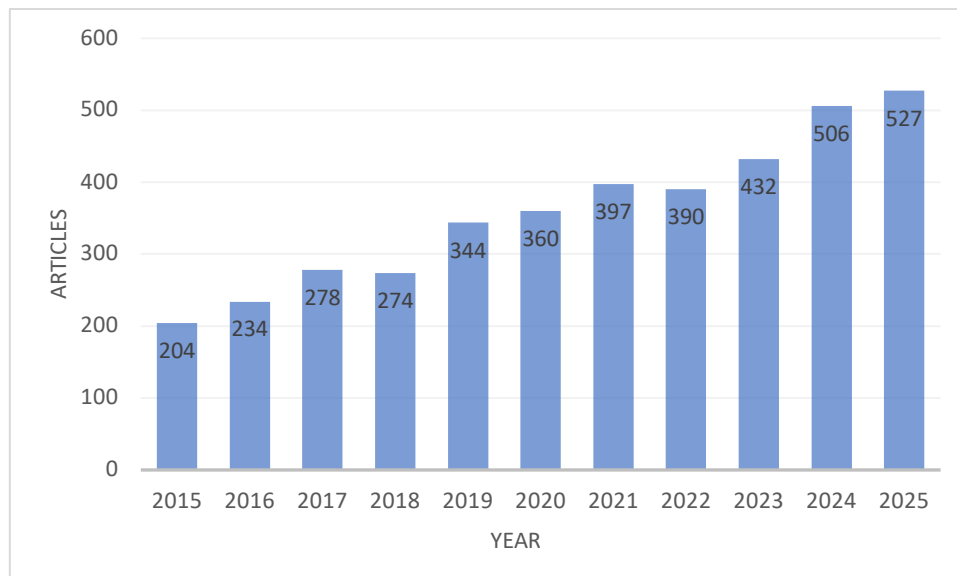


Figure 1: Annual Scientific Production of LCEA related publications, 2015-2025

Table 1: General information about the retrieved documents

Description	Results
Timespan	2015:2025
Sources (Journals, Books, etc)	659
Documents	3946
Annual Growth Rate %	9.96
Document Average Age	4.13
Average citations per doc	23.56
References	0
DOCUMENT CONTENTS	
Keywords Plus (ID)	14136
Author's Keywords (DE)	8327
AUTHORS	
Authors	11104
Authors of single-authored docs	144
AUTHORS COLLABORATION	
Single-authored docs	178
Co-Authors per Doc	4.1
International co-authorships %	25.77
DOCUMENT TYPES	
Article	3021
Conference paper	925

## Performance of Journals

A total of 556 journals has published literature related to building LCEA from 2015-2025. Table 2 shows the performance of the top 10 journals in relation to building LCEA publications over the decade. The most impactful journal is Energy and Buildings which contributed to 148 publications and has an h-index of 39. Hence, The Journal of Energy and Buildings demonstrated its leadership in terms of number of publications as well as its h-index, which is a reflection of its citation count. This is followed by Journal of Building Engineering (101, h-index 27), and Energy (46, h-index 26).

It is interesting to note that journals such as Buildings, Energies and Sustainability (Switzerland) with 74, 68 and 59 number of publications respectively had lower h-index values compared to sources such as Energy and Applied Energy regardless of the later having a smaller number of publications compared to the former. This indicates that the influence of the latter in relation to building LCEA is greater than the former. Hence, the influence of a journal is not directly proportional to the number of publications attributed to the journal, but rather its h-index, a reflection of its citation count is its true measure of impact. In Fig. 2, the observed trend is that the annual production of the sources has increased over the years, a fact that may be an indicator of the growing awareness about the need for the whole life cycle assessment of the energy performance of buildings.

Table 2: Performance of Journals regarding LCEA publications

Source	h-index	g-index	m-index	TC	NP
Energy and Buildings	39	65	3.545	5313	148
Journal of Building Engineering	27	40	2.7	2038	101
Energy	26	41	2.364	1693	46
Applied Energy	25	34	2.273	2564	34
Building and Environment	22	33	2.2	1154	47
Energies	17	24	1.7	837	68
Sustainability (Switzerland)	17	27	1.545	881	59
Buildings	14	21	1.273	632	74
Journal of Cleaner Production	14	20	1.4	625	20
Renewable Energy	14	22	1.273	530	27

Sources' Production over Time

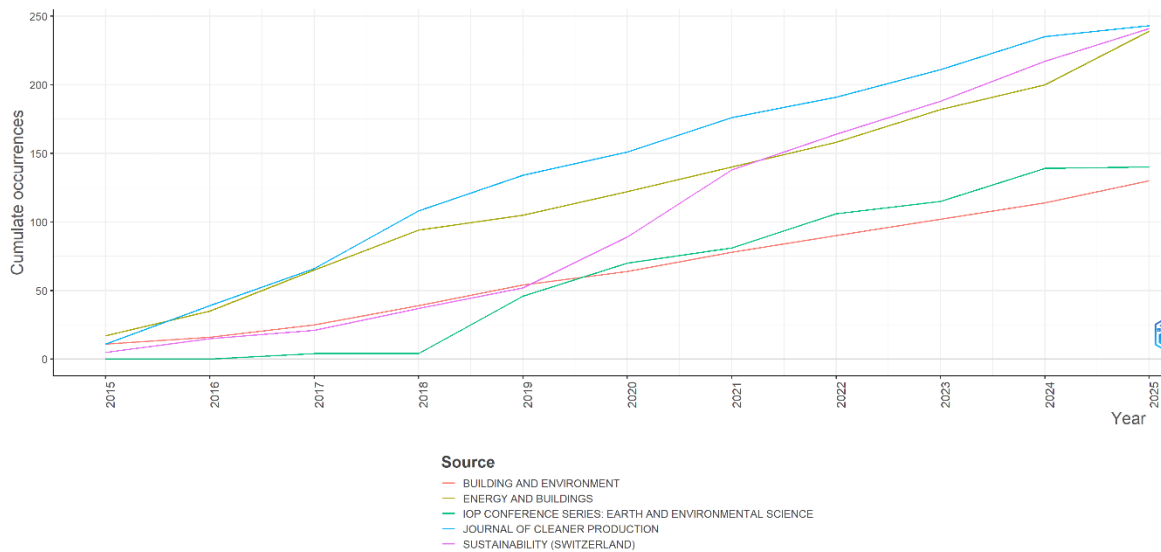


Figure 2: Sources production over time, 2015-2025

## Countries and Institutions

From 2015-2025, a total of 93 countries have contributed to LCEA related publications. These countries were involved in the publication of the 3946 articles and conference papers related to building LCEA. Of the 3946 publications, about 26% are accounted for by international collaborations. The most influential country in relation to building LCEA publication is China associated with 580 publications, followed by Italy (450), USA (424), Germany (264), and Spain (263). This is vividly illustrated in Fig. 3,

a map showing the productivity of countries in relation to LCEA related publications globally. China's interest in optimizing the performance of building is clearly portrayed in these statics. China's rise to a global force is clearly seen to be centered not only on economic outputs but in its current position in global literature. This observation clearly illustrates the commitment and investment China has made regarding LCEA studies. It is evident that China has made research a priority driving its developmental strides.

In addition, the findings point to the fact that LCEA studies are thriving within the European continent spearheaded by countries such as Italy, Germany and Spain. However, a few studies related to building LCEA were found in regions such as Africa and most parts of South America. This shows that the global south has not received much attention in terms of building LCEA related studies and that the penetration of LCEA related publications is on the low in these regions.

Fig. 3 and Fig. 4 provide a picture of the performance of the top ten (10) most productive countries in line with LCEA related studies globally. From these figures, it is evident that China is the most productive country globally. Furthermore, Fig. 5 shows the scientific production of the topmost five (5) nations with reference to building LCEA related publications worldwide from 2015-2025. The graph shows that all these nations have experienced continual growth in their productivity annually over the past decade, from 2015-2025. It is observed that USA was the most productive country from 2015 to 2020 in relation to building LCEA publications globally. However, the trend took another turn in 2021 as China moved to occupy the front seat in terms of building LCEA related publications around the world. China has since remained the most productive country, with the other nations trailing behind. Following closely behind China is Italy, which is the second most productive country in terms of building LCEA literature.

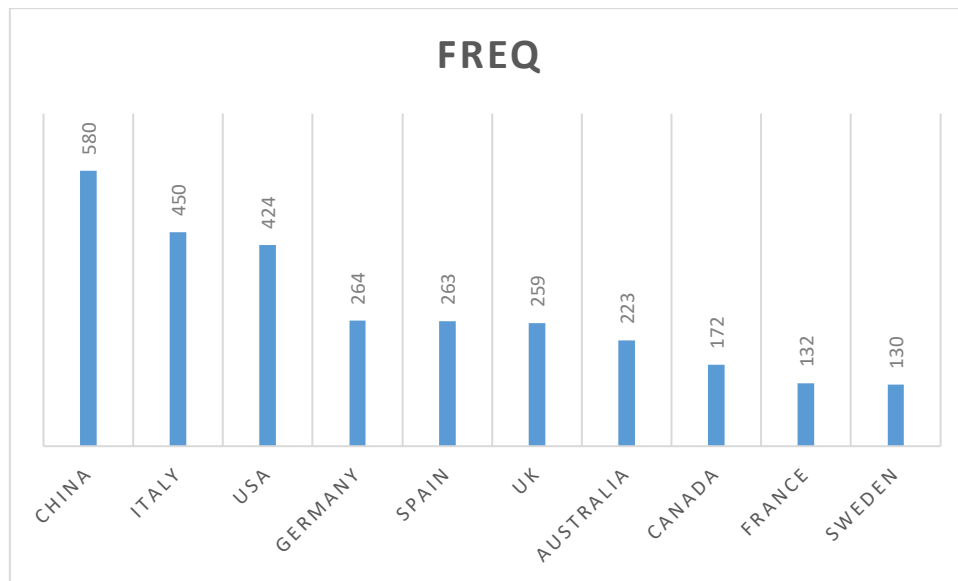


Figure 3: Country scientific production, 2015-2025

USA's productivity though has seen increase from 2021 to 2025, yet it is now occupying the third place in the global ranking of the most productive countries in relation to building LCEA literature. This indicates that China and Italy have intensified their efforts and are paying much attention to LCEA related studies. Additionally, the general growth in the body of knowledge related to building LCEA from 2015 to 2025 is an indicator that building LCEA studies have received much attention over these years within the research community.

## Country Scientific Production

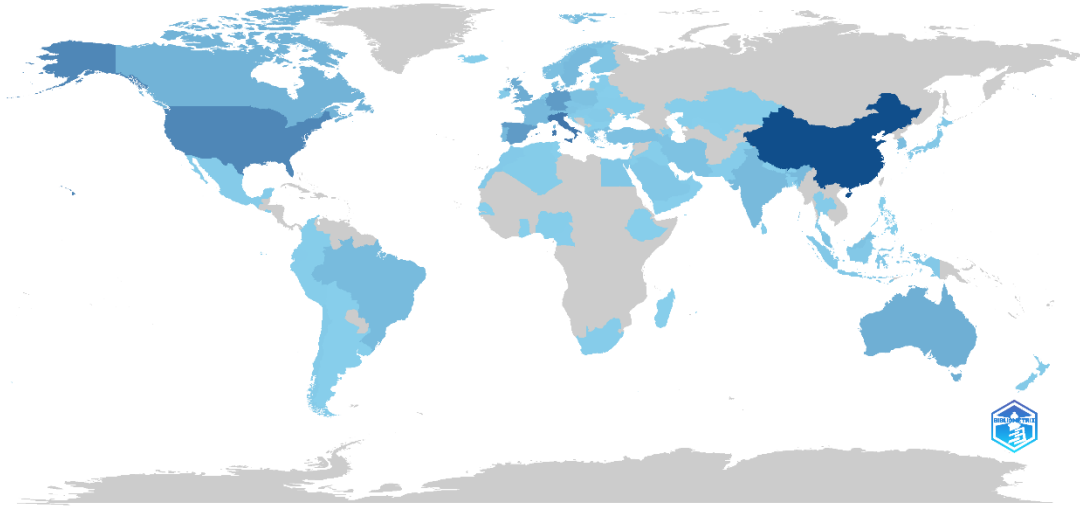


Figure 4: Country Scientific production

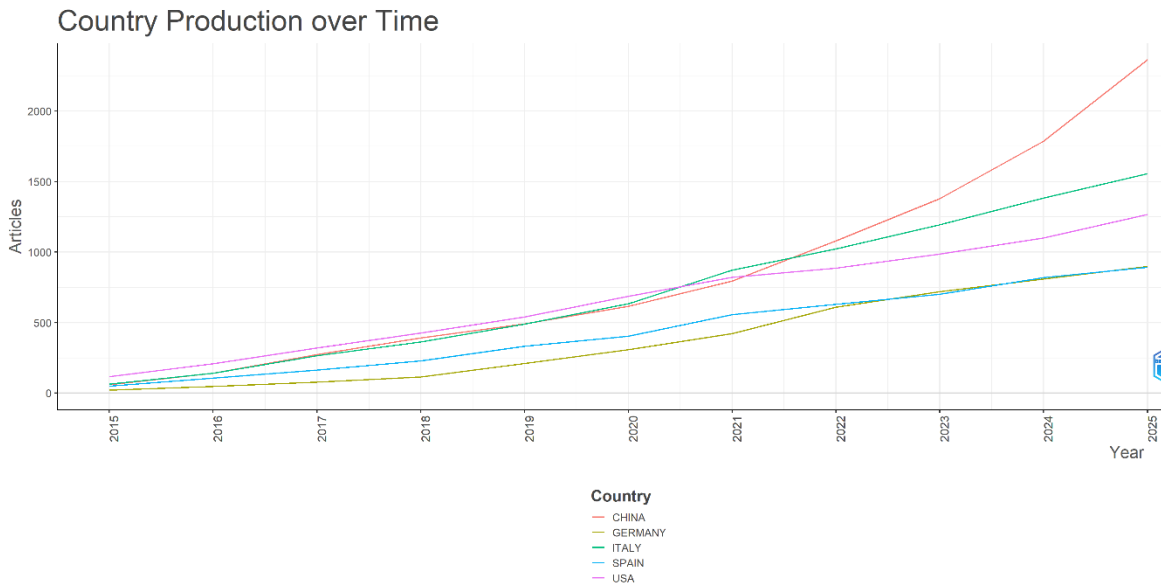


Figure 5: Country scientific production over time, 2015-2025

A total of 2044 institutions have contributed to the publication of LCEA related literature from 2015 to 2025. The most productive institution among all these is the Norwegian University of Science and Technology, followed by University of Bologna, Italy, and taking the third place is the University of British Columbia, Canada as shown in Fig. 6. It is interesting to note that although China took the lead among the most productive nations regarding LCEA related studies, only two (2) Chinese institutions were found among the top ten (10) most productive institutions, as compared to the second most productive country, Italy which featured three (3) institutions in the top ten most influential institutions.

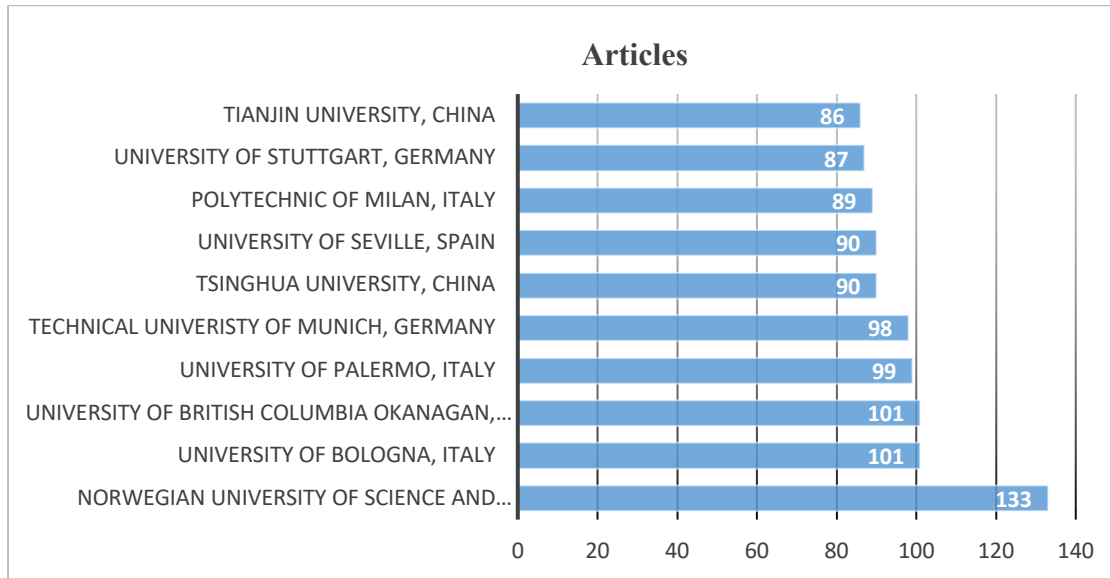


Figure 6: Most influential institutions

### Major Areas of Building LCEA Studies

Based on word frequency and co-word analysis, hot and trending topics in the area of building LCEA related studies could be easily identified to provide glimpse of the direction of research in this field. A total of 8,327 author keywords were obtained from the search. Keywords which were found to be synonymous were merged in an effort to reveal the hot topics trending in building LCEA related publications. For instance, “building” and “buildings” were merged as one hot keyword and hot topic. Again, sustainability and sustainable development were merged as a single keyword and hot topic. This led to the identification of hot topics such as life cycle assessment, sustainable development, environmental impact, buildings, energy utilization, energy efficiency, greenhouse gases, global warming, architectural design and construction industry. For the purposes of this study, life cycle assessment and buildings were not further analysed since they form the core part of the current study.

### Hot Topics Identified

As shown in Fig. 6, over the past decade, life cycle assessment has been the prevalent theme among LCEA related publications as should be expected. This trend may be due to the fact that most studies on LCEA include life cycle assessment as one of its keywords. Some of the predominant topics aside those already captured as keywords for the present study (Life cycle assessment and buildings) include sustainable development, environmental impact, energy utilization, energy efficiency, greenhouse gases, global warming, architectural design and the construction industry. In an effort to assess the energy use of buildings and their associated impact over the life cycle of buildings, the themes mentioned above have become very relevant.

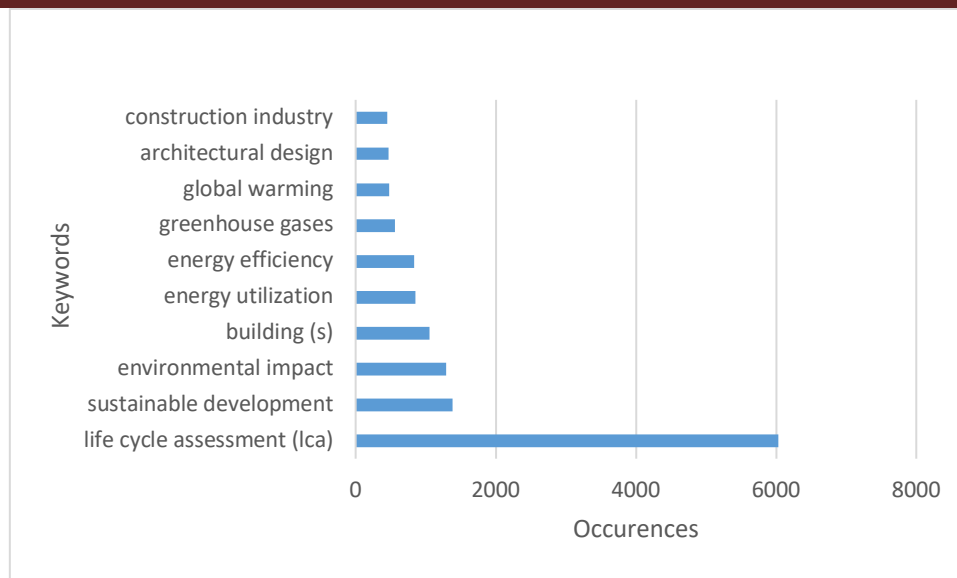


Figure 7: Hot topics pertaining to building LCEA

### ***Energy utilization and energy use***

The life cycle of buildings is posited to consist of four main stages; material manufacture and transportation, construction, operation and demolition or reuse (Wikman et al., 2023). These stages have been recognised as the four broad stages that make up the life cycle of buildings. All these stages consume energy, hence making energy one of the hot topics within the field of building life cycle energy assessment. It is estimated that operational energy and embodied energy constitutes the largest bulk of the energy consumed by a building over its lifespan, accounting for about 80-95% of all building related energy use (Torres-quezada et al., 2024).

### ***Sustainable development***

Fundamentally, sustainable development focuses on the responsible use of resources to meet the needs of the present generation without denying the subsequent generations similar opportunities. It involves an equitable and prudent distribution of resources, to advance society without incurring negative repercussions (Dinbabo & Mazani, 2025). In relation to the life cycle performance analysis of buildings, sustainable development has become a relevant topic because global development is predominantly powered by energy (Ali et al., 2022). Energy use is indispensable; hence the goal is to source and use energy in a sustainable manner especially in buildings, owing to their significant share of energy use worldwide (United Nations Environment Programme, 2025).

### ***Environmental impact (Global warming and greenhouse gases)***

Among the hot topics associated with building life cycle energy assessment is environmental impact. This is no surprise as energy use has been linked to a number of negative impacts on the environment globally. These include air pollution, resource depletion, greenhouse gas emission, global warming, health hazards and the like (United Nations Environment Programme, 2025). Owing to the grave effects these have on the environment and the global population, it has become a necessity to investigate how buildings will impact the world throughout their life cycle based on their energy use. Environmental impact as a hot topic is closely associated with hot topics such as “Global warming” and “Greenhouse gases”, as such they were treated as one.

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## **Architectural design**

Architectural design surfaced as one of the hot topics in the area of building life cycle energy performance due to how design decisions taken by architects and other building professionals affect the energy use of buildings. It is argued that the fundamental approach to reducing energy use in buildings is making the right design choices from the onset (Olatunde et al., 2024). These decisions may affect factors such as material choices, building orientation, shading, building form and wind path. These decisions taken by designers from the inception of the building design influence the energy performance of the building over its entire lifespan. It is also a known fact that reducing the energy load of a building over its lifespan is a two-pronged approach, combining both passive strategies and active technologies in an efficient manner (Olatunde et al., 2024). Therefore, the emergence of architectural design among the hot topics associated with building LCEA is a must. This suggest that building designers such as architects contributes to the lifecycle energy performance of the buildings they design.

## **Construction industry**

For a number of years now, the construction industry has been a notable and significant contributor to both global energy use and global emissions (Tabrizikahou & Nowotarski, 2021). This has made the construction industry a target for research with the goal of reducing the negative impact of the industry on the environment. According to the Global status report, the construction industry accounted for 32% of energy demand globally and was responsible for the emission of 34% of CO<sub>2</sub> in 2023 (United Nations Environment Programme, 2025). This makes it increasingly important to investigate the energy use within the construction industry as a whole, focusing on all the various phases of the construction process. Thus, making the construction industry as a whole a hot topic in relation to building LCEA and LCA.

## **The Most Influential Articles**

The impact of an article is measured by the number of citations accrued by the article. Out of the 3946 documents retrieved from the Scopus database, the ten most cited articles are presented in Table 3 along with their total citation counts and annual citations. The most cited article regarding LCEA is “Embodied GHG emissions of buildings- The hidden challenge for effective climate change mitigation.” The journal responsible for the publication of this article is Applied Energy. It has been cited 818 times and has about 136 citations per year. Some key highlights of the study include the systematic analysis of over 650 building LCA cases on life cycle GHG emissions. The study revealed a reduced life cycle GHG emissions largely attributed to the improvements in energy efficiency and increased embodied energy.

The second most cited document was published in the journal of Resources, Conservation and Recycling and it is titled “Comparative environmental evaluation of aggregate production from recycled waste materials and virgin sources by LCA”. This paper was published in 2016 and has been cited 487 times. It has an annual citation count of about 48 citations per year. The study assessed the environmental impact associated with the production of aggregates from construction and demolition waste and waste glass and the production of aggregates from virgin material using natural means. The mode of assessment was LCA. The study asserted that the production of coarse aggregates from construction and demolition waste and waste glass led to the reduction of energy use by 58% and also minimized GHG emissions by a whopping 65%. The study concluded that significant environmental benefits can be achieved through the production of aggregates from construction and demolition waste as compared to the production of aggregates from virgin sources.

The third among the most highly cited articles in relation to building LCEA is titled “Ten questions concerning occupant behavior in buildings: The big picture”. The study was published in 2016 by the journal of Building and Environment, and has been cited 482 times, with an annual citation count of 53. The study presented ten questions and answers pertaining to energy related occupant research. The study posited that occurrence of prediction gaps between the building design and operation energy use is predominantly due to the interaction of occupants with their indoor environment to create comfortable experience. Again, the authors argued that the impact of building users on energy consumption have been overly simplified in building performance simulations, leaving out a lot details

which have a bearing on the overall energy performance of a buildings. Lastly, the study highlighted the potential of reducing energy use of buildings by up to 20% through the application of the appropriate behavioral energy-saving interventions.

The above is an indicator that a lot of progress has been made regarding building LCEA (LCA) literature globally.

Table 3: The most influential articles

Paper	Year	Journal	TC	TC/Year	Normalized TC
Embodied GHG emissions of buildings- The hidden challenge for effective climate change mitigation	2020	Applied Energy	818	136	27.39
Comparative environmental evaluation of aggregate production from recycled waste materials and virgin sources	2016	Resources, Conservation and Recycling	487	48	11.09
Ten questions concerning occupant behaviour in buildings: The big picture	2017	Building and Environment	482	54	12.32
Building Information Modelling (BIM) for green buildings: A critical review and future directions	2017	Automation in Construction	469	52	11.98
IEA EBC Annex 66: Definition and simulation of occupant behaviour in buildings	2017	Energy and Buildings	398	44	10.17
Calculation of a building's life cycle carbon emissions based on Ecotect and building information modelling	2016	Cleaner Production	398	40	9.07
Circular economy in the building and construction sector: A scientific evolution analysis	2021	Building Engineering	383	77	14.13
A comparative study of environmental performance between prefabricated and traditional residential buildings in China	2015	Cleaner Production	355	32	7.85
Material efficiency strategies to reducing greenhouse gas emissions associated with buildings, vehicles, and electronics – A review	2019	Environmental Research Letters	348	50	10.99
Al3+ intercalation/de-intercalation-enabled dual-band electrochromic smart windows with high optical modulation, quick response and long cycle life	2018	Energy and Environmental Science	329	41	7.41

## CONCLUSIONS

A total of 4585 documents were retrieved from the Scopus database in relation to building LCEA related studies covering the time period of 2015-2025. Out of these documents, 65.83% were journal articles and 20.16% conference papers, contributing to 3946 documents out of the 4585. The results of the bibliometric analysis shows that building LCEA related studies have experienced steady growth over this period, characterised by consistent annual growth in production and citations. In all, 556 journals are responsible for the retrieved building LCEA related publications globally. Among these journals, the five (5) most productive are as follows; Energy and Buildings, Building Engineering, Energy, Applied Energy, and Building and Environment.

China is the most productive country as far as building LCEA studies are concerned, followed by Italy, USA, Germany and Spain placing 5th among the top five most productive countries. Studies on building LCEA are concentrated in the Global North, with scant literature found within the Global South. The Norwegian University of Science and Technology emerged as the most influential institution contributing the most to building LCEA related publications worldwide. Following closely behind is the University of Bologna located in Italy, with the third place occupied by the University of British Columbia, Canada.

The hot topics dominating building LCEA studies include life cycle assessment, sustainable development, environmental impact, buildings and energy. Additional areas of emphasis include greenhouse gases, global warming, architectural design and the construction industry. It is evident that studies on building LCEA covers a broad area as many factors are known to contribute to the life cycle energy performance of buildings.

Bibliometric analysis is a systematic and scientific investigation in a particular field of study to identify trends, patterns and the general characteristics of publications in relation to the subject area. This study provides a perspective on the global outlook of building LCEA related publications. This provides researchers a useful view on areas and regions worth focusing in terms of building LCEA studies. It vividly portrays the current status of building LCEA related studies and also serves as a springboard for future research paths to be taken by researchers through its emphasis on hot topics dominating literature regarding building LCEA.

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