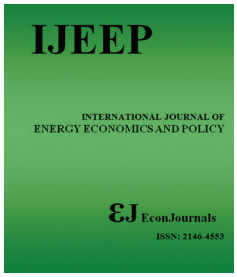

International Journal of Energy Economics and Policy

ISSN: 2146-4553

available at http: www.econjournals.com

International Journal of Energy Economics and Policy, 2024, 14(1), 31-36.

# Exploring the Landscape of Energy Audits: A Bibliometric Analysis

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**Received:** 03 August 2023 **Accepted:** 04 December 2023 **DOI:** https://doi.org/10.32479/ijeep.15087

**ABSTRACT**

The term "sustainability" has emerged as a popular catchphrase for the challenges we face in the twenty-first century, which need a radical rethinking of our economic, social, and environmental practices. Energy audit has evolved as a significant instrument in the search of a sustainable future, and it may be used to leverage other sustainability initiatives. Businesses may actively contribute to a more sustainable future and align operations with global environmental objectives by adopting energy practices. The purpose of this study is to do a bibliometric analysis of scholarly works that discuss energy auditing and its role in promoting sustainability. We may learn more about the major issues, trends, and contributions to green energy audit for sustainable development by reviewing the relevant academic literature.

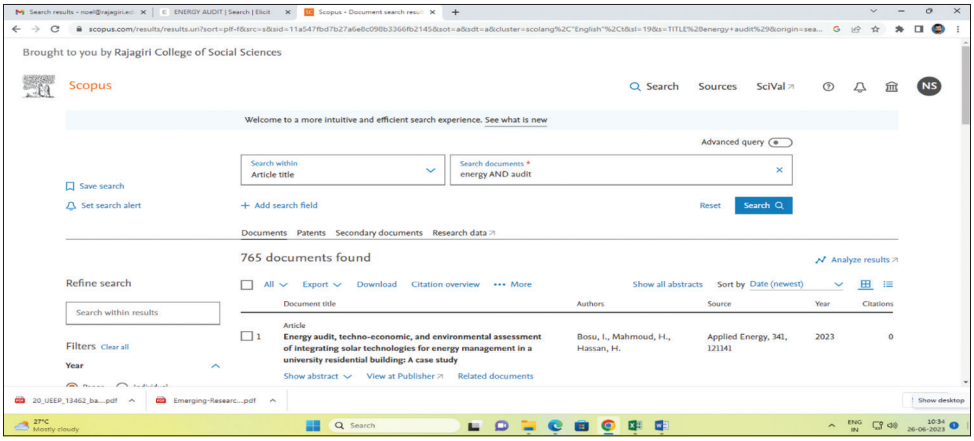
**Keywords:** Bibliometric Analysis, Energy Audit, Sustainable Development
**JEL Classifications:** M40, M41, F65, Q01, Q56

## 1. INTRODUCTION

The seventh Sustainable Development Goal of the UN focuses on providing inexpensive and clean energy, which is essential for the growth of business, communications, education, healthcare, and transportation. Energy access issues impede both economic and human development. According to the most recent data, progress towards sustainable energy goals is still being made. However, the current development rate needs to be improved to achieve Goal 7 by 2030. Access to contemporary renewable energy still needs to be improved. The cost of manufacturing and delivering solar photovoltaic modules, wind turbines, and biofuels has risen due to rising commodity, energy, and shipping prices, adding uncertainty to a development trajectory already substantially below Goal 7. To advance the Sustainable Goals of providing accessible, affordable, dependable, and sustainable energy for everyone, it is imperative to conduct an energy audit as a critical and necessary measure. Energy conservation and sustainable development both depend on energy audits. An energy audit is a thorough evaluation that pinpoints energy use across various services and makes recommendations for energy-saving measures (Hassan et al., 2022). Energy efficiency, energy quality, and energy intensity are the three main areas of attention for energy audits, which are crucial for both developed and developing nations (Sharma et al., 2021).

A significant mobilisation of public and private finance for clean and renewable energy, especially in developing nations, will be necessary to achieve energy and climate goals (UN, 2023). There is a relationship between energy efficiency, energy audits, and environmental performance. It can directly affect environmental performance (Saputra et al., 2022). One of the ways to reduce carbon footprints while saving energy and money is through energy audits. It is a thorough investigation of how a facility consumes energy, the cost, and eventually a suggested plan for alterations to operational procedures or energy-guzzling machinery that will cost-effectively reduce energy costs. An energy audit is one lever to reduce carbon emissions from an organisation's industrial site, residential building, etc. (Mbaye, 2022). The energy audit is occasionally referred to as an energy survey or an

**Figure 1:** Search results



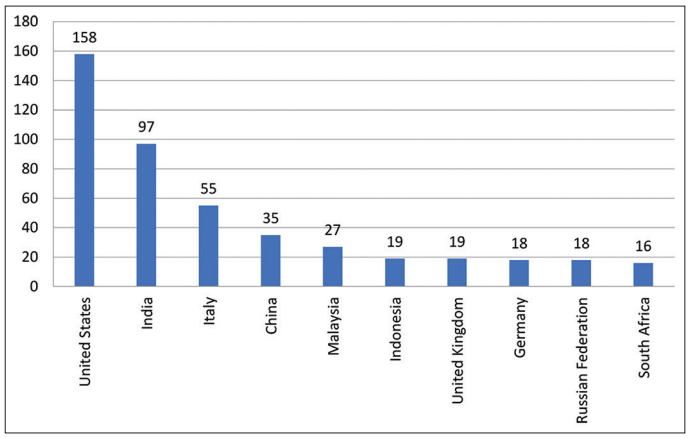

energy analysis to avoid the negative connotation of an audit in the sense of a financial audit. Numerous organisations carry out energy audits. Large commercial or industrial customers may hire an engineering consultant to conduct an extensive energy assessment. Other businesses may form an energy management team or engage an energy manager responsible for recurring audits and staying abreast of new energy-saving technology (Firdaus and Amrina, 2015).

Due to the abundance of published studies available on a given study field or research subject, it can occasionally be difficult for researchers and practitioners to have a comprehensive overview of relevant data. Using the bibliometric analysis method makes it feasible to present a comprehensive overview of the existing scientific literature. Bibliometric analysis is a widely used and rigorous approach for examining and evaluating substantial amounts of scientific material. It allows us to analyse the subtle changes in a particular field's development while also illuminating the new and developing regions within that field (Donthu et al., 2021). Scientific activities in experimental research are evaluated using quantitative and statistical approaches in bibliometric analysis, a branch of scientometrics (Callon et al., 1991) All fields are progressively utilising bibliometrics. It is especially well suited for scientific mapping at this point, when the focus on empirical inputs has led to numerous, dispersed, and contentious research streams. Science mapping is multi-step and usually necessitates various and different software tools, not all of which are necessary freeware, making it difficult and unwieldy (Aria and Cuccurullo, 2017). The purpose of this study is to do a bibliometric analysis of scholarly works that discuss energy auditing and its role in promoting sustainability. We may learn more about the major issues, trends, and contributions to green energy audit for sustainable development by reviewing the relevant academic literature.

## 2. METHODOLOGY

On June 26, 2023, SCOPUS was used for the literature review and analysis. "Energy audit" was the search term used, and it was limited to English-language journal publications. The word "energy audit" is mentioned in the articles' titles of the search result. Figure 1 shows the 765 journal articles about energy audits that were found between the years 1974 and 2023, as of June 26, 2023.

**Figure 2:** Major contributors




Bibliometrics uses quantitative analysis to study the bibliographic data. It offers effective methods for categorising data from a scientific area (Merigó and Yang, 2014). The basic characteristics of publications on energy audit are mostly broken out from two angles in this study: (1) The main points, which are the effectiveness and impact of publications in light of specific bibliometric pointers like the total number of publications (TP) and the number of citations (TC), the average number of citations per publication (CPP), and (2) sources, authors, countries/nations, co-occurrence, collaborating countries and phrase relationships This paper uses Vos viewer and R Programming to introduce the visualisation network, which is useful to notify the research areas of interconnectedness.

## 3. RESULTS AND DISCUSSION

### 3.1. Major Contributing Countries

A total of 765 publications are available in the English language globally in the Scopus database as of 26th June 2023. The number of year-wise publications in the area of energy audit at the global level, before 2006, was in the single digit for the majority of years and there have been only three years without publications. Globally the number of publications spiked in 2006 and kept on

increasing. Figure 2 illustrates the major contributing countries in the field of Energy audit research. The top three contributors in this area are the USA (158), India (97) and Italy (55). The top 6 countries which also include China (35), Malaysia (27) and Indonesia (19) have contributed to more than 50% of the total global publication in this area.

### 3.2. Main Information

There are 765 published documents in the field of Energy Audit research as on 18th June, 2023 globally. Table 1 indicates the summary data of publications between the timespan 1974 and 2023. These papers are published in 451 different sources. The average annual growth rate and average citation per publication is 6.3% and 7.45% respectively. 1309 keywords were used by authors in 765 documents. There are a total of 1970 authors in this area and co-authors per document is 2.96 and international co-authorship per doc is 11.11% which indicates that an average of approx. 3 authors have contributed to each published document.

### 3.3. Document Type

Figure 3 depicts the proportion of documents types of publications in the area. Most publications are in the form of articles and conference paper, all other are far behind.

**Table 1: Publications between 1974 and 2023**

| Description | Results |
|---|---|
| Timespan | 1974:2023 |
| Sources (Journals, Books, etc) | 451 |
| Publications | 765 |
| Annual Growth Rate % | 6.3 |
| Document Average Age | 12.7 |
| Average citations per doc | 7.395 |
| References | 12299 |
| Keywords Plus (ID) | 3939 |
| Author's Keywords (DE) | 1309 |
| Authors | 1970 |
| Authors of single-authored docs | 159 |
| Single-authored docs | 182 |
| Co-Authors per Doc | 2.96 |
| International co-authorships % | 11.11 |

**Figure 3:** Types of documents

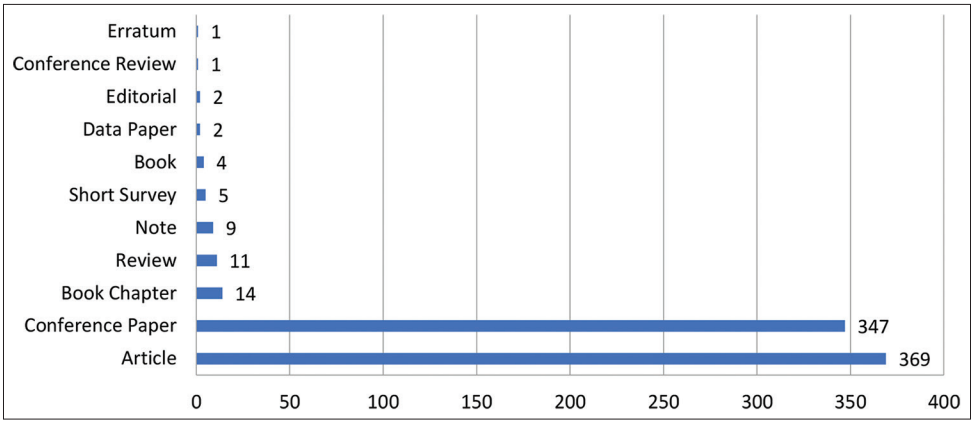



**Figure 4:** Area of subject

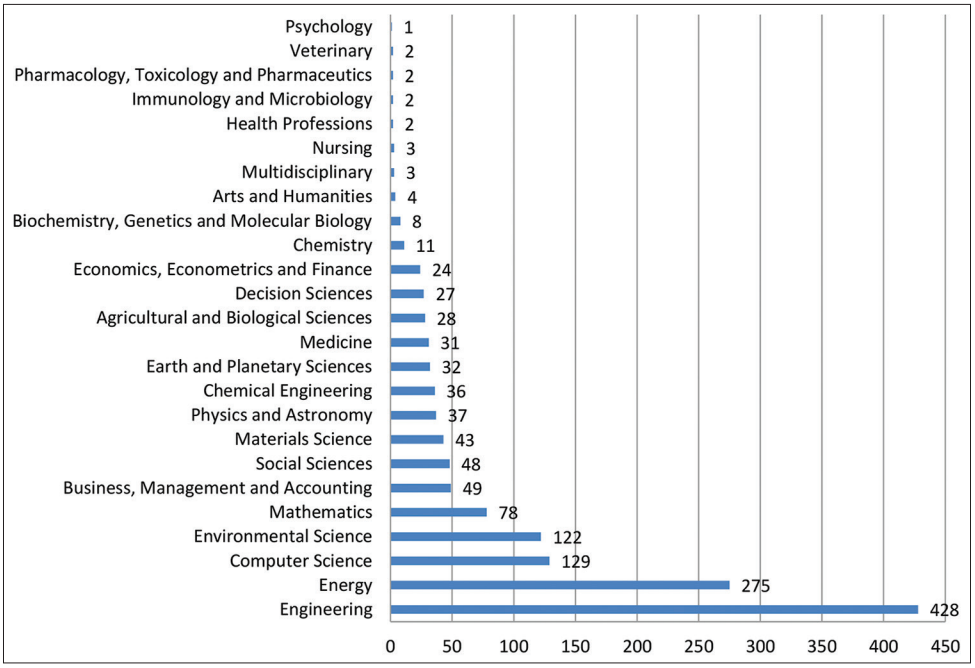
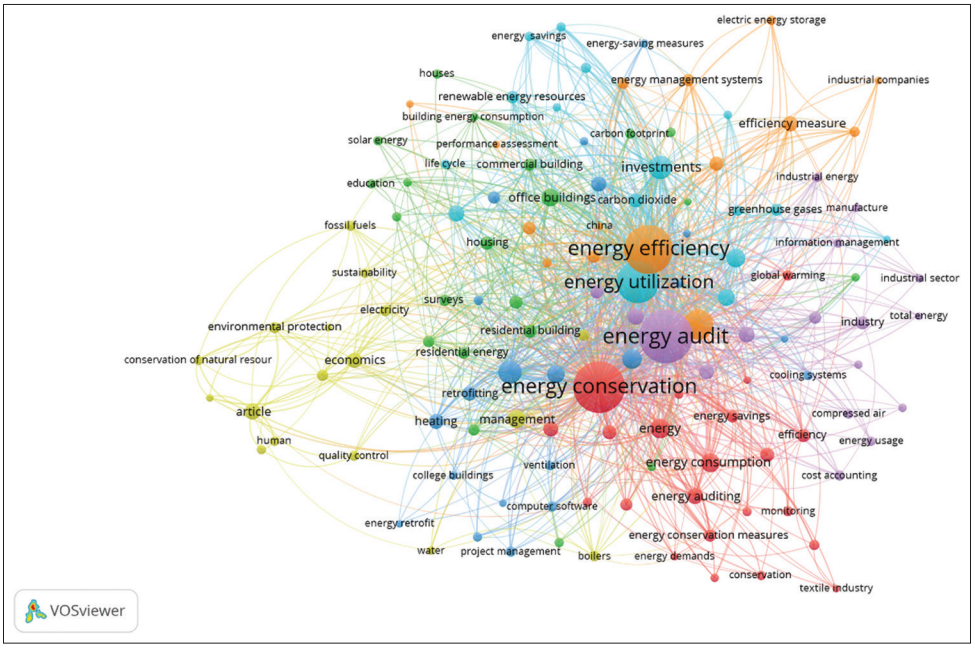


**Figure 5:** Co-occurrence analysis




## 3.4. Yearly Trend

Figure depicts the annual growth of publications from 1974 to 2023. During this period, there was a significant gap in publication, with no publication following the first publication in 1975 until 1977. In terms of the number and growth of publications, there was no discernible pattern. The year with the highest number of publications was 2019, while the years with the most publications were 2016 and 2022.

## 3.5. Subject Area

The area of energy has implications on every sphere of life. As depicted in Figure 4, majority of the research on energy auditing come from the area of "Engineering," 428 articles which is followed by "computer science," 275 articles. Other prominent areas of research include "Mathematics," (78) "Social sciences" (49), "physics and astronomy," (37) and "Earth and planetary science" (32). There is still greater scope for research in the area of Psychology, Medicine, and multidisciplinary research which are identified to be the lowest contributing areas.

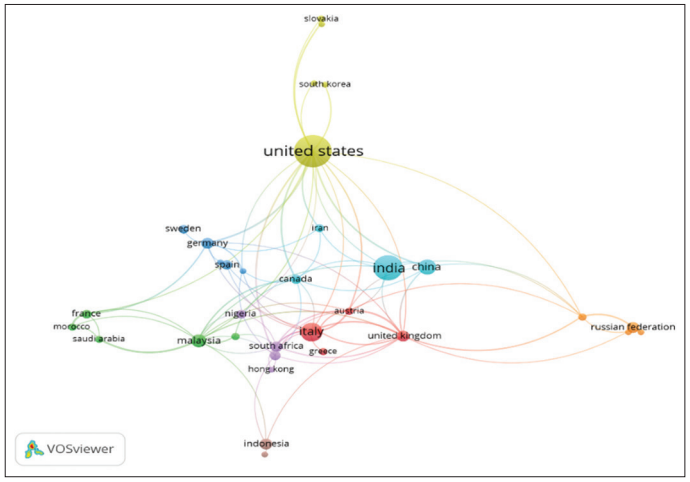
## 3.6. Main Contributing Authors

The table 2 represents the most cited papers on energy audits, highlighting the authors, paper titles, publication sources, total citations (TC), and citations per paper (CPP). It showcases the papers with the highest impact and influence in the realm of energy audit research, reflecting their significance within the field based on the number of citations received. The paper titled Information programs for technology adoption: The case of energy-efficiency audits, authored by Soren T Anderson and Richard G Newell tops the table.

## 3.7. Co-occurrence Analysis

Analysing counts of co-occurring entities within a collection of units is the main goal of co-occurrence analysis. The co-occurrence matrix is a common type of data in co-occurrence analysis, where the items from the row and column headers and the intersection of the two represent the co-occurrence analysis in bibliometrics is used to investigate the possible association between two bibliographic entries that appear in the same dissertation. Over the past two decades, bibliometrics' co-occurrence analysis techniques have advanced (Zhou et al., 2022). The Figure 5 depicts the analysis which was conducted to identify the co-occurrence of keywords. following are the major co-occurring keywords identified, energy audit is the major keyword with occurrence - 327 and total link strength – 1704, (cluster 5), followed by energy efficiency with an occurrence of 269 and total link strength of 1553, (cluster 7), energy conservation: occurrence – 302, total link strength – 1508, (cluster 1), energy utilization: occurrence – 202, total link strength – 1221, (cluster 6), energy management: occurrence -105, total link strength – 578, investments: occurrences -64, total link strength -476.

**Figure 6:** Country wise co-authorship analysis




## 3.8. Country Wise Co-Authorship Analysis and Collaboration Map

Figure 6 shows that united states leads with total link strength of 32 and 157 documents, followed by India with total link strength of 8 and 97 documents, US and India have the greatest number of documents but

**Table 2: List of most contributing authors**

| Authors | Title | Source | TC | CPP |
|---|---|---|---|---|
| Anderson and Newell, 2004 | Information programs for technology adoption: The case of energy-efficiency audits | Resource and Energy Economics | 316 | 16.63 |
| Fleiter et al., 2012 | Adoption of energy-efficiency measures in SMEs-An empirical analysis based on energy audit data from Germany | Energy Policy | 185 | 16.82 |
| Fenu et al., 2010 | Energy audit of a full scale MBR system | Desalination | 158 | 12.15 |
| Lucchi, 2018 | Applications of the infrared thermography in the energy audit of buildings: A review | Renewable and Sustainable Energy Reviews | 141 | 28.2 |
| Cabrera et al., 2010 | Energy audit of water networks | Journal of Water Resources Planning and Management | 135 | 10.38 |
| Thollander and Palm, 2012 | Improving energy efficiency in industrial energy systems: An interdisciplinary perspective on barriers, energy audits, energy management, policies, and programs | Improving Energy Efficiency in Industrial Energy Systems: An Interdisciplinary Perspective on Barriers, Energy Audits, Energy Management, Policies, and Programs | 110 | 11 |
| Dall'O' et al., 2013 | Infrared screening of residential buildings for energy audit purposes: Results of a field test | Energies | 93 | 9.3 |
| Kluczek and Olszewski, 2017 | Energy audits in industrial processes | Journal of Cleaner Production | 90 | 15 |
| Alajmi, 2012 | Energy audit of an educational building in a hot summer climate | Energy and Buildings | 86 | 7.82 |
| Fresner et al., 2017 | Energy efficiency in SEMs: Lessons Learned from 280 energy audits across Europe | Journal of Cleaner Production | 84 | 14 |

CPP: Citations per publication, TC: Total number of citations, SEMs: Small and medium enterprises

**Figure 7:** Country collaboration map

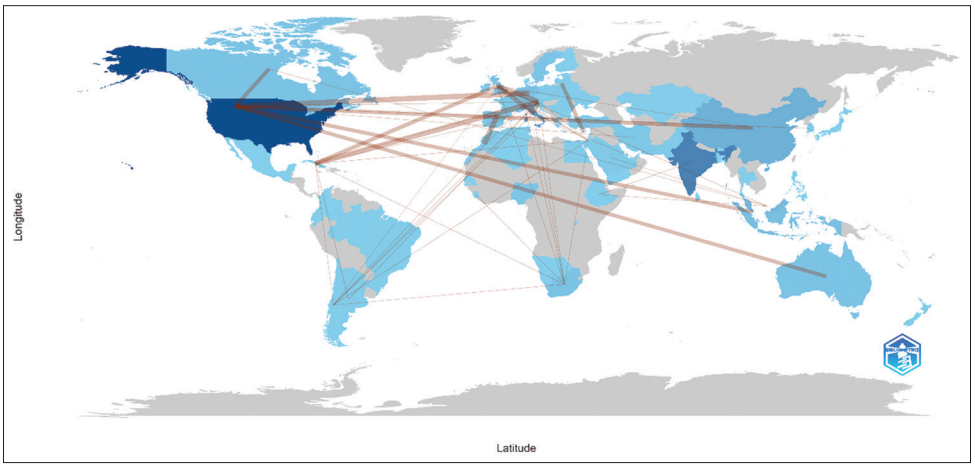
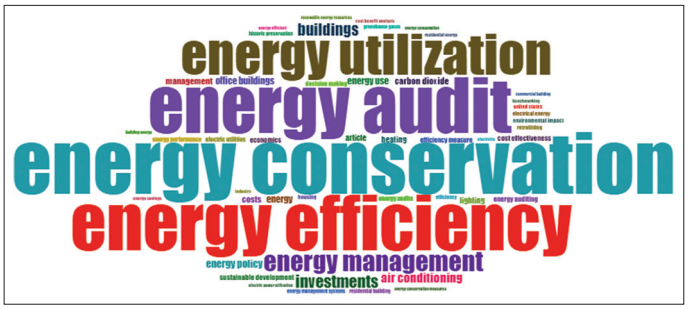



**Figure 8:** Word cloud




UK has total link strength of 23 with just 19 docs and Malaysia has total link strength of 19 with 27 documents, so we can conclude that US, UK and Malaysia are most collaborating countries in term of co-authorship.

Collaboration between countries (Figure 7) shows that United States has the highest and India has the second highest average collaboration between different countries. The countries are shaded in different intensities of blue, which represent the volume of publications or the level of activity in research, with darker shades likely indicating higher activity. The lines connecting the countries represent collaborations on research papers, where researchers from different countries have worked together. Most of the collaborations are between US and China. North and South American region, European macro-region, Australia and some of the Asian countries are developing this theme mostly. The analysis also shows that regions such as Africa and Russia are not scientifically analysing the issue.

### 3.9. Key Word Analysis

Figure 8 depicts the most popular keywords in the field of study. The most number of occurrence keyword is energy conservation there are 308 occurrences of this word in the data set. It most likely relates to the process of minimizing waste and energy use. And

it is followed by the word energy audit there are 277 occurrences of the word "energy audit" throughout the data set. The word "energy efficiency" appears 276 times and "energy efficiency appears 207 times

## 4. CONCLUSION

Energy audit provides a framework for assessing, reporting, and controlling an organization's environmental effects; it is therefore integral to the practice of sustainability. As the importance of preserving the planet grows, energy audit has emerged as a powerful instrument for businesses and governments to effect good change and build a more sustainable and resilient society. It is clear that by using energy audit, businesses may determine the scope of their environmental impacts, establish priorities for change, and put plans into action to lessen their negative effects on the environment. This not only helps businesses to save money and run more smoothly, but it also encourages a mindset of environmental responsibility.

An overview of the state of energy audit studies in the context of sustainability is provided by the bibliometric study. The results show that the last 5 years have seen a significant increase in interest in the topic, as seen by an uptick in publications and contributions from scholars across the globe. Methodologies, policy creation, business sustainability, and economic and social ramifications are only some of the topics that have emerged as central to energy audit studies. The analysis draws attention to the most important players in the development of the area by honoring prominent writers and institutions. In sum, this bibliometric study has much to offer scholars, policymakers, and practitioners who are interested in energy auditing and its function in advancing environmental sustainability.

## REFERENCES


Alajmi, A. (2012), Energy audit of an educational building in a hot summer climate. Energy and Buildings, 47, 122-130.

Anderson, S.T., Newell, R.G. (2004), Information programs for technology adoption: The case of energy-efficiency audits. Resource and Energy Economics, 26(1), 27-50.

Aria, M., Cuccurullo, C. (2017), Bibliometrix: An R-tool for comprehensive science mapping analysis. Journal of Informetrics, 11(4), 959-975.

Cabrera, E., Pardo, M.A., Cobacho, R., Cabrera, E. Jr. (2010), Energy audit of water networks. Journal of Water Resources Planning and Management, 136(6), 669-677.

Callon, M., Courtial, J.P., Laville, F. (1991), Co-word analysis as a tool for describing the network of interactions between basic and technological research: The case of polymer chemistry. Scientometrics, 22(1), 155-205.

Dall'O', G., Sarto, L., Panza, A. (2013), Infrared screening of residential buildings for energy audit purposes: results of a field test. Energies, 6(8), 3859-3878.

Donthu, N., Kumar, S., Mukherjee, D., Pandey, N., Lim, W.M. (2021), How to conduct a bibliometric analysis: An overview and guidelines. Journal of Business Research, 133, 285-296.

Fenu, A., Roels, J., Wambecq, T., De G`ussem, K., Thoeye, C., De Gueldre, G., Van De Steene, B. (2010), Energy audit of a full scale MBR system. Desalination, 262(1-3), 121-128.

Firdaus, A., Amrina, U. (2015), Energy audit analysis by business intelligence application. Sinergi, 19(3), 3.

Fleiter, T., Schleich, J., Ravivanpong, P. (2012), Adoption of energy-efficiency measures in SMEs-An empirical analysis based on energy audit data from Germany. Energy Policy, 51, 863-875.

Fresner, J., Morea, F., Krenn, C., Uson, J.A., Tomasi, F. (2017), Energy efficiency in small and medium enterprises: Lessons learned from 280 energy audits across Europe. Journal of Cleaner Production, 142, 1650-1660.

Hassan, M.T., Abdelgeliel, M., Hamad, M.S. (2022), Energy audit and Management on Residential and Commercial Building: A Case Study. In: 2022 11th International Conference on Renewable Energy Research and Application (ICRERA), Istanbul, Turkey, p.424-429.

Kluczek, A., Olszewski, P. (2017), Energy audits in industrial processes. Journal of Cleaner Production, 142, 3437-3453.

Lucchi, E. (2018), Applications of the infrared thermography in the energy audit of buildings: A review. Renewable and Sustainable Energy Reviews, 82, 3077-3090.

Mbaye, A. (2022), Review on energy audit: Benefits, barriers, and opportunities. American Journal of Energy and Natural Resources, 1(1), 45-58.

Merigó, J.M., Yang, J.B. (2014), Bibliometric Analysis in Financial Research. In: 2014 IEEE Conference on Computational Intelligence for Financial Engineering and Economics (CIFEr). p223-230.

Saputra, K.A.K., Subroto, B., Rahman, A.F., Saraswati, E. (2022), Eco-efficiency and energy audit to improve environmental performance: An empirical study of hotels in Bali-Indonesia. International Journal of Energy Economics and Policy, 12(6), 175-182.

Sharma, P., Salkuti, S.R., Kim, S.C. (2021), Energy audit: Types, scope, methodology and report structure. Indonesian Journal of Electrical Engineering and Computer Science, 22, 45.

Thollander, P., Palm, J. (2012), Improving Energy Efficiency in Industrial Energy Systems: An Interdisciplinary Perspective on Barriers, Energy Audits, Energy Management, Policies, and Programs. Berlin: Springer Science and Business Media.

UN. (2023), Energy. United Nations Sustainable Development. Available from: https://www.un.org/sustainabledevelopment/energy [Last accessed on 2023 May 21].

Zhou, X., Zhou, M., Huang, D., Cui, L. (2022), A probabilistic model for co-occurrence analysis in bibliometrics. Journal of Biomedical Informatics, 128, 104047.