ENERGY MANAGEMENT IN HIGHER EDUCATION INSTITUTIONS: A BIBLIOMETRIC ANALYSIS OF PAST AND FUTURE RESEARCH TRENDS

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Abstract

This article discusses energy management in higher education institutions using bibliometric analysis to understand past and future research trends, so that future energy needs can be met. This review uses a bibliometric approach, involving 2,266 journals obtained from Web of Science, using two science mapping approaches, namely co-citation analysis and co-word analysis. This is done to investigate the past knowledge structure and future research directions on energy management in higher education institutions. Current research trends on energy management focus on developing frameworks and strategic implementations by considering certain important factors and decision-making strategies. In the future, articles on energy management will focus more on the overall framework and efficiency strategies in implementing energy management in higher education institutions, along with how to anticipate obstacles in its implementation. This article provides benefits for researchers and decision-making practitioners on energy management, by increasing understanding of implementing energy management in higher education institutions. This article provides results and conclusions that can be used by decision-makers in higher education institutions to implement effective and efficient energy management and encourage continuous improvement in higher education institutions.

Keywords: Energy Management, Higher Education Institutions, Bibliometric Analysis, Energy Efficiency, Research Trends

INTRODUCTION

The application of energy management in higher education institutions has become increasingly important in recent years due to its increasing use. Higher education institutions as a place for the development of science and leadership are the right place to lead sustainable energy management practices. However, the level of energy consumption in higher education institutions is often inefficient, mainly due to outdated systems and inadequate energy-saving strategies. The increasing use of energy in higher education institutions such as the use of electronic devices in classrooms, laboratories, and use in other sectors can increase operational costs and carbon emissions that cause climate change (Shafie et al., 2021; Patil et al., 2023).

The implementation of energy management practices not only supports energy efficiency in higher education institutions but also becomes a form of environmental concern by implementing environmentally friendly building designs and smart energy systems to reduce energy consumption and increase continuous improvement.(Dewi & Yuliani, 2024). There is a very significant knowledge gap regarding the development of energy management in higher education institutions, previous studies have discussed the waste that occurs in higher education institutions such as the use of water pumps for too long, lighting systems using large power that does not match the needs and air conditioners that remain on when not needed (Pasisahra, 2020; (Indriyati et al., 2021). In addition, the increase in the number of students who register each year can also increase the energy needs in higher education institutions (Kartini et al., 2022).

Based on this gap, bibliometric analysis is used to map research on energy management in higher education institutions on past and future research trends. By evaluating the structure and development of research on energy management in higher education institutions. This analysis aims to provide a better understanding of the themes, obstacles, and development directions of the research topic. The science mapping method helps to identify areas/topics that have not been explored, highlight emerging trends, and provide suggestions for further researchers on topics to be researched in the future according to the development of research topics (Donthu et al., 2021; Zupic & Čater, 2015).

The purpose of this study is to fill the research gap by conducting a comprehensive bibliometric analysis to determine past and future research trends on energy management in higher education institutions using co-citation analysis and co-word analysis. Thus, this study seeks to achieve the following objectives:

1. To investigate the past knowledge structure of energy management in higher education institutions using co-citation analysis.
2. To predict future research directions on energy management in higher education institutions using co-word analysis.

This article is structured in a well-structured format, consisting of a short introduction, a comprehensive section explaining the bibliometric methodology used, the research findings focused on past and future research trends, the next section explaining the implications and limitations of the study and offering recommendations for future research and closing with the researcher's conclusion.

RESEARCH METHOD

Bibliometric Approach

This article uses a bibliometric analysis approach methodology to analyze energy management research trends in higher education institutions. Bibliometric analysis is a systematic method for identifying patterns, trends, and impacts of scientific publications in a particular field. Bibliometric analysis allows researchers to better understand the development of research on a particular topic and identify gaps in articles that can be filled by further researchers (Passas, 2024; Wider et al., 2024). Bibliometric analysis is important because it has the advantage of providing a comprehensive picture of research in a particular field. By using a quantitative approach, this analysis can identify patterns, trends, and relationships between literature objectively and systematically (Zupic & Čater, 2015). One of the advantages of bibliometric analysis is that it can analyze large amounts of data efficiently so that it can find out the development of research in depth. Bibliometric analysis uses the Vosviewer application to produce information and visually identify emerging trends in a particular topic and the development of research on the topic (van Eck & Waltman, 2015). Techniques used in bibliometric analysis such as co-citation analysis and co-word analysis can help reveal conceptual relationships, topic proximity, and relevant key terms in the literature (Donthu et al., 2021). The following is an explanation of co-citation analysis and co-word analysis:

1. Co-citation analysis is a technique used in articles to evaluate the relationship between documents that are frequently cited together in previous research (Park & Shea, 2020). This analysis technique helps to identify past research trends and conceptual structures in the topic of energy management in higher education institutions (Klarin, 2024).
2. Co-Word Analysis is a technique applied to determine the direction of future research, by mapping the occurrence of keywords that are often used in energy management literature. This technique helps in providing insight into the main themes and concepts that form the basis for further research developments (Klarin, 2024). This analysis reveals how the relationships between concepts and their development over time are used to predict future research trends (Callon et al., 1983).

Search Strategy and Data Collection Procedures

The search and data collection were conducted on November 3, 2024, using the Web of Science (WOS) database. This database is well-known for supporting bibliometric analysis, as it provides access to a large and reliable scientific dataset, containing more than 74.8 million records in 254 disciplines used in articles (Singh et al., 2021). Keywords serve as important descriptions of a document connected by boolean operators such as AND, OR, and NOT, which are used to search for journals relevant to a topic in the Web of Science (Firoozeh et al., 2020; Muhammad, 2017). By using the main keyword "energy management" which is then diversified by using its synonyms, related terms, and variations. With the search string used to retrieve data from database: TS = (("energy management" OR "energy optimization*" OR "energy efficiency*" OR "energy conservation*" OR "energy consumption management" OR "energy-saving strategy*" OR "energy literacy" OR "energy audit" OR "renewable energy management" OR "energy system management") AND ("campus*" OR "university*" OR "college*" OR "higher education" OR "HEI*" OR "higher learning" OR "IHL*")).

RESULTS AND DISCUSSION

Descriptive Analysis

The search results using the Web of Science database resulted in 2,266 documents successfully obtained, with 22,631 citations and 22,194 without self-citations with an H-index of 59, with an average of 9.57 citations per article. Figure 1 displays the number of publications and citations from 2020 to 2024, the chart shows the increasing interest in studying energy management in higher education institutions. The number of publications and citations is expected to continue to increase in the future. Research on energy management in higher education institutions does not limit a certain period of publications included, because the main purpose of this study is to explain a comprehensive review related to all available literature on energy management found in the Web of Science. Thus, this study can find all developments in energy management in higher education institutions in past and future research trends.

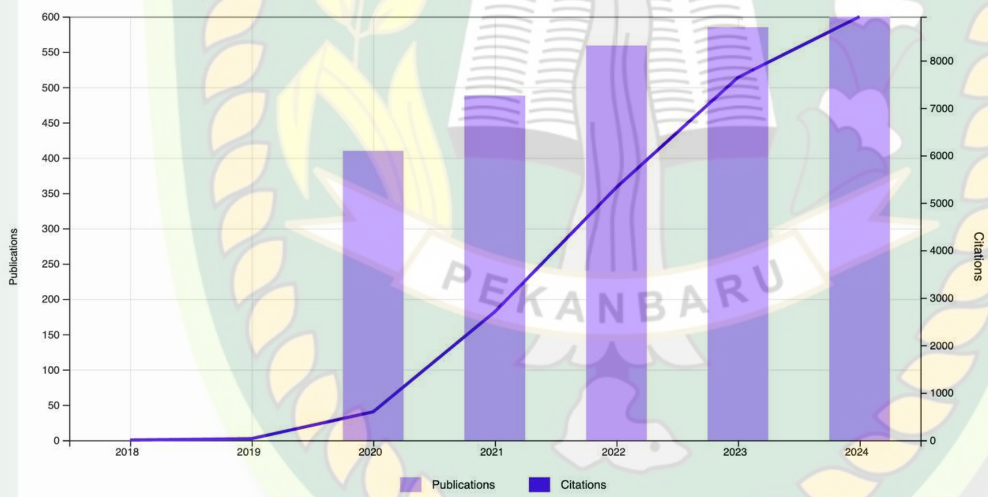

Figure 1.
Number of Publications and Citations on Energy Management in the WoS Database
Source: WoS database, retrieved on November 3, 2024

Co-citation Analysis

Co-Citation Analysis is performed using the same database, to identify relationships between the most frequently cited documents in the literature, by selecting an appropriate threshold to avoid irrelevant cluster results (Geng et al., 2020). This analysis examines 10 to 12 occurrences to generate the most coherent themes. Co-citation analysis presents 12 of 98,725 references that meet the 46-occurrence threshold, resulting in three cluster groups.

Too high a threshold may result in over-filtering, causing relevant clusters to be missed, while too low a threshold may result in the creation of many clusters, resulting in duplicate themes.(Rejeb et al., 2022). Table 1 presents the top 10 documents used in the co-citation analysis.

Table 1
10 Documents with the Most Citations

Ranking	Publication	Number of Citation Documents	Total Link Strength
1	Pérez-Lombard et al., (2008): A review on buildings energy consumption information.	52	47
2	Chung & Rhee, (2014): Potential opportunities for energy conservation in existing buildings on university campus: A field survey in Korea.	27	45
3	Ge et al., (2018): Energy efficiency optimization strategies for university research buildings with hot summer and cold winter climate of China based on the adaptive thermal comfort	16	37
4	Khoshbakht et al.,(2018): Energy use characteristics and benchmarking for higher education buildings.	15	33
5	Leal Filho et al., (2019): A comparative study of approaches towards energy efficiency and renewable energy use at higher education institutions.	19	33
6	Song et al., (2017): Energy efficiency-based timetabling course for university buildings	15	13
7	Ajzen, (1991): The Theory of Planned Behavior	21	32
8	Husein and Chung, (2018): Optimal design and financial feasibility of a university campus microgrid considering renewable energy incentives.	16	30
9	Alshuwaikhat and Abubakar, (2008): An integrated approach to achieving campus sustainability: assessment of the current campus environmental management practices	15	29
10	Amaral et al.,(2020): A review of empirical data of sustainability initiatives in university campus operations	13	28

Source: Created by the Author Using Vosviewer Analysis and Bibliometric Metadata

Network visualization of the analysis co-citation is presented in Figure 2, with a division of three different clusters with different themes. Cluster 1 is colored red, cluster 2 is colored green, and cluster 3 is colored blue. The author has labeled each cluster based on the results of inductive interpretation. Table 2 presents a summary of the co-citation analysis consisting of cluster numbers and colors, cluster labels, number of publications, and representative publications.

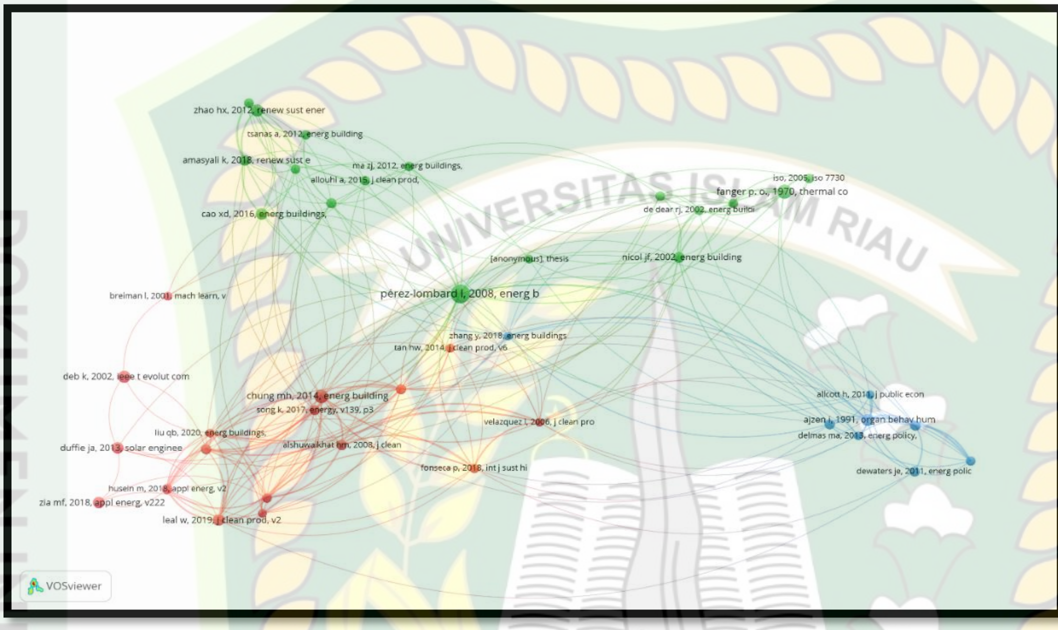

Figure 2.
Co-Citation Analysis of Energy Management in Higher Education Institutions
Source: Created by the author using VOSviewer.

Table 2
Co-Citation Analysis of Energy Management in the Context of Higher Education Institutions

Cluster No. and Color	Representing Publications	Number of publications	Cluster Labels
1 (red)	Chung & Rhee, (2014)),Fonseca et al., (2018), Ge et al., (2018),Guan et al., (2016),Husein & Chung, (2018).	17	Energy efficiency and sustainability in higher education institutions.
2 (green)	Pérez-Lombard et al.(2008),Zhao and Magoulès,(2012),Cao et al.	17	Key strategies and insights to improve energy efficiency, energy

Cluster No. and Color	Representing Publications	Number of publications	Cluster Labels
	(2016),Nicol and Humphreys, (2002),Amasyali & El-Gohary,(2018).		consumption prediction, and comfort conditions in buildings.
3 (blue)	Ajzen, (1991), DeWaters and Powers, (2011), Allcott, (2011), Zhang et al.(2018), Delmas et al.(2013).	8	Behaviors and strategies to promote energy conservation and environmental awareness.

Source: Created by the Author Based on Vosviewer and Bibliometric Metadata

The network structure of the co-citation analysis in Figure 2 shows three clusters representing three different themes in this domain. The three clusters are labeled according to the author's interpretation. Here is a further explanation of each cluster:

Cluster 1 (red): Energy efficiency and sustainability in higher education institutions. Consisting of 17 items that discuss the potential for energy conservation in higher education institutions by 6% - 30%, by utilizing good and proper use of buildings and limited operating hours during semester holidays.(Chung & Rhee, 2014). The strategy of adjusting activities in higher education institutions, especially in the use of heating and air conditioning according to needs, has been proven to be able to increase energy efficiency in higher education institutions (Ge et al., 2018).

Steps to save costs can be taken by using LED lights and photovoltaic (PV) systems, allowing a reduction in energy consumption of up to 30 kWh/m2 with a total saving of 42.4%.(Fonseca et al., 2018). The database approach is also important to analyze long-term energy usage accurately and to know how to optimize the use of that energy (Guan et al., 2016).

In the context of continuous improvement in higher education institutions, a framework that combines environmental management, public participation, and continuing education can enhance positive impacts on the environment (Alshuwaikhat & Abubakar, 2008). Globally, sustainability trends in higher education institutions focus on increasing renewable energy and reducing building energy consumption in higher education institutions as has been done by developed countries.(Amaral et al., 2020).

The conclusion of the explanation above is to achieve sustainable energy efficiency in higher education institutions, it is necessary to implement the use of buildings according to needs, the use of heating and air conditioning if needed, the use of LED lights in lighting systems and photovoltaic (PV) systems. The combination of environmental management frameworks, public participation, and continuing education can increase the positive impact on the environment focus on renewable energy systems, and reduce energy consumption in higher education institution buildings.

Cluster 2 (green): Key strategies and insights to improve energy efficiency, energy consumption prediction, and comfort conditions in buildings. 17 items discuss key strategies and insights to improve energy efficiency, energy consumption prediction, and comfortable conditions in the use of facilities in higher education institutions. These articles highlight various strategies and approaches to optimize energy use in higher education institutions. Amasyali and El-Gohary, (2018) found that data-driven models are very effective in predicting energy usage using the right data.

Technologies that combine design, energy-efficient systems, and renewable energy could be a solution to reducing global energy demand and carbon emissions (Cao et al., 2016). Allouhi et al., (2015) emphasize the importance of comprehensive energy policies and the availability of up-to-date data to effectively manage and reduce energy consumption. The database approach can improve the accuracy of predicting energy consumption, although in practice it has not been implemented well.(Bourdeau et al., 2019). Meanwhile, Zomorodian et al.,(2016) found that comfort in the classroom is often a problem and that further study is needed in the higher education institution environment.

The conclusion from the explanation above is that data-based models are very effective in predicting energy use using the right data, and show that technologies that combine design, energy-efficient systems, and renewable energy can be a solution to the high demand for energy. To overcome the problem of classroom comfort, further research is needed in the environment of higher education institutions.

Cluster 3 (blue): Behaviors and strategies to promote energy conservation and environmental awareness. 8 items discuss behavior and strategies to encourage energy conservation and environmental awareness. The articles discuss approaches to encourage changes in people's behavior in energy consumption. Information-based strategies can be used to reduce energy consumption (Delmas et al., 2013), as well as the importance of energy literacy through education to improve knowledge, attitudes, and behavior in energy management (DeWaters & Powers, 2011).

The study was conducted by Allcott, (2011) to explain the influence of social norms in reducing energy consumption. To achieve energy efficiency, strategies such as giving awards to energy savers can be implemented to change energy waste behavior (Abrahamse et al., 2005). As well as, Ajzen, (1991) offers a theoretical framework for understanding the psychological factors that influence individual decisions about energy management.

The conclusion of the explanation above is to encourage energy conservation, it is necessary to implement energy-saving behavioral strategies and environmental awareness to encourage changes in people's behavior in consuming energy. Implementing information-based strategies on energy use can also be used in designing energy management systems and presenting data on the importance of energy literacy through education to improve knowledge, attitudes, behaviors, and psychological factors that influence decisions in energy management.

Co–Word Analysis

Co-word analysis is performed using the same database, to identify the relationships between the most frequently used keywords in the literature, by choosing an appropriate threshold will avoid the results of irrelevant clusters, the same as co-citation analysis, too high a threshold can result in excessive filtering, which causes relevant clusters to be missed, while too low a threshold can lead to the creation of many clusters, which results in duplication of themes (Geng et al., 2020). This analysis tested 27 to 30 occurrences to produce the most coherent themes. Out of 11,189 keywords, 56 keywords met the 30-occurrence threshold and were grouped into 3 clusters. The 15 most frequently used keywords are listed in Table 3. The keyword "energy efficiency" appeared 504 times, followed by "performance" 338 times. The following is a further explanation of the clusters.

Table 3
Top 15 Keywords in Co-Word Analysis

Ranking	Keywords	Frequency Emergence	Total Link Strength
1	Energy efficiency	504	956
2	Performance	338	921
3	Optimization	282	703
4	Design	222	619
5	Model	198	505
6	Buildings	151	492
7	Consumption	157	471
8	Simulation	155	415
9	System	153	413
10	Energy	163	371
11	Energy Management	143	354
12	Efficiency	121	352
13	Thermal comfort	108	320
14	System	107	307
15	Impact	104	296

Note: Sorted by the Number of Occurrences.

Network visualization of the co-word analysis is presented in Figure 3, with a division of three different clusters with different themes. Cluster 1 is colored red, cluster 2 is colored green, and cluster 3 is colored blue. The author has labeled each cluster based on the results of inductive interpretation. Table 4 presents a summary of the co-word analysis consisting of cluster numbers and colors, cluster labels, number of publications, and representative publications.

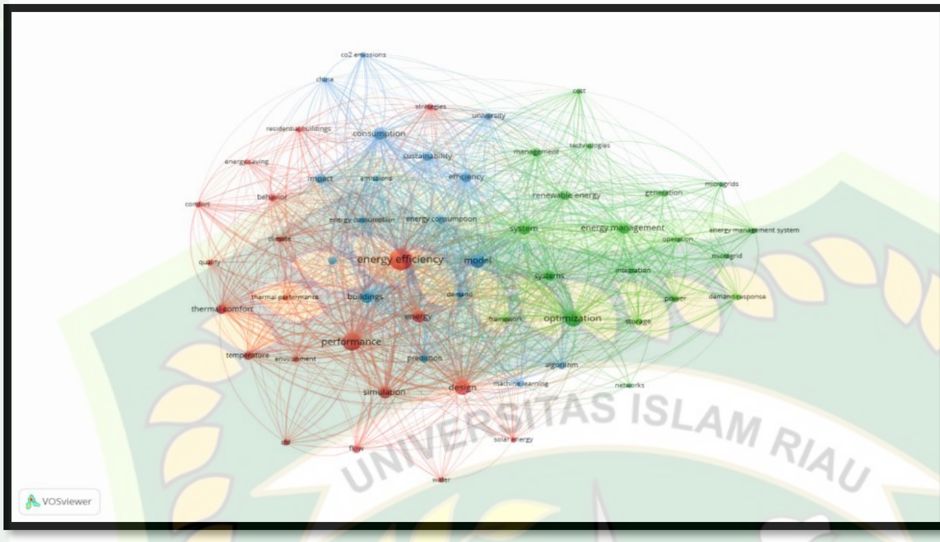

Figure 3.
Co-Word Analysis of Energy Management Research in Higher Education Institutions
Source: Created by the author using VOSviewer.

Table 4
Summary of Co-Word Analysis on Energy Management in Higher Education Institutions

Cluster No and Color	Keywords Represent	Number of Keywords	Cluster Labels
1 (red)	Behavior, CFD, climate, comfort, design, energy, energy efficiency, energy saving, environment, solar energy.	20	Optimizing energy systems for cost efficiency and integrated energy management.
2 (green)	Cost, demand response, energy management, energy management system, framework, generation, integration, management, microgrid.	19	Smart technologies for energy efficiency in buildings.
3 (blue)	Algorith, buildings, co2 emissions, consumption, demand, efficiency, emissions, energy conservation, energy consumption, impact, machine learning.	17	Sustainable energy solutions through integrated intelligent systems.

Source: Created by the Author Based on the Results of Vosviewer Analysis and Bibliometric Metadata

The network structure of the co-word analysis in Figure 3 shows three clusters representing three different themes in this domain. The three clusters are labeled according to the author's interpretation. Here is a further explanation of each cluster:

Cluster 1 (red): Optimizing energy systems for cost efficiency and integrated energy management. Consisting of 20 keywords that focus on energy efficiency in buildings and thermal comfort, it is of particular concern related to sustainable design approaches, simulations, and implementation strategies. The goal of this effort is to optimize energy consumption while creating a comfortable environment. Energy-saving strategies in buildings involve a combination of technologies.

A study in Applied Energy shows that the integration of solar panel technology and energy control systems using the Internet of Things (IoT) can increase energy efficiency by 30% compared to conventional methods.(Yang et al., 2014). Thermal comfort is something that affects the productivity and comfort of building users, by using an adaptive building concept, building users can adjust their needs to the environment, such as opening windows, using fans, and using air conditioning depending on the needs at that time.(Tobias et al., 2024).

The summary of the explanation above is that energy efficiency is a special concern related to the design approach, simulation, and sustainable implementation strategies. The purpose of energy efficiency is to optimize energy consumption by creating ventilation, using heat management materials, using solar panel technology, and implementing the Internet of Things (IoT).

Cluster 2 (green): Smart technologies for energy efficiency in buildings. Consisting of 19 items that focus on design, simulation, and performance in the context of energy efficiency, buildings, and the environment which are important in energy management. This discussion also includes design strategies that support energy consumption reduction and optimization of comfort for building users. The use of tools such as Computational Fluid Dynamics (CFD) is very important to predict and analyze air, temperature, and the performance of building energy systems. In addition, the integration of energy-saving technologies and sustainable materials has an important role in creating buildings that are efficient in energy consumption and environmentally friendly (Tian et al., 2018).

Building energy efficiency depends not only on physical design but also on the integration of intelligent technologies such as Building Information Modeling (BIM) and the Internet of Things (IoT) which can improve real-time energy management.(Knudsen & Petersen, 2020).The conclusion from the explanation above is that energy management can be realized by focusing on design, using tools such as Computational Fluid Dynamics (CFD) to analyze air, temperature, and building system performance, as well as using smart technology such as Building Information Modeling (BIM) and Internet of Thing (IoT) which can improve energy management in real-time.

Cluster 3 (blue): Sustainable energy solutions through integrated intelligent systems. Consisting of 17 items that focus on energy management and technology integration in sustainable energy systems, based on efficient management of energy resources to meet energy needs. Energy optimization is carried out by implementing an Energy Management System (EMS) designed to monitor and reduce energy consumption, both on a small scale and a larger scale.

Microgrids are designed to support sustainability through renewable resources, real-time energy load management, and energy storage optimization (Zhou et al., 2016). The success of technology integration in the energy system cannot be separated from the role of the Internet of Things (IoT), which allows monitoring to be carried out centrally. This can increase transparency and data security in energy management and ensure the sustainability of energy management. Thus, energy management can run well according to the objectives of continuous improvement (C. Zhang et al., 2018).

The conclusion of the cluster explanation above explains energy management and technology integration in sustainable systems. By implementing an Energy Management System (EMS) designed to monitor and reduce energy consumption, both on a small scale and a larger scale, Microgrid is designed to support sustainability through renewable resources, real-time energy load management, and energy storage optimization, and implementing the Internet of Thing (IoT) to conduct centralized monitoring of energy usage.

This study provides very significant implications for energy management in higher education institutions. The results of this study discuss the importance of the role of energy efficiency technology, environmentally friendly building design, and the involvement of building user behavior in reducing energy consumption. From these findings, it is shown that to achieve sustainable energy efficiency in higher education institutions, not only technology needs to be considered but also human factors, such as student behavior and other activities in higher education institutions (Zhang et al., 2018; Ge et al., 2018).

For theoretical knowledge, this article can be a literature on energy management by providing insights related to research trends, past and future using a bibliometric approach with co-citation analysis and co-word analysis methods that have introduced trend mapping and relationships between relevant topics for further studies on energy management in higher education institutions (Zupic & Čater, 2015; Donthu et al., 2021). This study also helps identify gaps in the literature, such as the lack of studies integrating technology and behavior in energy management strategies.

The results of these findings can be used by policymakers and decision-makers in designing efficient energy management strategies, by implementing the use of renewable energy systems, data-based energy planning, and the influence of behavioral policies on energy savings to improve sustainability in higher education institutions.(Alshuwaikhat & Abubakar, 2008;Guan et al., 2016). Several studies have highlighted that the implementation of energy management in higher education institutions has not been maximized so energy waste still occurs in higher education institutions.

Researchers suggest that higher education institutions create energy consumption guidelines through efficient building design and data-based energy-saving policies. And better energy management education for all parties in higher education institutions. This study also opens up opportunities for further researchers to conduct research in terms of integration between technologies and making suggestions for implementing energy efficiency in higher education institutions (Amasyali & El-Gohary, 2018; Bourdeau et al., 2019).

CONCLUSION

The bibliometric analysis review presents a perspective on the implementation of energy management in higher education institutions, through co-citation analysis and co-word analysis. This study provides an overview of past and future research trends on energy management in higher education institutions. A total of 2266 articles on energy management were retrieved from the WoS database. Studies have been increasing steadily since 2020 and are expected to continue to increase every year in implementing energy management in higher education institutions by reducing energy waste. This can ultimately improve performance and continuous improvement in higher education institutions. Co-citation analysis produces three themes representing past research trends discussing energy efficiency, energy consumption prediction, building comfort conditions, and conservation strategies, while co-word analysis produces three themes on optimizing energy systems for cost efficiency, implementing smart technologies and sustainable energy solutions that provide suggestions for future researchers on energy management in higher education institutions.

This study has several limitations, first, this study only examines the publication of articles published in the WoS journal, not using other sources such as books, conference proceedings, and other sources. Choosing WoS as a data source for this study because WoS has a comprehensive coverage of high-quality journals, conducted by previous researchers and can be used in the VOSviewer software application to conduct bibliometric analysis. However, this can ignore important publications contained in other databases such as Scopus, PubMed, or Dimensions. Combining various types of publications and other sources can provide a broader analysis because each database can combine various types of publications, regional journals, or new topics that are not yet included in WoS. For further research, it is recommended to consider this weakness by expanding the scope of data sources to include other databases. This will improve the understanding of energy management in higher education institutions in various regions.

Both subjectivities in classifying research themes are based on the author's interpretation, which can lead to differences in themes based on the research context. For example, when different groups of authors interpret network visualizations, different themes may be produced. However, it is a norm in quantitative research to produce different themes, which are used for evaluation tools in research.

REFERENCES

Abdelaziz, E. A., Saidur, R., & Mekhilef, S. (2011). A review on energy saving strategies in industrial sector. *Renewable and Sustainable Energy Reviews*, *15*(1), 150–168. https://doi.org/10.1016/j.rser.2010.09.003

Abrahamse, W., Steg, L., Vlek, C., & Rothengatter, T. (2005). A review of intervention studies aimed at household energy conservation. *Journal of Environmental Psychology*, *25*(3), 273–291. https://doi.org/10.1016/j.jenvp.2005.08.002

Ajzen, I. (1991). The Theory of Planned Behavior. *Academic Press, Inc.*, *50*(1), 179–211. https://doi.org/10.47985/dcidj.475

Allcott, H. (2011). Social norms and energy conservation. *Journal of Public Economics*, *95*(9–10), 1082–1095. https://doi.org/10.1016/j.jpubeco.2011.03.003

Allouhi, A., El Fouih, Y., Kousksou, T., Jamil, A., Zeraouli, Y., & Mourad, Y. (2015). Energy consumption and efficiency in buildings: Current status and future trends. *Journal of Cleaner Production*, *109*, 118–130. https://doi.org/10.1016/j.jclepro.2015.05.139

Alshuwaikhat, H. M., & Abubakar, I. (2008). An integrated approach to achieving campus sustainability: assessment of the current campus environmental management practices. *Journal of Cleaner Production*, *16*(16), 1777–1785. https://doi.org/10.1016/j.jclepro.2007.12.002

Amaral, A. R., Rodrigues, E., Gaspar, A. R., & Gomes, Á. (2020). A review of empirical data of sustainability initiatives in university campus operations. *Journal of Cleaner Production*, *250*, 119558. https://doi.org/10.1016/j.jclepro.2019.119558

Amasyali, K., & El-Gohary, N. M. (2018). A review of data-driven building energy consumption prediction studies. *Renewable and Sustainable Energy Reviews*, *81*(March 2017), 1192–1205. https://doi.org/10.1016/j.rser.2017.04.095

Bourdeau, M., Zhai, X. qiang, Nefzaoui, E., Guo, X., & Chatellier, P. (2019). Modeling and forecasting building energy consumption: A review of data-driven techniques. *Sustainable Cities and Society*, *48*(February), 101533. https://doi.org/10.1016/j.scs.2019.101533

Callon, M., Courtial, J.-P., Turner, W. A., & Bauin, S. (1983). Colloquium on the sociological analysis of scientific and technical research. In *Social Science Information* (Vol. 22, Issue 2, pp. 191–235).

Cao, X., Dai, X., & Liu, J. (2016). Building energy-consumption status worldwide and the state-of-the-art technologies for zero-energy buildings during the past decade. *Energy and Buildings*, *128*, 198–213. https://doi.org/10.1016/j.enbuild.2016.06.089

Chung, M. H., & Rhee, E. K. (2014). Potential opportunities for energy conservation in existing buildings on university campus: A field survey in Korea. *Energy and Buildings*, *78*, 176–182. https://doi.org/10.1016/j.enbuild.2014.04.018

Delmas, M. A., Fischlein, M., & Asensio, O. I. (2013). Information strategies and energy conservation behavior: A meta-analysis of experimental studies from 1975 to 2012. *Energy Policy*, *61*, 729–739. https://doi.org/10.1016/j.enpol.2013.05.109

DeWaters, J. E., & Powers, S. E. (2011). Energy literacy of secondary students in New York State (USA): A measure of knowledge, affect, and behavior. *Energy Policy*, *39*(3), 1699–1710. https://doi.org/10.1016/j.enpol.2010.12.049

Dewi, N. R., & Yuliani, S. (2024). Strategi efisiensi energi bangunan pada kampus fakultas teknik infrastruktur institut teknologi bacharuddin jusuf habibie. *Jurnal Ilmiah Mahasiswa Arsitektur*, *7*(2), 630–641. https://jurnal.ft.uns.ac.id/index.php/senthong/index%0ASTRATEGI

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*(March), 285–296. https://doi.org/10.1016/j.jbusres.2021.04.070

Firoozeh, N., Nazarenko, A., Alizon, F., & Daille, B. (2020). Keyword extraction: Issues and methods. *Natural Language Engineering*, *26*(3), 259–291. https://doi.org/10.1017/S1351324919000457

Fonseca, P., Moura, P., Jorge, H., & de Almeida, A. (2018). Sustainability in university campus: options for achieving nearly zero energy goals. *International Journal of Sustainability in Higher Education*, *19*(4), 790–816. https://doi.org/10.1108/IJSHE-09-2017-0145

Ge, J., Wu, J., Chen, S., & Wu, J. (2018). Energy efficiency optimization strategies for university research buildings with hot summer and cold winter climate of China based on the adaptive thermal comfort. *Journal of Building Engineering*, *18*, 321–330. https://doi.org/10.1016/j.jobe.2018.03.022

Geng, K., He, T., Liu, R., Dalapati, S., Tan, K. T., Li, Z., Tao, S., Gong, Y., Jiang, Q., & Jiang, D. (2020). Covalent Organic Frameworks: Design, Synthesis, and Functions. *Chemical Reviews*, *120*(16), 8814–8933. https://doi.org/10.1021/acs.chemrev.9b00550

Guan, J., Nord, N., & Chen, S. (2016). Energy planning of university campus building complex: Energy usage and coincidental analysis of individual buildings with a case study. *Energy and Buildings*, *124*, 99–111. https://doi.org/10.1016/j.enbuild.2016.04.051

Husein, M., & Chung, I. Y. (2018). Optimal design and financial feasibility of a university campus microgrid considering renewable energy incentives. *Applied Energy*, *225*(February), 273–289. https://doi.org/10.1016/j.apenergy.2018.05.036

Indriyati, C., Daud, A., & Prima, R. (2021). Analisis Konservasi dan Efisiensi Energi Pada Tower Fakultas Hukum Universitas Sriwijaya Berdasarkan Sertifikasi Green Building Indonesia. *Syntax Literate: Jurnal Ilmiah Indonesia p–ISSN: 2541-0849 e-ISSN : 2548-1398*, *6*(17), 2662–2678.

Kartini, S., Ashgar, A., Gungat, L., Sarman, A. M., & Bolong, N. (2022). An Evaluation of Sustainable Campus Guidelines in Energy Management Context. *Transactions on Science and Technology*, *9*(2), 152–163.

Khoshbakht, M., Gou, Z., & Dupre, K. (2018). Energy use characteristics and benchmarking for higher education buildings. *Energy and Buildings*, *164*, 61–76. https://doi.org/10.1016/j.enbuild.2018.01.001

Klarin, A. (2024). How to conduct a bibliometric content analysis: Guidelines and contributions of content co-occurrence or co-word literature reviews. *International Journal of Consumer Studies*, *48*(2), 1–20. https://doi.org/10.1111/ijcs.13031

Knudsen, M. D., & Petersen, S. (2020). Economic model predictive control of space heating and dynamic solar shading. *Energy and Buildings*, *209*. https://doi.org/10.1016/j.enbuild.2019.109661

Leal Filho, W., Salvia, A. L., Paço, A. do, Anholon, R., Gonçalves Quelhas, O. L., Rampasso, I. S., Ng, A., Balogun, A. L., Kondev, B., & Brandli, L. L. (2019). A comparative study of approaches towards energy efficiency and renewable energy use at higher education institutions. *Journal of Cleaner Production*, *237*, 117728. https://doi.org/10.1016/j.jclepro.2019.117728

Muhammad, B. A. (2017). Efficiency of Boolean Search strings for Information Retrieval. *American Journal of Engineering Research*, *6*(11), 216–222. www.ajer.org

Muqeet, H. A., Javed, H., Akhter, M. N., Shahzad, M., Munir, H. M., Nadeem, M. U., Bukhari, S. S. H., & Huba, M. (2022). Sustainable Solutions for Advanced Energy Management System of Campus Microgrids: Model Opportunities and Future Challenges. *Sensors*, *22*(6). https://doi.org/10.3390/s22062345

Nicol, J. F., & Humphreys, M. A. (2002). Adaptive thermal comfort and sustainable thermal standards for buildings. *Energy and Buildings*, *34*(6), 563–572. https://doi.org/10.1016/S0378-7788(02)00006-3

Park, H., & Shea, P. (2020). A review of ten-year research through co-citation analysis: Online learning, distance learning, and blended learning. *Online Learning Journal*, *24*(2), 225–244. https://doi.org/10.24059/olj.v24i2.2001

Pasisahra, D. S. (2020). Penempatan Svc (Static Var Compensator) Pada Jaringan Distribusi Bangkinang Untuk Mengurangi Rugi-Rugi Daya Menggunakan Software Etap 7.5.0. *Orbith: Majalah Ilmiah Pengembangan …*, *16*(1), 45–49. https://jurnal.polines.ac.id/index.php/orbith/article/view/2068/0

Passas, I. (2024). Bibliometric Analysis: The Main Steps. *Encyclopedia*, *4*(2), 1014–1025. https://doi.org/10.3390/encyclopedia4020065

Patil, G. N., Tanavade, S. S., Sudhir, C. V., & Saravanan, A. M. (2023). Strategic Energy Management and Carbon Footprint Reduction in University Campuses: A Comprehensive Review. *International Journal of Energy Economics and Policy*, *13*(6), 15–27. https://doi.org/10.32479/ijeep.14873

Pérez-Lombard, L., Ortiz, J., & Pout, C. (2008). A review on buildings energy consumption information. *Energy and Buildings*, *40*(3), 394–398. https://doi.org/10.1016/j.enbuild.2007.03.007

Rejeb, A., Rejeb, K., Simske, S. J., & Keogh, J. G. (2022). Blockchain technology in the smart city: a bibliometric review. In *Quality and Quantity* (Vol. 56, Issue 5). Springer Netherlands. https://doi.org/10.1007/s11135-021-01251-2

Shafie, S. M., Nu'man, A. H., & Yusuf, N. N. A. N. (2021). Strategy in energy efficiency management: University campus. *International Journal of Energy Economics and Policy*, *11*(5), 310–313. https://doi.org/10.32479/ijeep.11265

Singh, V. K., Singh, P., Karmakar, M., Leta, J., & Mayr, P. (2021). The journal coverage of Web of Science, Scopus and Dimensions: A comparative analysis. *Scientometrics*, *126*(6), 5113–5142. https://doi.org/10.1007/s11192-021-03948-5

Song, K., Kim, S., Park, M., & Lee, H. S. (2017). Energy efficiency-based course timetabling for university buildings. In *Energy* (Vol. 139). Elsevier B.V. https://doi.org/10.1016/j.energy.2017.07.176

Tian, W., Han, X., Zuo, W., & Sohn, M. D. (2018). Building energy simulation coupled with CFD for indoor environment: A critical review and recent applications. *Energy and Buildings*, *165*, 184–199. https://doi.org/10.1016/j.enbuild.2018.01.046

Tobias, K., Schiavon, S., & Veronica, G.-H. (2024). Spatial Thermal Autonomy (sTA): A New Metric for Enhancing Building. *EScholarship.Org*. https://github.com/tkramer/2024-paper-conference-cate

van Eck, N. J., & Waltman, L. (2015). Software survey: VOSviewer, a computer program for bibliometric mapping. *Leiden: Univeristeit Leiden*, *March*, 1–29. http://www.vosviewer.com/documentation/Manual_VOSviewer_1.6.1.pdf

Wider, W., Iwinska, K., Lin, J., Fauzi, M. A., Hossain, S. F. A., Jiang, L., & Udang, L. N. (2024). Academia as a driver of change: a bibliometric analysis of pro-environmental behavior in higher education institutions. *International Journal of Sustainability in Higher Education*, *ahead-of-p*(ahead-of-print). https://doi.org/10.1108/IJSHE-08-2023-0353

Yang, L., Yan, H., & Lam, J. C. (2014). Thermal comfort and building energy consumption implications - A review. *Applied Energy*, *115*, 164–173. https://doi.org/10.1016/j.apenergy.2013.10.062

Zhang, C., Wu, J., Zhou, Y., Cheng, M., & Long, C. (2018). Peer-to-Peer energy trading in a Microgrid. *Applied Energy*, *220*(December 2017), 1–12. https://doi.org/10.1016/j.apenergy.2018.03.010

Zhang, Y., Bai, X., Mills, F. P., & Pezzey, J. C. V. (2018). Rethinking the role of occupant behavior in building energy performance: A review. *Energy and Buildings*, *172*, 279–294. https://doi.org/10.1016/j.enbuild.2018.05.017

Zhao, H. X., & Magoulès, F. (2012). A review on the prediction of building energy consumption. *Renewable and Sustainable Energy Reviews*, *16*(6), 3586–3592. https://doi.org/10.1016/j.rser.2012.02.049

Zhou, K., Yang, S., & Shao, Z. (2016). Energy Internet: The business perspective. *Applied Energy*, *178*, 212–222. https://doi.org/10.1016/j.apenergy.2016.06.052

Zomorodian, Z. S., Tahsildoost, M., & Hafezi, M. (2016). Thermal comfort in educational buildings: A review article. *Renewable and Sustainable Energy Reviews*, *59*, 895–906. https://doi.org/10.1016/j.rser.2016.01.033

Zupic, I., & Čater, T. (2015). Bibliometric Methods in Management and Organization. *Organizational Research Methods*, *18*(3), 429–472. https://doi.org/10.1177/1094428114562629