buildings

MDPI

Article

Energy Consumption in Higher Education Institutions: A Bibliometric Analysis Focused on Scientific Trends

Juan P. Laporte [1,*] and José M. Cansino [2,3]

[1] Facultad de Ingeniería, Universidad Autónoma de Chile, Pedro de Valdivia 425, Providencia, Santiago 7500912, Chile
[2] Department of Economic Analysis and Political Economy, Facultad de Ciencias Económicas y Empresariales, Universidad de Sevilla, Avda. Ramón y Cajal 1, 41018 Sevilla, Spain; jmcansino@us.es
[3] Facultad de Negocios, Universidad Autónoma de Chile, Pedro de Valdivia 425, Providencia, Santiago 7500912, Chile
* Correspondence: author: jplaporte@uautonoma.cl

Abstract: While universities are expected to exemplify sustainable practices, they often encounter high energy demands. This dichotomy highlights the necessity for research into their energy consumption. Through a Systematic Literature Review, we examined international research trends in this field and explored factors influencing energy consumption. The importance of this article stems from its novel approach to energy consumption in universities, addressed from a global and comprehensive perspective, offering generalizable insights. Additionally, it pioneers in the use of a market concentration indicator (Herfindahl–Hirschman index) to measure the level of diversity in various bibliometric aspects. The extended perspective of our approach helps to close knowledge gaps about scientific trends and common energy consumption factors. Our results show that this topic has been investigated with limited involvement of social sciences. Building function, research intensity, and disciplinary orientation are distinctive factors in energy consumption in this field. Most influential authors, countries, and journals in this area were identified. This analysis contributes academically, by mapping research trends and providing guidance for future studies; practically, by offering insights for educational administrators on common factors affecting energy consumption; and in terms of policy, by advocating for the promotion of social sciences-based investigations on the topic.

Keywords: academic trends; energy consumption; higher education institutions; Systematic Literature Review; scholarly output; university buildings

Citation: Laporte, J.P.; Cansino, J.M. Energy Consumption in Higher Education Institutions: A Bibliometric Analysis Focused on Scientific Trends. *Buildings* **2024**, *14*, 323. https://doi.org/10.3390/buildings14020323

Academic Editor: Emin Açıkkalp

Received: 13 December 2023
Revised: 18 January 2024
Accepted: 22 January 2024
Published: 24 January 2024

1. Introduction

Universities must set a prominent example of sustainable management, actively pursuing a positive impact on society. Higher education leaders hold important responsibilities in terms of balancing financial, social, and environmental objectives, which are often intertwined. They should understand that universities' goals (educating students, generating and distributing knowledge) demand a large number of resources; therefore, the different types of higher education institutions (HEIs) must seek to reduce energy consumption (EC) and cut costs [1].

University buildings are intensive energy and water consumers, with specific consumption factors and patterns that have been less studied than other types of buildings [2]. Each university has specific EC characteristics, depending on the institution's orientation and its area of specialization [3]. Premises in HEIs are often described as energy intensive [4], with electricity being the major source of energy; it is used in heating and cooling systems, laboratories, lighting systems, and elevators, as well as in computing and instructional facilities [5].

The higher education sector significantly impacts the environment. Recognizing this, many universities have taken measures to reduce their ecological footprint. These initiatives include raising awareness about unnecessary energy use, developing more energy-efficient facilities, and implementing renewable energy generation projects on campus [6]. Overall, universities have been working to lessen both their greenhouse gas emissions and their EC, prioritizing renewable and sustainable energy sources [7,8].

Universities, both public and private, play an important role in society. They face the challenge of educating future graduates on a sustainable culture [9], fostering more responsible and environmentally conscious professional behavior. Additionally, HEIs must be role models by engaging in specific actions that demonstrate their commitment to sustainable principles [10]. Furthermore, universities lead the research activities seeking technological progress toward a post-carbon civilization [11], playing a flagship role in the endeavors to understand and mitigate climate change.

Given the prominent role universities hold in the society as examples of sustainable behavior and their significant EC, we believe that a thorough scientific investigation into this topic is essential. This investigation aims to solidify the scientific knowledge in this area and to guide future researchers in their scientific projects on the matter, as well as to raise awareness of the importance of energy utilization in universities. Additionally, gaining a deep understanding of this topic is crucial for drawing general conclusions from specific cases. Such insights can assist managers in higher education institutions to devise and implement effective measures aimed at reducing EC within their organizations. The significance of our study is further underscored by the recent emergence of this topic as a rapidly growing field of research. This is particularly evident considering that several researchers have studied EC patterns among specific universities in countries such as Ecuador, Greece, Mexico, the USA, and Turkey (see examples in Appendix A). As shown in Figure 1, there is increasing academic interest in the EC of HEIs. This is evidenced by the constant growth in both the number of articles published and the number of citations; moreover, both figures have reached their highest values in recent years. We believe that this sustained surge in academic interest in this topic justifies conducting a Systematic Literature Review in this area. This academic research method uses a structured, organized, and reproducible approach to extract evidence about a certain issue or topic from reliable research [12]. A Systematic Literature Review involves identifying and selecting primary studies, followed by extracting, analyzing, and synthesizing the data [13] (see examples of similar research in references [12,14]).

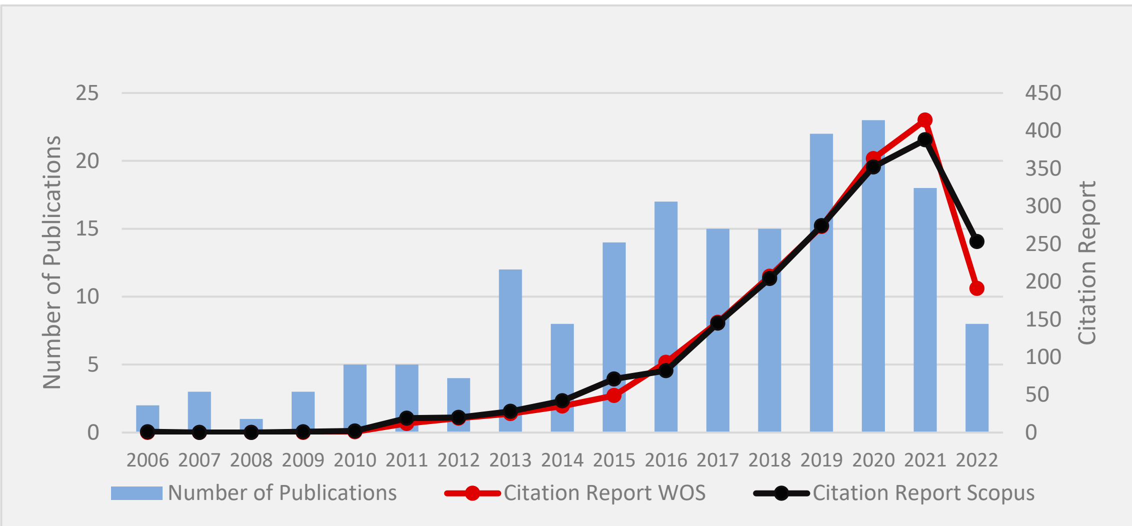

Figure 1. Selected publications and citations about EC in universities. Source: Own elaboration from Web of Science Core Collection/Scopus Database. Extracted on 27 April 2022.

It is important to note that since the extraction of articles was carried out in April 2022, and considering the usual delay in scientific articles being published, the data for the years 2021 and 2022 appear diminished. This situation is expected to change in future analyses.

A review of selected literature about models of sustainable practices in universities, unrestricted in its geographical scope, was carried by Mohammadalizadehkorde and Weaver [15]. They reviewed the bibliography on the sustainability of universities, synthesizing large groups of literature, but describing their study as "necessarily non-exhaustive". Therefore, we believe that the aims and methodology of their research differs from ours.

Although there have been academic studies focusing specifically on certain universities or geographical areas, to the best of our knowledge, there are no scientific articles which address EC in universities by analyzing the factors that are common to HEIs in different regions or countries. Overall, research about EC in the higher education sector is still in its early stages [16,17]. Moreover, the issue of consumption patterns in HEI buildings remains somewhat overlooked [18]. Consequently, there is a knowledge gap about common characteristics of EC within the higher education sector at an international scale, which is worth investigating. Filling the aforementioned knowledge gap will help universities to fulfil their role as leaders in society; indeed, this objective is the main motivation for this research.

Additionally, we have identified a lack of understanding about the academic trends forging this topic. The simple review of the scientific sources points to some authors, countries, and HEIs as forerunners in scholarly output; nevertheless, a more thorough analysis must be undertaken to determine how knowledge has been spread. Also, as mentioned above, reducing universities' EC encompasses both technical and managerial aspects. Consequently, it is important to clarify whether the research on this topic has been oriented toward exact sciences or social sciences. This can be determined by analyzing the discipline orientation of journals and conference proceedings used to disseminate the scientific articles. Previous studies have used the Herfindahl–Hirschman index (HHI) as a measure of multidisciplinarity [19] on a given topic. This index is an important tool used by regulators to evaluate market concentration [20], and we propose that it can be applied to measure the level of concentration of different aspects of a bibliometric analysis.

Building on the previous analysis and considering the knowledge gaps identified, this study establishes three specific objectives: (1) to determine the key characteristic of scientific papers about EC in universities; (2) to analyze the current academic trends in the topic, identifying leading authors, countries, and universities; and (3) to explore the main factors explaining EC in universities. The analysis was carried out for the period from 2006 to 2022. This 16-year time span was selected to cover the period in which there has been a considerable surge in the publications about the studied topic (see Figure 1). Since universities are the main driving force of academic research, understanding how the scientific community has investigated the topic in question is crucial. Therefore, the three established objectives will be addressed in a Systematic Literature Review about EC in HEIs, aiming to answer the following three research questions:

(1) What are the main characteristics of sources publishing academic articles on EC in universities, including leadership, concentration, and multidisciplinarity?
(2) Which countries, universities, and authors are the leading contributors to scholarly output regarding EC in universities?
(3) What factors determine EC in universities according to the literature?

The novelty of this paper lies in addressing EC in universities from a broad, international perspective and seeking common characteristics among different organizations, a contrast to previous articles. This approach marks a departure from the lack of scientific literature tackling the topic in such a comprehensive manner, as outlined in the previous paragraphs. This feature will aid future researchers in focusing their investigations on the topic and will also assist higher education managers in identifying common factors of EC, an area where knowledge is still limited. Another novelty is the application of the HHI to measure the concentration level in various aspects of a bibliometric analysis.

The major findings are that: (i) this topic has been studied under a combination of technical disciplines, but there has been only limited involvement of social sciences; (ii) the USA, China, and the UK are the leading countries in scholarly output about EC in HEIs; (iii) the University of Sheffield leads in terms of publishing papers about this subject, while Energy and Buildings is the most utilized journal; Zhonghua Gou is the most productive author researching this topic, whereas Gul and Patidar are the most cited ones; and (iv) factors driving EC in universities do not differ from those of other sectors.

The rest of the paper is structured as follows. Section 2 explains the research method of the Systematic Literature Review. Section 3 presents the results. Section 4 offers a discussion of the results, while the main conclusions are presented in Section 5.

2. Research Method

In this article, the PRISMA Protocol (Preferred Reporting Items for Systematic Reviews and Meta-Analyses) is utilized to identify appropriate research articles, which facilitates the investigation of the three research questions related to energy consumption in HEIs, as highlighted in the introduction section. Specifically, this procedure was utilized to identify, screen, check their eligibility, and include the final set of texts (see example of its application on [21,22]). Following the iterative search method detailed in Section 2.1, we identified 933 articles from scientific databases. Using the PRISMA protocol, we subsequently filtered out 758 of these articles, ultimately selecting 175 publications for our analysis. In general, the criterion for selection focused on texts that analyze EC in buildings, specifically in university premises, and their determinants. For exclusion, articles were discarded if they, though addressing EC, did not concentrate on university buildings or their main theme was not energy utilization in HEIs. Additionally, works related to energy generation plants managed by universities, energy distribution systems, and energy management systems such as microgrids or smart grids were excluded. This was done in order to concentrate on EC, omitting energy generation or distribution. These criteria for selection are further specified and explained in Section 2.2.

2.1. Identify

This article conducts a search and analysis of scientific publications in the Web of Science (WOS) Core Collection [23], Scielo [24] and Scopus [25] databases, through a combination of keywords related to HEIs and energy.

In order to select the most pertinent set of publications about EC in universities and to limit the outcome to a manageable number of articles, a computer-based routine relying on Visual Basic and Microsoft Access was developed. The desired size and composition of the target set of publications was established at 900–950 publications, with at least 25% of them being WOS articles. In each iteration of the method, the metadata of selected publications were extracted, reorganized, and input into a database. Iteratively, several comprehensive searches (queries) in the scientific publications databases, utilizing varying key concepts (keywords), were conducted. Each search was carefully crafted using different sets of keywords, tailored to explore various aspects of the research area. The queries were formed by two main clauses connected by an "AND" operator; additionally, each clause comprises various keywords linked by an "OR" operator. The main objective of the first clause is to concentrate on the specific topic of interest within the scientific database, which in this case includes terms associated with EC (e.g., "Energy Conservation", "Energy Efficiency", and other related expressions). The second clause aims to identify the domain that is being affected by the topic of interest (e.g., "Higher Education", "University Buildings", etc.). The keywords were adjusted in each iteration, changing the topic and domain; this approach aimed to identify articles that could potentially answer the research questions, while striving to achieve the desired number and composition of the final set of papers. Eleven queries, each with a unique focus and set of keywords, were conducted. For simplicity, we use the letter "Q" to denote them, followed by consecutive numbers. The definitive query in the series was labeled "Q_{FInal}". It is important to note that Q_{Final} was split into two separate queries, one for the WOS and Scielo databases, and another for Scopus. The outcome of each iteration was analyzed in terms of the number of articles containing the respective keyword. Based on this information, the keywords to be used in the next iteration were selected. The search keywords used in each query are listed in Table 1. For instance, the keyword "Campus" was omitted in queries Q_{01}, Q_{02}, Q_{03}, Q_{04}, Q_{05}, Q_{08}, and Q_{09}, while it was included in queries Q_{06}, Q_{07}, Q_{10}, and Q_{Final} (only in its WOS/Scielo version). The result of each query in terms of the number of articles found is displayed in Table 2.

Table 1. Combination of keywords used in each query to the scientific publications' databases.

Keyword	Clause	Type	Boolean Operator	Q_{01}	Q_{02}	Q_{03}	Q_{04}	Q_{05}	Q_{06}	Q_{07}	Q_{08}	Q_{09}	Q_{10}	Q_{Final}	
														WOS/ Scielo	Scopus
Electrical energy consumption	1	Topic	Or	No	No	No	No	No	No	Yes	No	No	No	No	No
Electricity consumption	1	Topic	Or	No	No	No	No	No	No	No	No	No	No	No	No
Electricity-consumption	1	Topic	Or	No	No	No	No	No	No	Yes	No	Yes	No	No	Yes
Energy	1	Topic	Or	No	No	Yes	Yes	Yes	Yes	No	No	No	Yes	Yes	No
Energy conservation	1	Topic	Or	No	No	No	No	No	No	Yes	Yes	Yes	No	No	Yes
Energy consumption	1	Topic	Or	No	Yes	No	No	No	No	Yes	Yes	Yes	No	No	Yes
Energy efficiency	1	Topic	Or	Yes	Yes	No	No	No	No	Yes	Yes	Yes	No	No	Yes
Energy expenditure	1	Topic	Or	No	No	No	No	No	No	Yes	No	No	No	No	No
Energy intake	1	Topic	Or	No	No	No	No	No	No	Yes	No	No	No	No	No
Energy intensity	1	Topic	Or	No	No	No	No	No	No	No	No	No	No	No	No
Energy saving	1	Topic	Or	No	Yes	No	No	No	No	Yes	No	No	No	No	No
Energy savings	1	Topic	Or	Yes	Yes	No	No	No	No	No	No	Yes	No	No	Yes
Energy use	1	Topic	Or	No	No	No	No	No	No	Yes	Yes	Yes	No	No	Yes
Energy use intensity	1	Topic	Or	No	No	No	No	No	No	Yes	Yes	No	No	No	No
Energy utilization	1	Topic	Or	No	No	No	No	No	No	Yes	No	No	No	No	No
			And												
Campus	2	Domain	Or	No	No	No	No	No	Yes	Yes	No	No	Yes	Yes	No
Educational institutions	2	Domain	Or	No	No	No	No	No	No	Yes	No	No	No	No	No
Higher education	2	Domain	Or	No	Yes	Yes	No	No	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Higher education buildings	2	Domain	Or	No	No	No	No	No	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Higher education institution	2	Domain	Or	No	No	No	No	No	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Higher education institutions	2	Domain	Or	No	No	No	No	No	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Universities	2	Domain	Or	Yes	Yes	Yes	Yes	Yes	No	No	No	No	No	No	No
Universities *	2	Domain	Or	No	No	No	No	No	Yes	Yes	Yes	Yes	Yes	Yes	Yes
University	2	Domain	Or	Yes	Yes	Yes	No	No	No	No	No	No	Yes	Yes	No
University building	2	Domain	Or	No	No	No	No	No	Yes	Yes	Yes	Yes	Yes	Yes	Yes
University buildings	2	Domain	Or	No	No	No	No	No	Yes	Yes	Yes	Yes	Yes	Yes	Yes
University campus	2	Domain	Or	No	No	No	Yes	No	Yes	Yes	Yes	Yes	Yes	Yes	Yes
University campus *	2	Domain	Or	No	No	No	No	Yes	No	No	No	No	No	No	No
University campuses	2	Domain	Or	No	No	No	No	No	Yes	Yes	Yes	No	Yes	Yes	No
University operations	2	Domain	Or	No	No	No	No	No	Yes	Yes	Yes	No	Yes	Yes	No
University sector	2	Domain	Or	No	No	No	No	No	No	Yes	No	No	No	No	No

Source: own elaboration. Extracted on 27 April 2022. (*) A special operator was used in Scopus restricting search to the plural form of the keyword. Yes: included. No: not included. Q_1 to Q_{10} and Q_{Final} denote the order in which the queries were carried out.

Table 2. Outcome of the queries.

Source	Q01	Q02	Q03	Q04	Q05	Q06	Q07	Q08	Q09	Q10	QFINAL
Scielo	2	3	14	1	3	1				14	15
Scielo/Scopus			1			2	1			1	
Scopus	1127	1777	8515	8276	1690	2376	1212	581	607	8754	577
WOS	5	7	55	11	11	33	9	5	7	70	257
WOS/Scopus	29	62	209	41	41	181	90	47	53	271	84
Total general	1163	1849	8794	8329	1745	2593	1312	633	667	9110	933

Source: own elaboration. Extracted on 27 April 2022. Q_1 to Q_{10} and Q_{Final} denote the order in which the queries were carried out.

As presented in Table 2, the number of documents encountered in queries on the Scopus database heavily outweighs the number found in WOS and Scielo. Publications found simultaneously in the WOS and Scopus databases were denominated "WOS/Scopus", and those found in Scielo and Scopus were denoted by "Scielo/Scopus". The final query, which delivered the set of papers to be analyzed, was a combination of queries Q_{09} for Scopus and Q_{10} for WOS + Scielo; it is shown as Q_{Final} (extracted on 27 April 2022) in Table 1. As can be seen in Table 2, query Q_{Final} delivered 15 Scielo, 577 Scopus, 257 WOS, and 84 WOS/Scopus publications.

There were 84 publications shared by the WOS and Scopus databases (see Table 2). Nevertheless, since the WOS and Scopus databases sometimes do not display the exact characters in the titles of some publications (for example, variations in spaces and hyphens), the Visual Basic routine was unable to directly identify 50 of them (not included in the 84 "shared" publications) as being the same articles. Consequently, these publications did not appear as duplicates in the results at this stage. These instances of overlap were manually reclassified as WOS/Scopus after the final screening.

2.2. Screen, Select, Check Eligibility, and Include

After preselecting 933 publications, we scrutinized them using the PRISMA Protocol. This process involved screening, assessing their eligibility, and selecting the final set of texts for inclusion. This was done considering a set of three conditions:

(C1) EC in buildings

This condition evaluates whether the title and the abstract of the document selected suggest that it analyzes one or more factors that explain EC in any kind of building. C1 focused on EC, leaving out, for example, papers which address energy generation initiatives or the energy sources supplying HEIs.

(C2) EC in universities

If C1 is satisfied, then only articles focusing on university buildings are selected, while papers concerning other types of edifices are discarded.

(C3) Factors explaining EC in universities:

C3 evaluates whether the title and the abstract of the document suggest that it focuses on analyzing EC in universities and its determinants. The article under analysis must focus on EC in HEIs; therefore, papers that address this topic but not as their main objective were omitted from the selection. Also, articles focusing on energy generation plants managed by universities, energy distribution, and energy management systems, such as micro grids or smart grids, were left out.

Figure 2 shows 193 publications fulfilling the three conditions for inclusion. Additionally, only texts catalogued as "articles" or "conference papers" in the databases and written in English were selected. The application of these conditions yielded a final set of 175 publications (see Appendix B). The final selection of papers is shown in Table 3.

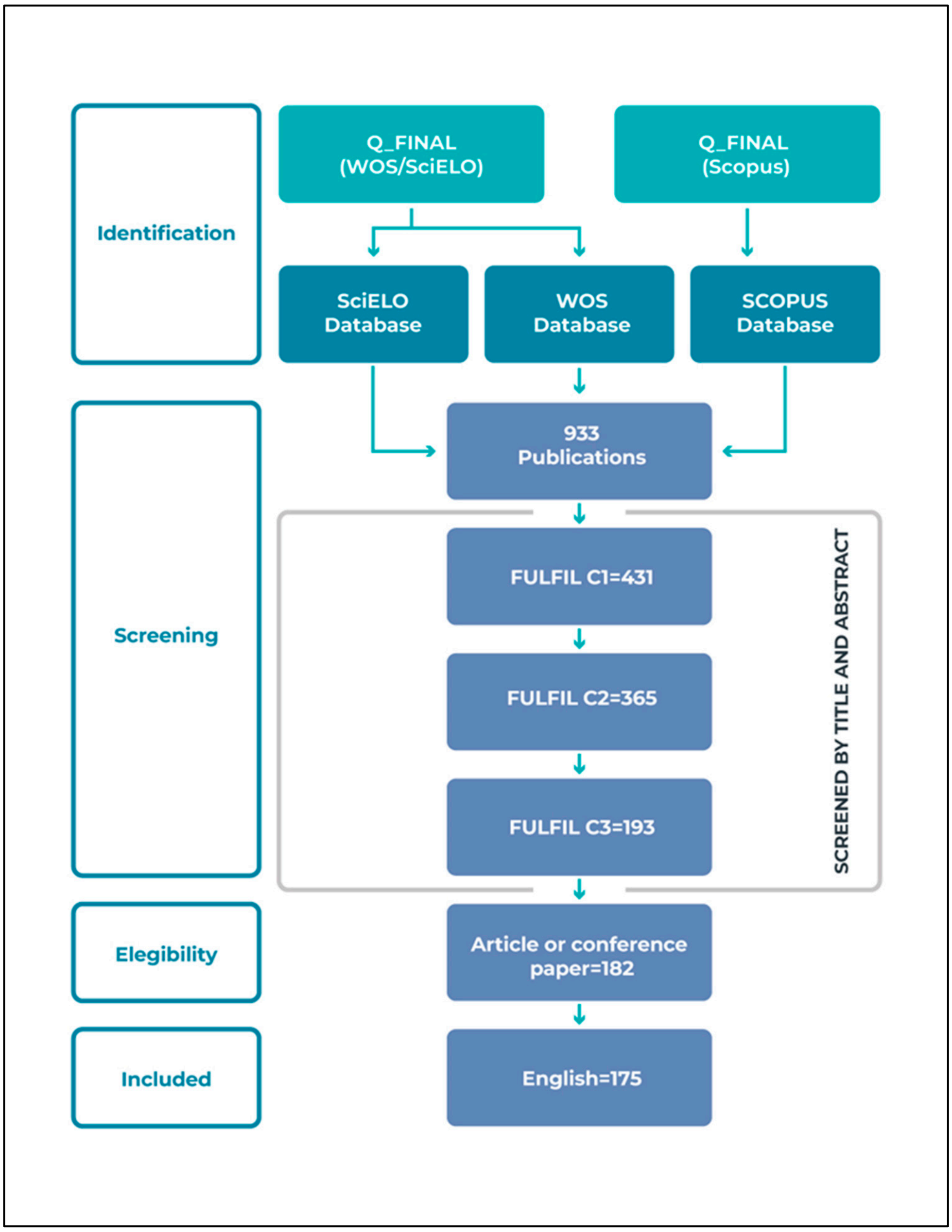

Figure 2. Screening results. Source: own elaboration, adapted from [21].

Table 3. Final set of documents selected by database.

Database	Articles	Conference Papers	Total
Scopus	14	62	76
WOS/Scopus	98 (*)		98 (*)
WOS	1 (**)		1 (**)
Total	113	62	175

Source: own elaboration. (*) 50 extra publications found in both Scopus and WOS databases. Extracted on 27 April 2022. (**) Kiatlertnapha and Vorayos 2017 [26].

2.3. Extract and Report

As in Safarzadeh et al. [12], different aspects of the articles selected were examined, focusing on top authors, journals, disciplines, citations, countries, institutions, and main EC determinants. The Software VOSviewer 1.6.17 (VOS) [27] and CiTNetExplorer 1.0.0

(CNE) [28] were utilized to examine the papers. The following section reports the results from the information analyzed.

3. Results

This section explores relevant aspects of the documents selected. Bibliometric data were analyzed in order to understand core characteristics of the papers studied. Additionally, selected papers were scrutinized to determine factors affecting EC in HEIs.

3.1. Sources and Disciplines

To answer the first research question, the 175 selected articles were analyzed to identify the different publishing sources and the involvement of diverse academic disciplines. The aforementioned documents were published in 103 different sources, encompassing 57 journals, 42 conference proceedings, and 4 book series. Table 4 displays the most common sources used for publishing the articles selected.

Table 4. Top journals for EC in HEIs.

Source Title	Source Type	Publisher	Articles Selected	Share of 175	Subject Area	SJR Best Quartile (Scopus)	JIF Best Quartile (WOS)
Energy and Buildings	Journal	Elsevier	24	13.7%	Engineering	Q1	Q1
International Journal of Sustainability in Higher Education	Journal	Emerald	9	5.1%	Social Sciences	Q1	Q1
Sustainability	Journal	MDPI	7	4.0%	Computer Sciences; Engineering; Energy; Environmental Sciences; Social Sciences	Q1	Q2
Journal of Cleaner Production	Journal	Elsevier	6	3.4%	Business Management; Energy; Engineering; Environmental Sciences	Q1	Q1
Energies	Journal	MDPI	6	3.4%	Energy; Engineering; Mathematics	Q1	Q3
Applied Mechanics and Materials	Book Series	Trans Tech Publications Ltd.	4	2.3%	Engineering	N/A	N/A
Energy Policy	Journal	Elsevier	4	2.3%	Energy; Environmental Science	Q1	Q1
Advanced Materials Research	Book Series	Trans Tech Publications Ltd.	3	1.7%	Engineering	N/A	N/A
Energy Procedia	Conference Proceedings	Elsevier	3	1.7%	Energy	N/A	N/A
E3S Web of Conferences	Conference Proceedings	EDP Sciences	3	1.7%	Earth and Planetary Sciences; Energy; Environmental Science	N/A	N/A
Smart Innovation, Systems and Technologies	Book Series	Springer Nature	3	1.7%	Computer Sciences; Decision Sciences	Q3	N/A
IOP Conference Series: Earth and Environmental Science	Conference Proceedings	Institute of Physics Publishing Ltd.	3	1.7%	Earth and Planetary Sciences; Environmental Science	N/A	N/A

Source: own elaboration based on WOS and Scopus data extracted on 10 November 2022.

In order to assess the concentration of journals publishing papers about the studied topic, authors used the *HHI*. This index is widely used to measure market concentration and competitiveness. Moschini et al. applied this method in a bibliometric study [19] to analyze the level of multidisciplinarity in academic production. It is calculated according to Equation (1).

$$HHI(v) = \sum_{i}^{n} v_i^{\,2} \quad v_i \in V \tag{1}$$

Here, V corresponds to a vector containing the percentage of articles published in n journals, conference proceedings, or book series. *HHI* takes values from 0 to $\left(1 - \frac{1}{n}\right)$. The closer to zero the value, the less concentrated the vector studied. According to the regulation of the US Department of Justice (when applied to markets), an $HHI \leq 0.1$ denotes competitiveness and unconcentrated areas, $0.1 < HHI \leq 0.18$ is classified as moderately concentrated, and an $HHI > 0.18$ represents a highly concentrated sector [29].

This definition was applied to assess the level of concentration among the 103 sources publishing documents about EC in universities. The HHI takes a value of 0.032, denoting an unconcentrated selection of sources.

The analysis of the disciplines involved in the selected documents clarifies whether the topic has been studied using a multidisciplinary approach. As mentioned in the introduction, efforts to reduce EC in universities entail not only technical initiatives such as improving the efficiency of buildings, but also sociological aspects such as raising awareness of energy use among students. Therefore, articles addressing this topic are expected to incorporate both social sciences and exact sciences. Figure 3 shows the subject areas (disciplines) of the 175 documents selected, according to the Scopus classification. (It is important to mention that articles inherit the subject area assigned by Scopus to their publishing sources [19]; therefore, it is assumed that papers are published in journals which properly mirror their characteristics in terms of discipline orientation.

Engineering and Energy are the predominant subject areas among the selection of papers, denoting a bias toward technical disciplines in this research field. Conversely, there is a significant scarcity of documents in the broad area of social sciences/humanities. This suggests that the social sciences encompass knowledge gaps worth investigating on EC in HEIs, possibly related to students' attitudes toward energy use.

The documents selected show the involvement of several disciplines, with 90 out of 175 articles (51%) covering more than one subject area (1.92 areas per document on average). The most frequent overlap occurs between Engineering and Energy (29 times), followed by Environmental Science and Energy (28 times). This indicates that the multidisciplinarity in this field is sought through the combination of exact sciences, but it is not generally attained through extension to the social sciences.

To further assess the multidisciplinarity among the selected papers, the HHI for the subject areas was determined. The index takes a value of 0.176, indicating a moderately concentrated pool of disciplines, albeit nearing the threshold of being considered highly concentrated.

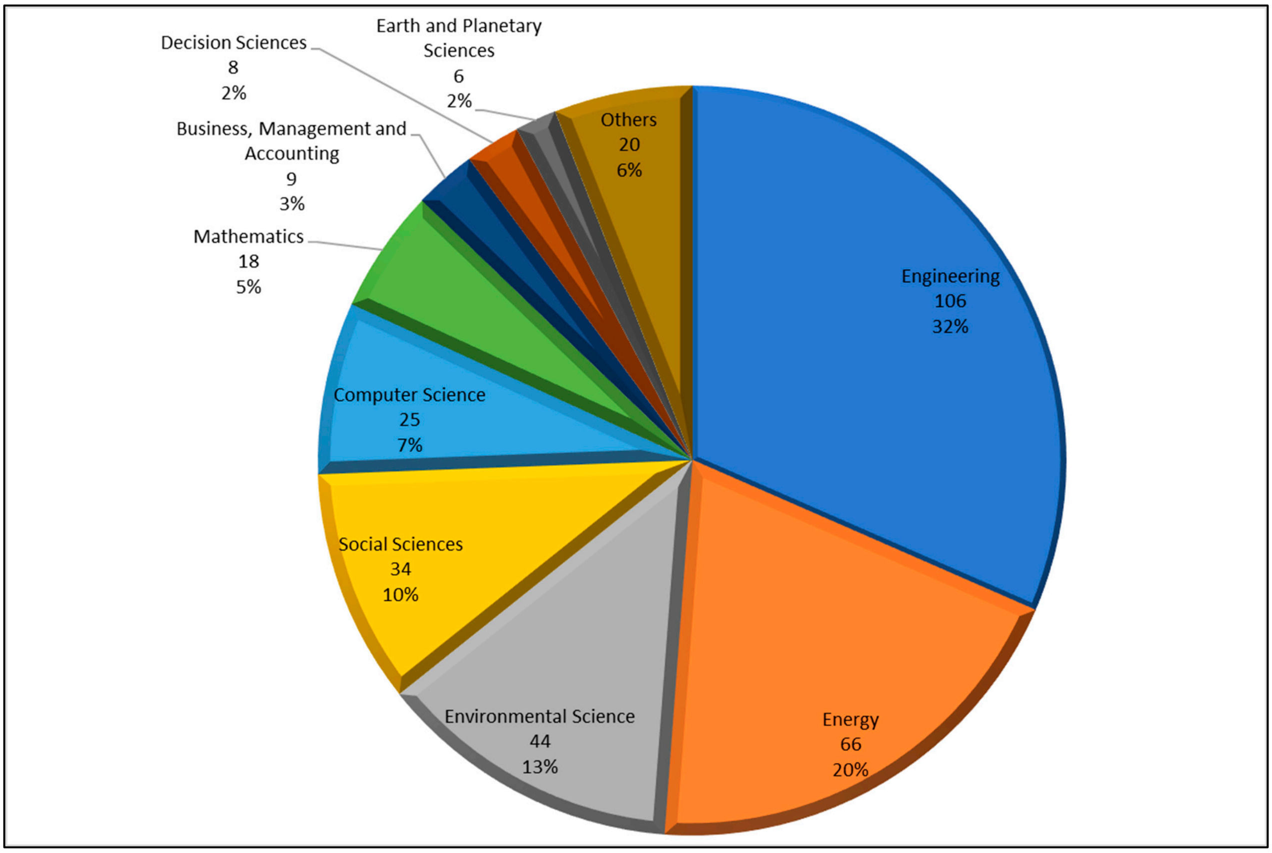

Figure 3. Categorization of subject areas of the selected documents. Kiatlernapha and Vorayos [26] (not available in Scopus) is categorized in Web of Science (WOS) as "Social Science interdisciplinary"; we standardized it as "Social Science" for the Scopus classification. Articles might be assigned by Scopus to more than one subject area. Source: own elaboration from WOS and Scopus extracted on 25 October 2022. Others: Chemical Engineering, 4 (1%); Physics and Astronomy, 4 (1%); Material Science, 3 (1%); Arts and Humanities, 2 (1%); Economics, Econometrics, and Finance, 2 (1%); Medicine, 2 (1%); Multidisciplinary, 2 (1%); Agricultural and Biological Sciences, 1 (0.3%).

3.2. Leading Countries, Universities, and Authors

To answer research question 3, it is necessary to determine the leading countries in terms of scientific research about this subject. It is important to note that the total scholarly output (all topics) is heterogeneous in terms of countries' contributions, with the USA responsible for 25% of the papers, followed by China with 17% (WOS Database, 2008–2022). Given this, the analysis of leadership in research on EC in universities should be undertaken not only in absolute terms, but also by studying the deviations between the productivity in this topic and the total output of academic articles.

The set of selected articles includes affiliations to 49 different nations. Table 5 displays the leading countries (three or more articles) among the papers selected and their percentage contribution to the set of selected articles. These values were compared with the percentage contributions of countries to all articles (26,345,327) indexed in the WOS Database (2008–2022) and all documents (45,339,374) in the Scopus Database (2006–2022) in the same time span as that for the selected publications. Table 5 is ordered by the number of articles selected from the Scopus database, since it contains 174 of the 175 documents selected, with this value being a proxy for the total contribution of each country (Kiatlertnapha and Vorayos [26] was assigned to Thailand).

Table 5. Articles per country within the selected papers (a single article could be assigned to more than one country, so the sum of all the percentages adds up to more than 100%).

	WOS			Scopus		
Country	**Articles Selected**	**Share of Selected Articles**	**Share of Total Scholarly Output (*)**	**Articles Selected**	**Share of Selected Articles**	**Share of Total Scholarly Output (**)**
USA	15	15%	25%	26	15%	23%
China	15	15%	17%	25	14%	17%
United Kingdom	15	15%	8%	18	10%	7%
Spain	10	10%	4%	12	7%	3%
Brazil	6	6%	3%	11	6%	2%
Italy	6	6%	4%	11	6%	4%
Malaysia	2	2%	1%	11	6%	1%
Portugal	9	9%	1%	10	6%	1%
Australia	7	7%	4%	8	5%	3%
Greece	3	3%	1%	7	4%	1%
Canada	4	4%	4%	6	3%	4%
South Africa	3	3%	1%	6	3%	1%
Hong Kong	0	0%	1%	5	3%	1%
Germany	2	2%	6%	4	2%	6%
Japan	2	2%	5%	4	2%	5%
Nigeria	1	1%	0%	4	2%	0%
Saudi Arabia	3	3%	1%	4	2%	1%
South Korea	2	2%	3%	4	2%	3%
Mexico	2	2%	1%	3	2%	1%
Romania	1	1%	1%	3	2%	0%
Russian Federation	0	0%	3%	3	2%	2%
Turkey	0	0%	2%	3	2%	1%

Source: own elaboration from WOS and Scopus data extracted on 15 October 2022 and 23 October 2022. (*) 26,345,328 articles. (**) 45,339,374 documents.

As can be seen in Table 5, the USA, China, and UK are the leading countries for articles related to EC in universities. This either reflects a particular scientific interest in the topic or is a consequence of the countries' scholarly capabilities. Consequently, we examined the discrepancy in percentages between each country's contribution to the set of selected articles and their respective share of total publications in the period. This comparison, illustrated in Figure 4, uses black bars and red dots to represent these contributions and shares, respectively.

As displayed in Figure 4, the USA's share of the 99 selected WOS articles (15%) is lower than their share of total WOS publications (25%); the same can be said for the Scopus database. On the other hand, some countries have a higher share in the set of selected documents about EC in universities than they do in total scholarly output; most notably, Portugal, the UK, Spain, Australia (WOS), Brazil, and Malaysia (Scopus). This suggests a particular interest in the topic in those countries.

The HHI was calculated according to each country's share in the articles selected about this subject. It took a value of 0.052, denoting an unconcentrated environment. This is consistent with the leading countries (USA and China) having a lower share than they have in total scholarly output, indicating that the production on this topic is more evenly distributed among countries.

We observed that international collaboration plays a significant role in the field, as evidenced by our findings. Specifically, 38 out of the 175 reviewed papers (22%) involve international collaboration, with the UK emerging as the leading country in this regard. The details regarding the number of articles written through international collaboration can be found in Table 6.

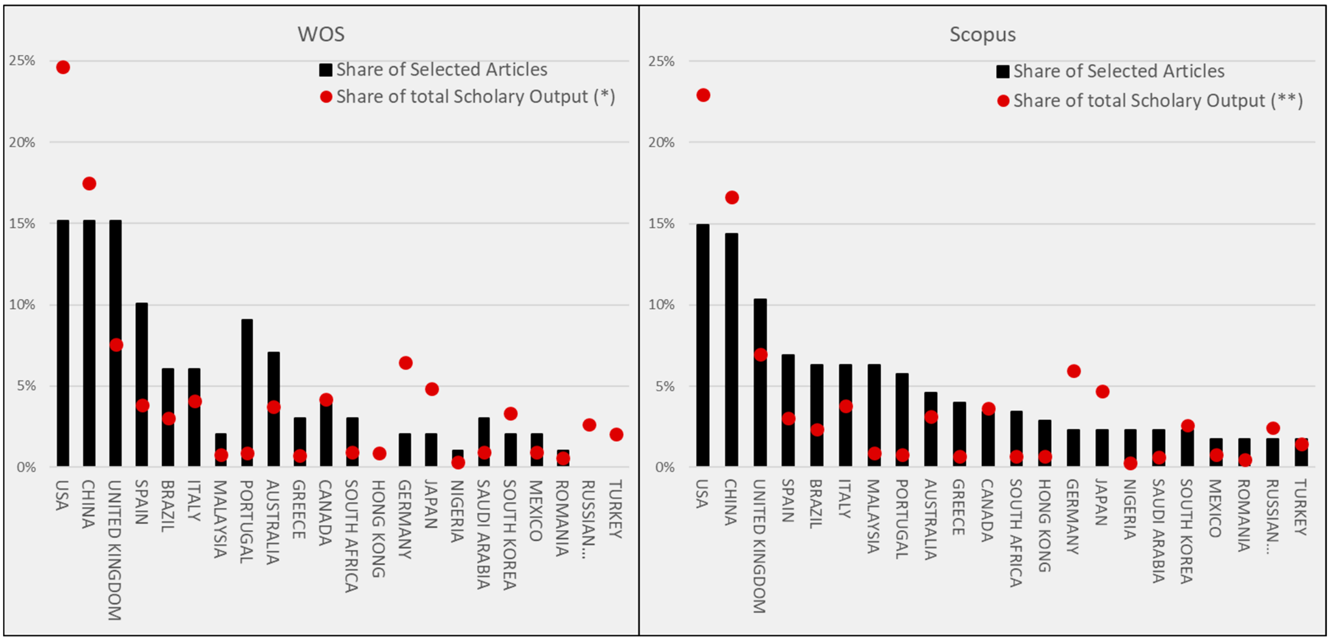

Figure 4. Gap between share of total scholarly output and share of selected articles (articles could be assigned to more than one country, so the sum of all the percentages adds up to more than 100%). Source: own elaboration from WOS and Scopus data extracted on 15 October 2022 and 23 October 2022. (*) 26,345,328 articles. (**) 45,339,374 documents.

Table 6. Internationally collaborative publications.

Country	Total Publications (*)	International Collaboration	%
United Kingdom	18	7	39%
United States	26	6	23%
China	25	6	24%
Brazil	11	6	55%
Italy	11	5	45%
Portugal	10	5	50%
Australia	8	5	63%
Spain	12	4	33%
Hong Kong	5	4	80%
Nigeria	4	3	75%
Saudi Arabia	4	3	75%

(*) Within the 174 Scopus selected articles. Three or more internationally collaborative documents. Source: own elaboration from Scopus data extracted on 27 October 2022.

Co-authorship among different countries was examined with the analytical Software VOS (Figure 5). The resulting map is based on the 174 publications housed in the Scopus database, in order to cover 99% of the selected publications set. (VOS works with WOS and Scopus files, but separately. We chose to use the broader Scopus set of documents.)

Maps provided by VOS are classified as distance-based maps, since the closeness of the items to one another reflects the strength of the relationship between them. The size of the label and its circle denotes the importance of an item [27]. In this case, label size indicates the number of papers corresponding to a certain country. Colors indicate the clusters to which each country was allocated by the software. Seven clusters were identified by the analysis. The top six countries contributing to the set of articles (the USA, China, the UK, Spain, Brazil, Italy, and Malaysia) were all assigned to separate clusters. Portugal and Brazil are situated at close proximity in the map, sharing the same grouping. Also, these two countries have collaborated with each other in three publications (the highest number among the papers selected). This international collaboration is a factor that explains both Portugal's and Brazil's overrepresentation in this topic when compared to overall academic output (see Table 5). This is because international collaboration leverages academic production.

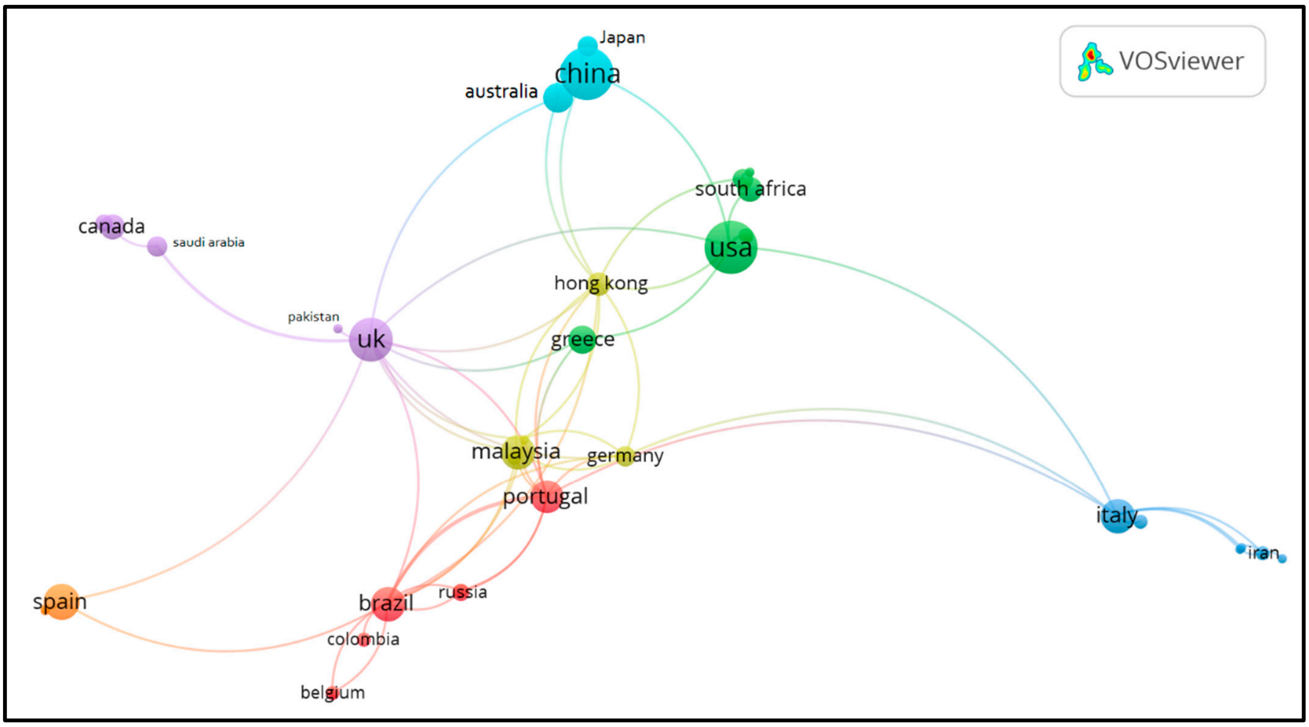

Figure 5. International collaboration map of the 174 Scopus papers. Source: own elaboration utilizing VOSviewer.

In order to identify leading universities researching EC in HEIs, Scopus and WOS data about authors' affiliations were restructured. The reason for doing so is because this information is often presented in terms of departments or colleges; therefore, it was transformed to denote universities or research institutes.

Table 7 displays the top institutions (articles can be indexed under more than one organization) researching EC in universities according to authors' affiliation. Additionally, the table includes the 2023 Times Higher Education Ranking [30] to provide information on how these institutions are placed within the global landscape of universities.

Overall, 237 organizations participated in the 175 papers studied (an average of 1.35 institutions per document), with 91 publications being indexed under more than one organization, as displayed Table 8. The wide range of institutions investigating this topic gives rise to a fragmented distribution, which is characterized by an HHI of 0.006.

Research question 2 also requires the analysis of authors' influence. This was analyzed through the quantity of articles published by scholars, the number of citations their articles have received, and by a citation network which displays the academic influence between authors.

The set of 175 publications under analysis includes a total of 576 different authors (an average of 3.3 per document). Some authors participated in more than one publication, which demonstrates their particular interest in this area. This is displayed in Table 9, ordered by the number of publications contained in the Scopus Database. Zhonghua Gou is the most prolific author that appears in the set of documents selected, with four articles simultaneously housed in both databases; nevertheless, this author is not listed as the first author in any of the selected publications. In terms of concentration among authors researching this topic, the environment can be described as competitive and even fragmented, since the HHI has a value of 0.002.

Table 7. Top institutions according to authors' affiliation (3 or more articles).

University	Country	Time Higher Education Rank 2023	1st Author		Total	
			WOS	SCOPUS	WOS	SCOPUS
University of Sheffield	United Kingdom	114	4	5	5	6
Universiti Teknologi Malaysia	Malaysia	601–800	0	4	0	5
Griffith University	Australia	251–300	4	4	4	4
Universitat Politècnica de Catalunya	Spain	801–1000	2	3	2	4
Polytechnic University of Turin	Italy	601–800	1	3	2	4
South China University of Technology	China	401–500	1	1	1	4
Universiti Tun Hussein Onn Malaysia	Malaysia	1201–1500	1	4	1	4
University of Passo Fundo	Brazil	1501+	1	3	2	4
University of Coimbra	Portugal	601–800	3	3	3	3
University of Lisbon	Portugal	501–600	2	2	2	3
Democritus University of Thrace	Greece	1201–1500	1	3	1	3
National Autonomous University of Mexico	Mexico	1001–1200	1	2	2	3
Universidade da Beira Interior	Portugal	801–1000	1	2	2	3
University of California, Berkeley	USA	8	1	1	3	3
University of Naples Federico II	Italy	351–400	1	3	1	3
Universiti Malaysia Kelantan	Malaysia	1201–1500	0	0	0	3
University of Bergamo	Italy	801–1000	0	0	1	3
University of Florida	USA	151	0	3	0	3
University of Molise	Italy	-	0	0	1	3

Source: own elaboration from WOS, Scopus and Times Higher Education Ranking data extracted on 27 April 2022 and 14 November 2022.

Table 8. Co-authorship distribution among organizations.

Number of Organizations in Collaboration	Articles
2	62
3	16
4	8
5	3
6	1
7	0
8	0
9	1

Source: own elaboration from WOS and Scopus data extracted on 27 April 2022.

Table 9. Authors with three or more of the 175 selected articles.

Author	1st Author		Total	
	WOS	Scopus	WOS	Scopus
Gou Z.	0	0	4	4
Ishak M.H.	0	3	0	4
Altan H.	1	2	2	3
Borrelli M.	0	0	0	3
Brandli L.L.	0	0	2	3
De Masi R.F.	0	0	0	3
Gui X.	3	3	3	3
Sapri M.	0	1	0	3
Sipan I.	0	0	0	3
Su Y.	0	3	0	3
Vanoli G.P.	0	0	0	3
Zhang L.	0	1	0	3

Source: own elaboration from WOS and Scopus data extracted on 15 October 2022 and 25 October 2022: 99 articles only in WOS, 174 articles in WOS and Scopus simultaneously, 175 total articles.

The citations received by an article is an indicator of the academic influence exerted on other authors. Table 10 displays the top 10 analyzed articles according to the number of citations received. Average citations per year are presented as a complementary indicator.

Table 10. Top 10 citations ranking of selected papers.

Rank	Title	Year	WOS		SCOPUS		Author
			Total Citations	Average Citations Per Year	Total Citation	Average Citation Per Year	
1	Understanding the energy consumption and occupancy of a multi-purpose academic building	2015	169	21	217	27	Gul and Patidar [31]
2	Potential opportunities for energy conservation in existing buildings on University campus: A field survey in Korea	2014	93	10	112	12	Chung and Rhee [32]
3	Occupancy diversity factors for common University building types	2010	89	7	102	8	Davis and Nutter [33]
4	Application of an energy management and control system to assess the potential of different control strategies in HVAC systems	2010	75	6	96	7	Escrivá-Escrivá et al. [34]
5	Development of green campus in China	2014	76	8	87	10	Tan et al. [35]
6	Energy use characteristics and benchmarking for higher education buildings	2018	46	9	55	11	Khoshbakht et al. [36]
7	Effectiveness of daylighting design and occupant visual satisfaction in a LEED Gold laboratory building	2011	49	4	53	4	Hua et al. [37]
8	A variation focused cluster analysis strategy to identify typical daily heating load profiles of higher education buildings	2017	47	8	52	9	Ma et al. [38]
9	Development of a web based energy management system for University Campuses: The CAMP-IT platform	2016	42	6	51	7	Kolokotsa et al. [39]
10	Energy saving on campus: A comparison of students' attitudes and reported behaviours in the UK and Portugal	2016	42	6	51	7	Cotton et al. [40]

Source: own elaboration from WOS and Scopus data extracted on 15 October 22 and 25 October 22.

As some authors have contributed multiple publications to the set of documents selected, total citations received per author can be examined. This information is presented in Table 11.

Table 11. Top 20 authors according to citations received.

Author	1st Author WOS	1st Author Scopus	Total WOS	Total Scopus	Publications (*)
Gul M.S.	169	217	169	217	1
Patidar S.	0	0	169	217	1
Chen S.	0	0	113	135	2
Chung M.H.	93	112	93	112	1
Rhee E.K.	0	0	93	112	1
Davis III J.A.	89	102	89	102	1
Nutter D.W.	0	0	89	102	1
Nord N.	0	0	84	100	2
Alcázar-Ortega M.	0	0	75	96	1
Escrivá-Escrivá G.	75	96	75	96	1
Segura-Heras I.	0	0	75	96	1
Wang L.	0	5	76	92	2
Shi Q.	0	0	76	87	1
Tan H.	76	87	76	87	1
Gou Z.	0	0	67	80	4
Altan H.	37	40	64	70	3
Srebric J.	0	0	63	70	2
Brandli L.L.	0	0	47	62	3
Dupre K.	0	0	46	55	1
Khoshbakht M.	46	55	46	55	1

Source: own elaboration from WOS data extracted on 15 October 2022 and 22 July 2022. (*) within the 175 selected.

Even though Mehreen S. Gul contributed only one article to the set of selected publications, this author still leads in terms of citations, both as first author and overall. Moreover, among the top 20 authors in terms of citations, only 7 of them have contributed more than one publication to the set of chosen articles. It can thus be seen that multiple publications do not necessarily lead to a higher number of citations received.

The academic influence between authors can be represented through a citation network with the assistance of CNE software. This computer-based tool displays and analyzes citation networks of articles [28] using (only) information extracted from the WOS database. CNE was thus utilized to create a citation network based on the 99 WOS articles selected. The final citation network consisted of a total of 120 publications as it included 21 extra articles cited by at least 5 of the original 99 WOS research papers. CNE ranks publications according to an indicator called the "citation score" which accounts for the number of citations within the network being studied. Figure 6 presents the citation network displaying the 40 publications with the highest citation scores. Table 12 presents the top publications according to their citation score, with Chung and Rhee [32] being the most cited article (of the 99 WOS publications selected) in the citation network.

As in the study by van Eck and Waltman [28], core publications were defined as those having citation relations with at least five other core articles. A total of 29 core publications were identified, 19 of which are displayed in blue in Figure 6. Interestingly, the article by Alshuwaikhat and Abubakar [41] has a high citation score, even though it is an external publication (not included in the 99 selected articles). This article focused on campus sustainability influenced articles ranked second (Chung and Rhee, [32]) and sixth (Khoshbakht et al., [36]) in Table 10. The citation network was reduced to a sub-net formed only by the 29 core publications. CNE identifies two clusters based on the citation relationships among articles (see Figure 7).

Table 12. Top publications according to their citation score.

Title	Citation Score	Type	Authors
Potential opportunities for energy conservation in existing buildings on University campus: A field survey in Korea	19	Internal	Chung and Rhee [32]
An integrated approach to achieving campus sustainability: assessment of the current campus environmental management practices	14	External	Alshuwaikat and Abubakar [41]
A review on buildings energy consumption information	12	External	Pérez-Lombard et al. [42]
Energy use characteristics and benchmarking for higher education buildings	12	Internal	Khoshbakht et al. [36]
Determinants of energy use in UK higher education buildings using statistical and artificial neural network methods	10	External	Hawkins et al. [43]
Sector review of UK higher education energy consumption	9	Internal	Ward et al. [44]
Survey of energy consumption and energy conservation measures for colleges and Universities in Guangdong province	9	Internal	Zhou et al. [45]
Energy consumption and GHG emission scenarios of a University campus in Mexico	9	Internal	Escobedo et al. [46]
Understanding the energy consumption and occupancy of a multi-purpose academic building	7	Internal	Gul and Patidar [31]

Source: own elaboration using CNE. Internal = Within the 99 WOS articles selected. External = citated by at least 5 of the original 99 WOS research papers.

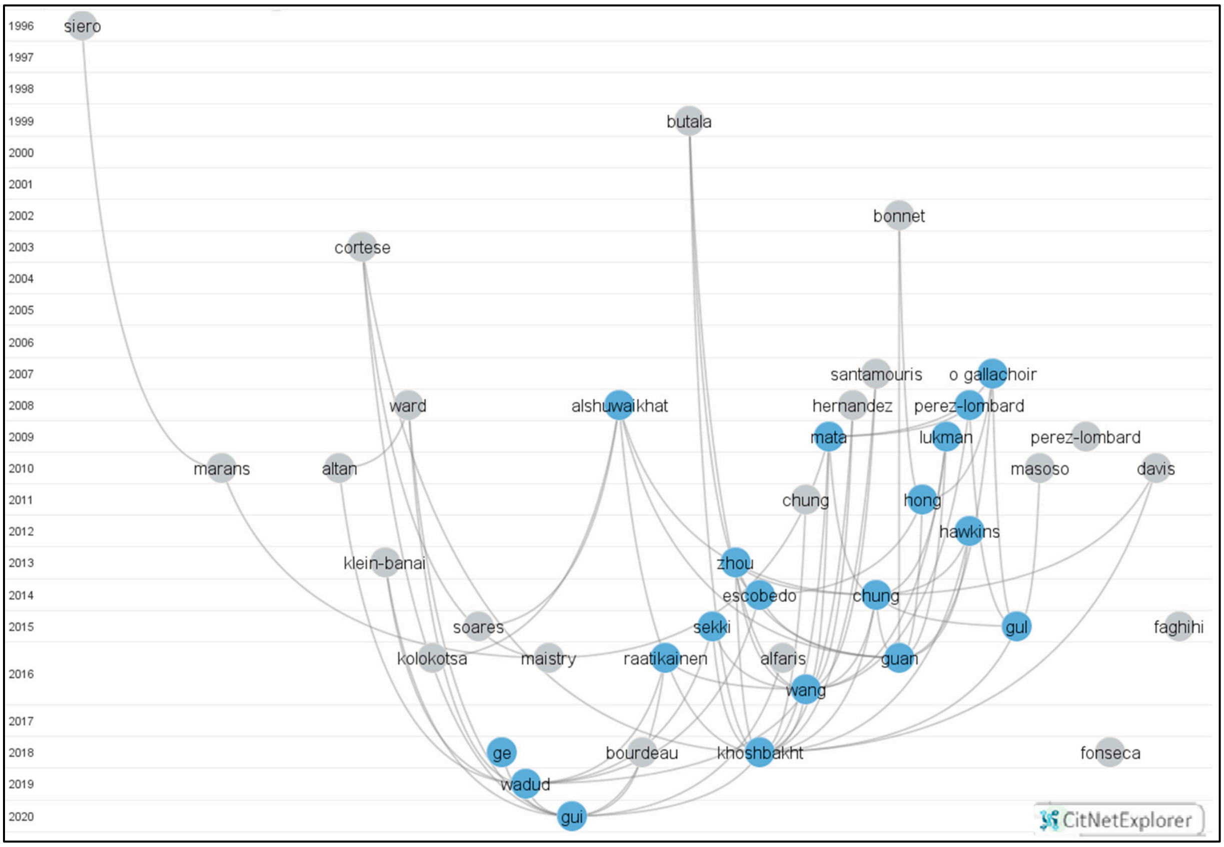

Figure 6. Citation network. Source: own elaboration using CiteNetExplorer.

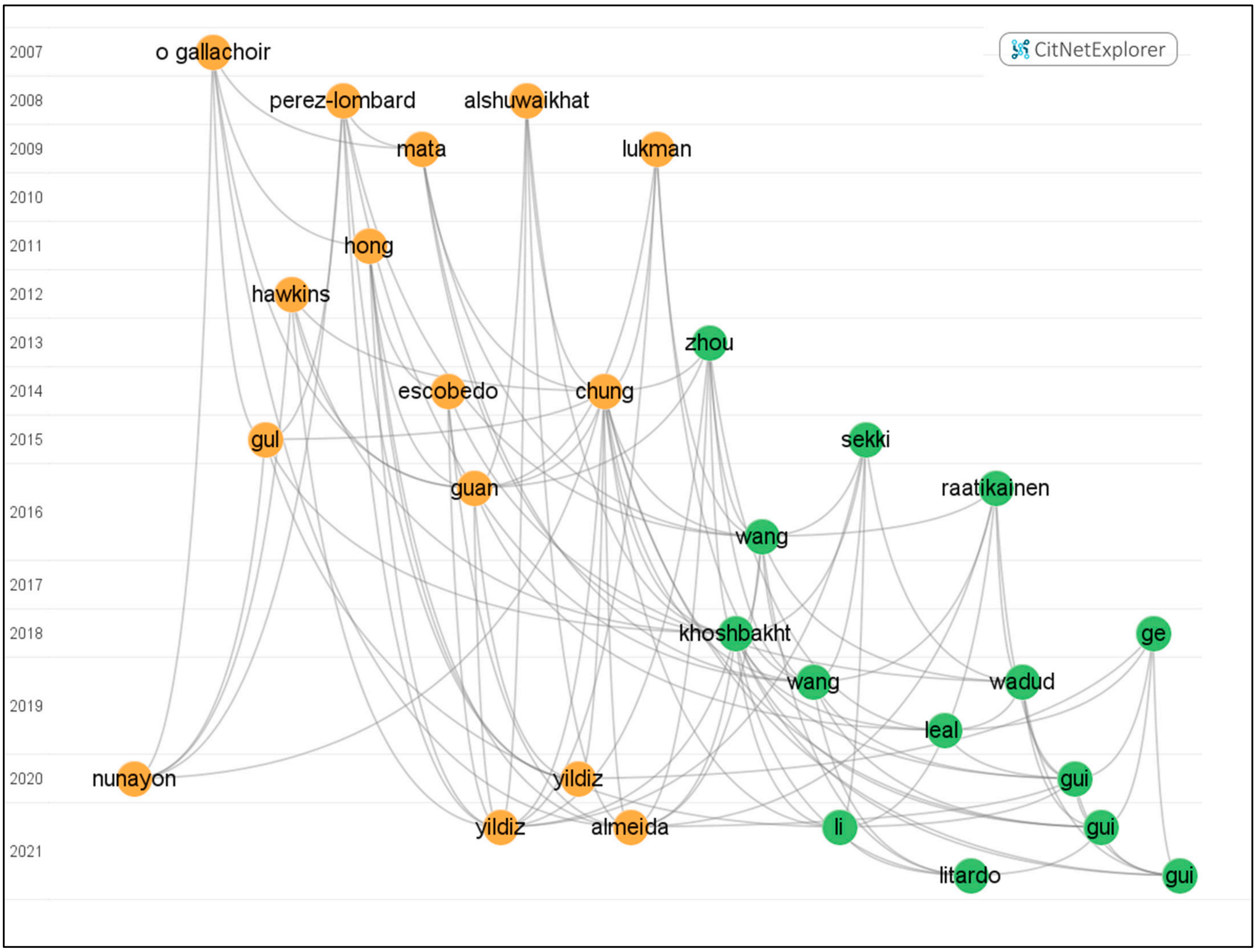

Figure 7. Sub-net of core publications. Orange and green circles denote different clusters. Source: own elaboration using CiteNetExplorer.

The earliest publications in the first cluster (orange) are external: Gallachóir et al. [47], Pérez-Lombard et al. [42], and Alshuwaikhat and Abubakar [41]. The first two of these papers are directly linked with Gul and Patidar [31], which is the most cited article among the 175 publications selected. In the other cluster (green), the oldest publication is Zhou et al. [45], while Sekki et al. [48], and Raatikainen et al. [49] are external publications which exert influence in this group.

3.3. Factors Driving EC in Universities

Answering research question 3 requires the exploration of factors driving EC in HEIs. These factors were obtained from the exhaustive review of the 175 selected texts. This review allowed us to determine which were the energy consumption factors mentioned in each text, and then they were labeled, making references to similar concepts. It is important to note that papers often mention multiple factors. Table 13 represents the main determinant of EC in HEIs according to the documents studied. The results obtained do not differ from those found in the literature for buildings serving other sectors [50–52]. These factors are often interrelated and will be discussed in Section 4.3.

Table 13. Main consumption factors mentioned in the selected articles (appearing more than 10 times).

Factor	Type of Factor	Number of Selected Articles Mentioning the Factor
Heating, Ventilation, and Air Conditioning Systems	Technical	69
Occupancy Factors (Patterns/Total)	Behavioral	59
Climate	Climatic	52
Building Function	Institutional	40
Lighting Systems	Technical	39
Occupant Behavior	Behavioral	23
Equipment/Electronic Devices	Technical	17
Gross Floor Area	Institutional	17
Building Envelope	Technical	16
Building Age	Technical	15
Research intensity/Discipline Orientation	Institutional	14
Building Design	Technical	13

Source: own elaboration.

4. Discussion

4.1. Sources and Disciplines

The analysis of leading sources and disciplines has proven useful for determining the main characteristics of the papers selected. The 175 articles were published in 103 different sources. Notably, 82 of these sources contributed only a single paper each. This unconcentrated scenario is reflected in the HHI when applied to the pool of sources, as it displays a value of 0.032. Nevertheless, when calculating the HHI for the subject areas in which the documents are classified, there is an increase in the index value, rising to 0.176. The important rise in the HHI when shifting from sources to subject areas (see Figure 8) indicates that the selection of journals, conference proceedings, and book series for publishing the articles was not random. Although there is wide dispersion among sources, the variety in subject areas is comparatively more limited. This indicates that authors tend to concentrate on a specific set of disciplines, and that the selection of sources is directly influenced by the subject areas involved. Consequently, scholars often choose sources that align with their specific discipline orientation.

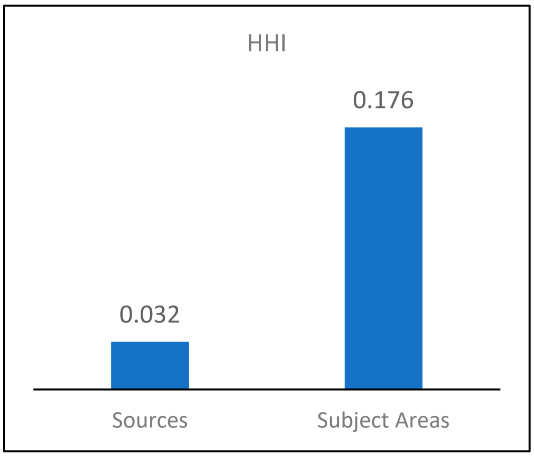

Figure 8. HHI comparison between sources and journals. Source: own elaboration.

Since EC in universities is driven by behavioral, climatical, institutional, and technical factors (see Table 13), there is a need to involve multiple disciplines when researching this topic. The analysis reveals a moderately concentrated range of disciplines, though the HHI approaches the 0.18 threshold, which would suggest a high level of concentration. This assessment draws on the premise that the HHI's classification criteria, commonly applied in financial market analyses, are also relevant and applicable to this particular field of study. Comparable values were reported in the study of Moschini et al. [19]. Those authors collected a sample of articles by researchers at the Italian Institute of Technology, which was expected to be multidisciplinary, scoring an HHI of 0.06. This was compared with the National Institute of Physics, which is less multidisciplinary as it focuses on a specific science. It scored an HHI of 0.29, denoting high concentration among the subject areas covered by its researchers. The HHI for the disciplines included in the articles analyzed in this study (0.176) lies between the aforementioned values. This confirms the moderately concentrated level of multidisciplinarity previously suggested, with the potential for certain disciplines to become more prominent. We refer specifically to the social sciences.

It is crucial to highlight the relative absence of social sciences among the disciplines studying this topic. We believe this absence is significant because HEIs are complex systems where human interactions shape the key aspects of academic activities. Therefore, analyses of phenomena occurring within these institutions should incorporate this scientific area. We attribute the mentioned absence of social sciences in this research field to the tendency of research in other scientific disciplines to focus on providing solutions to specific, unsolved problems. This includes challenges such as limitations in building insulation, complexities in thermal inertia, constraints related to the materials used, or limitations regarding energy sources. Research in the social sciences, being less specific, requires more comprehensive approaches. These approaches not only analyze measures aimed at reducing energy consumption but also evaluate their cost-effectiveness, the challenges in implementation, and potential responses from involved stakeholders. The complexity of these investigations helps to explain the relative scarcity of contributions from the field of social sciences to the topic analyzed in this article.

4.2. Leading Countries, Universities, and Authors

HEIs face important challenges in terms of adapting to changes in the energy sector [53], in terms of future higher costs and sustainable behavior. Therefore, the analysis of leading countries, universities, and authors investigating this topic reveals where the scientific foundations needed to address the predicted changes are being laid and by whom.

The leading countries investigating this topic are the USA and China (followed by the UK). Since these are the main countries in terms of overall academic output, their leading role in exploring EC in universities can be attributed to their more advanced research capabilities. On the other hand, there are countries whose share of the scholarly output on this subject surpasses their share of total output (Australia, Brazil, Malaysia, Portugal, the UK, and Spain). We point to a combination of three factors that can explain this situation: (1) there is a particular interest in investigating this matter in these countries; (2) the EU's stringent environmental regulation and strategic objective of reducing emissions [54,55] has become a motivating factor for British, Portuguese, and Spanish researchers; and (3) international collaboration helps to leverage countries' scholarly output, which boosts Australian, Brazilian, British, Portuguese, and Spanish academic output on this matter (see Table 6 and Figure 5).

The analysis of leading institutions reveals that the University of Sheffield is the most prolific. However, its leading margin is small, and its prominent position should be examined over a longer period. In terms of the organizations that have contributed articles to the set of 175 documents selected, we found not only universities but also governmental institutions. China's Ministry of Education has contributed to the publication of two articles [56,57], whereas Greece's Ministry of Education was involved in one [58], highlighting the political concern about the topic studied.

Zhonghua Gou is the most productive author on this subject. Nevertheless, this scholar does not appear as the first author in any of his four publications about this matter. Therefore, his leadership status relies on the criteria used in those publications to display the order of the authors. On the other hand, the analysis of citations reveals a prominent role for Mehreen S. Gul and Sandhya Patidar, whose paper is the most cited one, conferring them an unquestionable leadership status.

Finally, in terms of HHI, countries, universities (organizations), and authors are described as unconcentrated environments (see Figure 9). Countries present an HHI almost one order of magnitude superior to that of organizations and authors. This is consistent with the finding that only 49 different countries are included in the selected articles, whereas there are 237 different organizations and 576 authors, forming much more fragmented environments.

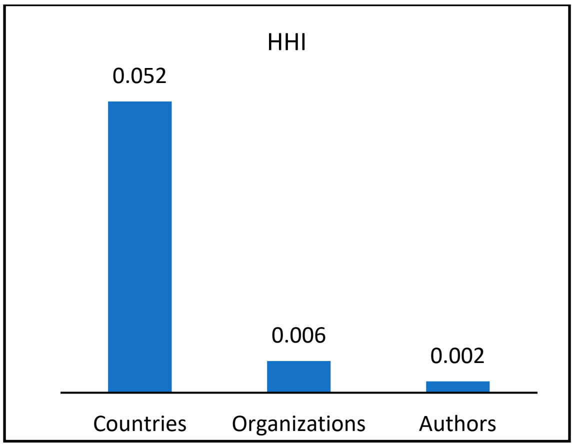

Figure 9. HHI comparison between countries, organizations, and authors. Source: own elaboration.

4.3. Factors Driving EC

This section discusses the energy consumption factors in higher education institutions found in the 175 texts analyzed, presented in Section 3.3. These factors do not differ significantly from the energy consumption of other types of buildings; however, what changes is the importance of the factors in these institutions. On the other hand, it is important to note that various authors (see [59] as an example) highlight the strong link between economic growth and energy consumption at a country level. The absence of this variable in the studies suggests that the energy consumption of a particular university is not linked to the economic growth of its country, implying that the institution's energy intensity does not depend on it. Following this introduction, we will now discuss the factors that have the most significant impact on the EC of universities.

4.3.1. Behavioral Factors

Management is frequently mentioned by some authors as a factor that promotes energy savings. To progress toward an energy-efficient campus, the involvement of effective leadership and proactive management is crucial [35]. It is essential for HEIs to demonstrate their willingness to implement and support sustainable policies before asking students and lecturers to change their behavior [60]. In this sense, effective environmental management within HEIs has a double effect; it not only seeks to establish a green, energy-saving campus, but also encourages all stakeholders to change their environmental behavior. Managers should address several issues to develop a culture focused on reducing EC. They are responsible for raising awareness and fostering participation among the community and for developing a robust energy management team [61]. Particularly, the administrators should focus on reducing energy wastage, bearing in mind that it occurs because of the lack of awareness among staff and students, often combined with the absence of managerial guidelines [62].

The results shown in Table 13 stress the importance of Occupant Behavior as a factor driving EC in HEIs, as evidenced by its mention in 23 articles. Universities host a huge number of students, lecturers, administrative workers, and guests, whose different energy utilization habits have a significant impact on EC [63]. The impact of occupants' actions and behavior has been found to strongly affect the energy performance of HEIs' buildings [64]. Put simply, "buildings don't use energy, people do" [65], and HEIs are no exception. Moreover, a correlation was found between Occupant Behavior and EC by comparing a normal situation with an altered situation in which electricity consumption was 9% lower [8]. This shows that user behavior can be influenced to foster energy savings. Among the selected articles, examples were found of how Occupant Behavior influences EC, such as people's tendency to bring their personal electric equipment to campus [66] and the unwillingness to shut down PCs or turn off lights and audio-visual devices [31]. This highlights the importance of management involvement in the normative aspect of occupants' conduct, with behavior assessment being a task that facilities managers must undertake [67]. This aspect is especially important considering the energy savings achievable through enhanced awareness. Furthermore, gathering data about users' conduct and its influence on energy use is crucial to develop an effective strategy for energy management [68]. Similarly, it is important to analyze how students' attitudes differ depending on their countries of origin and gender. These variables have an impact on EC [40], emphasizing the significance for managers to understand factors explaining diverse energy use behavior among users.

The number of students, lecturers and employees attending university buildings over a year presents important seasonal fluctuations. Consequently, Occupancy is a factor that must be considered when analyzing EC in HEIs. Summer breaks are commonly observed, while winter breaks occur more frequently in certain countries. The relationship between the number of occupants in different periods and EC has been suggested in 59 of the 175 papers studied (see [69,70]). Indeed, several authors have recently studied the impacts of COVID-19 lockdowns on EC in HEIs, noting that even though there is a baseline energy demand, the absence of staff and students reduced consumption significantly. In that regard, occupation analysis helps to uncover inefficiencies in energy utilization (see [71] for the specific case of the Aristotle University of Thessaloniki). Subsequently, if EC does not drop during lower occupancy periods, administrators can foster energy savings by analyzing inefficiencies attributed to high baseline consumption (probably due to research activities) or to careless user behavior.

4.3.2. Institutional Factors

Building Function is the fourth most mentioned factor affecting EC on HEIs (Table 13). University buildings host different activities, which produce diverse impacts on the overall energy utilization [72]. This diverse range of buildings, from traditional teaching facilities and residential services to hospitals and research laboratories, highlights the importance of classifying different building functions when analyzing energy utilization. Khoshbakht et al. [36] established several building categories and calculated both total EC per edifice and their Energy Use Intensity (EUI), which denotes the energy usage of a building relative to its area and is expressed as the consumption per square meter per year [73]. The results indicated that libraries consume more energy than other types of buildings (as they often use a large proportion of gross floor area), whereas EUI values are higher in research buildings. Similar findings were provided by Gui et al. [74], with teaching buildings accounting for high use of total electricity, while research buildings had the highest EUI [75,76]. For the specific case of research equipment in Stanford University campus, see [77].

Data centers constitute a specific case of energy intensive buildings, as they use between 25% and 50% more energy per gross floor area than regular office spaces [1]. In universities which have not outsourced their data centers, buildings containing specialized IT equipment tend to be the most intensive energy consumers, alongside hospitals [78].

Gross Floor Area of buildings is a significant factor influencing EC, as gas and electricity usage directly correlate with the size of these structures [32,79]. Although Gross Floor Area is an important factor, it is mentioned in only 17 papers (see Table 13), given that most authors analyzed EC in terms of EUI. Interestingly, some authors have proposed the existence of some economies of scale between Gross Floor Area and EC, with larger HEIs being more energy efficient and displaying lower EUI values [16].

According to Table 13, the Research Intensity Level of HEIs and their Discipline Orientation are factors that affect or explain EC. These factors are often interrelated in terms of their effect on energy intake, both determining the need for energy-intensive equipment and laboratories. Universities present differences in their EUI according to their discipline classification, with those oriented to exact sciences being more energy intensive than those associated with the humanities [36,45,80]. The University of Thessaly is an interesting example in this regard [81]. Similarly, research-intensive universities usually utilize more energy than teaching-focused ones [16] because laboratories have high EUI; indeed, correlations between research activities and EC have been established by Wang [82]. Overall, this suggests that research activities generate externalities in terms of EC and environmental impact, which must be addressed.

4.3.3. Climate

Local Climate is one of the most commonly mentioned factors among the selected papers (see Table 13), with weather affecting EC by regions [74], and through different parameters such as temperature, humidity, and visibility [83]. Several authors have established correlations between weather characteristics and EC. Interesting cases in this regard have been presented by Heidarinejad et al. [84] concerning Penn State University and Harvard. Hot weather environments tend to demand high amounts of energy to maintain a comfortable indoor temperature; therefore, June is the peak energy-consuming period in the northern hemisphere for universities located in hot weather zones [5], such as California [58], Saudi Arabia [85], and Hong Kong [86]. At the other extreme, as expected, the more pressing issue for HEIs in cold climates is energy demand for heating [87], which also leads to high-EC scenarios. This analysis raises the question whether governments should encourage the establishment of universities in mild weather regions, or conversely, whether HEIs located in zones of extreme climate should be subsidized to help them handle the higher expenditure on energy resources.

4.3.4. Technical Factors

Although Building Design is only mentioned as an EC driver in 13 articles, some authors consider it notably relevant (see [88]). Indoor environmental comfort and illumination are factors that determine energy utilization, which depend on the orientation and size of buildings [89]. The number, shape, and surface area of windows should be analyzed thoughtfully as there is a compromise to be reached between thermal and lighting requirements [32]. Overall, energy saving strategies should be examined at the planning stage of a building development project to achieve energy savings goals [57], considering research requirements and discipline orientation. Also related to the early stages of building design, Building Envelope is a characteristic addressed by 10 authors studying this topic and one which merits careful consideration.

Building Age is a factor influencing EC that has been mentioned in 15 articles. Newer buildings tend to have lower EUI due to better lighting and thermal insulation standards, as well as more efficient systems [90–92]. Nevertheless, there is not a complete agreement on this factor, with some authors dismissing its relevance because in some cases EC does not show a statistically significant correlation with Building Age [36].

The most commonly mentioned factor (see Table 13) within the articles selected is the utilization of Heating, Ventilation, and Air Conditioning Systems (HVAC). Their impact on energy use affects all kinds of buildings, accounting for up to 40% of their EC [93]. University buildings are no exception [94,95], with several articles reporting examples of HVAC being a significant determinant of EC in geographically dispersed HEIs [63,96,97]. As HVAC utilization is such a critical factor for EC, there is an important academic trend focused on studying potential reductions in the resources required by those systems, with authors proposing that their optimization is the most effective measure to reduce energy expenditure [34].

Lighting Systems are a common source of EC addressed in 39 of the 175 selected papers. It is a central factor driving energy use, and in some geographical areas is even as important as HVAC [98]. As such, Lighting Systems present opportunities to save energy, with retrofitting being a measure that can be used to increase efficiency. Automatic control systems also offer interesting opportunities, as in some cases considerable energy waste occurs due to lights being left on outside working hours [99].

5. Conclusions

A Systematic Literature Review focused on EC in HEIs was conducted for the period 2006–2022. This method has proven useful in determining key characteristics of scientific papers, academic trends, and common consumption factors. In terms of practical contributions, we believe that these key characteristics and trends not only facilitate an understanding of the current foundational knowledge in this area but also indicate where this knowledge has predominantly been produced. This insight will be beneficial for future researchers in the field. Furthermore, the Systematic Literature Review has enabled us to identify the main factors influencing EC in HEIs. Additionally, it allows us to extend the applicability of findings, initially focused on local contexts, to a broader scale. This capability will significantly aid educational managers in their efforts to mitigate these factors.

The analysis of the literature highlights the importance of HEIs becoming sustainable institutions, given their prominent position in society. They must embrace sustainability, demonstrate their commitment to eco-friendly policies and thus ask the university community to change their environmental behavior.

Major findings point to a technical bias in this research field, as Engineering and Energy are the leading disciplines among the selected papers, with a limited role played by Social Sciences. The USA, China, and the UK are revealed as the main countries behind the scientific papers on this topic. Energy and Buildings is the preferred journal for publishing articles about this subject, while the University of Sheffield (albeit by a small margin) is the leading organization in this regard. In terms of authors, Zhonghua Gou is the most prolific, while Mehreen Gul and Sandhya Patidar are the most cited.

Based on the results obtained, we can conclude that although this topic has attained a moderate degree of multidisciplinarity, it has been achieved through a combination of exact sciences, lacking significant inclusion of social sciences. Therefore, in terms of policy recommendations, both academic leaders and administrative managers of institutions should promote research projects about EC in HEIs that include disciplines related to social sciences. This approach aims to enhance the understanding of how the behavior of students, scholars, and higher education workers impacts EC.

The analyzed papers identified 12 main factors determining EC in HEIs, which we recommend that managers understand and address. These were (i) HVAC, (ii) Occupancy Factors, (iii) Climate, (iv) Building Function, (v) Lighting Systems, (vi) Occupant Behavior, (vii) Electronic Devices, (viii) Gross Floor Area, (ix) Building Age, (x) Research intensity/Discipline Orientation, (xi) Building Design, and (xii) Building Envelope. These EC factors align with those of other sectors, such as the residential sector. However, when focusing on EC in HEIs, Building Function, Research intensity, and Discipline orientation were revealed as distinctive factors. This finding indicates that technically specialized institutions and research-oriented universities are intense energy consumers, with laboratories having high EUI. As a consequence, a specific energy saving design for buildings in these kinds of institutions is recommended, along with the acquisition of energy efficient equipment. On the other hand, for teaching-oriented institutions, whose EC is determined by larger floor areas used by libraries and classrooms, a different energy saving design must be considered. The latter approach focuses on reducing energy consumed for heating and cooling.

Our findings were limited by the following constraints: (i) only articles and conferences papers written in English were considered; (ii) papers published before 2007 were not available in the WOS database; (iii) the papers studied were extracted on 27 April 2022, therefore any new additions to the scientific databases after this date were not included in this study; and (iv) articles are not characterized individually within a discipline, but are automatically assigned that of the publishing source. Finally, given the rapid growth in scholarly output about this topic, a new Systematic Literature Review should be conducted in the near future to compare these results with those from a more extensive set of articles.

Author Contributions: J.P.L.: conceptualization, methodology, software, investigation, validation, visualization, formal analysis, writing—original draft, writing—review and editing. J.M.C.: conceptualization, methodology, supervision, writing—review and editing. All authors have read and agreed to the published version of the manuscript.

Funding: This research received no external funding.

Data Availability Statement: The data presented in this study are openly available in the WOS and Scopus platforms. The data can be accessed through the identification numbers of the articles.

Acknowledgments: The first and second authors wish to acknowledge the funding provided by the Universidad Autónoma de Chile (Chile). The second authors wish to acknowledge the funding provided by the Following institutions: (1) the Andalusian Regional Government (project SEJ-132), (2) the "Cátedra de Economía de la Energía y del Medio Ambiente" sponsored by Red Eléctrica de España at the University of Seville, and (3) from Departamento de Análisis Económico y Economía Política (Department of Economic Analysis and Political Economy Universidad de Sevilla) at the University of Seville.

Conflicts of Interest: The authors have no relevant financial or non-financial interests to disclose, except for Juan Pablo Laporte, who is currently employed as Vice-Chancellor for Administration and Finance at Universidad Autónoma de Chile.

List of Abbreviations

CNE	CiTNetExplorer
EC	Energy consumption
EUI	Energy use intensity
HVAC	Heating, ventilation, and air conditioning systems
HEIs	Higher education institutions
HHI	Herfindahl-Hirschman Index
PRISMA	Preferred Reporting Items for Systematic Reviews and Meta-Analyses
VOS	VOSviewer
WOS	Web of Science

Appendix A. Examples of Articles Researching EC in a Specific Institution or Country

Table A1. Examples of articles researching EC in a specific institution or country.

References	Country	University	Findings
[100]	Ecuador	Escuela Politécnica del Litoral	Analysis of electrical loads indicated that most of the electricity is used by both air conditioning equipment and lighting (65%).
[101]	Greece	Democritus University of Trace	The energy intake of education buildings represents an important amount of the country's total energy demand. This due to the large number of educational buildings in the country, forcing the state to incur considerable costs for the operation and maintenance of those premises
[46]	Mexico	National Autonomous University of Mexico	Analyzed the energy demand at the main campus of National Autonomous University of Mexico (130,000 Students), which consumed 81.3 GWH of electricity in 2011 (11 million USD)
[102]	Turkey	Balikesir University	The Balikesir University presents potential for energy savings of 60% in the analyzed buildings
[66]	USA	University of Michigan	Staff are most concerned about conserving energy in university buildings while students are the least concerned.

Appendix B. The Reviewed Studies on EC in Universities

Table A2. The reviewed studies on EC in universities.

ID	Title	Doc Type	Source	Author
1	A comparative study of approaches towards energy efficiency and renewable energy use at higher education institutions	Article	WOS_CORE/SCOPUS	[103]
2	A comparative study on electrical energy usage of University residences in South Africa	Conference Paper	SCOPUS	[73]
3	A Heuristic-Based Smart HVAC Energy Management Scheme for University Buildings	Article	WOS_CORE/SCOPUS	[17]
4	A methodology to estimate baseline energy use and quantify savings in electrical energy consumption in higher education institution buildings: Case study, Federal University of Itajubá (UNIFEI)	Article	WOS_CORE/SCOPUS	[104]
5	A modelling applied to active renewable energy for an existing building of higher educational institution	Article	WOS_CORE/SCOPUS	[105]
6	A new Generation of Thermal Energy Benchmarks for University Buildings	Article	WOS_CORE/SCOPUS	[106]
7	A Preliminary assessment of energy consumption behaviour pattern and factors influence among Malaysian higher education institutions students	Article	SCOPUS	[68]
8	A review on Energy Performance in Malaysian Universities Through Building Information Modelling (BIM) Adaptation	Conference Paper	SCOPUS	[62]
9	A Roadmap for climate action at the University of Calgary: higher education campuses as climate leaders	Article	WOS_CORE/SCOPUS	[107]
10	A Study on the energy conservation policy of South Korean Universities	Conference Paper	SCOPUS	[108]
11	A Study on the energy performance of school buildings in Taiwan	Article	WOS_CORE/SCOPUS	[82]
12	A Study on the energy-saving potential of University campuses in Turkey	Article	WOS_CORE/SCOPUS	[102]
13	A summary of the research on building load forecasting model of colleges and Universities in North China based on energy consumption behaviour: A case in North China	Article	WOS_CORE/SCOPUS	[63]
14	A variation focused cluster analysis strategy to identify typical daily heating load profiles of higher education buildings	Article	WOS_CORE/SCOPUS	[38]
15	Actual building energy use patterns and their implications for predictive modelling	Article	WOS_CORE/SCOPUS	[84]
16	An Energy saving potential analysis of lighting retrofit scenarios in outdoor lightingsystems: A case study for a University campus	Article	WOS_CORE/SCOPUS	[109]
17	An intelligent energy management system for educational buildings	Article	WOS_CORE/SCOPUS	[110]
18	Analysis of energy consumption structure of a science and engineering University campus in Southern China	Article	SCOPUS	[111]
19	Analysis of energy data of existing buildings in a University Campus	Article	WOS_CORE/SCOPUS	[92]
20	Analysis of energy performance of University campus buildings using statistical and energy modelling approaches	Conference Paper	SCOPUS	[112]
21	Analysis of energy use intensity and greenhouse gas emissions for Universities in Taiwan	Article	WOS_CORE/SCOPUS	[5]
22	Analysis of the energy usage in University buildings: The case of Aristotle University campus	Conference Paper	SCOPUS	[71]
23	Analysis of University science facilities energy consumption	Article	SCOPUS	[113]
24	Analysis on Energy Consumption and Energy-Saving Retrofit of University Buildings in Hot Summer and Cold Winter Zone of China	Conference Paper	SCOPUS	[94]

Table A2. *Cont.*

ID	Title	Doc Type	Source	Author
25	Application of an energy management and control system to assess the potential of different control strategies in HVAC systems	Article	WOS_CORE/SCOPUS	[34]
26	Application of international energy efficiency standards for energy auditing in a University buildings	Article	WOS_CORE/SCOPUS	[114]
27	Application of smart electronic systems, firm characteristics and efficient energy Consumption—a case of public Universities in Uganda	Article	WOS_CORE/SCOPUS	[115]
28	Application study of green building technology in Universities and colleges in cold regions	Conference Paper	SCOPUS	[87]
29	Applications of occupancy and booking information to optimize space and energy use in higher education institutions	Conference Paper	SCOPUS	[4]
30	Assessing the impact of the COVID-19 lockdown on the energy Consumption of University buildings	Article	WOS_CORE/SCOPUS	[116]
31	Assessing the nearly zero-energy building gap in University campuses with a feature extraction methodology applied to a case study in Spain	Article	WOS_CORE/SCOPUS	[117]
32	Assessing unregulated electricity Consumption in a case study University	Article	WOS_CORE/SCOPUS	[118]
33	Assessment of Energy Wastage and Saving Potentials for Higher Educational Institutional Buildings in South Western Nigeria	Conference Paper	SCOPUS	[88]
34	Assessment of the potential savings resulting from shutting down University buildings during periods of very low occupancy: A case study	Conference Paper	SCOPUS	[119]
35	Benchmark analysis of electricity consumption for complex campus buildings in China	Article	WOS_CORE/SCOPUS	[120]
36	Benchmarking Energy Use at University of Almeria (Spain)	Article	WOS_CORE/SCOPUS	[121]
37	Bridging the gap between energy and comfort: Post-occupancy evaluation of two higher-education buildings in Sheffield	Article	WOS_CORE/SCOPUS	[122]
38	Building energy consumption in the Universities of China: Situation and countermeasures	Conference Paper	SCOPUS	[123]
39	Building energy use prediction owing to climate change: A case study of a University campus	Conference Paper	SCOPUS	[124]
40	Building simulation tools and their role in improving existing building designs	Conference Paper	SCOPUS	[125]
41	Carbon-Neutral-Campus Building: Design Versus Retrofitting of Two University Zero Energy Buildings in Europe and in the United States	Article	WOS_CORE/SCOPUS	[126]
42	Case study for energy efficiency measures of buildings on an urban scale	Conference Paper	SCOPUS	[127]
43	Challenges in load profile monitoring: Case study	Conference Paper	SCOPUS	[85]
44	Cluster analysis of University campus smart meter data	Conference Paper	SCOPUS	[128]
45	Comparative studies of the occupants' behaviour in a University building during winter and summer time	Article	SCOPUS	[129]
46	Comprehending the energy consumption pattern of occupancy of an academic structure	Conference Paper	SCOPUS	[130]
47	COVID-19 Pandemic Effect on Energy Consumption in State Universities: Michoacan, Mexico Case Stud y	Article	WOS_CORE/SCOPUS	[131]
48	Data Analysis on building load profiles: A stepping stone to future campus	Conference Paper	SCOPUS	[132]
49	Decarbonising Universities: Case Study of the University of Exeter's Green Strategy Plans Based on Analysing Its Energy Demand in 2012–2020	Article	WOS_CORE/SCOPUS	[133]
50	Decision Support System in Establishing Energy Management System for the Engineering Building of Bulacan State University	Conference Paper	SCOPUS	[97]

Table A2. *Cont.*

ID	Title	Doc Type	Source	Author
51	Determination of territorial compactness and analysis of optimization of energy-efficient characteristics of the University campus	Conference Paper	SCOPUS	[134]
52	Determining key drivers of efficient electricity management practices in public Universities in Southwestern Nigeria An empirical study	Article	WOS_CORE/SCOPUS	[61]
53	Development of a web based energy management system for University Campuses: The CAMP-IT platform	Article	WOS_CORE/SCOPUS	[39]
54	Development of green campus in China	Article	WOS_CORE/SCOPUS	[35]
55	Diagnosis and reduction of electricity consumption exceedance in public University buildings	Article	SCOPUS	[81]
56	Distributed Energy Optimization for HVAC Systems in University Campus Buildings	Article	WOS_CORE/SCOPUS	[95]
57	Dual assessment Framework to Evaluate LEED-Certified Facilities Occupant Satisfaction and Energy Performance: Macro and Micro Approaches	Conference Paper	SCOPUS	[135]
58	Effect evaluation of introduced building energy management system in University campus	Conference Paper	SCOPUS	[7]
59	Effectiveness of daylighting design and occupant visual satisfaction in a LEED Gold laboratory building	Article	WOS_CORE/SCOPUS	[37]
60	Effects of occupant behaviour on energy performance in buildings: a green and non-green building comparison	Article	WOS_CORE/SCOPUS	[64]
61	Efficient energy modelling of heterogeneous building portfolios	Article	WOS_CORE/SCOPUS	[90]
62	Electrical Consumption in the Higher Education sector, during the COVID-19 shutdown	Conference Paper	SCOPUS	[18]
63	Electricity conservation opportunities within private University campuses in Bangladesh	Article	WOS_CORE/SCOPUS	[136]
64	Encouraging pro-environmental behaviour: Energy use and recycling at Rhodes University, South Africa	Article	WOS_CORE/SCOPUS	[137]
65	Energy and environmental performance of a higher education sector—a case study in the United Kingdom	Article	WOS_CORE/SCOPUS	[138]
66	Energy audit and multi-criteria decision analysis to identify sustainable strategies in the University campuses: Application to politecnico di Torino	Conference Paper	SCOPUS	[11]
67	Energy challenges: isolating results due to behaviour change	Article	WOS_CORE/SCOPUS	[8]
68	Energy conservation attitudes, knowledge, and behaviours in science laboratories	Article	WOS_CORE/SCOPUS	[76]
69	Energy conservation in China's higher education institutions	Article	WOS_CORE/SCOPUS	[80]
70	Energy Consumption Analysis of Education Buildings: The Case Study of Balikesir University	Article	WOS_CORE/SCOPUS	[139]
71	Energy consumption and GHG emission scenarios of a University campus in Mexico	Article	WOS_CORE/SCOPUS	[46]
72	Energy Consumption and the Power Saving Potential of a University in Korea: Using a Field Survey	Article	WOS_CORE/SCOPUS	[6]
73	Energy consumption pattern analysis by University building characteristics for the composition of green campus in Korea	Article	SCOPUS	[140]
74	Energy Consumption, Pandemic Period and Online Academic Education: Case Studies inRomanian Universities	Conference Paper	SCOPUS	[3]
75	Energy cost saving potential in educational buildings-case study of MUT campus	Conference Paper	SCOPUS	[141]
76	Energy efficiency actions at a Brazilian University and their contribution to sustainable development Goal 7	Article	WOS_CORE/SCOPUS	[142]
77	Energy efficiency analysis and energy conservation measures for Ethiopian Universities: Introducing green campus initiative	Conference Paper	SCOPUS	[143]

Table A2. *Cont.*

ID	Title	Doc Type	Source	Author
78	Energy efficiency analysis carried out by installing district heating on a University campus. A case study in Spain	Article	WOS_CORE/SCOPUS	[144]
79	Energy efficiency analysis in buildings of a University campus using the procel RTQ-C	Conference Paper	SCOPUS	[98]
80	Energy Efficiency and Distributed Generation: A Case Study Applied in Public Institutions of Higher Education	Article	WOS_CORE/SCOPUS	[145]
81	Energy Efficiency in School Buildings: The Need for a Tailor-Made Business Model	Conference Paper	SCOPUS	[146]
82	Energy efficiency index by considering number of occupants: A study on the lecture rooms in a University building	Article	SCOPUS	[147]
83	Energy efficiency interventions in UK higher education institutions	Article	WOS_CORE/SCOPUS	[53]
84	Energy efficiency measurements in a Malaysian public University	Conference Paper	SCOPUS	[148]
85	Energy efficiency of higher education buildings: a case study	Article	WOS_CORE/SCOPUS	[9]
86	Energy efficient management application in University buildings: Case of Malaysia public University	Article	SCOPUS	[149]
87	Energy management in the buildings of a University campus in Saudi Arabia—A case study	Conference Paper	SCOPUS	[150]
88	Energy Performance and Benchmarking for University Classrooms in Hot and Humid Climates	Article	WOS_CORE/SCOPUS	[151]
89	Energy performance evaluation of campus facilities	Conference Paper	SCOPUS	[152]
90	Energy performance of campus Leed buildings: Implications for green building and energy policy	Article	WOS_CORE/SCOPUS	[153]
91	Energy planning of University campus building complex: Energy usage and coincidental analysis of individual buildings with a case study	Article	WOS_CORE/SCOPUS	[70]
92	Energy refurbishment of a University building in cold Italian backcountry. Part 1: Audit and calibration of the numerical model	Conference Paper	SCOPUS	[154]
93	Energy refurbishment of a University building in cold Italian backcountry. Part 2: Sensitivity studies and optimization	Conference Paper	SCOPUS	[155]
94	Energy Saving Measures and Potential of Energy Efficiency at the University of Surabaya, Based on EDGE Simulation	Conference Paper	SCOPUS	[156]
95	Energy saving measures for University public library: A case study of UTHM library	Conference Paper	SCOPUS	[157]
96	Energy saving on campus: a comparison of students attitudes and reported behaviours in the UK and Portugal	Article	WOS_CORE/SCOPUS	[40]
97	Energy Savings Due to Daylight Saving in Mexico; Case Study: Buildings and Facilities of CU-UNAM	Conference Paper	SCOPUS	[158]
98	Energy use characteristics and benchmarking for higher education buildings	Article	WOS_CORE/SCOPUS	[36]
99	Enhancing the accountability and comparability of different campuses' energy profiles through an energy cluster approach	Article	WOS_CORE/SCOPUS	[78]
100	Estimating energy consumption and conservation measures for ESPOL Campus main building model using Energy Plus	Conference Paper	SCOPUS	[100]
101	Estimating potential saving with energy consumption behaviour model in higher education institutions	Article	SCOPUS	[159]
102	Estimation of Energy Savings Potential in Higher Education Buildings Supported by Energy Performance Benchmarking: A Case Study	Article	WOS_CORE/SCOPUS	[160]
103	Evaluation of environmental design strategies for University buildings	Article	WOS_CORE/SCOPUS	[161]

Table A2. *Cont.*

ID	Title	Doc Type	Source	Author
104	Examining the effect of an environmental social marketing intervention among University employees	Article	WOS_CORE/SCOPUS	[60]
105	Explorative Multidimensional Analysis for Energy Efficiency: DataViz versus Clustering Algorithms	Article	WOS_CORE/SCOPUS	[162]
106	Fostering the energy efficiency through the energy savings: The case of the University of Palermo	Conference Paper	SCOPUS	[163]
107	Green BIM-based study on the green performance of University buildings in northern China	Article	WOS_CORE/SCOPUS	[56]
108	How to improve eco-efficiency and indoor comfort at University of passo fundo—Brazil	Conference Paper	SCOPUS	[10]
109	Identifying the determinants of energy use in Texas A&M University campus at Kingsville	Conference Paper	SCOPUS	[164]
110	Impact of occupancy rates on the building electricity consumption in commercial buildings	Article	WOS_CORE/SCOPUS	[69]
111	Impact of the COVID-19 Pandemic on the Energy Use at the University of Almeria (Spain)	Article	WOS_CORE/SCOPUS	[165]
112	Incorporating machine learning with building network analysis to predict multi-building energy use	Article	WOS_CORE/SCOPUS	[166]
113	Influence of building and indoor environmental parameters on designing energy efficient buildings	Article	WOS_CORE/SCOPUS	[89]
114	Influence of occupants' behaviour on energy and carbon emission reduction in a higher education building in the UK	Article	SCOPUS	[167]
115	Internal benchmarking of higher education buildings using the floor-area percentages of different space usages	Article	WOS_CORE/SCOPUS	[168]
116	Inter-University Sustainability Benchmarking for Canadian Higher Education Institutions: Water, Energy, and Carbon Flows for Technical-Level Decision-Making	Article	WOS_CORE/SCOPUS	[79]
117	Living Building Laboratory—Educational Building Project in Cluj-Napoca	Conference Paper	SCOPUS	[169]
118	Management strategies for sustainability education, planning, design, energy conservation in California higher education	Article	WOS_CORE/SCOPUS	[58]
119	Methodology for estimating energy and water Consumption patterns in University buildings: case study, Federal University of Roraima (UFRR)	Article	WOS_CORE/SCOPUS	[2]
120	Methodology of measurement and calculation of building energy management system in University campus	Conference Paper	SCOPUS	[170]
121	Modelling energy Consumption behaviour using "energy culture" concept for student accommodations in Malaysian public Universities	Article	WOS_CORE/SCOPUS	[67]
122	Modelling energy demand from higher education institutions: A case study of the UK	Article	WOS_CORE/SCOPUS	[16]
123	Multi-agent system for energy consumption optimisation in higher education institutions	Article	WOS_CORE/SCOPUS	[171]
124	Non-domestic energy use—Experiences of the Higher Education sector	Conference Paper	SCOPUS	[72]
125	Occupancy diversity factors for common University building types	Article	WOS_CORE/SCOPUS	[33]
126	Occupant thermal feedback for improved efficiency in University buildings	Article	WOS_CORE/SCOPUS	[96]
127	Optimization of the management of building stocks: An example of the application of managing heating systems in University buildings in Spain	Article	WOS_CORE/SCOPUS	[172]
128	Optimizing the energy efficiency of higher education institutions	Conference Paper	SCOPUS	[173]
129	Parametric studies on European 20-20-20 energy policy targets in University environment	Article	WOS_CORE/SCOPUS	[174]
130	Potential opportunities for energy conservation in existing buildings on University campus: A field survey in Korea	Article	WOS_CORE/SCOPUS	[32]
131	Potential reduction of energy consumption in public University library	Conference Paper	SCOPUS	[175]

Table A2. *Cont.*

ID	Title	Doc Type	Source	Author
132	Prevalence of Findings from ASHRAE Level 2 Energy Assessments at 13 Colleges	Article	SCOPUS	[1]
133	Prioritizing Energy-efficiency and Renewable-energy Measures in a Low-carbon Campus using Analytic Hierarchy Process with Social Awareness Criterion	Article	WOS	[26]
134	Quantifying potential savings from sustainable energy projects at a large public University: An energy efficiency assessment for Texas state University	Article	WOS_CORE/SCOPUS	[176]
135	Quantity and electricity consumption of plug load equipment on a University campus	Article	WOS_CORE/SCOPUS	[77]
136	Recommending a thermal energy benchmark based on CIBSE TM46 for typical college buildings and creating monthly energy models	Article	WOS_CORE/SCOPUS	[177]
137	Reducing University energy use beyond energy retrofitting: The academic calendar impacts	Article	WOS_CORE/SCOPUS	[75]
138	Reflection upon energy saving and emission reduction in colleges in the context of low carbon city construction	Conference Paper	SCOPUS	[178]
139	Regression Model-Based Short-Term Load Forecasting for University Campus Load	Article	WOS_CORE/SCOPUS	[83]
140	Research on Construction Strategy of Energy Conservation and Emission Reduction in University Campuses in Beijing	Conference Paper	SCOPUS	[179]
141	Research on saving energy and reducing cost of the higher learning institution	Conference Paper	SCOPUS	[180]
142	Research on the building energy efficiency design strategy of Chinese Universities based on green performance analysis	Article	WOS_CORE/SCOPUS	[57]
143	Retrofit of educational facility through passive strategies in hot climate	Conference Paper	SCOPUS	[181]
144	Review of the research on energy consumption evaluation index system of campus	Article	SCOPUS	[182]
145	Sector review of UK higher education energy consumption	Article	WOS_CORE/SCOPUS	[44]
146	Significant factors of energy consumption behaviour pattern among Malaysian Higher Education Institutions students	Conference Paper	SCOPUS	[183]
147	Status and countermeasures of energy management in Chinas college	Conference Paper	SCOPUS	[184]
148	Strategies for a sustainable campus in Osaka University	Article	WOS_CORE/SCOPUS	[185]
149	Student Housing Energy Consumption: A Comparison of Chilled Water, Heating, and Electricity Use	Conference Paper	SCOPUS	[186]
150	Study of electricity load profiles in University Campuses: The case study of democritus University of thrace	Conference Paper	SCOPUS	[99]
151	Study on energy consumption quotas development method of colleges and Universities in Hubei	Conference Paper	SCOPUS	[187]
152	Survey of energy consumption and energy conservation measures for colleges and Universities in Guangdong province	Article	WOS_CORE/SCOPUS	[45]
153	Survey on energy consumption and indoor thermal environment of University Building in Changsha, China	Conference Paper	SCOPUS	[188]
154	Sustainability and natural resources uses at a South Brazilian University: Proposing an environmental plan to University of Passo Fundo	Conference Paper	SCOPUS	[189]
155	Sustainability in University campus: options for achieving nearly zero energy goals	Article	WOS_CORE/SCOPUS	[190]
156	Sustainable and smart University Campuses; Strategic approach to sustainability and building intelligence for University Campuses	Conference Paper	SCOPUS	[191]
157	Sustainable Campus: The Experience of the University of Lisbon at IST	Article	WOS_CORE/SCOPUS	[192]

Table A2. *Cont.*

ID	Title	Doc Type	Source	Author
158	Sustainable management of existing building stock: A strategy to reduce the energy consumption and the environmental impact	Conference Paper	SCOPUS	[193]
159	The energy planning according to the ISO 50001 contribute to the consolidation of a Sustainable Campus to the Universidad Autónoma de Occidente	Conference Paper	SCOPUS	[194]
160	The human dimension of energy conservation and sustainability. A case study of the University of Michigan energy conservation program	Article	WOS_CORE/SCOPUS	[66]
161	The impact of Climate Change on a University Campus' Energy Use: Use of Machine Learning and Building Characteristics	Article	SCOPUS	[91]
162	The impact of COVID-19 on higher education building energy use and implications for future education building energy studies	Article	WOS_CORE/SCOPUS	[195]
163	The motivation and development impact of energy saving to sustainability in the construction of green campus: a case study of the Zhejiang University, China	Article	WOS_CORE/SCOPUS	[196]
164	The Potential Role of Stakeholders in the Energy Efficiency of Higher Education	Article	WOS_CORE/SCOPUS	[197]
165	The relationship between energy use and space use of higher educational buildings in subtropical Australia	Article	WOS_CORE/SCOPUS	[74]
166	The successful introduction of energy efficiency in higher education institution buildings	Conference Paper	SCOPUS	[93]
167	Towards energy transition at the Faculty of Education of Bilbao (UPV/EHU): diagnosing community and building	Article	WOS_CORE/SCOPUS	[198]
168	Transformation of a University building into a zero energy building in Mediterranean climate	Article	WOS_CORE/SCOPUS	[101]
169	Understanding Campus Energy Consumption—People, Buildings and Technology	Conference Paper	SCOPUS	[199]
170	Understanding the energy consumption and occupancy of a multi-purpose academic building.	Article	WOS_CORE/SCOPUS	[31]
171	University building: Energy diagnosis and refurbishment design with cost-optimal approach. Discussion about the effect of numerical modelling assumptions	Article	WOS_CORE/SCOPUS	[200]
172	University campuses energy performance estimation in Ukraine based on measurable approach	Article	WOS_CORE/SCOPUS	[201]
173	Use of electrical energy in University buildings: a Hong Kong case study	Article	SCOPUS	[86]
174	Using energy profiles to identify University energy reduction opportunities	Article	WOS_CORE/SCOPUS	[202]
175	Workflow automation for combined modelling of buildings and district energy systems			

References

1. Madigan, M.J.; Neimeier, R.M.; Spiegel, S.J. Prevalence of Findings from ASHRAE Level 2 Energy Assessmensts at 13 Colleges. *Strateg. Plan. Energy Environ.* **2015**, *35*, 43–72. [CrossRef]
2. Almeida, A.P.; Sousa, V.; Silva, C.M. Methodology for Estimating Energy and Water Consumption Patterns in University Buildings: Case Study, Federal University of Roraima (UFRR). *Heliyon* **2021**, *7*, e08642. [CrossRef] [PubMed]
3. Andrei, H.; Diaconu, E.; Gheorghe, A.; Bizon, N.; Mazare, A.; Ionescu, L.; Stanculescu, M.; Porumb, R.; Seritan, G.; Andrei, P.; et al. Energy Consumption, Pandemic Period and Online Academic Education: Case Studies in Romanian Universities. In Proceedings of the 7th IEEE International Symposium on Electrical and Electronics Engineering, ISEEE 2021, Galati, Romania, 28–30 October 2021.
4. Azizi, S.; Rabiee, R.; Nair, G.; Olofsson, T. Application of Occupancy and Booking Information to Optimize Space and Energy Use in Higher Education Institutions. In Proceedings of the 12th Nordic Symposium on Building Physics, NSB 2020, Tallinn, Estonia, 6–9 September 2020; Volume 172.
5. Wang, J.C. Analysis of Energy Use Intensity and Greenhouse Gas Emissions for Universities in Taiwan. *J. Clean. Prod.* **2019**, *241*, 118363. [CrossRef]
6. Hong, W.H.; Kim, J.Y.; Lee, C.M.; Jeon, G.Y. Energy Consumption and the Power Saving Potential of a University in Korea: Using a Field Survey. *J. Asian Archit. Build. Eng.* **2011**, *10*, 445–452. [CrossRef]
7. Su, Y.; Yan, J.W. Effect Evaluation of Introduced Building Energy Management System in University Campus. *Appl. Mech. Mater.* **2013**, *368–370*, 1222–1227. [CrossRef]
8. Boulton, K.; Pallant, E.; Bradshaw-Wilson, C.; Choate, B.; Carbone, I. Energy Challenges: Isolating Results Due to Behavior Change. *Int. J. Sustain. High. Educ.* **2017**, *18*, 116–128. [CrossRef]
9. Soares, N.; Pereira, L.D.; Ferreira, J.; Conceicao, P.; da Silva, P.P. Energy Efficiency of Higher Education Buildings: A Case Study. *Int. J. Sustain. High. Educ.* **2015**, *16*, 669–691. [CrossRef]
10. Frandoloso, M.A.L.; Brandli, L.L.; Dias, F.P. How to Improve Eco-Efficiency and Indoor Comfort at University of Passo Fundo—Brazil. In Proceedings of the 28th International PLEA Conference on Sustainable Architecture + Urban Design: Opportunities, Limits and Needs—Towards an Environmentally Responsible Architecture, PLEA 2012, Lima, Peru, 7–9 November 2012.
11. Becchio, C.; Bottero, M.; Corgnati, S.; Dell'Anna, F.; Vergerio, G. Energy Audit and Multi-Criteria Decision Analysis to Identify Sustainable Strategies in the University Campuses: Application to Politecnico Di Torino. *Smart Innov. Syst. Technol.* **2021**, *178 SIST*, 1187–1197. [CrossRef]
12. Safarzadeh, S.; Rasti-Barzoki, M.; Hejazi, S.R. A Review of Optimal Energy Policy Instruments on Industrial Energy Efficiency Programs, Rebound Effects, and Government Policies. *Energy Policy* **2020**, *139*, 111342. [CrossRef]
13. Xiao, Y.; Watson, M. Guidance on Conducting a Systematic Literature Review. *J. Plan. Educ. Res.* **2019**, *39*, 93–112. [CrossRef]
14. Zeng, L.; Li, R.Y.M. Construction Safety and Health Hazard Awareness in Web of Science and Weibo between 1991 and 2021. *Saf. Sci.* **2022**, *152*, 105790. [CrossRef]
15. Mohammadalizadehkorde, M.; Weaver, R. Universities as Models of Sustainable Energy-Consuming Communities? Review of Selected Literature. *Sustainability* **2018**, *10*, 3250. [CrossRef]
16. Wadud, Z.; Royston, S.; Selby, J. Modelling Energy Demand from Higher Education Institutions: A Case Study of the UK. *Appl. Energy* **2019**, *233*, 816–826. [CrossRef]
17. Jindal, A.; Kumar, N.; Rodrigues, J. A Heuristic-Based Smart HVAC Energy Management Scheme for University Buildings. *IEEE Trans. Ind. Inf.* **2018**, *14*, 5074–5086. [CrossRef]
18. Birch, C.; Edwards, R.; Mander, S.; Sheppard, A. Electrical Consumption in the Higher Education Sector, during the COVID-19 Shutdown. In Proceedings of the 7th Annual IEEE PES/IAS PowerAfrica Conference, PowerAfrica 2020, Nairobi, Kenya, 25–28 August 2020.
19. Moschini, U.; Fenialdi, E.; Daraio, C.; Ruocco, G.; Molinari, E. A Comparison of Three Multidisciplinarity Indices Based on the Diversity of Scopus Subject Areas of Authors' Documents, Their Bibliography and Their Citing Papers. *Scientometrics* **2020**, *125*, 1145–1158. [CrossRef]
20. Busu, M. A Market Concentration Analysis of the Biomass Sector in Romania. *Resources* **2020**, *9*, 64. [CrossRef]
21. David, A.; Yigitcanlar, T.; Li, R.Y.M.; Corchado, J.M.; Cheong, P.H.; Mossberger, K.; Mehmood, R. Understanding Local Government Digital Technology Adoption Strategies: A PRISMA Review. *Sustainability* **2023**, *15*, 9645. [CrossRef]
22. Afzal, M.; Yi, R.; Li, M.; Shoaib, M.; Ayyub, M.F.; Chiara Tagliabue, L.; Bilal, M.; Ghafoor, H.; Manta, O. Delving into the Digital Twin Developments and Applications in the Construction Industry: A PRISMA Approach. *Sustainability* **2023**, *15*, 16436. [CrossRef]
23. Document Search—Web of Science Core Collection. Available online: https://www.webofscience.com/wos/woscc/basic-search (accessed on 24 October 2022).
24. Document Search—SciELO Citation Index. Available online: https://www.webofscience.com/wos/scielo/basic-search (accessed on 24 October 2022).
25. Scopus—Document Search | Signed In. Available online: https://www.scopus.com/search/form.uri?display=basic#basic (accessed on 24 October 2022).
26. Kiatlertnapha, D.; Vorayos, N. Prioritizing Energy-Efficiency and Renewable-Energy Measures in a Low-Carbon Campus Using Analytic Hierarchy Process with Social Awareness Criterion. *Asr Chiang Mai Univ. J. Soc. Sci. Humanit.* **2017**, *4*, 57–70. [CrossRef]

27. van Eck, N.J.; Waltman, L. Software Survey: VOSviewer, a Computer Program for Bibliometric Mapping. *Scientometrics* **2010**, *84*, 523–538. [CrossRef]
28. van Eck, N.J.; Waltman, L. CitNetExplorer: A New Software Tool for Analyzing and Visualizing Citation Networks. *J. Inf.* **2014**, *8*, 802–823. [CrossRef]
29. Hays, F.H.; DeLurgio, S.A.; Gilbert, A.H. Concentration, the Internet and Pricing of Bank Assets and Liabilities. Research in Business and Economics Journal, Vol.1. Available online: https://www.aabri.com/rbej.html (accessed on 21 January 2024).
30. World University Rankings 2023 | Times Higher Education (THE). Available online: https://www.timeshighereducation.com/world-university-rankings/2023/world-ranking#!/page/0/length/25/name/sheffield/sort_by/rank/sort_order/asc/cols/stats (accessed on 13 November 2022).
31. Gul, M.S.; Patidar, S. Understanding the Energy Consumption and Occupancy of a Multi-Purpose Academic Building. *Energy Build.* **2015**, *87*, 155–165. [CrossRef]
32. Chung, M.H.; Rhee, E.K. Potential Opportunities for Energy Conservation in Existing Buildings on University Campus: A Field Survey in Korea. *Energy Build.* **2014**, *78*, 176–182. [CrossRef]
33. Davis, J.A.; Nutter, D.W. Occupancy Diversity Factors for Common University Building Types. *Energy Build.* **2010**, *42*, 1543–1551. [CrossRef]
34. Escrivá-Escrivá, G.; Segura-Heras, I.; Alcázar-Ortega, M. Application of an Energy Management and Control System to Assess the Potential of Different Control Strategies in HVAC Systems. *Energy Build.* **2010**, *42*, 2258–2267. [CrossRef]
35. Tan, H.W.; Chen, S.Q.; Shi, Q.; Wang, L.L. Development of Green Campus in China. *J. Clean. Prod.* **2014**, *64*, 646–653. [CrossRef]
36. Khoshbakht, M.; Gou, Z.H.; Dupre, K. Energy Use Characteristics and Benchmarking for Higher Education Buildings. *Energy Build.* **2018**, *164*, 61–76. [CrossRef]
37. Hua, Y.; Oswald, A.; Yang, X. Effectiveness of Daylighting Design and Occupant Visual Satisfaction in a LEED Gold Laboratory Building. *Build. Env.* **2011**, *46*, 54–64. [CrossRef]
38. Ma, Z.; Yan, R.; Nord, N. A Variation Focused Cluster Analysis Strategy to Identify Typical Daily Heating Load Profiles of Higher Education Buildings. *Energy* **2017**, *134*, 90–102. [CrossRef]
39. Kolokotsa, D.; Gobakis, K.; Papantoniou, S.; Georgatou, C.; Kampelis, N.; Kalaitzakis, K.; Vasilakopoulou, K.; Santamouris, M. Development of a Web Based Energy Management System for University Campuses: The CAMP-IT Platform. *Energy Build.* **2016**, *123*, 119–135. [CrossRef]
40. Cotton, D.; Shiel, C.; Paco, A. Energy Saving on Campus: A Comparison of Students' Attitudes and Reported Behaviours in the UK and Portugal. *J. Clean. Prod.* **2016**, *129*, 586–595. [CrossRef]
41. Alshuwaikhat, H.M.; Abubakar, I. An Integrated Approach to Achieving Campus Sustainability: Assessment of the Current Campus Environmental Management Practices. *J. Clean. Prod.* **2008**, *16*, 1777–1785. [CrossRef]
42. Pérez-Lombard, L.; Ortiz, J.; Pout, C. A Review on Buildings Energy Consumption Information. *Energy Build.* **2008**, *40*, 394–398. [CrossRef]
43. Hawkins, D.; Hong, S.M.; Raslan, R.; Mumovic, D.; Hanna, S. Determinants of Energy Use in UK Higher Education Buildings Using Statistical and Artificial Neural Network Methods. *Int. J. Sustain. Built Environ.* **2012**, *1*, 50–63. [CrossRef]
44. Ward, I.; Ogbonna, A.; Altan, H. Sector Review of UK Higher Education Energy Consumption. *Energy Policy* **2008**, *36*, 2939–2949. [CrossRef]
45. Zhou, X.; Yan, J.W.; Zhu, J.W.; Cai, P.P. Survey of Energy Consumption and Energy Conservation Measures for Colleges and Universities in Guangdong Province. *Energy Build.* **2013**, *66*, 112–118. [CrossRef]
46. Escobedo, A.; Briceno, S.; Juarez, H.; Castillo, D.; Imaz, M.; Sheinbaum, C. Energy Consumption and GHG Emission Scenarios of a University Campus in Mexico. *Energy Sustain. Dev.* **2014**, *18*, 49–57. [CrossRef]
47. Ó Gallachóir, B.P.; Keane, M.; Morrissey, E.; O'Donnell, J. Using Indicators to Profile Energy Consumption and to Inform Energy Policy in a University—A Case Study in Ireland. *Energy Build.* **2007**, *39*, 913–922. [CrossRef]
48. Sekki, T.; Airaksinen, M.; Saari, A. Measured Energy Consumption of Educational Buildings in a Finnish City. *Energy Build.* **2015**, *87*, 105–115. [CrossRef]
49. Raatikainen, M.; Skön, J.P.; Leiviskä, K.; Kolehmainen, M. Intelligent Analysis of Energy Consumption in School Buildings. *Appl. Energy* **2016**, *165*, 416–429. [CrossRef]
50. Cansino, J.M.; Dugo, V.; Gálvez-Ruiz, D.; Román-Collado, R. What Drove Electricity Consumption in the Residential Sector during the SARS-CoV-2 Confinement? A Special Focus on University Students in Southern Spain. *Energy* **2023**, *262*, 125467. [CrossRef] [PubMed]
51. Cibinskiene, A.; Dumciuviene, D.; Andrijauskiene, M. Energy Consumption in Public Buildings: The Determinants of Occupants' Behavior. *Energies* **2020**, *13*, 3586. [CrossRef]
52. Gao, G.; Li, J.; Wen, Y. DeepComfort: Energy-Efficient Thermal Comfort Control in Buildings Via Reinforcement Learning. *IEEE Internet Things J.* **2020**, *7*, 8472–8484. [CrossRef]
53. Altan, H. Energy Efficiency Interventions in UK Higher Education Institutions. *Energy Policy* **2010**, *38*, 7722–7731. [CrossRef]
54. Annunziata, E.; Frey, M.; Rizzi, F. Towards Nearly Zero-Energy Buildings: The State-of-Art of National Regulations in Europe. *Energy* **2013**, *57*, 125–133. [CrossRef]
55. Cave, L.A.; Blomquist, G.C. Environmental Policy in the European Union: Fostering the Development of Pollution Havens? *Ecol. Econ.* **2008**, *65*, 253–261. [CrossRef]

56. Liu, Q.; Wang, Z. Green BIM-Based Study on the Green Performance of University Buildings in Northern China. *Energy Sustain. Soc.* **2022**, *12*, 12. [CrossRef]
57. Liu, Q.B.; Ren, J. Research on the Building Energy Efficiency Design Strategy of Chinese Universities Based on Green Performance Analysis. *Energy Build.* **2020**, *224*, 110242. [CrossRef]
58. Petratos, P.; Damaskou, E. Management Strategies for Sustainability Education, Planning, Design, Energy Conservation in California Higher Education. *Int. J. Sustain. High. Educ.* **2015**, *16*, 576–603. [CrossRef]
59. Mutumba, G.S.; Odongo, T.; Okurut, N.F.; Bagire, V. A Survey of Literature on Energy Consumption and Economic Growth. *Energy Rep.* **2021**, *7*, 9150–9239. [CrossRef]
60. Gregory-Smith, D.; Manika, D.; Wells, V.K.; Veitch, T. Examining the Effect of an Environmental Social Marketing Intervention among University Employees. *Stud. High. Educ.* **2018**, *43*, 2104–2120. [CrossRef]
61. Nunayon, S.S.; Olanipekun, E.A.; Famakin, I.O. Determining Key Drivers of Efficient Electricity Management Practices in Public Universities in Southwestern Nigeria An Empirical Study. *Int. J. Sustain. High. Educ.* **2020**, *21*, 281–314. [CrossRef]
62. Latif, A.F.; Ahmad, N.A.; Abdullah, M.R.; Ismail, A.; Ghani, A.A.A. A Review on Energy Performance in Malaysian Universities Through Building Information Modelling (BIM) Adaptation. In Proceedings of the 2019 3rd International Conference on Energy and Environmental Science, ICEES 2019, Seoul, Republic of Korea, 26–28 January 2019; Volume 291.
63. Wei, Q.; Li, Q.; Yang, Y.; Zhang, L.; Xie, W. A Summary of the Research on Building Load Forecasting Model of Colleges and Universities in North China Based on Energy Consumption Behavior: A Case in North China. *Energy Rep.* **2022**, *8*, 1446–1462. [CrossRef]
64. Almeida, L.; Tam, V.W.Y.; Le, K.N.; She, Y.J. Effects of Occupant Behaviour on Energy Performance in Buildings: A Green and Non-Green Building Comparison. *Eng. Constr. Archit. Manag.* **2020**, *27*, 1939–1962. [CrossRef]
65. Janda, K.B. Buildings Don't Use Energy: People Do. *Arch. Sci. Rev.* **2011**, *54*, 15–22. [CrossRef]
66. Marans, R.W.; Edelstein, J.Y. The Human Dimension of Energy Conservation and Sustainability A Case Study of the University of Michigan's Energy Conservation Program. *Int. J. Sustain. High. Educ.* **2010**, *11*, 6–18. [CrossRef]
67. Ishak, M.H. Modelling Energy Consumption Behaviour Using "Energy Culture" Concept for Student Accommodations in Malaysian Public Universities. *Facilities* **2017**, *35*, 658–683. [CrossRef]
68. Ishak, M.H.; Sipan, I.; Mar Iman, A.H.; Sapri, M. A Preliminary Assessment of Energy Consumption Behaviour Pattern and Factors Influence among Malaysian Higher Education Institutions Students. *J. Teknol.* **2015**, *74*, 59–71. [CrossRef]
69. Kim, Y.S.; Srebric, J. Impact of Occupancy Rates on the Building Electricity Consumption in Commercial Buildings. *Energy Build.* **2017**, *138*, 591–600. [CrossRef]
70. Guan, J.; Nord, N.; Chen, S.Q. Energy Planning of University Campus Building Complex: Energy Usage and Coincidental Analysis of Individual Buildings with a Case Study. *Energy Build.* **2016**, *124*, 99–111. [CrossRef]
71. Pappi, I.N.; Paterakis, N.G.; Catalao, J.P.S.; Panapakidis, I.; Papagiannis, G. Analysis of the Energy Usage in University Buildings: The Case of Aristotle University Campus. In Proceedings of the 2015 Australasian Universities Power Engineering Conference: Challenges for Future Grids, AUPEC 2015, Wollongong, NSW, Australia, 27–30 September 2015. [CrossRef]
72. Altan, H.; Ward, I. Non-Domestic Energy Use—Experiences of the Higher Education Sector. In Proceedings of the Annual Research Conference of the Royal Institution of Chartered Surveyors, COBRA 2006, London, UK, 7–8 September 2006.
73. Michael, M.; Ntsaluba, S.B.K.; Zhang, L. A Comparative Study on Electrical Energy Usage of University Residences in South Africa (2017). In Proceedings of the 27th International Conference on the Domestic Use of Energy, DUE 2019, Wellington, South Africa, 25–27 March 2019; pp. 201–205.
74. Gui, X.C.; Gou, Z.H.; Zhang, F. The Relationship between Energy Use and Space Use of Higher Educational Buildings in Subtropical Australia. *Energy Build.* **2020**, *211*, 109799. [CrossRef]
75. Gui, X.C.; Gou, Z.H.; Lu, Y. Reducing University Energy Use beyond Energy Retrofitting: The Academic Calendar Impacts. *Energy Build.* **2021**, *231*, 110647. [CrossRef]
76. Kaplowitz, M.D.; Thorp, L.; Coleman, K.; Kwame Yeboah, F. Energy Conservation Attitudes, Knowledge, and Behaviors in Science Laboratories. *Energy Policy* **2012**, *50*, 581–591. [CrossRef]
77. Hafer, M. Quantity and Electricity Consumption of Plug Load Equipment on a University Campus. *Energy Effic.* **2017**, *10*, 1013–1039. [CrossRef]
78. Sonetti, G.; Cottafava, D. Enhancing the Accountability and Comparability of Different Campuses' Energy Profiles through an Energy Cluster Approach. *Energy Effic.* **2022**, *15*, 19. [CrossRef]
79. Alghamdi, A.; Haider, H.; Hewage, K.; Sadiq, R. Inter-University Sustainability Benchmarking for Canadian Higher Education Institutions: Water, Energy, and Carbon Flows for Technical-Level Decision-Making. *Sustainability* **2019**, *11*, 2599. [CrossRef]
80. Lo, K. Energy Conservation in China's Higher Education Institutions. *Energy Policy* **2013**, *56*, 703–710. [CrossRef]
81. Zogou, O.; Stamatelos, T. Diagnosis and Reduction of Electricity Consumption Exceedance in Public University Buildings. *Open Fuels Energy Sci. J.* **2014**, *7*, 34–46. [CrossRef]
82. Wang, J.C. A Study on the Energy Performance of School Buildings in Taiwan. *Energy Build.* **2016**, *133*, 810–822. [CrossRef]
83. Madhukumar, M.; Sebastian, A.; Liang, X.; Jamil, M.; Shabbir, M.N.S.K. Regression Model-Based Short-Term Load Forecasting for University Campus Load. *IEEE Access* **2022**, *10*, 8891–8905. [CrossRef]
84. Heidarinejad, M.; Cedeno-Laurent, J.G.; Wentz, J.R.; Rekstad, N.M.; Spengler, J.D.; Srebric, J. Actual Building Energy Use Patterns and Their Implications for Predictive Modeling. *Energy Convers. Manag.* **2017**, *144*, 164–180. [CrossRef]

85. Khairalla, M.; Gaouda, A.M.; Abdel-Hafez, M.; Shuaib, K.; Alahmad, M. Challenges in Load Profile Monitoring: Case Study. In Proceedings of the 1st International Conference on Electrical and Information Technologies, ICEIT 2015, Marrakech, Morocco, 25–27 March 2015; pp. 65–70.
86. Wong, W.P.; Fellows, R.F.; Liu, A.M.M. Use of Electrical Energy in University Buildings: A Hong Kong Case Study. *Facilities* **2006**, *24*, 5–17. [CrossRef]
87. Qiu, J.; Xia, L.B. Application Study of Green Building Technology in Universities and Colleges in Cold Regions. In Proceedings of the 4th International Conference on Green Building, Materials and Civil Engineering, GBMCE 2014, Hong Kong, 21–22 August 2014; pp. 595–597.
88. Obaju, B.N.; Adeleke, J.S.; Yusuf, T.O.; Buari, T.A.; Tokede, C.A. Assessment of Energy Wastage and Saving Potentials for Higher Educational Institutional Buildings in South Western Nigeria. In Proceedings of the 1st International Conference on Energy and Sustainable Environment, ICESE 2019, Ota, Nigeria, 18–20 June 2019; Volume 331.
89. Eromobor, S.O.; Das, D.K.; Emuze, F. Influence of Building and Indoor Environmental Parameters on Designing Energy-Efficient Buildings. *Int. J. Build. Pathol. Adapt.* **2020**, *39*, 507–524. [CrossRef]
90. Pacheco-Torres, R.; Heo, Y.; Choudhary, R. Efficient Energy Modelling of Heterogeneous Building Portfolios. *Sustain. Cities Soc.* **2016**, *27*, 49–64. [CrossRef]
91. Im, H.; Srinivasan, R.S.; Maxwell, D.; Steiner, R.L.; Karmakar, S. The Impact of Climate Change on a University Campus' Energy Use: Use of Machine Learning and Building Characteristics. *Buildings* **2022**, *12*, 108. [CrossRef]
92. Aguayo-Ullao, E.; Valderrama-Ulloa, C.; Rouault, F. Analysis of Energy Data of Existing Buildings in a University Campus. *Rev. Construcción* **2018**, *17*, 172–182. [CrossRef]
93. Franco, D.V.H.K.; Maes, M.; Vanstraelen, L.; Casas, M.; Schepers, M. The Successful Introduction of Energy Efficiency in Higher Education Institution Buildings. *Smart Innov. Syst. Technol.* **2020**, *163*, 147–158. [CrossRef]
94. Zhang, L.; Liu, Z.; Hou, J.; Wei, D.; Hou, Y.; Du, J.; Shen, Q. Analysis on Energy Consumption and Energy-Saving Retrofit of University Buildings in Hot Summer and Cold Winter Zone of China. In *Environmental Science and Engineering, Proceedings of the 11th International Symposium on Heating, Ventilation and Air Conditioning (ISHVAC 2019), Harbin, China, 12 July–15 July 2019*; Springer: Singapore, 2020; pp. 1145–1153. [CrossRef]
95. Xie, D.; Yu, L.; Jiang, T.; Zou, Y. Distributed Energy Optimization for HVAC Systems in University Campus Buildings. *IEEE Access* **2018**, *6*, 59141–59151. [CrossRef]
96. Pritoni, M.; Salmon, K.; Sanguinetti, A.; Morejohn, J.; Modera, M. Occupant Thermal Feedback for Improved Efficiency in University Buildings. *Energy Build.* **2017**, *144*, 241–250. [CrossRef]
97. Alba, A.R.; Vincent Santiago, R. Decision Support System in Establishing Energy Management System for the Engineering Building of Bulacan State University. In Proceedings of the 11th IEEE International Conference on Humanoid, Nanotechnology, Information Technology, Communication and Control, Environment, and Management, HNICEM 2019, Laoag, Philippines, 29 November–1 December 2019.
98. Pinto Oliveira, D.C.; Pimentel Filho, M.C.; Alencar Freitas, A.A. Energy Efficiency Analysis in Buildings of a University Campus Using the Procel RTQ-C. In Proceedings of the 14th IEEE International Conference on Industry Applications, INDUSCON 2021, São Paulo, Brazil, 15–18 August 2021; pp. 710–715.
99. Papadopoulos, T.A.; Giannakopoulos, G.T.; Nikolaidis, V.C.; Safigianni, A.S.; Panapakidis, I.P. Study of Electricity Load Profiles in University Campuses: The Case Study of Democritus University of Thrace. In Proceedings of the Mediterranean Conference on Power Generation, Transmission, Distribution and Energy Conversion, MedPower 2016, Belgrade, Serbia, 6–9 November 2016; Volume 2016.
100. Litardo, J.; Hidalgo-Leon, R.; MacIas, J.; Delgado, K.; Soriano, G. Estimating Energy Consumption and Conservation Measures for ESPOL Campus Main Building Model Using EnergyPlus. In Proceedings of the 39th IEEE Central America and Panama Convention, CONCAPAN 2019, Guatemala City, Guatemala, 20–22 November 2019.
101. Mytafides, C.K.; Dimoudi, A.; Zoras, S. Transformation of a University Building into a Zero Energy Building in Mediterranean Climate. *Energy Build.* **2017**, *155*, 98–114. [CrossRef]
102. Yildiz, Y.; Koçyiğit, M. A Study on the Energy-Saving Potential of University Campuses in Turkey. *Proc. Inst. Civ. Eng. Eng. Sustain.* **2020**, *173*, 379–396. [CrossRef]
103. Leal Filho, W.; Salvia, A.L.; Paço, A.D.; Anholon, R.; Gonçalves Quelhas, O.L.; Rampasso, I.S.; Ng, A.; Balogun, A.-L.; Kondev, B.; Brandli, L.L. A Comparative Study of Approaches towards Energy Efficiency and Renewable Energy Use at Higher Education Institutions. *J. Clean. Prod.* **2019**, *237*, 117728. [CrossRef]
104. Ocampo Batlle, E.A.; Escobar Palacio, J.C.; Silva Lora, E.E.; Martínez Reyes, A.M.; Melian Moreno, M.; Morejón, M.B. A Methodology to Estimate Baseline Energy Use and Quantify Savings in Electrical Energy Consumption in Higher Education Institution Buildings: Case Study, Federal University of Itajubá (UNIFEI). *J. Clean. Prod.* **2020**, *244*, 118551. [CrossRef]
105. Chakraborty, T.; Ghosh, P.; Mal, S.; Biswas, U. A Modelling Applied to Active Renewable Energy for an Existing Building of Higher Educational Institution. *Int. J. Syst. Assur. Eng. Manag.* **2019**, *10*, 1361–1368. [CrossRef]
106. Vaisi, S.; Mohammadi, S.; Nastasi, B.; Javanroodi, K. A New Generation of Thermal Energy Benchmarks for University Buildings. *Energies* **2020**, *13*, 6606. [CrossRef]
107. Perdue, J.L.; Stoker, A.D. A Roadmap for Climate Action at the University of Calgary: Higher Education Campuses as Climate Leaders. *J. Green. Build.* **2013**, *8*, 44–61. [CrossRef]

108. Park, J.C.; Lee, K.G.; Shim, I.C.; Hong, W.H. A Study on the Energy Conservation Policy of South Korean Universities. *Adv. Mat. Res.* **2013**, *724–725*, 1602–1607. [CrossRef]
109. Gorgulu, S.; Kocabey, S. An Energy Saving Potential Analysis of Lighting Retrofit Scenarios in Outdoor Lighting Systems: A Case Study for a University Campus. *J. Clean. Prod.* **2020**, *260*, 121060. [CrossRef]
110. Al-Daraiseh, A.; Shah, N.; El-Qawasmeh, E. An Intelligent Energy Management System for Educational Buildings. *Int. J. Distrib. Sens. Netw.* **2013**, *2013*, 209803. [CrossRef]
111. Su, Y.; Takaguchi, H.; Yan, J. Analysis of Energy Consumption Structure of a Science and Engineering University Campus in Southern China. *J. Environ. Eng.* **2012**, *77*, 399–407. [CrossRef]
112. Fathi, S.; Srinivasan, R.S. Analysis of Energy Performance of University Campus Buildings Using Statistical and Energy Modeling Approaches. In Proceedings of the Winter Simulation Conference, WSC 2015, Huntington Beach, CA, USA, 6–9 December 2015; pp. 3356–3366.
113. Ohashi, T.; Miyazaki, M.; Shimoda, Y. Analysis of University Science Facilities' Energy Consumption. *J. Environ. Eng.* **2015**, *80*, 45–53. [CrossRef]
114. Shcherbak, V.; Ganushchak-Yefimenko, L.; Nifatova, O.; Dudko, P.; Savchuk, N.; Solonenchuk, I. Application of International Energy Efficiency Standards for Energy Auditing in a University Buildings. *Glob. J. Environ. Sci. Manag.-GJESM* **2019**, *5*, 501–514. [CrossRef]
115. Isingoma-Wakaisuka, J.; Ibanda, C.K.K.; Naluwooza, R.; Namaganda, C. Application of Smart Electronic Systems, Firm Characteristics and Efficient Energy Consumption—A Case of Public Universities in Uganda. *Int. J. Soc. Econ.* **2020**, *47*, 1023–1041. [CrossRef]
116. Gaspar, K.; Gangolells, M.; Casals, M.; Pujadas, P.; Forcada, N.; Macarulla, M.; Tejedor, B. Assessing the Impact of the COVID-19 Lockdown on the Energy Consumption of University Buildings. *Energy Build.* **2022**, *257*, 111783. [CrossRef] [PubMed]
117. Medrano, M.; Marti, J.M.; Rincon, L.; Mor, G.; Cipriano, J.; Farid, M. Assessing the Nearly Zero-Energy Building Gap in University Campuses with a Feature Extraction Methodology Applied to a Case Study in Spain. *Int. J. Energy Environ. Eng.* **2018**, *9*, 227–247. [CrossRef]
118. Birch, C.; Edwards, R.; Mander, S.; Sheppard, A. Assessing Unregulated Electricity Consumption in a Case Study University. *Build. Serv. Eng. Res. Technol.* **2020**, *41*, 305–314. [CrossRef]
119. Torres, C.; Siller, E.; Allen, Y.; Caeiro, J.A.J. Assessment of the Potential Savings Resulting from Shutting down University Buildings during Periods of Very Low Occupancy: A Case Study. In Proceedings of the 2013 Architectural Engineering National Conference: Building Solutions for Architectural Engineering, AEI 2013, State College, PA, USA, 3–5 April 2013; pp. 795–803.
120. Ding, Y.; Zhang, Z.; Zhang, Q.; Lv, W.; Yang, Z.; Zhu, N. Benchmark Analysis of Electricity Consumption for Complex Campus Buildings in China. *Appl. Therm. Eng.* **2018**, *131*, 428–436. [CrossRef]
121. Chihib, M.; Salmeron-Manzano, E.; Manzano-Agugliaro, F. Benchmarking Energy Use at University of Almeria (Spain). *Sustainability* **2020**, *12*, 1336. [CrossRef]
122. Lawrence, R.; Keime, C. Bridging the Gap between Energy and Comfort: Post-Occupancy Evaluation of Two Higher-Education Buildings in Sheffield. *Energy Build.* **2016**, *130*, 651–666. [CrossRef]
123. Liu, Z.-L.; Li, S.-Q.; Li, M.-Q.; Feng, L.-X. Building Energy Consumption in the Universities of China: Situation and Countermeasures. In Proceedings of the 19th International Conference on Industrial Engineering and Engineering Management: Engineering Management, Changsha, China, 27–29 October 2012; pp. 51–59.
124. Im, H.; Srinivasan, R.; Fathi, S. Building Energy Use Prediction Owing to Climate Change: A Case Study of a University Campus. In Proceedings of the 1st ACM International Workshop on Urban Building Energy Sensing, Controls, Big Data Analysis, and Visualization, UrbSys 2019—Part of BuildSys 2019, New York, NY, USA, 13–14 November 2019; pp. 43–50.
125. Melki, S.; Hayek, M. Building Simulation Tools and Their Role in Improving Existing Building Designs. In Proceedings of the 2009 International Conference on Advances in Computational Tools for Engineering Applications, ACTEA 2009, Beirut, Lebanon, 15–17 July 2009; pp. 503–507.
126. Del Borghi, A.; Spiegelhalter, T.; Moreschi, L.; Gallo, M. Carbon-Neutral-Campus Building: Design Versus Retrofitting of Two University Zero Energy Buildings in Europe and in the United States. *Sustainability* **2021**, *13*, 9023. [CrossRef]
127. Dirutigliano, D.; Brüntjen, M.A.; Fliegner, C.; Frisch, J.; Corrado, V.; van Treeck, C. Case Study for Energy Efficiency Measures of Buildings on an Urban Scale. *Build. Simul. Appl.* **2017**, *2017*, 403–410.
128. Kazaki, A.G.; Papadopoulos, T.A. Cluster Analysis of University Campus Smart Meter Data. In Proceedings of the 53rd International Universities Power Engineering Conference, UPEC 2018, Glasgow, UK, 4–7 September 2018.
129. Serghides, D.K.; Chatzinikola, C.K.; Katafygiotou, M.C. Comparative Studies of the Occupants' Behaviour in a University Building during Winter and Summer Time. *Int. J. Sustain. Energy* **2015**, *34*, 528–551. [CrossRef]
130. Oyedepo, S.O.; Dirisu, J.O.; Efemwenkiekie, U.K.; Fayomi, O.S.I.; Essien, E.E. Comprehending the Energy Consumption Pattern of Occupancy of an Academic Structure. In Proceedings of the 3rd International Conference on Engineering for Sustainable World, ICESW 2019, Ota, Nigeria, 3–8 July 2019; Volume 1378.
131. López-sosa, L.B.; Alvarado-flores, J.J.; Marín-aguilar, T.N.J.; Corral-huacuz, J.C.; Aguilera-mandujano, A.; Rodríguez-torres, G.M.; Morales-máximo, M.; Rodríguez-magallón, M.C.; Alcaraz-vera, J.v.; Ávalos-rodríguez, M.L.; et al. COVID-19 Pandemic Effect on Energy Consumption in State Universities: Michoacan, Mexico Case Study. *Energies* **2021**, *14*, 7642. [CrossRef]

132. Wang, L.; Ding, Y.; Riedel, T.; Miclaus, A.; Beigl, M. Data Analysis on Building Load Profiles: A Stepping Stone to Future Campus. In Proceedings of the 2017 International Smart Cities Conference, ISC2 2017, Wuxi, China, 14–17 September 2017.
133. Chaplin, G.; Dibaj, M.; Akrami, M. Decarbonising Universities: Case Study of the University of Exeter's Green Strategy Plans Based on Analysing Its Energy Demand in 2012-2020. *Sustainability* **2022**, *14*, 4085. [CrossRef]
134. Nizamutdinova, Z.F.; Potonova, N.A. Determination of Territorial Compactness and Analysis of Optimization of Energy-Efficient Characteristics of the University Campus. In Proceedings of the 2020 International Baikal Investment and Construction Forum on Spatial Restructuring of Territories, Irkutsk, Russia, 4 December 2020; Volume 751.
135. Chokor, A.; El Asmar, M.; Tilton, C.; Srour, I. Dual Assessment Framework to Evaluate LEED-Certified Facilities' Occupant Satisfaction and Energy Performance: Macro and Micro Approaches. *J. Archit. Eng.* **2016**, *22*. [CrossRef]
136. Murshed, M. Electricity Conservation Opportunities within Private University Campuses in Bangladesh. *Energy Environ.* **2020**, *31*, 256–274. [CrossRef]
137. Mtutu, P.; Thondhlana, G. Encouraging Pro-Environmental Behaviour: Energy Use and Recycling at Rhodes University, South Africa. *Habitat. Int.* **2016**, *53*, 142–150. [CrossRef]
138. Amber, K.P.; Ahmad, R.; Chaudhery, G.Q.; Khan, M.S.; Akbar, B.; Bashir, M.A. Energy and Environmental Performance of a Higher Education Sector—A Case Study in the United Kingdom. *Int. J. Sustain. Energy* **2020**, *39*, 497–514. [CrossRef]
139. Yildiz, Y.; Kocyigit, M. Energy Consumption Analysis of Education Buildings: The Case Study of Balikesir University. *Gazi Univ. J. Sci.* **2021**, *34*, 665–677. [CrossRef]
140. Choi, D.-S.; Lee, M.-E.; Cho, K.-H.; Jeon, H.-C.; An, J.-H. Energy Consumption Pattern Analysis by University Building Characteristics for the Composition of Green Campus in Korea. *Int. J. Appl. Eng. Res.* **2014**, *9*, 24847–24855.
141. Numbi, B.P.; Malinga, S.J.; Chidzonga, R.F.; Mulangu, T.C. Energy Cost Saving Potential in Educational Buildings-Case Study of MUT Campus. In Proceedings of the 2017 International Conference on the Industrial and Commercial Use of Energy (ICUE), Cape Town, South Africa, 15–16 August 2017. [CrossRef]
142. Rebelatto, B.G.; Salvia, A.L.; Reginatto, G.; Daneli, R.C.; Brandli, L.L. Energy Efficiency Actions at a Brazilian University and Their Contribution to Sustainable Development Goal 7. *Int. J. Sustain. High. Educ.* **2019**, *20*, 842–855. [CrossRef]
143. Adame, B.O.; Salau, A.O. Energy Efficiency Analysis and Energy Conservation Measures for Ethiopian Universities: Introducing Green Campus Initiative. In Proceedings of the 8th Annual IEEE Power and Energy Society and Industrial Applications Society PowerAfrica Conference, PowerAfrica 2021, Nairobi, Kenya, 23–27 August 2021.
144. Marina Domingo, A.M.; Rey-Hernández, J.M.; San José Alonso, J.F.; Crespo, R.M.; Rey Martínez, F.J. Energy Efficiency Analysis Carried out by Installing District Heating on a University Campus. A Case Study in Spain. *Energies* **2018**, *11*, 2826. [CrossRef]
145. Faria, A.; Alvarenga, B.; Lemos, G.; Viajante, G.; Domingos, J.L.; Marra, E. Energy Efficiency and Distributed Generation: A Case Study Applied in Public Institutions of Higher Education. *Energies* **2022**, *15*, 1217. [CrossRef]
146. Franco, D.V.H.K.; Macke, J.; Schepers, M.; Segers, J.P.; Maes, M.; Cruyplandt, E. Energy Efficiency in School Buildings: The Need for a Tailor-Made Business Model. *Smart Innov. Syst. Technol.* **2021**, *203*, 89–101. [CrossRef]
147. Zakaria, N.A.; Hassan, M.Y.; Abdullah, H.; Abdullah, M.P.; Hussin, F.; Hussin, S.M.; Bakar, N.N.A. Energy Efficiency Index by Considering Number of Occupants: A Study on the Lecture Rooms in a University Building. *Indones. J. Electr. Eng. Comput. Sci.* **2019**, *15*, 1154–1160. [CrossRef]
148. Ahmad, S.A.; Hassan, M.Y.; Abdullah, H.; Rahman, H.A.; Majid, M.S.; Bandi, M. Energy Efficiency Measurements in a Malaysian Public University. In Proceedings of the 2012 IEEE International Conference on Power and Energy, PECon 2012, Kota Kinabalu, Malaysia, 2–5 December 2012; pp. 582–587.
149. Shafie, S.M.; Harits, N.; Hami, N.; Firman; Hassan, M.G.; Yanti, S.R. Energy Efficient Management Application in University Buildings: Case of Malaysia Public University. *Int. J. Adv. Sci. Technol.* **2020**, *29*, 1704–1711.
150. Jomoah, I.M.; Al-Abdulaziz, A.U.M.; Sreerama Kumar, R. Energy Management in the Buildings of a University Campus in Saudi Arabia—A Case Study. In Proceedings of the 2013 4th International Conference on Power Engineering, Energy and Electrical Drives, POWERENG 2013, Istanbul, Turkey, 13–17 May 2013; pp. 659–663.
151. Litardo, J.; Hidalgo-Leon, R.; Soriano, G. Energy Performance and Benchmarking for University Classrooms in Hot and Humid Climates. *Energies* **2021**, *14*, 7013. [CrossRef]
152. Lee, S.H.; Augenbroe, G. Energy Performance Evaluation of Campus Facilities. In Proceedings of the Construction and Building Research Conference of the Royal Institution of Chartered Surveyors, COBRA 2007, Atlanta, GA, USA, 6–7 September 2007.
153. Chen, Q.; Kleinman, L.; Dial, A. Energy Performance of Campus LEED® Buildings: Implications for Green Building and Energy Policy. *J. Green. Build.* **2015**, *10*, 137–160. [CrossRef]
154. Ascione, F.; Borrelli, M.; de Masi, R.F.; De'Rossi, F.; Vanoli, G.P. Energy Refurbishment of a University Building in Cold Italian Backcountry. Part 1: Audit and Calibration of the Numerical Model. In Proceedings of the 2018 Renewable Energy Integration with Mini/Microgrid, REM 2018, Rhodes, Greece, 29–30 September 2019; Volume 159, pp. 10–15.
155. Ascione, F.; Borrelli, M.; de Masi, R.F.; Rossi, F.D.; Vanoli, G.P. Energy Refurbishment of a University Building in Cold Italian Backcountry. Part 2: Sensitivity Studies and Optimization. In Proceedings of the 2018 Renewable Energy Integration with Mini/Microgrid, REM 2018, Rhodes, Greece, 29–30 September 2019; Volume 159, pp. 2–9.
156. Kartikasari, F.D.; Tarigan, E.; Fransiscus, Y.; Lidyawati, T. Energy Saving Measures and Potential of Energy Efficiency at the University of Surabaya, Based on EDGE Simulation. In Proceedings of the 5th International Conference on Information Technology, Computer and Electrical Engineering, ICITACEE 2018, Semarang, Indonesia, 27–28 September 2018; pp. 89–92.

157. Noranai, Z.; Mohamad, M.H.H.; Salleh, H.; Yusof, M.Z.M. Energy Saving Measures for University Public Library: A Case Study of UTHM Library. *Appl. Mech. Mater.* **2014**, *660*, 1072–1075. [CrossRef]
158. Rivera-Castro, A.F.; Fuentes-Velazquez, J.G.; Angeles-Camacho, C. Energy Savings Due to Daylight Saving in Mexico; Case Study: Buildings and Facilities of CU-UNAM. In Proceedings of the 39th IEEE Central America and Panama Convention, CONCAPAN 2019, Guatemala City, Guatemala, 20–22 November 2019.
159. Ishak, M.H.; Sipan, I.; Sapri, M.; Mar Iman, A.H.; Martin, D. Estimating Potential Saving with Energy Consumption Behaviour Model in Higher Education Institutions. *Sustain. Environ. Res.* **2016**, *26*, 268–273. [CrossRef]
160. Bernardo, H.; Oliveira, F. Estimation of Energy Savings Potential in Higher Education Buildings Supported by Energy Performance Benchmarking: A Case Study. *Environments* **2018**, *5*, 85. [CrossRef]
161. Lawrence, R.; Elsayed, M.; Keime, C. Evaluation of Environmental Design Strategies for University Buildings. *Build. Res. Inf.* **2019**, *47*, 883–900. [CrossRef]
162. Cottafava, D.; Sonetti, G.; Gambino, P.; Tartaglino, A. Explorative Multidimensional Analysis for Energy Efficiency: Dataviz versus Clustering Algorithms. *Energies* **2018**, *11*, 1312. [CrossRef]
163. Bisegna, F.; Cirrincione, L.; lo Casto, B.M.; Peri, G.; Rizzo, G.; Scaccianoce, G.; Sorrentino, G. Fostering the Energy Efficiency through the Energy Savings: The Case of the University of Palermo. In Proceedings of the 19th IEEE International Conference on Environment and Electrical Engineering and 2019 IEEE Industrial and Commercial Power Systems Europe, EEEIC/I and CPS Europe 2019, Genoa, Italy, 11–14 June 2019.
164. Caeiro, J.A.J.; Gang, W.; Glusing, J.; ASCE, A.E.I. of Identifying the Determinants of Energy Use in Texas A&M University Campus at Kingsville. In Proceedings of the AEI 2011: Building Integrated Solutions, Oakland, CA, USA, 30 March–2 April 2011; pp. 228–234.
165. Chihib, M.; Salmeron-Manzano, E.; Chourak, M.; Perea-Moreno, A.J.; Manzano-Agugliaro, F. Impact of the COVID-19 Pandemic on the Energy Use at the University of Almeria (Spain). *Sustainability* **2021**, *13*, 5843. [CrossRef]
166. Xu, X.; Wang, W.; Hong, T.; Chen, J. Incorporating Machine Learning with Building Network Analysis to Predict Multi-Building Energy Use. *Energy Build.* **2019**, *186*, 80–97. [CrossRef]
167. Darby, H.; Elmualim, A.; Clements-Croome, D.; Yearley, T.; Box, W. Influence of Occupants' Behaviour on Energy and Carbon Emission Reduction in a Higher Education Building in the UK. *Intell. Build. Int.* **2016**, *8*, 157–175. [CrossRef]
168. Li, S.M.; Chen, Y. Internal Benchmarking of Higher Education Buildings Using the Floor-Area Percentages of Different Space Usages. *Energy Build.* **2021**, *231*, 110574. [CrossRef]
169. Ciugudeanu, C.; Beu, D.; Rastei, E. Living Building Laboratory—Educational Building Project in Cluj-Napoca. *Energy Procedia* **2016**, *85*, 125–131. [CrossRef]
170. Su, Y.; Yan, J.W. Methodology of Measurement and Calculation of Building Energy Management System in University Campus. *Appl. Mech. Mater.* **2013**, *368–370*, 454–459. [CrossRef]
171. Al-Daraiseh, A.; El-Qawasmeh, E.; Shah, N. Multi-Agent System for Energy Consumption Optimisation in Higher Education Institutions. *J. Comput. Syst. Sci.* **2015**, *81*, 958–965. [CrossRef]
172. Mata, E.; López, F.; Cuchí, A. Optimization of the Management of Building Stocks: An Example of the Application of Managing Heating Systems in University Buildings in Spain. *Energy Build.* **2009**, *41*, 1334–1346. [CrossRef]
173. Sergeev, S.; Barykin, S.; Kalinina, O.; Naumova, E.; Dedyukhina, N.; Dmitrieva, T. Optimizing the Energy Efficiency of Higher Education Institutions. In Proceedings of the 22nd International Scientific Conference on Energy Management of Municipal Facilities and Sustainable Energy Technologies, EMMFT 2020, Voronezh, Russia, 8–10 December 2020; Volume 244.
174. Prada, M.; Popescu, D.E.; Bungau, C.; Pancu, R.; Bungau, C. Parametric Studies on European 20-20-20 Energy Policy Targets in University Environment. *J. Environ. Prot. Ecol.* **2017**, *18*, 1146–1157.
175. Noranai, Z.; Azman, A.D.F. Potential Reduction of Energy Consumption in Public University Library. In Proceedings of the 2nd International Conference on Computational Fluid Dynamics in Research and Industry, CFDRI 2017, Songkhla, Thailand, 3–4 August 2017; Volume 243.
176. Mohammadalizadehkorde, M.; Weaver, R. Quantifying Potential Savings from Sustainable Energy Projects at a Large Public University: An Energy Efficiency Assessment for Texas State University. *Sustain. Energy Technol. Assess.* **2020**, *37*, 100570. [CrossRef]
177. Vaisi, S.; Pilla, F.; McCormack, S.J. Recommending a Thermal Energy Benchmark Based on CIBSE TM46 for Typical College Buildings and Creating Monthly Energy Models. *Energy Build.* **2018**, *176*, 296–309. [CrossRef]
178. Fen, H.H. Reflection upon Energy Saving and Emission Reduction in Colleges in the Context of Low-Carbon City Construction. *Adv. Mat. Res.* **2013**, *724–725*, 1539–1542. [CrossRef]
179. Tang, S.; Zhao, Y.; Xu, W.; Deng, J.; Yang, X.; Hou, X. Research on Construction Strategy of Energy Conservation and Emission Reduction in University Campuses in Beijing. In Proceedings of the 2nd International Conference on Civil Architecture and Energy Science, CAES 2020, Changchun, China, 20–22 March 2020; Volume 165.
180. Wang, Q.Y. Research on Saving Energy and Reducing Cost of the Higher Learning Institution. *Appl. Mech. Mater.* **2011**, *99–100*, 800–803. [CrossRef]
181. Fernandes, L.O.; Labaki, L.C.; Velux, E.O.E.R. Retrofit of Educational Facility through Passive Strategies in Hot Climate. In Proceedings of the 9th International Windsor Conference 2016: Making Comfort Relevant, NCEUB 2016, Buildings, UK, 7–10 April 2016; pp. 532–541.

182. Ying, H.; Jianqiang, H.; Guoqiang, X.; Shikuan, L.; Jing, C. Review of the Research on Energy Consumption Evaluation Index System of Campus. *Open Fuels Energy Sci. J.* **2014**, *7*, 84–87. [CrossRef]
183. Sapri, M.; Ishak, M.H.; Sipan, I.; Iman, A.H.M. Significant Factors of Energy Consumption Behaviour Pattern among Malaysian Higher Education Institutions Students. In Proceedings of the 25th International Business Information Management Association Conference—Innovation Vision 2020: From Regional Development Sustainability to Global Economic Growth, IBIMA 2015, Amsterdam, The Netherlands, 7–8 May 2015; pp. 505–516.
184. Ao, S.-J. Status and Countermeasures of Energy Management in China's College. In Proceedings of the 2011 International Conference on Materials for Renewable Energy and Environment, ICMREE2011, Shanghai, China, 20–22 May 2011; Volume 2, pp. 1922–1926.
185. Yoshida, Y.; Shimoda, Y.; Ohashi, T. Strategies for a Sustainable Campus in Osaka University. *Energy Build.* **2017**, *147*, 1–8. [CrossRef]
186. Asmar, M.E.; Tilton, C. Student Housing Energy Consumption: A Comparison of Chilled Water, Heating, and Electricity Use. *Procedia Eng.* **2015**, *118*, 1038–1043. [CrossRef]
187. Xue, S.H.; Li, Y.Y.; Ma, Y.C.; Yu, Y. Study on Energy Consumption Quotas Development Method of Colleges and Universities in Hubei. *Adv. Mat. Res.* **2014**, *953–954*, 1624–1627. [CrossRef]
188. Tian, P.; Zhou, H.; Li, N.; Su, Q. Survey on Energy Consumption and Indoor Thermal Environment of University Building in Changsha, China. In Proceedings of the 6th International Symposium on Heating, Ventilating and Air Conditioning, ISHVAC 2009, Nanjing, China, 6–9November 2009; Volume 1, pp. 65–71.
189. Leite Frandoloso, M.A.; Grala Da Cunha, E.; Brandli, L.; de Brito Rodrigues, F.; Rostirolla, J.A.; Turella, L.; de Negri, L.; Marchiori, T. Sustainability and Natural Resources Uses at a South Brazilian University: Proposing an Environmental Plan to University of Passo Fundo. In Proceedings of the International Conference on Sustainable Construction, Materials and Practices: Challenge of the Industry for the New Millennium, Portugal SB 2007, Lisbon, Portugal, 12–14 September 2007; pp. 139–146.
190. Fonseca, P.; Moura, P.; Jorge, H.; de Almeida, A. Sustainability in University Campus: Options for Achieving Nearly Zero Energy Goals. *Int. J. Sustain. High. Educ.* **2018**, *19*, 790–816. [CrossRef]
191. Skopek, J. Sustainable and Smart University Campuses; Strategic Approach to Sustainability and Building Intelligence for University Campuses. In Proceedings of the CESB 2010 Prague—Central Europe towards Sustainable Building "From Theory to Practice", Prague, Czech, 30 June–2 July 2010; pp. 1–4.
192. Ferreira, J.G.; de Matos, M.; Silva, H.; Franca, A.; Duarte, P. Sustainable Campus: The Experience of the University of Lisbon at IST. *Sustainability* **2021**, *13*, 8050. [CrossRef]
193. Mata, É.; López, F.; Cuchí, A. Sustainable Management of Existing Building Stock: A Strategy to Reduce the Energy Consumption and the Environmental Impact. In Proceedings of the International Conference on Sustainable Construction, Materials and Practices: Challenge of the Industry for the New Millennium, Portugal SB 2007, Lisbon, Portugal, 12–14 September 2007; pp. 171–177.
194. del Pilar Castrillon, R.; Quintero, A.M. The energy planning according to the ISO 50001 contribute to the consolidation of a Sustainable Campus to the Universidad Autonoma de Occidente. In Proceedings of the IEEE International Conference on Automation/23rd Congress of the Chilean Association of Automatic Control: Towards an Industry 4.0, ICA-ACCA 2018, Concepcion, Chile, 17–19 October 2018.
195. Gui, X.C.; Gou, Z.H.; Zhang, F.; Yu, R.R. The Impact of COVID-19 on Higher Education Building Energy Use and Implications for Future Education Building Energy Studies. *Energy Build.* **2021**, *251*, 111346. [CrossRef] [PubMed]
196. Zhu, B.F.; Wang, Z.K.; Sun, C.Y.; Dewancker, B. The Motivation and Development Impact of Energy Saving to Sustainability in the Construction of Green Campus: A Case Study of the Zhejiang University, China. *Env. Dev. Sustain.* **2021**, *23*, 14068–14089. [CrossRef]
197. Garrido-Yserte, R.; Gallo-Rivera, M.-T. The Potential Role of Stakeholders in the Energy Efficiency of Higher Education Institutions. *Sustainability* **2020**, *12*, 8908. [CrossRef]
198. Lasuen, U.O.; Iragorri, M.A.O.; Diez, J.R. Towards Energy Transition at the Faculty of Education of Bilbao (UPV/EHU): Diagnosing Community and Building. *Int. J. Sustain. High. Educ.* **2020**, *21*, 1277–1296. [CrossRef]
199. Jafary, M.; Wright, M.; Shephard, L.; Gomez, J.; Nair, R.U. Understanding Campus Energy Consumption—People, Buildings and Technology. *IEEE Green. Technol. Conf.* **2016**, *2016*, 68–72. [CrossRef]
200. Bellia, L.; Borrelli, M.; De Masi, R.F.; Ruggiero, S.; Vanoli, G.P. University Building: Energy Diagnosis and Refurbishment Design with Cost-Optimal Approach. Discussion about the Effect of Numerical Modelling Assumptions. *J. Build. Eng.* **2018**, *18*, 1–18. [CrossRef]
201. Deshko, V.I.; Shevchenko, O.M. University Campuses Energy Performance Estimation in Ukraine Based on Measurable Approach. *Energy Build.* **2013**, *66*, 582–590. [CrossRef]
202. Maistry, N.; Annegarn, H. Using Energy Profiles to Identify University Energy Reduction Opportunities. *Int. J. Sustain. High. Educ.* **2016**, *17*, 188–207. [CrossRef]