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Review

Mapping Drivers, Barriers, and Trends in Renewable Energy Sources in Universities: A Connection Based on the SDGs

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Abstract: Universities play a pivotal role in modern society and must lead the way in achieving energy efficiency, directly contributing to the Sustainable Development Goals (SDGs). Like small towns in resource consumption and population mobility, many universities and research centers face significant challenges transitioning to renewable electricity systems. This study aims to (i) map the current scientific literature on renewable energy sources used by universities; (ii) discuss the drivers, barriers, and trends of implementing renewable energy; and (iii) establish a connection with the SDGs. More specifically, the authors conducted a systematic literature review based on three stages: (i) data collection, (ii) bibliometric analysis, and (iii) content analysis. Forty-two articles were obtained and defined as the studied sample. The findings of this review illuminate critical research themes, leading countries in renewable energy adoption, and the prevalent electricity sources, shedding light on the primary authors shaping the discourse. Wind and solar energy exhibit a notable growth trajectory, offering environmentally friendly alternatives compared to conventional sources. Furthermore, it is essential to highlight that the distribution of research documents in the sample is uneven, with a predominant concentration in European countries. Additionally, the study identifies the field's key drivers, barriers, and emergent trends. The theoretical contributions encompass a comprehensive compilation of renewable energy sources, discernible research trajectories, and strategies to navigate obstacles. In practical terms, this work offers valuable insights for the selection of energy sources and stakeholder engagement, facilitating informed decision-making processes. This article's novelty lies in its holistic examination of renewable energy adoption in university settings, providing a comprehensive overview of the current landscape and actionable insights for stakeholders seeking sustainable energy solutions within these institutions. This aligns with multiple SDGs, including Goal 7 (Affordable and Clean Energy), Goal 11 (Sustainable Cities and Communities), and Goal 13 (Climate Action), underscoring the critical role of universities in driving sustainable development.

Keywords: renewable energy; sustainable energy; solar energy; university; review

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1. Introduction

Energy plays an essential role in any country's economic growth [1]. Finding alternative energy sources that meet the population's needs is necessary to meet its growing demand. Unfortunately, fossil fuels are a concerning problem with electricity generation [2], harming the environment, depleting natural resources, and causing pollution. In this sense,

new energy sources, especially those of renewable origin, must be present in countries' energy matrices.

In residential and industrial settings, renewable energy has been pursuing the forefront on a large scale [3]. However, implementing renewable sources for electricity generation in higher education institutions (HEI) is still a topic for scientific research. Nevertheless, HEI have studied hybrid renewable energy adoption [4–6]. To Kolokotsa et al. [7], university campuses are like small-scale cities. In such a way, according to Avila et al. [8], the occupancy profiles of cities are vast, and the use of spaces is so diverse that a university campus resembles a community or a neighborhood in a city. Once universities can be characterized as small cities, they must embrace the implementation of renewable energy to set an example for the community on behalf of sustainable development. Based on this university–city relationship, it is possible to see the importance of expanding renewable and sustainable energy technologies on campuses.

Given universities' role in modern society, they must take the lead in analyzing energy efficiency, characterizing themselves as smart and sustainable universities [9–11]. The definition of a sustainable university is commonly associated with the three pillars of sustainability, as universities are responsible for mitigating environmental, economic, and social impacts; promoting health and well-bing; and disseminating these values globally [12–14]. Furthermore, Cortese [15] argued that teaching, research, operations, and extension are part of a sustainable university's integrated system; therefore, a sustainable university focuses on inseparability, considering the impacts it suffers.

Universities face barriers to joining a renewable energy system. For example, many public institutions are burdened with supplying and maintaining diesel generators [4]. Also, Avila et al. [8] suggested that bottom-up initiatives may fail due to a lack of financing and support from administrative boards. Further, it is notable that the barriers for implementing these systems in HEI are common across the board, including, e.g., lack of funding, lack of human and technological resources, lack of support from administration, resistance from collaborators, and lack of knowledge about the importance of renewable energy generation [16–20], with most of the impediments to the adoption of this type of energy system coming from a lack of governmental support for its adoption in universities.

Given this research gap, this study aims to (i) map the current scientific literature on renewable energy sources used by universities; (ii) discuss the drivers, barriers, and trends of implementing renewable energy; and (iii) to establish a connection with the Sustainable Development Goals. To do so, we used a systematic literature review in three stages: (i) data collection, (ii) bibliometric analysis, and (iii) content analysis. This manuscript presents a dyad of theoretical and practical contributions. A compilation of renewable energy sources, research trends, and strategies to mitigate barriers is given regarding the former. The latter is directed at the types of energy and stakeholders that support decision making and the list of management trends and opportunities that support clean energy implementation in universities. In addition, this study aligns with some of the Sustainable Development Goals (SDGs) established by the 2030 Agenda.

Therefore, this paper is organized as follows: The first section contextualizes the study's theme and aim. The following section shows the methodology used in the systematic literature review on the topic. Section 3 reports the results of the bibliometric analysis. Section 4 discusses the trends, barriers, and trends for further study. Finally, Section 5 presents the final remarks and limitations of the research.

2. Materials and Methods

A methodology was adopted for data collection, selection of relevant documents for analysis, and obtaining answers to the research questions: the systematic review, which was uniquely and methodically used on each selected paper to narrow down and summarize the content of the files to specific results consistent with the research [21–23]. In addition, the methods used enable the inclusion of an empirical analysis of the data obtained, commonly used to complement systematic reviews and show the practical and functional side of the

research [19]. Based on the method of Denyer and Tranfield [20], it focuses on three stages: (i) data collection, (ii) bibliometric analysis, and (iii) content analysis.

2.1. Data Collection

The protocol used in this research was the Preferred Reporting Item for Systematic Reviews and Meta-Analysis (PRISMA), developed by Moher et al. [24]. It was established to assist in classifying and selecting the articles. This research used the following search string: ((University OR Universities) AND ("Renewable Energy" OR "Sustainable Energy") AND (Empirical OR "Case Study") AND (Strategy OR Strategies OR "Public Policy" OR "Public Policies")). Based on the string results, the entire gathered dataset was taken from the Web of Science database, a comprehensive and diverse platform regarding scientific content [25]. At the end of the searches, 2534 documents were found, as presented in Figure 1 through the PRISMA protocol.

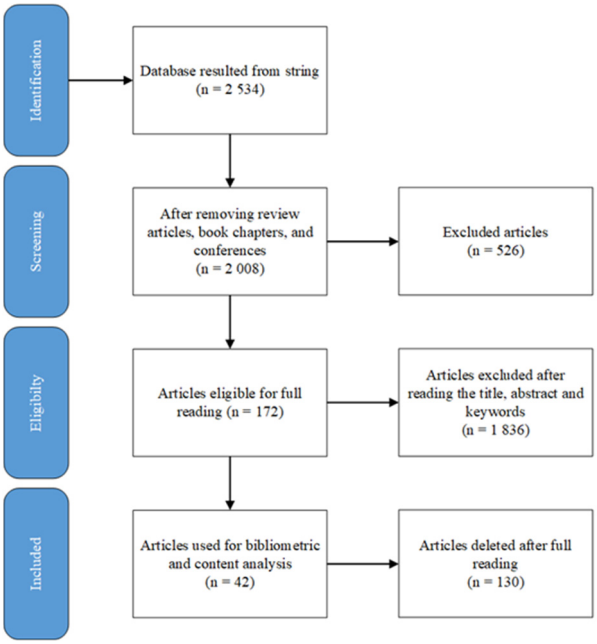


Figure 1. PRISMA protocol.

The use of PRISMA followed three filtering steps: (i) exclusion of review articles, book chapters, books, and conference articles, resulting in 2008 records; (ii) reading titles, abstracts, and keywords, resulting in 172 records; and (iii) complete reading of the sample articles, resulting in 42 documents. The Mendeley ® v1.19.8 software was used as a support tool for managing references [26]. The final sample of articles was used for bibliometric analysis (Section 2.2) and content analysis (Section 2.3).

2.2. Bibliometric Analysis

The Bibliometrix tool 4.1 was used for the research analysis and mapping. The tool developed by Aria and Cuccurullo [27] makes it possible to quantitatively analyze many documents based on the accumulated database examined by the package. It also helps in empirical studies since it is based on experiences that have occurred. As a form of modernization and adequacy, Bibliometrix used the RStudio® software 3.6.0 as a support tool for the graphics [27].

Thus, Bilbliometrix is a visualization tool for obtaining bibliometric data. Therefore, once the analysis method is defined, the platform needs a more apparent data classification to analyze each provided element accurately and concisely. Consequently, it was necessary to export the entire database in BibTex format. In this file model, it is possible to detail all the elements obtained from the database in text form [28]. Other information was

considered in the bibliometric analysis because it is information referring to the articles in the sample studied: (i) research method employed, (ii) type of energy source used, and (iii) stakeholders.

2.3. Content Analysis

Lastly, content analysis was used to categorize all articles in the final sample according to the topics the research addresses [29]. This analysis followed the steps suggested by Elo and Kyngäs [30], such as open coding, categorization, and abstraction. Through these steps, we sought to identify relevant information through a deductive process while coding the studied documents. This information was analyzed in two ways: bibliometric analysis and content analysis. Finally, the abstraction step supported the discussions among the sample authors for the results presented in Sections 3 and 4. This was carried out by retrieving the information from the articles according to specified categories so that the content analysis could occur in an organized manner. Therefore, the following categories were used: (i) drivers, (ii) barriers, and (iii) trends. Thus, based on the established categories, a detailed reading of the documents in the final sample was initiated to identify the information related to each category.

3. Overview of the Studied Sample

This section discusses the bibliometric analyses carried out in this study. The obtained database allowed us to identify how the documents and authors position themselves and relate to the studied themes. Figure 2 shows the analysis of the articles concerning the year of publication, the journal of publication, the university of affiliation, and the global citations.

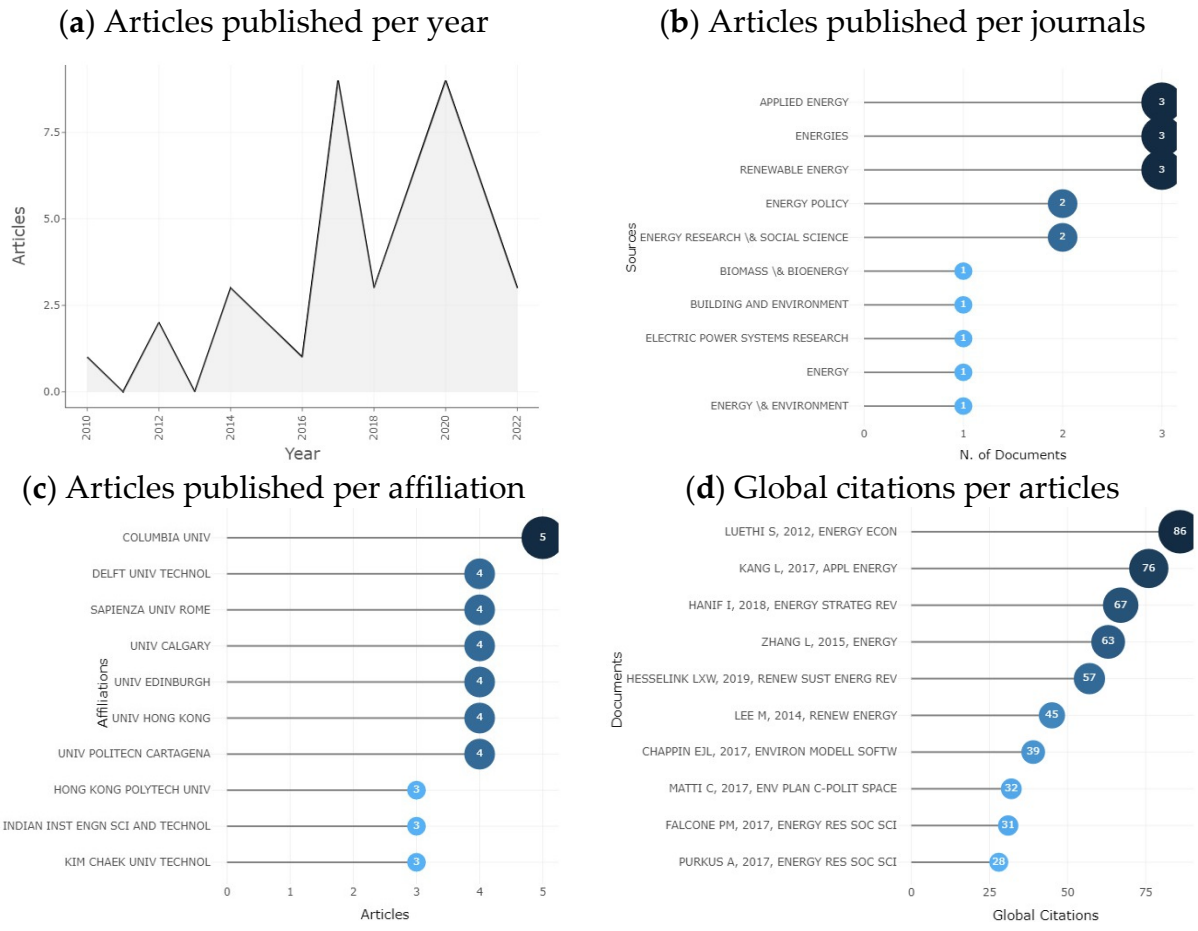


Figure 2. Articles by year, journal, affiliation, and global citations [31–40].

Figure 2a shows the publications on renewable energy and their applications in universities between 2010 and 2022, presenting a considerable increase starting in 2016. Furthermore, the volume of studies in this area declined between 2021 and 2022. Yet, they are still more frequent than in years before 2016, pointing to the topic's great importance in academia.

The manuscript was constructed from a systematic review of the literature, following methodological procedures for searching documents, filters, and selection. The literature does not provide a clear answer as to why the number of publications decreased in 2018 and 2022. However, given the general history, the topic is growing. One issue that might relate to the decline is that studies are more focused on empirical applications of renewable energy in other fields, such as manufacturing, agriculture, and cities.

Figure 2b exhibits an analysis of the journal's area of knowledge and the frequency of publication of these studies. The first three journals with the highest number of publications are *Applied Energy*, *Energy*, and *Renewable Energy*, which are part of the scope of the topic presented. Other journals cited were *Energy Policy* and *Energy Research & Social Science*; all five of these journals are recognized as top journals in energy research. Figure 2c shows which universities are affiliated with which articles in the study's portfolio. The leading university, having affiliation in five articles, is Columbia University/USA, followed by Delft University of Technology/The Netherlands, Sapienza University of Rome/Italy, University of Calgary/Canada, the University of Edinburgh/Scotland, and the University of Hong Kong/Japan, which have affiliations in four studies each. Most of the universities cited in this paper are related to the continents America, Europe, and Asia.

Figure 2d presents the number of citations of the analyzed articles globally. The most cited author is Luethi S., followed by Kang L. and Hanif I. They are also characterized as the three most cited authors in other articles. Another analysis was performed on the relationship among the main research themes. In this sense, Figure 3 shows the bibliometric analysis regarding the themes, their interconnections, and published studies by country.

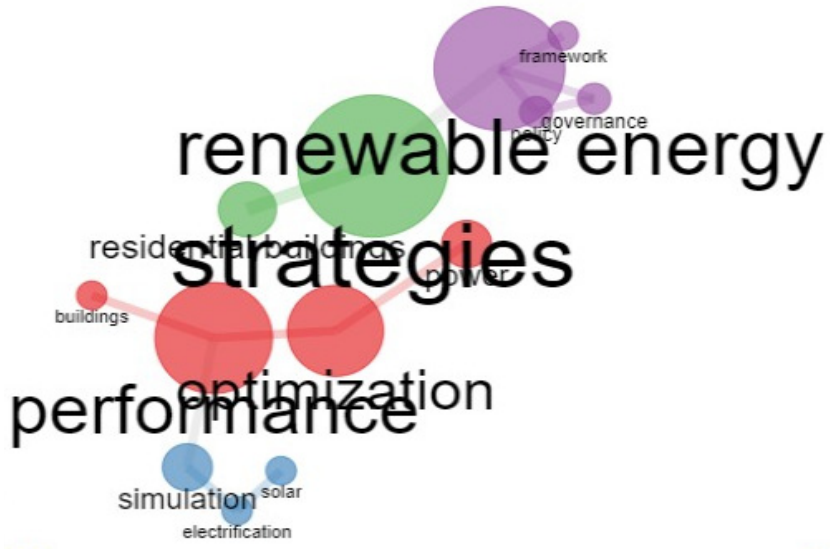


Figure 3. Main themes and their relationships.

The main themes in the articles highlighted in Figure 3 are renewable energy, strategies, and performance. Thus, it is notable that, within the selected articles, the main objects of study are the types of renewable energy, the possible strategies to be adopted, and the performance of tools within this theme. Secondary themes, still having significant incidence, are optimization, simulation, solar, buildings, and governance. Considering the occurrence of words, strategies were cited by 33 papers (78.54%), renewable energy by 22 papers (52.36%), and performance by 18 papers (42.84%). To complement the analysis, Figure 4 shows the map of countries with the most prominent number of analyzed publications.

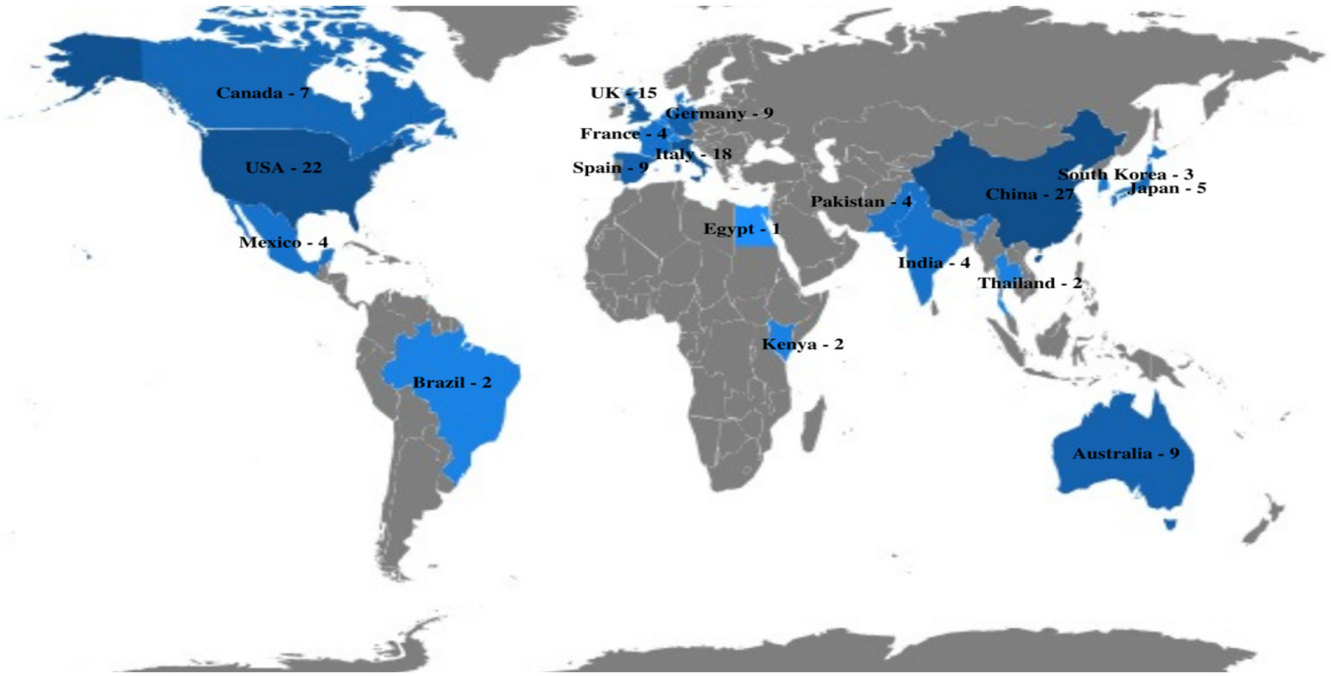


Figure 4. Published studies by authors in each country.

Figure 4 shows in more intense colors (darker shades of blue) where there is a higher incidence of articles being published. Considering occurrence per continent, Europe presented 55 authors (37.41%), Asia 45 authors (30.61%), America 35 authors (23.80%), Oceania 9 authors (6.12%), and Africa 3 authors (2.04%). China and the USA are the main countries in which this theme is addressed and have the highest number of publications. Subsequently, the incidence is also considerable in Italy, the UK, Germany, Spain, and Australia, with fewer publications. Therefore, there is a need to increase the discussion in different countries and continents on how to deal with the energy application of their universities to increase the number of studies published on the subject. Furthermore, in Figure 5, the correspondence analysis of the studied theme is shown based on interrelated studies.

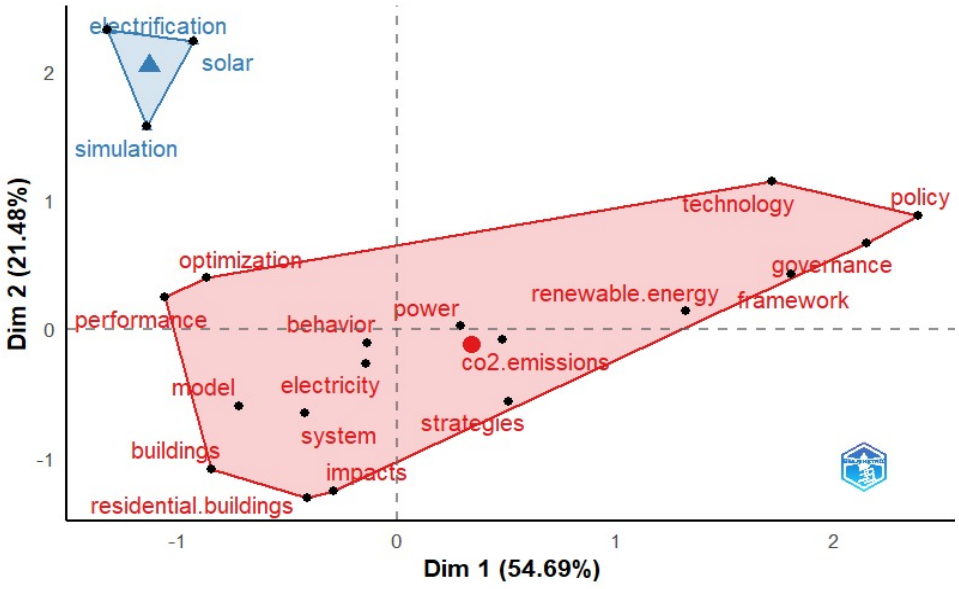


Figure 5. Correspondence analysis of the studied sample. The dotted line and red dot show where the zero is located, that is, it is possible to identify the four quadrants of the image.

In Figure 5, there are two groups with correlated words. The first group (the smaller one—in blue) presents the concepts of electrification, solar, and simulation. This indicates that these three themes intersect in similar works and are directly linked. The second group (in red) has a broader range of concepts that can be related more frequently by proximity, with the main topics being CO_2 emissions, policy, and electricity. It can be noticed from Figure 5 that the closer to a positive value in the axis, the greater the incidence of the word in the articles in the sample; in addition, the percentage shown in the dimensions demonstrates the number of studies that belong to it.

Furthermore, Table 1 allows one to identify the research method employed, energy type, and stakeholders present in the analyzed articles as well as the frequency or incidence with which they appear in the studies.

Table 1. Methods, energy source types, and stakeholders in the sample.

Classification		Articles (n)	References	%
Research method employed	Mixed method (qualitative and quantitative)	25	[31–35,41–60]	59.5%
	Qualitative	8	[33,36–39,61–63]	19.0%
	Quantitative	9	[40,55,64–70]	21.4%
Type of energy source	Solar	20	[31–33,35,37,40,44,46,52,55,58,62–64,67–69]	47.6%
	Wind	7	[38,47,56,60,61,66,70]	16.7%
	Geothermal	4	[41,48,53,71]	9.5%
	Hybrid	3	[43,50,65]	7.1%
	Biomass	3	[34,39,45]	7.1%
	Tidal wave	2	[54,59]	4.8%
	Nuclear	1	[51]	2.4%
	Hydropower	1	[69]	2.4%
	Fossil fuels	1	[36]	2.4%
Stakeholders	Community	4	[31,37,43,65]	9.5%
	Entrepreneurs	2	[41,55]	4.8%
	University	8	[35,40,44,49,60,62,64,66]	19.0%
	NGOs	1	[61]	2.4%
	Project developers	1	[32]	2.4%
	Farmers	1	[45]	2.4%
	Countries	21	[33,34,38,46,48,50–59,63,68–70]	50.0%
	Politicians	1	[39]	2.4%
	Entrepreneurs, community, and government	2	[47,71]	4.8%
	University and community	1	[67]	2.4%

The research methods employed by the sample articles are divided into qualitative, quantitative, and mixed methods (qualitative and quantitative). Most studies use mixed methods to measure their results, totaling 59.5% of the sample. This provides information stating that studies are not being conducted solely in diagnostic form but rather with empirical and longitudinal applications for implementing renewable energy in universities. Additionally, it is possible to analyze the types of energy used during the studies: geothermal, solar, wind, hybrid, fossil fuels, nuclear, tide wave, hydropower, and biomass. In this analysis, it was noted that some types are more prevalent than others within the articles. An example is photovoltaic and wind energy, which account for 45.2% and 16.7% of the sample. Geothermal and hybrid energy were characterized as 7.1% of the analyzed studies.

In fact, solar energy has a large and positive representation in the global context for potential installation in universities for a few reasons. First, it is clean, renewable energy with low-carbon prospects and follows global movements towards a lower-carbon economy. Secondly, installation and maintenance costs have decreased considerably in recent years, increasing consumer potential.

The stakeholders of each study were defined, with 10 of them based on reading the articles. Among them are the countries involved in half of the analyzed articles, while the university is present in 19.0%. The community and entrepreneurs are also present in 9.5% and 4.8% of the sample. Besides these stakeholders acting alone in the studies, a group is also involved in some studies, such as the entrepreneurs allied to the government and the community, representing 4.8% of the analyzed articles. Also, the university allied with the community in 2.4% of the sample.

4. Drivers, Barriers, and Trends of Renewable Energy Sources in Universities

This section addresses the main results of this article's content analysis, identifying drivers, barriers, and trends for future research.

4.1. Drivers

After analyzing the 42 documents in the final sample, the importance of using renewable energy was made explicit both concerning the efficiency of sustainable energy models and the benefits to the environment and the health of the population, as shown in Table 2.

Table 2. Drivers to implement renewable energy in universities.

Cluster	Type of Energy Source	Reference	Main Drivers
Sustainable and renewable energy employed by universities	Solar energy	[44]	Dealing with uncertain links and disturbances that are present in microgrid systems in some universities.
		[67]	Performing future evaluations and analyses of its potential is key to its consolidation and dissemination.
		[32]	Validating the data with larger samples through future research. Investigating whether renewable energy policy risk assessment differs by type of investors (e.g., large vs. small companies).
		[55]	Engaging in future research to understand the psychological benefits regarding the intention to install solar energy, alongside the mediation of an eco-friendly lifestyle.
		[52]	Standardizing ecosystem monetary methods.
		[58]	Exploring the integration of additional upgrading measures. Explore land and locations that are being used in large university campuses, with potential for installing solar energy
	Other (wind, hydroelectric, tidal, geothermal)	[70]	Identifying the best sustainable conditions for powering consumer.
		[48]	Conducting further analysis concerning large university buildings through future work.
		[51]	Studying the impacts of introducing taxes on carbon generation.
	Multiple energy types	[46]	Performing tests through case studies of policies for different issues, varied sectors, and delimitations.
		[33]	Extending the investigation to include environmental variables and conducting comparative analyses across sectors for a sustainable transition.
		[34]	Further studying the relative share of each alternative clean energy resource.

Table 2. *Cont.*

Cluster	Type of Energy Source	Reference	Main Drivers
Public policy and external projects to implement sustainable and renewable energy	Public policies	[37]	Relating the modeling of different energy technologies to the adoption barriers beyond those already known.
		[63]	Developing ways to engage the dynamic consciousness of historical relationships about the causes of contradictions in a proactive way to support systemic transformations based on future research.
		[36]	Enhancing the influence of energy management policies to ensure sustainable development in the region by integrating civil society into fundamental development and environmental policies.
	External projects	[41]	Initiating a multiple-case-study project could do more to suggest a general model of the process previously identified, in addition to conducting a survey for technology entrepreneurs about their experiences with the early stages of the commercialization process.
		[65]	Seeking to understand exactly how the physical and socioeconomic conditions of the landscape influence the development, success, and possible scaling up of sustainable energy initiatives.
		[71]	Conducting investigations across sectors and beyond the European continent.
		[43]	Using techniques considering the future uncertainty of electricity-type growth.

Through the analyses and after tabulating the data, it was possible to observe that most authors carried out research focused on solar energy. At least fifteen of them discussed their articles in various ways while commenting on the use of solar energy. In addition, some researchers showed how the transition from using energy with high carbon emission rates to renewable energy from the sun happens. Secondly, the type of energy they depicted the most is wind energy, which was demonstrated in some instances through calculations of the energy efficiency coming from atmospheric air currents. Furthermore, the authors referred to other renewable energy types, such as biomass, hydroelectric, and geothermal.

However, the data obtained note the importance of using renewable resources to capture energy. Due to increasing globalization, the rate of CO_2 emissions has also increased dramatically. Therefore, systems that avoid the emission of undesired gasses into the ecosystem must be sought at all costs.

Solar energy is the most convenient and straightforward technology to obtain today in terms of size and complexity, and it has become the most coherent technology when considering its application anywhere. After all, it requires roof space and a place for energy storage. According to [67], in addition to the great potential that exists in the production of energy from photovoltaic cells, there are incentives for those who have a network to generate energy from renewable sources, as the implementation of this type of energy demands a high investment, which must be considered in a compensation calculation.

Moreover, underdeveloped countries do not use this type of energy in ample supply [67] but only a tiny portion compared to the production and use of other methods. Therefore, aside from the potential environmental benefits of solar energy generation, there are other incentives to start this process, at least to some degree. Following Lee et al. [31], implementing a power distribution network based on photovoltaic cells presents many expenses due to the plate number, amount of energy stored, distance, and terrain. Con-

sidering the installed equipment, this distribution system offers one of the simplest and most affordable ways to spread the adoption of this type of energy because of its easy maintenance and modular components; i.e., its products have great versatility.

Bearing in mind that acquiring this system is very costly, Lüthi and Wustenhagen [32] commented that governments are creating financial incentives for projects with photovoltaic technology. Similarly, several countries are encouraging the adaptation and usage of renewable energy sources, considering the climate problems the planet has been suffering. In summary, microgrids were created to study energy generation capacity, in which reliability and compensation calculations are made for possible more significant investments.

Photovoltaic solar energy is one of the many renewable energy options available worldwide. It is a solution in several cases that require an energy source transition. Lakhani et al. [52] stated that the two most recurrent installations of this type of energy are the systems implemented on the roof and the photovoltaic panels installed on the ground. Therefore, regarding the implementation of photovoltaic technology, a precise analysis is necessary to decide where to place it. If the impact of land use for installing the system directly on the ground is too high, the solution is to implement it on roofs. It can be stated that for the direct implementation of this energy in a university, its impact must be analyzed and calculated in a general way, both concerning the structure of the building and the influence on the ecosystem. Li et al. [69] stated that several ways to implement a solar system in a building exist. They can be installed separately and added to the building after its construction, or they can even be used to replace some elements of the original building.

Wind energy is a renewable source from nature with infinite capacity, for it renews itself endlessly. In this sense, the wind is one of the forces of nature with an inexhaustible capacity, as it is a mass of air that varies in direction, intensity, and speed. The capture of wind energy has been happening for a long time, constituting a considerable portion of the world's energy supply. These data are remarkable if we analyze the number and extent of wind farms scattered around the globe. In agreement with Choe et al. [70], the capture occurs through wind turbines positioned in strategic locations with a high wind-incidence rate, which moves the propellers of the equipment, moving the turbine that generates energy. There are different sizes of turbines, and the energy production is proportional to them. Thus, the biggest problem for implementing a wind turbine at a university is the area to install the equipment, as the space limits its size, consequently limiting energy generation. Despite that, the turbines can be operated parallel to conventional methods, whereby storing the energy generated and directing it to more basic purposes is possible. Considering that this type of energy production depends on the constant occurrence of wind to move the turbines and that the storage generators are usually diesel-powered, this system would help to keep carbon emissions on the planet to a minimum and not stop the energy supply.

Tidal Energy is one of several ways to obtain renewable energy. The capture of energy through tidal power is performed by converting the waves' kinetic energy into electricity for the population or nearby industries. According to Gray et al. [59], this relatively new method of energy production has both positive and negative sides, the two most prominent being that the energy is clean, and its implementation cost is high. However, considering that some universities have their facilities in coastal cities, constructing a small machine for extracting kinetic energy is possible due to the advantages of the geographical location.

Many papers deal with energy transitions, i.e., the change of generating energy from conventional non-renewable means with high rates of carbon emissions that are incredibly harmful to people and the environment to a means of sustainable energy production from renewable sources. According to Falcone et al. [33], energy transition happens for different reasons, such as energy crises, an aggravating factor that generates the need for alternative energy production. However, many factors amidst crises should be considered to analyze the best alternative energy. Moreover, among the positive aspects, this transition generates many jobs for developing and implementing renewable sources, hence having a positive financial impact. Based on this principle, the application of a renewable energy

source in a university should occur after the analysis of numerous factors, such as the energy consumption values of the location, labor costs, the prices of the equipment to be implemented, and the social acceptance of the people who circulate in the environment, alongside political factors that involve the energy application.

Public policies are an aggravating and necessary factor for implementing a renewable energy source. They will determine the bids needed for projects and the amount of energy produced, which, in some cases, should be able to meet local demand. Further, spare parts that are not stored can be destined for the population, determining sustainability laws concerning energy production and some other minor details. Moreover, since many energy generation processes require much capital, there is the possibility of acquiring investment from the public to assist in creating new renewable energy sources.

Finally, Thoyre [64] reported that companies that generate energy using fossil fuels have constantly damaged their investments because they still use methods that emit too much carbon, harming the environment. To change companies' methods of obtaining energy, laws to encourage the use of renewable sources to generate energy have been created, through which places like universities would benefit from receiving monetary aid to develop and assist studies on the energy efficiency of renewable sources.

4.2. Barriers and Strategies

The barriers refer directly to the difficulties identified regarding implementing a particular type of renewable energy, whether in a conventional residence, building, or university. These difficulties can be identified by analyzing all the aspects involving energy and their crucial factors, whether environmental, socioeconomic, or political.

It is possible to point out that solar energy is currently one of the cleanest and most widely used energy types in the world, but this does not mean there are no difficulties when implementing a project in a specific location. As exemplified by Sarkar et al. [49], one of the main barriers regarding this type of energy would be the variation of solar incidence in the region, which would negatively affect the energy production of the photovoltaic panels and make them not as effective as they should be.

Furthermore, Lakhani et al. [52] reported different ways to install photovoltaic panels to meet specific energy demands without harming the environment, such as installing these panels on the roof of the building in question without harming untouched land. Another option would be implementing them on the ground, as described by the authors. However, it is notable that, given their proportions, both ways have installation difficulties. Taking a university as an example, it is necessary to analyze the roof of the building to identify whether it is appropriate to receive the panels in a way that does not damage its structure and to study the possibility of an energy transition of the structure to an alternative type of energy. Additionally, a prior study should be performed on the possibility of such an installation, as its implementation on the ground harms the land it will occupy. There may not be available land around the university in question.

Wind power is a solution for certain cases since its implementation directly depends on ample available territorial space in which there is also an incidence of wind for power generation. According to Yuan et al. [56], this results in other barriers, such as the fact that, in most cases, the availability of these lands only happens in remote areas; in other words, there is difficulty in taking the energy produced to the final consumer across these great distances. Moreover, when it comes to implementing wind energy at a university, it can be said that, except in some specific cases, there is usually not enough space to install it within the university itself, further limiting the use of this technology. From this, Matti et al. [38] also highlighted the obligation to analyze the region's governmental policies regarding properly implementing this type of energy since it cannot be applied in any location or situation. Thus, it might not be a viable solution to meet the demand for sustainable energy.

Regarding tidal energy, which comes from the force exerted by tidal phenomena and the transformation of this kinetic energy into electrical energy, its application strongly depends on the sea's presence in the implementation region, thus prioritizing coastal

regions. Regarding such locations, it is indispensable that tidal energy plays an increasingly active role in meeting the demand for energy production [54] since the most common types are solar, wind, and hydroelectric power. From this, Gray et al. [59] demonstrated that, compared to the types of energy mentioned above, tidal power has a much higher application cost due to its specificities and evident territorial limitations.

As for energy transition, the application of one or more sources of renewable energy is directly influenced by local laws and public policies. In this sense, Tanaka et al. [46] showed that, in Japan, electric utilities significantly impact the decisions regarding energy policy, which results in significant difficulties when the government implements legislation regarding energy generation from renewable sources. Therefore, it is essential to consider all the possibilities and feasibility of implementing these energies [34]; this becomes critical when deciding whether to create or continue a sustainable power generation project within universities.

Therefore, most of the barriers to implementing a renewable energy system are limited to the current country's public policies, which results in fewer possibilities for applications within universities or any other type of structure. As highlighted by some authors, scarce funding for renewable energy projects [43], barriers to energy-efficiency adoption [37], and the complexity of carrying out the energy transition process due to the extended timeframe [65] make the political and socioeconomic environment two of the biggest causes of difficulties when implementing sustainable energy generation and upgrading the energy system.

The innovative barriers and strategies are (i) the energy transition from fossil sources to renewable sources, (ii) installation and use of alternative sources such as wind and solar, and (iii) promoting research and development in the university environment for clean, safe, and affordable energy.

Towards climate change mitigation, the transition from fossil energy to renewable energy is an impetus for modern society, including universities. Given this, some energy sources have positive characteristics in terms of the low environmental impact generated, the efficiency in electricity production, and the reduction in implementation costs (compared to other sources). These characteristics are based on solar, wind, and biogas sources. Furthermore, the best environment to foster the development of new technologies and practical applications is the university.

4.3. Trends by SDGs

Studies on the 17 SDGs developed by the UN are widely reported in the scientific literature, such as in the area of indicators associated with equitable and sustainable well-being (BES) [72], pragmatic sustainability [73], digital transformation and Industry 5.0 [74], companies headquartered in the European Union [75], monitoring the outcomes of the SDGs by evaluating the Italian regions [76], and many others.

This section addresses questions that researchers and supporters can use to develop new empirical studies related to renewable and sustainable energy at universities and what their public policies are, as presented in Table 3.

Based on the list of trends (Table 3), it is suggested that authors in the area answer the questions raised, which are of paramount importance for the beginning of new research, in addition to identifying the best strategies and types of energy to be utilized. In a specific case, such as the implementation of renewable energy at a university, that list is essential in identifying the authors who relate to the methods of application and their connection to the geographical territory and its climate. Regarding the bureaucracy involved in the application, one must analyze which laws make the use of renewable energy viable at a university and how the creation of public policies can assist in this process.

Based on all the above, we highlight that this study aligns with some of the SDGs established by the 2030 Agenda [77].

Table 3. Trends to support researchers.

Cluster	Question	References
Sustainable and renewable energy employed by universities	What is the energy efficiency regarding the location of the application of a photovoltaic energy grid between the ground, roof, and curtains of capture?	[31,32,52,67]
	What is the feasibility and efficiency of using batteries for electrical energy storage in conjunction with wind systems?	[43,60,66]
	In what ways can tidal energy be further implemented despite its high cost?	[54,59]
	What are the alternatives for assisting the supply of energy in periods when no generation occurs due to the lack of incidence of both sun and wind?	[49,66]
	Considering the application of an energy grid at a university, what would be the advantage of applying a system based on photovoltaic cells?	[31,32,67]
	Considering the high incidence of tropical winds in Brazil, what are the advantages of creating mini wind grids in universities?	[66,70]
Public policies and external projects to implement sustainable and renewable energy	What are the implementation laws, and how do they influence the adoption of renewable energy in universities?	[38,63,64]
	What are the incentive policies for creating new renewable energy generators, and how do they apply to universities?	[37,63,64]
	What are the monetary aid policies used for renewable energy implementation at universities?	[35,64]
	If the study site has some energy supply, what are the public policies for this energy transition?	[36,65]
	How do social beliefs and interests impact the implementation of a renewable energy source?	[46,61,63]
	What is the influence of public policies to ensure sustainable development in the region by applying renewable energy?	[36,63]

Goal 4 refers to quality education. Some specific goals in higher education can contribute to achieving this SDG. Ensuring access to inclusive, quality, and equitable education and promoting lifelong learning opportunities for all needs to be on the agenda of many schools, research institutes, and universities [78,79]. In addition, a sustainable structure, in terms of renewable electricity, can be a viable solution in this field. Collaborating with other institutions, governments, and organizations to promote sustainable educational practices and sharing best practices is part of sustainable development in higher education. Furthermore, it should be ensured that the institution's physical infrastructure is adequate to support effective and modern learning, preparing students to face the challenges of the 21st century.

Goal 7 dwells on clean and affordable energy. Access to reliable, sustainable, modern energy sources in the teaching environment is important. Industries must produce and consume clean energy, and educational buildings (schools and universities) must also act. A higher education institution can adopt practices and technologies that promote the efficient use of energy and the adoption of renewable sources [80]. This includes installing solar, wind, or other renewable energy systems to reduce dependence on fossil fuels. Additionally, universities often conduct advanced research into energy technologies, including energy storage, energy efficiency, and new energy sources. This environment is extremely rich in possibilities for developing new technologies and patents in the electrical energy sector.

Goal 11 covers sustainable cities and communities. This study focuses on making communities and educational environments more inclusive, safe, resilient, and sustainable. Universities must produce knowledge; operate in inclusive, resilient systems; and, above all, be sustainable. Universities are most often established in central regions of the city or close to it. In few cases is a university located very far from the city. The reason for its location is the ease of transporting students, teachers, staff, and supplies. Therefore, working with sustainable mobility and using bikes, scooters, public transport, and walking can make sense. Additionally, universities often have large campuses that can be thought of as small urban communities. A higher education institution can adopt sustainable urban planning principles in its physical development, promoting the efficient use of

space, the preservation of green areas, waste management, and the reduction of the carbon footprint [81].

Finally, strengthening the means of implementation and revitalizing the global partnership for sustainable development is an impetus for a more sustainable future in universities.

5. Conclusions

It is possible to identify different ways of capturing energy from renewable sources, the most cited being electrical grids based on photovoltaic cells and energy from wind turbines. When considering the application of an electric grid based on renewable sources in a university, several options are available regarding which source type to employ. This choice is usually based on the terrain, i.e., analyzing the incidence of wind, the amount of sunlight received, or the possibility of using the ocean to capture kinetic energy.

When choosing the renewable energy method or source, we must investigate the political and socioeconomic environment, identifying public policies that assist in implementing the energy network and facilitate the installation. In other words, one must consider the high costs of the installation and check the policies for financial aid for the implementation of the project. In addition, promoting studies concerning energy efficiency at the university and improving sustainability using low-carbon emission energy align directly with multiple SDGs.

Besides the difficulties due to current policies, environmental and socioeconomic factors are still directly related to their implementation. The incidence of sunlight for capturing energy through photovoltaic panels, the recurrence of wind force to make the turbines work, and the presence of waves and tides in coastal regions for kinetic energy generation are clear examples of the barriers encountered when dealing with these types of renewable energy. However, it is worth pointing out the advantages for the environment and its use in general through the decrease in harmful non-renewable sources, which contributes to sustainability and prolongs energy generation due to its inexhaustible source.

Finally, the best choice for implementing energy from a renewable source in a university would be based on photovoltaic cell networks. It presents a high degree of versatility. Besides the conventional panels deployed on the roofs or fixed on the ground, curtains can still capture the sun's rays. In addition, this type of energy generation uses a modular system in its panels, making the maintenance and exchange of equipment parts straightforward and practical. In this way, the energy transition from conventional carbon-based means to technological energy generation systems through renewable sources becomes feasible.

The study is not free from limitations. Some documents may have been left out of this analysis due to the set of keywords and the databases used. In further research, we highlight the need to explore other less prominent renewable energy sources that might be more readily available at the university level, such as biomass, which can be derived from food waste and might be a cheaper alternative in terms of infrastructure while also helping to manage existing waste and environmental influence on the campus. Other sources also deserve exploration. As a suggestion for future work, a case study reporting descriptions of sustainable universities implementing renewable sources, pointing out the technical and economic viability, can be developed. Furthermore, daily energy consumption in universities, different building types, seasonal variations, and external parameters can be considered. Additionally, the alignment of these initiatives with SDGs such as Goal 7 (Affordable and Clean Energy), Goal 11 (Sustainable Cities and Communities), and Goal 13 (Climate Action) should be emphasized to highlight their broader impact on sustainable development.

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