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Review

Past, Present, and Future of Critical Issues in Energy: Poverty, Transition and Security—A Systematic Review

Catalin Popescu [1], Eglantina Hysa [2,*], Mirela Panait [3,4] and Arjona Çela [2]

1 Business Administration Department, Faculty of Economic Sciences, Petroleum-Gas University of Ploiesti, Bd Bucuresti, No.39, 100680 Ploiesti, Romania; cpopescu@upg-ploiesti.ro
2 Department of Economics, Epoka University, 1011 Tirana, Albania; acela@epoka.edu.al
3 Department of Cybernetics, Economic Informatics, Finance and Accounting, Faculty of Economic Sciences, Petroleum-Gas University of Ploiesti, Bd Bucuresti, No.39, 100680 Ploiesti, Romania; mirela.matei@upg-ploiesti.ro
4 Institute of National Economy, Romanian Academy, 050711 Bucharest, Romania
* Correspondence: ehysa@epoka.edu.al

Abstract: In these last decades, especially after the Russia–Ukraine war, the impact of energy related to issues, such as energy poverty, energy transition, and energy security have been heavily debated. To comprehend the conceptual development of this subject in the academic literature, few studies tackle the problems above by reviewing earlier research on the subject. Inspired by this interest and literature ago in this field, this study aimed to address the past, present, and future advancements of critical issues in this regard. Thus, in this review paper performed during February–April 2023, we employed the PRISMA method selecting and checking the review papers articles indexed in the three databases of Web of Science (WoS), Scopus, and JSTOR. Then, the research was followed by extending it and adding some other articles discovered on the gray literature. After a detailed classification of articles, a total of 2615 review articles were deemed valid for this analysis. The study's key contributions is the classification of the some cluster themes for the metasynthesis analyses, which point to potential future directions with a special focus on governmental policies to pursue some macrolevel goals concerning energy poverty, energy transition, and energy security in our daily lives.

Keywords: energy poverty; energy transition; energy security; PRISMA method

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1. Introduction

This work studies three main concepts in the field of energy policy and sustainability, such as: (1) *energy poverty*, (2) *energy transition*, *and* (3) *energy security*. These three main concepts are essential, as they are key drivers for future energy policy both domestically and globally, therefore taking them into analysis and observing how they are studied in the literature review is essential for future research. Energy is essential in our lives, and the access to affordable, sustainable, and modern energy is a vital determinant of household's wellbeing and living standards. Moreover, it is very important for sustainable development and prosperity. Clean energy policies and investment are important factors in reaching sustainable development goals. According to [1], there are more than 1 billion people worldwide who do not have access to electricity and more than 3 billion who lack access to clean fuel and technology for cooking. Studies have shown that there is a link between access to energy and economic development [1–3]. Access to affordable and modern energy allow poor households to have lighting, thermal comfort, and other services offered specifically by electricity [4]. Electricity is one of the most important sources as it allows households to use computers, telephone, internet service, and other equipment necessary for daily and business activity. It is for this reason that ensuring reliable, affordable, and modern energy is the focus of the Sustainable Development Goal 7.

The concept of energy poverty is considered, in general terms, as being unable to have access to regular and sufficient energy due to high cost or a lack of proper infrastructure [5], while energy security is related to the security of energy systems that are vital for society, this concept still does not have an acceptable definition in the literature. Therefore, there is an increasing number of literature reviews that concentrate on defining and measuring this concept. The definition provided by the International Energy Agency states that energy security is having uninterrupted access to energy sources at affordable prices. Energy security is also related to environmental sustainability, as the demand for energy is increasing due to increasing economic activity and population [6]. Therefore, lately there is an increased focus on clean and sustainable energy that do not degrade the environment. Currently climate changes concerns are pushing towards a transition to clean, low-emission energy sources, that is, mostly electricity generated from solar-, wind-, and hydropower. Therefore, nowadays, the concept of energy transition means a transition to clean energy. However, there are concerns that some policies that push toward environmentally sustainable energy can decrease economic development and increase poverty. Therefore, there are many concerns related to energy poverty, security and transition that are currently discussed in the literature. The aim of this work is to provide an understanding on how these concepts are studied in the literature by employing a metasynthesis approach.

The remaining part of the paper is structured as follows: Section 2 contains a brief literature review on the main concepts studied, i.e., energy poverty, energy transition, energy security and other energy issues; Section 3 presents the methodological approach employed in this paper; Section 4 provides the metasynthesis results; and Section 5 includes the discussion and conclusions, which summarizes the main findings of the conducted study.

2. Literature Background

2.1. Energy Poverty

Energy poverty is an important social and economic topic in 2020 as in the EU, 50 million household live in energy poverty, and COVID-19 pandemic aggravated the situation even more [7]. Studies, such as [8,9], show that there is a worsening of the energy poverty situation in the EU due to the negative effects of COVID-19 crisis. The negative effects of this crisis causing the worsening energy poverty will improve slowly, according to the authors, but not many countries will be able to return to prepandemic levels. In addition, the transition to renewable energy introduces further costs that increase the price of electricity and energy in general, and this can push many households to energy poverty. According to [10], the transition to renewable energy can increase costs in the short run. However, in the long run, this cost is most likely going to be neutralized and the adoption of the renewable energy could provide partial resilience to shocks in energy poverty and contribute to economic development and one's well-being.

In 2019, around 30 million Europeans were unable to keep their home adequately warm [4]. According to [2], around 16.5% of household in Poland are in hidden energy poverty. The importance of access to affordable reliable, sustainable, and modern energy was recognized and included in the United Nation's Sustainable Development Goals (SDG) in the 2030 agenda. Access to affordable and uninterrupted energy has an impact on one's well-being and wealth. Energy provides thermal comfort, cooked food, hot showers, internet, and many other facilities that are important for daily life. According to [11], it provides energy services that are considered to be benefits produced for human well-being, depending on what the users of energy want, such as a cooked meal, warm home, fast internet, etc. Access to energy is essential for socioeconomic development because it makes it possible to use resources, time, and technology in an efficient way. This increases productivity and leads to economic growth. Studies have shown that there is a correlation between economic growth and access to energy [1,3].

Boardman defines household energy as being poor if the cost of energy exceeds 10% of the total household income [12]. This methodology has its own problems, as it identifies the rich households, who overuse energy as poor. Therefore, there are discussions on which variable should be used to measure energy poverty. According to [4], in 2020, there is still a lack of both a definition and a methodology on how to quantify energy poverty. The EU Energy Poverty Observatory, a project launched in 2018, acknowledges energy poverty as a multidimensional phenomenon and developed a set of four primary indicators: arrears on utility bills, low absolute energy expenditures, inability to keep one's home adequately warm, and high percentage of energy cost taken from income. There are two ways to determine energy poverty according to the European Fuel Poverty Observatory: The first suggests subjective variables and the second expenditure line suggest variables such as energy expenditures [13]. The authors of Ref. [14] also highlight that there is no consistent international or regional definition of energy poverty. The definition varies between developing to developed economies. In developed economies, the definition highlights the lack of access to modern energy services, and in developing economies, it emphasizes the access to affordable energy services.

2.2. Energy Transition

Energy is the driving force of economies nowadays, and we cannot imagine societies functioning without energy. Clearly, for the moment, the world relies on fossil fuels, which is a very unsustainable and is causing environmental problems, such as air pollution and global warming [15]. Therefore, there is a need for transition to cleaner, sustainable, and more environmentally friendly energy sources. An energy transition is seen as an evolving process, and throughout history, societies have transitioned between major energy sources, with some of these shifts lasting over a century or longer. However, in the 21st century, the world will need to shift faster considering the scarcity of petroleum supplies and global climate changes [16].

The current energy transition is a shift towards cleaner, low-carbon energy sources, and electricity, which is the most important source. The most successful clean energy is electricity generated by solar-, wind-, and hydropower technologies, and many countries are promoting the usage of this energy source in industries and buildings to reduce carbon emissions [17]. In the Paris Agreement held in 2015, as a response to global warming, it was decided to reaffirm the goal of limiting the global temperature increase to well below 2 degrees Celsius, while pursuing efforts to limit the increase to 1.5 degrees. Therefore, since then countries are shifting towards using different policies to transition towards low-emission energy sources. One of the characteristics of this transition identified by [18] is the difference from past energy transition processes. This transition is driven by policies that aim for low carbon emissions.

Although technology plays an important role, the main driver of the transition appears to be policies. Governments are using a variety of policies, such as those that stimulate the technological progress of renewable energy in order to impose taxes and tariffs for the consumption of energy sources that are not friendly for the environment, such as coal. While the first type of policies creates a positive supply shock, the second create a negative supply shock as they increase the price of energy. The authors of Ref. [16] argue that it is extremely difficult and unlikely that a global energy transition will happen very fast even though there are international agreements and policies to shift to cleaner and more sustainable energy sources.

The transition to clean energy is an important and necessary step for Europe and the world. However, this transition to clean energy has its risks. According to [2], a transition to clean energy in Poland means replacing coal with natural gas. However, this can have an impact on energy poverty as it increases energy cost for households. This transition, in case of Poland, increases hidden energy poverty by 19.3%. The authors of Ref. [14] discuss that increasing energy prices due to renewable energy levies create a heavy burden for low-income households in the case of Germany. Therefore, low carbon development energy policies that are designed to support the improvement of energy efficiency, production of clean energy, and reduction in energy consumption need to be in accordance with energy poverty mitigation policies. While approaches such as levies and taxes increase energy prices and create a burden for low-income households by increasing energy poverty, approaches that target increasing energy efficiency and the reduction in energy consumption, such as the construction of energy efficient houses, help households escape energy poverty.

According to [18], renewable energy represents the solution to energy poverty, representing a transition from fossil fuels to renewable energy, which supports low-income households and lowers CO_2 emissions. In this context, the transition to renewable energy (RE) was impetuous, with energy sources that do not pollute being the primary goal [19]. Besides benefits to the environment, this transition is considered as an important transition that positively influences economic growth [20–23].

2.3. Energy Security

The definition of energy security has changed over time. In 1970, the definition of energy security was about avoiding oil supply shocks from the Middle East. Later on, the definition evolved with the changes in the world's energy regime [24]. Nowadays, the definition focuses on three primary energy sources: oil, gas, and electricity [25]. The authors of Ref. [26] define energy security as the "low vulnerability of vital energy systems". According to the authors, this definition of energy security is flexible enough to be applied even in the future, when energy systems might change. The vulnerability of energy systems is a combination risk and resilience. Energy security is about protecting energy systems, as any issues with these systems can send society into a state of instability. The authors of Ref. [27] state that although there is not a commonly accepted definition of energy security, there are however definitions that have three desirable elements of energy security. These elements are the physical availability and accessibility of supply sources, the economic affordability, and the long-term environmental sustainability.

In general, according to [28], there is a focus in the literature on the supply side of energy security, which emphasizes the security of primary energy sources. Other works from the International Energy Agency [29] define energy security as consisting of two components: one is the physical availability component, and the other is price component. According to the International Energy Agency [29], "the relative importance of these depends on the market structure, and in particular the extent to which prices are set competitively or not". In an earlier definition, [30] refers to energy security as the reduction in the welfare as a result of changes in the prices or availability of energy. Therefore, nowadays, energy security is seen as energy market functioning properly, and a competitive market is seen as the most effective way of delivering energy. In competitive markets, in the case of a supply shortage, prices increase, and this leads to consumers reducing their consumption as they are unwilling to pay higher prices. When there is no link between prices and the volume of energy, a supply shortage can lead to the physical unavailability of energy. The authors of Ref. [31] state that energy security definitions fall into two categories: the first category is about the supply and availability of energy and its price, and the second category includes more dimensions, such as availability, affordability, adequate capacity, and sustainability. According [31], a more comprehensive broader definition of energy security is needed. The authors believe that there are four more dimension that should be addressed with the concept of energy security: (a) economic, (b) technological, (c) environmental, and (d) sociocultural and military/security.

2.4. Other Critical Energy Issues

Apart of positive spillovers during an energy transition to new sources and renewable solutions for the environment, an important contribution is also observed in economic growth [32,33]. Indeed, in order to go through such a transition into innovative solutions, governments and businesses have to invest in technological innovation [34–39]. In order to conclude the transition into an energy supply, there are technological challenges to need be fixed, leading to innovations that are considered a crucial factor in the process of the transition [19]. In this regard, developed countries are the leaders in creating a suitable environment for innovation, including renewable energies [40].

Other key factors that support innovation are the well-established institutions and a robust economy that are considered important pillars to such development [41–44]. The breakthroughs of technology may be displayed in patent filings [22]. Referring the study of [45], there exists a database called the International Standards and Patents in Renewable Energy that maintains information on the patents and pursues them.

Furthermore, an additional crucial factor to facilitate such a transition and to achieve a sustainable development is companies' adoption of the Green Finance Framework, which is focused on nonfossil fuels projects, the main segments of which being renewable energy, clean transportation, and pollution prevention and control [46,47]. In this regard, the United Nations Sustainable Development Goals (SDGs) has focused on solving the challenges that contemporary society has faced by involving SDG7, which aims to improve energy sustainability.

Lastly, it could be said that technology is a promising new and practical solution to energy and related issues given the robustness of energy security, accessible, affordable, and clean energy required to prevent and mitigate energy poverty and improve societal well-being.

3. Materials and Methods

In this review paper, we employed the Preferred Reporting Items for Systematic reviews and Meta-Analyses (PRISMA) method. Initially, the search process was performed for all articles. Then, we decided to narrow down the selection by selecting and checking only the review papers since we would like to summarize the main findings included in these types of articles in separate sections, such as the dedicated Discussions and Conclusions sections, and describe the focus and trends over time related to the topics declared in the first section of this article. Accordingly, in the first phase, only articles in the three databases, Web of Science (WoS), Scopus, and JSTOR were examined. Then, the search was followed by extending it and adding other articles discovered in the gray literature. The search was performed in the period of February–April 2023.

We used Boolean operators for the following word combinations: TS = (Energy Poverty * OR Energy Transition * OR Energy Security *).

In the identification phase, the search terms used and declared above generated 432,492 records in WoS; 500,613 records in Scopus; 2605 records in JSTOR; and 2156 records in gray literature after a search process in Google Scholar.

Figure 1 shows all the steps of the literature review process related to the PRISMA flowchart.

In fact, the goal of this article was to analyze the issues stated in the Literature Background section, starting from a broader, more general, and implicitly more generous and useful search. Then, we narrowed the content of our searches to the analysis of some papers that include, in turn, reviews of some reference articles regarding the three declared critical areas: *energy poverty, energy transition, and energy security*. That is why, for the broader search, we used the Boolean operator "OR" in the combination of the three targeted critical terms. After the generation of a large quantity of documents, it was necessary to apply some selection criteria that would reduce the entire analysis to a sufficiently comprehensive level in order to obtain relevant results for the research. Here, the following were considered criteria:

- the number of articles registered in the four representative databases;
- the analysis of only review-type articles;
- the studies of papers that deal with socioeconomic and environmental aspects;
- duplicated studies found in several databases;
- the elimination of studies published in a language other than English (these representing a percentage of 0.8% of the total research carried out at a general level and cumulates to only 0.5% of the total citations received by all review-type articles that contain the targeted topics).

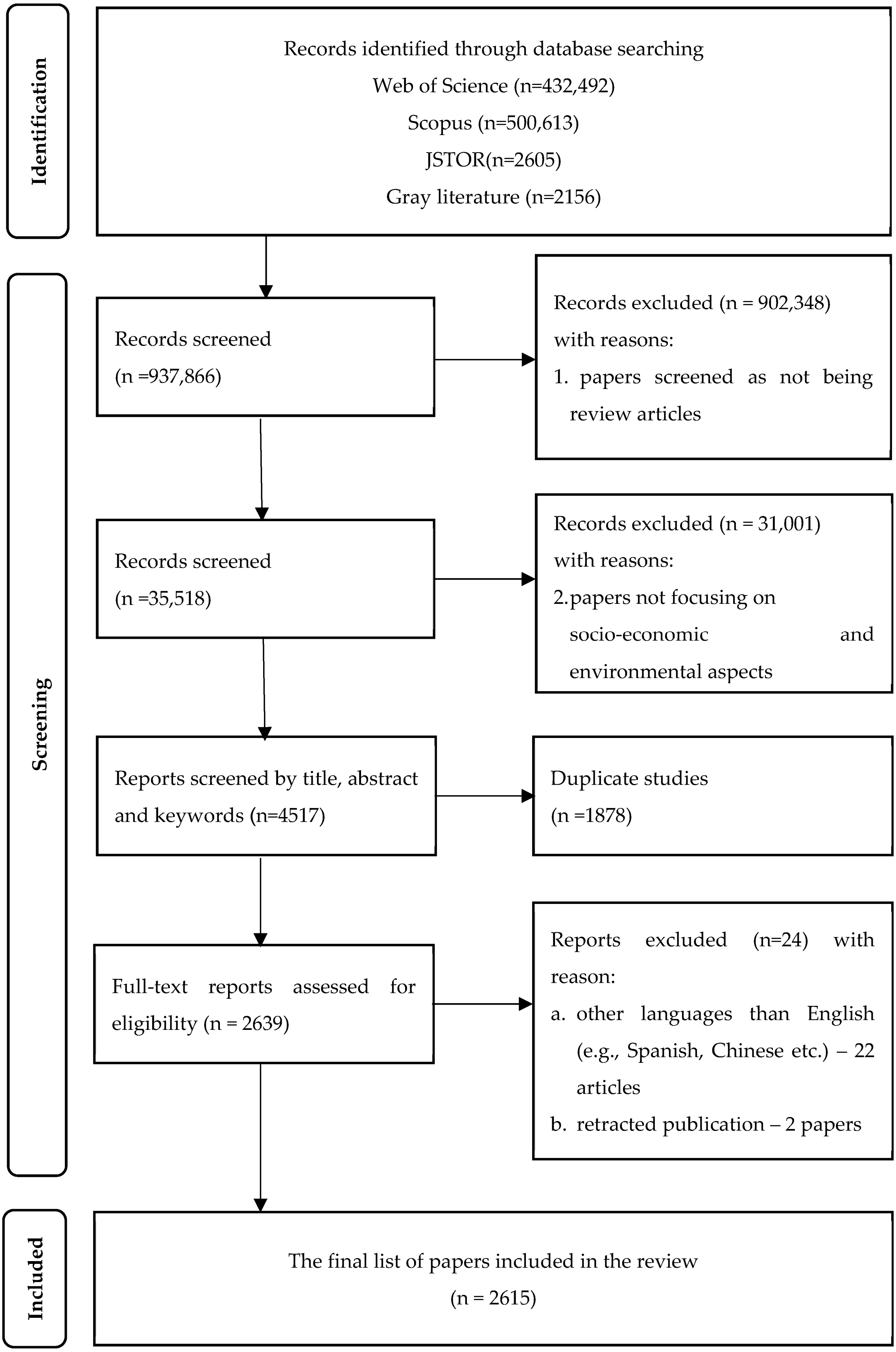

Figure 1. PRISMA flowchart of literature review process based on the combined search of three critical concepts: *energy poverty*, *energy transition*, and *energy security*.

Thus, the search on the databases was refined based on document type (review article). The results obtained are as follows: 18,541 records were discovered in WoS; 16,727 records exist in Scopus; and 250 records are identified in JSTOR. The next refining search included only papers that focused on socioeconomic and environmental issues. The next step was to remove duplicate articles and include only papers written in English. Finally, we removed retracted publications. Therefore, 2615 review articles remained valid to be analyzed. In order to generate a comprehensive image related to the publications content and the most cited papers, we analyzed the content of the WoS and Scopus databases for the same period, i.e., from 1975 to 2023. Here, we discovered that there was a total of 101,382 citations (without self-citations) in WoS and 68,099 citations in Scopus (again, excluding self-citations). Due to the total number of citations, we decided to select the WoS database. Next, to carry out our review, we used VOSviewer in the following scenario. We considered the top 500 most cited papers in WoS. This decision was also based on the limitations generated by the capabilities of VOSviewer software 1.6.18 and also on the limitations in the Export Records to Tab Delimited File function for Full Record and Cited References (quote: "No more than 500 records at a time").

This bibliometric analysis using VOSviewer could provide different information related to some analysis types and units of analysis. In our study, we started from the combination of energy poverty, energy transition, and energy security, and then we analyzed the following different issues: top most cited papers; top record count publications; top record publishers; annual record of publications; most productive and most cited authors; organizations with the most productive and cited authors; the keywords for the paper topics; the most cited papers; the most representative papers and authors; most cited journals; the most representative journals in terms of published and the most citations received; the most representative organizations in terms of published and cited documents; and the most representative countries in terms of published and cited documents. For every kind of analysis, VOSviewer was used as the main tool for the representations related to this complex analysis, and through network visualization, different types of clusters were generated. For each case, these clusters generated a comprehensive picture related to our research and created a useful idea of how things have developed over the years regarding the topics related to *energy poverty, energy transition, and energy security*.

The analysis of all the mentioned aspects was performed by means of the VOSviewer tool. At the end of Metasynthesis Results section, the main ideas are described and developed, through which all significant findings and results regarding the major subjects treated in the research will be outlined.

In fact, the entire analysis intends to answer to a basic research question: "What was, is and will be the state of studies and research, but also the evolution in the field of energy poverty, energy transition and energy security?".

As shown above (Figure 1), of the 4517 records initially retrieved, only 2615 records were included in our comprehensive analysis.

4. Metasynthesis Results

The results are generated from and explained by the combination of energy poverty, energy transition, and energy security. In a first statistics, we extracted the top 10 most cited papers in order to discover which are the most cited authors and what are the keywords for these articles (Table 1).

Table 1. Top 10 most cited papers in WoS on specific topics.

Authors	Title	Year	Journal	Citations WoS (Citations All Databases)	Author Keywords
Ellabban, O; Abu-Rub, H; Blaabjerg, F. [48]	Renewable energy resources: Current status, future prospects and their enabling technology	2014	*Renewable& Sustainable Energy Reviews*	1383 (1402)	Biomass energy; Geothermal energy; Hydropower energy; Marine energy; Solar energy; Wind energy; Smart grid
Jacobson, MZ [49]	Review of solutions to global warming, air pollution, and energy security	2009	*Energy& Environmental Science*	1011 (1040)	Greenhouse-Gas Emissions; Gasoline Vehicles; Power-Plants; Black Carbon; Wind-Power; Ethanol; Ozone; Costs; Consequences; Aerosols
Bruce, N; Perez-Padilla, R; Albalak, R [50]	Indoor air pollution in developing countries: a major environmental and public health challenge	2000	*Bulletin of the World Health Organization*	985 (1024)	Air pollution; Indoor-adverse effects; Fossil fuels-toxicity; Lung diseases; Smoke inhalation injury; Cataract; Developing countries
Smith, A; Voss, JP; Grin, J [51]	Innovation studies and sustainability transitions: The allure of the multi-level perspective and its challenges	2010	*Research Policy*	911 (923)	Socio-technical transitions; Sustainable innovation; Greening innovation systems
Smith, P; Davis, SJ; Creutzig, F; Fuss, S; Minx, J; Gabrielle, B; Kato, E; Jackson, RB; Cowie, A; Kriegler, E [52]	Biophysical and economic limits to negative CO_2 emissions	2016	*Nature Climate Change*	728 (735)	Greenhouse-Gas Mitigation; Climate-Change; Land-Use; Carbon-Dioxide; Human Appropriation; Food Security; Energy; Bioenergy; Capture; Impacts
Suganthi, L; Samuel, AA [53]	Energy models for demand forecasting-A review	2012	*Renewable & Sustainable Energy Reviews*	697 (708)	Energy models; Forecasting model; Energy demand management; Econometric models; Demand side management
Jenkins, K; McCauley, D; Heffron, R; Stephan, H; Rehner, R [54]	Energy justice: A conceptual review	2016	*Energy Research& Social Science*	672 (673)	Energy justice; Energy policy; Whole energy systems; Energy economics
Asif, M; Muneer, T [55]	Energy supply, its demand and security issues for developed and emerging economies	2007	*Renewable & Sustainable Energy Reviews*	670 (675)	Renewable energy; Solar and wind power; Energy security; Sustainable energy supply
Jacobsson, S; Lauber, V [56]	The politics and policy of energy system transformation—explaining the German diffusion of renewable energy technology	2006	*Energy Policy*	619 (627)	Renewable energy; Regulatory framework; Market creation
Pfenninger, S; Hawkes, A; Keirstead, J [57]	Energy systems modeling for twenty-first century energy challenges	2014	*Renewable & Sustainable Energy Reviews*	548 (551)	Energy systems modeling; Energy policy; High-resolution modeling; Uncertainty; Complexity

Next, the top record count publications based on the WoS categories are given in Table 2. It is important to underline that almost half of these publications are considered as part of the energy fuels category.

Table 2. Top six record count publications based on WoS categories for the following combination: energy poverty, energy transition, and energy security.

Field: Web of Science Categories	Record Count	% from 2615 Articles
Energy Fuels	1240	47.419%
Green Sustainable Science Technology	1023	39.120%
Environmental Sciences	546	20.880%
Environmental Studies	401	15.335%
Engineering Environmental	138	5.277%
Economics	47	1.797%

Also, we underlined the most important publishers for these topics (Table 3).

Table 3. Top five record publishers in WoS database for the following combination: energy poverty, energy transition, and energy security.

Field: Publishers	Record Count
Elsevier	1298
MDPI	441
Wiley	165
Springer Nature	127
Taylor & Francis	70

Regarding the research and studies (as review articles) published on these topics, with the exception of 2023 as the year has not ended at the time of this study, it can be observed that year by year, the number of articles has increased constantly, explaining the relevance and interest of researchers in these topics (Table 4).

Table 4. Records for publication years on WoS database for the following combination: energy poverty, energy transition, and energy security.

Field: Year	Record Count
2023	247
2022	443
2021	364
2020	269
2019	254
2018	224
2017	189
2016	136
2015	97
2014	85

The analysis generated with the support of VOSviewer started with the study of the most important authors for the selected topics (in terms of scientific production and most cited papers). In this regard, we imposed a minimum of two documents and 10 citations as the threshold criteria (Figure 2).

This resulted in twenty-four items that met the criteria (from a total of 1773 authors) that were then divided into four groups—a red group consisting of seven items, a green group consisting of seven items, a blue group consisting of five items, and a yellow group consisting of five items.

In this particular case, the citation (as type of analysis) and the authors (as unit of analysis) are combined, and a minimum number of 2 documents per author and a minimum number of 10 citations per author as 10 are chosen. So, based on the greatest total link strength, VOSviewer generated four clusters in the network visualization. These clusters are designed in relation with the total link strength attribute and indicate the total strength of the co-authorship links of a researcher with another researcher.

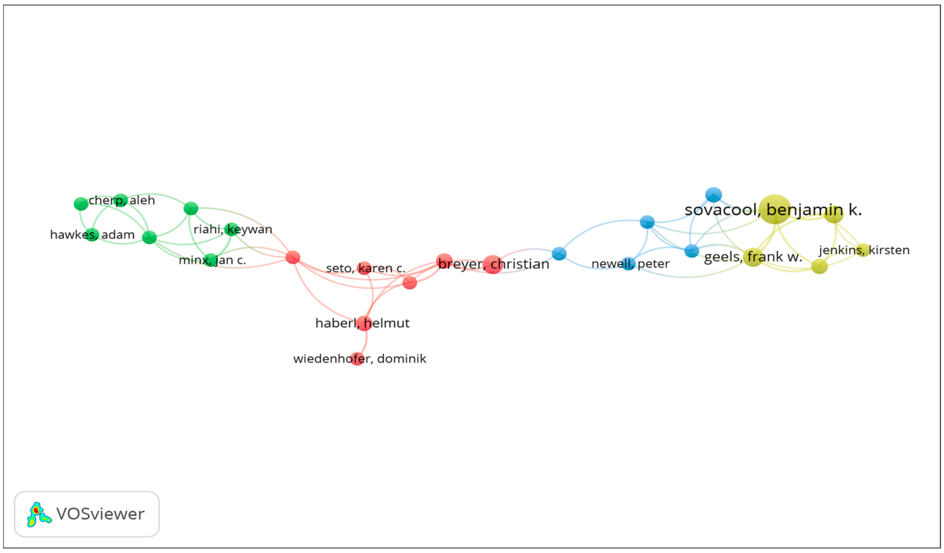

Figure 2. VOSviewer diagram containing the most productive and most cited authors.

The centralization of data related to the most prolific authors (eight most productive and most cited authors) are presented in Table 5.

Table 5. Information related to the most prolific authors.

Author	Documents	Citations
Sovacool, Benjamin K.	14	2309
Geels, Frank W.	5	839
Breyer, Christian	5	464
Sorrell, Steve	4	1334
Ringler, Claudia	4	837
Hannan, M.A.	4	432
Asif, M.	3	900
Schwanen, Tim	3	480

Through the utilization of the *co-authorship* analysis with *countries* as the unit of analysis, a minimum of 10 documents and 10 citations were selected as the threshold criteria. This resulted in 27 items that met the criteria and were subsequently divided into four groups—a red group consisting of 10 items, a green group consisting of 10 items, a blue group consisting of 6 items, and a yellow group consisting in 1 item (Figure 3).

Then, through the utilization of *co-authorship* analysis with *organizations* as the unit of analysis, a minimum of five documents and 50 citations were selected as the threshold criteria. This resulted in twenty-five items that met the criteria and were subsequently divided into six groups (Figure 4):

- red group consisting of six items;
- green group consisting of six items;
- blue group consisting of four items;
- yellow group consisting in four items;
- magenta group consisting in three items;
- light blue group with two items.

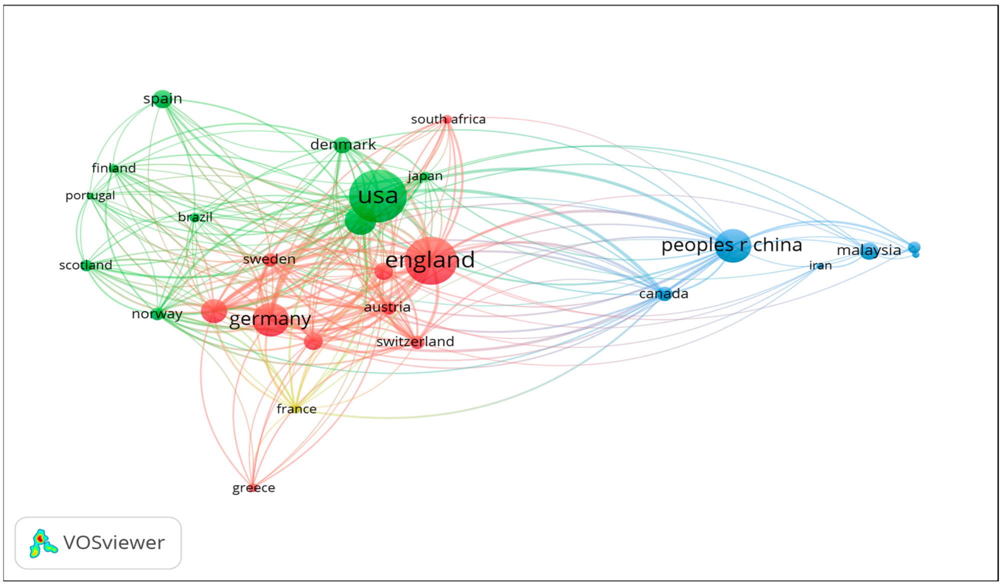

Figure 3. VOSviewer diagram containing countries with the most productive and most cited authors.

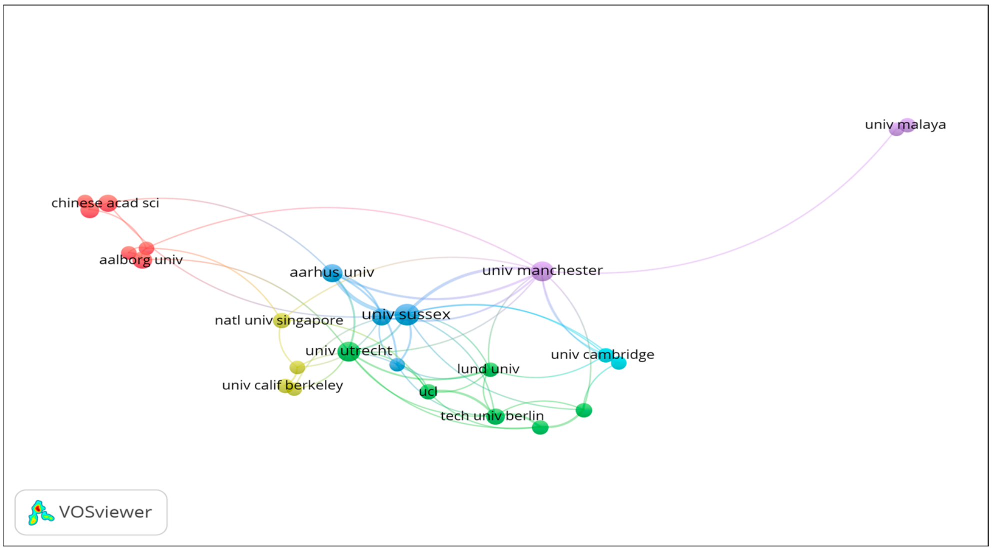

Figure 4. VOSviewer diagram containing organizations with the most productive and most cited authors.

If we use the *co-occurrence* method and *author keywords* as a unit of analysis while imposing 15 as the minimum number of occurrences of a keyword, of the 3083 keywords, we have 53 keywords that meet the threshold (divided into four clusters). This representation is presented in Figure 5.

In Figure 5, the red cluster contains 17 items (with keywords such as renewable energy, security, challenges, technologies, generation, system, smart grid, model, wind power, optimization, electricity-generation, impact, integration, rural electrification, etc.). Then, the green cluster includes 14 items (with keywords such as energy security, climate change, greenhouse-gas emissions, consumption, CO_2 emissions, energy transition, impacts, wind energy, energy policy, etc.). The blue cluster has 12 items (with keywords such as policy, transition, systems, power, innovation, transition, electricity, wind, performance, strategies, etc.). Last but not the least, the yellow cluster contains 10 items (with keywords such as energy, sustainability, sustainable development, life-cycle assessment, management, circular economy, energy efficiency, governance, framework, etc.).

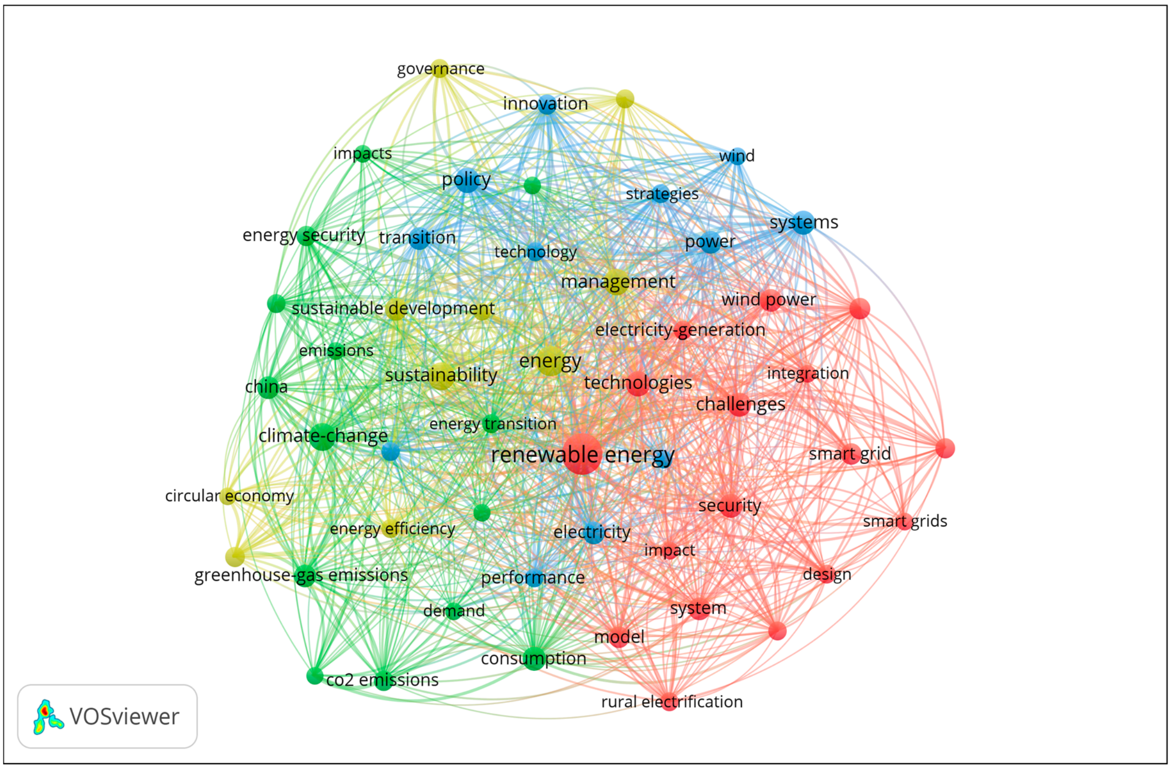

Figure 5. VOSviewer diagram containing the most important author keywords.

At the same time, to underline the use of these keywords within the analyzed papers, a table was designed containing the number of occurrences of each keyword as well as the total link strength (the number of publications in which the two keywords appear simultaneously) (Table 6). This construction was generated for the 20 most important keywords.

Table 6. Information related to the most used keywords within the analyzed papers.

Keyword	Occurrences	Total Link Strength
Renewable energy	131	357
Energy	60	173
Sustainability	46	158
Climate-change	47	139
Policy	37	135
Technologies	37	130
Challenges	35	120
Management	40	119
Systems	35	118
Power	30	106
Security	33	104
Consumption	33	102
Transition	30	96
Electricity	29	93
Sustainable development	30	92
Generation	26	91
System	29	88
Greenhouse-gas emissions	27	86
Electricity generation	20	85
Strategies	18	83

Also, for a better understanding of the key issues of the review related to the critical topics of (1) *energy poverty*, (2) *energy transition, and* (3) *energy security*, a word cloud based on the keywords frequency in analyzed review papers was designed, which includes the keywords presented in Figure 5 and Table 6 (Figure 6).

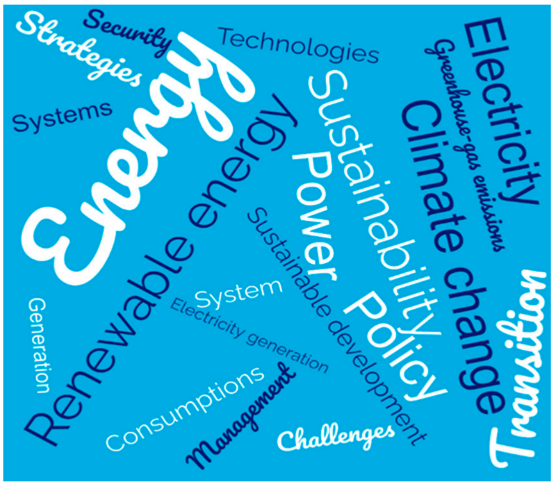

Figure 6. Word cloud based on keyword frequency (number of occurrences).

If we use the *citation* method and *documents* as a unit of analysis, imposing a minimum number of 200 citations per document, 84 documents meet the threshold (divided into four clusters), as represented in Figure 7.

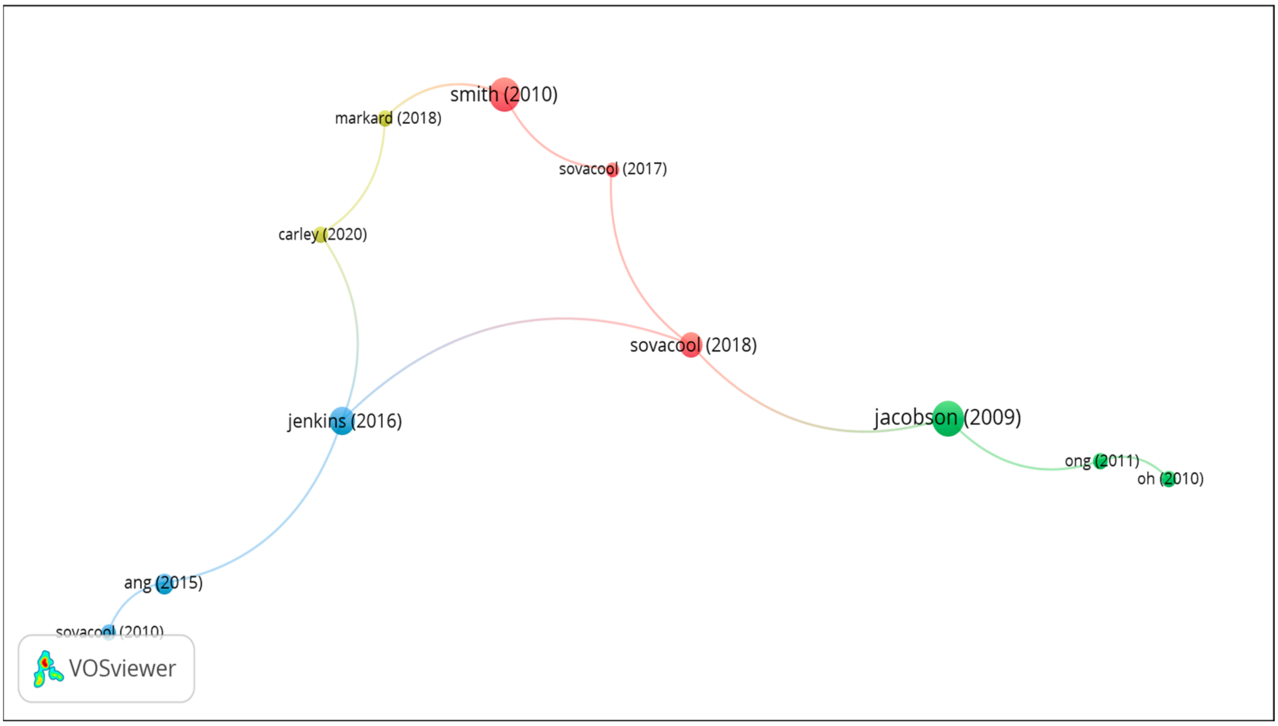

Figure 7. VOSviewer diagram containing the most cited papers.

At the same time, it is important and useful to list the most representative papers and authors for the analysis carried out (Table 7).

Table 7. Information related to the most representative papers and authors within the analyzed papers.

Document	Original Paper Name	Citations	Links
Ringler (2013) [58]	The nexus across water, energy, land and food (WELF): potential for improved resource use efficiency?	364	6
Endo (2017) [59]	A review of the current state of research on the water, energy, and food nexus	336	5
Shahsavari (2018) [60]	Potential of solar energy in developing countries for reducing energy-related emissions	313	4
Jenkins (2016) [54]	Energy justice: A conceptual review	672	3
Jacobsson (2006) [56]	The politics and policy of energy system transformation—explaining the German diffusion of renewable energy technology	619	3
Sovacool (2018) [61]	Promoting novelty, rigor, and style in energy social science: Towards codes of practice for appropriate methods and research design	531	3
Evans (2012) [62]	Assessment of utility energy storage options for increased renewable energy penetration	414	3
Jacobson (2009) [49]	Review of solutions to global warming, air pollution, and energy security	1011	2
Smith (2010) [51]	Innovation studies and sustainability transitions: The allure of the multi-level perspective and its challenges	911	2
Suganthi (2012) [53]	Energy models for demand forecasting-A review	697	2
Ellabban (2014) [48]	Renewable energy resources: Current status, future prospects and their enabling technology	1383	1
Bruce (2000) [50]	Indoor air pollution in developing countries: a major environmental and public health challenge	985	1
Pfenninger (2014) [57]	Energy systems modeling for twenty-first century energy challenges	548	1

By using the *citation* method and analyzing the *sources*, a map of the most cited journals is generated through VOSviewer. By imposing a minimum number of three documents per source and a minimum number of five citations per source, of the 132 identified sources, 26 meet the threshold, which were subsequently divided into nine clusters (Figure 8). The top four journals are *Renewable Sustainable Energy Reviews* with 32,834 citations (for 221 documents), *Energy Research & Social Science* with 3097 citations (for 21 documents), *Journal of Cleaner Production* with 2803 citations (for 26 documents), and *Applied Energy* with 2009 citations (for 13 documents).

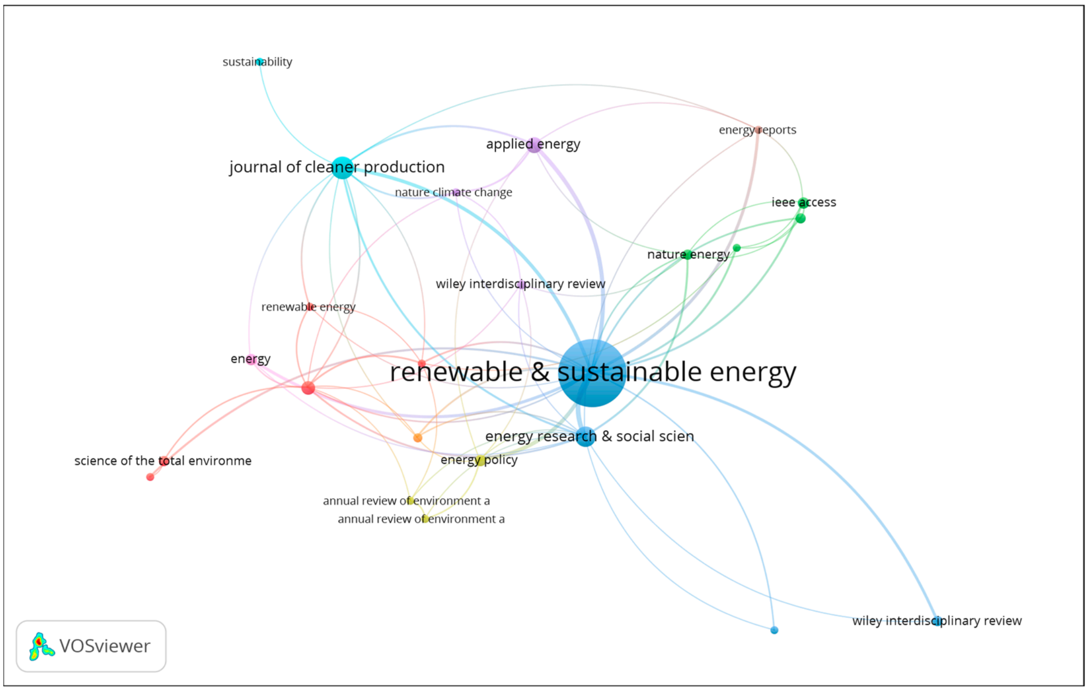

Figure 8. VOSviewer diagram containing the most cited journals.

The evidence of journal articles is also useful in relation to the analyzed subjects and are relevant from the perspective of hosting a significant number of papers (Table 8).

Table 8. Information related to the most representative journals in terms of published and the most citations received.

Source/Journal	Number of Documents	Citations	Total Link Strength
Renewable Sustainable Energy Reviews	221	32,834	111
Energy Research & Social Science	21	3097	41
Journal of Cleaner Production	26	2803	31
Applied Energy	13	2009	25
Current Opinion in Environmental Sustainability	10	1371	20
Energy Policy	7	1218	19
Energy	7	744	12
Energy Reports	3	471	12
Environmental Research Letters	3	638	10
Nature Energy	6	1123	10
IEEE Access	7	702	9
Nature Climate Change	3	1252	9
Technological Forecasting and Social Change	4	527	8
Wiley Interdisciplinary Reviews—Energy and Environment	5	485	8
Computer Communications	3	468	7
Energies	6	614	7
Renewable Energy	3	562	6

By using the *citation* method, analyzing the *organizations*, and imposing a minimum number of five documents of a source and a minimum number of five citations of a source, of the 791 identified organizations, 29 meet the threshold, which are subsequently divided into five clusters (Figure 9).

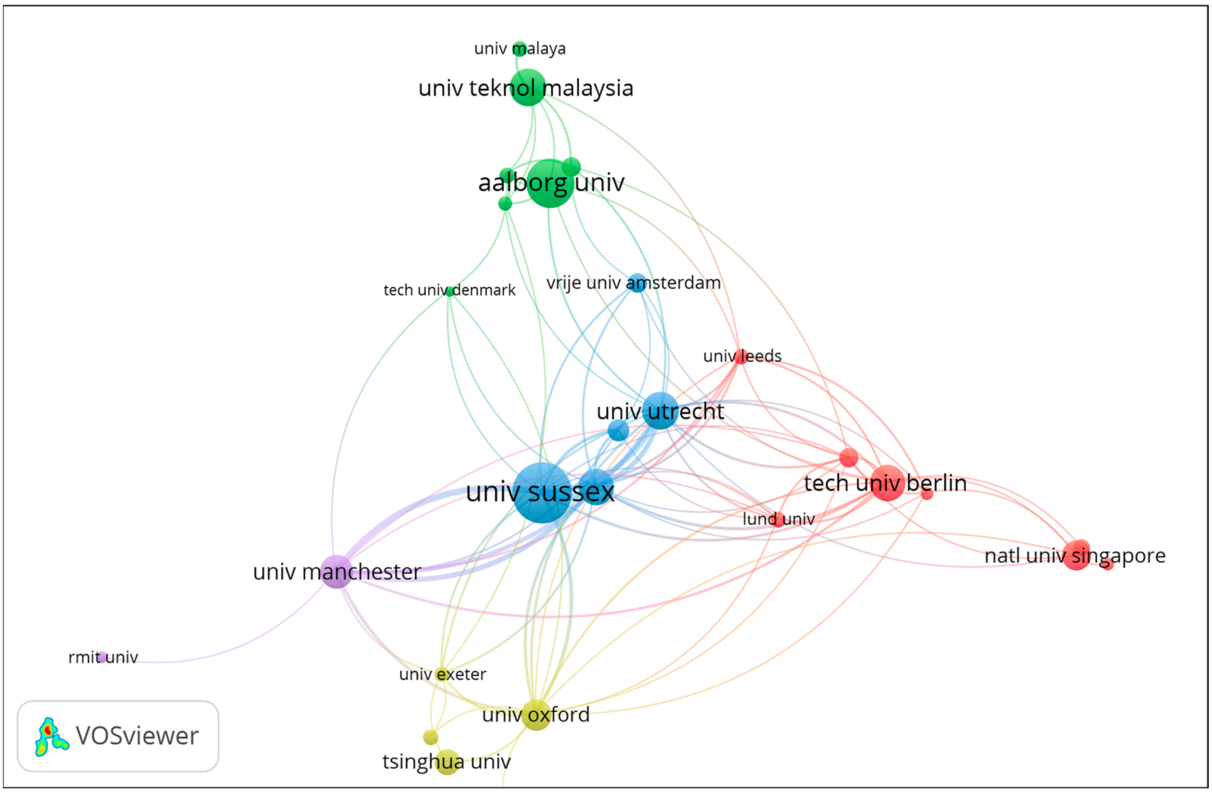

Figure 9. VOSviewer diagram containing the most representative organizations in terms of published and cited documents.

Another interesting statistic is that of the representative organizations that have reference authors in the analyzed research fields (Table 9).

Table 9. Information related to the most representative organizations in terms of documents and citations.

Organizations	Number of Documents	Citations	Total Link Strength
Univ. Sussex	16	3332	79
Aarhus Univ.	11	1801	69
Univ. Utrecht	13	1889	61
Univ. Manchester	13	1702	56
Univ. Oxford	9	1524	32
Tech. Univ. Berlin	8	1834	27
Univ. Leeds	6	695	19
Simon Fraser Univ.	5	1001	16
UCL	7	888	16
Univ. Exeter	5	629	12
Lund Univ.	6	660	11
Univ. Teknol. Malaysia	10	1908	9
Aalborg Univ.	9	2631	8
Chinese Acad. Science	9	898	8
Vrije Univ. Amsterdam	5	899	8
Natl. Univ. Singapore	7	1453	7
Tech. Univ. Denmark	5	423	5
Tsinghua Univ.	8	1271	3
Univ. Malaya	6	680	3
Beijing Normal Univ.	5	687	2
Univ. Calif. Berkeley	6	765	2

By using the *citation* method, analyzing the *countries*, and imposing a minimum number of 10 documents per source and a minimum number of 10 citations per source as 10, of the 78 identified countries, 27 meet the threshold, divided into three clusters (Figure 10). These items are divided as follows: a red group consisting of twelve items, a green group consisting of eight items, and a blue group consisting of seven items.

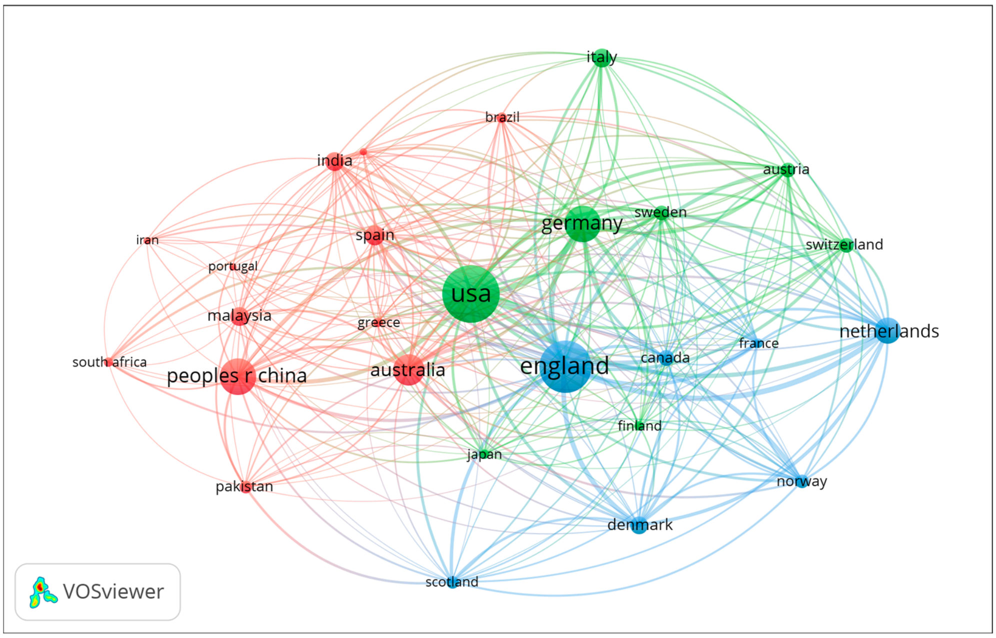

Figure 10. VOSviewer diagram containing the most representative countries in terms of published and cited documents.

The following paragraphs will describe the main results and major findings regarding the analysis carried out.

The need to analyze the problems of energy poverty, transition, and security has its origin in the accelerated growth of the population in the last two decades, in the increase in the level of urbanization, and also in the modernization of processes and activities of all kinds in order to improve general and individual comfort. These phenomena significantly increased the demand for energy, generating three important effects:

- an increase in the price of energy and making access to energy resources more expensive, including through the manifestation of economic and social inequities;
- an increase in pressure on the implementation of projects that generate energy from renewable resources in relation to the need to significantly reduce gas emissions into the atmosphere and the greenhouse effect (greenhouse gas emission);
- the need for alternative solutions for the production and use of energy from renewable sources by which to limit the energy dependence of many countries on the monopoly of some states that hold important fossil fuel resources.

At the same time, projections indicate a significant surge in global energy demand in the upcoming years.

Currently, the world heavily relies on fossil fuels, including oil, gas, and coal, which account for nearly 80% of the global energy consumption. In contrast, renewable energy sources and nuclear power only contribute 13.5% and 6.5%, respectively, to the total energy needs [63–66]. The substantial energy consumption worldwide has detrimental effects on the planet's ecosystem. Fossil fuels, as the primary energy source, have significant impacts on the environment. Human-driven climatic changes, particularly the emission of greenhouse gases (GHGs), have direct consequences on the environment.

First, many articles, studies, and laws are mentioning, besides the main pillars, the defining indicators for energy poverty.

Energy poverty presents itself as a multifaceted and intricate issue, where household income, energy expenses, and the efficiency of housing stock intersect. Although there is an increasing interest in addressing energy poverty and several new initiatives have emerged, challenges remain in defining and measuring its extent.

Many studies and researches aim to review the existing definitions and measurements of energy poverty [23–25]. In the majority of cases, a taxonomy of energy poverty measures is proposed, categorizing them, basically, into four main groups: vulnerability-based measures versus poverty-based measures, and self-reported/subjective measures versus objective measures.

Within the European Union (EU) framework, the aspects of energy poverty and vulnerability were incorporated into Directives 2009/72/EC and 2009/73/EC of the European Parliament and the Council. These directives address the establishment of uniform regulations for the internal market in electricity and natural gas supply. One of the key provisions of these directives is the requirement for member states to establish a definition for "vulnerable customers" among other provisions.

Energy poverty can be defined as a situation where a household lacks access to the socially and materially necessary level of energy services within their home. In the context of the European Union (EU), the causes and consequences of energy poverty largely align with those of the more narrowly defined concept of 'fuel poverty'. The concept of fuel poverty focuses on examining the energy vulnerabilities present within communities with the goal of achieving two primary objectives: (1) to bring attention to the existence of distributional unfairness and (2) to mitigate such inequities by enhancing individuals' ability to access and consume energy [67]. Numerous studies addressing energy poverty have raised concerns regarding the unequal distributional impact of increasing energy prices [68]. However, despite limited research conducted so far, it can be inferred that energy poverty is primarily influenced by factors such as high-energy prices, low household incomes, inadequate building infrastructure, inefficient appliances, and specific energy needs of households. This issue is particularly prevalent in Eastern, Central, and Southern

Europe, where it predominantly affects groups that are already vulnerable to income poverty. In recent years, there has been a shift in the mainstream understanding of domestic energy deprivation towards more complex and nuanced considerations of household needs, adaptability of the built environment, and social resilience [69].

Currently, energy poverty arises when a significant portion of consumers' income is allocated towards energy bills, or when they are compelled to curtail their household's energy usage to an extent that adversely affects their health and overall welfare. So, starting from reliability, resilience, and efficiency, the decision-makers have to focus on of affordability, accessibility, and sustainability.

At the same time, other studies state a much wider approach since they consider that energy security should incorporate five interconnected aspects pertaining to its availability, affordability, advancement of technology, sustainability, and regulation [11]. On the other hand, given their substantial impact and wide-ranging repercussions, environmental concerns associated with climate change and global warming have taken center stage in global discourse and discussions [48].

Access to electricity and a dependable energy supply are indispensable factors for local economic progress and the alleviation of poverty. In order to tackle these challenges, it is necessary to establish suitable policies and mechanisms at the national and regional levels. Creating a conducive environment for renewable energies and energy efficiency is crucial, as it not only helps preserve the environment and mitigate the impacts of climate change but also reduces energy poverty and enhances living standards for the populace [70]. Making this a primary objective of the government is imperative.

A methodology based on a geographical information system (GIS) has been developed to identify and assess appropriate locations for the implementation of renewable energy projects. This methodology allows for the calculation of the sustainable renewable energy potential in a given area, and it can be applied at various spatial scales, ranging from local to national levels. The methodology also accommodates the consideration of different restriction layers, making it a suitable tool for planning the deployment of sustainable renewable energy projects in both onshore and offshore regions [71].

Another relevant research focused on the evaluation and prioritization of significant energy-related solutions that have been proposed to address global warming, air pollution mortality, and energy security [49]. The assessment takes into account the potential impacts of these proposed solutions on various factors, including water supply, land use, resource availability, thermal pollution, and undernutrition.

There is a need for a more structured approach in the development and assessment of interventions, which takes into account the interconnectedness between poverty and reliance on polluting fuels [50,72].

The pursuit of sustainable development has sparked a re-evaluation of innovation and technological advancements. A reference review paper contributed to this reassessment in three ways [51]. Firstly, it explored how the history of innovation studies related to sustainable development can be understood as a progression of linking broader analytical frameworks to increasingly comprehensive problem formulations. Secondly, it introduced a promising framework, known as the multi-level perspective on socio-technical transitions (MLP), which offers a comprehensive view of the subject. While this theory is gaining attention in policy circles and academia, it is not without its challenges. Therefore, the third objective of that review paper is to identify and elaborate on these challenges, presenting them as areas that require further research and development.

The concept of greener innovation has been a recurring theme in discussions surrounding the mitigation of environmental degradation during the course of industrial development.

The field of innovation studies holds great potential for individuals seeking to ensure that new products, processes, and services contribute to human well-being without compromising the integrity of environmental support systems. By examining the dynamics of innovation, this field can shed light on the factors that drive the emergence or absence of environmentally friendly production and consumption practices [48].

Energy transitions towards sustainability have garnered significant attention in the realms of politics and science. A relevant study employs a socio-technical and multi-level theory on transitions to extract valuable insights from a long-term analysis of the Dutch electricity system [73]. By examining technical advancements, changes in regulations and perspectives, and the social networks that support or resist renewable energy options, the article takes a comprehensive approach. It explores both emerging renewable energy technologies and the underlying structural trends within the established electricity regime. The analysis reveals that an energy transition has been underway since the 1960s and 1970s, primarily driven by liberalization and European integration. While environmental considerations have become integral to this ongoing transition, they do not serve as its primary driving force. Numerous barriers exist for achieving a sustainability transition, yet there are also opportunities.

The energy sector confronts substantial challenges, including oil dependency, reliability issues, and environmental concerns. Transitions to a new energy system hold the potential for significant leaps in environmental efficiency, as highlighted by Weaver et al. (2017) [74]. Consequently, there is a growing interest among NGOs and policy makers in these transitions, as emphasized by Raskin et al. (2002) [75].

In order to have a greater than 50% probability of limiting global warming to below 2 °C, recent scenarios generated by integrated assessment models (IAMs) indicate the need for extensive deployment of negative emissions technologies (NETs) [52]. These technologies aim to remove greenhouse gases from the atmosphere, resulting in a net reduction. In this respect, the potential global impacts of different NETs on various factors, such as land use, greenhouse gas emissions, water resources, nutrient availability, and energy requirements, was assessed. By doing so, the biophysical limitations and economic costs associated with the widespread application of these technologies was determined. The resource implications vary depending on the specific NETs employed and must be effectively addressed in order for NETs to play a significant role in achieving climate goals.

Energy plays a crucial role in facilitating the sustainable development of nations, encompassing social, economic, and environmental aspects. Global energy consumption has experienced a significant surge in the past decade. Effective energy management is vital for ensuring future economic prosperity and environmental security. To ensure efficient allocation of available resources, energy demand management becomes imperative. Over the last decade, several innovative techniques have emerged for accurately forecasting future energy requirements [53]. In fact, these kind of researches aims to review various energy demand forecasting models, providing insights into their effectiveness and applicability.

The concept of energy justice has gained prominence as a multidisciplinary research agenda, aiming to apply principles of justice to various aspects of energy, including policy, production and systems, consumption, activism, security, and climate change [51]. Energy has become a central focus for scholars interested in justice. The global "energy challenge" is well documented, characterized by the combination of resource scarcity, population growth, and an increasingly unpredictable social and environmental climate. To better comprehend and address these complex issues, several conceptual frameworks have emerged. These frameworks, although subject to debate, provide distinct perspectives on the content and objectives of energy research. Energy justice is interconnected with specific concepts—energy transition, energy security, and energy poverty.

Energy security entails the evaluation of two key aspects: (1) the security of energy supply and production, and (2) emerging insecurities related to factors like availability and pricing. The primary objective of energy security is to ensure the protection and preservation of energy supply and domestic production capabilities [76,77].

Energy is an essential requirement for human existence, and the availability of a secure and accessible energy supply is imperative for the sustainability of modern societies. However, the continued reliance on fossil fuels is anticipated to encounter numerous challenges. These challenges include the depletion of fossil fuel reserves, concerns related to global warming and other environmental issues, geopolitical tensions and conflicts, and more recently, persistent and significant increases in fuel prices [55]. Therefore, in light of mounting concerns surrounding climate change, the depletion of fossil fuel reserves, and the human drive to pursue cleaner and more innovative forms of energy, it can be reasonably inferred that a transition to renewable energy sources is both feasible and attainable.

In order to mitigate the effects of climate change, it is crucial to facilitate a swift transition toward a low-carbon economy, ideally within a century. As a result, the rate at which new technologies, such as those involved in generating electricity from renewable energy sources, are adopted becomes a pivotal concern [56]. Often the factors contributing to the rapid adoption of two such technologies (wind turbines and solar cells) are associated with the policy instruments used and the regulations imposed that facilitated their implementation.

Energy is intricately connected to a convergence of significant challenges and prospects, which has led to an increased emphasis on enhancing model-based analysis of energy systems in the twenty-first century. These challenges encompass the security, affordability, and resilience of energy supply, along with environmental issues spanning from local pollution of air and water to the paramount concern of climate change and global sustainability [57]. However, within these challenges lie opportunities such as introducing innovative technologies to the market, fostering the development of competitive industries, and offering extensive sustainable energy production to regions experiencing rapid economic growth.

5. Discussion and Conclusions

The negative externalities generated by human activity on the environment determine increasingly intense concerns at the international and national level for promoting the principles of sustainable development and finding appropriate tools. Sustainable development is promoted internationally through various initiatives, such as the Global Compact Principle applicable to companies, but also to universities (Principles for Responsible Management Education) and portfolio investors (Principles for Responsible Investment). The involvement of stakeholders is necessary on different levels to ensure not only the financial performance but also the social and environmental performance of corporations that are in a complex process of metamorphosis in terms of their role in the economy and society [78–80]. The reduction in carbon emissions is also achieved through a new energy transition aimed at the predominant use of renewable energy. Global warming and air pollution are increasingly analyzed in the context of the energy transition that reduces the impact of human activity on the environment. The energy transition comes not only with business solutions and opportunities, but also with challenges generated by energy security and poverty [81–83].

Public institutions and companies must find technical solutions that allow the use of renewable energy under conditions of economic profitability, so that the environment is protected but also ensure the achievement of the economic objectives of profit maximization for shareholders. The energy transition must ensure not only the use of renewable energy but also the population's access to reasonable energy prices. Despite the level of economic development specific to EU countries, energy poverty affects a certain part of the population, with this phenomenon being felt throughout the year, both in the summer and winter months. Energy poverty generates not only economic and social challenges for the population but also health problems [84–86]. Difficulties in accessing energy for certain categories of people have also generated multidisciplinary concerns for applying the principles of justice to various aspects of energy, such as policy, production and systems, consumption, activism, security, and climate change.

The energy transition comes with numerous economic, environmental, social, and technical challenges, which is why researchers initiate studies that try to find solutions for this complex process. Researchers not only carry out scientific studies but also review papers to identify trends in research and establish future directions. The issue of the energy transition has become an intensely debated topic following the invasion of Ukraine by Russia and the economic and political measures imposed by the European Union and the

USA for the actions of the invader. The sanctions imposed were drastic, which is why Russia stopped fossil fuel exports, a fact that proved the importance of energy security and improving the energy mix to ensure independence from traditional suppliers. The geopolitical situation has proven the importance of renewable energy but also the fragility of the renewable energy process because the problems related to improving the profitability of these sources have not yet been resolved. Reconsidering coal and nuclear energy was the solution found [87–95].

Access to energy has become an international priority, and concerns about reducing energy poverty are increasingly intense, which is why a key instrument was launched at the European Union level, namely the just transition, which tries to achieve a balance between the need to protect the environment through the use of renewable energy and the mitigation of the socioeconomic impact of the transition. The just transition mechanism provides funding for areas with the highest CO_2 emissions or those regions where jobs are provided by industry based on fossil fuels. Through this mechanism, new employment opportunities appear in the fields of renewable energy. In order to improve the access to energy, improving the energy efficiency of homes could be a solution for combating energy poverty. Therefore, access to clean energy, constantly supplied and at reasonable prices, could be improved.

Through this comprehensive analysis, the main interests and main concerns related to the combination of energy poverty, energy transition, and energy security issues are discovered. over time, some useful contributions made by some representative authors was established and profiling possible future developments in these sectors was achieved. Energy efficiency can be a solution to ensure the reduction in energy poverty and the increase in energy security and can also be a solution for the energy transition. Unconsumed energy is itself a source of energy. Investment in energy efficiency infrastructure are essential both for the transition and the low-carbon economy, but it also ensures the promotion of a circular economy. The construction of new buildings or the improvement of the energy performance of existing buildings generates the reconsideration of construction and demolition practices, the waste resulting from these processes can be used for energy production.

This review paper was performed during February–April 2023. The PRISMA method was used, in which we selected and checked the review papers articles indexed in the main databases of Web of Science (WoS), Scopus, and JSTOR. Then, the search was followed by extending it and adding some other articles discovered in the gray literature. After a classification of articles, a total of 2615 review articles remained valid for this analysis. The study's key contribution is the classification of the clusters' themes for the metasynthesis analyses, which point to potential future directions with a special focus on governmental policies to pursue some macrolevel goals concerning energy poverty, energy transition, and energy security in our daily lives.

Naturally, as the number of criteria increases, limitations associated with the study become apparent. However, our research proposal effectively mitigates the risk of encountering such limitations by avoiding the inclusion of stringent criteria concerning the collection of information on the contributions of key authors (most productive and cited authors). This approach ensures a valuable and comprehensive pool of elements pertaining to the analyzed subjects.

We focused on review-type works that included important summary and cumulative information, and we took care to analyze the most cited papers with constructive reviews related to the content. We consider that, through this approach, we have reduced the subjectivity of an analysis of this type quite a bit by not wanting to use any kind of speculation regarding the subjects treated.

This paper demonstrates the importance of the correlation of economic policies aimed at related fields, namely energy, water, and food. In addition, the authors emphasized the importance at the social level of the expense of the environmental level of the energy transition. Even if this energy transition was determined by considerations related to the protection of the environment, the current situation demonstrated the complexity of the phenomenon and the importance of the social elements that must govern the reconfiguration of the energy mix. For these reasons, coal-based energy and nuclear energy are reconsidered in the new geopolitical context generated by the invasion of Ukraine by Russia.

Being aware of the limits of this research, the authors have in mind the continuation of the study of the energy transition process and its economic, social, and technical implications and the analysis of the new trends identified in the international literature, namely just transition and energy justice. In addition, taking into account the urbanization, globalization, and climate change trends, new direction for futures research would be focused on the water–energy–food nexus. Water, energy, and food are interlinked and increasingly more experts draw attention to some ethical aspects regarding the use of agricultural land for the cultivation of crops intended for the production of biofuels and not for the production of food. In addition, water is used for production of energy, and energy is used to treat and deliver the water. So, these important resources are interlinked. The increasingly intense concerns regarding the circular economy generate a new direction of research, namely the energy–circular economy relationship. On the one hand, waste recycling requires energy consumption, but on the other hand, waste can be used for energy production [96–98].

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