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Towards Renewable Energy Transition: Insights from Bibliometric Analysis on Scholar Discourse to Policy Actions

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Abstract: Mounting climate concerns are making energy transition inevitable. Providing a reliable, cost-effective energy supply that meets the needs of all, as set up by Sustainable Development Goal 7, and promotes climate neutrality, as set up by the European Green Deal, is a complex task that requires complex and combined interventions in various sectors and policy areas. This paper aims to conduct a systematic analysis of the scholarly work focusing on energy transition towards renewables and to contribute to the existing knowledge by offering a holistic perspective on the dynamic landscape of energy transformation and the transition to renewables. To this end, advanced bibliometric techniques, combined with a systematic in-depth review of the existing literature and desk research, are used to uncover the intellectual landscape and identify influential works and emerging themes within this critical intersection of the economic, governance, political, social, and climate dimensions of energy transition. This analysis not only highlights prevailing trends and influential works but also sets the stage for future research and discussions critical to shaping the transition to renewable energy and policy actions in a rapidly evolving world. The results are useful guidance in the formulation of policy actions.

Keywords: renewable energy; energy transition; energy policy actions

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1. Introduction

Mounting climate concerns are making the energy transition inevitable. The global vision, as shaped by Sustainable Development Goals (SDGs) [1] and the European Green Deal [2], is clear: we are moving towards a cleaner, more sustainable energy matrix. Providing a reliable, cost-effective energy supply that meets the needs of all, as set up by SDG 7 [1], is a complex task that requires complex and combined interventions in various sectors (such as the energy, transport, buildings, technology, agriculture, and food industries) and policy areas (employment, research and development, and funding) to address the technical, social, political, economic, legal, and ethical challenges that arise.

This paper aims to conduct a systematic analysis of the scholarly work focusing on energy transition towards renewables and to contribute to the existing knowledge by offering a holistic perspective on the dynamic landscape of energy transformation and the transition to renewables. The complex multifaceted nature of the energy transition is reflected in the large number of scholarly papers that address various aspects of the energy transition in the context of the economic, governance, political, social, and climate dimensions of our society. In response, in this paper, the authors have conducted a comprehensive systematic analysis of the evolving scholarly work focusing on energy transition towards renewables. The aim is to contribute to the existing knowledge by offering a holistic perspective on the dynamic landscape of energy transformation and transition. The analysis not only highlights prevailing trends and influential works but also sets the stage for future research and discussions critical to shaping the renewable energy transition and policy actions in a rapidly evolving world. The results are useful for providing guidance in the formulation of policy actions.

By bringing together expertise from various research areas and by interacting with industry players and policymakers, universities provide a unique environment for scholars to explore and develop new ideas and deliver scholarly research and studies, enabling technological advancements and the development of robust and efficient solutions designed to meet energy transition challenges [3]. Interdisciplinary collaboration among scholars creates grounds for delivering innovative interdisciplinary solutions for a smoother and more effective energy transition, empowering individual actions in this direction [4], postulating alternative economic models necessary for the transition [5], and engaging scholars in the formulation of energy and climate policies [6].

As we explore the scholarly literature, it is clear that the challenges posed by climate challenges and energy transition require a deeper understanding of their complexities [7–9]. Bibliometric analysis is an effective methodology for gaining systematic insights into scholarly conversations. It involves examining citation patterns, co-authorship networks, and thematic evolution to enhance understanding in various interdisciplinary domains. Bibliometric analysis is a systematic and quantitative examination of bibliographic data. It is a powerful tool for organizing and understanding knowledge within specific research fields. Studies conducted by prominent researchers [10–15] have evidenced this approach. This approach serves as a roadmap for navigating the latest trends, critical works, and overall structure of a given academic domain. However, its application to the specific intersection of energy transition and renewable energy at a global level requires further exploration.

To identify the key elements defining the renewable energy transition, a critical systematic review of the existing work and the relevant scientific literature was conducted, starting from the results of the bibliometric analysis. Relevant articles and scholarly work were selected, mostly from WOS-indexed publications. Desk research (of strategies, policy documents, and official reports) was also conducted in order to position and connect scholarly research with the renewable energy transition strategic framework. Finally, the authors have combined and triangulated the results of these research methods with the aim of contributing to the existing knowledge by providing a holistic perspective on the dynamic landscape of energy transformation and transition, not only for highlighting the prevalent trends and influential works but also for identifying and selecting the relevant scholarly findings to shape the renewable energy transition and policy actions.

The remainder of this paper is structured as follows. Section 2 provides a background of the analysis by presenting the strategic policy approach to renewable energy transition, as obtained through desk research. Section 3 presents the main methods and materials used: bibliometric analysis combined with an in-depth systematic literature review combined with desk research. Section 4 presents the main results obtained by applying the research method. In Section 5, we have discussed the findings of the bibliometric analysis combined with a systematic and critical literature review and desk research to frame the conceptualization, drivers, and challenges of the renewable energy transition, along with an examination of the policy implications and recommendations that have emerged from this analysis. Section 6 presents the main conclusions and limitations of this paper, along with further directions for research.

2. Background of the Research: Strategic Set-Up for Renewable Energy Transition

The growing environmental concerns and technological advances are paving the way for the ascendance of low-carbon energy technologies and a net zero emissions (NZE) economy [1,16]. The target of 1.5 degrees Celsius [17] represents a viable pathway towards achieving climate neutrality. In light of the fact that global warming is primarily the consequence of greenhouse gas emissions, which are predominantly generated by a carbon-intensive economy, it is imperative to pursue net zero emissions targets in order to achieve climate neutrality [16].

At the global scale, the Sustainable Development Scenario (SDS), aimed at achieving the Paris Agreement's less ambitious goal to limit the temperature to "well below 2 °C", is also setting up targets for energy access and renewables, while the NZE Scenario sets out a pathway for the energy sector to achieve net zero CO_2 emissions by 2050.

At the global scale, under the NZE Scenario, CO_2 emissions are expected to fall by 40% between 2020 and 2030, and to net zero in 2050 with significant contributions from the following key sectors (in terms of energy supply and consumption): electricity and power generation, fuel supply, industry, transport, and buildings [17]. The NZE Scenario ambition for 2050 is built upon a broad energy transition from fossil fuels (demand is expected to fall by 90% for coal, 75% for oil, and 55% for natural gas) to renewables (expected to represent 70% of the energy supply) and nuclear energy (expected to account for 10% of the energy supply) [17]: fossil fuels are not expected to be fully eliminated but limited use is expected, namely in the production of non-energy goods where the carbon is embodied in the product or in industries where low-emissions technology options are scarce [17]. With renewables rapidly becoming a dominant force in global power generation, the energy transition is driven by key renewable energy and energy efficiency technologies.

To meet the target of 1.5 degrees Celsius set out in the Paris Agreement [17], it is imperative to remain consistent in adhering to the remaining emissions budget, estimated at approximately 420 to 1200 billion tons of CO_2 by the year 2100 [18,19]; still, it is likely to contribute to a reduction in global warming of only 1.8 degrees Celsius [19]. Therefore, meeting the target of 1.5 degrees Celsius would call for more ambitious national targets.

By 2018, a total of 190 countries worldwide submitted their Nationally Determined Contributions (NDCs) that outlined the climate commitments and actions that they would undertake on a voluntary basis until 2030, of which 153 NDCs were updated and revised by 2022 [20]. As the International Energy Agency [21] reported, the majority of NDCs have an energy sector target, but approximately 70% of NDCs have a conditional component that is contingent on a range of possible conditions, such as financial, technical, and capacity-building support. Under the NZE Scenario, it is anticipated that technologies that facilitate or enable zero-emission energy or energy services will constitute 47% of spending in 2030, while technologies that offer emissions reductions but do not themselves deliver zero-emission energy or energy services are expected to account for a further 7% [21].

It is important to mention that achieving the targets for renewables in total energy generation of 85% under SDS and 90% under NZE by 2050 requires significant additional consistent efforts in all regions of the world [22].

Decarbonization remains a major element of climate and environmental targets, guiding energy transition at the global scale. Consequently, there is a strong commitment from all large economies to reduce greenhouse emissions and increase renewables, as shown in Table 1.

Table 1. Climate and environmental targets in selected countries.

Country	Targets and Policies
Canada	2050: 80% reduction of greenhouse gas (GHG) emissions relative to 2005, with an interim target of 30% by 2030. Policies for uptake of renewable energy sources, increased energy efficiency, and elimination of coal-fired electricity generation.
United States of America	2025: 26% reduction of GHG emissions relative to 2005. Policies for uptake of renewable energy sources. Withdrew from the Paris Agreement in 2017.
China	2030: 60% reduction of CO_2 intensity relative to 2005; 20% of non-fossil energy in total primary energy consumption. Policies for uptake of renewable energy sources, increased energy efficiency, and restructuring of the economy.

Table 1. *Cont.*

Country	Targets and Policies
Japan	2050: 80% reduction of GHG emissions, with an interim target of 26% by 2030 relative to 2013. Policies for uptake of renewable energy sources and nuclear energy, as well as increased energy efficiency.
India	2030: 33% reduction of CO_2 intensity relative to 2005; 40% installed power of non-fossil energy technologies. Policies and measures supporting energy efficiency, use of clean fuels/technologies (renewable energy included), and renewables.
Russia	2050: 88% reduction of GHG emissions, with an interim target of 25–30% by 2030 relative to 1990. Policies supporting renewable energy sources and energy efficiency.
Australia	2030: 26–28% reduction of GHG emissions relative to 2005. Policies supporting renewable energy.
Brazil	2030: 43% reduction of GHG emissions relative to 2005. Policies for the uptake of renewable energy sources and renewable fuels.
European Union	2050: 95% reduction of GHG emissions, with an interim target of at least 40% by 2030 relative to 1990. Climate neutrality. Policies for Energy Trading Systems for carbon pricing, ambitious CO_2 standards, energy efficiency measures, uptake of renewable energy sources, and clean fuels.

Source: Adapted from [18].

On a global scale, it is the European Union that assumed the highest level of ambition for reducing harmful greenhouse emissions and climate neutrality to guide the energy transition towards renewables. In addition, as shown in Table 1, very few countries have consistent long-term climate/emissions targets to guide their energy transition, with most of them having set up their ambitions relative to 2030.

By adopting the European Green Deal (EGD) in December 2019, the European Union (EU) has set the ambitious objective of achieving climate neutrality by 2050 [2]. Climate neutrality refers to the mitigation of all greenhouse gases and includes carbon neutrality targets. The European Green Deal consists of a comprehensive package policy intervention [23] tapped into the roadmap of key policies for the EU climate change agenda [24] and green transition [25], with a clear focus on energy emissions [23] and energy policy. Taking into consideration its position in the world economy and trade, for achieving climate neutrality and with the aim of taking leadership, the European Union has set up ambitious targets to mitigate emissions of detrimental greenhouse gases, aiming for a 55% reduction by 2030 and expecting a reduction of at least 80% up to 95% by 2025 as compared to 1990 [26].

Since energy is responsible for more than 75% of greenhouse gas emissions [27], the energy transition has been inextricably linked from its inception with the potential it holds for reducing greenhouse gas emissions by phasing out fossil fuels and replacing them with renewable energy sources at the global scale. The energy sector remains one of the most important stakeholders to contribute to climate neutrality [28] and full decarbonization of the energy systems is essential for the EU's climate neutrality ambition. The regulatory and strategic package for energy subsequent to the European Green Deal has been setting up targets and approaches to guide the energy transition: the EU has committed to act to achieve an 11.7% improvement in energy efficiency [29] and a share of renewable energy of at least 42.5% in gross final energy consumption by 2030, as set up in EU Directive 2023/24 [29,30]. Under the Green Deal, the energy transition aims at reducing greenhouse emissions to reverse climate change and ensure energy security by reducing the EU's energy dependence on fossil fuels [31].

The European Green Deal is built on three key principles to guide a clean and just energy transition, which will help reduce greenhouse gas emissions and enhance the quality of life of citizens [2,32]: (a) developing a fully integrated, interconnected, and digitalized EU energy market; (b) improving energy efficiency, including the energy performance of our buildings, and developing renewable sources based on the power sector; and (c) ensuring a secure and affordable EU energy supply.

To this end, the European Green Deal and subsequent strategic documents contain specific measures for: (a) phasing out fossil/carbon-based fuel sources and consumption; (b) increasing energy efficiency and the efficient use of resources; and (c) investing in renewable green energy production and storage [31,33]. Measures are delivered under the form of regulatory actions together with funding for investments (new technologies, R&D, and infrastructures (grid extension and improvement and production and storage facilities)) and a just energy transition (with a particular focus on the most vulnerable populations, sectors, and territories).

As compared to the EU, the commitments under SDG (guiding energy transition) in other regions of the world have a lower level of ambition. Combined with different energy mixes and resources, this delivers diverse renewable energy transition pathways across various regions of the world.

In Africa, only 12 countries, producing about 43% of global CO_2 emissions (as in 2020) [34], have announced long-term net zero emissions pledges, with the objective of achieving carbon neutrality by 2050 (of which the most important are South Africa, Namibia, Malawi, and Liberia), 2060 (Nigeria), or 2070 (Mauritius) [34,35]. At the Conference of the Parties (COP26), only seven African countries and the East African Development Bank signed the Statement on International Public Support for the Clean Energy Transition, which sets up the end of financial support for unabated fossil fuel-based power generation by the end of 2022; under this Statement, Morocco committed to refrain from constructing any new coal-fired power plants, while Egypt has committed to phasing out coal-fired power stations. On the other hand, South Africa has only committed to reducing coal use [34]. In the case of Africa, if fully implemented, the 53 NDCs would collectively result in the mitigation of approximately 550 Mt CO_2 in 2030, equivalent to approximately 40% of the continent's current emissions [34]. It is important to mention that all African NDCs contain targets and actions in the energy sectors; this is mostly due to the fact that the current power mix in Africa is dominated by fossil fuels, with coal, natural gas, and oil accounting for approximately 72% of the power generated in 2023 [36]. The African Union Agenda 2063, developed by the African Union, is a blueprint and master plan for transforming Africa into the global powerhouse of the future [37]. It outlines the objective to establish renewable and clean sources as the foundation for the expansion of Africa's energy systems to ensure energy security and decarbonization [19,35]. However, as the necessity for decarbonization becomes paramount in the context of increasingly stringent energy transition regulations and climate policies, it is anticipated that the share of Africa's renewable-driven (solar PV, onshore wind, and hydro) power mix will rise from 25% in 2023 to 75% by 2050. In addition, the role of fossil fuels in the power mix is anticipated to decline gradually, with natural gas reducing its presence in the energy sector from 42% of the power generated in 2023 to 10% in 2050 [36].

In Asia, climate commitments and renewable energy transition encompass variations at the sub-continental level and across countries. At COP-26, India committed to achieving Net Zero by 2070, with key milestones for 2030 (50% of energy requirements supplied by renewable energy sources, an emissions reduction of 1 billion tons, and a reduction in the economy's carbon intensity of 45%) and 2047 (energy independence) [38]. In addition, the ASEAN countries referred to their climate ambitions in COP 26, but full commitments and clear roadmaps seem to be missing, unclear, or conditional: (a) the Indonesian government has increased its climate ambition to reach net zero emissions by 2060 or sooner (with a target reduction of 29 for greenhouse emissions by 2030); (b) Thailand has suggested that the target of net zero emissions should be reached by the mid-century and is aiming to achieve carbon neutrality by 2050 (with a target of a 20% reduction in greenhouse emissions by 2030); (c) Vietnam announced a net zero target by 2050 (with a target of a 27% reduction in greenhouse emissions by 2030); and (d) Brunei Darussalam (with an oil and gas industry that is dominant in the economy) declared its net zero target by 2050 (with a target of a 20% reduction in greenhouse emissions by 2030) [39]. For ASEAN countries, the existing roadmaps suggest that, under the NZE Scenario, the share of renewable energy in total final energy consumption will increase to 65% by 2050 [39].

In Southeast Asia, ambition in terms of renewable energy remains very low compared to other regions of the world. As the International Energy Agency [22] reported, in Southeast Asia, despite the rapid expansion of renewable energy sources, fossil fuels continue to meet the majority of the growth in energy demand. Their consumption will continue to increase until at least the mid-century and it is anticipated that the aggregate proportion of fossil fuels in the energy mix will remain above 70% in 2050 (compared to 77% in 2022) [22]. In Southeast Asia, renewables currently account for nearly 25% of total generation, and the share of renewables is expected to rise to nearly 40% by 2050 [22], which is significantly lower compared to SDS and NZE Scenario ambitions. Therefore, the transition to renewables is likely to be very costly since the region is home to the youngest coal power fleet in the world (with an average coal plant age of 12 years of activity in 2022 and investments for decommissioning are estimated at approximately 13% of the region's total investment requirements [40]).

For Central Asia, for the last three decades, there was minimal focus on energy efficiency and environmental concerns. The energy sector continues to be managed through a centralized system and, despite their renewable energy potential, the energy transition seems to be impeded in countries that are rich in fossil-based energy resources [41].

Latin America and Caribbean countries are rich in natural resources, particularly fossil fuels (as is the case for Venezuela, Brazil, Mexico, Argentina, and Colombia), with many economies dependent on fossil fuels. The primary energy supply in the region is mainly from fossil fuels (69%), while only 1/3 of the supply is derived from renewable sources [42]. This may explain why only 16 out of the 33 countries in the region have promised to achieve net zero emissions targets by the mid-century or earlier, and only six countries have explicitly mentioned an absolute or relative target, while the rest rely on a counterfactual business-as-usual scenario to specify their potential emission reductions as reported by the International Energy Agency [34]. Still, in the region, 65% of electricity generation is renewable [42] which is likely to contribute to a smooth energy transition to renewables. Latin America and Caribbean countries are demonstrating advancements across multiple domains in their efforts to transition to a more sustainable energy future, which include national energy policies that reflect their commitment to this transition, for example, Uruguay's 2005–2030 Energy Policy, Mexico's 2020–2024 National Program for Sustainable Energy Use, Chile's Energy 2050 policy, and Costa Rica's 2015–2030 National Energy Plan [42].

Cross-examination of these commitments reveals the critical role of renewable energy in achieving climate and sustainability targets. At the same time, it is worth mentioning that solar and wind energy are common elements in all strategies, policies, and action plans.

December 2019 to August 2024 (the present time) stands out as a pivotal era for energy transition, characterized by rapid and transformative shifts towards renewable energy, and is of particular interest for this paper. Following the adoption of the European Green Deal in December 2019, giving a boost to the renewable energy-driven transition in the EU, several interconnected factors converged to accelerate this process, primarily in Europe. The onset of the COVID-19 pandemic (late 2019–early 2020) initially dampened energy demand but subsequently catalyzed a renewed focus on sustainability and resilience. As economies rebounded, there was a growing recognition of the vulnerability of fossil fuel-dependent energy systems. This crisis acted as a catalyst for diversifying energy sources and investing in cleaner alternatives. Concurrently, the intensifying impacts of climate change, manifested in increasingly frequent and severe extreme weather events, amplified the global imperative to transition to a low-carbon economy. Public and political pressure mounted on governments and businesses to adopt ambitious climate action plans.

Geopolitical shifts, notably the Russian invasion of Ukraine in February 2022, disrupted global energy markets and underscored the critical importance of energy security [43,44]. In particular, European countries, heavily reliant on Russian gas, were compelled to expedite their efforts to reduce fossil fuel dependence and diversify energy supplies. In response to the attack on Ukraine, the European Union (EU) has taken the decision to reduce its reliance on imported hydrocarbons from Russia, which has had global impacts by prompting major players in energy markets to re-evaluate their investment strategies. In addition, the global discourse on energy transition and climate change has reached unprecedented levels, with a notable shift towards renewable energy sources [36]. This crisis served as a powerful impetus for rapid renewable energy deployment and investments in energy efficiency. Moreover, technological advancements in renewable energy, particularly solar and wind power, and declining costs made these technologies increasingly competitive with traditional fossil fuels. This economic viability, supportive government policies, and financial incentives fostered the widespread adoption of renewable energy sources.

These global, regional, and national insights are shaping the strategic landscape for scholars to deliver solutions to challenges and policy recommendations for governments for a smoother and more effective energy transition to support climate targets to which countries have committed.

3. Materials and Methods

Research methods were combined to achieve the aims of this paper. This paper relies on bibliometric analysis and secondary data.

The research design consists of several phases:

1. Desk research—with the aim of setting up the strategic policy framework of the subject of this paper, namely the transition to renewable energy;
2. Bibliometric analysis using "energy transition" and "renewable energy" to identify the relevant literature;
3. Selection of the relevant literature—since the bibliometric analysis revealed a large number of scholarly works tackling the topic of renewable energy transition, funnel-like techniques were used for selecting the relevant literature for systematic review. Additional filtering consisted of applying additional keywords revealed by bibliometric analysis, which were relevant for the aim of this paper, the temporal frame, and the relevance of this article (also measured by "most cited", "hot papers", etc.). In addition, papers addressing only technologies and technology issues were excluded since this subject does not fall under the scope of this paper;
4. Systematic review of the relevant selected papers, with a particular interest in the specific features, challenges, and implications of the transition to renewable energy;
5. Combining the results of the research methods deployed to identify relevant issues to be considered in policy-making.

The research design of this paper, which combines different research methods that complement each other, allows the authors to properly position the topic of research and to map and analyze only the recent and most relevant scholarly literature, delivering a holistic perspective on the dynamic landscape of energy transformation and the transition towards renewables. The research design and methods used ensure the reasonableness of the selected literature sample. The relevant scholarly literature reflecting the prevailing trends was selected, as well as influential works (using funnel-like techniques and additional filters, including filtering by "most cited").

Desk research was conducted to identify the main patterns and policy elements guiding and shaping the global landscape of energy transition, as well as the main strategic guidelines and targets for a smooth and sustainable energy transition. Legislation, reports, policy documents, and strategies from European Union institutions and the United Nations were consulted. In addition, reports from the International Energy Agency (IEA), the International Renewable Energy Agency (IRENA), and the World Economic Forum (WEF) were analyzed to frame the policy options for an effective and just renewable energy transition. Websites hosting these official documents, statistics, and reports were accessed from 1 June 2024 to 6 August 2024. The desk research contributed to the identification of the key pillars and main drivers for the renewable energy transition policy framework, and it was used for setting up the regional and global strategic set-up governing and orienting the renewable energy transition.

The rapid growth of scientific knowledge due to advancing information technology has led researchers to explore new methods for analyzing large amounts of data. This has given rise to the field of bibliometrics. Bibliometric methods, as demonstrated by various studies [45–47], can provide accurate and reliable quality indicators, especially useful for comparing or categorizing comprehensive subjects [48,49]. While these measures are effective for comparing broad research topics, they may not capture the nuances of individual research efforts [10,50–56]. For the assessment of experimental behavior, bibliometric analysis is valuable for researchers seeking insightful data [48,53,54,57–60]. Bibliometric analysis was selected for organizing and understanding knowledge within specific renewable energy transition research fields. The bibliometric analysis was conducted using the WoS Core Collection database. The search query included the keywords "energy transition" and "renewable energy" connected by the "and" connector to ensure comprehensive retrieval of relevant articles. Filters were applied to restrict the search to articles and reviews published in English between December 2019 and August 2024, capturing a significant period of actions towards energy transition worldwide: the COVID-19 pandemic, the Russian invasion of Ukraine in February 2022, and severe climate degradation manifested through severe weather phenomena. Therefore, the period from December 2019 to August 2024 represents a unique opportunity to study the accelerated pace of the energy transition. By examining the interplay of these factors, researchers can gain valuable insights into the drivers of change, the impact of policies and investments, and the implications for the future of the energy sector. Consequently, the study analyzed English-language articles and reviews from the Web of Science (WoS) database published between 11 December 2019 and 6 August 2024.

VOSviewer, version 1.6.15, was the selected bibliometric analysis method—a freely accessible information technology system developed for generating and visualizing bibliometric maps [61]. VOSviewer tools are used to generate a keyword chart, and this paper concludes with a discussion of the study's findings, limitations, and recommendations for future research. Setting itself apart from other information technology tools, VOSviewer emphasizes the creation of graphical maps, proving especially beneficial for analyzing extensive datasets and demonstrating impressive capability in producing network-based maps [62–65]. VOSviewer, which was accessed on 7 August 2024, at www.vosviewer.com, is a specialized computer program that is specifically designed for creating, visualizing, and analyzing scientific bibliometric maps. One of its key features is the ability to generate term maps, which are two-dimensional visual representations where the size of word labels corresponds to the frequency of the words, and the distance between terms indicates their relatedness based on their co-occurrence in the corpus file [10,66,67]. The software also has functionalities for identifying countries, frequently cited authors, and relevant keywords in the research [68].

The bibliographic data that was gathered were then exported and processed for analysis using VOSviewer, set at a minimum word frequency threshold to exclude rarely used terms and make the keyword map clearer. This research examines the temporal development, the distribution among journals and countries, author and institutional perspectives, and citations received by the publications to assess their impact on the scientific literature. Additionally, it used co-occurrence cutoffs to identify statistically significant relationships between keywords. It also utilized a VOS clustering algorithm to find thematic areas within the research landscape. Mapping and clustering techniques [62,69] are valuable for identifying patterns and uncovering connections within these networks, providing researchers with a comprehensive view of the dynamics and interrelationships within a research domain. This method helped visualize the intellectual structure of the field and revealed prominent research clusters related to energy transition and renewable energy.

With the results of the bibliometric analysis as a starting point, a critical systematic review of the existing scholarly literature was conducted to identify the key elements defining the renewable energy transition. A systematic review of the scholarly literature is an essential tool in all research areas for collecting and analyzing data [70] and for revealing and describing previous research and relevant findings [71] on a specific topic. As a research method, a systematic literature review synthesizes research findings in a systematic, transparent, and reproducible manner [72], providing a broad perspective in selected research/study areas by incorporating findings, approaches, and results from many empirical findings and a large number of research papers, making it suitable for addressing research questions with a completeness and power that no individual study has [71].

As revealed by the bibliometric analysis, "energy transition" and "renewable energy", as key parts of the conceptual design of "renewable energy transition", have been extensively examined by researchers from a multitude of perspectives, whose work is reflected in a large number of articles and studies covering diverse disciplines and fields of research. Thus, a systematic review of the existing literature was required to uncover the intellectual landscape and identify influential works and emerging topics within this critical intersection of the economic, governance, political, social, and climate dimensions of the energy transition toward renewables. The systematic review of the existing scholarly literature, complementing the bibliometric analysis, becomes necessary to reduce biases and to provide reliable evidence for drawing relevant conclusions [73], supporting decision-making for the proper achievement of the targets defined in strategic and policy documents revealed by the desk research.

Because of the impressive scholarly work covering renewable energy transition, a comprehensive review of the literature was impossible. Therefore, a funnel-like technique was used for optimizing the selection of the relevant literature to be reviewed and appraised to properly achieve the aims of this research. Thus, a funnel-like technique was used: additional filtering was deployed and allowed the authors to move from broad to narrow, i.e., from general results to the more specific literature to be discussed. The bibliometric analysis and selected filters were correlated. The authors made use of the clusters resulting from the bibliometric analysis (an "implications" cluster, a "system" cluster, and a "challenges" cluster), and the literature was filtered by additional keywords: renewable energy transition and additional (second-layer) filters were connected by the "and" connector. The most relevant additional filters included the following keywords: effects, impact, challenges, patterns, just transition, fairness, development, social impact, energy system, storage, sustainability, sustainable development, renewable, power system, capacity, generation, demand, adoption, greenhouse emissions, policy, and stakeholder (also reflected in the "implications" and "system" clusters of the bibliometric analysis). Then, for every additional keyword, there were two independent exercises for filtering the literature (peer-reviewed scholarly articles) by (1) "most cited" and "hot papers" for the temporal horizon of interest (2019–2024) to select the most influential works and (2) "most recent" (2023–2024) to cover the newest works (which are likely not covered by "most cited"). Therefore, to select the most influential and newest scholarly literature for a more in-depth review, usually, for each filtering, the first 50 articles (or all articles if fewer than 50) were scrutinized by the authors to ensure that relevant methods, findings, and conclusions were selected and referred to in this paper. Articles relevant to two or more keywords were of particular interest to the authors and were examined in more depth.

The bibliometric analysis revealed that the most prominent and most quoted articles cover technological fields (in particular, technology development and uptake, technological processes, technological effectiveness, etc.), but they were excluded from the systematic/more in-depth review since the focus of this article is not on covering technological processes or technology-related issues. Its aim is not to identify technical methods/solutions to improve technology, nor to identify the newest technologies/processes/methods specific to renewable energy/renewables. The finding of the bibliometric analysis revealed that the mounting amount of scholarly work in the "technology" block is an indication for policymakers to implement proper design for R&D&I policies and an adequate investment framework in systems based on renewable energy-specific technologies; however, it is not the aim of this article to provide insights related to the newest technological developments revealed in the existing recent literature.

Relevant articles and scholarly work were selected, mostly from WOS-indexed publications; the preference for WOS-indexed publications was in connection with the bibliometric analysis, the results of which are also integrated in this paper. The literature review covered the period from 2014/2015–6 August 2024, divided into two sub-periods: 2014/2015–2019 (prior to and after the adoption of the Sustainable Development Goals) and December 2019–6 August 2024 (after the adoption of the European Green Deal and the subsequent challenges of this period). We have considered that these two periods were essential for conceptualizing the renewable energy transition. The adoption of the Sustainable Development Goals (SDGs) [1], particularly SDG 7 "Ensure access to affordable, reliable, sustainable and modern energy for all", oriented the works of the scholars after 2015 towards energy transition and renewable energy (features, patterns, drivers, and implications). Similarly, attention on the renewable transition received a boost in the scholarly work after the adoption of the European Green Deal in December 2019 and its ambitious objective of transforming the European Union into the first climate-neutral economy by 2050 [2]. The period 2020–2024 has been particularly scrutinized in this paper to reflect the most recent scholarly work. In line with the bibliometric analysis, this period was of particular interest in conducting the literature review and the desk research due to the specific challenges, particularly the COVID-19 pandemic, the Russian invasion of Ukraine in February 2022, and accelerated climate degradation (manifested through severe weather phenomena), which have accelerated the phasing out of fossil energy and the implementation of a renewable-driven energy transition on grounds of sustainability, security, and resilience.

The focus on the 2019/2020–2024 period for selecting the scholarly literature is reasonable and duly justified for at least three main reasons. First, it was a period of disruptive changes: the COVID-19 pandemic, Russian aggression against Ukraine, and severe climate deterioration raised additional challenges, but also incentivized governments to speed up the renewable energy transition. Secondly, more ambitious targets for reducing greenhouse emissions and climate neutrality (and subsequent action plans were adopted with the European Union as a leader); the increased levels of ambition combined with fast technological advancements are likely to give a boost to the renewable energy transition and redesign the transition pathways and tools. Thirdly, rapid advancements in technology and other domains are altering the durability of the results of any scholarly work. Therefore, only recent and relevant scholarly works in the field of renewable energy transition were selected for analysis and their results could provide reliable and updated guidance for policy-making. It is important to mention that the earlier literature was considered, to a lesser extent, only for the purposes of following the evolution of renewable energy transition.

Moreover, bibliometric analysis, while a powerful tool for understanding research trends, has inherent limitations, particularly when applied to interdisciplinary research, such as in this article. One significant challenge lies in its inability to accurately capture the full spectrum of research activities. This limitation is exacerbated in interdisciplinary fields where research may be published in a variety of journals across different disciplines, making it difficult to comprehensively identify the relevant literature. As noted by Paez [74], bibliometric analysis often overlooks research published in non-traditional outlets, such as books, conference proceedings, and grey literature, which can significantly underestimate the scope of research in interdisciplinary areas.

Another limitation of bibliometric analysis is the potential for duplicate results. This occurs when the same research is published multiple times in different journals or under different titles. While some databases employ algorithms to detect and remove duplicates, these methods are not always perfect, leading to inflated citation counts and skewed results. As Haustein and Larivière [75] point out, duplicate publications can introduce bias into bibliometric analyses, particularly when assessing the impact of individual researchers or institutions. Therefore, in our paper, VOSviewer software was used to conduct the bibliometric analysis to avoid the use of duplicated publications. As stated in its manual [76], "If there are duplicate documents in the data provided as input to VOSviewer, the documents will automatically be deduplicated."

Furthermore, bibliometric analysis often relies on a limited set of exclusion criteria, which can hinder the accuracy of results. For instance, many databases exclude self-citations and co-citations, which can be particularly problematic in interdisciplinary research where collaborations are common. Additionally, bibliometric analysis may not adequately account for the quality of research, as citation counts alone do not necessarily reflect the significance or originality of a study. As various books and articles argue [77–80], bibliometric analysis should be complemented by other methods, such as expert review and content analysis, to provide a more comprehensive understanding of research trends. Therefore, our paper has extended the conducted research by in-depth desk research.

Finally, the authors of this paper have combined and triangulated the results of the research methods used with the aim of contributing to the existing knowledge by offering a holistic perspective on the dynamic landscape of energy transformation and transition, not only to highlight the prevalent trends and influential works but also to identify and select the relevant scholarly findings to shape the renewable energy transition and policy actions.

This paper contributes to the existing knowledge by proposing a descriptive model of the renewable energy transition as outlined by the scholarly literature (based on the analysis performed), the model of which provides valuable insight for a better understanding of the renewable energy transition to orient policy-making and policy actions.

4. Results

4.1. Renewable Energy Transition: Results of the Bibliometric Analysis

The central objective of the bibliometric analysis is to explore the intricate interconnections between "energy transition" and "renewable energy" in the last five years (2019–2024), namely from the publication of the document "Communication on the European Green Deal" (11 December 2019) until the present day (6 August 2024). Employing bibliometric techniques as a critical analytical tool, this research seeks to unravel the associations and relationships between these key concepts within the evolving landscape it encompasses.

An exhaustive keyword search was conducted utilizing the Social Sciences Citation Index (SSCI) database within the ISI—Web of Science platform from Clarivate Analytics to gather relevant data for this study. The selection of WoS, renowned for its reliability and comprehensive coverage, reinforces the credibility of this research. The search spanned multiple fields within the records, including titles, abstracts, author-assigned keywords, and Keywords Plus. Moreover, the search was focused on articles and reviews published between December 2019 and August 2024.

Applying these criteria generated a total of 12,259 articles. A thorough refinement process was undertaken to eliminate irrelevant data from the dataset. This process involved filtering for document type (either "article" or "review article") and language (English). As a result of this refinement, the dataset was reduced from 12,259 to 11,597 (based on Document type) and eventually to 11,456 (Based on Language). This led to the creation of a highly curated collection of 11,456 documents encompassing energy transition and renewable energy in their title, abstract, or keywords, covering the period from 2019 to 2024.

Based on data collection and a literature review [10,81], this study involves three types of analysis related to the relationship between "energy transition" and "renewable energy":

1. *Examining selected articles and reviews*, including their distribution by publication year and country, identifying leading journals, institutions, and authors, and categorizing papers based on the research field:

a. The temporal distribution of publications provides insights into the evolutionary trajectory of the field, shedding light on the emergence of novel research paradigms and the waning prominence of previously dominant areas of inquiry. Furthermore, the spatial distribution of publications offers an illuminating portrayal of the global reach of research in the realm of energy transition and renewable energy, signifying widespread international collaboration and the cross-fertilization of ideas within this domain.
b. The identification of leading journals establishes a benchmark for evaluating the quality and impact of research within a specific field. These renowned journals are recognized for disseminating significant contributions to the discipline, and their substantial publication output underscores their importance in scholarly discourse.
c. The acknowledgment of prominent institutions and authors highlights the key players in driving research in energy transition and renewable energy. These institutions and individuals have made substantial contributions to the field through their pioneering research and mentorship. Their prominence reflects their impact on advancing knowledge.
d. The process of categorizing papers by research fields has played a crucial role in enhancing our comprehension of the diverse themes present within the research domain. Through this categorization, we have been able to discern the multiple subfields within the broad topics of energy transition and renewable energy. Each of these subfields exhibits a distinct focus and research agenda, contributing to a comprehensive understanding of the complexities within these areas of study.

2. The significance of the selected papers was evaluated through a *quantitative analysis of their citation counts*. This assessment revealed a subset of papers that demonstrated markedly higher citation rates than others, signifying their profound impact within the scholarly literature under consideration. These papers, by virtue of their high citation rates, have emerged as influential works, thereby underscoring their substantial contributions to the academic domain and their enduring influence on current research pursuits. Furthermore, the citation patterns observed among these papers elucidate the interconnectedness of research topics and the evolutionary trajectory of the field. Through this analysis, key research domains, emergent trends, and distinguished scholars who have substantially shaped the field were identified.
3. The *in-depth analysis of keywords* encompassed their occurrence, link strength, and the creation of a keywords map, with a specific focus on the context of energy transition and renewable energy. This analysis unveiled the primary themes and subfields that dominate research concerning the research focus, demonstrating the evolving nature of the field as new keywords surfaced and existing keywords fluctuated in prominence over time. Furthermore, the keywords map provided a dynamic visualization of the thematic landscape, enabling the identification of clusters of interconnected keywords and the comprehension of the interrelatedness of various research areas. This visual representation facilitated a profound understanding of the interconnectedness between energy transition and renewable energy.

The research approaches outlined in this paper are specifically crafted to align with the article’s focus. They serve as the foundation for the upcoming data analysis and the discussion of findings in the sections that follow.

4.1.1. Examination of the Selected Articles and Reviews

The examination of publications on energy transition and renewable energy spanning from December 2019 to August 2024 has unveiled a consistent uptrend in published works. Although the number of published documents in 2024 is fewer than in 2023, it is important to note that the analysis only encompasses the initial eight months of the year. In 2023, the most significant number of publications occurred, with 3160 papers, constituting 27.58%

of the total 11,456 papers. The substantial increase in research activity within this domain signifies a heightened interest in these subjects (refer to Figure 1).

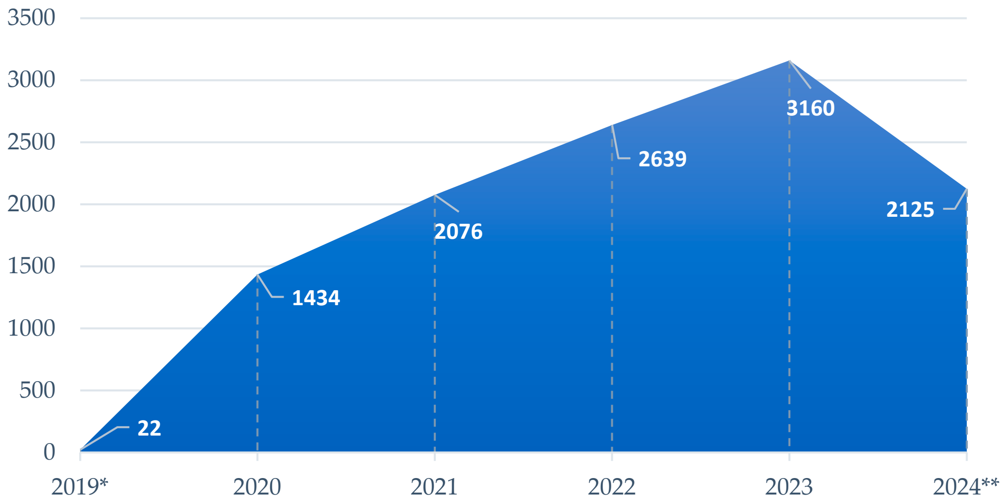

Figure 1. Number of research papers published annually (Notes: *—the publications for 2019 are from the 11th of December until the end of the year; **—the publications for 2024 are from the beginning of the year until the 6th of August). Source: Analysis developed by the authors using information extracted from WoS, 2024.

China is at the forefront of publications on energy transition and renewable energy sources with 2623 papers, followed by the United States of America with 1429 papers and Germany with 1032 papers. According to Figure 2, which shows the countries that have published articles and reviews on this subject, China, the United States of America, Germany, the United Kingdom, and Italy are the primary hubs of research in this field, accounting for 58.27% of the total papers.

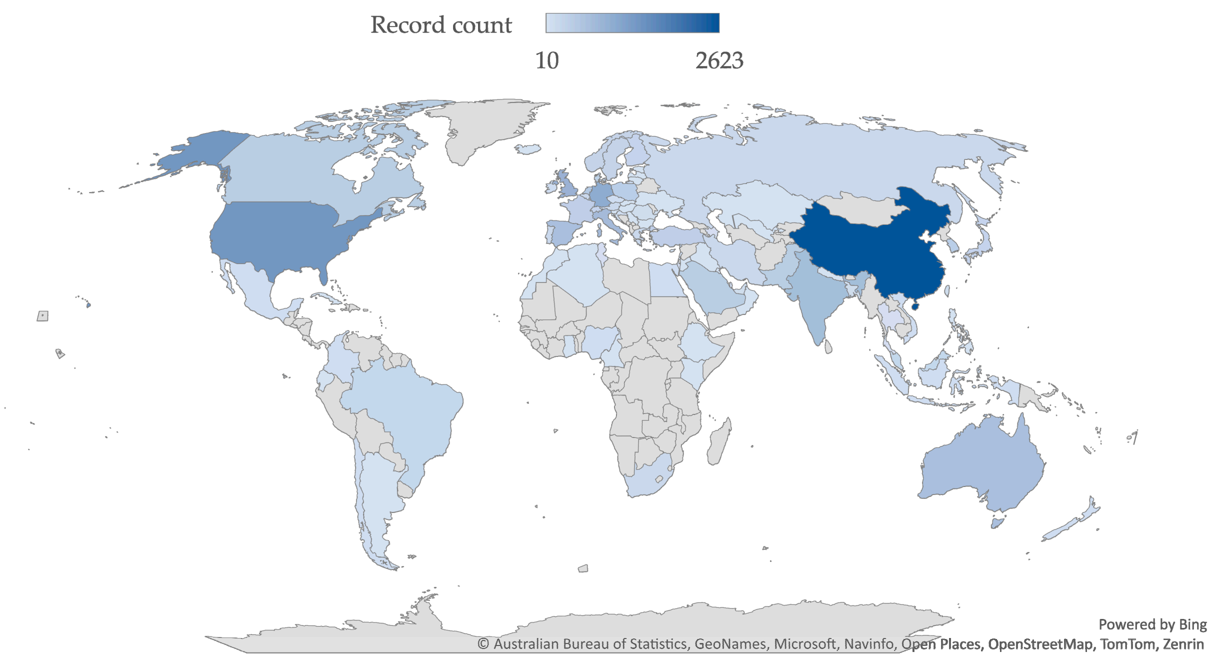

Figure 2. Geographical distribution of research papers based on authors' affiliations. Source: Analysis developed by the authors using information extracted from WoS, 2024.

Between December 2019 and August 2024, significant research on energy transition and renewable energy was published in 25 influential journals, as outlined in Table 2. These 25 journals contributed to 30.07% of the 11,456 articles and reviews analyzed in this study. Moreover, the 11,456 selected papers were published in a wide variety of 1728 journals that addressed the research's subject matter.

Table 2. Top 25 Most Productive Journals.

Publication	Record Count	% of 11,456
Energies	943	8.231
Sustainability	459	4.007
Energy Research Social Science	410	3.579
Renewable Sustainable Energy Reviews	363	3.169
Energy Policy	311	2.715
Energy	306	2.671
Journal of Cleaner Production	289	2.523
Applied Energy	285	2.488
Renewable Energy	272	2.374
International Journal of Hydrogen Energy	224	1.955
Environmental Science and Pollution Research	207	1.807
Energy Reports	149	1.301
Journal of Energy Storage	140	1.222
Energy Conversion and Management	118	1.030
Energy Economics	109	0.951
Resources Policy	101	0.882
Energy Strategy Reviews	95	0.829
Frontiers in Energy Research	91	0.794
Ieee Access	87	0.759
Environmental Innovation and Societal Transitions	67	0.585
Sustainable Energy Technologies and Assessments	67	0.585
Journal of Environmental Management	63	0.550
Heliyon	61	0.532
Energy for Sustainable Development	58	0.506
Energy Sustainability and Society	57	0.498

Source: Analysis developed by the authors using information extracted from WoS, 2024.

Table 3 presents the top 25 most prolific researchers in energy transition and renewable energy. These researchers are identified based on their published works from 34,212 authors who have contributed to this topic.

Table 3. The 25 Authors with the Highest Publication Output.

Authors	Record Count	% of 11,456
Breyer C	69	0.602
Murshed M	50	0.436
Liu Y	47	0.410
Wang Y	47	0.410
Wang L	39	0.340
Li Y	37	0.323
Zhang Y	34	0.297
Li J	32	0.279
Bogdanov D	30	0.262
Wang Q	30	0.262
Zhang H	30	0.262
Wang H	28	0.244
Kumar A	27	0.236
Zhou Y	27	0.236
Sovacool BK	26	0.227

Table 3. *Cont.*

Authors	Record Count	% of 11,456
Wang C	26	0.227
Streimikiene D	25	0.218
Aghahosseini A	24	0.209
Kim H	24	0.209
Zhang L	24	0.209
Zhang XY	24	0.209
Ali S	23	0.201
Liu X	23	0.201
Wang J	23	0.201
Zhang Q	23	0.201

Source: Analysis developed by the authors using information extracted from WoS, 2024.

According to Table 3, Breyer Christian from the Lappeenranta University of Technology has the most individual contributions to the topic under study, with a remarkable 69 publications on energy transition and renewable energy. Breyer's research has been highly influential, earning her a H-index of 62 and garnering over 12,452 citations. Closely following Breyer is another author, Murshed Muntasir, who has authored 50 articles on this field of research.

Figure 3 illustrates the wide variety of research fields (155) investigated in the publications that were analyzed, with the number of articles published in each field depicted. It is crucial to understand that one article can contribute to multiple research fields simultaneously, demonstrating the dynamic and interconnected nature of this expansive area of study.

Figure 3. The top 25 research domains with the highest number of published papers. Source: Analysis developed by the authors using information extracted from WoS, 2024.

The analysis of the 11,456 articles and reviews in this study revealed that "Energy Fuels", "Environmental Sciences", "Green Sustainable Science Technology", "Environmental Studies", and "Chemistry Physical" emerged as the top five research areas with the highest number of associated publications. "Energy Fuels" gained the most attention, with 4626 publications dedicated to this field. "Environmental Sciences" followed behind with less than half as many publications, namely 2235. "Green Sustainable Science Technology" occupied the third position with 2181 publications, highlighting the persistent focus on energy resources and their sustainable utilization. "Environmental Studies" solidified its position as a fundamental pillar of energy transition and innovation, amassing 1952 publications. "Chemistry Physical" drew attention in 953 publications.

4.1.2. Quantitative Analysis of the Citations

The next phase of this study focuses on evaluating the citation metrics of the selected 9920 articles within a specific timeframe. A further refinement of the article list was necessary as the WoS tools have limitations on analyzing citations for more than 10,000 works. Therefore, only articles were included in this part of the analysis. Table 4 presents the ten most influential scientific works on the intersection of energy transition and renewable energy, published between December 2019 and August 2024. This compilation offers valuable insights into the foundational knowledge that has influenced our understanding of this crucial intersection.

Table 4. Top 10 most cited articles and reviews.

Title of the Article	Authors	Publication Year	Total Citations December 2019–August 2024	Average Citations per Year
Materials for hydrogen-based energy storage—past, recent progress and future outlook	Hirscher, M., Yartys, V.A., Baricco, M., von Colbe, J.B., Blanchard, D., Bowman Jr, R.C., Broom, D.P., Buckley, C.E., Chang, F., Chen, P. and Cho, Y.W.	2020	527	105.4
Hydrogen in energy transition: A review	Kovač, A., Paranos, M. and Marciuš, D.	2021	492	123
Mechanism of Oxygen Evolution Catalyzed by Cobalt Oxyhydroxide: Cobalt Superoxide Species as a Key Intermediate and Dioxygen Release as a Rate-Determining Step	Moysiadou, A., Lee, S., Hsu, C.S., Chen, H.M. and Hu, X.	2020	486	97.2
A study on hydrogen, the clean energy of the future: Hydrogen storage methods	Tarhan, C. and Çil, M.A.	2021	454	113.5
Platinum single-atom catalyst coupled with transition metal/metal oxide heterostructure for accelerating alkaline hydrogen evolution reaction	Zhou, K.L., Wang, Z., Han, C.B., Ke, X., Wang, C., Jin, Y., Zhang, Q., Liu, J., Wang, H. and Yan, H.	2021	419	104.75
Engineering active sites on hierarchical transition bimetal oxides/sulfides heterostructure array enabling robust overall water splitting	Zhai, P., Zhang, Y., Wu, Y., Gao, J., Zhang, B., Cao, S., Zhang, Y., Li, Z., Sun, L. and Hou, J.	2020	418	83.6
Cooperative CO_2-to-ethanol conversion via enriched intermediates at molecule-metal catalyst interfaces	Li, F., Li, Y.C., Wang, Z., Li, J., Nam, D.H., Lum, Y., Luo, M., Wang, X., Ozden, A., Hung, S.F. and Chen, B.	2020	407	81.4
Highly selective electrocatalytic CO_2 reduction to ethanol by metallic clusters dynamically formed from atomically dispersed copper	Xu, H., Rebollar, D., He, H., Chong, L., Liu, Y., Liu, C., Sun, C.J., Li, T., Muntean, J.V., Winans, R.E. and Liu, D.J.	2020	403	80.6

Table 4. *Cont.*

Title of the Article	Authors	Publication Year	Total Citations December 2019–August 2024	Average Citations per Year
Direct evidence of boosted oxygen evolution over perovskite by enhanced lattice oxygen participation	Pan, Y., Xu, X., Zhong, Y., Ge, L., Chen, Y., Veder, J.P.M., Guan, D., O'Hayre, R., Li, M., Wang, G. and Wang, H.	2020	396	79.2
Efficient electrically powered CO_2-to-ethanol via suppression of deoxygenation	Wang, X., Wang, Z., García de Arquer, F.P., Dinh, C.T., Ozden, A., Li, Y.C., Nam, D.H., Li, J., Liu, Y.S., Wicks, J. and Chen, Z.	2020	375	75

Source: Analysis developed by the authors using information extracted from WoS, 2024.

The 9920 articles on energy transition and renewable energy published between December 2019 and August 2024 have received 132,139 citations, an average of 13.32 citations per year.

Table 4 provides a quantitative assessment of each article's scholarly impact, tracking the cumulative number of citations received since its publication until August 2024, focusing on the top 10 most influential publications. Notably, the highest number of citations, 527, belongs to the work "Materials for hydrogen-based energy storage—past, recent progress and future outlook" by Hirscher, M., Yartys, V.A., Baricco, M., von Colbe, J.B., Blanchard, D., Bowman Jr, R.C., Broom, D.P., Buckley, C.E., Chang, F., Chen, P. and Cho, Y.W. (2020). This indicates that this article has accumulated 105.4 citations annually since its publication.

4.1.3. In-Depth Analysis of Keywords

The final stage of this study involves conducting an extensive analysis of the keywords used in 11,456 scrutinized articles and review articles. This comprehensive assessment includes an examination of both the keywords provided by the authors and the "keywords plus" automatically extracted from the Web of Science database. Subsequently, these keywords were subjected to scrutiny using VOSviewer software, which generated a visual representation of the keyword distribution based on bibliographic data.

A database has been established to encompass data related to 11,456 chosen articles and reviews. These data include the author's name, article title, abstract, publication year, keywords, and other pertinent details. The information was sourced from the WoS database and integrated into VOSviewer software for subsequent analysis.

A total of 187,917 keywords were identified within the papers, articles, and reviews pertaining to globalization, sustainability, and the European energy sector. To refine the focus, we established a minimum occurrence threshold of 400, resulting in 134 keywords meeting the criteria for further analysis. The 80 most relevant keywords, representing 60% of the total, were utilized to generate the keyword map illustrated in Figure 4.

The analysis of keywords indicated a significant emphasis on terms related to "energy transition", such as "system" (3740 occurrences), "impact" (3151 occurrences), "challenge" (2778 occurrences), "process" (2531 occurrences), "policy" (2419 occurrences), "potential" (1555 occurrences), "scenario" (1548 occurrences), "government" (891 occurrences), and "policymaker" (647 occurrences). Additionally, the concept of "renewable energy source" was referenced 1980 times, and "sustainability" was mentioned 1086 times.

This comprehensive analysis offers valuable insights into the predominant themes and terminology found within the research on energy transition and renewable energy. It effectively underscores the numerous challenges inherent in this sector, particularly in relation to its ongoing development and transformative processes. Furthermore, it boldly underscores the pressing need for additional research and exploration in this particular domain.

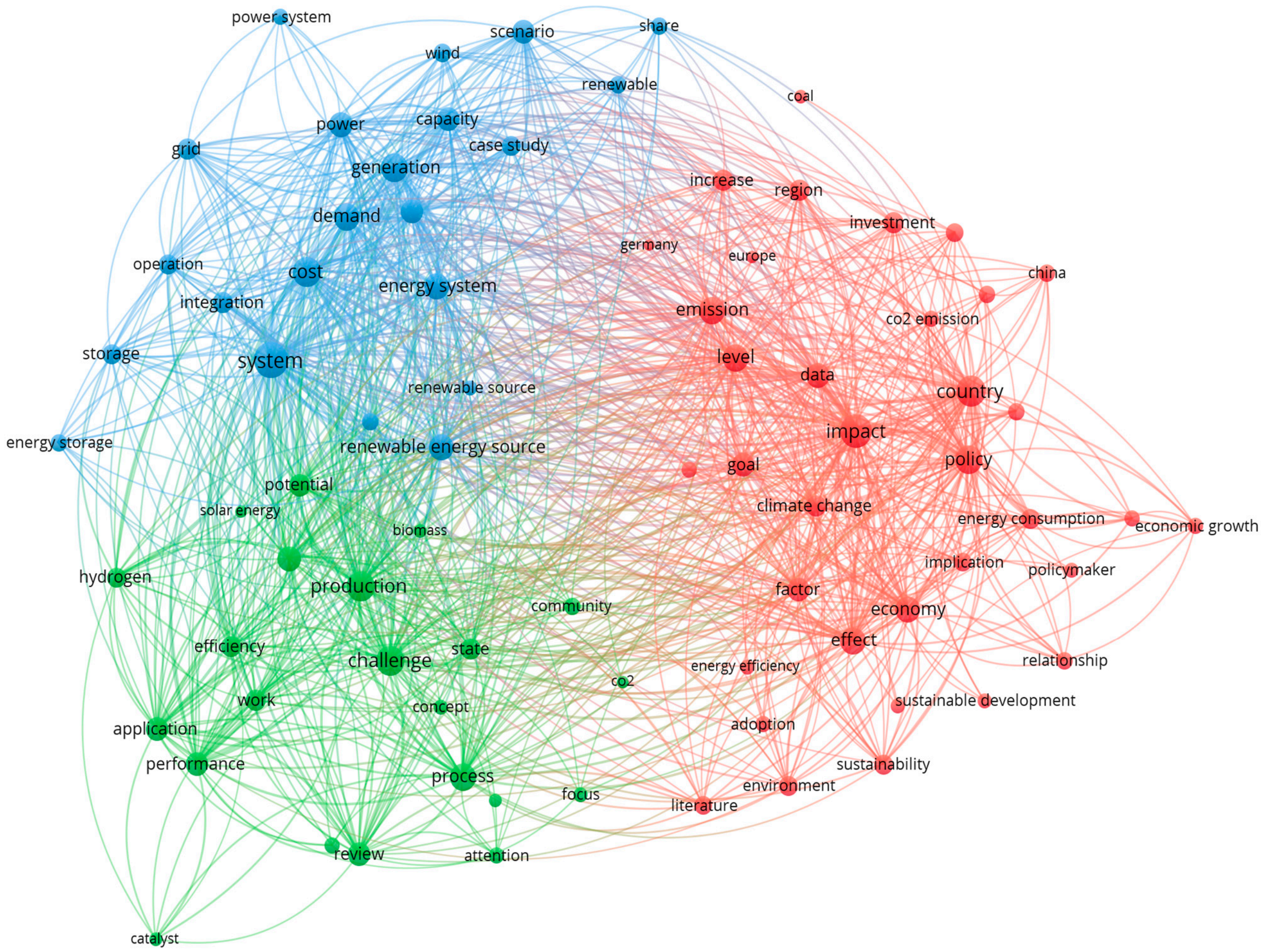

Figure 4. Graphical representation of the keywords used in the selected articles. Source: Analysis developed by the authors using information extracted from WoS, 2024.

The utilization of VOS clustering, a widely esteemed methodology employed by several researchers [62,82–85], was employed to represent keywords and visually categorize them into clusters. The VOS clustering algorithm constructs a map based on various factors, including node count, interconnections, total links, and overall link strength. The positioning and distances of the nodes on a two-dimensional map, achieved through a visualization technique, are determined by considering these factors. In Figure 4, the visualization map of the 80 representative keywords is presented, illustrating the application of the aforementioned principles.

The visualization in Figure 4 effectively depicts the thematic landscape resulting from the bibliometric analysis conducted using VOSviewer. This graphical representation, a keyword co-occurrence map, delineates three distinct clusters, each characterized by a unique color and emblematic of key research themes within the domain of energy transition and renewable energy:

- **Red Cluster** (*impact* focus)—The prominent red cluster, anchored by the term “impact” and comprising a substantial 36 nodes, underscores the central role of impact assessment in the broader context of energy transition and renewable energy research. This cluster signifies a concentrated research focus on understanding the multifaceted consequences of shifting energy systems and the integration of renewable energy sources. Key themes within this cluster encompass “energy efficiency” (598 occurrences), “policy” implications (2419 occurrences), and the economic effects (“economy”—1965 occurrences and “economic growth”—695 occurrences) of the transition. By delving into these areas, researchers aim to quantify the benefits, challenges, and trade-offs associated with different energy pathways. Ultimately, this cluster serves as a critical foundation for informing evidence-based policies and decision-making to accelerate the transition to a sustainable energy future.

- **Green Cluster** (*challenge* focus)—This cluster, centered around the concept of "challenge" and comprising 22 nodes, highlights the critical obstacles and complexities inherent in energy transition and renewable energy integration. This cluster underscores the research focus on identifying and addressing the developmental implications of these shifts within the broader context of global integration. Key themes within this cluster include the challenges of sustainable energy development ("challenge" appears 2778 times), the complex interplay between energy access and economic growth (various sources of energy are being linked together, such as "biomass"—536 occurrences, "hydrogen"—1232 occurrences, or "solar"—490 occurrences), and the broader geopolitical factors influencing energy transitions (connected with terms such as "potential"—used 1555 times and "performance"—used 1929 times). By examining these challenges, researchers aim to develop strategies and solutions for overcoming barriers to a just and equitable energy future.
- **Blue Cluster** (*system* focus)—This cluster, of equal size to the green cluster with 22 nodes, is centered around the concept of "system". This indicates a research focus on the interconnectedness and interdependencies within the energy landscape. It highlights the importance of examining individual country-level responses to the broader challenges and opportunities presented by energy transition and globalization. Key themes within this cluster include national energy policies ("power"—1726 occurrences, "capacity"—1597 occurrences, and "storage"—1090 occurrences), strategies for renewable energy integration ("scenario"—used 1548 times), and the impact of globalization on energy security at the country level ("grid"—1246 occurrences and "integration"—1173 occurrences). By analyzing these factors, researchers can identify best practices, challenges, and opportunities for different countries as they navigate the complex path toward a low-carbon future.

By examining the key terms within each cluster and how they relate to one another, we can identify the core research areas and their connections. This visual representation provides a foundation for more in-depth investigations.

Therefore, the keyword clusters identified in this analysis reveal a complex interplay of factors driving research on energy transition and renewable energy. The red cluster (*impact* focus), green cluster (*challenge* focus), and blue cluster (*system* focus) are interconnected, with each cluster influencing and informing the others. The red cluster highlights the importance of understanding the impacts of energy transition and renewable energy integration. These impacts, as captured by terms such as "energy efficiency", "policy", and "economy", are directly influenced by the green cluster's focus on challenges. For instance, the challenges of sustainable energy development, energy access, and geopolitical factors can significantly impact the economic and social outcomes of energy transition. Additionally, the blue cluster's emphasis on system-level factors, such as national policies and grid integration, is essential for effectively addressing the challenges and maximizing the benefits of renewable energy adoption.

Conversely, the green cluster is shaped by the insights gained from the red cluster and blue cluster. The red cluster's focus on impact helps to identify the specific challenges that need to be addressed to achieve the desired outcomes. The blue cluster's analysis of system-level factors provides a broader context for understanding the challenges and opportunities associated with energy transition.

In essence, the three clusters are interdependent, and a comprehensive understanding of energy transition requires a holistic perspective that considers the impacts, challenges, and system-level factors. By examining the interrelationships between these clusters, researchers can develop more effective strategies for navigating the complex path toward a sustainable and equitable energy future.

4.2. Mapping the Renewable Energy Transition: Systematic Scholarly Literature Review

As revealed by the bibliometric analysis, energy transition is a topic of enormous importance for scholars and covers a broad range of topics including technologies and processes, innovation, energy sources, system adaptation, energy efficiency, energy security and independence, and financing tools and models, as well as social, economic, social, environmental, and climate implications. Energy transition is of equal importance for policymakers and practitioners since the scholarly work explores ideas and potential solutions to address energy transition challenges.

The effectiveness of the policy in any area depends on the proper knowledge and understanding of that policy area. Therefore, the conceptualization, identification, and understanding of the specific features of the area/areas related to the policy are essential for assessing and anticipating the challenges and implications of various policy choices. A systematic review of the literature provides the conditions for an in-depth understanding of the transition to renewable energy, the identification of future trends, assessing the implications of various actions and evolutions, and exploring possible solutions to address the anticipated challenges. The systematic scholarly literature review provides valuable insights and guidance for policy-making and the scholarly results have the potential to provide directions and guidelines for effective policy action in the field of renewable energy transition.

4.2.1. Conceptualizing the Renewable Energy Transition

Energy transition refers to the shift from one dominant energy resource(s) to another, e.g., switching from low-efficiency energy sources towards high-efficiency ones [86], and describes the process by which the dominant resource/set of resources is initially challenged and then replaced by another energy source/mix of sources [87]. Energy transition is associated with changes in the nature and/or patterns of how energy is produced [88] and how it is used [89], the type of fuels [90] used as energy sources, and their related technologies [88].

The use of traditional fossil fuels and highly intensive carbon technology for energy generation has resulted in a persistent deterioration of the natural environment, largely due to harmful gas emissions. Furthermore, the continuously diminishing availability of fossil fuels and other non-renewable resources (due to their overexploitation in response to industrialization and economic growth, as well as increasing demands) has led to price increases. Consequently, energy transition has become an "absolute necessity" [91] that requires urgent action to phase out fossil fuels and utilize alternative solutions, such as renewable energy sources, that are greener and more affordable.

Following previous transitions [86,92,93] (from firewood to coal and from coal to oil), the current phase of energy transition is associated with the shift from carbon-based energy to a lower-carbon energy model [93] and is embedded into a substantial transformation at an unprecedented speed and on a global scale, which is required for meeting the energy net zero emissions aim by 2050 [17].

The current phase is mostly referred to as a "renewable energy transition" (RET), as it is characterized by a gradual shift from fossil fuel-based energy and from heavy reliance on fossil fuels to renewable sources (RES), as well as the sustainable use of RES across economies and societies [25,94]. Transition to renewable energy is a consistent and comprehensive transformation from substantial reliance on fossil fuels towards a more sustainable use of renewable energy sources, triggering profound socioeconomic transformations far beyond the scope of an industrial revolution [31] while mitigating the carbon-intensive economy that is driving climate change and severe environmental degradation [86,95].

Renewable energy transition consists of the ongoing seismic shifts across the energy value chain and fundamental changes in countries' energy mix [96] towards a cleaner, carbon-free energy system that is mostly based on renewable [86], clean, and sustainable energy sources [31], driving substantial transformations in the systems of energy generation, delivery, and consumption [93]. It involves the phasing out of fossil fuels [31,86] and increasing the share of renewable energy sources [86,93,97,98] and nuclear energy [93] as cleaner energy sources that have close to zero emissions, along with increasing energy efficiency [86,93].

Table 5 outlines the most relevant features and the explicit and implicit transformations induced by renewable energy transition.

Table 5. Specific features of renewable energy transition.

Features	Description
Speed of Transformation	Unlike earlier energy transitions (defined by a gradual reduction in the utilization of "last-generation" fuels in favor of alternative energy sources with superior technical and economic attributes), under the current renewable energy transition, there is a radical restructuring of energy systems, wherein a comprehensive array of green, renewable sources is supplanting carbon fuels and nuclear power at a pace estimated to be two or three times more rapid [93].
Type and complexity of transformations	Explicit transformations: type of energy sources (shifting from fossil fuels to renewable to renewables); transportation modes (from pipelines and energy channels to smart electricity grids); and spatial distribution (from uneven to a more balanced and decentralized/local model [86]). Implicit transformations: technology focus (energy technologies); energy management (shifting from monopoly and centralization of fossil fuels towards a distributed and intelligent approach and decentralized energy geographies) [86].
Decarbonization	Transitioning to a cleaner, carbon-free energy system that is mostly based on renewable energy [86]. The phasing out of fossil fuels [31,86] and increasing the share of renewable energy sources [86,93,97,98] as cleaner energy sources with close to zero emissions. Full global commitment to decarbonization, reduction of greenhouse emissions, and climate neutrality (as outlined in Section 2. Background of the research).
Advanced technologies	The fundamental premise is the implementation of technical policies that encompass pivotal engineering solutions, technical specifications, and organizational measures that are synchronized with the objectives of the energy transition [93]. Renewable energy transition is largely associated with and dependent on cutting-edge technology advances generated as part of Industry 4.0 [99].
Social focus and fairness	An inclusive and just energy transition to catalyze transformational co-benefits for the achievement of the SDG [16]. Renewable energy transition is based on fairness and equity [100], according to the principle that "nobody is left behind" [2]. Renewable energy transition is also possible due to the robust public demand for clean energy and domestic and industrial consumers are increasingly reluctant to accept a passive role with respect to energy consumption as the global low-carbon initiative expands [93,101,102].

Source: Prepared by authors based on the literature surveyed.

Renewable energy sources include wind power, solar power (thermal, photovoltaic, and concentrated), hydro power, ocean energy (tidal, wave, and thermal), geothermal energy, ambient heat captured by heat pumps, biofuels, and the renewable part of waste [103–105]. Interest in solar and wind power has seen significant growth in recent years, eclipsing bioenergy and hydropower in the research and scholarly literature [103], with a particular focus on processes and technologies (for power generation, storage, and distribution) to improve their efficiency. Renewable energy sources represent more than mere technical alternatives. They are driving significant transformation in the manner of energy production and consumption, reflecting a broader commitment to sustainability, environmental protection, and resilience [31] in line with increasing social awareness about environmental degradation [106] and mitigation of climate change.

Scholarly work was accompanied by policy decisions and important public investments in renewable energy that are considered, at a global scale, as key elements of existing scenarios to achieve the net zero emissions target [1,17] and climate neutrality ambition of the European Union [2]. The work of Breyer et al. [103] shows that due to their low cost, high efficiency, wide applicability, mature technologies, and vast access to renewable resources, renewable electricity and energy efficiency combined will play a dominant role in the energy transition. Ambitious targets of net zero emissions and climate neutrality are based on the assumption of a CO_2-free energy system. This signifies, in most countries, the prevalence of a renewable energy supply [103], including up to 100% renewable energy supply in at least one power sector, as is the case for 48 countries under COP 22 and 116 countries under COP 28 in 2023 [107], with a particular focus on solar and wind energy, or up to 100% in all energy sectors as is the case for Denmark [108].

The current phase of energy transition is associated with specific concepts of renewable energy, sustainable energy, and clean energy. It is common among scholars and practitioners to use "sustainable energy" and "renewable energy" as interchangeable concepts (renewable energy is less polluting and less harmful to the environment and climate and, therefore, it is considered clean and more sustainable); however, some differences may be observed [105]. "Renewable" energy refers to energy derived from natural sources that can be replenished at a rate that is greater than the rate of consumption [109], making these resources unlimited (since they regenerate naturally) and capable of satisfying manifest and increasing energy demand [105,110]. Renewable energy is considered "clean" energy since it has the capability of satisfying needs at affordable prices while reducing resource waste, decreasing the carbon footprint, and mitigating harmful emissions. Therefore, it promotes environmental sustainability [95,110,111] and sustains economic growth [112]. "Sustainable" energy is embedded into the broader concept of sustainable development and intergenerational solidarity, allowing the present energy needs to be satisfied for all without jeopardizing the ability of future generations to also meet their needs [1,2,113] by preserving the environment and the planet for future generations [105]. Sustainable energy is based on two pillars [114]: renewable energy (increased use to reduce dependence on fossil fuels to their complete replacement, which is also contributing to reduced environmental damage) and energy efficiency (to meet the increasing demand for energy which comes with economic growth). Therefore, energy efficiency is a critical part of the renewable energy transition, as it is essential to making better use of renewable energy to achieve sustainability and climate goals.

None of the energy transitions, RET included, have occurred solely as a result of technological advancements, instead evolving from a combination of factors including changes in market structures and resource availability; sociopolitical dynamics and public opinion, including changes in lifestyle, awareness, and economic capabilities; and geopolitical evolutions (as in the case of wars) and/or environmental crises that substantially altered government priorities and the availability of resources [31]. The potential of renewable energy sources was well-known by industries and governments, but technological advances (and incumbent cost reduction associated with these advances, particularly in the case of photovoltaic panels) proved insufficient for their large-scale adoption [31], which was rather influenced by an urgent global call to mitigate climate change [31,110,112,115] and accelerated by the COVID-19 pandemic [43] and Russian aggression in Ukraine, proving that dependence on fossil fuels from a few producers is seriously threatening energy security [43,44,112]. Recent crises and geopolitical challenges (the COVID-19 pandemic and subsequent energy crisis of 2021–2022 alongside the Russian invasion of Ukraine) have the potential to slow the progress being made towards sustainability and the subsequent goals of net zero emissions/carbon neutrality, prompting many countries to address the objective of energy security [44] and "energy independence" [112]. At the same time, these shocks represent an opportunity to challenge the status quo and to enact the requisite policy measures to foster more resilient and ecological energy transition pathways, which may facilitate decarbonization and climate neutrality [44,115]. Under these challenging evolutions, it is renewable energy that could deliver a remedy for imminent energy scarcity and dependence on fossil fuels and their suppliers [112]. Therefore, the transition to renewable energy is put at the core of policy action to mitigate negative consequences of energy vulnerabilities in various regions, as is the case for the European Union, and "energy security" and "energy independence" are embedded into the renewable energy transition's broader conceptual and policy frameworks. In addition, these shocks have positively impacted public opinion towards clean renewable energy [43], creating favorable conditions to speed up the energy transition to renewables.

Renewable energy transition, based on an increasing share of RES in the energy mix, also responds to social expectations of supplying adequate quantities of affordable energy without environmental degradation while meeting energy security requirements [91].

"Justice" or "fairness" are fundamental attributes of renewable energy transition and are embedded under the term of a "just transition". A just transition basically refers to "a fair and equitable transition from a carbon-based to a low-carbon economy" [100] (to address the specific needs of vulnerable communities, particularly low-income households and communities from carbon-dependent industries [2], which are most affected by the energy transition to achieve climate neutrality). The European Commission [2] refers to the just transition as the imperative that "nobody is left behind", which emphasizes the mandatory requirement of engaging with affected communities and ensuring that their voices are heard in the decision-making process [116]. Therefore, a just transition calls for functional and effective collaborative relationships between diverse stakeholders (including workers, trade unions, civil society organizations, and the government) [100] and for policy actions to create conditions, through training and further assistance, for workers transitioning from carbon-intensive industries and carbon-dependent regions [117] to participate in the emerging carbon-free/climate-neutral economy. The "just" attribute will contribute to higher social acceptance of the renewable energy transition [116,118].

The current ongoing energy transition consists of a gradual evolution in shifting from carbon-intensive fossil fuels to renewable sources alongside an evolution for more efficient energy solutions and technologies [119]. Energy efficiency is critical to deliver a just transition since it can help make renewable energy more affordable for consumers [114]. Technological advancement has resulted in the emergence of innovative technologies and a decline in the cost of renewable energy systems, but renewable energy solutions still remain expensive, leading, in the short and medium term, to a disproportionate impact on low-income communities, who are bearing the brunt of rising energy costs [114]. This could increase the risk of poverty for these vulnerable communities [120]. In the early phases of transition, renewable energy is not affordable for all, particularly for low-income households. This calls for energy efficiency measures (including incentives for technology advances to reduce the costs of renewable energy solutions) and financial support from the government (incentives for vulnerable groups to enable the faster adoption of renewable energy solutions) to ensure a just renewable energy transition.

4.2.2. Renewable Energy Transition: Implications and Challenges

Energy is essential for economic development and social progress [110]. Since the beginning of the 20th century, economic development has been fueled by energy from fossil resources that are supplied by a limited number of countries. This continuously increased the dependence of the entire world on these very few suppliers and their will for their energy needs, and the suppliers are not always reliable and have discretionary powers to control production and prices, as shown in the 1973 crisis [94,121]. This reliance is also challenging the security of dependent countries, as recently experienced by the European Union due to its dependence on Russia as a supplier of natural gas. In addition, the volatility of the prices for fossil fuels, together with the negative impact of harmful greenhouse emissions associated with the extraction, distribution, and use of fossil fuels [121], calls for more efficient and sustainable solutions. Renewable energy emerged as a solution to deliver self-sufficiency in energy production [94,103], which increases energy security and the independence of various economies at lower costs in terms of environmental and climate degradation [122]. It also provides the electricity necessary for economic development and improved living standards in rural and remote off-the-grid areas [94].

The focus on renewable energy is fully justified because of the benefits generated. Adoption of renewable energy has positive implications, particularly the reduction of greenhouse emissions, CO_2, and other harmful gases [106,123,124], the reduction of dependence on fossil fuels [106], increased energy security and independence, particularly for oil and gas, where the volatility of the markets remains high, and the diversification of energy supplies and the energy mix [123], as well as the development and growth of green industries and technologies which are accompanied by green job creation [86]. The utilization of renewable energy has the potential to provide an abundant and cost-effective energy source, ensuring the availability of energy for future use under environmental sustainability [110,125]. Renewable energy contributes to the alleviation of poverty and the diminishment of environmental damage [126,127], reducing dependence on non-renewable energy sources and promoting more sustainable economic growth [128]. Renewable energy "intersects with quality of life and socio-economic development" as energy access is critical to improving the development of vulnerable areas [31]. Renewable energy provides innovative decentralized and off-grid solutions for remote and isolated areas, contributing to the achievement of SDG 7 of ensuring access to affordable, reliable, and sustainable energy for all.

This encourages an increasing number of countries (with the EU as a leader) to commit to expanding their capacities for clean energy generation by increasing investment in renewable energy [129]. This has resulted in the formation of an engaging and comprehensive renewable energy transition pathway that appears to be irreversible. Renewable energy transition facilitates the design of more sustainable energy futures and delivers a wide array of pathways that point towards the achievement of socioeconomic, environmental, and governance goals [44]. Table 6 depicts relevant findings on the possible impacts of renewable energy and renewable energy transition.

Renewable energy transition is also a very challenging process.

The availability of RES differs across countries and their geographical variability [96] influences country-level and local specific energy transition pathways [105,130].

Table 6. Impacts of renewable energy and renewable energy transition.

Type	Impact	
Energy systems	Increased share of renewables in energy systems	"The fundamental structure of the global energy system can shift from conventional, low-efficient burning of extracted fuels towards almost pure exergy, which is electricity, generated from low-cost solar, wind, and other natural energy resources" [130].

Table 6. *Cont.*

Type		Impact
SDG/NZE targets, environment and biodiversity protection	Global GHG emissions to zero	"The results of the global transition towards a 100% renewable energy system indicate a steady decline in global GHG emissions to zero until 2050" (under the assumption of 98% renewables in global electricity generation in 2040) [130]. An increase in the proportion of renewable energy consumption contributes to the reduction in CO_2 emissions in Europe [131] and in toxic gases and environmental degradation in the USA [132]; modeling for the 1995–2015 period delivered similar results for 97 countries [133].
	Reducing environmental degradation	"Renewable energy is a promising tool for combating ecological degradation due to its clean and pollution-free nature [110] and still less harmful than fossil fuels [103] and it can be a viable means of meeting the energy needs of high-carbon countries, improving air quality and realizing the SD goals" and "more renewable energy usage can promote the levels of SD and lessen eco-logical degradation" [110].
	Negative impact on the environment and natural resources	Production of renewable energy consumes many natural resources [110], such as agricultural land for solar PV and wind farms [134], deforestation of tropical areas [103], rare metals (such as copper, zinc, nickel, lithium, and cobalt) for storage capacities [103,135], and wood and pulp (for biomass production) [136], and contributes to the deterioration of seawater quality [137] and soil [94], which is detrimental to biodiversity conservation.
Entrepreneurship and employment	Promoting entrepreneurship	"Energy transition can empower vulnerable groups with sustainable entrepreneurship (. . .) but is not always guaranteed" [44].
	(Green) Job creation	Expected job creation by 2050 in the energy sector (under the assumption of 100% electricity generation from RES): 34 mil. globally, 3.7 mil. in Europe, 2,7 mil. in North America, 1,7 mil. in South America, 3.2 mil. in Southeast Asia, and around 10 mil. in Northeast Asia (incl. China and Japan) [138]. Positive impact is not always guaranteed [44].
	Unemployment	Unemployment in fossil fuel-dependent industries and territories [2,116].
Poverty	Alleviating poverty	"Renewable energy tends to reduce the degree of environmental destruction caused by poverty in developing countries; since an increase in poverty leads to environmental degradation, the significant use and consumption of renewable energy can contribute to a decrease in the poverty rate and promote environmental sustainability" [139]. Renewable energy provides better access to energy and reduces energy poverty in Latin America [140]; photovoltaic systems improve households electricity access [141]; promoting renewable energy access contributes to poverty reduction [140–142]; and better access to renewable energy has a positive impact on reducing poverty in developing countries.

Source: Prepared by authors based on the scholarly literature.

It is important to note that variability is an inherent characteristic of renewable energy sources, particularly those derived from solar energy based on photovoltaic technology and wind power based on turbines. Solar and wind energy generation is dependent on external climate conditions (namely temperature, wind speed, fluctuations in intensity, and the availability of solar and wind resources throughout the year); therefore, solar- and wind-generated electricity fluctuates and cannot guarantee a constant supply (particularly during periods of high peak consumption). The capacity of existing electricity grids is challenged to uptake excess electricity or to secure reliability and stability of provision to end users. Thus, "intermittency"/discontinuity" is a defining attribute of these types of renewable energy [103,135,143]. Because of this distinctive feature of variability, photovoltaic solar and wind power plants require inverter-based technologies to connect them to the grid (to ensure reliability and stability of the energy systems based on these non-synchronous sources) [103] and interconnections between local/national electricity grids (to reduce variability over broader geographic areas and countries) [144]. The variability of renewable energy calls for measures and investments in energy storage solutions to meet the peak demand [94,103]. Therefore, scholarly work addressed the issue of storage technologies as a feasible solution to mitigate the intermittent nature of renewable energy [94,103,130,144–148]. Investments in renewable energy storage technologies and capacities integrated into the electricity grids have become an important part of the energy transition framework.

The variable nature of renewable energy sources brings additional challenges, as they are not a constant source of energy. (a) The deployment of storage solutions, use of new-generation inverters, and specific solutions for connecting RES-based power plants to existing grids [103,144] and (b) setting up new infrastructures for RES (for power generation, inverters, or storage solutions) require substantial initial capital [31,103] for investments and can make renewable energy more expensive [149].

The existing conventional energy infrastructure is challenged by the renewable energy transition. Renewable energy production, as is the case for solar, wind, and geothermal energy, is rather decentralized [31] and is localized according to the geographical availability of these renewable resources [94,103,135,144,145]. On the other hand, existing national grids are rather centralized. The customization and extension of the existing grids for connecting to and fully covering RES-abundant regions may increase the costs of renewable energy, meaning that more cost-effective solutions become necessary.

Renewable energy is facing fierce competition from the fossil fuels industry [31,150]. Fossil fuel resources are concentrated in a few countries which, in most cases, are cooperating in producers' alliances and cartels to control production and prices. Therefore, suppliers have the ability to manipulate the market by decreasing the prices of fossil fuels and making them a more attractive alternative to renewable energy sources [150]. Since RES technologies are still emergent and their large-scale deployment requires significant financing (for research and development, technological development, infrastructure development, and territorial coverage), and due to their decentralized and variability patterns, the renewable energy industry cannot equally compete with the fossil fuels industry. Thus, renewable energy still remains costly and less attractive than fossil fuels, which may slow the wide-scale uptake of RES. To address this challenge, governments are called to identify and implement inventive and effective financing solutions for the renewable energy sector.

Despite their potential for electricity generation, discontinuity associated with RES (particularly solar and wind power) requires the deployment of storage solutions. Existing storage solutions, of which batteries are the most common, and new types of inverters (used to connect solar and wind power plants to the electricity grid) require specific materials (such as copper, zinc, nickel, lithium, and cobalt) and could generate new dependencies [103,135]. Thus, the objectives of energy security and independence associated with the transition to renewable energy seem to be challenged by this new dependence on raw materials, which are essential for renewable energy storage. Domestic sourcing, as an alternative to avoid dependency, is limited [135] and subject to environmental risks (as production could require mining, which is detrimental to the soil and ecosystems), economic risks (higher costs induced by conformation to stricter environmental regulations or labor regulations), or due to the scarcity of materials [151].

Despite its contribution to reduced greenhouse emissions and sustainability [110], scholarly work is also tackling the renewable energy challenges to the environment, which policymakers should consider for policy choices and solutions to offset potential negative impacts. Although significantly less harmful as compared to fossil fuels, renewable energy generation consumes natural resources and could damage the environment and biodiversity [152]. Earlier works emphasize the detrimental impact of biofuel production on soils, forests, and agricultural land (which are decommissioned and converted into lands for energy crops) [134] and the additional CO_2 emissions and pollution generated by the production of ethanol (which requires large quantities of sugar cane) [112]. Photovoltaic farms for solar energy and wind farms are usually constructed on land previously used for agricultural purposes [153], effectively appropriating it for this purpose. More recent works reveal that large quantities of wood and pulp required for the production of biomass can cause soil contamination [136], while deterioration of the quality of marine waters and marine ecosystems and biodiversity is observed in the construction of tidal energy stations [137]. In addition, some renewable energy storage solutions could be very expensive and detrimental to the soil, as in the case of pumped hydro storage (PHS), which requires underground reservoirs and mining [94]. Hydropower may require the relocation of communities and deforestation and could have negative externalities on biodiversity and ecosystems. In addition, RES power plants may require steel and other carbon-intensive materials [103], which are detrimental to the environment and climate.

Social acceptance of RES [123] continues to remain a challenge. The initial high cost of installing individual capacities (such as photovoltaic panels or wind farms) for renewable energy generation (such as photovoltaic panels or wind farms) and storage, the variability of power generation induced by the variable nature of RES [31], combined with noise or landscape change, and low awareness or a lack of information could make end users and communities reluctant to adopt renewable energy solutions.

5. Discussion

The bibliometric analysis has revealed several significant insights, illuminating the intricate and dynamic nature of the interplay between energy transition and renewable energy. (1) The relationship between energy transition and renewable energy is intricate and interconnected, with profound implications for global energy security, sustainability, and economic development. (2) National policy frameworks play a crucial role in shaping the integration of energy markets, facilitating cross-border energy flows, and promoting renewable energy technologies to drive energy transition. (3) Ongoing challenges have a substantial impact on energy prices, the security of energy supply, and innovation in the energy transition. Countries must address these challenges while leveraging opportunities from successful global energy markets. (4) Achieving sustainable energy transition is an urgent global challenge, as evidenced by the extensive recent research in this field [7,92,154–159]. Addressing these challenges requires a comprehensive and integrated approach that harmonizes network integration, globalization, and technological advancements.

The comprehensive bibliometric analysis reveals critical implications for future research and policy concerning the intricate interactions between energy transition and renewable energy. (1) Further research is imperative to gain a comprehensive understanding of these interactions and inform strategic decision-making. (2) Policymakers are urged to meticulously consider the significant impact of transition on the energy sector and devise comprehensive strategies to address the attendant challenges and opportunities effectively. (3) Active engagement from industry stakeholders is essential in shaping the future of the energy sector, leveraging the opportunities presented by the transition and globalization while responsibly addressing associated challenges.

The bibliometric analysis of most cited papers reveals a clear focus of the recent literature on renewable energy technologies and solutions. Advancements in technologies and technical solutions are critical drivers for the adoption rates of renewable energy [25]. Since the initial costs of adopting new RES technologies remain high [25,44,110], incentives for investing in research and innovation to support the development and uptake of new technologies should be part of policy actions aiming to identify more efficient renewable energy solutions. Most of the research work on new renewable energy technologies seems to originate from China and the United States, which have patented their results. Taken together, these make up about 50% of global brevets and patents within the last decade [25], covering photovoltaics, solar cells, storage solutions, wind turbine design, and green hydrogen solutions.

The combined use of bibliometric analysis, a systematic scholarly literature review, and desk research revealed that the achievement of the global ambition of climate neutrality, as set up for 2050, requires a multi-decade stable and overarching policy framework for an effective and just energy transition. It is incumbent upon national policymakers to develop action plans and strategies that are driven by stakeholders, are socially inclusive, and commercially viable to maximize benefits and mitigate negative consequences. These should address concerns such as the elimination of fossil fuel subsidies and the promotion of renewable energy through viability gap funding [160]. Any effective policy design (a) should set up and enforce legally binding climate and energy transition targets and associated policies to advance energy transition and (b) should regulate, finance, and provide incentives to enhance the advantages of policy innovations pertaining to the energy transition and mitigate the adverse externalities associated with renewable energy sources [86]. It is important to mention that the role played by various forms of renewable energy (solar, wind, hydro, geothermal, and biomass) in the energy mix is crucial in steering the direction of the energy transition [31] and for policy choices at national and global levels. It is imperative that targets defined by governments are achievable, not limited to power systems alone (but should cover all energy users and producers), and should be supported by open, reliable, and accountable governance systems [160]. As suggested by Li et al. [161], policy design for renewable energy transitions should consider three key parameters for the effective promotion of RE: (a) renewal potential assessment, (b) infrastructure development, and (c) successful integration into the system.

Due to the complexity of the renewable energy transition, as revealed by bibliometric analysis and a scholarly literature review, policymakers are required to deploy integrative policies that combine financial, fiscal, and regulatory incentives with socio-economic reforms and the advancement of reliable technology, along with the creation of an enabling ecosystem to facilitate the market structure and acceptance necessary for the production, provision, and innovation of energy transition services and technologies [160]. For effective policy design, this requires proper mapping of energy transition enablers [118] and enabling conditions, critical investments and actions in key industries and areas, and the driving forces [17,162].

The Energy Technology Institute [118] identifies three key enablers of energy transition, namely (a) government regulation and policy; (b) technology performance and innovation; and (c) social acceptance.

Governments have the essential role of shaping the regulatory and policy framework for energy transition. Governments are responsible [17,94,118,162] for:

- Defining climate/energy ambition and targets and establishing adequate strategies, roadmaps, and plans to meet the targets while addressing multiple levels and groups (e.g., industries, regions and territories, producers, and end users/consumers);
- Setting up the legislative and regulatory mechanisms driving energy transition, including codes and standards (e.g., tradeable emission standards) and penalty schemes (such as taxes for pollution and carbon taxes);
- Promoting cross-sectoral coordination (covering strategy/policy/regulatory layers);
- Designing and implementing just transition planning and support mechanisms (particularly for the most affected categories and territories);
- Designing financial support schemes, including public direct funding (e.g., subsidies, grant schemes, tax reductions, and certificates), sustainable investment schemes, and effective schemes to mobilize private funding (e.g., low interest loans, blended finance, and guarantees).

The effectiveness of regulation and policy as an enabler of energy transition is critically dependent on the integrative cross-sectoral approach embedded in the multi-decade timeframe. The difficulty arises, in particular, from the political environment. The government is responsible for regulatory and policy design and implementation, but governments are subject to political swings and mandates with different ideologies and agenda transitions [17,118,162], which jeopardizes the requirement of long-term consistent actions specific to energy transition.

Technology performance and advances are a critical enabler of energy transition [17,94,103,118,162]. New and more performant technologies could support the large-scale use of energy from renewable resources to achieve net zero emissions and climate neutrality targets. As part of the energy transition, innovation can lead to the creation of new business models and new markets (as might be the case for net zero emissions materials, inverters, or renewable energy storage capacities). Policymakers should incentivize the uptake of performant technologies for a timely and effective energy transition.

Social acceptance of renewable energy and low-carbon solutions is important for energy transition. The large-scale adoption of renewable energy by end users depends on their awareness and understanding, as well as the perceived risks they associate with renewable energy. Renewable energy, as a decentralized energy solution, may require higher costs for the end-users adopting it, with individuals from poor and rural or remote areas being the most affected. Therefore, these individuals may be the most reluctant to take up renewable energy. Alongside the financial capacity to switch to renewables, the willingness of individuals and businesses to adopt alternative energy solutions should be explored and tackled by policymakers using specific measures to generate a behavioral change in favor of renewable energy [94,103,118,162].

Key policy actions are expected to target technology production and development, the deployment of available efficient energy solutions, and demand and recycling in key sectors and for target groups (such as vulnerable consumers and territories, SMEs, and producers).

In renewable energy transition policy frameworks, enabling conditions [162] should be considered, such as (a) international cooperation and fair competition; (b) infrastructure optimization (planning and development); and (c) accurate and efficient data tracking and monitoring.

The costs associated with energy transition remain high. Additionally, economic measures will be implemented to address concerns such as the elimination of fossil fuel subsidies and the promotion of renewable energy through viability gap funding [160]. Therefore, governments are called to implement inventive and effective financing solutions for the energy transition to renewables. Qadir et al. [94] provide policymakers with a synoptic picture of financing practices (in various countries), which are regrouped under the following areas: (a) tax and financial incentives (of which financial subsidies/loans are the most common); (b) R&D incentives (of which support for R&D activities is the most common); (c) market incentives (quotas and market regulation); (d) grid connection incentives (with feed-in tariffs and net virtual metering as the most common tools); and (e) incentives via regulation (green certificates, emissions certificates, and purchase power legislation). This scholarly work may serve as a source of inspiration for other governments seeking to identify inventive financing solutions for their renewable energy transition.

Since renewable energy transition is dependent on advanced technologies [118], many studies [31,94,103,105,125] emphasized the critical importance of publicly financing research, development, and innovation (R&D&I) for renewable energy. Public funding is required to overcome the existing financing gap and to develop renewable energy technologies. The financing gap is significant if we only consider the estimated budget of EUR 55 billion [163] for R&D&I in renewables for the achievement of the original EU 2023 targets of a 40% reduction in emissions relative to 1990. As revealed by scholars, technology is critical for a renewable energy transition. Therefore, public funding in R&D&I and for technology improvement contributes to lower costs for producing, storing, and using renewable energy and lowers the cost of RE while mitigating environmental and sustainability risks of using various types of RES [94,118]. Public funding should also be complemented by efforts from private investors and businesses [164] for faster and more ambitious results. Public funding in the renewable energy sector and technology may incentivize private investors to invest in renewable energy and technology due to expected higher returns on energy investments [94,103,160,164].

Diversification of financing mechanisms and supplementing financial resources to energy transition to overcome the high capital outlay for the achievement of RES targets are needed. Even in the ideal situation, where 100% renewable energy could be produced, investments in grids, connectors, and storage technologies will be needed to ensure a stable energy supply. Efforts to identify additional public resources and incentives and simplify access to finance are necessary to empower businesses to adopt renewable energy and encourage private investment.

One of the most significant challenges, as revealed by the bibliometric analysis and the literature review, is centered around the "system" node.

The discontinuity of power generation [135,143] makes renewable resources, particularly solar and wind energy, different from conventional, synchronously connected power plants [103]. Therefore, renewable resources are challenging the existing electricity that was originally designed for deployment in large-scale conventional power installation, generation, and transmission systems [103,165]. Existing power systems and conventional electricity grids are confronted with difficulties pertaining to the integration of renewable energy sources and they require modifications to accommodate a variety of decentralized and intermittent systems (a renewable energy supply and an increasing number of customers also acting as prosumers) [166]. Consequently, policy actions should address the energy systems' adaptability to ensure their capability to meet demand and overcome the unpredictable nature of renewable energy. Significant work and investments will be needed for the integration of decentralized renewable energy with centralized energy systems [167]. Proper policy actions are rooted in "ongoing planning that is grounded in robust data and stakeholders' input" [160].

For carbon-intensive sectors (such as heating, transportation, and heavy industries), renewable energy-based electrification could be a solution for the net zero emissions ambition [25]; however, implementing renewable energy-based electrification solutions for various industries calls for infrastructure upgrade and redesign. Thus, infrastructure becomes critical for policy actions, which should cover energy and power generation, storage capacities, and efficient energy transmission systems [25]. Innovation and intelligent solutions, such as digitization and smart grids, could be effective solutions to address the specific challenges of renewable energy [168]. Given the variability and decentralized nature of renewable energy production and distribution, policy actions targeting infrastructure and energy systems are essential to meet the commitment to sustainable energy transition. In particular, this includes the adaptation of existing national grids designed for centralized fossil fuel energy production to RES patterns [31] and increasing the capacity storage of renewable energy and connectors to the existing grid.

The interoperability of energy systems between nation states [168] is also critical for addressing fluctuations in renewable energy generation influenced by the availability of renewable sources (wind, solar, and biomass) at regional and national levels depending on seasonal factors, geographical position, and weather conditions. International collaboration between nation states is crucial to overcome the intermittency and limitations in the renewable energy resource endowments of countries [162], which depends on their climate and geographical positions, capital constraints, and technology.

The digitization of the energy sector offers opportunities but, at the same time, it can become a double-edged sword. On the one hand, the transition to digital energy promises unprecedented efficiency of renewable energy transition. On the other hand, it can mask major risks, such as data privacy concerns, potential cyber-attacks on energy infrastructures, and the digital divide, with vulnerable groups at risk of being left behind. This requires governments to act to develop measures to address challenges driven by the digitization of energy systems.

Increasing interest in renewable energy is empowered by increasing public awareness of RES and the rising cost of energy [91], as well as increasing concerns for environmental issues, triggering preferences for greener energy solutions [169] and positively influencing RES adoption rates. Therefore, this requires governments to act to strengthen this trend [123] by the use of financial incentives to make the cost of setting up RES infrastructures and technology more accessible for end consumers and businesses [94,121].

Renewable energy transition involves several phases of decarbonization, for which specific policy responses are required. Theoretical perspectives on transition phases are frequently the subject of studies on technological diffusion and sustainability transitions [117]. Building on the work of Nacke et al. [170], which is grounded in socio-technical systems theory, Cantoni [117] identifies the main policy areas for the decarbonization of carbon-dependent regions as (1) the phasing out of fossil fuels; (2) responses from firms and industries; and (3) regional strategies for socioeconomic recovery. In addition, building on the previous work of other researchers, Cantoni [117] identifies the main response actions to cope with challenges raised by renewable energy transition in carbon-dependent regions, namely (a) resistance strategies with the intention of preserving existing conditions and maintaining the status quo of fossil fuel economies or preventing perceived or anticipated inequalities associated with the development of renewable energy-based economies; (b) adaptation strategies to gradually shift from fossil fuel-based to renewable energy-based economies while maintaining existing power structures and the broader industrial context; and (c) transformative strategies seeking to deploy the reorganization of systems of production and consumption. Resistance is mostly specific to phase 1 and phase 2; it manifests itself in the form of protests from workers in carbon-intensive industries and its magnitude depends on factors such as economic diversification, industry tradition, the effectiveness of the lobby on renewables, the just transition measures to assist communities in the phasing out of fossil fuels, government credibility, and the energy mix [117]. Adaptative actions are implemented mostly in phase 2 (when incumbent fossil systems are in decline, yet the industry is attempting to maintain their viability and prevent destabilization), while transformative strategies are adopted in phase 2 and dominate phase 3 of the renewable energy transition as the new energy system and the low-carbon economy consolidate [117]. Several case studies in European coal-dependent regions revealed that government strategies and policy actions have different results, depending on the transition phase, the individual patterns of the communities and regions affected, the energy mix, and stakeholders' participation [117].

The review of the scholarly literature reveals that the achievement of a timely renewable energy transition requires the involvement of a number of key players (innovators, producers, aggregators, distributors, investors, and public and private financial institutions), who must engage in multistage collaboration with one another in the process of developing a modern, clean, and sustainable energy system [160]. Scholars emphasize the importance of enhanced cooperation between various stakeholders, particularly between policymakers, the industrial sector, and society (citizens, academia, and civil society representatives). They also call for further examination of alignments and misalignments between the local, regional, national, and transnational scales and their implications since distinct dynamics emerge at varying jurisdictional and geographical scales in line with RET phases [171].

As revealed by the literature review and public discourse, effective energy transition is critically dependent on stakeholders' cooperation, from all countries [162], as a key driver [17] to deliver an effective, smooth, inclusive, and just energy transition. The magnitude of the current energy transition calls for concerted actions and cooperation from stakeholders from all countries [162]. In order to have a clearer picture of the energy transition policy framework, it is necessary to identify the stakeholders as accurately as possible, an important step in addressing the complex challenges associated with the development of renewable energy in any region. This activity is necessary to ensure the fulfillment of the proposed goal of achieving a green economy in optimal conditions. Numerous scientific articles emphasize the need to map stakeholders, considering this action beneficial especially in strategic planning, risk identification and management, resource efficiency, conflict avoidance, promotion of transparency, etc. [172]. Stakeholder theory presents a large body of knowledge that focuses on considering the interests of different stakeholders simultaneously [173]. Stakeholders can be classified according to the literature into several categories: primary stakeholders, i.e., those who have control over resources, and secondary parties who do not have a direct, individual influence but need to take collective action to achieve change. In addition, in the field of energy transitions towards sustainability, generally due to the complexity of the decisions and the multitude of actors involved, it must be considered that the stakeholders may have district interests both favorable and unfavorable to the process (positive but also negative interests). As such, the degree of influence of each can be decisive in defining future strategies [174]. For a more complete renewable energy transition policy framing, it is important to track the attributes of citizens, as consumers/end users and consequently stakeholders in RET. Considering that public awareness is the direct result of citizens' perceptions of RET and continues to remain a challenge for RES adoption, citizen engagement in renewable energy transition is even more important. Successful energy transition will require a change of mindset in approaching the process [175].

Participatory approaches significantly involve all actors, multi-stakeholder coalitions, and public–private partnerships that contribute to shaping the desired energy future. The private sector must play a significant role in implementing the transition. Almost as important are citizens as co-producers, research institutions, and indigenous communities to become part of the energy system [162].

Due to the complexity of the renewable energy transition, effective policy actions should also integrate economic factors, such as the cost-effectiveness of renewable energy sources [25] and the accessibility, affordability, and social acceptance of renewable energy.

The ongoing influence of technology, economics, and markets on renewable energy choices worldwide is evident and this could also explain the increasing work of scholars on renewable energy transition (whose outcomes could support better policy-making); however, it is the actions of policymakers that will prove pivotal in effecting transformation within the global energy sector [130].

6. Conclusions

The bibliometric analysis and the scholarly literature review have provided valuable insights into the intricate dynamics that define the interaction between energy transition and renewable energy. This research significantly enhances our comprehension of the challenges, opportunities, and future pathways within the energy landscape by systematically examining prominent trends, emerging themes, and influential works. Such knowledge is critical for policymakers, scholars, and industry stakeholders working towards constructing a more sustainable, secure, and integrated energy system in an increasingly interconnected global context.

While acknowledging its limitations, it is important to note that this study draws data solely from the Web of Science, potentially excluding research published in other repositories or formats. This could result in the omission of pertinent papers that have not yet been indexed in this specific database and may impact the comprehensiveness and completeness of the scholarly work selected, potentially influencing the identification of influential works and leading trends. This limitation is considered as a starting point for future work for the authors who will integrate the literature from other databases. The use of broad keywords ("energy transition" and "renewable energy") led to an extensive body of literature from the WOS database, which is likely to make the systematic review of the relevant literature more difficult. Therefore, funnel-like techniques were deployed to address this limitation. Additionally, this study's usage of VOSviewer software limits its ability to integrate data from diverse databases for keyword analysis, serving as another constraint. Further work of the authors based on more sophisticated software will be considered.

Scholarly work exclusively rooted in technical fields (technology, techniques, and technical processes) was not considered in this paper, which limits the multidisciplinary and multidimensional ambition of this paper; thus, influential work on technological processes was not considered and cannot be used for setting up priorities and guidance for research and development and innovation policies, nor for financing policies and mechanisms.

The results of the bibliometric analysis performed by the authors revealed an impressive number of scholarly literature covering the topic of the energy transition towards renewables, despite the fact that the selection base was limited to WoS publications and to a narrow temporal frame (2019–2024).

Similar results were obtained by other studies [160] using multiple selection criteria, identifying 2169 relevant articles from the WoS and Scopus databases. In addition, bibliometric analysis confirmed the most prominent author (Breyer C. – the most cited author according to Table 3), whose work is likely to shape renewable energy policy. The most important focus of scholars (most cited articles and authors) [160] covered the "role of renewable energy in global energy transformation" and "energy governance", unlike our findings, which indicate a higher orientation towards challenges, implications, and system considerations.

Recent bibliometric analysis of articles from the Wos database [176] outlines the high interest of the scholars in renewable energy and its contribution to sustainability (2900 articles filtered), confirms China's domination over scholarly works on renewable energy's contribution to sustainability, and provides evidence that the academic literature has an important role in shaping and implementing environmental policies, emphasizing their influence on political and academic decisions related to renewable energy-based sustainability. A bibliometric analysis of the scholarly work of research institutes in Poland and Germany [177] indicates an increasing interest in "energy security" and "energy transformation" nodes in Poland, aligned with the countries' imperative need to transition from coal-based energy sources and tackle energy security concerns and an increasing interest in "prosumers" and "energy systems" nodes in Germany (as they represent relevant challenges that need to be addressed by tailored policies).

These findings reconfirm the necessity of the descriptive model of renewable energy transition to support and orient renewable energy policy-making. Despite its limitations, the insights of renewable energy transition, a multifaceted process, delivered by our study can serve as a valuable source of information for policymakers, scholars, and stakeholders.

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References

1. United Nations. *Resolution Adopted by the General Assembly on 25 September 2015: Transforming Our World: The 2030 Agenda for Sustainable Development*; United Nations: New York, NY, USA, 2015.
2. European Commission. *Communication from the Commission to the European Parliament, the European Council, the Council, the European Economic and Social Committee and the Committee of the Regions: The European Green Deal*; European Commission: Brussels, Belgium, 2019.
3. European University Association. *Energy Transition and the Future of Energy Research, Innovation and Education: An Action Agenda for European Universities Others Achieve*; European University Association: Brussels, Belgium, 2017.

4. Abdulai, A.-R.; Chireh, V.K.; Tchoukaleyska, R. Engaging Diverse Audiences: The Role of Community Radio in Rural Climate Change Knowledge Translation. *J. Community Engagem. Scholarsh.* **2021**, *13*, 8. [CrossRef]
5. Kraskes, J. *Universities and the Doughnut Strategy: Comparative Analysis of University Strategies and the in-Tegration of Planetary and Social Boundaries and the General Concept of Sustainable Development*; Linköping University: Linköping, Sweden, 2022.
6. Kranz, J.; Schwichow, M.; Breitenmoser, P.; Niebert, K. The (Un) Political Perspective on Climate Change in Education—A Systematic Review. *Sustainability* **2022**, *14*, 4194. [CrossRef]
7. Popescu, M.-F.; Constantin, M.; Chiripuci, B.C. Transition to a Sustainable Energy Production and Consumption Model—Mapping the Pat-Terns of Success. *J. Bus. Econ. Manag.* **2022**, *23*, 915–936. [CrossRef]
8. Voicu-Dorobanțu, R.; Volintiru, C.; Popescu, M.-F.; Nerău, V.; Ștefan, G. Tackling Complexity of the Just Transition in the EU: Evidence from Romania. *Energies* **2021**, *14*, 1509. [CrossRef]
9. Popescu, M.-F.; Hurduzeu, G. Energy Challenges for Europe—Scenarios of the Importance of Natural Gas Prices from a Game Theory Perspective. *J. Game Theory* **2015**, *4*, 26–35. [CrossRef]
10. Castillo-Vergara, M.; Alvarez-Marin, A.; Placencio-Hidalgo, D. A Bibliometric Analysis of Creativity in the Field of Business Economics. *J. Bus. Res.* **2018**, *85*, 1–9. [CrossRef]
11. Xu, Z.; Wang, X.; Wang, X.; Skare, M. A Comprehensive Bibliometric Analysis of Entrepreneurship and Crisis Literature Published from 1984 to 2020. *J. Bus. Res.* **2021**, *135*, 304–318. [CrossRef]
12. Casprini, E.; Dabic, M.; Kotlar, J.; Pucci, T. A Bibliometric Analysis of Family Firm Internationalization Research: Current Themes, Theoretical Roots, and Ways Forward. *Int. Bus. Rev.* **2020**, *29*, 101715. [CrossRef]
13. Modak, N.M.; Lobos, V.; Merigó, J.M.; Gabrys, B.; Lee, J.H. Forty Years of Computers & Chemical Engineering: A Bibliometric Analysis. *Comput. Chem. Eng.* **2020**, *141*, 106978. [CrossRef]
14. Xie, Y.; Li, X.; Hu, X.; Hu, X. The Landscape of Academic Articles in Environmental Footprint Family Research: A Bibliometric Analysis during 1996–2018. *Ecol. Indic.* **2020**, *118*, 106733. [CrossRef]
15. Guedes, G.B.; Paganin, L.B.Z.; Borsato, M. Bibliometric and Systemic Analysis on Material Flow Mapping and Industrial Ecosystems. *J. Ind. Integr. Manag.* **2018**, *3*, 1850001. [CrossRef]
16. United Nations. *Global Roadmap for Accelerated SDG7 Action in Support of the 2030 Agenda for Sustainable Development and the Paris Agreement on Climate Change*; United Nations: New York, NY, USA, 2021.
17. International Energy Agency. *Achieving Net Zero Heavy Industry Sectors in G7 Members*; OECD Publishing: Paris, France, 2022.
18. Fragkos, P.; Laura Van Soest, H.; Schaeffer, R.; Reedman, L.; Köberle, A.C.; Macaluso, N.; Evangelopoulou, S.; De Vita, A.; Sha, F.; Qimin, C.; et al. Energy System Transitions and Low-Carbon Pathways in Australia, Brazil, Canada, China, EU-28, India, Indonesia, Japan, Republic of Korea, Russia and the United States. *Energy* **2021**, *216*, 119385. [CrossRef]
19. International Energy Agency. *Africa Energy Outlook 2022*; International Energy Agency: Paris, France, 2023.
20. United Nations. *Framework Convention on Climate Change (UNFCCC) 2023 NDC Synthesis Report*; United Nations: New York, NY, USA, 2023.
21. International Energy Agency. *World Energy Investment Outlook 2024*; International Energy Agency: Paris, France, 2024.
22. International Energy Agency. *Southeast Asia Energy Outlook 2022*; International Energy Agency: Paris, France, 2022.
23. Arestis, P.; Sawyer, M.C. Arestis, P.; Sawyer, M.C. A Green New Deal: Opportunities and Constraints. In *Economic Policies for Sustainability and Resilience*; International Papers in Political Economy; Palgrave Macmillan: Cham, Switzerland, 2022; pp. 269–317. ISBN 978-3-030-84288-8.
24. Siddi, M. The European Green Deal: Assessing Its Current State and Future Implementation. In *Finnish Institute of International Affairs Working Paper*; FIIA: Helsinki, Finland, 2020.
25. Gajdzik, B.; Nagaj, R.; Wolniak, R.; Bałaga, D.; Žuromskaitė, B.; Grebski, W.W. Renewable Energy Share in European Industry: Analysis and Extrapolation of Trends in EU Countries. *Energies* **2024**, *17*, 2476. [CrossRef]
26. European Council. *Fit for 55*; European Council: Brussels, Belgium, 2021.
27. European Commission. The European Green Deal Striving to Be the First Climate-Neutral Continent. Available online: https://commission.europa.eu/strategy-and-policy/priorities-2019-2024/european-green-deal_en (accessed on 12 September 2024).
28. López González, D.M.; Garcia Rendon, J. Opportunities and Challenges of Mainstreaming Distributed Energy Resources towards the Transition to More Efficient and Resilient Energy Markets. *Renew. Sustain. Energy Rev.* **2022**, *157*, 112018. [CrossRef]
29. European Commission. 2050 Long-Term Strategy—European Commission. Available online: https://climate.ec.europa.eu/eu-action/climate-strategies-targets/2050-long-term-strategy_en (accessed on 12 September 2024).
30. European Commission. *Directive (EU) 2023/1791 of the European Parliament and of the Council of 13 September 2023 on Energy Efficiency and Amending Regulation (EU) 2023/955 (Recast) (Text with EEA Relevance)*; European Commission: Brussels, Belgium, 2023.
31. Hassan, Q.; Viktor, P.J.; Al-Musawi, T.; Mahmood Ali, B.; Algburi, S.; Alzoubi, H.M.; Khudhair Al-Jiboory, A.; Zuhair Sameen, A.; Salman, H.M.; Jaszczur, M. The Renewable Energy Role in the Global Energy Transformations. *Renew. Energy Focus* **2024**, *48*, 100545. [CrossRef]
32. European Commission. Energy and the Green Deal. Available online: https://commission.europa.eu/strategy-and-policy/priorities-2019-2024/european-green-deal/energy-and-green-deal_en (accessed on 12 September 2024).
33. Panarello, D.; Gatto, A. Decarbonising Europe—EU Citizens' Perception of Renewable Energy Transition amidst the European Green Deal. *Energy Policy* **2023**, *172*, 113272. [CrossRef]
34. International Energy Agency. *Latin America Energy Outlook 2023*; International Energy Agency: Paris, France, 2023.

35. United Nations Development Programme; African Union Commission; United Nations Economic Commission for Africa; African Development Bank. *2023 Africa Sustainable Development Report—Accelerating the Recovery from the Coronavirus Disease (COVID-19) and the Full Implementation of the 2030 Agenda for Sustainable Development and African Union Agenda 2063 at All Levels*; United Nations: Geneva, Switzerland, 2023.
36. African Energy Chamber. *The State of African Energy 2024 Outlook Report*; African Energy Chamber: Johannesburg, South Africa, 2024.
37. African Union. Agenda 2063: The Africa We Want. Available online: https://au.int/agenda2063/overview (accessed on 15 September 2024).
38. Chaturvedi, V.; Malyan, A. *Implications of a Net-Zero Target for India's Sectoral Energy Transitions and Climate Policy*; Council on Energy, Environment and Water: New Delhi, India, 2021.
39. International Renewable Energy Agency. *Renewable Energy Outlook for ASEAN: Towards a Regional Energy Transition*, 2nd ed.; International Renewable Energy Agency: Abu Dhabi, United Arab Emirates, 2022.
40. Do, T.N. Insider Perspectives on Southeast Asia's Clean Energy Transition. *Asia Pac. Policy Stud.* **2024**, *11*, e390. [CrossRef]
41. Radovanović, M.; Filipović, S.; Andrejević Panić, A. Sustainable Energy Transition in Central Asia: Status and Challenges. *Energy Sustain. Soc.* **2021**, *11*, 49. [CrossRef]
42. Economic Commission for Latin America and the Caribbean. *The Challenge of Accelerating the 2030 Agenda in Latin America and the Caribbean: Transitions towards Sustainability*; Economic Commission for Latin America and the Caribbean: Santiago, Chile, 2024.
43. Zakeri, B.; Paulavets, K.; Barreto-Gomez, L.; Echeverri, L.G.; Pachauri, S.; Boza-Kiss, B.; Zimm, C.; Rogelj, J.; Creutzig, F.; Ürge-Vorsatz, D.; et al. Pandemic, War, and Global Energy Transitions. *Energies* **2022**, *15*, 6114. [CrossRef]
44. Gatto, A. The Energy Futures We Want: A Research and Policy Agenda for Energy Transitions. *Energy Res. Soc. Sci.* **2022**, *89*, 102639. [CrossRef]
45. Rousseau, R.; Egghe, L.; Guns, R. *Becoming Metric-Wise: A Bibliometric Guide for Researchers*; Chandos Publishing, an Imprint of Elsevier: Cambridge, MA, USA, 2018; ISBN 978-0-08-102474-4.
46. Abramo, G.; D'Angelo, C.A. Evaluating Research: From Informed Peer Review to Bibliometrics. *Scientometrics* **2011**, *87*, 499–514. [CrossRef]
47. Mann, G.S.; Mimno, D.; McCallum, A. Bibliometric Impact Measures Leveraging Topic Analysis. In Proceedings of the 6th ACM/IEEE-CS Joint Conference on Digital Libraries, Chapel Hill, NC, USA, 11–15 June 2006; ACM: Chapel Hill, NC, USA, 2006; pp. 65–74.
48. Ellegaard, O. The Application of Bibliometric Analysis: Disciplinary and User Aspects. *Scientometrics* **2018**, *116*, 181–202. [CrossRef]
49. Durieux, V.; Gevenois, P.A. Bibliometric Indicators: Quality Measurements of Scientific Publication. *Radiology* **2010**, *255*, 342–351. [CrossRef]
50. Romanelli, J.P.; Gonçalves, M.C.P.; De Abreu Pestana, L.F.; Soares, J.A.H.; Boschi, R.S.; Andrade, D.F. Four Challenges When Conducting Bibliometric Reviews and How to Deal with Them. *Environ. Sci. Pollut. Res.* **2021**, *28*, 60448–60458. [CrossRef] [PubMed]
51. Szomszor, M.; Adams, J.; Fry, R.; Gebert, C.; Pendlebury, D.A.; Potter, R.W.K.; Rogers, G. Interpreting Bibliometric Data. *Front. Res. Metr. Anal.* **2021**, *5*, 628703. [CrossRef] [PubMed]
52. Parida, V.; George, N.M.; Wincent, J. Strategic Diagnosis of Information Processing Structures and Commercialization in New Ventures. *J. Bus. Res.* **2018**, *85*, 83–90. [CrossRef]
53. Rey-Martí, A.; Ribeiro-Soriano, D.; Palacios-Marqués, D. A Bibliometric Analysis of Social Entrepreneurship. *J. Bus. Res.* **2016**, *69*, 1651–1655. [CrossRef]
54. Gingras, Y. *Bibliometrics and Research Evaluation: Uses and Abuses*; MIT Press: Cambridge, MA, USA, 2016; ISBN 978-0-262-33766-3.
55. Haustein, S.; Larivière, V. The Use of Bibliometrics for Assessing Research: Possibilities, Limitations and Adverse Effects. In *Incentives and Performance: Governance of Research Organizations*; Welpe, I.M., Wollersheim, J., Ringelhan, S., Osterloh, M., Eds.; Springer International Publishing: Cham, Switzerland, 2015; pp. 121–139. ISBN 978-3-319-09785-5.
56. Merigó, J.M.; Mas-Tur, A.; Roig-Tierno, N.; Ribeiro-Soriano, D. A Bibliometric Overview of the Journal of Business Research between 1973 and 2014. *J. Bus. Res.* **2015**, *68*, 2645–2653. [CrossRef]
57. Mourao, P.R.; Martinho, V.D. Forest Entrepreneurship: A Bibliometric Analysis and a Discussion about the Co-Authorship Networks of an Emerging Scientific Field. *J. Clean. Prod.* **2020**, *256*, 120413. [CrossRef]
58. Costa, D.F.; Carvalho, F.D.M.; Moreira, B.C.D.M. Behavioral Economics and Behavioral Finance: A Bibliometric Analysis of the Scientific Fields. *J. Econ. Surv.* **2019**, *33*, 3–24. [CrossRef]
59. Si, H.; Shi, J.; Tang, D.; Wen, S.; Miao, W.; Duan, K. Application of the Theory of Planned Behavior in Environmental Science: A Comprehensive Bibliometric Analysis. *Int. J. Environ. Res. Public Health* **2019**, *16*, 2788. [CrossRef] [PubMed]
60. Gläser, J.; Laudel, G. A Bibliometric Reconstruction of Research Trails for Qualitative Investigations of Scientific Innovations. *Hist. Soc. Res.* **2015**, *40*, 299330. [CrossRef]
61. Waltman, L.; van Eck, N.J. A New Methodology for Constructing a Publication-Level Classification System of Science. *J. Am. Soc. Inf. Sci. Technol.* **2012**, *63*, 2378–2392. [CrossRef]
62. van Eck, N.J.; Waltman, L. Software Survey: VOSviewer, a Computer Program for Bibliometric Mapping. *Scientometrics* **2010**, *84*, 523–538. [CrossRef] [PubMed]

63. Qiang, Y.; Tao, X.; Gou, X.; Lang, Z.; Liu, H. Towards a Bibliometric Mapping of Network Public Opinion Studies. *Information* **2022**, *13*, 17. [CrossRef]
64. Smyrnova-Trybulska, E.; Morze, N.; Kuzminska, O.; Kommers, P. Mapping and Visualization: Selected Examples of International Research Networks. *J. Inf. Commun. Ethics Soc.* **2018**, *16*, 381–400. [CrossRef]
65. Jeong, D.; Cho, K.; Park, S.; Hong, S. Effects of Knowledge Diffusion on International Joint Research and Science Convergence: Multiple Case Studies in the Fields of Lithium-Ion Battery, Fuel Cell and Wind Power. *Technol. Forecast. Soc. Chang.* **2016**, *108*, 15–27. [CrossRef]
66. Alkhammash, R. Bibliometric, Network, and Thematic Mapping Analyses of Metaphor and Discourse in COVID-19 Publications from 2020 to 2022. *Front. Psychol.* **2023**, *13*, 1062943. [CrossRef]
67. Cardona, G.; Sanz, J.P. Publication Analysis of the Contact Lens Field: What Are the Current Topics of Interest? *J. Optom.* **2015**, *8*, 33–39. [CrossRef]
68. Orduña-Malea, E.; Costas, R. Link-Based Approach to Study Scientific Software Usage: The Case of VOSviewer. *Scientometrics* **2021**, *126*, 8153–8186. [CrossRef]
69. Bascur, J.P.; Verberne, S.; van Eck, N.J.; Waltman, L. Browsing Citation Clusters for Academic Literature Search: A Simulation Study with Systematic Reviews. In Proceedings of the 10th International Workshop on Bibliometric-Enhanced Information Retrieval, Lisbon, Portugal, 14 April 2020; Volume 2591, pp. 53–65.
70. Liberati, A. The PRISMA Statement for Reporting Systematic Reviews and Meta-Analyses of Studies That Evaluate Health Care Interventions: Explanation and Elaboration. *Ann. Intern. Med.* **2009**, *151*, W-65–W-94. [CrossRef] [PubMed]
71. Snyder, H. Literature Review as a Research Methodology: An Overview and Guidelines. *J. Bus. Res.* **2019**, *104*, 333–339. [CrossRef]
72. Davis, J.; Mengersen, K.; Bennett, S.; Mazerolle, L. Viewing Systematic Reviews and Meta-Analysis in Social Research through Different Lenses. *SpringerPlus* **2014**, *3*, 511. [CrossRef]
73. Moher, D. Preferred Reporting Items for Systematic Reviews and Meta-Analyses: The PRISMA Statement. *Ann. Intern. Med.* **2009**, *151*, 264. [CrossRef] [PubMed]
74. Paez, A. Gray Literature: An Important Resource in Systematic Reviews. *J. Evid.-Based Med.* **2017**, *10*, 233–240. [CrossRef] [PubMed]
75. van Raan, A. Measuring Science: Basic Principles and Application of Advanced Bibliometrics. In *Springer Handbook of Science and Technology Indicators*; Glänzel, W., Moed, H.F., Schmoch, U., Thelwall, M., Eds.; Springer Handbooks: Cham, Switzerland, 2019; pp. 121–139. [CrossRef]
76. van Eck, N.J.; Waltman, L. *VOSviewer Manual*; 2019; pp. 1–53. Available online: https://www.vosviewer.com/documentation/Manual_VOSviewer_1.6.13.pdf (accessed on 30 August 2024).
77. Wang, Q.; Su, M. Integrating Blockchain Technology into the Energy Sector—From Theory of Blockchain to Research and Application of Energy Blockchain. *Comput. Sci. Rev.* **2020**, *37*, 100275. [CrossRef]
78. Koskinen, J.; Isohanni, M.; Paajala, H.; Jääskeläinen, E.; Nieminen, P.; Koponen, H.; Tienari, P.; Miettunen, J. How to Use Bibliometric Methods in Evaluation of Scientific Research? An Example from Finnish Schizophrenia Research. *Nord. J. Psychiatry* **2008**, *62*, 136–143. [CrossRef]
79. Alsolbi, I.; Wu, M.; Zhang, Y.; Joshi, S.; Sharma, M.; Tafavogh, S.; Sinha, A.; Prasad, M. Different Approaches of Bibliometric Analysis for Data Analytics Applications in Non-Profit Organisations. *J. Smart Environ. Green Comput.* **2022**, *2*, 90–104. [CrossRef]
80. Matorevhu, A. Bibliometrics: Application Opportunities and Limitations. In *Bibliometrics—An Essential Methodological Tool for Research Projects*; IntechOpen: London, UK, 2024.
81. Popescu, M.-F. The Link Between Innovation, Digitalization and the Energy Sector. *A Bibliometric Analysis. J. Emerg. Trends Mark. Manag.* **2020**, *1*, 306–318.
82. Li, J.; Goerlandt, F.; Reniers, G. An Overview of Scientometric Mapping for the Safety Science Community: Methods, Tools, and Framework. *Saf. Sci.* **2021**, *134*, 105093. [CrossRef]
83. Pan, X.; Yan, E.; Cui, M.; Hua, W. Examining the Usage, Citation, and Diffusion Patterns of Bibliometric Mapping Software: A Comparative Study of Three Tools. *J. Informetr.* **2018**, *12*, 481–493. [CrossRef]
84. Waltman, L.; Van Eck, N.J.; Noyons, E.C.M. A Unified Approach to Mapping and Clustering of Bibliometric Networks. *J. Informetr.* **2010**, *4*, 629–635. [CrossRef]
85. van Eck, N.J.; Waltman, L. VOS: A New Method for Visualizing Similarities Between Objects. In Proceedings of the Advances in Data Analysis, Berlin, Germany, 8–10 March 2006; Springer: Berlin/Heidelberg, Germany, 2007; pp. 299–306.
86. Yang, Y.; Xia, S.; Huang, P.; Qian, J. Energy Transition: Connotations, Mechanisms and Effects. *Energy Strategy Rev.* **2024**, *52*, 101320. [CrossRef]
87. Melosi, M. Energy Transitions in Historical Perspective. In *The Energy Reader*; Nader, L., Ed.; Wiley-Blackwell: Chichester, UK; Malden, MA, USA, 2010; ISBN 978-1-4051-9983-4.
88. Miller, C.A.; Richter, J.; O'Leary, J. Socio-Energy Systems Design: A Policy Framework for Energy Transitions. *Energy Res. Soc. Sci.* **2015**, *6*, 29–40. [CrossRef]
89. Araújo, K. The Emerging Field of Energy Transitions: Progress, Challenges, and Opportunities. *Energy Res. Soc. Sci.* **2014**, *1*, 112–121. [CrossRef]
90. Hirsh, R.F.; Jones, C.F. History's Contributions to Energy Research and Policy. *Energy Res. Soc. Sci.* **2014**, *1*, 106–111. [CrossRef]

91. Chomać-Pierzecka, E.; Sobczak, A.; Urbańczyk, E. RES Market Development and Public Awareness of the Economic and Environmental Dimension of the Energy Transformation in Poland and Lithuania. *Energies* **2022**, *15*, 5461. [CrossRef]
92. Solomon, B.; Krishna, K. The Coming Sustainable Energy Transition: History, Strategies, and Outlook. *Energy Policy* **2011**, *39*, 7422–7431. [CrossRef]
93. Gitelman, L.D.; Kozhevnikov, M.V. New Approaches to the Concept of Energy Transition in the Times of Energy Crisis. *Sustainability* **2023**, *15*, 5167. [CrossRef]
94. Qadir, S.A.; Al-Motairi, H.; Tahir, F.; Al-Fagih, L. Incentives and Strategies for Financing the Renewable Energy Transition: A Review. *Energy Rep.* **2021**, *7*, 3590–3606. [CrossRef]
95. Nandimandalam, H.; Gude, V.G.; Marufuzzaman, M. Environmental Impact Assessment of Biomass Supported Electricity Generation for Sustainable Rural Energy Systems—A Case Study of Grenada County, Mississippi, USA. *Sci. Total Environ.* **2022**, *802*, 149716. [CrossRef] [PubMed]
96. World Energy Council. Global Energy. Available online: https://www.kearney.com/industry/metals-mining/energy-transition (accessed on 30 June 2024).
97. TWI. What Is Energy Transition? (Definition, Benefits and Challenges). Available online: https://www.twi-global.com/technical-knowledge/faqs/energy-transition.aspx (accessed on 13 September 2024).
98. Huang, P.; Liu, Y. Toward Just Energy Transitions in Authoritarian Regimes: Indirect Participation and Adaptive Governance. *J. Environ. Plan. Manag.* **2021**, *64*, 1–21. [CrossRef]
99. Zvarikova, K.; Rowland, M.; Krulicky, T. Sustainable Industry 4.0 Wireless Networks, Smart Factory Performance, and Cognitive Automation in Cyber-Physical System-Based Manufacturing. *J. Self-Gov. Manag. Econ.* **2021**, *9*, 7. [CrossRef]
100. Silveira, A.; Pritchard, P. *Justice in the Transition to a Low Carbon Economy*; Cambridge Institute for Sustainability Leadership: Cambridge, UK, 2016.
101. Lupu, I.; Hurduzeu, G.; Lupu, R.; Popescu, M.-F.; Gavrilescu, C. Drivers for Renewable Energy Consumption in European Union Countries. A Panel Data Insight. *Amfiteatru Econ.* **2023**, *25*, 380. [CrossRef]
102. Chiripuci, B.; Popescu, M.-F.; Constantin, M. The European Consumers' Preferences for Organic Food in the Context of the European Green Deal. *Amfiteatru Econ* **2022**, *24*, 361. [CrossRef]
103. Breyer, C.; Khalili, S.; Bogdanov, D.; Ram, M.; Oyewo, A.S.; Aghahosseini, A.; Gulagi, A.; Solomon, A.A.; Keiner, D.; Lopez, G.; et al. On the History and Future of 100% Renewable Energy Systems Research. *IEEE Access* **2022**, *10*, 78176–78218. [CrossRef]
104. Eurostat. Renewables Take the Lead in Power Generation in 2023. Available online: https://ec.europa.eu/eurostat/web/products-eurostat-news/w/ddn-20240627-1 (accessed on 13 September 2024).
105. Zioło, M.; Bąk, I.; Spoz, A. Sustainable Energy Sources and Financial Development Nexus—Perspective of European Union Countries in 2013–2021. *Energies* **2024**, *17*, 3332. [CrossRef]
106. Relich, M. Renewable Energy in the European Union: The State of the Art and Directions of Development. *Wseas Trans. Bus. Econ.* **2024**, *21*, 630–637. [CrossRef]
107. United Nations. *Climate Change Conference (COP28) Global Renewables and Energy Efficiency Pledge*; United Nations: New York, NY, USA, 2023.
108. International Energy Agency. *Energy Policies of IEA Countries: Denmark 2023 Review*; IEA: Paris, France, 2023.
109. United Nations. What Is Renewable Energy? Available online: https://www.un.org/en/climatechange/what-is-renewable-energy (accessed on 13 September 2024).
110. Liu, F.; Su, C.W.; Qin, M.; Umar, M. Is Renewable Energy a Path towards Sustainable Development? *Sustain. Dev.* **2023**, *31*, 3869–3880. [CrossRef]
111. Atems, B.; Mette, J.; Lin, G.; Madraki, G. Estimating and Forecasting the Impact of Nonrenewable Energy Prices on US Renewable Energy Consumption. *Energy Policy* **2023**, *173*, 113374. [CrossRef]
112. Azarpour, A.; Mohammadzadeh, O.; Rezaei, N.; Zendehboudi, S. Current Status and Future Prospects of Renewable and Sustainable Energy in North America: Progress and Challenges. *Energy Convers. Manag.* **2022**, *269*, 115945. [CrossRef]
113. Brundtland Commission. *Our Common Future*; Oxford University Press: Oxford, UK; New York, NY, USA, 1987; ISBN 978-0-19-282080-8.
114. Halawa, E. Sustainable Energy: Concept and Definition in the Context of the Energy Transition—A Critical Review. *Sustainability* **2024**, *16*, 1523. [CrossRef]
115. Pianta, S.; Brutschin, E.; Van Ruijven, B.; Bosetti, V. Faster or Slower Decarbonization? Policymaker and Stakeholder Expectations on the Effect of the COVID-19 Pandemic on the Global Energy Transition. *Energy Res. Soc. Sci.* **2021**, *76*, 102025. [CrossRef]
116. Wang, X.; Lo, K. Just Transition: A Conceptual Review. *Energy Res. Soc. Sci.* **2021**, *82*, 102291. [CrossRef]
117. Cantoni, R.; Claire Brisbois, M. En Route to Decarbonization: A Periodisation of Just Transition in Four Carbon-Intensive EU Regions. *Geoforum* **2024**, *154*, 104061. [CrossRef]
118. Debarre, R.; de Kleijn, M.; Forrest, R.; Ledanois, N. A Pragmatic Approach to Selecting Technologies for a Successful Energy Transition—Energy Transition Institute—Kearney. Available online: https://www.energy-transition-institute.com/article/a-pragmatic-approach-to-selecting-technologies-for-a-successful-energy-transition (accessed on 13 September 2024).
119. Sinha, A.; Bekiros, S.; Hussain, N.; Nguyen, D.K.; Khan, S.A. How Social Imbalance and Governance Quality Shape Policy Directives for Energy Transition in the OECD Countries? *Energy Econ.* **2023**, *120*, 106642. [CrossRef]

120. IPCC. *Climate Change and Land: An IPCC Special Report on Climate Change, Desertification, Land Degradation, Sustainable Land Management, Food Security, and Greenhouse Gas Fluxes in Terrestrial Ecosystems*; IPCC: Geneva, Switzerland, 2019.
121. Xiangchengzhen, M.; Yilmaz, S. Renewable Energy Cooperation in Northeast Asia: Incentives, Mechanisms and Challenges. *Energy Strategy Rev.* **2020**, *29*, 100468. [CrossRef]
122. Wang, K.-H.; Su, C.-W.; Umar, M.; Peculea, A.D. Oil Prices and the Green Bond Market: Evidence from Time-Varying and Quantile-Varying Aspects. *Borsa Istanb. Rev.* **2023**, *23*, 516–526. [CrossRef]
123. Dębicka, A.; Olejniczak, K.; Radomski, B.; Kurz, D.; Poddubiecki, D. Renewable Energy Investments in Poland: Goals, Socio-Economic Benefits, and Development Directions. *Energies* **2024**, *17*, 2374. [CrossRef]
124. Eweade, B.S.; Akadiri, A.C.; Olusoga, K.O.; Bamidele, R.O. The Symbiotic Effects of Energy Consumption, Globalization, and Combustible Renewables and Waste on Ecological Footprint in the United Kingdom. *Nat. Resour. Forum* **2024**, *48*, 274–291. [CrossRef]
125. Zhou, M.; Li, X. Influence of Green Finance and Renewable Energy Resources over the Sustainable Development Goal of Clean Energy in China. *Resour. Policy* **2022**, *78*, 102816. [CrossRef]
126. Derouez, F.; Ifa, A.; Al Shammre, A. Energy Transition and Poverty Alleviation in Light of Environmental and Economic Challenges: A Comparative Study in China and the European Union Region. *Sustainability* **2024**, *16*, 4468. [CrossRef]
127. Liang, T.; Zhang, Y.-J.; Qiang, W. Does Technological Innovation Benefit Energy Firms' Environmental Performance? The Moderating Effect of Government Subsidies and Media Coverage. *Technol. Forecast. Soc. Chang.* **2022**, *180*, 121728. [CrossRef]
128. Marques, A.C.; Fuinhas, J.A.; Pereira, D.A. Have Fossil Fuels Been Substituted by Renewables? An Empirical Assessment for 10 European Countries. *Energy Policy* **2018**, *116*, 257–265. [CrossRef]
129. Guo, Y.; Yu, C.; Zhang, H.; Cheng, H. Asymmetric between Oil Prices and Renewable Energy Consumption in the G7 Countries. *Energy* **2021**, *226*, 120319. [CrossRef]
130. Bogdanov, D.; Ram, M.; Aghahosseini, A.; Gulagi, A.; Oyewo, A.S.; Child, M.; Caldera, U.; Sadovskaia, K.; Farfan, J.; De Souza Noel Simas Barbosa, L.; et al. Low-Cost Renewable Electricity as the Key Driver of the Global Energy Transition towards Sustainability. *Energy* **2021**, *227*, 120467. [CrossRef]
131. Grodzicki, T.; Jankiewicz, M. The Impact of Renewable Energy and Urbanization on CO2 Emissions in Europe—Spatio-Temporal Approach. *Environ. Dev.* **2022**, *44*, 100755. [CrossRef]
132. Jeon, H. CO_2 Emissions, Renewable Energy and Economic Growth in the US. *Electr. J.* **2022**, *35*, 107170. [CrossRef]
133. Chen, C.; Pinar, M.; Stengos, T. Renewable Energy and CO2 Emissions: New Evidence with the Panel Threshold Model. *Renew. Energy* **2022**, *194*, 117–128. [CrossRef]
134. Abbasi, T.; Abbasi, S.A. Is the Use of Renewable Energy Sources an Answer to the Problems of Global Warming and Pollution? *Crit. Rev. Environ. Sci. Technol.* **2012**, *42*, 99–154. [CrossRef]
135. Andersen, E.V.; Shan, Y.; Bruckner, B.; Černý, M.; Hidiroglu, K.; Hubacek, K. The Vulnerability of Shifting towards a Greener World: The Impact of the EU's Green Transition on Material Demand. *Sustain. Horiz.* **2024**, *10*, 100087. [CrossRef]
136. Yuan, X.; Su, C.-W.; Umar, M.; Shao, X.; Lobonţ, O.-R. The Race to Zero Emissions: Can Renewable Energy Be the Path to Carbon Neutrality? *J. Environ. Manag.* **2022**, *308*, 114648. [CrossRef] [PubMed]
137. Hannan, M.A.; Al-Shetwi, A.Q.; Ker, P.J.; Begum, R.A.; Mansor, M.; Rahman, S.A.; Dong, Z.Y.; Tiong, S.K.; Mahlia, T.M.I.; Muttaqi, K.M. Impact of Renewable Energy Utilization and Artificial Intelligence in Achieving Sustainable Development Goals. *Energy Rep.* **2021**, *7*, 5359–5373. [CrossRef]
138. Ram, M.; Aghahosseini, A.; Breyer, C. Job Creation during the Global Energy Transition towards 100% Renewable Power System by 2050. *Technol. Forecast. Soc. Chang.* **2020**, *151*, 119682. [CrossRef]
139. Diallo, A.; Moussa, R.K. The Effects of Solar Home System on Welfare in Off-Grid Areas: Evidence from Côte d'Ivoire. *Energy* **2020**, *194*, 116835. [CrossRef]
140. Castro-Cárdenas, C.; Ibarra-Yunez, A. Understanding the Link between Energy Poverty and Economic Growth in Latin America. *Contad. Y Adm.* **2023**, *68*, 388. [CrossRef]
141. Lu, S.; Zhou, J.; Ren, J. Alleviating Energy Poverty through Renewable Energy Technology: An Investigation Using a Best-Worst Method-Based Quality Function Deployment Approach with Interval-Valued Intuitionistic Fuzzy Numbers. *Int. J. Energy Res.* **2023**, *2023*, 8358799. [CrossRef]
142. Narine, K.; Mahabir, J.; Koylass, N.; Samaroo, N.; Singh-Gryzbon, S.; Baboolal, A.; Guo, M.; Ward, K. Climate Smart Process Design for Current and Future Methanol Production. *J. CO2 Util.* **2021**, *44*, 101399. [CrossRef]
143. Halkos, G.E.; Aslanidis, P.-S.C. Green Energy Pathways Towards Carbon Neutrality. *Environ. Resour. Econ.* **2024**, *87*, 1473–1496. [CrossRef]
144. Child, M.; Kemfert, C.; Bogdanov, D.; Breyer, C. Flexible Electricity Generation, Grid Exchange and Storage for the Transition to a 100% Renewable Energy System in Europe. *Renew. Energy* **2019**, *139*, 80–101. [CrossRef]
145. Pilz, M.; Al-Fagih, L. A Dynamic Game Approach for Demand-Side Management: Scheduling Energy Storage with Forecasting Errors. *Dyn. Games Appl.* **2020**, *10*, 897–929. [CrossRef]
146. Parra, D.; Swierczynski, M.; Stroe, D.I.; Norman, S.A.; Abdon, A.; Worlitschek, J.; O'Doherty, T.; Rodrigues, L.; Gillott, M.; Zhang, X.; et al. An Interdisciplinary Review of Energy Storage for Communities: Challenges and Perspectives. *Renew. Sustain. Energy Rev.* **2017**, *79*, 730–749. [CrossRef]

147. Gallo, A.B.; Simões-Moreira, J.R.; Costa, H.K.M.; Santos, M.M.; Moutinho Dos Santos, E. Energy Storage in the Energy Transition Context: A Technology Review. *Renew. Sustain. Energy Rev.* **2016**, *65*, 800–822. [CrossRef]
148. Yao, L.; Yang, B.; Cui, H.; Zhuang, J.; Ye, J.; Xue, J. Challenges and Progresses of Energy Storage Technology and Its Application in Power Systems. J. Mod. Power Syst. *Clean Energy* **2016**, *4*, 519–528. [CrossRef]
149. Jacobson, M.Z. The Cost of Grid Stability with 100% Clean, Renewable Energy for All Purposes When Countries Are Isolated versus Interconnected. *Renew. Energy* **2021**, *179*, 1065–1075. [CrossRef]
150. Hoicka, C.E.; Lowitzsch, J.; Brisbois, M.C.; Kumar, A.; Ramirez Camargo, L. Implementing a Just Renewable Energy Transition: Policy Advice for Transposing the New European Rules for Renewable Energy Communities. *Energy Policy* **2021**, *156*, 112435. [CrossRef]
151. Braide, B. The Advantages and Disadvantages of Local and Global Sourcing. *Medium* **2021**. Available online: https://medium.com/@bomabraide/the-advantages-and-disadvantages-of-local-and-global-sourcing-135fd109f550. (accessed on 10 August 2024).
152. Al-Shetwi, A.Q. Sustainable Development of Renewable Energy Integrated Power Sector: Trends, Environmental Impacts, and Recent Challenges. *Sci. Total Environ.* **2022**, *822*, 153645. [CrossRef]
153. Argenti, N.; Knight, D.M. Sun, Wind, and the Rebirth of Extractive Economies: Renewable Energy Investment and Metanarratives of Crisis in Greece. *J. R. Anthropol. Inst.* **2015**, *21*, 781–802. [CrossRef]
154. Adelekan, O.A.; Ilugbusi, B.S.; Adisa, O.; Obi, O.C.; Awonuga, K.F.; Asuzu, O.F.; Ndubuisi, N.L. Energy Transition Policies: A Global Review Of Shifts towards Renewable Sources. *Eng. Sci. Technol. J.* **2024**, *5*, 272–287. [CrossRef]
155. Buonomano, A.; Barone, G.; Forzano, C. Latest Advancements and Challenges of Technologies and Methods for Accelerating the Sustainable Energy Transition. *Energy Rep.* **2023**, *9*, 3343–3355. [CrossRef]
156. Kabeyi, M.J.B.; Olanrewaju, O.A. Sustainable Energy Transition for Renewable and Low Carbon Grid Electricity Generation and Supply. *Front. Energy Res.* **2022**, *9*, 743114. [CrossRef]
157. Tovar-Facio, J.; Martín, M.; Ponce-Ortega, J.M. Sustainable Energy Transition: Modeling and Optimization. *Curr. Opin. Chem. Eng.* **2021**, *31*, 100661. [CrossRef]
158. Chen, B.; Xiong, R.; Li, H.; Sun, Q.; Yang, J. Pathways for Sustainable Energy Transition. *J. Clean. Prod.* **2019**, *228*, 1564–1571. [CrossRef]
159. Laurence, D. *Accelerating Sustainable Energy Transition (s) in Developing Countries: The Challenges of Climate Change and Sustainable Development*; Routledge Studies in Energy Transitions; Routledge: London, UK, 2017.
160. Harichandan, S.; Kar, S.K.; Bansal, R.; Mishra, S.K.; Balathanigaimani, M.S.; Dash, M. Energy Transition Research: A Bibliometric Mapping of Current Findings and Direction for Future Research. *Clean. Prod. Lett.* **2022**, *3*, 100026. [CrossRef]
161. Li, H.X.; Edwards, D.J.; Hosseini, M.R.; Costin, G.P. A Review on Renewable Energy Transition in Australia: An Updated Depiction. *J. Clean. Prod.* **2020**, *242*, 118475. [CrossRef]
162. United Nations. *Theme Report on Energy Transition*; United Nations: New York, NY, USA, 2021.
163. Bointner, R.; Pezzutto, S.; Sparber, W. Scenarios of Public Energy Research and Development Expenditures: Financing Energy Innovation in Europe. *WIREs Energy Environ.* **2016**, *5*, 470–488. [CrossRef]
164. De Negri, J.F.; Pezzutto, S.; Gantioler, S.; Moser, D.; Sparber, W. A Comprehensive Analysis of Public and Private Funding for Photovoltaics Research and Development in the European Union, Norway, and Turkey. *Energies* **2020**, *13*, 2743. [CrossRef]
165. Bénard-Sora, F.; Praene, J.P. Sustainable Urban Planning for a Successful Energy Transition on Reunion Island: From Policy Intentions to Practical Achievement. *Util. Policy* **2018**, *55*, 1–13. [CrossRef]
166. Gómez-Navarro, T.; Brazzini, T.; Alfonso-Solar, D.; Vargas-Salgado, C. Analysis of the Potential for PV Rooftop Prosumer Production: Technical, Economic and Environmental Assessment for the City of Valencia (Spain). *Renew. Energy* **2021**, *174*, 372–381. [CrossRef]
167. Kumar, A.; Pal, D.; Kar, S.K.; Mishra, S.K.; Bansal, R. An Overview of Wind Energy Development and Policy Initiatives in India. *Clean Technol. Environ. Policy* **2022**, *24*, 1337–1358. [CrossRef]
168. Khalid, M. Smart Grids and Renewable Energy Systems: Perspectives and Grid Integration Challenges. *Energy Strategy Rev.* **2024**, *51*, 101299. [CrossRef]
169. Sestino, A. Review about Consumers' Perception on Renewable Energy Market. *SSRN J.* **2018**. [CrossRef]
170. Nacke, L.; Cherp, A.; Jewell, J. Phases of Fossil Fuel Decline: Diagnostic Framework for Policy Sequencing and Feasible Transition Pathways in Resource Dependent Regions. *Oxf. Open Energy* **2022**, *1*, oiac002. [CrossRef]
171. Kanger, L.; Geels, F.W.; Sovacool, B.; Schot, J. Technological Diffusion as a Process of Societal Embedding: Lessons from Historical Automobile Transitions for Future Electric Mobility. *Transp. Res. Part D Transp. Environ.* **2019**, *71*, 47–66. [CrossRef]
172. Li, Y.; O'Donnell, J.; García-Castro, R.; Vega-Sánchez, S. Identifying Stakeholders and Key Performance Indicators for District and Building Energy Performance Analysis. *Energy Build.* **2017**, *155*, 1–15. [CrossRef]
173. Attanasio, G.; Preghenella, N.; De Toni, A.F.; Battistella, C. Stakeholder Engagement in Business Models for Sustainability: The Stakeholder Value Flow Model for Sustainable Development. *Bus. Strategy Environ.* **2022**, *31*, 860–874. [CrossRef]
174. Hallin, A.; Karrbom-Gustavsson, T.; Dobers, P. Transition towards and of Sustainability—Understanding Sustainability as Performative. *Bus. Strategy Environ.* **2021**, *30*, 1948–1957. [CrossRef]
175. Krishnan, M.; Tai, H.; Pacthod, D.; Smit, S.; Nauclér, T.; Houghton, B.; Noffsinger, J.; Simon, D. *The Path to Net Zero: A Guide to Getting It Right*; McKinsey: Chicago, IL, USA, 2023.

176. Androniceanu, A.; Veith, C.; Ionescu, Ș.A.; Marinescu, P.; Sima, A.G.; Paru, A. Shaping Sustainable Futures: Public Policies and Renewable Energy Insights Based on Global Bibliometric Analysis. *Sustainability* **2024**, *16*, 4957. [CrossRef]
177. Kut, P.; Pietrucha-Urbanik, K. Bibliometric Analysis of Renewable Energy Research on the Example of the Two European Countries: Insights, Challenges, and Future Prospects. *Energies* **2023**, *17*, 176. [CrossRef]