The Role of the Energy Sector in Contributing to Sustainability Development Goals: A Text Mining Analysis of Literature

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Article

The Role of the Energy Sector in Contributing to Sustainability Development Goals: A Text Mining Analysis of Literature

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Abstract: This text mining study delves into the multifaceted contributions of the energy sector to the Sustainable Development Goals (SDGs). By analyzing a wide range of academic literature, we uncover key themes, trends, and challenges shaping the intersection of energy and sustainability. The findings reveal that the energy sector plays a pivotal role in achieving SDGs such as affordable and clean energy (SDG 7) and climate action (SDG 13). Critical issues encompass governance, policy frameworks, and technological innovations. This research underscores the need for interdisciplinary collaboration and holistic approaches in addressing complex energy-related sustainability challenges. The insights derived here provide guidance to policymakers, researchers, and stakeholders seeking to harness the energy sector's potential for a more sustainable and equitable future.

Keywords: Energy Sector; Circular Economy; Sustainable Development Goals; SDG; Text Mining; VOSviewer

1. Introduction

The intersection of energy and sustainability has emerged as a pivotal arena in the global pursuit of the Sustainable Development Goals (SDGs). In a world marked by growing concerns about environmental degradation, climate change, and socio-economic disparities, understanding the multifaceted contributions of the energy sector to sustainable development has become imperative. As the global population burgeons, the demand for energy continues to soar, and with it, the importance of ensuring that energy production and consumption align with the principles of sustainability.

This paper embarks on a comprehensive exploration, employing a sophisticated text mining analysis of existing literature, to unravel the intricate connections and contributions of the energy sector to the pursuit of sustainability and SDG. The objective is to unveil the nuanced intersections between energy policies, practices, and their impact on key dimensions of sustainable development.

The energy sector, encompassing a spectrum of sources from traditional fossil fuels to renewable alternatives, plays a multifaceted role in influencing economic growth, environmental preservation, social equity, and technological innovation. Through the lens of text mining, we seek to discern patterns, emerging themes, and critical insights embedded within the extensive body of literature. By deciphering the language employed by researchers, policymakers, and industry experts, we aim to construct a comprehensive narrative that goes beyond surface-level discussions. This endeavor not only contributes to the academic discourse but also holds practical implications for shaping informed policies and fostering sustainable practices within the energy sector.

This study exploits how energy sector are contributing to the SDGs, by uncovering the underlying themes, trends, and challenges that shape this intersection. By analyzing the academic literature, we seek to elucidate the role of the energy sector in driving progress towards the SDGs, particularly those related to affordable and clean energy (SDG 7) and climate action (SDG 13).

For this purpose, the present study analyzed 363 papers in order to answer three research questions:

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1. What clusters of SDGs terms appear in energy sector literature, and which clusters have been given the most attention?
2. To what extent is the SDGs present in energy sector literature?
3. What guidelines can future energy sector initiatives follow so this sector can strongly contribute for the achievement of SDG?

At the core of this analysis, it becomes evident that the energy sector is not merely a passive observer in the pursuit of overarching goals; rather, it is a central actor that both influences and is influenced by these objectives. The intricate facets of this relationship encompass a range of critical issues, spanning governance, policy frameworks, and technological innovations. Our findings underscore that addressing the multifaceted challenges tied to energy-related sustainability requires a comprehensive approach, calling for interdisciplinary collaboration, innovative solutions, and transformative policies.

This research emphasizes the importance of acknowledging the interdependence between energy and sustainability. It serves as a valuable resource for policymakers, researchers, and stakeholders aiming to leverage the substantial potential of the energy sector to construct a more sustainable and equitable future. By delving into the insights derived from this study, we can navigate the intricacies of the energy-sustainability nexus more effectively, contributing to global endeavors to create a world that is both environmentally responsible and socially just.

The text mining techniques applied in this study produced new insights based on the corpus of scientific papers analyzed and provided intuitive visualizations of the clustering results. The findings outline a conceptual framework for energy sector company on how SDGs are being addressed and clarify the ways this sector has applied to contribute to the SDGs. The multidimensional insights from the clusters collectively contribute to advancing the objectives of SDGs 7 and 13, underscoring the interconnected nature of energy, climate, economic growth, and social development.

From an implication point of view, the research provides actionable insights that can be tailored to the specific roles and responsibilities of different stakeholders, ensuring a targeted and effective contribution to sustainable development within the energy sector.

2. Literature Review

The achievement of sustainable development goals countries most attend to the environmental and energy challenges [1]. Since the industrial revolution, energy holds a significant role economic development. Energy is considered as a public good, and government must ensure that energy is available at a reasonable cost. Energy it is also essential for maintaining a modern way of life and tackling major social and economic issues like poverty, hunger, disease, and illiteracy. In fact, it is consensual that a limited and costly access to secure energy is a barrier to progress in developing nations due their importance to supply basic services such as education and health, water purification, sanitation, and refrigeration of essential medicines. In general, large quantities of high-quality energy seems to positively influence the overall welfare of society [2], and energy is considered as a key enabler in achieving the Sustainable Development Goals (SDGs) and energy emerges as the cornerstone in eradicating poverty and hunger, facilitating essential services like healthcare, education, and water access, while also sustaining economic growth and environmental preservation [3] and for advancing the circular economy in the energy sector and achieving broader sustainability goals [4].

Several studies suggest a strong correlation between per capita energy consumption and the human development index (HDI) [5-7].

United Nation in the SDG 7 "Ensure Access to Affordable, Reliable, Sustainable and Modern Energy for All", the world continues trying to achieve these goals until 2030. United Nations argued that the current pace of progress is insufficient to achieve Goal 7 until 2030. SDG 7 desires the achievement of widespread access to energy that is not only affordable and reliable but also sustainable. This encompasses enhancing energy efficiency, amplifying the proportion of renewable sources, and broadening the energy mix, all while ensuring that energy remains economically accessible for all citizens [8].

According to [9] enhancements in energy efficiency must pick up the pace to achieve the climate objective of reducing greenhouse gas emissions. A considerable number of individuals still face a lack of electricity access, and the sluggish headway in adopting clean cooking solutions poses a health

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risk to 2.4 billion people. Substantial inequalities in access to modern sustainable energy persist, widening the gap for the most vulnerable. In certain nations, the strides previously taken have been compromised or undone by the impacts of the COVID-19 pandemic. Meeting energy and climate objectives demands sustained policy backing and a substantial mobilization of both public and private funds, particularly directed towards clean and renewable energy initiatives, especially in developing nations.

Nevertheless, [2] argued that the challenge at hand involves the balance between escalating energy needs and the imperative for modern, sustainable energy services, all while considering the impact on our global natural resources and the environment. This complexity underscores the importance of addressing the Sustainable Development Goals (SDGs) comprehensively. Developing an effective energy plan becomes a puzzle, requiring a nuanced understanding of how achieving different SDG targets will ripple through the intricate landscape of energy supply and demand scenarios.

In fact, the achievement of most SDG targets will involve energy as an input, which will give rise to the energy demand. The interconnections between SDG are evident [10].

For instance, if we examine the articulating of its targets, the energy goal (SDG 7) is explicitly connected to three other goals: addressing inequality (SDG 10), promoting sustainable consumption and production (SDG 12), and combating poverty (SDG 1). However, the interconnections between energy and vital areas like health (SDG 3), education (SDG 4), climate change mitigation (SDG 13), food security (SDG 2), and water access (SDG 6) were not explicitly outlined. Another study proposed a nexus between SDGs related to energy and water [11] and among the triad food-water-energy [12].

According to European Union [13] sinergies and trade-offs between SDG7 and other SDGs. The sinergies denote that progress of SDG7 may contribute or enable progress on the other connected SDGs. Trade-offs indicate that the achievement of SDG7 may have a negative effect and deteriorate progress towards the other linked SDGs. This study, identified in EU 57 actions target for SDG7, and highlight that these actions play an important role to poverty eradication (SDG1), Economic Growth (SDG 8) and climate change (SDG 13) [13].

In a nutshell, follow the energies metrics keeping is back in the spotlight, thanks to the 2030 Agenda for Sustainable Development. Specifically, Goal 7 (SDG7) in particular, is all about ensuring everyone has access to energy worldwide [14]. An adequate management for achieving the SDG7 involves a multidimensional scenario planning that embraces numerous indicators [15] these indicators must be substantive, largely indicative, and effective in taking the different dimensions of energy access [16, 17].

For SDG7, it is possible to identify indicators-based assessment, that can be used with different proposal, such as decision making and monetarizing the progress. Table 1 present a set of indicators proposed for SDG7 and suggest their influence in the achievement (positive) or not (negative) the SDG7 and an interconnection with SDG13 (Climate action).

Table 1. Set of SDG7 Indicators.

Indicator		Character
SDG_07_10	Primary energy consumption per capita	Negative
SDG_07_11	Final energy consumption per capita	Negative
SDG_07_20	Final energy consumption in households	Negative
SDG_07_30	Energy productivity	Positive
SDG_07_40	Production of renewable energy	Positive
SDG_07_50	Energy import dependency by products	Negative
SDG_07_60	Population unable to keep home adequately warm by poverty status	Negative
SDG_13_20	Total GHG Emissions Including Land-Use Change and Forestry	Negative

Source: [18], adapt.ed

3. Methodology

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In this study, our primary objective was to delineate clusters of concepts within the realm of the energy sector, focusing on its related literature. To achieve this, we employed content analysis techniques aimed at extracting and categorizing the terminologies used by scholars to mention companies operating within the energy sector. The sheer magnitude of the dataset under examination rendered the utilization of computer-automated methodologies more pragmatic compared to traditional, labour-intensive systematic reviews. Previous research has demonstrated the efficacy of computer-assisted algorithms, particularly those centred around topic modelling and clustering [19]. These methods offer distinct advantages, including expedited text processing and the capacity to handle substantial volumes of data.

It is important to note that our study was exploratory in nature, signifying that the outcomes provide a comprehensive insight into the strategies and initiatives within the energy sector. These strategies and initiatives are designed to contribute to the attainment of SDGs.

3.1. Data source and search process

This study utilized bibliometric data extracted from the Scopus database in October 2023, following the precedent set by numerous prior researchers [20]. The Scopus database consists of indexed, high-quality, peer-reviewed journals, which also encompass publications with a specific focus on the energy sector. Given the objectives of our study, we concentrated on academic articles that delve into the management of the energy sector within the context of the SDGs.

We formulated a query containing energy-related terms and keywords in connection with the SDGs. The first set of terms was derived from the lexicon validated and utilized in the research conducted by authors in previous research related with energy sector [21]. In addition to “energy sector” term, we also included “energy industry”, “power sector”, and “power indust”. The keywords associated with the SDGs were “Sustainable Development Goals”, “Sustainable Development Goal”, “SDGs” and “SDG”. The search query designed to identify academic articles that specifically incorporated both energy sector and SDGs-related terms in their titles, abstracts, or keywords, was:

TITLE-ABS-KEY (("energy sector" OR "energy industry" OR "power sector" OR "power indust") AND ("Sustainable Development Goals" OR "Sustainable Development Goal" OR "SDGs" OR "SDG"))

In total, we retrieved 383 articles published up to the year 2023 from 224 different journals. The following journals contributed in a major number to this production: Sustainability (21), Energies (20), Journal of Cleaner Production (15), Energy Policy (12), Environmental Science and Pollution Research (10), and Renewable and Sustainable Energy Reviews (9). The papers were produced by 100 distinct publishers, in which Elsevier, MDPI, and Springer are the top one.

3.2. Dataset characterization

Open access documents are in higher number (194 from total of 383), even though both types of access are quite similar. Most of the contributions are published in scientific articles, as shown in Table 2.

Table 2. Number of documents per type.

Document type	Number
Article	261
Conference paper	43
Book chapter	36
Review	30
Book	6
Note	2
Data paper	2
Conference review	2

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Short survey	1
Total	**383**

Source: Authors.

Although in 2022 occurred a decrease in the number of documents published, we can see a consistent increase in the contributions for this field of knowledge (Figure 1).

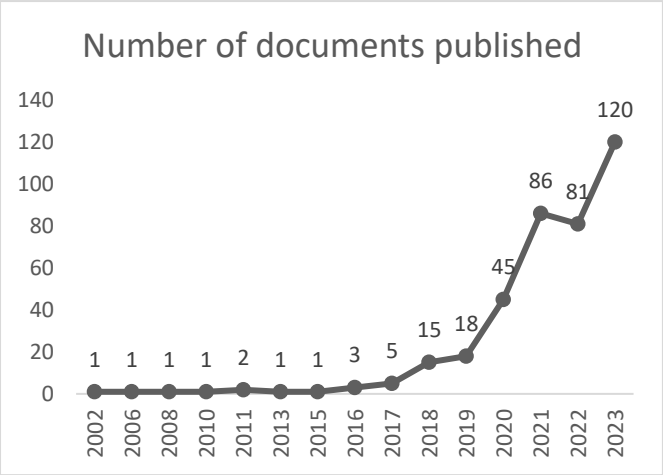

Figure 1. Number of documents published by year. Source: Authors.

In fact, in the most recent year (i.e., 2023), the publication achieved the higher number of ever (120).

3.3. Text mining

Text mining techniques have the capacity to unveil concealed patterns in various forms of textual content, including documents, comments, and reviews [22]. These methods empower researchers to explore textual content for single or multi-word terms and to reveal patterns based on the frequency of their occurrence within the text [19]. In the application of text mining to the abstracts in our sample, we implemented two critical procedures to ensure that only meaningful words were considered: stemming and the removal of stop words [23]. Furthermore, the elimination of stop words effectively eliminated inconsequential terms, such as "the," "a," and "or," as well as specific words used in the selection of the literature sample, like "SDG" or "Sustainable Development Goals."

The resultant dataset generated through these procedures, referred to as the "corpus," served as the input for co-word analysis. This analytical method employs text mining techniques to identify connections between words that co-occur within the same text [19] (van Eck & Waltman, 2010). For conducting this type of analysis, we employed VOSviewer, an open-source software equipped with a natural language processing algorithm from the Apache OpenNLP library, a machine learning-based toolkit for clustering [11]. VOSviewer is a versatile tool, well-suited for data analysis and visualization, and has been widely embraced by scholars in diverse fields, including those focused on emerging research trends in business and management [24, 25].

With the assistance of VOSviewer analysis tools, our study categorized the thematic content of the selected articles based on a semantic similarity and association strength matrix, employing co-occurrence of more than 60% of the most significant terms, specifically those that appeared more than 10 times in the abstracts of the articles. This analysis yielded five distinct thematic clusters. Subsequently, a manual, in-depth examination was conducted on the articles featuring the most crucial terms within each cluster to provide notable examples of research on prominent themes.

4. Results

The text mining technique produced five thematic clusters. Each cluster's words appear in that group's color on the VOSviewer word network graph (see Figure 2).

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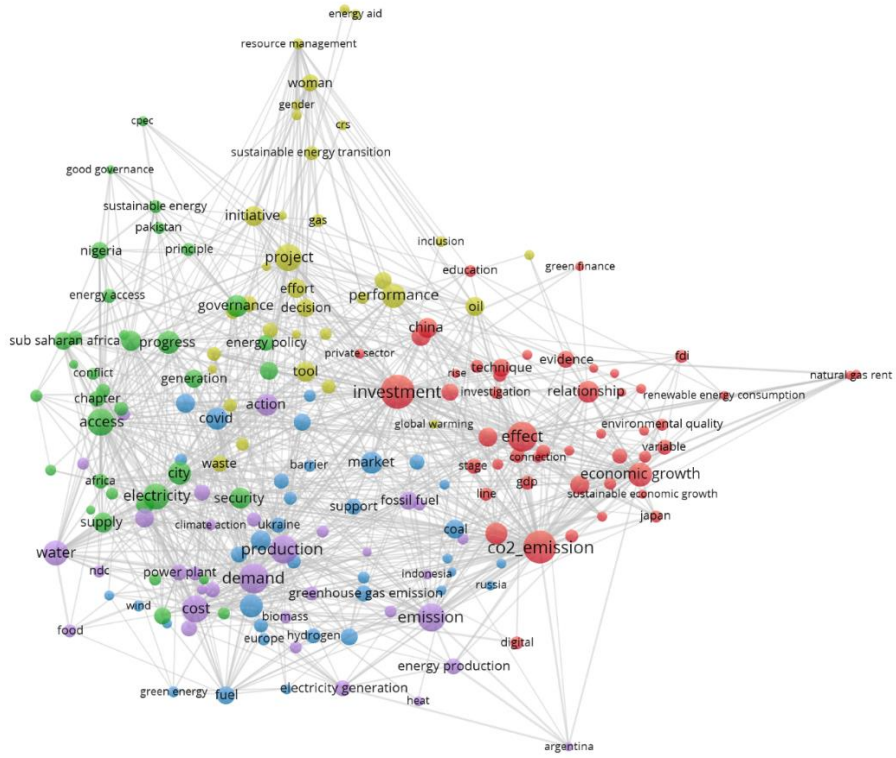

Figure 2. Clusters of terms in VOSviewer co-occurrence map. Source: Authors.

4.1. Cluster profiles

The five clusters found in documents are as follows: Cluster 1 Compliance Risk (red), Cluster 2 Resource Consumption (green), Cluster 3 Tech-nology Transition (dark blue), Cluster 4 E-Mobility (yellow), Cluster 5 Renewable Ener-gy (purple). Table 3 lists the 10 most frequently used terms in each cluster and each term's number of occurrences.

Table 3. Cluster characterization.

Clusters	Terms	Number of occurrences	Terms	Number of occurrences
#1	investment	138	energy efficiency	59
	co2_emission	133	china	49
	effect	105	quality	46
	economic growth	69	energy	46
	relationship	59	consumption	42
			risk	
#2	Access	89	security	56
	electricity	83	supply	49
	city	63	community	48
	progress	62	population	41
	governance	59	sub saharan africa	39
#3	energy system	62	coal	42
	market	57	fuel	41
	covid	57	energy resource	36
	state	51	ecosystem	35
	pandemic	43	support	32
#4	Project	85	effort	42
	performance	68	decision	41
	tool	51	stakeholder	36

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	initiative	48	woman	35
	oil	43	society	33
	Demand	105	action	59
	emission	95	planning	45
#5	production	94	fossil fuel	38
	cost	85	health	33
	water	74	pathway	32

Source: Authors.

Cluster 1, in red, is the most prominent group as it includes terms such as investment, CO2 emission, effect, economic growth, relationship. The literature encompasses a diverse array of studies exploring the intersections between climate change, sustainable development, and economic growth across various regions. The Glasgow Climate Change Conference (COP26) is discussed in relation to its implications for Sub-Saharan African economies, emphasizing the need for concerted efforts to address climate challenges in the region [26]. Wu et al. [27] examines the influence of financial restrictions on development of green economic growth and sustainable development goals, concluding that the combination of green financial investment, insurance, and credit shows the greatest positive supportive impact. Several papers focus on specific countries and regions, such as the examination of United Arabic Emirates [UAE]'s government policies driving the transition towards a circular economy and the analysis of Japan's energy mix in relation to economic growth. The role of public-private partnerships in boosting energy efficiency in Turkey is also explored. Furthermore, studies delve into the impact of investment and financing optimization policies on photovoltaic power generation in Cameroon, emphasizing the importance of dynamic models in assessing such initiatives. These papers collectively contribute to a comprehensive understanding of the economic, environmental, and policy dimensions of energy transitions and sustainable development.

Taking a longitudinal view, the themes clustered in yellow in Figure 3 represent the most recently addressed topics in the literature. This indicates a growing concern and increasing interest in exploring the intersection of climate change, sustainable development, and economic growth across diverse regions.

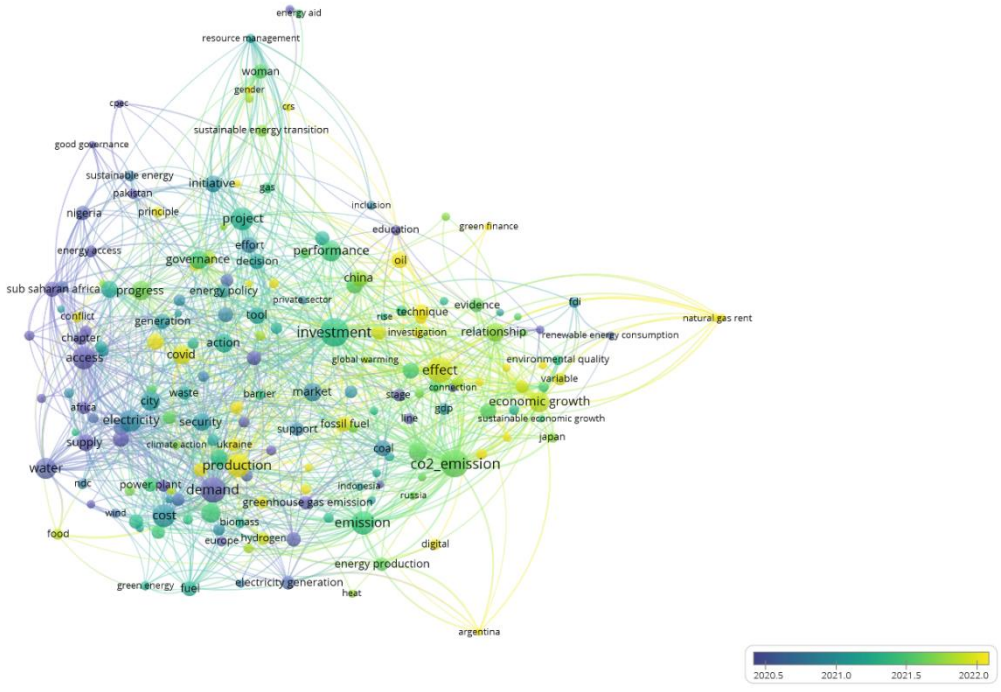

Figure 3. Clusters of terms in VOSviewer overlay visualization. Source: Authors.

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Cluster 2, in green, includes terms as access, electricity, city, progress. Studies contribute for the knowledge on the accessibility of energy by communities. The literature review presents a focused examination of sustainable energy initiatives in Africa, particularly with regard to Chinese-funded projects for creating new electricity generation models [28]. The paper investigating investment and financing optimization policies for developing photovoltaic power generation in Cameroon employs a dynamic model assessment, shedding light on effective strategies for advancing renewable energy infrastructure [29].

Additional research delves into specific countries, such as Rwanda, where the focus is on residential energy demands using robust models, and Nigeria, examining the role of good governance in promoting sustainable development in off-grid electricity solutions [30]. The synergies and trade-offs between energy and sustainable development goals are explored through a case study of off-grid solar energy in Rwanda, providing insights into the interconnected nature of these objectives [31].

Several papers address broader regional challenges and opportunities, such as the costs and policy implications of providing access to electricity in selected countries in Sub-Saharan Africa, the perpetuation of energy poverty in unmet African electricity markets, and the employment footprint of decentralized renewable energy technologies in Sub-Saharan Africa [32, 33]. These studies collectively contribute to a nuanced understanding of the complexities surrounding sustainable energy development in the region, offering valuable insights for policymakers, practitioners, and researchers. This cluster received more contributions in 2020 and earlier, meaning it is not the main focus of researchers (see Figure 3).

Cluster 3, in blue, comprises terms covering energy sector (using fuel) challenges felt during pandemic period. The studies explore the dynamic intersection of environmental, social, and governance factors within the context of the energy sector, particularly in response to the challenges posed by the COVID-19 pandemic. Ameli et al. [34] conducts a scenario analysis using fuzzy cognitive map modelling to assess the impact of COVID-19 on the achievement of SDGs, shedding light on the intricate relationships between the pandemic and broader sustainability objectives.

The specific repercussions of the COVID-19 pandemic on access to affordable and clean energy are also investigated, highlighting the disruptions and challenges faced in maintaining progress toward SDG 7 [35]. Vukovic and Nevalennyi [36] examine the post-pandemic landscape, particularly in relation to the solar energy market, with a focus on its implications for female entrepreneurship. Lastly, some studies provide a comprehensive perspective on energy sustainability in the aftermath of COVID-19, offering insights into how the global community can navigate the complexities of achieving sustainable development in a post-pandemic world [37]. Together, these papers contribute to a nuanced understanding of the evolving dynamics and challenges within the energy sector against the backdrop of the COVID-19 crisis and the broader sustainability agenda.

Cluster 4, in yellow, includes terms related to project, performance, decision making, but also gender equality related topics. The literature comprises a diverse set of studies centered around sustainability and corporate social responsibility (CSR) initiatives, with a particular focus on renewable energy, plastic waste recycling, and their impact on economic growth and development [38]. Researchers also propose a sustainable CSR index to evaluate the performance of the energy industry, utilizing a hybrid decision-making methodology [39]. These efforts highlight a growing interest in aligning corporate practices with sustainability goals.

The literature highlights the ongoing challenge of achieving gender equality in the energy sector, hindering the timely realization of SDG 5 on empowering women. Capello et al. [40] provide an overview of the initiative's progress, emphasizing its maneuvering through the pandemic to deliver quick wins, particularly in the oil and gas, geothermal, and mining sectors. The initiative focuses on creating dialogues, networks, webinars, and recommendations to increase gender participation in resource management.

Cluster 5, in purple, incorporates terms cost production of energy (water, fuel) but also its impact in environment and health. Studies addressing these terms investigate the critical role of rare earth elements as raw materials, emphasizing their economic importance and potential environmental implications [41]. Modern ways of production of energy is explored, namely low and medium enthalpy geothermal energy [42]. Biomass energy production, adoption, and sustained use is explored in African countries, shedding light on the entire life cycle of this renewable energy source

[43]. Hydrogen is another energy source addressed by studies, in which authors examine its future prospects and the associated challenges in production, storage, and applications as an energy carrier [44].

Researchers investigate the interconnected nexus of energy, climate, and health in the context of energy planning, utilizing a case study set in Brazil to illustrate these complex relationships [45]. Lastly, Internet of Energy emerges as a trend in smart energy management for enabling real-time monitoring, control and optimization of energy production, distribution, and consumption [46].

5. Discussion and implications

The findings of this study hold significant implications for several SDGs, particularly SDG 7 (Affordable and Clean Energy) and SDG 13 (Climate Action). The identified clusters shed light on diverse aspects of the intersection between energy, sustainable development, and economic growth, offering insights into the complexities and challenges faced in different regions.

The literature in Cluster 1 emphasizes the importance of addressing climate challenges for sustainable economic growth. The discussions surrounding the COP26 underscore the global commitment to mitigating climate change, with specific attention to its implications for African economies. Researchers argue for concerted efforts in the region, aligning with the goals of SDG 13. Furthermore, Wu et al. (2023) posit that green financial investment, insurance, and credit play a pivotal role in supporting sustainable development, aligning with the objectives of both SDG 7 and SDG 13.

The individual country-focused studies, such as those on the UAE and Japan, contribute nuanced perspectives on the relationship between government policies, energy transitions, and economic growth. These findings collectively enhance our understanding of the economic, environmental, and policy dimensions of energy transitions, providing a foundation for informed decision-making in support of SDGs 7 and 13.

Cluster 2 focuses on energy accessibility and progress, directly contributing to SDG 7. The studies on Chinese-funded projects in Africa and investment and financing optimization in Cameroon unveil the importance of dynamic models in advancing renewable energy infrastructure. The examination of off-grid electricity solutions in Rwanda and Nigeria highlights the intricate interplay between energy and SDGs, emphasizing the need for holistic approaches to address energy challenges in the region.

The comprehensive exploration of regional challenges and opportunities, such as the costs and policy implications of providing electricity in Sub-Saharan Africa, contributes valuable insights for policymakers. These insights are crucial for achieving SDG 7 by promoting universal access to affordable, reliable, and modern energy services.

The Cluster 3 explores the impacts of the COVID-19 pandemic on the energy sector, specifically addressing SDG 7. Ameli et al. [34] utilize scenario analysis to reveal the intricate relationships between the pandemic and broader sustainability objectives, including SDGs. The studies on the specific repercussions of the pandemic on access to affordable and clean energy highlight the disruptions faced in maintaining progress toward SDG 7. Additionally, the examination of the post-pandemic landscape, particularly in the solar energy market, provides insights into the gender dimensions of energy entrepreneurship, aligning with SDG 5.

The Cluster 4 significantly addresses CSR, in which studies on renewable energy and plastic waste recycling underscore the growing interest in aligning corporate practices with sustainability goals. Literature also proposed new tools, like sustainable CSR index, aligns with SDG 13 by evaluating the performance of the energy industry in the context of environmental sustainability. This Cluster's related studies also emphasis on gender equality in the energy sector, addressing the barriers hindering the achievement of SDG 5.

Finally, Cluster 5 delves into the production of energy and its environmental impact, contributing to SDG 7 and SDG 13, and other related goals. Studies on rare earth elements, geothermal energy, biomass, hydrogen, and the interconnected nexus of energy, climate, and health provide a holistic perspective on the environmental implications of different energy sources. The exploration of the Internet of Energy as a trend in smart energy management aligns with the broader goals of optimizing energy production, distribution, and consumption for sustainable outcomes.

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In conclusion, the multidimensional insights from these clusters collectively contribute to advancing the objectives of SDGs 7 and 13, underscoring the interconnected nature of energy, climate, economic growth, and social development.

The nuanced understanding of regional challenges, economic implications, and environmental considerations presented in this literature review informs policymakers, practitioners, and researchers, facilitating informed decision-making for a sustainable and inclusive future. From a policy perspective, policymakers can use this insight to inform the development of policies that prioritize and incentivize the transition to renewable energy. For instance, they might design financial mechanisms to support the growth of renewable energy projects, aligning these initiatives with SDG 7 (Affordable and Clean Energy). For energy companies, these companies can strategically invest in projects that not only contribute to economic growth but also align with sustainable development goals. For instance, they might prioritize investments in technologies that enhance energy efficiency or projects that promote social equity in the communities where they operate.

From a research point of view, studies should use these insights to guide their future inquiries. For example, if gender equality within the energy sector is identified as an underexplored theme, researchers may conduct studies on the challenges and opportunities for women in the industry, contributing to both academic knowledge and societal advancement (SDG 5). Finally, nonprofits can leverage this study's insight to advocate for community engagement and social impact assessments in energy projects. This approach aligns with SDG 10 (Reduced Inequalities) and ensures that energy initiatives benefit all segments of society.

In essence, the research provides actionable insights that can be tailored to the specific roles and responsibilities of different stakeholders, ensuring a targeted and effective contribution to sustainable development within the energy sector.

6. Conclusions

In conclusion, this paper has undertaken a comprehensive exploration of the intricate connections between the energy sector and sustainable development, employing sophisticated text mining analysis to unravel underlying themes, trends, and challenges. The global pursuit of SDGs, particularly SDG 7 (Affordable and Clean Energy) and SDG 13 (Climate Action), has accentuated the significance of understanding the multifaceted contributions of the energy sector.

The analysis of 383 scientific documents revealed critical insights into the intersection of energy and sustainability, highlighting the energy sector's pivotal role in influencing economic growth, environmental preservation, social equity, and technological innovation. The findings unveil that the energy sector is not merely a passive participant but a key actor shaping and being shaped by the pursuit of SDGs. Governance, policy frameworks, and technological innovations emerged as critical issues underpinning the relationship between the energy sector and sustainability.

Addressing the complex challenges of energy-related sustainability requires a holistic approach, necessitating interdisciplinary collaboration, innovative solutions, and transformative policies.

The significance of recognizing the interdependence of energy and sustainability cannot be overstated. This research serves as a valuable resource for policymakers, researchers, and stakeholders, offering insights into navigating the complexities of the energy-sustainability nexus. By delving into the findings, we can better harness the immense potential of the energy sector for building a more sustainable and equitable future.

6.1. Limitations and future research

Despite the comprehensive analysis, this study has certain limitations. The text mining techniques applied, while producing valuable insights, are inherently reliant on the existing body of literature and may not capture emerging themes not yet addressed in academic discourse. This can occur in case the terms used in the studies are not very representative (minimum number of times is 10).

Future research endeavors could explore emerging trends in the energy sector beyond the existing literature, incorporating real-time data and qualitative insights. A longitudinal study could track changes in discourse over time, providing a dynamic understanding of the evolving relationship between the energy sector and sustainability. Moreover, a deeper exploration of the social and cultural dimensions of the energy-sustainability nexus could enrich our understanding

and contribute to more inclusive and context-specific policies. Additionally, comparative analyses across regions or countries could provide valuable insights into the effectiveness of different approaches in achieving SDGs.

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