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Literature review and analysis of the social impact of a just energy transition

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Introduction: The energy transition is now the focus of global attention. This transition will have a significant impact on the global energy system as well as the political and economic landscape. Research on the social impact of the energy transition can help us get a deeper understanding of the energy transition and propose suggestions for future development.

Methods: This paper focuses on the history and characteristics of the social impact evaluation of the energy transition, using bibliometric methods and the Web of Science Core Collection database with the help of HistCite and VOSviewer analysis tools. This paper discusses what is energy transition, just energy transition and its social impact and how to assess social impacts of just energy transition. In order to reduce the negative impacts of energy transition, interdisciplinary research, social impact research and social impact assessment of construction projects are three directions to be discussed.

Results: The study find that existing research mainly focuses on the connotation, pathways and different types of a just energy transition. There are three hot areas of research on the impact of a just energy transition: the sustainable development of energy, political economy and society. There is a general lack of research on the social impact of a just energy transition and an even greater lack of relevant research on social impact evaluation.

Discussion: Based on the global goal of just energy transition, this paper makes specific recommendations on what developed and developing countries, as well as sectors and enterprises within countries, should do.

KEYWORDS

energy transition, social impacts, justice, climate change, sustainability

1. Introduction

As the global economy continues to grow, carbon emissions are on the rise, resulting in severe energy consumption, environmental degradation, disease, and loss of social welfare. Shifting the demand associated with traditional energy sources and products helps to control pollution, improve environmental quality, facilitate the energy transition and promote sustainable human development (Naqvi et al., 2020). The energy transition has become a global concern. The energy transition will have important impacts on the global energy, political and economic pattern (Zhang et al., 2015). This transition can have social impacts such as changes in employment or lower incomes. On the one hand, the energy transition directly destroys or creates jobs and spreads through supply chains and income changes affecting the whole economy. On the other hand, more ecological goods and services in the energy transition may lead to higher prices, leaving less income available for other goods and services (García-García et al., 2020).

The energy transition also has different impacts on developed and developing countries. As a result, the impact of the energy transition is also likely to be greater. In addition, the energy transition poses greater challenges for developing countries, especially in terms of their dependence on traditional biomass and fossil fuels. This dependence makes developing countries vulnerable and makes them fall into a poverty trap, where countries without access to modern energy services have to pay more for the energy they use (Vanegas Cantarero, 2020). As a result, global decarbonization and the transition to green energy in the context of addressing environmental degradation and socioeconomic issues have raised public concern about a just energy transition.

In 2002, the cumulative number of publications in the literature related to a just energy transition was only 10. After 2012, the cumulative number reached 100, and after 2018, the growth in the literature related to a just energy transition has been particularly marked. By 2022, the cumulative number of publications had reached 616. Academic attention to the just energy transition is also growing. A wealth of research has been done on the connotation and path of just energy transition. The concept of a just energy transition is rooted in the union movement in the North American energy sector in the 1970s. At that time, the concept came from the concern of industrial transformation and workers' rights and had an involuntary nature. The concept spread during the 1990s, a period when it was applied to other branches of trade unionism and the Just Transition Coalition was formed. Over the past nearly three decades, the concept has been enriched in its international meaning. At the practical level, the international community is actively pursuing different means of promoting a just energy transition. Agreements such as the Paris Agreement, adopted in 2015, and the 2030 Agenda for Sustainable Development play a key role in a just energy transition and are central to climate change mitigation. At the national level, China proposes to adapt to local conditions, coordinate environmental protection and economic development, prepare for rainy days, and make plans for the orderly withdrawal of fossil energy as soon as possible (Shi, 2021). Greece's transition to a sustainable and socially just post-lignite era is based on a multilevel perspective framework, proposing measures such as the simultaneous creation of new jobs and innovative lignite mining, increased government investment in the clean sector, and citizen participation (Nikas et al., 2020). The Appalachian Transition in the US proposes four measures to build resilient communities, create sustainable jobs, engage affected workers and communities in collaboration, and secure long-term investment from a variety of sources; it also proposes to protect children's rights and develop education (Snyder, 2018).

The just energy transition is not just a technical issue but also a political and a social issue. Indeed, because it is characterized by issues of power, resource distribution and access, as well as political gamesmanship and economic development, it can be described as a profound power struggle. Social impact refers to the consequences brought by public or private behaviors that change people's way of living, working and leisure, as well as the changes in customs, values and beliefs that guide and regulate social cognition (Vanclay, 2006). Due to the broad connotation of social impact (Chen et al., 2022), for practical operability, we pay attention to the economic, political, social, cultural and human changes brought by the event and process of a just energy transition. The social impact of a just energy transition requires a multifaceted assessment. The study of the social impact of the just energy transition goes through a constantly changing process. The scope of research on its impact has expanded from the local and regional level to the national level and finally evolved to the global level. Since Barry's (2013) study, the political understanding of a just energy transition has been based on a clear understanding that we are faced with an "actually existing unsustainability" (as opposed to "sustainable development"). Healy and Barry (2017) focuses on the issue of injustice and is concerned about the lack of research related to supply-side climate policy analysis and decision-making. Concerns about the social impacts of the energy transition contribute to establishing a framework for a just energy transition. In general, the literature on the social impacts of a just energy transition has focused mostly on developed countries. Existing studies have mainly focused on labor issues and the distributional consequences of the transition. There is less research on the evaluation of the social impacts of a just energy transition. How to promote the just energy transition and evaluate its social impacts is an important research topic. Based on this, paper uses a bibliometric method to analyze the existing typical literature. This paper introduces the research methodology and data sources, shows the results obtained based on data analysis, including the growth trend of literature published in the field of just energy transition, the distribution of journals, core publication authors and major research countries, and analyzes the hot topics of interest in just energy transition. This is followed by a summary of the current research gaps based on the existing sample of literature on the "energy transition," the methods and pathways of a "just energy transition" and the evaluation of the social impact of a just energy transition, as well as theoretical directions and policy recommendations for future research.

The originality and contribution of this paper lie in the fact that, on the one hand, it visually reviews the results of existing research, reviews the research lineage of the social impact assessment of a just energy transition, and distills the research hotspots and shortcomings of the social impact assessment of a just energy transition. On the other hand, it illustrates the shortcomings of current theoretical research on the social impact assessment of a just energy transition and the directions for further research, enriching the research content of the field and providing a basis for further development of theoretical research in the field. At the same time, corresponding policy recommendations are proposed to further promote the practical process of a just energy transition and its evaluation.

2. Research methods and data

2.1. Research methods

This paper mainly uses bibliometric methods. Bibliometric methods are commonly used in library intelligence, information resource management and related research fields. Generally, mathematical and statistical methods are used to study the literature system and analyze the quantitative relationship between texts, focusing on the external characteristics of the literature, such as publication year, journal distribution, and core authors, to conduct regular analysis and generalization of the literature. Knowledge graphs, also known as scientific knowledge graphs, use a graph structure for the visual representation of documents, nodes to represent authors, academic institutions, scientific literature, or keywords, and connecting lines to represent the relationships between nodes. When knowledge mapping techniques are combined with bibliometrics, they can be used to statistically analyze the evolutionary dynamics, research hotspots and potential frontier trends in a subject area with their powerful computational power and intuitive graphical format (Chen, 2017). Information visualization and co-word analysis are two important

foundations of the knowledge mapping method. Information visualization can optimize and improve organization and retrieval and enhance the quality and efficiency of information acquisition (Deng, 2018). Co-term analysis is a content analysis method, whose principle is to count the number of occurrences of a group of words in the same document, cluster these words, and analyze the structural changes in the disciplines and topics they represent (Lu and Fuhai, 2006). HistCite is a citation chronology visualization system developed by renowned scient metricians Garfield et al. The system is able to graphically display the relationships between different works of literature in a field, helping us map out the history of a field's development and locate important literature in the field as well as the most recent important literature (Tian, 2014). HistCite has been widely used in China for scientific research activities (Gao, 2015). VOSviewer is a bibliometric analysis software package used to construct and view bibliometric maps. Using VOSviewer, we can analyze the overall research overview, the latest research progress, country-specific research, the distribution of institutions, and important researchers and important literature information in related fields to discover the mainstream academic groups and their representative figures, core technology areas and hot issues, which can be better used for scientific research activities (Gao, 2015). With the help of HistCite software and VOSviewer software, this paper further analyzes the obtained literature, displays the important literature and other information in this research field based on the data of the Web of Science Core Collection database, and analyzes the current hot spots in the field of just energy transition based on the cooccurrence of keywords.

2.2. Data source

The data in this paper are mainly obtained from the Web of Science Core Collection database, supplemented by important literature with high relevance searched in Google Scholar and ScienceDirect. First, the data were obtained by searching the Web of Science core database for the core search terms "just transition assessment," "just energy transition assessment framework," "just energy transition assessment framework" and "impacts of just transition." Moreover, to prevent the blurring of topics due to the large search scope, "environmental science," "management" and other humanities and social science categories related to the topic were selected as categories, and the search results were streamlined. Second, the titles, keywords, and abstracts of the documents were manually reviewed and selected to determine whether they were included in the bibliometric scope, and 641 documents with high relevance to the topic of this paper were obtained from 1993 to 2022 for further analysis. Finally, to prevent insufficient data support and the omission of important literature in the field, a search was conducted in ScienceDirect, Google Scholar and other databases with the same keywords to select a few nonduplicate highly relevant studies to be included in the analysis.

3. Results

3.1. Growth trend and periodical distribution

3.1.1. Growth trend

By consulting and reading the publication of literature on a just energy transition in the Web of Science Core Collection database, 25 articles without publication date were removed. Curve fitting and linear regression analysis were carried out on the cumulative publication data, and the results are shown in Figure 1 and Table 1. As shown in the following table, with the year and number of publications as independent variables and the cumulative number of publications as the dependent variable for linear regression analysis, the formula of the model is as follows: the cumulative publication amount = −4649.020 + 2.324* year +4.867* the number of publications. Additionally, the R^2 value of the model is 0.973, which means that the year and the number of publications can explain 97.3% of the variation in the cumulative publication amount. The model passed the F test ($F = 487.420$, $p = 0.000 < 0.05$), indicating that the year and at least one of the number of publications have an impact on the cumulative publication volume, and the regression coefficient value of the year was 2.324 ($t = 2.377$, $p = 0.025 < 0.05$). This means that the year will have a significant positive influence on the cumulative volume of publications. The regression coefficient value of the number of published papers was 4.867 ($t = 16.658$, $p = 0.000 < 0.01$), indicating that in each year the number of published papers has a significant positive impact on the cumulative publication volume.

According to the data analysis, combined with the current background of the energy transition and economic and social development, we infer that in the future, research on a just energy transition will further grow, its importance will be further increased, and the academic results will become more fruitful.

3.1.2. Journal distribution

With the help of HistCite software, the LCS (local citation score), TLCS (total local citation score) and TGCS (total global citation score) of 393 journals in 641 sample studies were calculated. The higher the total number of local citations is, the greater the influence of the journal. According to the obtained data, we took TLCS≥4 as the cutoff point and obtained 9 journals. The distribution results are shown in Table 1 below.

According to the number of articles published, ENERGY POLICY (21), CLIMATE POLICY (11), and NATURE ENERGY (18) are among the leading journals with high influence; ENERGY RESEARCH & SOCIAL SCIENCE (26) is the journal with the most articles published. It can be seen that the main journals that publish articles on a just energy transition are focused on energy, policy, and science, with less attention to the social, cultural, and economic fields. This also provides a direction for future research. As the economic and political factors behind the just energy transition are inseparable, we can increase the research on these aspects and publish more papers in the corresponding journals in the future (Table 2).

3.2. Core authors and countries distribution

3.2.1. Core authors

A core author is a term used in the field of library intelligence and bibliography to refer to a small number of distinguished authors in a particular discipline or field of expertise who have a high number of publications, a high citation rate, and a high impact. Core authors play a guiding role in a certain research field. They are the main force promoting scientific innovation and scientific development in the research field and are key for enhancing the academic influence of journals.

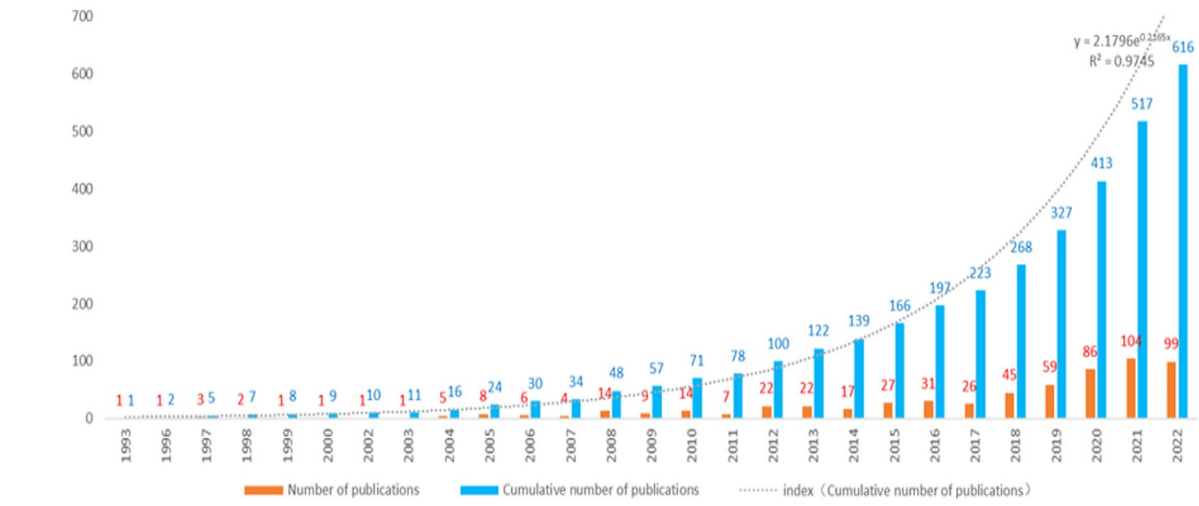

FIGURE 1
Temporal distribution of studies related to just the energy transition (1993–2022).

TABLE 1 Results of linear regression analysis (n=30).

	Nonstandardized coefficient		Standardized coefficient	t	p	VIF
	B	Standard error	*Beta*			
Constant	−4649.020	1958.275	–	−2.374	0.025*	–
Year	2.324	0.978	0.126	2.377	0.025*	2.812
Number of publications	4.867	0.292	0.882	16.658	0.000**	2.812
R^2	0.973					
Adjusted R^2	0.971					
F	$F(2,27) = 487.420$, $p = 0.000$					
D–W value	1.566					

Dependent variable: cumulative volume of publications.
*$p < 0.05$; **$p < 0.01$.

In this study, there were 2,160 authors associated with 641 sample documents, and the number of articles published by each author ranged from 1 to 9. According to Price's theorem, an author who publishes N papers is a core author, where $N = 0.749\ (n_{max})^{1/2}$, and where n_{max} is the number of papers published by the author with the most publications (Junping, 2007). In the sampled literature, Professor Benjamin K. Sovacool, Director of the Sussex Energy Group's Centre for Innovation and Energy Demand, published the most articles, with a total of 9 articles, and we calculated A = 2.247. Thus, we regard authors with ≥3 articles as the core authors in this research area and obtain a total of 11 core authors, accounting for only 0.5% of the total number of authors (Table 3). From these data, we can see that research on a just energy transition has received attention from many scholars in many fields, but we also find that the number of core authors in the whole field is very small, and the core authors in the whole field are still in the early growth stage.

Among the core authors, B. K. Sovacool ranked first in the number of publications. He is a researcher and consultant on energy policy, energy security, climate change mitigation and other issues. His research focuses on renewable energy and energy efficiency, the politics of large energy infrastructure, and more. In response to decarbonization, he points out that the research and policy community should consider and seek to minimize broader social and environmental sustainability risks (Sovacool et al., 2015). R. David is the other lead author of four papers in the field, mainly in the fields of the environment, dynamics, and the humanities. A.M. Foley, a faculty member in the School of Mechanical and Aerospace Engineering at Queen's University Belfast, joins the first two authors in focusing on energy poverty and suggesting that decarbonization is a politically sensitive and critical aspect of the energy transition and may exacerbate inequality or environmental vulnerability (Lowans et al., 2021). Morgan Bazilian focuses on greenhouse gases and hydropower. Together with B.K. Sovacool and A. M. Foley, she focuses on assessing the extraction and production of the minerals and metals needed for low-carbon energy, and presents current trends and projections that indicate that a low-carbon energy system of the future will have greater physical requirements than the current system. Therefore, a better understanding of the full impact of resource extraction can help ensure a sustainable and just transition

TABLE 2 Journal distribution of research literature on a just energy transition.

#	Journal	Recs	TLCS	TGCS
1	Energy policy	21	35	888
2	Climate policy	11	22	249
3	Nature energy	2	18	170
4	Environmental innovation and societal transitions	9	13	52
5	applied energy	7	12	301
6	Energy research and social science	26	8	403
7	Extractive industries and society-an international journal	3	5	67
8	one earth	2	4	34
9	Rural sociology	1	4	52

The total local citation score (TLCS), total global citation score (TGCS) in WOS, total local citation score per year (TLCS/t), and total global citation score per year (TGCS/t) are limited in space, and only journals with a TLCS of 4 times or more are listed.

TABLE 3 Core author posting volume display.

	Core authors	Number of published articles
1	Sovacool BK	9
2	Oei PY	5
3	Bazilian M	4
4	Kortetmaki T	4
5	Rooney D	4
6	Streimikiene D	4
7	de Coninck H	3
8	Foley AM	3
9	Lo K	3
10	Mayer A	3
11	Swennenhuis F	33

(Bazilian, 2020). A. Mayer, in her study of a just transition for coal miners, cites B.K. Sovacool as arguing that a "just transition" is a deliberate rejection of more managerial and apolitical approaches to transition academia (Mayer, 2018). In a paper co-authored by H. de Coninck and F. Swennenhuis, from the Department of Environmental Sciences, Institute of Water and Wetlands, Faculty of Science, Radboud University, cost and lack of stakeholder support are two key barriers to developing a carbon capture and storage (CCS) industry that can effectively mitigate climate change. The number of papers published by other non-core authors in this field is relatively small, and there are few cooperative associations between them. The authors in each research field change the definition of energy transition (Cha and Pastor, 2022), path (Snyder, 2018), impact (Xinxin Wang and Lo, 2021), and evaluation (Shah et al., 2022) and other disciplines are studied from different perspectives.

The energy transition issue has received increasing global attention in recent years. Especially after the world adopted two major international agreements in 2015, the Paris Agreement and the 2030 Agenda for Sustainable Development, the importance of the energy transition and the "just transition" to a low-carbon economy has continued to rise Different countries have begun to explore the "just transition" and cooperate and learn from each other in this academic field.

With the help of HistCite software, based on 641 sample documents, 71 countries were involved in the study of a just energy transition. Due to the large number of involved countries and the limited space, we selected countries with more than 10 articles for analysis. According to the data, a total of 23 countries meet this condition, accounting for 3.5% of the total of 641, which indicates that research on a just energy transition needs to be further expanded and deepened. The distribution results are shown in Table 3 below. As shown in the table, the top five countries in terms of the number of published documents are the US (191), the UK (129), China (63), Germany (54) and Australia (50). The US and UK rank first and second in terms of literature impact. The United States plays a leading role in the world economy, and its high rate of economic development and urbanization is causing it to consume more energy (Pata et al., 2022). According to a previous study, the U.S. energy system is currently undergoing a significant transition as unconventional drilling technologies have drastically increased the volume of natural gas and oil produced domestically, the cost of renewables has declined, and coal production has plummeted (Mayer, 2018), which has prompted the United States to pay more attention to the just energy transition. The Appalachian Transition and the Appalachian Regional Council (ARC) model, which may be extended to promote a just transformation, has received much attention in American studies (Snyder, 2018). Pata et al. (2022) suggests that the financial sector in the U.S. is closely linked to the renewable energy sector and that appropriate energy policies can encourage renewable energy by granting loans at a lower markup rate. The UK has also proposed to phase out coal by 2050, focusing more on the community and sustainable development path. In addition, we have found that whether countries are concerned about energy issues and whether they participate in the global energy transition process is closely related to their own level of development. China is the world's largest developing country, and it positively responds to a low-carbon economy and environmental protection in a responsible manner. Shi Xunpeng suggests that achieving a just transition requires the integration of environmental protection and economic development, early planning for the withdrawal of fossil energy, and the establishment of transparent and inclusive decision-making and implementation mechanisms to strive for an inclusive transition and development. Ning and Yang (2022) explore the legal regulatory path of China's energy transition from the perspective of energy justice.

Most of the literature on the just energy transition currently comes from more economically developed countries. A collaborative effort among countries is essential to promote a just energy transition globally. Different global economies should play an important role in leading a just energy transition. G-10 should be urged to develop more green energy, invest more in green and clean projects, and promote sustainable economic development (Zhang et al., 2015). Emerging industrialized countries, whose rapid economic development has exacerbated environmental degradation in recent years, are more

likely to make changes for a just energy transition and achieve sustainable economic development by focusing on measures such as environmental standards poverty reduction, training, and direct foreign investment (OFDI) (Zhang et al., 2021).

Interestingly, as a developing country, Pakistan has received much attention due to its energy transition and energy policies. Abbasi et al. (2021b) proposes that planning and investing in infrastructure growth is essential to meet the growing demand for electricity by analyzing electricity disasters due to failed energy policies in Pakistan; Abbasi et al. (2021c) analyzed the relationship between energy and the economy from a policy perspective, analyzed the consumption of electricity resources in Pakistan and suggested that measures should be taken to overcome electricity consumption and misuse (Table 4).

TABLE 4 Country distribution of research literature on a just energy transition.

#	Country	Recs	TLCS	TGCS
1	USA	191	84	5,076
2	UK	129	50	3,114
3	Peoples R China	63	8	2,859
4	Germany	54	18	1,218
5	Australia	50	14	1,248
6	Spain	40	1	400
7	Canada	36	3	837
8	Netherlands	36	4	1,064
9	Unknown	22	1	342
10	France	20	1	601
11	Sweden	20	4	2,559
12	Denmark	19	2	563
13	Italy	19	1	1961
14	India	17	2	347
15	Romania	16	0	56
16	Switzerland	16	2	216
17	Ireland	15	2	219
18	Finland	14	4	177
19	Japan	14	0	154
20	Portugal	13	1	268
21	Norway	12	0	228
22	Austria	11	3	390
23	Greece	10	3	125

The total local citation score (TLCS), total global citation score (TGCS), and Recs in WOSrepresent the number of records, which is limited by space constraints. This article only shows countries with ≥ 10 articles.

3.3. Hot topics

Based on the sample literature selected for this study, we can directly use the co-occurrence function of the natural language processing and visualization tool VOSviewer software to show the hot topics regarding a just energy transition. Specifically, we took the "abstract" in the literature as the analysis object of this paper, adopted the method of "all included," set the entry frequency as 9, extracted a total of 76 keywords, and then deleted the words like "review, care, access" from the selected keywords to express the entries related to the research method. Finally, a co-word map is generated (Figure 2), and three research hot topics of energy and power for sustainable development, political economy and social influence of just energy transition are obtained. We grouped the keywords we obtained, including water, dynamics and renewable energy, into the theme of sustainable development energy and dynamics to explore renewable energy and the dynamics involved in a just energy transition. We grouped policy, policies, markets, consumption and agriculture into the theme of political economy to explore the interaction between the process of a just energy transition and the economy and politics. We grouped health, gender and education into the theme of political economy to explore the social impacts of a just energy transition. Additionally, in the field of political economy, the close connection between the nodes indicates that it is a more researched and closely related topic for the impact of just energy transition.

A just energy transition is highly politicized and not merely a technological or sociotechnical issue (Healy and Barry, 2017). In fact, because it is characterized by power issues, resource allocation and access, political economy, etc., it can be said to involve a profound political struggle (Healy and Barry, 2017). Therefore, when discussing the just energy transition, it is necessary to discuss the key political obstacles and the role of politics in the energy transition, which indicates that more research in this field is essential to advocate energy justice (Goddard and Farrelly, 2018). On the economic side, the economic benefits of a just energy transition are well documented and academically agreed upon. A just energy transition can bring new jobs, boost job growth, benefit national finances, and help promote industry transformation, among other positive effects.

In terms of social life, studies on the just energy transition explore topics related to gender, family, education, health and other topics relevant to social life. Household energy transformation helps support global and national policy agendas related to everyone's access to affordable clean and sustainable energy and the transition to a low-carbon economy; a just transformation of energy can help alleviate discrimination based on gender or income (Musango and Bassi, 2021). However, in general, the literature concerning this aspect is still limited, and the topic of the social impacts of just energy transition can be expanded in the future to further enrich the relevant theory and practice.

4. Just energy transition and social impact assessment

4.1. Energy transition

Energy is a global issue. Our energy system, which is crucial to the world, is currently facing a double crisis (Rodriguez-Fernandez et al., 2022). On the one hand, with the arrival of the peak production of natural gas and oil, the world has begun to enter the stage of declining exploitation of these resources, resulting in a resource crisis. In addition, in terms of waste, the burning of fossil fuels, coal and other fuels leads to an increase in greenhouse gas emissions and an environmental crisis, thus requiring an unprecedented worldwide energy transition for the sustainable development of human society.

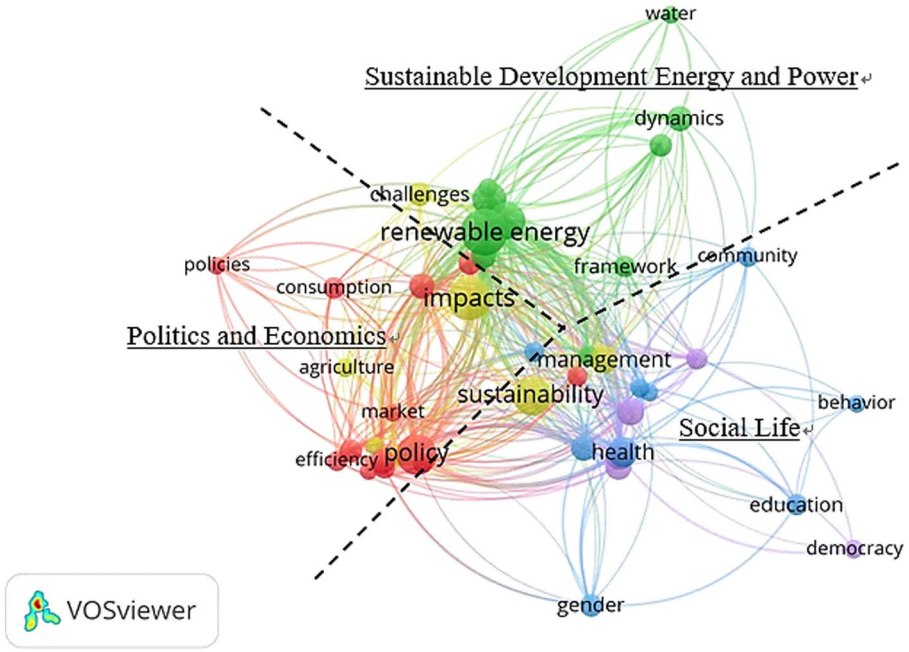

FIGURE 2
Cluster map of just energy transition research topic terms based on VOSviewer. Each node represents a keyword, the node size indicates the number of keywords mentioned, and the color indicates the cluster to which the keyword belongs. Sustainable development energy and power stand for energy and power in sustainable development; politics and economics refer to politics and the economy; and social life refers to areas such as education, health, and gender.

At present, the growth of energy consumption in developed countries is slow, as social development is gradually decoupled from energy consumption growth, and the development of distributed energy promotes a change in supply mode. With economic development, an energy science and technology revolution characterized by the deep integration of energy and information technology has emerged in this century (Zhang et al., 2015), and with the promotion of the Paris Agreement and the 2030 Agenda for Sustainable Development adopted in 2015, a new round of energy transformation has emerged. According to energy transformation theory, policy, innovation, markets and behavior are the driving factors of energy transformation. The driving mechanism of transformation is similar across countries, and the multidimensional driving factors are parallel (Fan and Yi, 2021).

Research on energy transformation has gradually gained scholarly attention. There are many studies on energy transformation and management. There is much research on the specific connotations, paths and types of energy transitions, and although relevant theoretical research has developed rapidly in recent years, there is still much room for further research. Zhang et al. (2021) proposed that the energy transition refers to the gradual replacement of fossil energy by new and renewable energy sources and the construction of a new energy supply and consumption system that is clean, low-carbon, safe and efficient by innovating low-carbon energy technologies, improving energy use efficiency, optimizing the energy supply structure and transforming energy consumption behavior. According to Shi (2021), the energy transition is not only a process of reshaping the energy system and replacing the "old" energy with "new" energy but also includes changes in the socioeconomic system. Thus, the energy transition is widely considered not only a matter of energy systems but also an issue involving socioeconomic systemic changes, such as structural changes in the economy, regional revitalization, industrial transformation, and worker retraining (Geels et al., 2017), and even influencing international relations through foreign investment and the energy trade. This shows that the energy transition is a major change that integrates economic, technological and social aspects. An energy transition is essentially the replacement of traditional fossil energy with renewable energy, but because the energy transition system involves different aspects and stakeholders with different interests, a suitable path for the energy transition should be developed according to the actual situation.

Energy transition is an important means of carbon emission reduction and a key factor affecting the low-carbon transition of the whole society. This transition requires complex sociotechnical changes with multifaceted and far-reaching implications, bringing enormous benefits and risks. The benefits include a more democratic and resilient energy system, industrial restructuring and technological progress, the alleviation of energy poverty, and attention to social and environmental legal issues within and between countries (Wang and Lo, 2021). Of course, the energy transition has positive effects on people's health and the global climate. Sievers et al. (2019) uses a macroeconomic model that takes into account regional, economic, and sectoral characteristics and finds that the net impact of the energy transition on economic growth and employment is generally positive, albeit moderate. However, there are also negative impacts of the energy transition, which are present in all aspects of the economy, politics and even ideology. The decline in traditional energy sources has resulted in massive job losses for workers in traditional energy industries, creating instability in social security. It can also exacerbate regional

imbalances in development. The injustice of the energy transition may also be reflected in the uneven distribution of benefits created by "green energy" that do not reach marginalized groups. The trend toward male dominance of high-skilled, high-paying jobs continues in renewable energy (Wang and Lo, 2021). Thus, a "just" energy transition is necessary for continued transformative development.

4.2. The just energy transition and its social impacts

"Energy justice" is defined as a global energy system that distributes the benefits and costs of energy services equitably (Sovacool et al., 2015). In the field of energy and climate, the concepts of "environmental justice," "climate justice," "development justice," and "energy justice" have received attention in recent years. Environmental justice is defined by Environmental Justice and the Schlosberg (1999) as the distribution of environmental hazards and access to all natural resources, including protection from burdens, meaningful participation in decision-making, and equity in benefits. "Climate justice" is about recognizing those who are primarily responsible and those who are victims of the current climate problem and seeking a reasonable division of responsibility for reducing carbon emissions. "Development justice" seeks to achieve the free, comprehensive and harmonious development of human beings so that the fruits of development can benefit everyone from the beginning, throughout the process and in the results of development. "Energy justice," which is centered on the idea that all individuals should have access to affordable, safe, sustainable energy that sustains a decent life, as well as the opportunity to participate in and lead energy decision-making processes and have the power to make change, is a key concept in the just energy transition.

The concept of a just energy transition originated in the trade union movement of the North American energy sector in the 1970s. The widespread dissemination of this concept occurred in the 1990s with the formation of the Just Transition Coalition. While the use of the concept of energy transition has declined in the United States over the past three decades, it has been enriched in its international meaning. Thus far, a "just energy transition" is vaguely defined as a situation where all groups have access to affordable, safe and sustainable energy and can maintain a decent lifestyle, have the opportunity to participate in the energy decision-making process, and enjoy the right to make changes (Bazilian et al., 2014). Cha and Pastor (2022) suggests that as fossil fuel activities decline, workers dependent on such activities will face negative economic and social consequences; mitigating these impacts and incorporating socioeconomic considerations into the energy transition is often referred to as a "just energy transition."

Wang and Lo (2021) discuss five themes around the concept of a just energy transition. First, transition is a labor-oriented concept. The concept of a just transition emerged from the labor movement, which saw the environment and the fate of workers as intertwined and decided to advocate for a just transition. Second, the just transition as a comprehensive framework for justice includes three dimensions: environmental justice, climate justice, and energy justice. Of these, environmental justice and climate justice share three principles of justice: distributive justice, recognition justice, and procedural justice. Climate justice is also concerned with intergenerational justice. All three justice frameworks emphasize distributive justice and procedural justice and agree that, despite the urgent need for transition, such a transition must be just and equitable in its effects and implementation. Third, just transitions are sociotechnical transitions. The global low-carbon transition is not only a sociotechnical issue but also a social equity issue. Fourth, a just transition is a governance strategy. Emphasis is placed on the need to study governance methods. Fifth, the just transition from the perspective of public perceptions explores public and community attitudes and the social impacts of a just energy transition.

Different countries, with different economic and social development and different cultural histories, adopt different measures to promote a just energy transition according to their own characteristics. To promote a just energy transition, China proposes policy measures that are tailored to local conditions, integrating environmental protection and economic development, planning ahead for an early and orderly withdrawal from fossil energy use, and establishing a transparent and inclusive decision-making and implementation mechanism (Shi, 2021). Australia has established a regulatory framework for a just transition, including the three criteria of financial support, green jobs for workers, and union and community participation, and increased exploration for better management practices to improve the likelihood of just outcomes (Goddard and Farrelly, 2018). The Netherlands proposes integrating local values and ideologies with renewable energy practices and policies with local support (Rasch and Kohne, 2017). Greece builds on a multilevel perspective to become sustainable and social justice in the post lignite era, proposing measures to create new jobs and innovate in mining lignite and aiming for increased government investment in the clean sector and citizen participation (Nikas et al., 2020). The Appalachian Transition in the United States proposes four measures to build resilient communities, create sustainable jobs, engage affected workers and communities in collaborative efforts, and secure long-term investments from a variety of sources; it also proposes to protect children's rights and develop education (Snyder, 2018).

Existing research on the social impact of a just energy transition is still at the conceptual and concrete response levels. According to Rawls' theory of justice, in essence, justice consists of having a certain degree of care for the interests of vulnerable groups under the premise of equal civil liberties and rights, while the equality of the basic rights of citizens is a higher priority and more important (Rawls, 1971). Based on the theory of justice and the law of energy transition, this paper summarizes various social impacts a of just energy transition through practical research and analyzes the basic elements and driving mechanisms of the impacts, as well as the main paths and coping mechanisms of the impacts, to form a systematic social impact theory of a just energy transition. Further studies are needed.

4.3. How can the social impacts of a just energy transition be assessed?

Social impact assessment is defined as "the process of determining the future impact of current or proposed actions on individuals, organizations, and macrosystems of society." It identifies future consequences of current or proposed actions that are relevant to individuals, organizations, and the broader system of society (Becker, 2001). The purpose of social impact assessment is to focus on the

analysis of the proposed action, including the interaction between the project and the local social and human environment, and to predict the likely social problems and impact of the implementation of the project on people's lives, community structure, population, income distribution, welfare, health, safety, education, culture, recreation, customs and community cohesion as well as how to consider these influences in decision making (Xiang, 1997).

The just energy transition goes beyond the existing fossil fuel energy paradigm and can effectively address climate change and socioeconomic issues. The impacts of a just energy transition are also multifaceted. For example, regarding the assessment of the social impact of a just energy transition, Mancini and Sala (2018) cites the mining sector as an example of its positive and negative effects in six areas: the economy, income and security; employment and education; land use and territorial aspects; population mobility; the environment, health and safety; and human rights. There is little international literature on the social impact assessment analysis of energy transitions. Most studies combine quantitative and qualitative methods with extensive empirical mathematical and empirical case studies. Hren et al. (2023) presents an overview of sustainability assessment from a life cycle assessment perspective using the water footprint, carbon footprint, ecological footprint, etc., as indicators. Mori and Christodoulou (2012) review several indicators, such as the ecological footprint, to discuss the conceptual requirements of the City Sustainability Index (CSI) to guide local governments in sustainable development. Bauer et al. (2017) discuss climate change using shared socioeconomic pathways (SSPs) and integrated assessment models (IAMs). SSPs provide a framework for assessing the socioeconomic challenges of climate change mitigation and adaptation and for analyzing broader social and environmental sustainability issues. Shah et al. (2022) proposed EFP as an upcoming tool that can be used to assess human endeavors on a planetary scale. This measure includes an understanding of environmental issues, including restrictions on energy use, global natural resource allocation, and sustainability of global resource use.

The energy transition faces different challenges in different countries due to differences in social, economic, political, and cultural contexts. Most of the country case studies in this area are in the Northern Hemisphere and OECD countries (Pai et al., 2020). Research on the just energy transition in the Southern Hemisphere has focused on labor and related inequality issues. There are also comparisons between countries involving national theories of a just transition, such as in Germany and South Africa (Hägele et al., 2022), or involving community ownership of local energy transitions, such as in Italy, Indonesia and Australia (Sarrica et al., 2018).

The relationship between justice and stability is characterized by difference, synergy, dynamic balance and overall optimization (Li and Zhang, 2005). Social injustice will increase the factors of social instability (Qin, 2003), and the injustice of energy transformation will lead to social instability (Shi, 2021). In the process of energy transformation, due to the lack of compensation for lost employment opportunities, some people are unemployed, which in turn increases the risk of social conflict. Using tools to assess the risks of social instability and then providing risk avoidance suggestions can promote social equity. In particular, the project of a just energy transition, which has a long construction cycle, involves a wide range of areas and is related to the complex real social system. Referring to the views (Li and Shi, 2011) in the preparation and planning stage of the project, many social factors can be taken into account in advance to avoid or reduce problems. Especially for the project of just energy transformation, which has a long construction cycle, involves a wide range of areas and is related to the complex real social system, referring to the views, in the preparation and planning stage of the project, many social factors can be taken into account in advance to avoid or reduce problems (Zhang et al., 2021). How to incorporate the tool of social stability risk assessment into the social impact assessment of the energy transition deserves further exploration. Abbasi et al. (2021b) used a new dynamic ARDL simulation model and 9 frequency domain causalities (FDCs) to conduct an empirical test and examined the impact of Thailand's energy consumption rate, renewable energy consumption rate, nonrenewable energy consumption rate and GDP on carbon dioxide emissions from 1980 to 2018. The results show that if Thailand does not completely change its economic environment and energy infrastructure, it will have to face the high cost of reducing carbon dioxide emissions. Among studies offering a comparative analysis between countries, the comparison between Germany and South Africa is typical. To realize potential synergies and trade-offs between a just energy transition and sustainable development and climate goals, Hägele et al. (2022) use a deductive qualitative approach to combine the theory and practice of energy justice and a just energy transition in a comparative analysis of two coal-dependent countries, Germany and South Africa. In the future, interdisciplinary and transdisciplinary research will be needed to analyze just energy transitions as a means of joint implementation of international or national climate and sustainable development goals. In addition, the energy transition has recently increasingly shifted to a paradigm based on small-scale infrastructure and short supply chains. In this new paradigm, the local dimension is crucial. In contextual studies of local communities in Italy, Indonesia, and Australia, Sarrica et al. use immersive and participatory methods that avoid prescriptive approaches to research, gain local understanding of energy and sustainability, and gain insight into local interactions between multiple forms of knowledge and power.

In general, assessing the social impacts of a just energy transition should follow a social impact assessment methodology that identifies future studies of the energy transition on individuals, organizations, and social macro-systems, and reasonably assesses the impacts of a just energy transition in terms of economy, income, and security; employment and education; land use and territorial aspects; population mobility; environment, health, and safety; and human rights. Referring to the international evaluation of social impacts of energy transition, quantitative and qualitative analyses such as life cycle assessment, shared socio-economic pathways, and integrated assessment model analysis methods can be used as references for both mathematical empirical studies and empirical case studies. In addition, the inclusion of social stability risk assessment as a tool can better promote social equity when assessing the social impacts of a just energy transition.

5. Discussion, conclusion, and policy recommendations

5.1. Discussion

This paper visually presents existing research, reviews the context of research on the social impact assessment of a just energy transition,

and summarizes the research hotspots and shortcomings of the social impact assessment of a just energy transition. On this basis, the shortcomings of current research on the theory of the social impact assessment of a just energy transition and directions for further research are discussed. The discussion is mainly carried out from three perspectives: encouraging interdisciplinary research, strengthening social impact research and drawing on the research results of social impact assessments of construction projects.

(1) Encouraging interdisciplinary research on the social impact assessment of a just energy transition. In terms of research content, the social impact assessment of a just energy transition requires both energy use research and transition-related research, as well as research related to energy policy and the social impact of policy implementation. In terms of research methods, not only quantitative research such as comprehensive assessment but also qualitative research on social impact analysis is needed. It has become necessary to encourage cross-sectional research in different disciplines. Markkanen and Anger-Kraavi (2019) note that to date, the social impacts and unequal outcomes of climate change mitigation policies have received little attention, and detailed discussion of these issues has tended to be narrow and scattered across disciplines. Additionally, interdisciplinary applications have a positive impact on energy transformation. Taking the phasing out of hard coal mining in Germany as an example, Oei et al. (2019) believe that the success of this policy lies in not only implementing the German Renewable Energy Law but also conducting scientific and reasonable evaluation, that is, first determining regional characteristics through qualitative and quantitative analysis. Economic indicators such as GDP, social indicators such as population density and geographical indicators such as mineral types developed in three interdisciplinary research projects between 2016 and 2019 were comprehensively evaluated. It can be seen that in research on a just energy transition, the combination of qualitative and quantitative methods and the cross-research methods of different disciplines such as law, economics, sociology and geography are worthy of being used as a reference.

(2) Strengthening research on the social impact of a just energy transition. Currently, research on energy use and a just energy transition is gradually increasing, but research on the social impact of a just energy transition, and social impact assessment is very limited. This is partly because the methodological challenge of capturing the full extent of the various types of common impacts has largely prevented their systematic inclusion in most quantitative policy analyses (Sonja and Harald, 2018). Therefore, for future research, this study recommends further expanding research on the social impact of a just energy transition. Specifically, the content, impact mechanisms and pathways of the social impacts of a just energy transition, as well as the impact assessment and countermeasures to eliminate the impacts, should be strengthened. In addition, some quantitative analysis methods should also be used to analyze social impact assessments. Quantitative analysis methods can be applied to evaluate research, including the construction of impact indicator systems, determination of influencing factor weights, and impact analysis methods.

(3) The research results of the social impact assessment of Engineering Construction Projects can provide implications for research on the social impact of a just energy transition. By analyzing and evaluating the positive and negative impacts of the energy transition on the goal of social justice and harmonious development, the social consequences of a just energy transition can be corrected in a timely manner and risk management can be strengthened. In the future, the application research of social impact assessment concept, assessment index system and assessment model in social impact assessment of energy transition can be strengthened. For example, with the help of the theory of social impact analysis of construction, the mechanism of social impact of just energy transition can be studied, and the framework, basic content, indicator system and method of social impact assessment of just energy transition can be proposed; With the help of the social impact assessment method of construction projects, we can study whether the fuzzy comprehensive assessment method and the hierarchical method are applicable in the fair energy transition; By using quantitative evaluation methods, evaluate the social impact of the just energy transformation, and combine the evaluation results with policy formulation to promote policy innovation and eliminate negative social impacts in the just energy transformation. In the process of social impact assessment of fair energy transformation, public participation experience in social impact assessment of construction projects can also be used to establish a public participation mechanism of fair energy transformation social impact assessment and improve public participation enthusiasm.

5.2. Conclusion

At present, the two major challenges to be addressed by the international community are environmental degradation and socioeconomic issues, in addition to three hot research areas: the sustainable development of energy, political economy and the social impact of a just energy transition. Existing studies have performed much research on the specific connotations and paths of energy transition as well as different types of energy transition and are characterized by multidisciplinary participation. Although the relevant theoretical research has developed rapidly in recent years, there is still much room for research.

"Energy justice" can be defined as a global energy system that equitably distributes the benefits and costs of energy services. The impacts of the energy transition are both positive and negative. They are primarily economic, employment and environmental. A just energy transition not only reduces fossil fuel use and contributes to environmental issues, but also promotes socially equitable development. The definition of "just energy transition" is vaguely defined by academics, and there is no universal framework to accurately define it. Although a just energy transition is not a panacea, as an engine of social development, a just and reasonable energy transition will promote sustainable economic and social development and reduce the use of fossil fuels. Social justice in energy transition is mainly achieved through a just transition, i.e., all groups should have access to energy that is affordable, safe, sustainable and capable of sustaining a decent lifestyle and have the opportunity to participate in the energy decision-making process. The impacts of a just energy transition is also multifaceted. An assessment of the social impacts of a just energy transition may encompass the economy, income and security, employment and education, land use and territory, population mobility, the environment, health and safety, and human rights. There is not much international literature on the social assessment analysis of the energy transition using SIA.

Research related to the social impacts of the just energy transition is generally lacking. Existing studies have mainly focused on studying labor issues and the distributional consequences of the transition. In terms of the social impact assessment of a just energy transition, there are even fewer relevant studies, mainly focusing on areas such as assessment concepts, contents and methods. Future research on the social impact and assessment of just energy transitions should be multidisciplinary and interdisciplinary in nature. In addition, it is necessary to strengthen theoretical research on the social impact content of a just energy transition, as well as the evaluation concept and content.

5.3. Policy recommendations

Simply decarbonizing the status quo is not energy justice, and justice and democracy cannot be ignored in the energy transition. The nations of the world should provide energy to those who do not have it, justice for those who work in and are affected by the fossil fuel economy, and try to manage the potential contradictions that can arise from pursuing energy and climate justice simultaneously.

At the practical level, specific measures to promote a just energy transition vary from country to country, but the basic measures should include creating new jobs, developing a new economy to facilitate the transition, encouraging community, trade union and public participation and understanding, increasing financial support to obtain investment, and protecting the legitimate rights and interests of the public. Policymakers should integrate climate, energy, social and structural policies and recognize local circumstances and global linkages to help guide a just and timely transition to global sustainable development. Specifically, developed countries should take stronger measures for example, Thompson (2022) argues that a ban on all fossil fuels by 2040 is necessary for other sectors, such as transportation in Canada. What is needed for a rapid policy shift is not a large target of net zero carbon by 2050 but a clear milestone every five years. In terms of the energy transition in developing countries, the theory of latecomer advantage (Lin, 2002) can provide good lessons. Regarding the energy transition, developing countries can then take advantage of the latecomer advantage to introduce technologies and equipment from advanced countries, save research costs and time, rapidly advance social development from a higher starting point, accelerate the use of clean energy, and promote leapfrog economic and social development.

For sectors and enterprises, five different types of effort can promote economic development in the energy transition process through workforce and economic diversification programs, energy assistance and climate change, expanded access to energy technologies, collective action initiatives, and new business development. In addition, strong governance structures can be extended to the public sector to ensure policies that prioritize the allocation of energy to enterprises that promote development. For enterprises, management choice plays a crucial role in resource selection (Abbas et al., 2020). These processes assume that the realization of dynamic capability value depends on the business environment and the conditions of organizational knowledge. The sustainable practice of corporate social responsibility can mediate the relationship between tax avoidance, employee behavior and sustainable business performance and contribute to corporate strategy (Li, 2019). Where job losses are inevitable, there needs to be adequate support for the people and sectors likely to lose out from the decarbonization of the economy, in the form of compensation and retraining for new jobs. Such support will also ensure that new jobs created in the low-carbon sector offer "decent" jobs paying a living wage, offering decent working conditions, being available to people with a wide range of skills, and offering clear opportunities for career development. Overall, just energy transition ensures that the intended socio-economic functions are achieved through decarbonized and renewable means of energy production and consumption and that social justice, equity and welfare are upheld.

Data availability statement

The original contributions presented in the study are included in the article/Supplementary material, further inquiries can be directed to the corresponding author.

Author contributions

ZhS: conceptualization and framework. YW and ZiS: writing—original draft. ZhS and FZ: writing—review and editing. All authors have read and agreed to the published version of the manuscript.

Conflict of interest

The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

The reviewer TJ declared a past co-authorship with the author ZhS to the handling editor.

Publisher's note

References

Abbasi, K. R., Adedoyin, F. F., and Hussain, K. (2021b). The impact of energy depletion and renewable energy on CO2 emissions in Thailand: fresh evidence from the novel dynamic ARDL simulation. *Renew. Energy* 180, 1439–1450. doi: 10.1016/j.renene.2021.08.078

Abbasi, K. R., Hussain, K., Fatai Adedoyin, F., Ahmed Shaikh, P., Yousaf, H., and Muhammad, F. (2021c). Analyzing the role of industrial sector's electricity consumption, prices, and GDP: a modified empirical evidence from Pakistan. *AIMS Energy* 9, 29–49. doi: 10.3934/energy.2021003

Abbas, J., Zhang, Q., Hussain, I., Akram, S., Afaq, A., and Shad, M. A. (2020). Sustainable innovation in small medium enterprises: the impact of knowledge management on organizational innovation through a mediation analysis by using SEM approach. *Sustainability* 12.

Barry, J. (2013). The politics of actually existing unsustainability: human flourishing in a climate changed, carbon-constrained world. *Int. J. Sustain. High. Educ.* 14:107. doi: 10.1111/1478-9302.12028_2

Bauer, N., Calvin, K., Emmerling, J., Fricko, O., Fujimori, S., Hilaire, J., et al. (2017). Shared socio-economic pathways of the energy sector–quantifying the narratives. *Glob. Environ. Change* 42, 316–330. doi: 10.1016/j.gloenvcha.2016.07.006

Bazilian, M., Nakhooda, S., and Thijs, V. D. G. (2014). Energy governance and poverty. *Energy Res. Soc. Sci.* 1, 217–225.

Becker, H. A. (2001). Social impact assessment. *Eur. J. Oper. Res.* 128, 311–321.

Cha, J. M. J., and Pastor, M. (2022). Just transition: framing, organizing, and power-building for decarbonization. *Energy Res. Soc. Sci.* 90. doi: 10.1016/j.erss.2022.102588

Chen, C. (2017). Science mapping: a systematic review of the literature. *J. Data. Inform. Sci.* 2, 1–40. doi: 10.1515/jdis-2017-0006

Chen, J., Ye, J., Liu, T., Cheng, W., and Tian, Y. (2022). Construction and evaluation of social impact system of national parks: the case of Qinling National Park. *China Garden (038-004)*.

Deng, W. (2018). A review of research progress in information visualization and analysis methods in library intelligence. *Sci. Technol. Commun.* 18:2. doi: 10.16607/j.cnki.1674-6708.2018.18.082

Fan, Y., and Yi, B. (2021). Evolution, driving mechanism, and pathway of china's energy transition. *J. Manag. World* 37, 95–105.

Gao, K. (2015). Research on the application of bibliometric analysis software VOSviewer. *J. Libr. Inf. Sci.* 25, 95–98.

García-García, P., Carpintero, Ó., and Buendía, L. (2020). Just energy transitions to low carbon economies: a review of the concept and its effects on labour and income. *Energy Res.* 70:101664. doi: 10.1016/j.erss.2020.101664

Geels, F. W., Sovacool, B. K., Schwanen, T., and Sorrell, S. (2017). Sociotechnical transitions for deep decarbonization accelerating innovation is as important as climate policy. *Science* 357, 1242–1244. doi: 10.1126/science.aao3760

Goddard, G., and Farrelly, M. A. (2018). Just transition management: balancing just outcomes with just processes in Australian renewable energy transitions. *Appl. Energy* 225, 110–123. doi: 10.1016/j.apenergy.2018.05.025

Hägele, R., Iacobuță, G. I., and Tops, J. (2022). Addressing climate goals and the SDGs through a just energy transition? Empirical evidence from Germany and South Africa. *J. Integr. Environ. Sci.* 19, 85–120. doi: 10.1080/1943815X.2022.2108459

Healy, N., and Barry, J. (2017). Politicizing energy justice and energy system transitions: Fossil fuel divestment and a "just transition". *Energy policy* 108, 451–459.

Hren, R., Vujanović, A., Van Fan, Y., Klemeš, J. J., Krajnc, D., and Čuček, L. (2023). Hydrogen production, storage and transport for renewable energy and chemicals: an environmental footprint assessment. *Renewable Sustainable Energy Rev.* 173:113113. doi: 10.1016/j.rser.2022.113113

Junping, Q. (2007). A review of domestic information resource management research. *Library Forum* 27:6.

Lin, Y. (2002). Latecomer Advantage and Latecomer Disadvantage—Debating with Professor Yang Xiaokai. *Intern. Pap.* 20:4.

Li, D. (2019). A study on the current situation and governance of corporate social responsibility fulfillment - based on listed enterprises in Zhejiang Province. *China Collective Economy* 34:2.

Li, Q., and Shi, L. L. (2011). Social impact assessment and its application in our country (in Chinese). *Acad. Circ.* 5, 23–31.

Li, L., and Zhang, S. (2005). A systematic discernment of social equity and social stability. *Science and Technology Entrepreneurship Monthly* 4:2.

Lowans, C., Rio, D., Sovacool, B. K., Rooney, D., and Foley, A. M. (2021). What is the state of the art in energy and transport poverty metrics? A critical and comprehensive review. *Energy Econ.* 3:105360.

Lu, F., and Fuhai, L. (2006). Theoretical advances in co-word analysis methods. *Journal of Library Science in China* 2, 88–92.

Mancini, L., and Sala, S. (2018). Social impact assessment in the mining sector: review and comparison of indicators frameworks. *Resour Pol.* 57, 98–111. doi: 10.1016/j.resourpol.2018.02.002

Markkanen, S., and Anger-Kraavi, A. (2019). Social impacts of climate change mitigation policies and their implications for inequality. *Clim. Policy* 19, 1–18.

Mayer, A. (2018). A just transition for coal miners? Community identity and support from local policy actors. *Environ. Innov. Soc. Trans.* 28:6. doi: 10.1016/j.eist.2018.03.006

Mori, K., and Christodoulou, A. (2012). Review of sustainability indices and indicators: Towards a new City Sustainability Index (CSI). *Environ. Impact Assess. Rev.* 32, 94–106.

Musango, J. K., and Bassi, A. M. (2021). Towards a systemic assessment of gendered energy transition in urban households. *Energies* 14:7251.

Naqvi, S. A. A., Shah, S. A. R., Anwar, S., and Raza, H. (2020). Renewable energy, economic development, and ecological footprint nexus: fresh evidence of renewable energy environment Kuznets curve (RKC) from income groups. *Environ. Sci. Pollut. Res.* 28, 2031–2032. doi: 10.1007/s11356-020-10485-w

Nikas, A., Neofytou, H., Karamaneas, A., Koasidis, K., and Psarras, J. (2020). Sustainable and socially just transition to a postlignite era in Greece: a multlevel perspective. *Energ. Source. Part B* 15, 513–544. doi: 10.1080/15567249.2020.1769773

Ning, L., and Yang, X. (2022). The legal regulation path of China's energy transition in the perspective of energy justice. *Journal of Shandong University (Philosophy and Social Science Edition)* 2, 175–184. doi: 10.19836/j.cnki.37-1100/c.2022.02.016

Oei, P. Y., Brauers, H., and Herpich, P. (2019). Lessons from Germany's hard coal mining phase-out: policies and transition from 1950 to 2018. *Clim. Policy* 20, 1–17

Pai, S., Harrison, K., and Zerriffi, H. (2020). *A Systematic review of the key elements of a just transition for fossil fuel workers*; Smart Prosperity Institute: Ottawa, ON, Canada,

Pata, U. K., Yilanci, V., Zhang, Q., and Shah, S. A. R. (2022). Does financial development promote renewable energy consumption in the USA? Evidence from the Fourier-wavelet quantile causality test. *Renew. Energy* 196, 432–443. doi: 10.1016/j.renene.2022.07.008

Qin, Y. (2003). A brief discussion on social justice and social stability in China. *Xinjiang Social Science Forum* 5:3.

Rasch, E. D., and Kohne, M. (2017). Practices and imaginations of energy justice in transition. A case study of the Noordoostpolder, the Netherlands. *Energy Policy* 107, 607–614. doi: 10.1016/j.enpol.2017.03.037

Rawls, J. (1971). A theory of justice. *Rawls. the Belknap.* doi: 10.4159/9780674042605

Rodriguez-Fernandez, L., Carvajal, A. B. F., and de Tejada, V. F. (2022). Improving the concept of energy security in an energy transition environment: application to the gas sector in the European Union. *Extr. Ind. Soc. Int. J.* 9, 1–2. doi: 10.1016/j.exis.2022.101045

Sarrica, M., Richter, M., Thomas, S., Graham, I., and Mazzara, B. M. (2018). Social approaches to energy transition cases in rural Italy, Indonesia and Australia: iterative methodologies and participatory epistemologies. *Energy Res. Soc. Sci.* 45, 287–296. doi: 10.1016/j.erss.2018.07.001

Schlosberg, D. (1999). Environmental justice and the new pluralism: The challenge of difference for environmentalism. *Environ. Ethics* 23, 109–110.

Shah, S. A. R., Naqvi, S. A. A., Anwar, S., Shah, A. A., and Nadeem, A. M. (2022). Socio-economic impact assessment of environmental degradation in pakistan: fresh evidence from the markov switching equilibrium correction model. *Environ. Dev. Sustain.* 1, 1–31. doi: 10.1007/s10668-021-02013-8

Shi, X. (2021). People-centered energy transition for equity and justice. *Environ. Econ. Res.* 6:7. doi: 10.19511/j.cnki.jee.2021.03.001

Sievers, L., Breitschopf, B., Pfaff, M., and Schaffer, A. (2019). Macroeconomic impact of the German energy transition and its distribution by sectors and regions. *Ecol. Econ.* 160, 191–204. doi: 10.1016/j.ecolecon.2019.02.017

Snyder, B. F. (2018). Vulnerability to decarbonization in hydrocarbon-intensive counties in the United States: a just transition to avoid postindustrial decay. *Energy Res. Soc. Sci.* 42, 34–43. doi: 10.1016/j.erss.2018.03.004

Sonja, K., and Harald, W. (2018). Building equity in: strategies for integrating equity into modelling for a 1.5°C world. *Philos. trans.* 376:20160461.

Sovacool, B., Dworkin, K., and Michael, H. (2015). Energy justice: conceptual insights and practical applications. *Appl. Energy* 142, 435–444. doi: 10.1016/j.apenergy.2015.01.002

Thompson, S. (2022). Green renewable power and policy in Canada: a just energy transition to net-zero. *J. Geosci. Environ. Prot.* 10, 1–12. doi: 10.4236/gep.2022.103001

Tian, J. (2014). A comparative analysis of information visualization analysis tools – CiteSpace, HistCite and RefViz as examples. *Libr. Stud.* 14:7. doi: 10.15941/j.cnki.issn1001-0424.2014.14.016

Vanclay, F. (2006). Principles for social impact assessment: A critical comparison between the international and US documents. *Environ. Impact Assess. Rev.* 26, 3–14.

Vanegas Cantarero, M. M. (2020). Of renewable energy, energy democracy, and sustainable development: a roadmap to accelerate the energy transition in developing countries. *Energy Res. Soc. Sci.* 70:101716. Available at:. doi: 10.1016/j.erss.2020.101716

Wang, X. X., and Lo, K. (2021). Just transition: a conceptual review. *Energy Res. Soc. Sci.* 82, 7–9. doi: 10.1016/j.erss.2021.102291

Xiang, Q. (1997). Review of "project social evaluation methods". *Stud. Dialect. Nature* 13:4. doi: 10.19484/j.cnki.1000-8934.1997.06.006

Zhang, Y., Ming, S., Guang, Y., and Lei, T. (2015). World energy transition development and implications for China. *Macroecon. Manag.* 12:3. doi: 10.19709/j.cnki.11-3199/f.2015.12.013

Zhang, Z., Binbin, P., Wei, X., Hua, L., Baojun, T., Xiaoli, Z., et al. (2021). Scientific research issues in the field of energy transition and management. *J. Manag. Sci.* 24, 147–153. doi: 10.19920/j.cnki.jmsc.2021.08.016

Glossary

LCS	Local citation score
TLCS	Total local citation score
TGCS	Total global citation score
TLCS/t	Total local citation score per year
TGCS/t	Total global citation score per year
ARC	The Appalachian Transition and the Appalachian Regional Council
CSI	City sustainability index
SSPs	Shared socioeconomic pathways
IAMs	Integrated assessment models
OECD	Organization for Economic Co-operation and Development
ARDL	Auto regressive distribute dlag
OFDI	Outward foreign direct investment
FDC	Frequency domain causality
SIA	System impact assessment
EFP	Ecological footprint
GTFP	Green total factor productivity
DEA-DFF	Data envelopment analysis and directional distance function
CCS	Carbon capture and storage