

Review

Drivers of green energy transition: A review

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ARTICLE INFO

Keywords:

Climate change
Green energy transition
Sustainable future
Conceptualisation

ABSTRACT

The pressing need for substantial actions to address climate change is globally recognised, notably through initiatives like the Green Energy Transition (GET) to foster a sustainable future. Despite this global acknowledgement, traditional energy sources maintain their dominance in the worldwide energy sector, with fossil fuels and solid biomass accounting for about 75% of total global Greenhouse Gas (GHG) emissions. The escalating GHG emissions levels directly threaten the climate, leading to global warming and adverse environmental consequences. A systematic literature review was employed to comprehensively examine the conceptualisation and drivers of the GET. The study identified Economic, Social, Political/Legal, Technological, and Environmental factors as drivers of GET. The study revealed diverse perspectives among researchers in conceptualising the GET, with a prevailing consensus that it is a global shift from carbon-intensive to sustainable and low-carbon emission energy alternatives and associated technologies. Predominantly, sustainability transition theories emerged as the most frequently applied conceptual frameworks. Commonly utilised tools for data analysis included Autoregressive Distributed Lag and Generalized Methods of Moments. Recognising the critical role of GET in mitigating GHG emissions and addressing climate change, the results underscore the importance of addressing the identified factors propelling the transition.

1. Introduction

The need for a worldwide shift towards Green Energy Transition (GET) has been underscored by IRENA (2019a), emphasising the necessity for all countries to address this critical issue. The international community has increasingly recognised the urgency for substantial actions to combat climate change through initiatives such as the GET (IRENA, 2019b; UNDP, 2021). Reacting to climate change and endorsing sustainable development necessitates a transformative approach in the worldwide energy sector, which is currently dominated by traditional energy, such as fossil fuels and solid biomass. These conventional sources contribute significantly to the GHG emissions crisis, accounting for over 75% of the total global emissions (IRENA, 2017; UNEP, 2022).

The escalating levels of GHG emissions pose a direct threat to the climate, leading to global warming and adverse environmental consequences (Carvalho et al., 2019). Despite efforts to address climate change, Earth has already faced a 1.1°C rise in temperature since the late 1800s, with projections indicating a potential rise of 1.4~5.8°C by the end of the century (IPCC, 2001; UNEP, 2022). The persistent rise in GHG emissions exacerbates the impact on human health, contributing to the

prevalence of diseases (WHO, 2023). The adverse effects of traditional energy sources are also evident in economic costs, with these sources causing \$2.9 trillion in combined economic and health costs in 2018 alone (WHO, 2023). Additionally, the increased use of solid biomass is responsible for deforestation and environmental degradation, further complicating climate change challenges (Kyaw et al., 2020).

Considering the immediate need to address these issues, a transition to green energy sources that reduce or eliminate GHG emissions is imperative. The GET emerges as a pivotal solution to meet the carbon zero goal by 2050 and achieve net GHG emissions by 2060–2070, aligning with the targets established under the 2015 Paris Agreement and Sustainable Development Goals, especially goals seven (7) and thirteen (13) (Elavarasan et al., 2023; UNTC, 2016).

Energy transition encompasses various perspectives, including the dominance of energy resources in the market over time, evolving energy conversion methods, and changes in socio-technical systems (Geels and Schot, 2010; Melosi, 2010; Smil, 2013). It involves complex, nonlinear processes with uncertain outcomes, influenced by multiple actors and feedback loops (Geels et al., 2018). The comprehension of energy transition extends to changes in fuel sources and associated technologies for

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energy generation (Hirsh and Jones, 2014), and it plays a crucial part in moulding energy consumption patterns within a society (Coronil, 2019).

GET is the gradual replacement of the worldwide energy structure, currently reliant on traditional sources, with an establishment anchored on green energy sources (Rodríguez, 2022). Green energy sources do not produce net positive emissions, distinguishing them from fossil fuels and solid biomass, which contribute to climate change through harmful emissions (EIA, 2020). While a standardised definition of GET remains elusive in academic literature, recent research suggests that it involves a multifaceted blend of technological, economic, political, behavioural, institutional, demographic, legal, ecological, and social changes (Pangriya and Singh, 2021; Sankhyayan and Dasgupta, 2019; Valeria Jana Schwanitz, 2020).

Despite the increasing attention to sustainability through GET and climate change, more extensive literature analysis is needed on the GET. Many existing studies treat it as a subtopic or focus on limited drivers. Moreover, there is a gap in exploring how the conceptualisation of the GET has evolved. This research aims to bridge these gaps by providing clear and concise conceptualisations and an analysis of the drivers of GET. Additionally, the study seeks to contribute to the broader understanding of GET. These gaps are achieved by providing answers to the following guiding questions.

- RQ1. How is the Green Energy Transition conceptualised?
- RQ2. What are the drivers of the Green Energy Transition?
- RQ3. Which theories and methodologies are applied to study Green Energy Transition?
- RQ4. What are potential research gaps that need to be addressed in the future?

2. Materials and methods

2.1. Systematic review

A systematic review methodology was employed to analyse existing research on the green energy transition over the past 34 years (1990–2024). A systematic literature review was chosen for the study because it provides a robust method to thoroughly examine relevant literature, including journal articles and gray literature, to address the research questions (Aveyard, 2019; Litte et al., 2008). This method ensures explicit and reproducible procedures for systematically identifying, selecting, evaluating, and synthesising pertinent published literature to answer the research question (Litte et al., 2008). Additionally, it involves formulating a comprehensive review protocol with a well-defined literature-searching strategy and eligibility criteria for the inclusion and exclusion of studies. Eligible journal articles, reports, and books undergo screening and objective evaluation for relevance and quality. In this study, procedures proposed by Denyer and Tranfield (2009) were adopted and elaborated in the following Sections.

2.2. Material collection

To ensure the selection of appropriate documents and articles for the systematic literature review, the following procedures guided the process.

2.2.1. Database selection

The focus was placed on databases providing metadata and abstracts, including information such as year of publication, journal title, volume, issue, and Digital Objective Identifier (DOI) number. Science Direct and Taylor & Francis were chosen due to their extensive coverage of peer-reviewed academic literature and their prevalence in bibliometric analyses. Google Scholar was also considered, especially for gray literature. Most studies in green energy transition are published by the journals covered in these databases.

2.2.2. Selection of journals

The leading journals publishing work on green energy transition were identified based on the cite factor and ABCD ranking. Forty-nine (49) journal articles were collected from forty (40) journals. Gray literature was sourced separately using Google General. Fifteen (15) reports from reputable organisations like the United Nations, World Bank, International Renewable Energy Agency, and International Energy Agency were identified and included for synthesis.

2.2.3. Material/content collection

The systematic selection of articles and documents commenced with defining critical search (Boolean) expressions. Search strings such as “Green Energy Transition,” “Renewable Energy Transition,” “Clean Energy Transition,” “Sustainable Energy Transition,” “Low-carbon Energy Transition,” and “Modern Energy Transition” were used. The search included “Allintext” and “Allintitle” search operators to ensure comprehensive coverage of articles and documents related to the GET. Fig. 1 indicates the output of the search strategy by April 9, 2024.

2.2.4. Criteria for exclusion and inclusion

2.2.4.1. Inclusion criteria. This study considered articles and documents published from 1990 to 2024, including those under press but accepted for publication. Since the scholar is more conversant with the language, only records written in English were included.

2.2.4.2. Exclusion criteria. Articles with high scientific content, technical reports, and conference papers were excluded. Mendeley soft was used to eliminate duplicates from the collected data.

2.2.5. Full article text review

The studies in this review utilised a diverse range of research and analytic approaches, encompassing quantitative and qualitative studies with various modeling and analysis techniques.

2.2.6. Data charting and analytical categories

For the 64 selected articles and documents, data extraction and coding were carried out using an Excel file. The file was designed to capture and characterise the details of each study. The data was organised into categories and themes, as shown in Table 1.

3. Synthesis of reviewed literature

This section analyses the 64 papers and documents reviewed, as summarised in Appendix A.

3.1. Annual distribution and evolution of green energy transition

Fig. 2 illustrates the annual distribution of articles and documents on the Green Energy Transition from 1990 to 2024 (see Table 2). The data reveals a noteworthy trend in the emergence of GET research, with publications dating back to the 1990s (Marschoff, 1998) and early 2000s (Murphy, 2001; SAGPI, 2014). Over the years, there has been a substantial increase in interest and scholarly contributions to this field. Notably, the momentum has accelerated, with 37% (24 out of 64) of the reviewed papers and documents being published in 2023. This surge in recent publications signifies the growing importance and relevance of Green Energy Transition as a research focus in addressing contemporary environmental challenges.

3.1.1. Distribution of the articles according to the publication journal

The articles synthesized in this review were published in several journals, as shown in Table 3. Economic research journal, energy policy journal, and energy reports journal all published three articles, each constituting 7.32%, totalling 21.96% of all the articles included

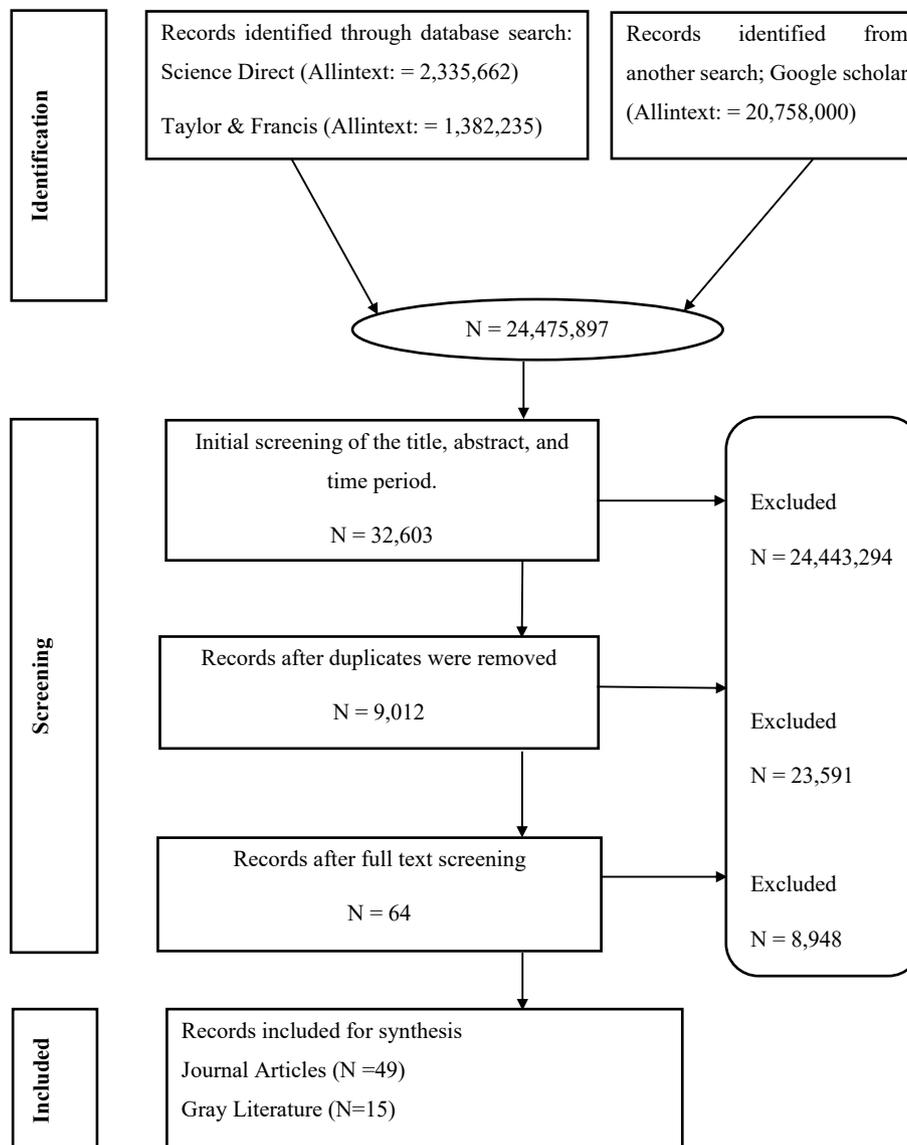


Fig. 1. Flowchart for studies selection.

Table 1 Analytical categories.

Category	Category description
Year of publication	The specific year in which the article or document was published.
Methodologies	Approaches employed by the study
a Data analysis tools and techniques	Analysis technique used for data analysis
b Theories	Theories applied by the researcher in their studies
c Conceptualisation	Articles and documents were categorised based on conceptualisations derived from the literature.
Drivers	Categorisation of drivers of Green Energy Transition into Economic, Social, Technological, Political/Legal and Environmental

in this study. Several journals, including *Energies Journal*, *Energy Strategy Reviews*, *Environmental Innovation and Societal Transitions*, *Journal of Environmental Management*, *Journal of Cleaner Production*, *Renewable and Sustainable Energy Reviews*, *Renewable Energy and Resources Policy*, published at least two articles in this data set. The rest of the remaining journals published at least one article.

3.2. Methodologies adopted in the reviewed studies

3.2.1. Data analysis tools and techniques

Table 3 shows an overview of the data analysis techniques employed in the study of green energy transition. Notably, the Autoregressive Distributed Lag (ARDL) method is the most frequently utilised, constituting 44.7%. Following closely is the Fully Modified Ordinary Least Squares (FMOLS), accounting for 13.16%, Generalized Method of Moments (GMM) (7.89%) and Dynamic Ordinary Least Squares (DOLS) (5.26%). The other methodologies each represent 2.63%.

The Autoregressive Distributed Lag (ARDL) procedure was introduced by (Pesaran et al., 2001; Pesaran & Shin, 1998) to address the limitations of traditional cointegrating models. This approach facilitates both short and long-term analyses, which is particularly beneficial for small sample sizes and integrated variables of varying orders (I(0) or I(1)). Advantages of employing ARDL include accurate analysis of variable dynamics, resolution of indigeneity issues, and the utilisation of bounds testing for integrated variables of I(0) or I(1), or a combination of both.

The Generalized Method of Moments (GMM), proposed by Karl Pearson in 1894 and later endorsed by Hansen (1982) as a

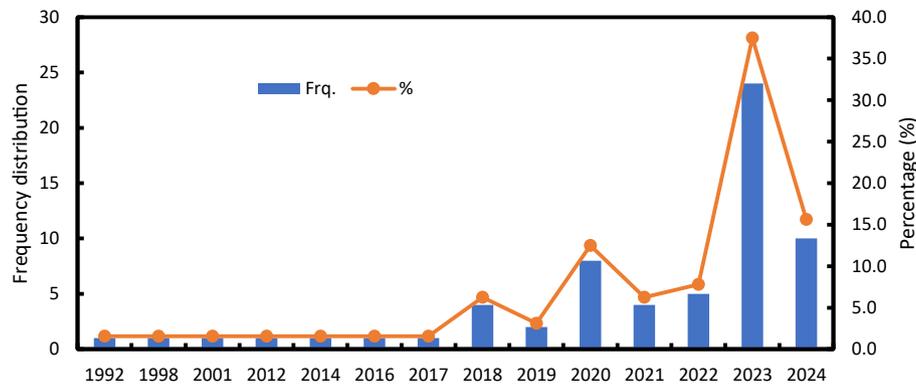


Fig. 2. Distribution of the reviewed journal articles and documents based on their year of publication.

Table 2
Distribution of the articles according to the journals.

JOURNAL	Freq.	IF	%
Business Strategy and the Environment	1	2.29	2.5
Economic Research	3	1.3	7.5
Energies	2	3.2	5
Energy Economics	1	7.042	2.5
Energy Nexus	1	5.2	2.5
Energy Policy	3	9	7.5
Energy Reports	3	4.937	7.5
Energy Research & Social Science	1	6.7	2.5
Energy Strategy Reviews	2	8.2	5
Environment and Planning	1	4.2	2.5
Environmental challenges	1	8.7	2.5
Environmental Innovation and Societal Transitions	2	13.1	5
Environmental Science and Pollution Research	1	5.8	2.5
Frontiers in Environmental Sciences	1	10.3	2.5
Future Business Journal	1	2.1	2.5
International Journal of Environmental Research and Public Health	1	4.614	2.5
International Journal of Hydrogen Energy	1	7.2	2.5
Journal of Cleaner Production	2	11.1	5
Journal of Environmental Management	2	8.7	5
Renewable and Sustainable Energy Reviews	2	15.9	5
Renewable and Sustainable Energy Transition	1	3.191	2.5
Renewable Energy	2	8.7	5
Resources Policy	2	10.2	5
Springer Nature Switzerland	1	1.31	2.5
Technological Forecasting and Social Change	2	12	5
Total	40		100

Table 3
Data analysis and techniques.

Data Analysis Techniques	Frequency	Percentage
Fully Modified Ordinary Least Squares (FMOLS)	5	13.16
Feasible Generalized Least Square (FGLS)	1	2.63
Dynamic Ordinary Least Squares (DOLS)	2	5.26
Generalized Method of Moments (GMM)	3	7.89
Autoregressive Distributed Lag (ARDL)	17	44.73
Granger causality	1	2.63
Panel Corrected Standard Error (PCSE)	1	2.63
Heterogeneous panel data Fixed-Effects estimation techniques	1	2.63
Robust Driscoll–Kraay Standard Errors	1	2.63
Phillips – Perron (PP)	1	2.63
Augmented Dickey-Fuller (ADF)	1	2.63
Bayer-Hank, Gregory, and Hansen cointegration	1	2.63
Vector Error Correction Model (VECM)	1	2.63
Canonical Cointegration Regression (CCR)	1	2.63
Quantile Regressions (QR)	1	2.63
TOTAL	38	100

generalisation of the method of moments, it minimises a specific norm of the sample averages of moment conditions. GMM can be viewed as a case of minimum distance estimation (Hayashi, 2000). GMM estimation necessitates misspecification tests to assess the suitability of regression outcomes, including first and second-order serial correlation tests (Sun et al., 2023a, 2023b). The fully Modified Ordinary Least Squares eradicate the challenges triggered by the long-run correlation between the cointegrating equation error and stochastic regressor innovations.

3.2.2. Theories applied by the reviewed studies

Fig. 3 outlines the theories used while studying green energy transition. Notably, the Multi-Level Perspective (MLP) (15%) appeared as the most utilised, followed by the Transition Management Theory (TMT) (10%), with the remaining 5% distributed across other theories. It is pertinent to highlight that only 17 records in the review applied a theory to analyse the Green Energy Transition.

Rooted in socio-technical transitions, MLP theory posits that transition arises from interactions among various actors at the niche, regime, and landscape levels (Frank, 2002; Smith et al., 2010). Developed by Rip and Kemp (1998), MLP draws from historical transition explanations and accentuates the socio-technical landscape's influence on niche and regime dynamics. It perceives transition as a non-linear process shaped by developments across three analytical levels (Frank, 2002; Geels and Schot, 2007; Rip and Kemp, 1998; Wittmayer et al., 2016).

The TMT is conceived to address contemporary complex challenges, serves as an intellectual outline utilising a historical dialectical method for understanding future policy on transitions (Loorbach, 2010). This theory emphasises collaborative governance and stakeholder engagement among policymakers, businesses, and civil society to formulate effective strategies for the Green Energy Transition (Loorbach, 2010). The dynamic and coevolutionary nature of TMT brings actors together to create aligned visions and goals, presenting valuable insights for policymakers (Greene-dewasmes, 2021).

Strategic Niche Management (SNM) explains transition as a regime change resulting from bottom-up niche innovation that eventually alters or substitutes existing establishments (Frank and Schot, 2010; Rip and Kemp, 1998). SNM posits that well-built technological niches can expedite sustainable innovation paths (Geels and Schot, 2007; Van den Bosch, 2010), creating protected spaces for experimentation in tandem with the reciprocal development of technology, user behaviour, and regulations. Furthermore, diverse theories, such as Polyanian-inspired IR theory, Antonio Gramsci's theory on hegemony, 'varieties of capitalism' perspective, socio-technical transition studies, and institutionalism theory, are employed to offer comprehensive insights into the intricate dynamics of green energy transition (Aligica and Tarko, 2012; Manfred and Simone, 2020; Thiel, 2016). Each theory contributes distinct perspectives, enhancing our understanding of the multifaceted nature of this transition.

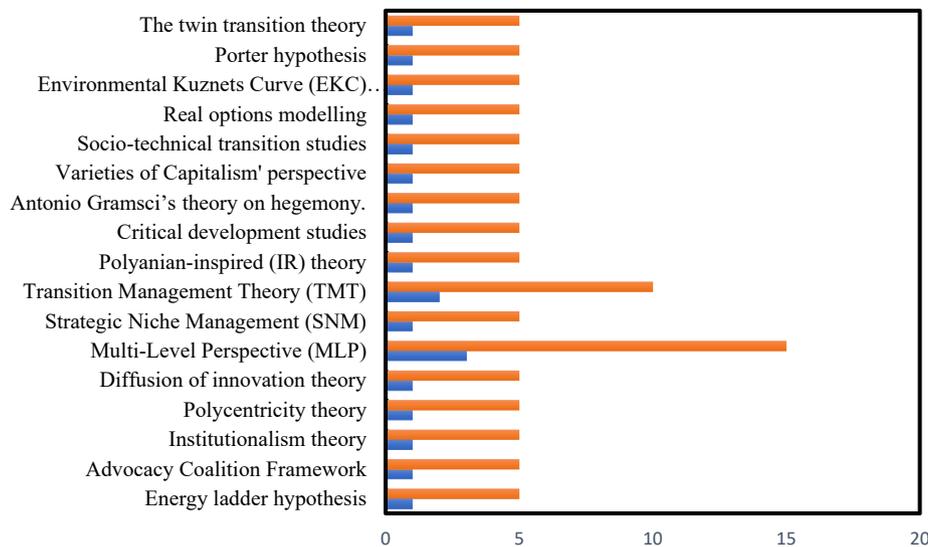


Fig. 3. Theories adopted by the reviewed studies.

3.3. Analysis

3.3.1. Conceptualisation of green energy transition

Table 4 shows the analysis regarding different scholars' varied conceptualisations of the green energy transition. Findings in Table 4 revealed that most of the reviewed articles and documents emphasised 'green' as an environmentally friendly and sustainable energy transition. Different scholars and reputable organisations have conceptualised Green Energy Transition with a focus on switching from energy sources that harm the environment to environmentally friendly and sustainable sources (SAGPI, 2014; IRENA, 2017, 2018; Naidoo, 2019; Lindberg,

Table 4
Conceptualisation of Green energy transition.

Description	Reference
GET is the transformation of the global energy sector from fossil fuel-based to zero carbon.	IEA, 2022
GET refers to the actions taken by economies to meet national pledges towards a green economy.	Greene-dewasmes (2021)
GET is a global phenomenon that entails both economic and technical changes in the energy industry, with energy generation and consumption as a key response to climate change.	IEA (2018)
GET refers to the process of switching from traditional energy sources to renewable and sustainable energy sources.	IEA (2017)
GET is the process of transforming the global energy system from the consumption of fossil fuels to low-carbon technologies to achieve the global goal of limiting climate change.	World Bank (2023)
GET is a human attempt to substitute environmentally unfriendly sources with sustainable energy.	Rasoulinezhad et al. (2023)
GET is a process of shifting a country's fossil fuel energy system to renewable energy.	UN-WIDER (2017)
GET is a vital component of meeting sustainable development, especially the SDGs seven (07) and thirteen (13) goals	Elavarasan et al. (2023)
GET is a process under which the energy sector goes through a sustainability transformation primarily catalysed by climate policy	Lindberg (2020)
GET is a process that involves guiding technological, governance, and social systems towards environmental alternatives.	Naidoo (2019)
GET is a structural change of the electricity sector to a low-carbon system by driving improvement in finance, technology, and policy	SAGPI (2014)

2020; Greene-dewasmes, 2021; IRENA & CPO, 2022; Elavarasan et al., 2023; Rasoulinezhad et al., 2023; World Bank, 2023).

3.3.2. Drivers of GET

The drivers influencing the green energy transition have been classified into economic, social, political/legal, technological, and environmental factors. As illustrated in Table 5, economic factors took precedence, with forty-eight (48) papers highlighting their significance. Political/Legal factors were the focus of seventeen (17) papers, technological aspects were discussed in twelve (12) papers, social factors garnered attention in twelve (12) papers, and environmental factors were the least emphasised, appearing in only seven (07) papers.

In addition to individual factors, economic growth was prominently featured and discussed in fourteen (14) papers, followed by financial development noted in seven (07) papers and concerns related to climate change/environment and Technology innovation, each mentioned in five (05) papers. GDP per capita was discussed in six (06) papers. At the same time, regulatory changes or additional policy incentives, public pressure for action on climate change, direct and indirect effects of foreign direct investment, human capital, and industrialisation were covered in three (03) papers. Additionally, several factors, including inflation, energy prices, foreign direct investments, environmental and carbon taxes, governance quality, control of corruption/lower corruption levels, institutional quality, favourable policy frameworks, carbon intensity/CO₂ emissions per capita and Artificial intelligence, were identified in two (02) papers, with the remaining factors reported in only one paper.

4. Discussion

The primary goal of this research was to understand the conceptualisation of the Green Energy Transition and its drivers. The review unveiled diverse conceptualisations and drivers associated with GET, as discussed in the following sub-sections.

4.1. Conceptualisation of GET

The concept of Green Energy Transition has been defined from various perspectives, necessitating an exploration of how scholars across time have conceptualised energy transition, specifically Green Energy Transition. Lindberg (2020) conceptualised GET as a transition toward sustainable practices within the energy sector, which is predominantly propelled by policies aimed at climate change mitigation and Elavarasan

Table 5
The summary of the drivers of Green energy transition.

Drivers	Number of studies
Economic	48
Economic growth	14
Industrialisation	3
Green financial innovation	1
Eco-financing	1
Economic openness	1
Inflation	2
GDP per capita	6
Financial development	7
Foreign Direct Investment	3
Income inequality	1
Research and development	1
Energy prices	2
Household net income	1
Lower real debt	1
Environmental Carbon taxes	2
Total Factor Productivity (TFP)	1
Rising prices of Oil	1
Social	12
Direct and indirect effects of human capital	3
Social imbalance	1
Population growth	1
Education Index	1
Public pressure for action on climate	3
Higher stakeholder participation	1
Class structures	1
Gender-Based customs and norms	1
Technological	12
Technological change	1
Artificial Intelligence	2
Technology innovation	5
Declining cost of green energy technologies	1
Efficiency	1
Short installation time	1
Ease of maintenance	1
Political/Legal	17
Control of corruption/Lower corruption levels,	2
Rule of Law	1
Voice and accountability	1
Institutional quality	2
Governance quality	2
Climate/Environmental policy	1
Regulatory changes or additional policy incentives	3
Favourable policy frameworks	2
Environmental governance	1
Governmental legal actions related to environmental issues	1
Local resource management regimes	1
Environmental factors	7
Carbon intensity/CO ₂ emissions	2
Climate change/Environmental concern	5

et al. (2023) highlighted it as vital for meeting sustainable development goals, especially SDGs seven (07) and thirteen (13). Moreover, the IRENA (2022) GET represents the journey of reshaping the worldwide energy sector from reliance on fossil fuels to a carbon-neutral framework. From an international perspective, Fouquet and Pearson (2012) defined Energy Transition as a change in energy and relevant technologies while Blazquez et al. (2019) saw it as a process of switching from an economic system reliant on particular sources of energy and technologies to a different one. Sovacool (2016) presented energy transition as a 'mainstream' view, considering it a long-term process taking decades to centuries to unfold. All the outlined conceptualisations align in acknowledging that GET is a global solution for climate challenges involving significant economic and technical changes within the energy sector. These changes encompass energy production, supply, distribution, and use, intended to minimise the climate change associated with the energy industry (IRENA, 2018).

Scholars define energy transition and green energy transition across various periods, perspectives, and contexts. IRENA (2018) asserts that GET is a change from traditional to sustainable and environmentally

friendly energy sources. Considering the diverse conceptualisations in the literature, this study defines GET as the global shift of the energy sector from traditional to green energy and technologies, as guided by SDG 7 and the Paris Agreement. The traditional energy sources, which include fossil fuels (crude oil, coal, and natural gas) and unsustainable solid biomass (such as wood and charcoal), emit carbon dioxide emissions. In contrast, green energy sources replenish naturally and emit zero to minimal or insignificant carbon emissions. Green energy includes solar, hydropower (water), wind, geothermal, and sustainable biomass (such as agricultural and municipal wastes).

4.2. Drivers of green energy transition

Different studies have explored the Green Energy Transition, each shedding light on various driving factors, as outlined in Table 5. The distribution of emphasis across these categories reflects the diverse nature of drivers influencing the green energy transition. Specifically, Economic, Political/Structural, Social, Technological, and Environmental factors collectively contribute to shaping the transition to sustainable and environmentally friendly energy alternatives. The following sections delve into the nuances of each factor, providing insights into their respective impacts on the GET.

4.2.1. Economic factors

Economic factors have garnered significant attention, evident in the substantial coverage across past studies (48), as depicted in Table 5. However, the primary focus in many studies appears to centre on economic growth, as noted by (Chien et al., 2023; Sadiq et al., 2023; Prempeh, 2023; Rasoulinezhad et al., 2023; UN, 2021a, 2021b; Yu and Guo, 2022), followed by financial development as observed in works such as those by (Asongu and Odhiambo, 2020; Bhamidipati, 2019; Mazzucato and Semi-eniuk, 2018; Nawaz and Rahman, 2023; Prempeh, 2023; SAGPI, 2014).

Several studies emphasised the association between economic growth and Green Energy Transition. Studies (Chien et al., 2023; Sadiq et al., 2023; UN, 2021a, 2021b) found positive links between economic growth, inflation, and sustainable or green energy consumption. However, Prempeh (2023) presented a different perspective, revealing a diverse effect of economic growth on the Green Energy Transition in Ghana. Similarly, Yu and Guo (2022) explored the effect of economic growth on China's Green Energy Transition, determining a negative long-term effect.

GDP per capita emerged as a recurrent identifier in numerous studies predicting green energy transition (Nawaz and Rahman, 2023; Oluoch et al., 2021; Serrano and Zaveri, 2020; Tudor and Sova, 2021). For example, Oluoch et al. (2021) emphasised its significant and positive association with the green energy transition, drawing from autoregressive distributed lag panel models. Similarly, Tudor and Sova (2021) explored the effects of Research and Development alongside GDP per capita, showcasing their role in promoting sustainable energy consumption in high-income economies.

For instance, Nawaz and Rahman (2023) employed panel-corrected standard error and feasible generalized least squares methods to scrutinise the influence of financial development on the Green Energy Transition in Sub-Saharan Africa. Their findings stressed the strategic significance of financial development reforms in driving the transition. Similarly, Sun et al. (2023a, 2023b) took a worldwide viewpoint, utilising a dynamic model and panel data of 103 countries to reveal the positive influence of financial development on energy transition at a macro level. Prempeh (2023) contributed insights into the long-term effects of financial development on the Green Energy Transition in Ghana, noting its role in accelerating renewable energy usage.

Notably, Lam et al. (2023) conducted a comprehensive investigation using Dynamic Auto-regressive Distributed Lags, exploring the impact of green financial innovation, eco-financing, carbon taxes, inflation, industrialisation and economic openness on the Green Energy Transition in Vietnam. Their empirical results underscored the positive and significant

linkages between these variables and green or sustainable energy transition.

Furthermore, [Asongu and Odhiambo \(2020\)](#) delved into the intersection of financial development, income inequality, and renewable energy consumption in Sub-Saharan Africa. Through the Generalized Method of Moments, they highlighted the promotion of green energy transition by financial development, contrasting with the countering effect of income inequality.

Industrialisation was identified as another pivotal factor positively affecting the Green Energy Transition ([Lam et al., 2023](#); [Rasoulinezhad et al., 2023](#)). However, [Chien et al. \(2023\)](#) presented diverging views, revealing no discernible effect of industrialisation on energy transition. Foreign Direct Investment (FDI) and inflation were explored concerning the Green Energy Transition ([Saadaoui and Omri, 2023](#); [Sadiq et al., 2023](#)). [Sadiq et al. \(2023\)](#) established positive associations between FDI, inflation, and green energy transition in China. Similarly, [Saadaoui and Omri \(2023\)](#) delved into the interlinkages between FDI and energy transition in Tunisia, highlighting the positive contribution of FDI to sustainable energy transition.

In different studies, additional economic factors, such as carbon taxes, environmental taxes, energy prices, and rising oil prices, demonstrated varying impacts on the Green Energy Transition. While [Lam et al. \(2023\)](#) found a positive relationship between carbon taxes and the Green Energy Transition in Vietnam, [Chien et al. \(2023\)](#) revealed an inverse effect of environmental taxes on the Green Energy Transition in China. [Rasoulinezhad et al. \(2023\)](#) highlighted the positive association between energy prices and Green Energy Transition, contrasting with [Premph \(2023\)](#) findings of a negative effect in Ghana. [Greene-dewasmes \(2021\)](#) contributed insights into external aid, oil prices, domestic credit, and real debt, showcasing their diverse relationships with green energy transition in Small Island Development States.

The compilation of these economic factors significantly impacts the energy sector from traditional to green energy sources, reflecting their essential role in achieving Sustainable Development Goals (SDGs) and addressing climate change. Aligning with [Bilan et al. \(2019\)](#) and [Kouton \(2021\)](#), the findings affirm that a robust domestic economy strengthens a country's ability to develop a green economy.

4.2.2. Social factors

Various social factors have profoundly impacted the transition to green energy. For instance, [Sadiq et al. \(2023\)](#), utilised the autoregressive distributed lag model to explore the effect of population growth on the Green Energy Transition in China. Their time series data analysis from 1981 to 2019 revealed a positive correlation, indicating that population growth promotes sustainable or green energy consumption. This aligns with a noticeable trend of increasing public pressure for climate action and a growing demand for cleaner and more sustainable energy alternatives. The positive results observed in this regard have been notable and are acknowledged by sources such as the [International Energy Agency \(2023a, 2023b\)](#) and [Naidoo \(2019\)](#).

[Oluoch et al. \(2021\)](#), delved into the impact of class structures, human capital, education, and the life expectancy index on green energy consumption. They discovered a significant and positive correlation between green energy consumption and the education index through panel autoregressive distributed lags analysis spanning 1998 to 2014 and involving 23 Sub-Saharan African countries. In contrast, green energy consumption exhibited a significant and inverse correlation with life expectancy in the long run.

Research by [Greene-dewasmes \(2021\)](#) explored the relationship between stakeholder participation and Green Energy Transition in Small Island Development States such as Barbados, Jamaica, and Mauritius. Their findings revealed a positive statistical association, indicating that higher stakeholder participation contributes to an increase in renewable energy uptake. In another study, [Sinha et al. \(2023\)](#) utilised the two-step System Generalized Methods of Moments method across panel data from 2000 to 2019 involving 37 OECD economies. Their research highlighted

that social imbalance has a dampening effect on the positive drivers of green energy. This underscores the importance of recognising and appreciating the contribution of social factors in ensuring a successful green energy transition.

4.2.3. Political/legal factors

Within the green energy transition realm, scholars increasingly recognise the pivotal role played by Political/Structural factors. This analysis underscores several noteworthy structural factors, as illuminated by scholars such as ([Sinha et al., 2023](#)). They observed that governance quality plays a critical part in amplifying the adverse effects of social imbalances that can impede the positive drivers of green energy. Similarly, [Chien et al. \(2023\)](#) Employing data from 1999 to 2019, the legit quantile autoregressive distributed lag model scrutinized the influence of governance on China's Green Energy Transition. The empirical findings indicated a positive correlation between governance and the Green Energy Transition.

Institutional quality emerges as another key aspect of the green energy transition, as emphasised by scholars ([Saba and Biyase, 2022](#); [Nawaz and Rahman, 2023](#)). [Nawaz and Rahman \(2023\)](#). For instance, an empirical examination focusing on Sub-Saharan Africa was conducted, utilising panel-corrected standard error and feasible generalized least square estimation methods. Their conclusion highlighted the strategic importance of reforms in institutional structures for effective green energy transition. A related study by [Saba and Biyase \(2022\)](#) employed fully modified ordinary least squares and dynamic ordinary least squares to explore the influence of institutional quality, the rule of law, control of corruption, voice and accountability on green energy transition in Europe. All independent variables were statistically significant and positively associated with the dependent variable.

[Greene-dewasmes \(2021\)](#) delved into the factors influencing the Green Energy Transition in small island developing economies like Mauritius, Jamaica, and Barbados. The empirical findings indicated that lower corruption levels exhibited a positive statistical relationship with green energy transition, leading to increased adoption of green energy. Additionally, [Lindberg \(2020\)](#) Highlighted climate policy as a critical driver of green energy transition. Environmental governance also emerged as a crucial driver, confirmed by [Yu and Guo \(2022\)](#) in their investigation of the influence of environmental governance on green energy transition in China. Their analysis, based on a bootstrap auto-regressive distributive lag model and data from Q1-2000 to Q4-2020, revealed a positive long-term impact of environmental governance on green energy transition.

Various Political/Legal factors, including governmental legal actions related to environmental issues and local resource management regimes, have been encountered in the literature. These favourable Political factors consistently propel the transition to green energy. These frameworks establish roadmaps, strategies, policies, and commitments crucial for driving successful green energy transition at the global, continental, regional, and national levels.

4.2.4. Technological factors

Technology is a pivotal component in the equation and is crucial in the Green Energy Transition. The landscape of technological factors is predominantly shaped by innovation, as evident in various sources ([SAGPI, 2014](#); [Kungl and Geels, 2017](#); [Naidoo, 2019](#); [Lena, 2020](#); [Yu and Guo, 2022](#)). Remarkably, Artificial intelligence has been noted to be very important in promoting energy transition, primarily through carbon emission reduction ([Wang et al., 2024](#)) and driving the corporate energy transition ([Chu et al., 2024](#)). [Yu and Guo \(2022\)](#) specifically delved into technological innovation's effect on China's Green Energy Transition. Employing a bootstrap auto-regressive distributive lag model and considering data from Q1-2000 to Q4-2020, it concluded that technological innovation exerts a positive and enduring influence on the trajectory of the Green Energy Transition.

Importantly, technological change, with its array of options for decarbonising all sectors, has been a significant driver (Manfred and Simone, 2020). This extends to the declining cost of green energy technologies, a facet underscored by the International Energy Agency (2023a, 2023b). The factors of short installation time and ease of maintenance, as highlighted by Bhamidipati (2019), contribute to the prominence of green technology. Furthermore, there is a notable emphasis on the improved efficiency of relevant technologies, as the (IEA, 2023a) pointed out.

In essence, the journey of the Green Energy Transition is intricately tied to technological progress. This progress addresses the intricate challenges of energy transition. It facilitates the shift through the adoption of cost-effective technologies and the enhancement of efficiency and maintenance in technologies integral to the transition.

4.2.5. Environmental factors

Several scholars have underscored the significance of environmental factors, specifically focusing on climate change and environmental concerns (IEA et al., 2023; CPI, 2017; Naidoo, 2019; UN, 2021a, 2021b). The role of carbon intensity and CO₂ emissions per capita has been explored, revealing these factors as pivotal drivers for the Green Energy Transition. For instance, Tudor and Sova (2021) conducted a comprehensive examination of carbon intensity's heterogeneous effects through an experimental analysis encompassing 94 economies and five income-based sub-panels from 1995 to 2019. The results, derived using heterogeneous panel data fixed effects estimation techniques alongside robust Driscoll-Kraay standard errors, highlighted the significant mitigating impact of carbon emissions intensity on the global green energy transition. Furthermore, the study noted a stronger association in low-income economies and a substantial impact even in high-income economies.

Similarly, Oluoch et al. (2021) delved into the relationship between carbon emissions per capita and green energy consumption. Using a panel autoregressive distributed lags approach on data from 23 Sub-Saharan African economies from 1998 to 2014. The study revealed a significant and inverse correlation between green energy consumption and carbon emissions per capita in the long run. These findings accentuate the critical role that environmental factors, particularly carbon-related indicators, play in steering the trajectory of the Green Energy Transition, emphasising the need for global attention and strategic interventions to address environmental concerns.

5. Conclusions

5.1. Summary of findings

This study used a systematic literature review approach to examine the conceptualisation of green energy transition (GET), drivers for GET, the trend in the publication of GET-related articles from 1990 to 2024, and research methodologies adopted in GET studies. The findings of the study are summarised as follows:

- The scholarly investigation highlights a discernible surge in publications on the Green Energy Transition, peaking in 2023.
- Scholars frame the Green Energy Transition as a decisive change from conventional, ecologically detrimental energy sources and technologies towards sustainable alternatives.
- The research methodologies in the analysed studies show a clear preference for Sustainability Transition Theories, notably the Multi-Level Perspective and Transition Management theories, which contextualise the green energy transition within broader social, ecological, and technological systems.
- Analytical tools such as the Autoregressive Distributed Lag Method and the Generalized Method of Moments are prominent, indicating reliance on quantitative analysis.
- Diverse drivers were categorised into Economic, Social, Political/Legal, Technological, and Environmental factors.

- The study found that only 26 out of the total (64) considered were based on any theory to describe the green energy transition and its underlying factors.

5.2. Limitations of the study

Since this study adopted a systematic review approach, the following are potential limitations of the study:

- Risk of publication bias and selective reporting in the identified studies. For instance, non-English language articles are excluded from this study
- Dependence on publicly available articles and reports, which may have overlooked emerging or unpublished research.

5.3. Suggestions for further study

The following are some overviews of the identified research gaps that need further study.

- Explore combined research methodologies that bridge different fields to capture the complex ecosystem of drivers influencing green energy transitions. This will help in understanding the multifaceted nature of the green energy transition, moving beyond economic aspects to include behaviours, policy dynamics, and socio-technical systems.
- Integrate economic theories with Sustainability Transition Theories to explain the Green Energy Transition: This integration will provide a more comprehensive understanding of the economic factors influencing the transition to green energy, thereby enhancing the effectiveness of policy formulation and decision-making.
- Investigate how different types or forms of green energy financing affect the Green Energy Transition: Understanding the impact of various forms of green energy financing, such as green debt, equity, and grants, will provide valuable insights into the financial mechanisms driving the transition to sustainable energy sources.
- Measure the transition to green energy from all possible dimensions, such as green energy generation, consumption, and GHG emissions: A holistic measurement approach will offer a comprehensive assessment of the progress and challenges in transitioning to green energy, facilitating a more nuanced understanding of the transition process.

CRedit authorship contribution statement

Francis Muhire: Writing – review & editing, Writing – original draft, Project administration, Methodology, Investigation, Formal analysis, Data curation, Conceptualization. **Dickson Turyareeba:** Supervision, Conceptualization. **Muyiwa S. Adaramola:** Supervision, Formal analysis. **Mary Nantongo:** Supervision, Investigation. **Ronnette Atukunda:** Supervision, Conceptualization. **Anthony M. Olyanga:** Supervision, Conceptualization.

Data availability

No data was applied in this study.

Funding

The study was funded by the Norwegian Agency for Development Cooperation (Norad) through the Norwegian Programme for Capacity Development in Higher Education and Research for Development (NORHED II) program.

Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

Acknowledgement

Francis Muhire acknowledges the PhD scholarship support by Makerere University Business School Kampala, Uganda. The

scholarship is funded by the Norwegian Agency for Development Cooperation (Norad) through the Norwegian Programme for Capacity Development in Higher Education and Research for Development (NORHED II) program.

Appendix A. List of the Journal Articles and Gray Literature Synthesized.

SN.	Author & Year	Geographical scope	Key Take Aways
1	Saba and Biyase (2022)	Europe	<ul style="list-style-type: none"> The study adopted the Fully Modified Ordinary Least Squares and Dynamic Ordinary Least Squares. The study demonstrated that institutional quality, control of corruption, rule of law, and voice and accountability have a statistically significant and positive effect on the development of renewable electricity. Most determinants were found to have a bidirectional causal relationship with the development of renewable electricity. The study's results suggest that strengthening policies related to institutional quality and governance indicators can significantly impact the development of renewable electricity.
2	Sinha et al. (2023)	OECD Countries	<ul style="list-style-type: none"> The study analysed the impacts of energy transition drivers using a two-step System GMM approach and data from 37 OECD countries. The results indicate that social imbalances dampen the positive effects of energy transition drivers, while governance quality helps augment those impacts. The study's outcomes are beneficial for advancing potential policy discourse and have important practical implications for developing the SDG-oriented policy framework, focusing on attaining SDGs 7 and 13. The paper proposes a new energy transition index based on the energy ladder hypothesis to capture the transition to cleaner and more energy-efficient sources.
3	Chien et al. (2023)	China	<ul style="list-style-type: none"> Using the legit quantile autoregressive distributed lag model and Granger causality in quantiles, the study finds that governance positively affects sustainable energy transition. In contrast, environmental resources negatively affect energy transition across all quantiles. Economic growth influences clean energy transition only at significantly higher quantiles (0.60–0.95), while industrialisation does not affect energy transition across the entire quantile range. The Granger causality analysis reveals a bidirectional causal association between clean energy transition and all the variables.
4	Lam et al. (2023)	Vietnam	<ul style="list-style-type: none"> The study recommends policies based on these findings. Using Dynamic Auto-regressive Distributed Lags, the study finds that green financial innovation, eco-financing, carbon taxes, economic openness, inflation, and industrialisation are positively and significantly linked to sustainable energy transition. The outcomes guide policymakers in establishing new policies related to sustainable energy transition.
5	Nawaz and Rahman (2023)	Sub-Saharan Africa	<ul style="list-style-type: none"> The study adopted the Panel corrected the standard error and feasible generalized least squares to investigate renewable energy consumption in 31 Sub-Saharan African countries from 2002 to 2019. The study findings suggest that the complementary effect of human capital and GDP per capita is a fundamental policy choice for the sample countries. The study also validates a U-shaped GDP-energy consumption nexus. It provides novel empirical evidence on energy transition and the channels through which it is affected by human capital, financial development, and institutional quality. The study recommends strategic improvements in GDP per capita, capacity enhancement of human capital, and reforms in financial and institutional frameworks for energy transition.
6	Tudor and Sova (2021)	Worldwide	<ul style="list-style-type: none"> With the heterogeneous panel fixed effects approach, the study found that; <ol style="list-style-type: none"> CO₂ intensity significantly and positively impacts renewable energy consumption. GDP per capita encourages renewable energy consumption when it surpasses the \$5000 threshold. Research and development are major contributors to the increase in renewable energy consumption in very high-income countries. The study suggests that policymakers need to consider the heterogeneity of the renewable energy consumption drivers to issue effective and congruent policies
7	Sun et al. (2023a, 2023b)	Global	<ul style="list-style-type: none"> Using a system of General Methods of Moments and a dynamic approach, the study found that financial development positively impacts renewable energy consumption at the macro level. The study suggests that policymakers should consider this positive effect when working on the relevant policies, especially in developing countries.
8	Sadiq et al. (2023)	China	<ul style="list-style-type: none"> Employing the autoregressive distributed lag approach, the research revealed a positive relationship between economic growth, population, inflation, and foreign direct investments with sustainable energy consumption. The study recommended that policymakers use these findings to develop frameworks related to renewable energy development.
9	Oluoch et al. (2021)	Sub-Saharan Africa	<ul style="list-style-type: none"> Utilising the panel autoregressive distributed lags for a period running from 1998 to 2014, the empirical results indicated that renewable energy consumption positively correlates with the education index and GDP per capita. Conversely, it is inversely associated with life expectancy and CO₂ emissions per capita in the long run.

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SN.	Author & Year	Geographical scope	Key Take Aways
10	Prempeh (2023)	Ghana	<ul style="list-style-type: none"> The research highlights the possibility of enhancing social indicators like education levels, boosting economies, and decreasing CO2 emissions through efficient management and execution of renewable energy development. Using various tests such as the ARDL, Gregory & Hansen Cointegration, Bayer-Hank, DOLS, VECM, FMOLS and CCR, the study found that financial progress encourages the adoption of renewable energy. In contrast, energy expenses and economic expansion have an adverse impact. This research offers valuable perspectives for policymakers to explore alternative energy sources to fulfil the nation's increasing energy demands.
11	Saadaoui and Omri (2023)	Tunisia	<ul style="list-style-type: none"> The study employed the autoregressive distributed lag model to investigate the interrelationships among renewable energies, Foreign Direct Investments (FDIs), Information and Communication technologies (ICT), trade openness, and Total Factor Productivity (TFP) in the context of Tunisia from 1984 to 2019. The results reveal the significant contribution of FDI and TFP in the sustainable energy transition. The study suggests that the diffusion of renewable energies should involve the private sector, not just the government, by encouraging FDI. However, trade and ICT inhibit Tunisia's transition to renewable energies, possibly due to economic recession, bad governance, and political instability. The study provides insights into Tunisia's challenges and opportunities for sustainable energy transition, emphasising the role of various factors such as FDI, trade, and ICT.
12	Asongu and Odhiambo (2020)	Sub-Saharan Africa	<ul style="list-style-type: none"> Employing Quantile Regressions and the Generalized Method of Moments and using data from 2004 to 2014, the study revealed that financial development drives renewable energy consumption. In contrast, income inequality discourages the consumption of renewable energy. The study recommends setting income inequality thresholds for both renewable energy consumption distribution's bottom and top quantiles. This will provide valuable policy implications for promoting renewable energy consumption.
13	Serrano and Zaveri (2020)	Worldwide	<ul style="list-style-type: none"> The study delves into the definition of green energy transition, how it is achieved, and the driving factors behind its realisation. Preliminary results suggest that household net income and governmental legal actions related to environmental issues are potential predictors of energy transition within countries. The paper's conclusion on the definition of energy transition is that it involves a shift towards a renewable energy system as a priority in the transition to a sustainable society. The study emphasises the importance of understanding the definition of green energy transition. It aims to spark new research directions to establish a common social and scientific understanding of energy transition.
14	Lindberg (2020)	Europe	<ul style="list-style-type: none"> The study notes that energy transition includes the increasing dynamics and scope of the energy transition, the rapid expansion of renewable energy worldwide, and the need for changes in the configuration of the electricity sector to accommodate increasing shares of renewable energy production. It utilises the multi-level perspective, the advocacy coalition framework, and institutional theory to investigate the implications of the European energy transition. The research results highlight the possibility of different sustainability transition pathways, the shifting relationship between markets and policies in the third phase of the transition, and the increasing importance of market design for succeeding with the energy transition. In terms of policy recommendations, the research suggests that policy studies would benefit from explicitly considering technological change to a greater degree and that policymakers and stakeholders could use the findings better to understand the effects of different policies and market designs, leading to improved solutions and further advancement of the energy transition.
15	Greene-dewasmes (2021)	Small Island Developing States (Jamaica, Barbados, and Mauritius)	<ul style="list-style-type: none"> The study highlights that the green energy transition conceptualisation includes the increasing integration of the notion of a greener economy with the global sustainable development agenda, mainly through the movement towards green energy targets set by small island developing states (SIDS). The study adopts an integrative approach from leading GET-related scholarship about sustainable development, small states, the green economy, climate governance, sustainability transitions, diffusion research, and polycentricity theory. The research suggests the need for more evidence-based literature on the GET experiences and outcomes within and across SIDS contexts. It emphasises the importance of understanding the drivers and barriers within these countries to support the green energy transition.
16	Shihundu and Nyadera (2022)	Eastern Africa	<ul style="list-style-type: none"> The authors note a gap in the literature, theory, and systematic framework concerning the effects of the shift to renewable energy on the region's geopolitics. The authors analyse academic publications, government reports, and other relevant sources to establish the relationship between geopolitics and the transition to renewable energy in the region. The study recommends increased adoption of renewable energy in the region, leveraging abundant resources to contribute to global efforts against climate change.
17	Bhamidipati, 2019	East Africa	<ul style="list-style-type: none"> The study anchors on the multilevel perspective framework to analyse the dynamics of change. The study finds that the diffusion of off-grid solar PV systems has shifted towards more private-sector engagement.

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SN.	Author & Year	Geographical scope	Key Take Aways
18	Murphy (2001)	Rural East Africa	<ul style="list-style-type: none"> • In contrast, utility-scale PV systems have emerged due to cost competitiveness, tailored policy instruments, investor risk guarantees, and improved regulatory procedures. • The research also highlights the critical role of higher levels of leadership, such as state and regulatory actors, in prioritising and accelerating the development of solar PV projects. • The study emphasises the need for political commitment and willingness to adapt institutional structures to accelerate the decarbonisation of energy systems. • The study challenges the concept of energy leapfrogging in rural East Africa, emphasising that energy transitions in rural areas are incremental processes dependent on the accumulation of technological capabilities at the household and regional levels. • It highlights the need to consider economic, social, and cultural factors when planning technology dissemination or energy supply projects in rural areas.
19	Mazzucato and Semieniuk (2018)	Global	<ul style="list-style-type: none"> • Using Bloomberg New Energy Finance (BNEF) data, the research examines the asset portfolios of various renewable energy technologies financed by different financial actors. • The study finds that public financial actors tend to invest in portfolios with higher-risk technologies and have increased their share in total investment over time. • The study's insights can help policymakers understand the influence of finance on renewable energy innovation and shape effective renewable energy policies.
20	Kungl and Geels (2017)	German	<ul style="list-style-type: none"> • The study replicates a multi-dimensional framework developed by Turnheim and Geels with a more contemporary focus on sustainability transitions. • The study identifies the role of multiple pressures in industry destabilisation, emphasising the sequence and alignment of these pressures. • The study suggests considering the sequence and alignment of multiple pressures in industry destabilisation for effective policy formulation.
21	Frei et al. (2018)	Worldwide	<ul style="list-style-type: none"> • Using a three-step methodology of document analysis, quantitative analysis of utilities' generation portfolios and illustrative quotes to investigate how 25 major electric utilities adapted their business portfolios during the energy transition from 2003 to 2015, the study found that utilities have been proactive in embracing decarbonisation. • The paper suggests the need for regulatory changes or additional policy incentives to promote system integration as a critical part of the energy transition.
22	Baker (2022)	South Africa & Mexico	<ul style="list-style-type: none"> • Generating renewable electricity on a large scale is crucial for reducing carbon emissions, yet there has been limited academic focus on its ownership. • While utility-scale renewable energy has positive environmental impacts, it has often overlooked or not benefited local communities. • The production of electricity involves a struggle between technological advancements and existing political, social, and economic power structures.
23	Lena (2020)	Germany	<ul style="list-style-type: none"> • The paper emphasises the need for further research to understand how equity pay-outs will react to changes in risk factors and the importance of developing hedging strategies in the Power Purchase Agreement market to ensure continued investment in renewable energy markets.
24	Naidoo (2019)	Worldwide	<ul style="list-style-type: none"> • The study employs a novel approach to bridging this polarity by interpreting the characteristics of the sustainability transition process from the perspective of the demands it places on the financial system. • The paper identifies five initial demands and offers dimensions for scholars to engage in to inform the response of financial systems to the demands of sustainability transitions.
25	Yu and Guo (2022)	China	<ul style="list-style-type: none"> • Using a bootstrap auto-regressive distributive lag model to evaluate the long-term relationship between economic policy uncertainty, technological innovation, ecological governance, and economic growth on China's green energy transition from Q1-2000 to Q4-2020, the empirical results indicate a long-term cointegration relationship among the variables, with economic policy uncertainty and economic growth negatively affecting the green energy transition in the long run. • Conversely, technology innovation and environmental governance positively influence the green energy transition. • The study suggests that strengthening environmental governance mechanisms and promoting technology innovation can accelerate the green energy transition.
26	Rasoulizhad et al. (2023)	Asia	<ul style="list-style-type: none"> • The study highlights that lack of capital for investment, weak governance of the green economy, and unclear legal structure have hindered the effectiveness of these programs. • The income level is an essential variable in energy policy in different Asian countries, particularly in developing and emerging economies, as it can expedite sustainable development. • Additionally, the development of digital green financing is proposed to attract foreign investment and increase private sector participation in green energy projects in Asian countries, especially in light of the current COVID-19 situation.
27	SAGPI, 2014	Sweden	<ul style="list-style-type: none"> • The study reveals that the energy transition is driven by increasingly competitive renewable energy technology, environmental concerns, and changing customer needs, leading to significant progress in the low-carbon transition. • However, substantial investment and a significant overhaul of the electricity industry design are needed to align the industry with the clean and efficient economy of the 21st century. • Critical barriers to this transition include the uncertain future of nuclear energy, policy limitations, and the need for coordinated innovation in markets, business models, and finance across the electricity sector. • To address these challenges, it is crucial to focus on technological innovation, cost reduction, and coordinated innovation in the energy system and restructure and decarbonise the power industry.
28	Manfred and Simone (2020)	Global	

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SN.	Author & Year	Geographical scope	Key Take Aways
			<ul style="list-style-type: none"> • The study notes that the UK has been a global leader in deploying renewable energy capacity, primarily through market-based approaches. • At the same time, China has rapidly increased its energy dependency and is focused on rapidly deploying renewables, which domestic companies and state-owned enterprises primarily drive. • The study concludes that direct government involvement and market-enabled policies with direct incentives can be effective strategies for decarbonisation. • It also emphasises the need for consistent and market-friendly government policies to attract foreign investment in emerging economies.
29	UNU-WIDER (2017)	US, Europe, China	<ul style="list-style-type: none"> • The US focuses on cost recovery and handling reductions in energy sales, while Europe emphasises sustainability objectives and smart metering targets. • In China, intelligent grid policies are driven by the surge in national electricity demand. • The authors recommend that regulators allow smart grid investments to remain outside the regulatory framework to support holistic smart grid developments and reduce regulatory uncertainty.
30	Sovacool (2016)	Global	<ul style="list-style-type: none"> • The study notes that the timing of energy transitions may not always align with conventional views. • The article calls for more transparent conceptions and definitions of energy transitions and emphasises the need for analysis that recognises their causal complexity.
31	Fouquet and Pearson (2012)	Global	<ul style="list-style-type: none"> • The study notes that the nature of transitions involves extended periods of change, with past energy transitions leading to substantial increases in energy consumption. • Key drivers of energy transitions include demand/end use and supply side/infrastructure issues and the roles of consumers, businesses, and governments. Trust, social acceptance, and the timing of events are critical factors. • Identifying both the similarities and differences between past and prospective transitions, particularly regarding low-carbon technologies and energy sources is essential. • There is uncertainty about the qualitative benefits of a low-carbon energy system, and deliberate management of the transition may be necessary due to the perceived urgency of climate change.
32	Blazquez et al. (2019)	Global	<ul style="list-style-type: none"> • The study highlights the driving role of policies and the potential disruptions to liberalised electricity markets. • Given current technologies and perspectives, it emphasises that the transition to renewable sources may be incomplete. • The shifting consumer preferences toward cleaner energy creates new business opportunities and challenges traditional models. • The study suggests that the outcome of energy transitions depends on the policies applied and points to the need for new market designs to facilitate a complete transition to renewable energy.
33	IEA (2023)	World	<ul style="list-style-type: none"> • The report highlights that the momentum behind clean energy investment has gained significant traction due to a convergence of costs, climate and energy security objectives, and industrial strategies. • Clean energy investment has outpaced fossil fuel investment, with more than USD 1.7 trillion allocated to clean energy in 2023. • The shift is driven by improved economics amid volatile fossil fuel prices, enhanced policy support, and a growing focus on climate and energy security goals. • The study raises concerns about uneven clean energy investment distribution, macroeconomic obstacles, rising technology costs, and limitations in renewable energy deployment in developing economies.
34	IEA (2023)	Emerging & Developing Economies	<ul style="list-style-type: none"> • The study notes that the energy transition in emerging markets and developing economies (EMDEs) is crucial for their sustainable development and the future of global energy and climate. • While clean energy technologies offer a promising way forward, the current pace of investment in clean energy in EMDEs is insufficient. To align with the Paris Agreement and sustainable development goals, annual investment in clean energy in EMDEs will need to triple to USD 2.2–2.8 trillion annually by the early 2030s. • The main components of increased spending include clean electrification, grid infrastructure, efficiency improvements, and low-emissions generation, primarily from renewables. • A significant portion of the investment is also required to achieve universal access to electricity and clean cooking fuels by 2030, focusing on expanding electricity access in Africa and clean cooking investment in Asia.
35	IRENA (2023)	Global	<ul style="list-style-type: none"> • Analysing the financial landscape from 2013 to 2022, the study highlights the need for increased investments in renewables for end uses. • The study emphasises the importance of deployment policies, such as targets and financial incentives, to accelerate the decarbonisation of the energy system.
36	IRENA (2018)	Global	<ul style="list-style-type: none"> • The study emphasises the importance of mobilising finance in the renewable energy sector to limit global mean temperature rise to below 2°C in line with the Paris Agreement. • It highlights the need for significant investments in renewables, with private finance playing a pivotal role alongside public finance sources. • The study also underlines the role of policy support in driving renewable energy investment decisions and the importance of falling technology costs in boosting renewable energy uptake.
37	International Renewable Energy Agency and Climate Policy Initiative, 2020	Global	<ul style="list-style-type: none"> • The report notes that global investment in renewable energy has made significant progress between 2013 and 2018, reaching USD 1.8 trillion. • Scaling up renewable energy investment must be accompanied by significantly reducing and redirecting fossil fuel investments to achieve international climate and development goals.
38	IRENA (2022)	World	

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SN.	Author & Year	Geographical scope	Key Take Aways
39	IRENA (2023)	World	<ul style="list-style-type: none"> This study highlights that the transition to a 1.5°C-aligned energy scenario requires substantial investments of USD 5.7 trillion annually until 2030, with a significant portion of annual investments in fossil fuels needing to be redirected towards energy transition technologies. The report emphasises the critical role of G20 and G7 countries in leading the global energy transition effort and the need for funds and knowledge to be availed to less wealthy nations to advance an inclusive and more equitable world. The report reveals that the energy transition is facing significant challenges due to the aftermath of the COVID-19 pandemic and the ripple effects of the Ukraine crisis, which have exacerbated the transition's obstacles. To limit global warming to 1.5°C, substantial reductions in carbon dioxide emissions and achieving net-zero emissions in the energy sector by 2050 are essential. Accelerating the transition will require comprehensive action, including substantial annual deployment of renewable power, policy and regulatory measures, and more significant investments in energy transition technologies. Bold and transformative actions will be necessary to overcome barriers to the transition and achieve a just, inclusive, and more sustainable world. Additionally, supporting developing countries in accelerating the energy transition and addressing its socio-economic implications will be crucial for its success.
40	UN (2021b)	World	<ul style="list-style-type: none"> The report highlights that the next decade will see significant changes in national energy systems due to climate and energy policy shifts, technological advancement, and changes in energy supply and demand. To achieve the goals of the Paris Agreement and the 2030 Agenda for Sustainable Development, the energy transition must become a transformational effort involving rapidly upscaling and implementing available technologies to innovate for the future. The recommendations include rapidly scaling up the deployment of renewable energy, increasing the average annual rate of energy efficiency improvement, investing in physical infrastructure, and phasing out coal by 2030 in OECD countries and by 2040 in non-OECD countries. Additionally, it is essential to mainstream energy policies into broader economic, industrial, labour, educational, and social strategies, establish medium and long-term integrated energy planning strategies, create regional energy markets, intensify international cooperation on energy transition, develop sustainable transport roadmaps, tailor labour and social protection policies to the specific needs of each region and country, and make the energy transition a participatory enterprise.
41	UNCTAD (2023)	World	<ul style="list-style-type: none"> The study reports that global foreign direct investment (FDI) declined by 12% in 2022 to \$1.3 trillion, mainly due to lower volumes of financial flows and transactions in developed countries. While international investment in renewable energy has nearly tripled since adopting the Paris Agreement, the most significant portion has been directed to the developed economies, highlighting the need for more support to attract sustainable energy financial flows in developing countries.
42	World Bank (2023)	Low & Middle-income countries.	<ul style="list-style-type: none"> The report indicates that the energy transition in low- and middle-income countries (LICs and MICs) will require a massive scaling up of renewable energy and energy efficiency to meet rapidly growing demand and a phasing down of coal-fired power generation. The paper highlights the barriers preventing LICs and MICs from mobilising needed financing, including limited affordability, limited access to private capital, high cost of capital, and limited availability of capital. The report suggests that multilateral development banks can help prepare bankable projects that match investors' risk-return expectations while also improving market conditions. The paper emphasises the need for strategic approaches to mobilise the largest possible amounts of private capital, including using concessional finance to mitigate risks and attract private capital at the scale necessary for power sector transition.
43	Wood and Baker (2020)	Global	<ul style="list-style-type: none"> The analysis notes that while the green technology approach shows potential for a low-carbon future, it may entrench existing global elites and shift responsibility to individuals. Transition networks, particularly transition towns, face barriers to entry and lack diversity, limiting their potential for social and economic change.
44	Marschoff, C.M. (1998)	Antarctica	<ul style="list-style-type: none"> The study suggests that fuel cells, particularly those powered by environmentally friendly fuels like methanol, could be economically viable for electricity generation and heat production in the six Argentine bases in Antarctica. Despite the challenges in obtaining political approval for demonstration projects, the economic study indicates a net cost benefit, even without factoring in the potential assets resulting from reduced pollution in Antarctica. The study underscores the potential commercial attractiveness of fuel cells in specific market niches.
45	Maliszewska-Nienartowicz, J., & Stefański, O. (2024).	Sweden	<ul style="list-style-type: none"> The study highlights the significance of a multi-level governance perspective in understanding the impact of decentralisation on energy transition. The research identifies the factors crucial for proactive clean energy policy at the regional and local levels by surveying representatives of regions and municipalities. The findings reveal that a balanced approach combining centralisation and decentralisation, along with clear task allocation, can enhance the effectiveness of energy transition. However, the study also underscores the challenges associated with proper coordination in the multi-level governance system, particularly concerning financial support and consultation.
46	Huda, M. S. (2024).	Global	

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SN.	Author & Year	Geographical scope	Key Take Aways
47	Hosan et al. (2024)	Developed Economies	<ul style="list-style-type: none"> The study notes that energy diplomacy is evolving to align with global efforts to achieve net zero emissions by 2050 and limit global warming to 1.5°C above pre-industrial levels. The proposed concept of renewable energy diplomacy introduces four interconnected elements: Collaborative Resource Governance, Digital Trust Building, Energy-Environment Interdependence, and Capacity Building. The study used quantitative analysis to assess how energy innovation funding influenced social equity in 23 developed economies from 1995 to 2020. It utilised various statistical techniques and a mediating model, revealing that increased energy innovation funding directly enhances social equity and indirectly promotes it by accelerating energy justice. The study's findings underscore the significance of effectively allocating and utilising public energy innovation budgets to drive the adoption of clean energy technologies, advance just energy transition, and improve social equity, inclusion, and community engagement. The research underscores the need for policy measures to focus on a fair transition to sustainable energy and to allocate funding for innovation in energy to develop robust and inclusive energy systems that support affordable and clean energy as outlined in Sustainable Development Goal 7.
48	Akpahou et al., 2024	Global	<ul style="list-style-type: none"> Employing the Preferred Reporting Items for Systematic Reviews and Meta-analysis (PRISMA) approach, the review offers a descriptive analysis of chosen research articles, highlighting prevalent energy modeling tools, their data requirements, and their applications within developing countries. The findings stress the significance of energy modeling tools in decision-making and policy formulation processes, especially for analysing energy demand and supply pathways and mitigating greenhouse gas emissions. The study underscores the necessity for new policies and the development of energy modeling tools tailored to the context of developing countries, integrating more renewable energy sources to address these challenges.
49	Sharma et al. (2023)	Worldwide	<ul style="list-style-type: none"> Analysing 610 peer-reviewed journal articles over the last 50 years to provide insights into the hydrogen economy, the study identifies critical multidisciplinary concerns and highlights research hotspots and emerging patterns in hydrogen energy. The study emphasises the critical role of green hydrogen generation, efficient storage, risk assessment studies, and techno-economic feasibility in shaping the socio-economic aspects of hydrogen energy research.
50	Germán López Pérez & Isabel María García Sánchez & José Luis Zafra Gómez (2024)	Global	<ul style="list-style-type: none"> The analysis reveals that while previous empirical evidence suggests a positive effect, the impact of eco-innovation on corporate performance is not universally applicable due to various conditioning factors. The study emphasises the influence of company size and the business environment as key factors affecting the relationship between eco-innovation and firm performance.
51	Chu et al. (2024)	China	<ul style="list-style-type: none"> Analysing corporate annual reports and over 200,000 patent application texts to establish indicators for corporate energy transition and AI technology application, the study suggests that AI can drive the corporate energy transition. The study provides strategic guidance for business managers and policymakers, offering insights for leveraging AI technology to optimise environmental and economic goals during the social energy transition process.
52	Bakhsh et al. (2024)	OECD Economies	<ul style="list-style-type: none"> Using the MMQR approach to examine the effects of environmental governance and economic complexity on transition in 20 OECD economies from 1990 to 2021, the findings show that environmental governance and economic complexity stimulate energy transition at different quantiles. However, the interaction of economic complexity with geopolitics transforms the positive influence of geopolitics into a negative impact on energy transition.
53	Liu et al. (2024)	Global	<ul style="list-style-type: none"> The study highlights that metallic and non-metallic mineral consumption hinders sustainable energy transition. Noting that the effect is more noticeable in samples with poor governance quality. The study further acknowledges the moderating roles of human capital, industrial structure advancement and financial development in the association.
54	Bashir et al., 2023	G7 Economies	<ul style="list-style-type: none"> The study highlights environmental stringency, economic development, and renewable energy as potential drivers of energy transition. In contrast, taxation revenues, governmental expenditure and fossil fuels discourage energy transition.
55	Wang et al. (2024)	Global	<ul style="list-style-type: none"> The study encourages policymakers to align environmental and fiscal policies. The investigation notes that AI contributes to energy transition and the reduction of carbon emissions, with trade openness mediating the effect. The study identifies specific thresholds of trade openness in the impact of AI on carbon emissions and energy transition, emphasising the interconnectedness of AI, trade openness, and energy outcomes. Additionally, the results suggest that income levels and AI levels influence the trade threshold necessary to achieve reductions in carbon emissions. While recognising the positive impact of AI on carbon emission reduction and energy transformation, the study highlights the importance of considering associated factors such as energy consumption for data storage and cooling. These insights can provide valuable guidance to policymakers in formulating targeted emission reduction policies.
56	Leach (1992)	Developing Economies	The study emphasises that the household sector's shift from traditional biomass to modern energy fuels strongly depends on urban size and household incomes.
57	Kamali Saraji and Streimikiene (2023)	Global	

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SN.	Author & Year	Geographical scope	Key Take Aways
58	Zhang et al. (2023)	USA	<ul style="list-style-type: none"> Using the PICOC approach, the study indicated that international agreements on climate change could increase the number of studies on low-carbon energy transition. The study's overall recommended policy addresses the identified social, economic, environmental, technical, and institutional challenges to facilitate the transition to a low-carbon energy system. Utilising the Bayer-Hanck and Johansen Fisher cointegration tests with data from 1985 to 2021 to examine the factors driving energy transition in the US, the empirical findings reveal that electricity production and economic growth promote the transition. The study further notes that natural resource extraction has been found to have an asymmetric impact on energy transition. Mineral and oil rents are positively associated with the transition, while forest and coal rents have an adverse effect. Geopolitical risk was observed to negatively affect energy transition, although the impact was deemed insignificant. The study suggests increasing renewable energy production and consumption, efficient utilisation of natural resources, and reducing geopolitical risk to enhance energy transition.
59	Lamnatou et al. (2024)	France	<ul style="list-style-type: none"> The study's methodology included classification, collection of scholarly documents, and bibliographic analysis to investigate the link between energy transition and factors associated with renewable energy sources in France. It highlighted the high dependence on nuclear power generation and emphasised the imperative role of renewable energy penetration in the French energy transition.
60	Sun et al. (2023a, 2023b)	China	<ul style="list-style-type: none"> Using the NARDL method on data from 2000 to 2018, the research found that natural resource rent stifled China's economic growth, while economic policy uncertainty affected the role of green financing in renewable energy and energy transition. The research recommends adopting short- and long-term corporate strategies and policies based on the findings. These may include guaranteeing the optimal utilisation of natural resources, reallocating funds at regional government levels, and shifting towards sustainable technology.
61	Rajendran et al. (2023)	G7 Countries	The study Proposes a framework that includes technology investment as a mediator variable between transition variables and Renewable Energy Shares.
62	Tzeremes et al. (2023)	BRICS	<ul style="list-style-type: none"> Applying the GMM-PVAR method to annual data from 2000 to 2017 indicated that economic growth and carbon emissions significantly and positively influence energy transition. Simultaneously, the study highlighted the significance of ICT in advancing energy transition and addressing environmental issues. The study underscored the necessity for governmental backing to foster ICT development within the BRICS nations.
63	Kamran et al. (2023)	Global	<ul style="list-style-type: none"> Using a systematic literature review, the study findings suggest that shifting to a low-carbon energy system is feasible, but it will necessitate addressing supply issues and strategic planning. A crucial risk mitigation approach involves enhancing material circularity, particularly to manage the increasing demand for cobalt in lithium-ion batteries, platinum in fuel cells and electrolysers, iridium in electrolysers, and dysprosium in permanent magnets. Copper is identified as a potentially critical element due to anticipated demand from developing nations and the energy transition. Geopolitical, social, and environmental risks associated with lithium, cobalt, rare earth elements, and platinum group metals could also impede future energy security as demand for these materials continues to rise.
64	Streimikiene and Kyriakopoulos (2022)	Global	<ul style="list-style-type: none"> The study, which utilised a literature review, confirmed the contentious nature of energy poverty at the regional and international levels of analysis. The analysis also noted that recent studies have highlighted the impact of the COVID-19 pandemic and the Russian-Ukrainian war on energy prices and energy poverty The study proposed future research guidelines for energy poverty alleviation.

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