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Emerging Issues in Energy Sustainability: A Systematic Review and Research Agenda

Aqsa Anjum*†, Jahangir Chauhan*, Marghoob Enam and Irfan Ali*****
*Department of Commerce, Aligarh Muslim University, Aligarh, U.P., India
**Department of Management, Indian Institute of Technology, Dhanbad, Jharkhand, India
***Department of Statistics, Aligarh Muslim University, Aligarh, U.P., India
†Corresponding author: Aqsa Anjum; aqsaanjum23@gmail.com

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ABSTRACT

This research paper seeks to investigate and categorize previous studies to understand better the role of energy generation technology in promoting sustainable development of a country country. The primary aim of this review is to identify and emphasize key issues related to energy sustainability. The study employs a systematic review approach, drawing on academic publications from the Web of Science and Scopus database. The analysis reveals five key issues: the nexus between energy generation and greenhouse gas emissions, energy generation and employment, the impact of energy generation and land use intensity, the association between energy generation and water footprint, and the nexus between energy generation and human health. This study delves into the theoretical dimensions of research concerning the interplay between energy sustainability and various aspects of energy generation technologies. Furthermore, it contributes to the existing body of knowledge concerning Sustainable Development Goal 7, with the overarching goal of enhancing both human well-being and economic prosperity through advancements in energy generation technologies. The study comprehensively explores the subject matter, offering an in-depth analysis of energy sustainability. Its unique contribution lies in its extensive examination of multiple facets of energy sustainability, making it a significant addition to the field of research.

INTRODUCTION

The nexus between energy utilization and its environmental consequences underscores the significance of comprehending the full spectrum of impacts associated with diverse energy sources. Globally, the escalating trajectory of energy generation poses significant ecological challenges. Achieving the Sustainable Development Goals (SDGs) by 2030 involves transitioning toward a low-carbon economy, a pivotal strategy highlighted in Goal 7. In the Indian context, the energy sector contributed 68.7 percent of greenhouse gas emissions (GHGs) in 2021. Addressing carbon emissions demands more incremental adjustments, necessitating a comprehensive reconfiguration in energy production, transportation, and consumption. The fifteenth goal of the SDGs accentuates the need to avert land degradation arising from the rising energy supply and consumption. One of India's SDG targets (Goal 6) also addresses the judicious management and prevention of water contamination. This involves providing affordable energy services, catering to immediate and future basic needs, aligning with environmental sustainability, and garnering societal and individual acceptance. Renewable energy technologies emerge as a salient avenue for addressing the exigency of energy scarcity (Ray 2019). The substitution of renewable resources for fossil fuels in the energy sector holds promise for diminishing CO_2 emissions and mitigating other pollutants. Delving into India's energy landscape, statistics for 2022 revealed a consumption of 12,75,534 Million Units (MU) and a supply of 12,70,663 Million Units (Ministry of Power 2022). In contemporary society, electricity distribution is pivotal in facilitating a consistent, sufficient, and economically viable energy supply that underpins many human activities. Coal, constituting over 60% of total energy generation, is India's predominant electricity source, as shown in Fig. 1. Projections by Energy Statistics (2022) indicated a trajectory of 772 million metric tons of coal consumption in the country by 2040.

Beyond the pressing need of meeting electricity requirement, the ramifications of fossil-based power generation extend to climate change and public health. The ramifications of power generation technologies go beyond their direct environmental effects, affecting public health, ecosystems, and climate change. Fossil fuel-based approaches are associated with air pollution, resource exhaustion, and sustained ecological disturbances. Fig. 2 illustrates the externalities associated with energy generation technologies. Decarbonizing the electricity generation landscape emerges as a strategic lever in curtailing the adverse climate and health effects of extant technologies. The inception of solar photovoltaic (PV) technology for electricity generation in India in the early 2000s marked a shift from the predominant reliance on coal. The global impetus towards sustainable energy production, aligned with sustainable development goals, prompted India to pioneer the Ministry of New and

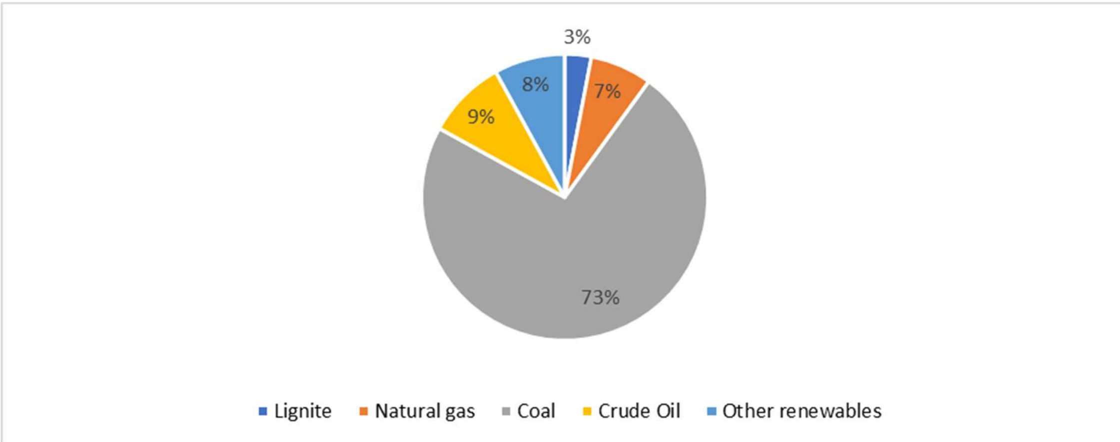


Fig. 1: Net electricity generation by fuel in India. (Energy Statistics 2022)

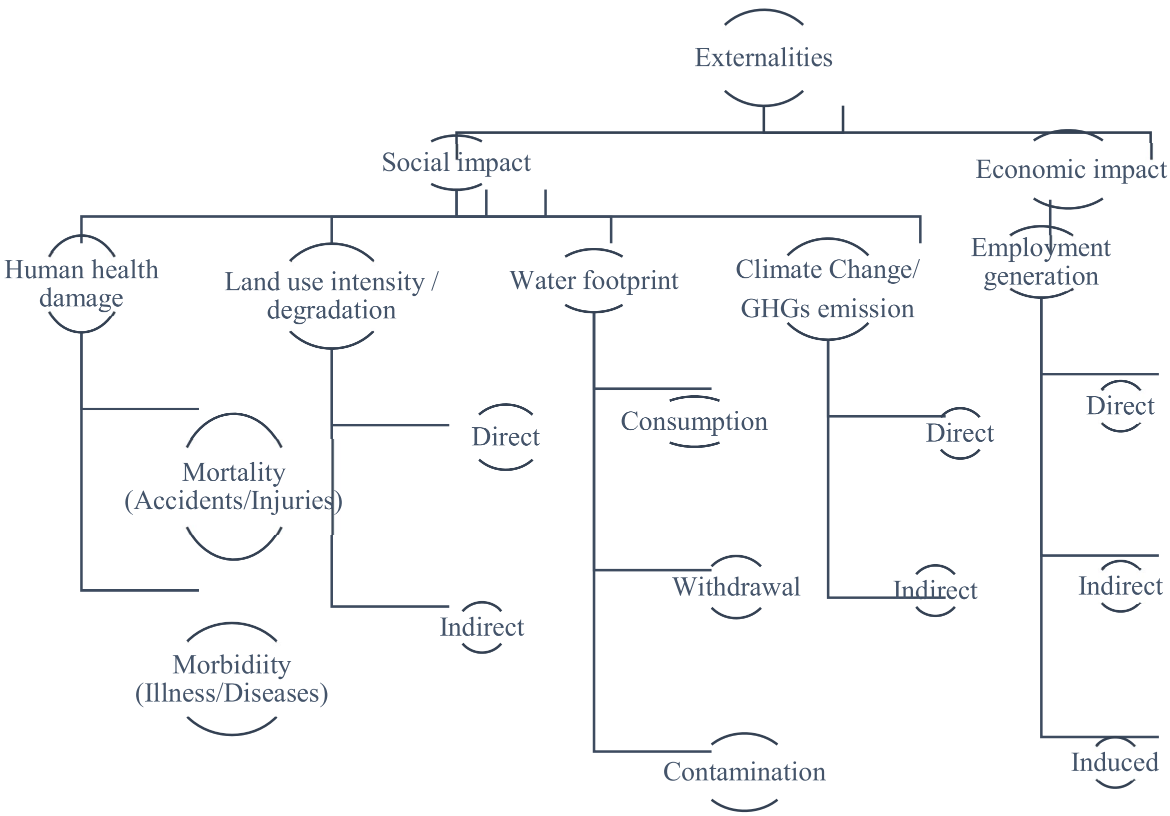


Fig. 2: Externalities of power generation technologies.

Renewable Energy (MNRE) establishment in the 1980s (MNRE). This institutional commitment positions India as a trailblazer in leveraging sustainable technologies, with a pronounced ambition of achieving a net-zero target by 2070.

The study of energy generation technology and sustainability, or energy sustainability, has been a popular research area since 1990. However, after 2009, there was an unprecedented expansion and popularization of energy-related literature. Initially, literature concentrated solely on the economic side of energy. With the expansion of the literature, the field experienced a drastic transition from formerly economic-focused studies to more probing studies of energy sustainability. The increasing interest in energy and sustainability may be seen in the growth of research articles over the last decade, worldwide conferences on sustainability and green energy reports. Energy sustainability has been critically analyzed in several scholarly works. Various aspects of energy generation, such as energy generation and air pollution, have been discussed by many researchers. However, research on energy sustainability is still ongoing, and there is much to be discovered on it. To highlight the key research advances and identify gaps in the various aspects of energy generation, this study attempts to thoroughly review the literature on energy generation and its connected issues. To accomplish this, the study focused on five key issues in the field of energy generation to uncover understudied sections of this field and its connections to various consequences to advance the academic study of energy generation. The study is organized according to a conventional structure. The following section presents a thorough literature analysis of pertinent studies on five distinct energy-generating concepts to support its links with the highlighted issues. The research approach is then described, followed by the discussion and conclusion. In the last, research implications, limitations, and direction for future research are presented.

MATERIALS AND METHODS

This systematic literature review (SLR) compiles and assesses several research papers to give a thorough overview of all the available literature pertinent to a particular research question. The main goal of the study is to find new issues in the energy generation field. The following research questions were chosen: 1. What are the emerging issues in energy sustainability? 2. What are the important research and study

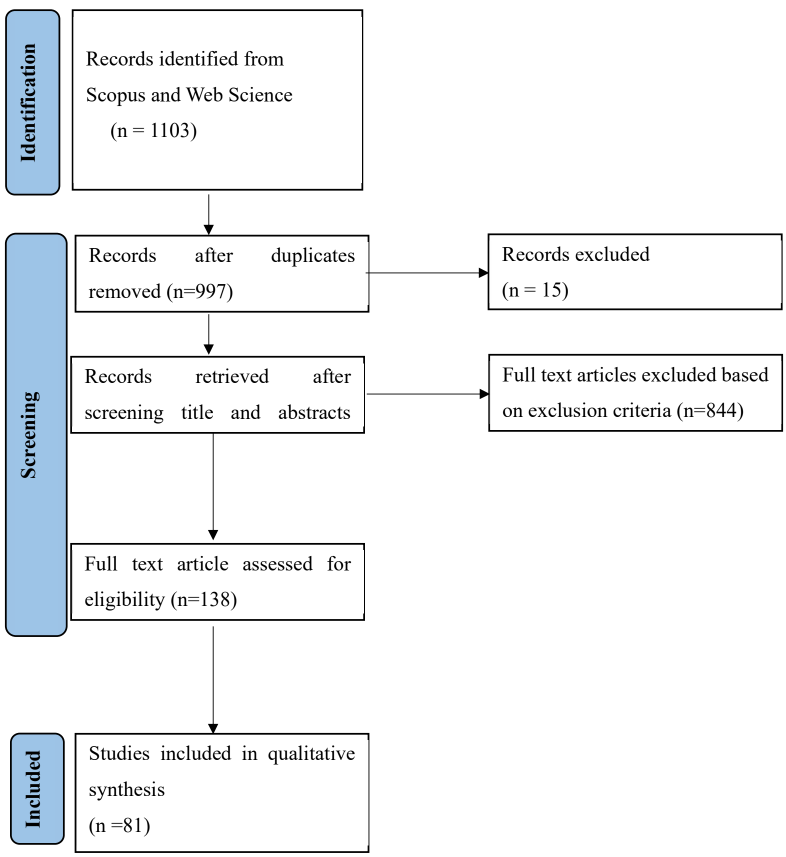


Fig. 3: Literature review workflow (PRISMA).

loops in energy generation sustainability that have been noted for each theme? 3. What fresh avenues of inquiry are recommended by the body of existing research?

The study followed the PRISMA standards when searching the literature. The PRISMA (Preferred Reporting Items for Systematic Reviews and Meta-Analyses) approach is frequently employed in systematic literature reviews because it provides a structured and transparent method for documenting the review procedure, improving quality and reliability (Sarkis-Onofre et al. 2021). It has become the industry standard for disclosing meta-analyses and systematic reviews in various disciplines. This approach enhances transparency and trustworthiness, improving the validity and applicability of the review results (Page 2017). The PRISMA method has several advantages over other alternative techniques for systematic literature reviews, including enhanced reproducibility, decreased bias risk, better presentation, and widespread acceptance. Two prominent research databases, Scopus and Web of Science, were used to locate relevant literature since they contain high-impact, peer-reviewed journal articles. Systematic reviews incorporate peer-reviewed journal articles, the quality and accuracy of the output gets increase (Mickan et al. 2013, Uttley et al. 2023).

The search combined the title, abstract, and keywords with the Boolean operators 'OR' and 'AND' to ensure that all potential articles were retrieved. The terms used in the search were 'Energy generation impacts' AND 'Coal energy generation' AND 'Cost of solar energy' AND 'Wind energy impact' OR 'Thermal plants' OR 'energy generation' OR 'Social cost of energy generation' OR 'Solar energy impact' OR 'Coal energy impacts' OR 'Energy generation impacts' OR 'Energy externalities.' This study considered studies published in peer-reviewed journals, written in English, and terms mentioned in the title, authors' keywords, or abstract. The study excludes book chapters, editorials, conference proceedings, and editorial notices. The data for this study was limited to 2009-2022. Fig. 3 depicts a full description of the approach used in this study.

RESULTS

Energy Generation and Water Footprint

The intricate connection between water consumption and energy technologies highlights their vital interdependence in modern life. Water plays a crucial role in various energy generation processes, creating a symbiotic relationship that requires careful consideration for sustainable energy solutions (Okadera et al. 2014, Jin et al.2019). As our reliance on diverse energy is increasing, there is a growing demand for water resources, necessitating strategies to optimize water usage and enhance energy efficiency while minimizing environmental impacts. Recognizing the reciprocal relationship between water and energy, from generation to distribution and consumption, underscores the need for holistic approaches to resource management. Population growth and increased water consumption in industrial sectors are predicted to reduce the average per capita water supply. The Indian energy sector drew over 20 billion cubic meters of water and consumed over 3 billion cubic meters in 2019. Almost 35% of coal energy plants use freshwater for cooling, primarily in water-stressed parts of India. Coal power plants are the largest consumers of fresh water since they require water during coal extraction and processing (Kenny et al. 2009, Pan et al. 2012, Qin et al. 2015). A study by (Meldrum et al. 2013) estimated water consumption and withdrawal in the operation and maintenance of coal plants and found that around 76 percent and 83 percent are utilized in these processes, respectively, leading to water source contamination. Even if the contaminated water is recycled, only eight percent of the wastewater released by coal plants can be used for cooling purposes (International Energy Agency (IEA) 2021). The transition towards renewables is required to reduce this consumption and contamination of the water. The most efficient way to lower the water consumption intensity of energy sector is to increase the use of renewable energy sources (Mekonnen et al. 2015, Ding et al. 2018). Groesbeck and Pearce (2018) revealed that wind turbines and solar PV panels need very little water to generate electricity, whereas water required to cool thermal energy plants ranges from 85% to 95%. Even if the water contamination issue of coal energy plants is resolved through desalination (quality improvement), it would not be an effective solution; the only alternative is renewable sources that supply energy without impacting the environment. Research findings by (Al-Karaghouli & Kazmerski 2012, Feria-Diaz et al. 2021) affirmed that adopting renewable energy sources can lessen the burden on freshwater resources. Conversely, Meldrum et al. (2013) highlighted that renewables cause water contamination in their operation and maintenance; around 20 $gal.MWh^{-1}$ of water is used to maintain the solar panels. Although solar photovoltaic utilities consume and withdraw less water than coal power plants, they consume more water during construction (Klise et al. 2013).

Table 1 shows the water footprint of different electricity generation technologies during their lifecycle. Maximum water footprint occurs in operating thermal power plants and constructing solar power plants. Findings of studies confirmed that solar energy technology could significantly cut water usage, withdrawals, and contamination (Tawalbeh et al. 2021, Jin et al. 2019). Various subjects showed a link between energy generation and conceptions of water use intensity. Few studies have thoroughly examined the intensity of water use in energy generation and other sectors. However, there is a need for more research investigating energy generation resources and their water use intensity, particularly in underdeveloped or developing countries. Furthermore, more research needs to be conducted on the multifaceted element of water utilization in energy generation. Such research would attract regulators, legislators, and manufacturers, particularly those with resources that must be made aware of sustainability.

Energy Generation and Greenhouse Gases (GHG) Emissions

The rising energy and fuel energy demand considerably add to greenhouse gas emissions and global climate change. According to the Ministry of Environment, Forest and Climate Change (2021), greenhouse gas emissions from the energy sector increased from 55.95 percent in 2011 to 56.66 percent in 2016. Chakravarty and Somanathan (2021) revealed that the mortality rate due to air pollution was 2.03 cents/kWh by coal energy generation in 2018. Their finding aligns with the findings of (Cropper et al. 2021, Sahu et al. 2021). Wiser et al. (2016) projected the ecosystem and human health benefits of renewable sources, inferring that solar energy is viable even without subsidies in the coming years. Bernal-Agustin and Dufo-Lopez (2006) investigated that investment in grid-connected PV systems is profitable from an economic and environmental perspective. However, the high payback period may deter investors; still, solar PV can save between 0.08 and 0.38 Euros per kWh, which calls for the substitution of coal power plants.

All types of PV systems are a potential method of electricity generation for reducing CO_2 emissions and conserving energy resources (Sherwani & Usmani 2010).

Table 1: Average consumptive water footprint per unit of electricity.

Technology	Construction (m^3 TJe^{-1})	Operation (m^3 TJe^{-1})	Fuel Supply (m^3 TJe^{-1})
Coal and lignite	1.1	440	54
Natural gas	1.1	240	6
Hydro energy	0.3	15100	0
Nuclear	0.3	610	68
Oil	1.1	440	55
Wind	1.1	0.2	0
Firewood	0.4	400	156000
Geothermal	2.1	340	0
Solar (PV + CSP)	90	50	0

Source: Martin (2012)

Likewise, many researchers supported renewable sources' positive implications for mitigating greenhouse gas emissions. Samadi (2017) inferred that renewable energy generation technologies exhibit fewer externalities than coal-based technologies. Wu et al. (2017) indicated that one megawatt solar PV plant would provide yearly 2.08×10^9 g CO_2 equivalent greenhouse gas emission savings. On the contrary, Desideri (2012) evaluated a hypothetical PV plant and inferred that even solar plants are not environmentally friendly as they produce 44.7 $g.kWh^{-1}$ emissions. Their finding corresponds to the study of Nugent et al. (2014), which revealed that both solar and wind systems cause GHG emissions during their lifecycle; they are not emissions-free technologies.

Despite a few disadvantages, solar energy technology is the most viable energy source for future global energy needs, followed by biomass and geothermal (Kabir et al. 2018). Emissions from thermal energy plants are extremely harmful; only 3.6 percent of solar PV is necessary to counteract life loss due to coal pollution (Ftehnakis et al. 2008). Energy generation through solar PV can save 69-100 million tonnes of CO_2, 69000-98000 tonnes of NOx, and 126000-184000 tonnes of SO_2 by 2030 (Shahsavari & Akbari 2018). Among energy technologies, hydro-energy emits only 0.011 tCO2/MWh, but it affects the aquatic habitat (Table 2). The next best alternative is nuclear energy, which emits less emissions but produces radioactive waste (Harris et al. 2013). Wind energy emits only 0.0295 $tCO2.MWh^{-1}$ but has wildlife-related risks because wind turbines kill Avian (Sanchez-Zapata et al. 2016, Teff-Seker et al. 2022). Solar photovoltaic energy is efficient in combating greenhouse gases without creating additional issues. It was determined that increased energy generation from fossil-fuel-based industries is connected with higher GHG emissions, and solar PV has the potential to reduce emissions drastically (Amponsah et al. 2014, Hardisty et al. 2012). Greenhouse gas emissions (GHGs) could not be utilized as a single metric to depict a technology's environmental sustainability (Georgakellos & Didaskalou 2014). Climate change must be prioritized among the impacts of energy generation systems, followed by land footprint (Turney & Fthenakis 2011).

Despite the global recognition of Sustainable Development Goals (SDGs), there is a significant gap in research addressing sustainability in energy generation technologies. Limited scholarly publications have explored energy generation systems through the lens of multi-dimensional sustainability, necessitating further examination. Moreover, sustainable energy generation technologies may sometimes involve extra costs for utilities. Consequently, empirical investigations are crucial to offer improved solutions and

Table 2: Total lifetime global warming potential (MT CO_2eq) for technologies.

Technology (5.5 TWh)	CO_2($\times10^6$)	CH_4 ($\times10^4$)	N_2O ($\times10^4$)	GWE ($\times10^6$)
Hydroelectric	0.51	0.084	0.85	0.51
Photovoltaic	1.1	0.78	8.7	1.1
Wind Farm	0.82	0.054	0.65	0.83
Coal	86	35	220	86
Natural Gas	51	50	220	54

Source: Bergerson & Lave (2002)

ascertain the willingness to incur these additional expenses for environmental betterment.

Energy Generation and Health Impacts

Health impacts include the effects of air pollution on human health, crop production, and buildings, leading to occupational diseases, injuries, and accidents at the workplace. The magnitude of the health impact is primarily connected to the population density and environmental conditions in the exposed areas. According to AirClim (2013), over 19 million people in India suffered from respiratory ailments, and 80,100 to 1,14900 premature deaths occurred due to harmful emissions from thermal energy plants in 2012. The environmental impact and health damage costs of thermal energy plants are approx. 39.3 cents per kWh (Nkambule & Blignaut 2012). According to Guttikunda and Jawahar (2014), if the emission control measures were not adopted, respiratory diseases would increase to 42.7 million by 2030, resulting in 23000 crore health care costs per year. Nonetheless, deaths from coal energy generation were significantly higher than those from solar energy generation in 2014 (Fig. 4). Major accidents occur due to operational errors in solar photovoltaic production and coal mining (Prehoda & Pearce 2017). However, operational errors in solar PV are minimal. In 2015, 0-202 per 100000 people were killed by PM2.5 emissions from coal energy plants, while the deaths due to NO2 ranged from 0-72 per 100000; this rate is anticipated to increase 2-3 times by 2030 (Khomenko et al. 2021). With the release of PM2.5 from coal-fired energy plants, the mortality rate would be 6 per 10000 by 2025 (Chio et al. 2019). Around 112000 deaths occur annually in India due to coal-fired energy plant emissions (Cropper et al. 2021). Coal and oil plants have impacted respiratory diseases and the fertility rate among people. Studies have considered the effects of early retirement of coal plants and the effects of the transition to renewable (Maamoun et al. 2020, 2022).

Fertility rates per 1000 women (15-44 yrs) increased by eight births within 5 km and two deliveries within 5-10 km near energy plants per year after the exit of thermal plants (Casey et al. 2018). One gigawatt hour (GWh) of solar energy reduces hospitalizations due to respiratory problems by 52 percent in cities near the displaced plants (~13 percent decline on average) (Rivera et al. 2021). The reductions in cardiovascular and pulmonary ailments were primarily evident in newborns, children (ages 6-14), and seniors due to the shift from thermal energy plants to solar energy generation. Between 2005 and 2016, the retirement of coal-based energy plant units saved 26,600 lives in the United States (Burney 2020). The value assessments from various studies discovered that switching to solar PV is not entirely viable, yet it saves lives and money (Breyer et al. 2015, Jenniches & Worrell 2019, Jager-Waldau et al. 2020). Understanding the origins and quantities of emissions produced by energy-producing systems is critical. Despite the energy sector's prominent position in public health damage, research on measuring health damage caused by energy-producing technologies is limited. Research on long-term solutions for managing and mitigating health damage, morbidity, and mortality caused by energy-producing technology is scarce. Furthermore, while there has been much research on health effect mitigation techniques in the energy industry in developed nations (Masnadi et al. 2018, Yeh et al. 2010), little work has been done in underdeveloped countries.

Source: Sovacoolet al. (2016), Markandya & Wilkinson (2007)

Fig. 4: Death rates from energy sources (per TWh).

Energy Generation and Employment Generation

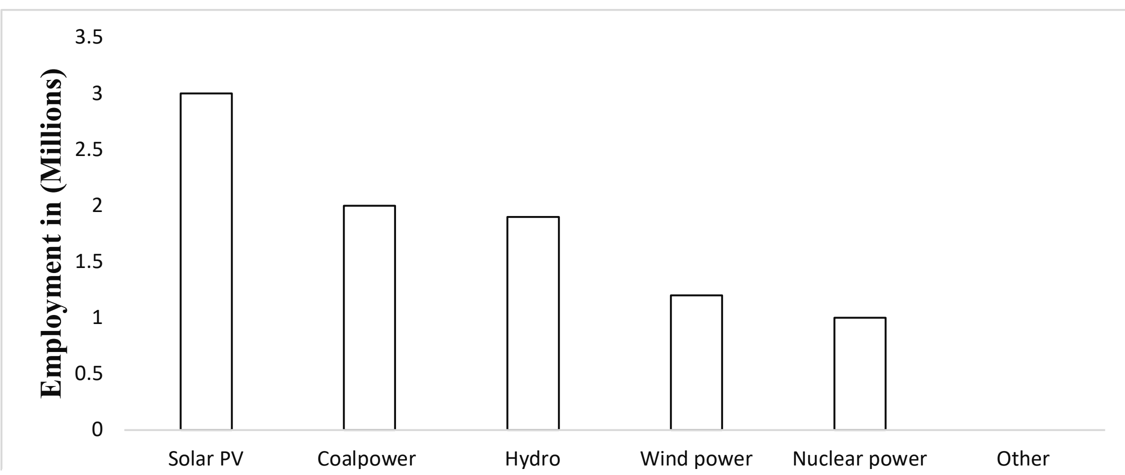
Energy generation technologies significantly impact the nation's employment rate (Bryan et al. 2017, Nagatomo et al. 2021). Even without considering the type of energy technology, the employment rate varies during different phases, like upstream and downstream processing of generation technology (Odeh & Cockerill 2008).

Coal energy employs more unskilled people in mining and transportation to obtain raw materials. In case ofrenewables, the rate of indirect and induced employment is higher than the rate of direct employment. However, the renewable energy sector engages skilled workers, such as skilled labor, in manufacturing modules and equipment and installing solar PV plants (Wei et al. 2010). Multiple studies supported adopting a renewable system for dealing with the unemployment problem globally. Ali et al. (2021) proposed enhancing reliance on renewable energy and reducing the usage of fossil fuels to ramp up the employment rate up to 2030. According to Natarajan and Nalini (2015), solar PV would generate 0.152 million jobs and 0.225 million on-grid and off-grid by 2022. The employment rate in the coal energy sector will decrease by 52% by 2040, owing to decarbonization. Solar Photovoltaic contributed to 3.98 million jobs among renewables in 2020. According to the International Renewable Energy Agency (IRENA 2021), on-grid solar employment generated 93,900 jobs, while off-grid solar employment generated 69,600 jobs in India. Moreover, a study by Stanford University stated that renewable technology might generate twenty-eight million jobs globally in the future. Employment by renewable plants would be five times more than that of fossil fuel plants.

Similarly, Garett-Peltier (2017) stated that every million USD spent on renewable energy creates 7.5 full-time equivalent jobs across the economy. Studies confirmed that green technologies benefit the energy generation industry and the overall economy, analyzing the impacts of technologies. More academic scholars from many nations are exploring the issue of 'employment generation' in the energy sectors. Future studies should prioritize a more comprehensive multidisciplinary examination of various aspects of employment in the energy generation sector. Fig. 5 depicts global employment due to energy generation technologies in which the share of solar photovoltaics is high. Assessing the effects on employment would assist policymakers in formulating transformation strategies influenced by climatic and environmental challenges and social factors.

Energy Generation and Land Use Intensity

The most apparent effect of land use is the quantity of land taken at the price of the natural ecosystem, leading to land and soil deterioration. One of the objectives of SDG 15 is to prevent land degradation induced by energy supply and consumption. Studies have considered land use differently: land occupation and transformation, direct land use, and indirect land use. Land use intensity, health damage, greenhouse gas emissions, energy cost, and energy security should be considered in energy system planning (Lovering et al. 2022). Coal energy plants cover the land for mining, storage, and evacuation of sites for raw coal. The installation of coal energy plants negatively impacts the environment because of the pollutants produced during extraction, construction, and energy generation. This makes the land unusable for irrigation and rehabilitation; as a result,



Source: IEA, 2022

Fig. 5: Global employment in energy generation technologies.

the people living there are forced to move. Multiple studies have studied the land use intensity of generation technologies and come up with different conclusions. Rej and Nag (2020) analyzed that the transition to a low-carbon economy by 2030 is associated with a massive land demand. Correspondingly, Kiesecker et al. (2019) estimated a 55000 to 125000 km^2 land requirement to build the projected energy capacity by 2022. In addition, they pointed out that there is more than enough land area (more than ten times) in India to achieve the target for solar and wind energy by 2022. Moreover, Fthenakis and Kim (2009) made a comparative analysis and revealed that the direct land use by solar PV is less than that needed for coal-fired and natural gas plants.

In case of coal, indirect land usage (more than 55%) for coal is greater than direct land use, indicating that the PV plants cause less land disturbance than others. Ong et al. (2013) assessed the land needed for solar PV. They estimated that around 2.1 -12.3 acres per MWac of direct land use is required for a solar PV installation, with an average overall land use of 3.6 acres per $GWh.Yr^{-1}$. Mohan (2017) analyzed that nuclear energy requires only six percent of the total land area of solar PV and around 1/5th of the land area for wind energy per GWh of electricity generated. Turney and Fthenakis made a similar comparison in 2011; they found that the land transformation rate of solar plants was lower than that of coal plants for more than 27 years. The utilization of land by hydropower projects varies greatly. Deepwater dams have a lower footprint than shallow dams because energy generation depends on hydraulic pressure and water flow rate (Fthenakis & Kim 2009).

Selecting energy technology based solely on land use impact is inadequate to support policy decisions fully, yet it is a crucial factor to consider (Mohan 2017). Locating solar systems (agrivoltaic systems) and wind systems alongside agriculture has been proposed as a strategy to reduce the land footprint of renewable energy systems (Dinesh & Pearce 2016, Ravi et al. 2016, Moretti & Marucci 2019). Table 3 shows that the land use intensity of all energy systems differs depending on the source, ranging from 0.1 to 500 $m^2.MWh^{-1}$. While estimating global warming potential is well advanced, many other indicators are still in the early stages of development. As the transition to more renewable-based systems occurs, these measurements will demand the same attention as those related to climate change. Otherwise, they may pose unexpected challenges to the energy transition.

Table 3: Land use intensity in electricity generation.

Energy sources	Land use Intensity [$m^2.MWh^{-1}$]
Nuclear	1
Natural gas	0.1
Coal (Underground)	0.2
Surface (open-cast)	0.4
Wind	0.7
Geothermal	2.5
HydroEnergy (large dams)	3.5
Solar photovoltaic	8.7
Solar – concentrated solar Energy	7.8
Biomass (from Crops)	450

Source: IINAS (2017)

DISCUSSION AND CONCLUSION

This study examined the literature on the social cost of energy generation using the Web of Science and Scopus databases. Articles emerging from the search were read, evaluated, and grouped in categories linked to the impacts of electricity generation for creating the systematic literature review. A reading procedure of articles was done to make the literature summary of existing studies in this area. Most studies focused on coal-based energy production technologies, while others focused on renewable energy generation technologies. Numerous studies found that the external costs of coal-based energy generation were high. Studies in this area were based on qualitative and quantitative approaches (maximum studies were quantitative). Very limited studies were based on primary research in this area, mostly based on secondary sources. Solar photovoltaic was analyzed as the most efficient renewable energy generation technology in land utilization efficiency, outperforming coal plants and other technologies. Wind was found to be the most efficient technology regarding water footprint, followed by solar PV, while coal plants were the least significant option. Solar photovoltaic technology was the leading option in job creation, while the coal energy sector was on the reverse side due to severe health impacts and job fall due to decarbonization. Saving lives by switching from coal-fired electricity to solar energy is proven viable in the existing literature, and this transition would create significant health and environmental benefits. According to studies, the externality of coal-fired energy is increasing, and coal is still the dominant source of energy generation. Replacing coal energy with solar energy benefits humans, the environment, and the economy. This transition would help ensure our planet's sustainability. It has been concluded that renewable energy technologies are the best solutions, even after considering the storage and dumping of waste after the end of their lifecycle.

Implications

Theoretical Implications

The significance of every study is determined by its contribution to research theory, technique, and knowledge advancement. This study adds to the literature on energy sustainability by expanding theoretical support on the connection between energy generation technologies and other factors by covering the issues under five themes. In addition to these factors, the study has identified gaps in each theme, directing academics to work on low-investigated aspects and associated issues. Research based on qualitative techniques must be expanded to significantly advance theoretical understanding in this field of study.

Practical Implications

This study has major implications for enterprises that provide sustainable products or services based on several qualities that foster sustainability, regional growth, economic development, and technical innovation. Sustainability issue can be found everywhere, notably in the energy sector, whether at the household, commercial, or industrial level. Understanding these five issues will allow developers to devise more efficient techniques for boosting green energy generation and meeting the energy demand. To be more precise, this review emphasizes the need to accept sustainable energy and how it may be shown as a crucial element of the community. This gives insight to business executives about the importance of focusing solely on green energy technology.

Limitation and Future Scope

This study contains limitations that pave the path for future research. To begin with, this analysis entirely uses theoretical data; subsequent research may use survey responses or interviews to objectively evaluate these relationships between energy generation and other factors. The review section summarizes each connected aspect to touch upon as many energy generation topics as is practical; further research could provide a more in-depth assessment of various factors related to energy sustainability. Future research should focus on issues like how energy creation affects waste disposal and how to encourage recycling of waste created by electricity generation technology. Finally, this analysis only included openly available research; future analyses can integrate more studies by subscription to various journals to reach works that are not publicly accessible and add to the body of existing knowledge.

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.

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ORCID DETAILS OF THE AUTHORS

Aqsa Anjum: https://orcid.org/0000-0002-2442-185X