

Review

Understanding Energy Poverty in China: Measurement, Impacts, and Policy Interventions

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Abstract: Energy poverty, defined as the inability to access reliable, safe, and affordable energy services necessary to meet basic needs, represents a critical global challenge alongside traditional poverty concerns. Unlike conventional poverty, energy poverty emphasizes the importance of energy availability and affordability, with inadequate access adversely affecting health, education, and social well-being. Recognized as a primary challenge within the global energy landscape, energy poverty has garnered considerable attention from both international communities and academic researchers. This paper provides a comprehensive overview, starting with the definition and measurement of energy poverty, discussing its current status, exploring its causes and impacts, and proposing actionable policy interventions. Finally, it outlines future prospects for addressing and mitigating energy poverty.

Keywords: energy poverty; multidimensional measurement; poverty

1. Introduction

The 79th session of the United Nations General Assembly in 2024 emphasized that with only six years remaining to achieve the Sustainable Development Goals (SDGs), the commitments outlined in the 2030 Agenda for Sustainable Development are under serious threat. The energy sector plays a pivotal role in driving numerous crises, including catastrophic heatwaves, droughts, floods, and wildfires. Fossil fuel production and consumption for energy and industrial purposes remain the largest contributors to global greenhouse gas emissions, accounting for approximately 85% of global carbon dioxide emissions. In recent years, price shocks in fossil fuels have further exacerbated challenges by driving up energy costs, fueling inflation, and increasing public hardship. This review seeks to support planners and analysts in addressing these pressing issues by providing a comprehensive overview of energy poverty. Although the Millennium Development Goals did not explicitly address energy, it is evident that access to adequate and affordable energy is a fundamental prerequisite for achieving many of these targets.

Energy serves as a foundational element and driving force for human survival and development. However, the global energy system faces three interrelated challenges: persistent energy poverty, increasing risks of energy supply disruptions, and the environmental threats arising from energy production and consumption. According to the International Energy Agency (IEA), global coal demand reached a record 8687 metric tons in 2023, marking a 2.5% year-on-year increase. Furthermore, global coal demand is projected to grow by an additional 1.0% by 2024.

As a developing country, China faces significant challenges related to energy poverty, which hampers its social and economic development, as well as national welfare. However,

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energy poverty is not confined to developing countries; it also exists in developed nations. Berry (2018) [1] highlighted that in France, 17.7% of the population experiences energy poverty in housing, 20.6% in transportation, and 30.9% in at least one of these areas. In the United Kingdom, 18% of households are energy poor, with 11.6% of these households also being income poor, and 50% of the income-poor households also experiencing energy poverty. In Bangladesh, 58% of the population is energy poor, with 46% of non-income-poor individuals also facing energy poverty, and 81% of the income-poor population also experiencing energy poverty. These figures illustrate that energy poverty and income poverty are distinct yet interrelated issues, representing a new form of poverty that persists even after addressing income poverty.

To effectively address energy poverty, it is essential to accurately identify the groups affected by it and understand the causes and impacts of energy poverty. This understanding is crucial for formulating relevant policies. However, the lack of existing research somewhat limits the government's ability to develop strategies to alleviate energy poverty.

Based on this context, our paper will begin by defining energy poverty, followed by an introduction to its measurement, current status, causes, and effects. The aim is to provide experts and scholars with a deeper understanding of energy poverty in China, facilitating more in-depth and targeted research. This, in turn, will enable enterprises to develop projects that better support energy development. Ultimately, this paper seeks to offer new perspectives on the assessment and elimination of energy poverty, providing a foundation for relevant policies and ensuring more precise and reasonable support for the target populations affected by energy poverty.

2. Definition of Energy Poverty

The concept of energy poverty originated from the 1982 UK Fuel Rights movement. Boardman (1991) [2] later expanded this concept to include residential houses with low energy efficiency. As attention increasingly shifts toward developing countries, the meaning of energy poverty has evolved accordingly.

Several definitions of energy poverty exist both domestically and internationally. The International Energy Agency (IEA) defines energy poverty based on the characteristics of populations that primarily rely on traditional biomass for cooking or lack access to electricity. Traditional biomass includes firewood, straw, rice husks, other agricultural waste, and livestock and poultry manure. This definition is the most widely recognized and applied in research. By examining these definitions, it becomes clear that energy poverty encompasses both access to modern energy services and the efficiency of energy use. As such, addressing energy poverty requires a comprehensive understanding of both access to energy and the efficiency of its use, particularly in the context of developing countries.

The United Nations (2000) introduced a modern concept of energy poverty, describing it as the lack of adequate, affordable, reliable, high-quality, safe, and environmentally sound energy services necessary for supporting economic and human development. This definition underscores the intrinsic link between energy access and environmental impacts. More than 300 million people worldwide rely on solid fuels, such as biomass (animal dung, firewood, and crop residues) and coal, to meet their daily needs for cooking, heating, and hot water. These households face a significant dilemma: discontinuing the use of these fuels often means resorting to eating raw food, while continuing their use entails dealing with the harmful effects of inefficient combustion.

Several international organizations define energy poverty as reliance on unsafe energy sources, such as traditional biomass and low-quality fuels. This mode of energy use negatively impacts both health and the environment [3]. The inability to secure a safe and reliable power supply forces people to heavily depend on solid fuels. Some scholars expand

the definition of energy poverty to encompass access to energy services, emphasizing that effective energy access is closely related to improving the quality of life. This approach supplements traditional measures of poverty by considering factors such as whether a household can use various electrical appliances, access to electricity (connection to the grid), market access, purchasing power, and the ability to buy equipment and electricity at competitive prices (World Bank, 2020).

Energy poverty also manifests as the inability to afford energy services. High energy costs can prevent individuals from covering their energy expenses while meeting other basic needs [4]. Therefore, addressing energy poverty involves ensuring both the availability of energy and the economic capacity to afford it, which is essential for enhancing the overall living standards and supporting sustainable development.

Thus, the definition of energy poverty encompasses the lack of reliable, safe, and affordable energy services, alongside over-reliance on traditional and unsafe energy sources. This situation negatively impacts living conditions, health, and economic development. Addressing energy poverty requires integrated policies and measures to provide reliable, safe, and affordable energy services, promote sustainable energy development, and improve energy efficiency. By implementing these strategies, it is possible to mitigate the adverse effects of energy poverty and support the overall human and economic development.

3. The Measure of Energy Poverty

The measure of energy poverty encompasses a wide range of dimensions, including energy accessibility, energy security, and the energy cost burden. These dimensions can be utilized individually or in combination, enabling a comprehensive analysis and assessment of energy poverty issues. In 2019, Zhang et al. [5] developed a two-dimensional Multidimensional Energy Poverty Index (MEPI) based on cooking energy types and energy consumption, representing accessibility and affordability, respectively. The most widely used index for assessing energy poverty today is the Multidimensional Energy Poverty Index (MEPI), proposed by Nussbaumer et al. (2011) [6]. MEPI incorporates five dimensions that reflect essential energy services: cooking, lighting, services provided through home appliances, entertainment/education, and communication.

The primary goal of these measurement indicators is to aid policymakers and researchers in better understanding and addressing energy poverty, thereby promoting sustainable energy development and social equity. Over the past two decades, numerous energy poverty measures have been based on physical energy consumption or by defining a poverty line, categorizing households consuming above this threshold as not energy poor. These methods typically define a minimum standard of living in terms of energy services required for cooking, lighting, and heating.

However, these methods have significant drawbacks. Variations in cooking and heating practices across different countries and regions make it challenging to determine a precise level of energy that satisfies basic needs. Moreover, global climatic differences result in substantial regional variations in energy consumption. The determination of minimum energy demand is often arbitrary, with different calculation methods yielding varying results. Physical measurements typically focus on the total amount of energy consumed, neglecting the differences in the quality of various energy types. For instance, natural gas and coal have distinct combustion characteristics. Additionally, there is insufficient attention paid to the negative environmental impacts of energy production, transportation, and consumption, such as greenhouse gas emissions and air pollution.

3.1. Single Dimensional Measurement

A single indicator measure of energy poverty evaluates and assesses individuals' access to and use of energy through a singular metric (shown in Table 1). This approach offers several advantages: it simplifies the assessment process, enhances comparability and operability, and facilitates the ease of tracking and monitoring. By focusing on key issues, this method helps to better understand and address energy poverty, thereby promoting sustainable energy development and social equity.

Table 1. Literature relating to the single dimensional measurement.

Single-Indicator Methodology	Bibliographic
TPR	Boardman (1991) [2]; Best et al. (2021) [7]; Legendre and Ricci (2015) [8]; Moore (2012) [9]
LIHC	Hills (2012) [10]; Bardazzi et al. (2021) [11]; Legendre and Ricci (2015) [8]
MIS	Moore (2012) [9]
2M	Castano-Rosa et al. (2019) [12]

The TPR (ten percent rule) indicator, introduced by Boardman (1991) [2], classifies households as energy poor if they spend 10% or more of their income on energy services. This index is simple and easy to understand, making it useful for quickly assessing whether a family is in energy poverty. Its straightforward calculation method helps policymakers and researchers identify problems and take appropriate measures. The TPR indicator is also highly objective, using a fixed 10% threshold to reduce the influence of subjective judgment. However, the TPR index has some disadvantages. It is overly simplistic, focusing solely on the proportion of household income spent on energy services and not considering other factors, such as household size. This can result in the misclassification of very wealthy families living in large, difficult-to-heat homes, such as villas, castles, or palaces, as energy poor [7]. Additionally, in developing countries where traditional biomass energy is non-commercial, the TPR index cannot accurately calculate the energy expenditure of poor households. The index has also been criticized for its over-reliance on energy prices [8,9].

The LIHC (low income high cost) indicator, as proposed by Hills (2012) [10], categorizes families based on their energy poverty (EP) status. It identifies households as being in energy poverty if they spend more than the median on energy and if their income, after accounting for these expenses, falls below 60% of the median net (after-tax) income. Measuring energy poverty simply as a percentage of household income may overlook some of the issues. For example, some households may incur higher energy costs and have a lower residual income, even though their energy expenditure as a percentage of their income may seem reasonable, due to inefficient energy equipment. The dual threshold setting of the LIHC indicator breaks the limitation of this one-dimensionality, and considers the two dimensions of high energy cost and low residual income.

However, the LIHC index has some shortcomings: it primarily focuses on energy service spending and income levels, neglecting to provide detailed information on other essential living costs, such as housing and food [11]; implementing the LIHC index may necessitate heightened monitoring and could become subject to political intervention [13]; the comparability of LIHC indicators may be compromised due to disparities in energy costs and income levels among different regions and countries. These limitations indicate that while the LIHC indicator offers valuable insights into energy poverty, it may not offer a complete depiction of households' overall financial situations and living standards. Incorporating additional factors and accounting for regional differences could enhance the accuracy and effectiveness of energy poverty assessments.

The MIS (minimum income standard) indicator identifies a household as being in an energy poverty situation if its income, after accounting for energy service expenditure, falls below the minimum income standard (MIS). This method, as described by Moore (2012) [9], provides a relatively objective measure of whether a family meets a basic standard of living. The MIS indicator uses the minimum income standard as an absolute threshold to address economic challenges, differing from other indicators that rely on relative standards. It aids policymakers in determining social security measures and minimum wage standards to uphold a basic standard of living. But the main role of the MIS indicator is to assess the impact of energy costs on the basic standard of living, for example, in cold regions, where adequate heating energy is essential for the health of residents. By incorporating energy costs into the calculation of MIS indicators, it is possible to more accurately assess how much income households need to pay for their energy bills in order to maintain a basic standard of living.

However, MIS indicators also have limitations. For example, MIS indicators may be subjective because the minimum income standard may be influenced by political, social, and cultural factors; MIS indicators cannot provide detailed information on other aspects of the family, such as expenditure on housing and medical care. These limitations suggest that while the MIS indicator provides an objective measure of meeting basic living standards, it may not capture the full financial picture or account for all essential expenses. Policymakers should consider these factors when using MIS indicators to assess energy poverty and develop relevant policies.

The 2M indicator, as developed by Castano-Rosa et al. (2019) [12], comprises four similar metrics: twice the median, twice the mean, twice the median share, and twice the average share of household energy expenditure. A household is deemed energy poor if its energy expenditure exceeds twice the median cost, twice the median, twice the median share, or twice the average share of household energy expenditure. These indicators complement each other, with twice the median providing an assessment of overall energy poverty and twice the mean focusing on households experiencing high levels of energy poverty.

However, the 2M index has faced criticism for several reasons. First, it determines the minimum income on an objective basis, leading to potential difficulties. Second, there are challenges in identifying normative standards for the 2M indicator. Non-convergence payments also impact the accuracy of the 2M indicator. Additionally, there is insufficient argumentation for why twice the national median serves as an appropriate threshold for defining energy poverty. These critiques highlight the complexities and limitations of the 2M indicator, suggesting the need for further refinement and justification of its methodology and threshold criteria.

Rizal (2024) [14] conducted a comparative analysis of various single-dimensional metrics, examining three weighting schemes and deprivation cutoffs for redundancy, robustness, and sensitivity. This comprehensive study utilized statistical models such as Logit, Probit, Tobit, and Heckman selection to decompose and ascertain the socioeconomic, demographic, and geographic factors of household heads. The findings of the study revealed that the LIHC index emerged as the most reliable single-dimensional indicator, with the TPR index following closely behind. This outcome underscores the effectiveness and credibility of these metrics in assessing energy poverty and providing valuable insights into the socioeconomic conditions of households.

Single-dimensional metrics indeed offer clarity, ease of calculation, and comparability, making them straightforward tools for assessment. However, their limitation lies in their narrow scope, often failing to capture the entirety of complex issues like energy poverty. Consequently, some economists criticize single indicators for lacking empirical

support or for addressing the problem in a limited manner. For instance, Fizaine and Kahouli (2019) [15] argue that single indicators may lack a robust empirical defense, potentially leading to inaccuracies or oversimplifications in assessing energy poverty. Similarly, Bouzarovski and Herrero (2017) [16] criticize single indicators for their excessively narrow approach to tackling the multifaceted aspects of the problem. These criticisms highlight the need for a more nuanced and comprehensive approach to measuring and addressing energy poverty, which may involve integrating multiple indicators or considering additional factors beyond a single-dimensional framework.

3.2. Multidimensional Measurement of Energy Poverty

To overcome the simplicity of single-dimensional indicators and the complexity inherent in capturing multidimensional aspects, analysis and interpretation can be facilitated by aggregating information from single-dimensional indicators (shown in Table 2). However, methodological issues, required assumptions, and value simplification necessitate further scrutiny of these metrics. When the data are overly simplistic or indicators are inadequately constructed, comprehensive indicators may mislead policy decisions. In the context of defining and measuring energy poverty, the emphasis often shifts toward economic aspects, favoring economic indicators as key measures.

Table 2. The multidimensional measurement of energy poverty.

Single-Indicator Methodology	Bibliographic
Affordability and Accessibility	Bonatz et al. (2019) [17]
RPVI	Gouveia et al. (2019) [18]
MEPI	Nussbaumer et al. (2011) [5]

Bonatz et al. (2019) [17] attempted to measure and compare energy poverty at the national level in China and Germany. The index they developed includes two dimensions: affordability and accessibility. Affordability is measured using metrics such as efficiency, revenue, and energy prices, while accessibility is assessed based on the availability of clean fuels, electricity, and affordable alternatives. However, this indicator fails to account for reliability, safety, and environmental impact, which are significant considerations. If reliability and safety are to be included in the measurement index, the specific regional and socio-economic priorities of the index need to be considered.

Gouveia et al. (2019) [18] recommend using the Energy Poverty Vulnerability Index (EPVI), which comprises two sub-indexes: one focusing on the socioeconomic characteristics of the population and the other on household energy performance. Specifically, these are the sub-index of the population's ability to implement mitigation measures and the sub-index of residential energy performance gap.

On the socioeconomic level, the EPVI is able to pinpoint vulnerable groups that are particularly susceptible to energy poverty. Socioeconomic factors include household income, employment status, family size, and other aspects. For example, low-income households are often more vulnerable when energy prices fluctuate or when energy supplies are unstable. The EPVI acts as a tool to identify households at a high risk of energy poverty due to their low socioeconomic status, considering these factors comprehensively.

From the perspective of household energy performance, the EPVI can evaluate the efficiency of household energy use. Household energy performance includes the energy efficiency of the house (e.g., thermal insulation, electrical efficiency) and the household's energy management habits (e.g., rational use of energy equipment). For instance, if a household resides in a poorly insulated house, its heating energy consumption may be high, and the EPVI accounts for this inefficiency to more accurately measure the household's vulnerability to energy poverty. While the EPVI could be improved by incorporating an

environmental dimension, its primary focus remains on socioeconomic vulnerability and household energy performance.

The most popular index today for assessing energy poverty is the Multidimensional Energy Poverty Index (MEPI). Proposed by Nussbaumer et al. (2011) [6], MEPI encompasses five dimensions representing essential energy services: cooking, lighting, services provided through home appliances, entertainment/education, and communication. These dimensions capture the most basic energy needs of households and provide a comprehensive reflection of their energy poverty status. The multidimensional approach of MEPI allows it to offer a more holistic assessment of energy poverty compared to single-indicator measures.

The MEPI employs six specific indicators across its five dimensions to provide a detailed assessment of energy poverty. These indicators include cooking with modern fuels; cooking with non-electric fuels such as LPG, natural gas, or biogas; electric lighting; home appliance ownership; ownership of recreational/educational equipment; and means of communication. These indicators reflect the current status and level of household energy services, offering a nuanced view of energy poverty. This refined selection allows for a more specific and comprehensive understanding of a family's energy challenges across all dimensions. Consequently, the MEPI can deliver a more accurate and actionable assessment of energy poverty.

However, the implementation of the MEPI faces significant challenges due to the vast amount of data required and the difficulty of applying the model in countries and regions with limited data collection capabilities. In the era of "big data", it is crucial not only to gather extensive data, but also professionally process and interpret this meaningful information. Consequently, the MEPI index demands sophisticated database management and higher levels of expertise.

Moreover, the MEPI is particularly applicable to developing countries, where energy poverty primarily stems from an inadequate access to modern energy services. In contrast, in developed countries, energy poverty is more closely associated with issues of low income and high energy prices. This duality underscores the need for different approaches to addressing energy poverty in diverse economic contexts.

There are some limitations to the indicator selection of MEPI. First, the MEPI indicators primarily focus on the quantity and quality of energy services, but do not adequately address the availability and sustainability of these services. This oversight may result in an incomplete assessment of households' access to energy services. Second, the MEPI's indicator selection involves a degree of subjectivity. For instance, in the cooking dimension, definitions and demands for modern and non-electric fuels can vary significantly across different regional and cultural contexts. This variability can affect the accuracy and relevance of the index in diverse settings.

In conclusion, while the MEPI offers significant advantages in its multidimensional and detailed approach, providing a comprehensive and nuanced assessment of energy poverty, it also has notable limitations. These include its insufficient consideration of availability and sustainability of energy services, and the inherent subjectivity in its indicator selection.

3.3. The Applicability of the Measurement Indicators in China

3.3.1. Reevaluating Traditional Energy Poverty Indicators in China

The indicators and standards used to assess energy poverty in China must be tailored to its specific context. Some of the conventional metrics, such as the availability of electricity, are no longer applicable due to the significant advancements made in rural electrification over the past few decades.

The unavailability of electricity is often seen as a key indicator of energy poverty [19]. However, in China, this issue has been largely resolved. Since the early 1980s, the gov-

ernment has implemented rural electrification initiatives and power poverty alleviation projects. By 2011, the national electricity coverage reached 99.9%, effectively eliminating the problem of electricity unavailability. Therefore, using the proportion of electricity availability to assess energy poverty in China fails to reflect current regional differences and is no longer relevant.

While many residents in rural China still rely on traditional biomass energy and lack clean cooking and heating equipment, this situation primarily affects rural areas. Urban residents have largely transitioned away from traditional biomass energy, with cooking and heating equipment meeting modern standards. Consequently, energy poverty indicators involving traditional biomass fuels and non-clean cooking heating equipment are not applicable to urban areas in China.

Historically, rural residents in China obtained firewood through logging, with firewood fuel coming from local forests. However, with the implementation of the Forest Law of the People's Republic of China and strict policies on forest resource management, deforestation is no longer a primary source of firewood for rural residents. Therefore, indicators that measure deforestation for harvesting traditional biomass energy are outdated and not suitable for assessing current energy poverty in rural China.

In conclusion, while traditional energy poverty indicators like electricity availability and biomass fuel usage have been crucial in other contexts, they no longer accurately reflect the energy poverty landscape in China. This highlights the need for context-specific indicators that consider the unique advancements and current realities in different regions.

3.3.2. Adjusted Indicators and Standards for Assessing Energy Poverty in China

Economic Burden of Household Energy Consumption: The "10% threshold" standard used in the UK to identify energy poverty is based on the proportion of household income spent on energy. While this method has been effective in the UK, it requires adjustment to fit China's context. Given the different stages of social development and living standards between China and the UK, as well as the government-regulated energy prices in China, a lower threshold is more appropriate. In China, urban residents spent an average of 719.2 yuan per year on electricity, fuel, and heating in 2011, accounting for 3.3% of their income. This is significantly below the UK's 10% threshold. Therefore, a lower threshold should be established for China, possibly around 5% or less, to accurately reflect the economic burden of energy costs on low-income households.

Commodity Energy Consumption: Both urban and rural residents in China consume commodity energy, although the extent and type of energy used may differ. Urban residents rely entirely on commodity energy, while rural residents use a mix of traditional and commodity energy sources. An indicator that captures the proportion of income spent on commodity energy can effectively highlight the economic burden on households. This indicator should be region-specific, considering the varying energy prices and income levels across different provinces and cities. Adjusting the threshold for different regions can provide a more accurate picture of energy poverty.

Household Energy Costs and Income Levels: A refined indicator should measure the proportion of household income spent on energy, with adjustments for regional income disparities and energy prices. This indicator would help identify households that are disproportionately burdened by energy costs. Urban areas may have a different threshold compared to rural areas, reflecting the higher dependency on commodity energy in cities and the mixed energy sources in rural regions.

Government-Regulated Energy Prices: The Chinese government's regulation of energy prices keeps them relatively low compared to market-driven prices in the UK. This regulatory environment should be factored into the assessment to avoid underestimating

the energy poverty experienced by households. The continuous monitoring of energy price changes and their impact on household expenditures is essential to ensure the thresholds remain relevant and reflective of the actual economic burden.

By adapting the “10% threshold” standard to better fit China’s economic and regulatory context, and considering the unique characteristics of urban and rural energy consumption, a more accurate and regionally sensitive assessment of energy poverty can be achieved. This approach will help in identifying and addressing the specific challenges faced by low-income households in China, ensuring that policies and interventions are effectively targeted.

3.3.3. Indicators and Standards Applicable to China’s Energy Poverty Assessment

The main manifestations of energy poverty in China align with those in other developing countries. Several indicators currently applicable to the assessment of energy poverty in China can provide a comprehensive understanding of the issue.

Per Capita Commodity Energy Consumption measures the average amount of commodity energy (e.g., electricity, natural gas) consumed per person. It is a useful metric for assessing the general access and usage levels of modern energy sources in both urban and rural areas. Proportion of Commodity Energy in Terminal Energy Consumption measures the share of modern market-purchased energy (commodity energy) within the total energy consumption. It helps with understanding the reliance on traditional versus modern energy sources. Per Capita Electricity Consumption in the Residential Sector tracks the average electricity usage per person within households. It is a direct measure of access to and usage of electricity, reflecting living standards and energy access.

Ownership of Household Appliances from Nussbaumer et al. (2011) [6] regarding household appliance ownership can be applied to China. This includes assessing the prevalence of essential appliances such as refrigerators, washing machines, and air conditioners, which are indicative of energy service access and quality of life improvements.

Modern Cooking Fuels and Equipment examines the usage of modern cooking fuels (such as LPG, natural gas, or electricity) and clean cooking equipment. Given the transition in China from traditional biomass fuels to cleaner options, this metric is critical for assessing energy poverty, especially in rural areas. Similar to cooking fuels, the type of heating fuel and equipment used is an important indicator. Modern and efficient heating solutions reflect better living conditions and lower health risks. However, the proportion of People Receiving Electricity is no longer relevant for China, as the country has achieved nearly universal electricity access with a national electricity rate of 99.9% as of 2011.

By focusing on these indicators, policymakers and researchers can obtain a nuanced and accurate assessment of energy poverty in China. These metrics not only capture the economic burden of energy costs, but also reflect the availability and usage of modern energy services. This approach allows for targeted interventions that address both urban and rural energy poverty, ensuring inclusive and sustainable energy access across the country.

4. Status Quo of Energy Poverty

Energy poverty has garnered significant international attention, with a continuous focus from organizations such as the United Nations Development Program and the International Energy Agency. Currently, energy poverty is prevalent worldwide, particularly in developing countries. Three primary issues characterize global energy poverty: the low level of energy use in developing countries, the inefficient use of traditional biomass energy, and the inability to afford modern clean energy due to economic constraints.

The inefficient consumption of traditional biomass energy in developing countries leads to severe environmental and health problems. Many residents in these regions rely

on traditional and inefficient equipment, such as three-stone stoves and earth stoves, for cooking and heating. It is estimated that by 2030, 2.6 billion people will still lack access to modern cooking equipment under existing energy policies.

In developed countries, energy-poor households spend a significant portion of their income on energy, affecting the overall social equity. However, this burden could decline to some extent if potential policy shifts or global commitments to address energy poverty, such as Sustainable Development Goal 7 (SDG 7), are implemented effectively.

China faces unique challenges, experiencing both types of energy poverty found in developed and developing countries. Approximately 423 million people in China rely on traditional biomass energy. According to the World Health Organization, the soot pollution from rural firewood stoves results in the premature deaths of 300,000 people annually. Rural households in 21 provinces primarily use traditional biomass energy for cooking, with utilization rates exceeding 80% in six provinces. Despite significant progress, as evidenced by the increase in renewable energy's share of final energy consumption from 5% in 2010 to 11.1% in 2020, solid energy remains the main source of household energy in rural China. Over the past decade, the structure of household energy consumption has shown little change, with residents continuing to rely on commodity and non-solid clean energy sources. While economic and social development in China may alleviate energy poverty, substantial reduction or elimination of energy poverty will require governmental attention and policy intervention.

Establishing a theoretical basis for energy poverty is essential, both globally and within China. It is necessary to design easily calculable indicators that can be flexibly applied to various situations, supported by reliable and comprehensive data collection. Given the diverse nature of energy poverty, it is crucial to balance methodological complexity with theoretical accuracy, as well as application practicality and transparency.

4.1. Current Situation of Energy Poverty in China

Li (2015) [20] designed a comprehensive evaluation index system based on the concept of energy poverty in China, focusing on selecting relevant subsystems from the two demand levels of survival and development, and evaluated the energy poverty problem in 30 provinces, autonomous regions and 8 economic regions in China from 2000 to 2012. The internationally recognized concept of energy poverty is defined from the perspective of meeting the basic survival needs of human beings. As a developing country with rising economic strength, it is impossible to define and solve energy poverty only from the perspective of survival needs to meet the development needs of the country and its people. Therefore, China also needs to assess energy poverty from a development perspective.

The results show that the level of energy poverty in China is not completely consistent with the level of economic poverty. Although on the whole, the problem of energy poverty in provinces, regions and municipalities with high level of economic development is not prominent, energy poverty cannot be evaluated solely on the level of economic development. Therefore, when selecting the target of energy poverty alleviation policy and determining the proportion of investment, it should be different from other relevant policies to promote economic and social development, improve infrastructure construction and improve people's livelihood. The implementation of energy poverty alleviation policy and the target of capital investment should not be concentrated in economically poor areas, but should fully consider the current situation of energy poverty in all provinces and municipalities, which also reflects the significance of energy poverty assessment.

In 2015, China completed the power construction project in areas without electricity, providing electricity guarantee for 40 million people without electricity, marking China's complete farewell to the primary stage of energy poverty. However, "everyone has electric-

ity use” only solves the problem of absolute energy poverty. The relative energy poverty problem reflected by the low level of energy use, poor energy use structure, and weak energy use capacity is still widespread.

Based on the definition of energy poverty and related theoretical analysis, Zhou et al. (2023) [21] constructed the relative energy poverty index from four dimensions of availability, affordability, reliability, and sustainability, and measured the relative energy poverty level in all provinces in China from 2010 to 2021. The results show that in terms of time evolution, the national average relative energy poverty index showed a downward trend from 2010 to 2021; in terms of spatial distribution, the relative energy poverty level shows the characteristics of “high in the west and low in the east, high in the north and low in the south”. The eastern region, dominated by Shanghai, Jiangsu, Zhejiang, and Shandong, has a low relative energy poverty. On the one hand, the region has a strong economic foundation and the poverty base is small; on the other hand, the region has a leading level of energy transition and a high degree of cleanliness. As a traditional industrial base, the northern region has a large energy consumption, and the energy structure is relatively coal. In addition, northern residents have a high demand for heating in winter, so it is difficult to change the production and life mode mainly with coal and gas, so the degree of energy poverty is relatively high.

Over the past two decades, China’s energy poverty alleviation policy has evolved from focusing solely on “energy access” to encompassing “affordable electricity”, “efficient electricity use”, and “sustainable electricity use”. Currently, rural areas in China have made significant strides in ensuring energy accessibility, and there has been notable improvement in the comprehensive utilization of energy. However, looking towards the future, there remain substantial disparities in energy levels and efficiency across different regions in China, indicating the potential for further progress.

In terms of optimizing energy utilization, it is crucial to initiate discussions on establishing a long-term mechanism for energy development and utilization in the context of poverty alleviation. This involves not only ensuring access to energy, but also promoting affordability, efficiency, and sustainability in energy use. By addressing these aspects comprehensively, China can continue its trajectory toward more inclusive and sustainable energy practices, contributing to broader socioeconomic development and poverty reduction efforts.

4.2. Status Quo of Energy Poverty in Other Countries

According to the World Bank, 89.6 percent of the world’s population had access to electricity in 2018, while only 59.34 percent had access to clean fuel and cooking technology in 2016. More specifically, in North America and the European Union, 100% of the population has electricity access, while in sub-Saharan Africa, only 47.7% of the population has the same access. Furthermore, a high proportion of the population in the EU, North America, the Middle East, and North Africa has access to clean fuel and cooking techniques, but the proportion of visits in sub-Saharan Africa is low.

These data suggest that the focus should be placed on increasing electrification rates in Africa and developing necessary facilities that could provide electricity and more people in the region with cleaner cooking fuels, thereby improving their living standards, health, and welfare. Furthermore, in South and East Asia, and in Latin America, clean fuel availability should be improved.

Asia: According to Abbas et al. (2020) [22], the adjusted MEPI was used to examine energy poverty in six countries in South Asia. Among the countries studied, Afghanistan and Bangladesh were the most affected by energy poverty, followed by India and Nepal, while Maldives and Pakistan were the least affected by energy poverty. The case focused

on India shows that despite the progress the country has made in reducing energy poverty over the past few years, a significant part of the population still lacks access to modern energy services. Therefore, policies and strategies aimed at providing essential energy services to as many people as possible still need to be continued.

Latin America: Santillán et al. (2020) [23] examined energy poverty in seven Latin American countries (Colombia, Dominican Republic, Guatemala, Haiti, Honduras, Mexico, and Peru). Estimates show that Haiti has the worst problem in energy poverty, and that Guatemala and Honduras also suffer from energy poverty at significance levels. Of the seven Latin American countries surveyed, the Dominican Republic and Mexico are the least affected by energy poverty, but they still have serious problems in population access to energy services. These results suggest the need for immediate action to provide affordable and reliable energy services and alleviate energy poverty in Latin America.

Africa: in a study on the current poverty status of energy poverty in African countries [6], showed that Ethiopia had the highest MEPI with severe energy poverty, while MEPI levels were significantly higher in Niger, Rwanda, Burkina Faso, Malawi, Mozambique, and Uganda. Among the countries studied, the lowest energy poverty was Egypt, and MEPI levels were also low in Morocco. These results indicate an urgent need for a set of development policies that can reduce high levels of energy poverty.

Europe: Bollino et al. (2017) [24] developed the Multidimensional Index of Energy Poverty (EPMI) to study the degree of energy poverty in European countries. EPMI focuses on the two main dimensions of energy poverty: affordability and efficiency. Central European and Mediterranean countries, such as Greece, Bulgaria, Cyprus, Hungary, Lithuania, Latvia, and Portugal, were identified as having significant energy poverty in 2012 and 2014. However, energy poverty is lower in northern countries such as Denmark, Norway, and Iceland.

4.3. Comparison of Energy Poverty Between China and Other Countries

This paper utilizes data from the International Energy Agency's official website for 2021 (as shown in Figure 1) to compare the energy poverty situations in China, India, Australia, and Mexico.

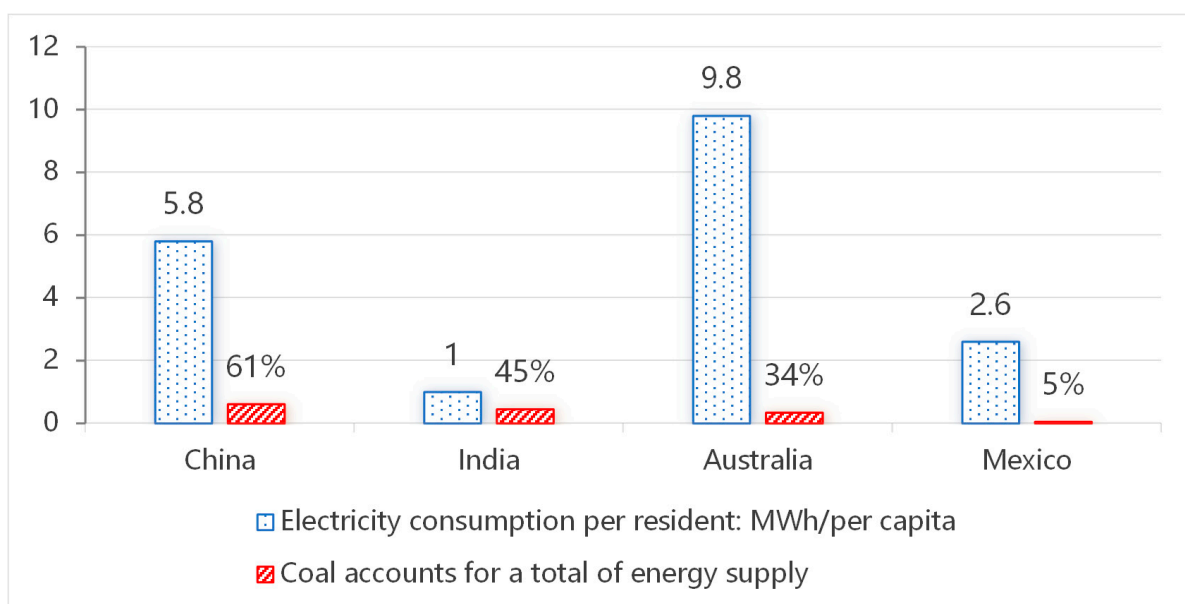


Figure 1. Electricity consumption and the proportion of coal in energy supply. Note: the data are from the International Energy Agency in 2021.

Coal, while typically a cheaper energy source, is also associated with higher pollution levels and lower efficiency. A high proportion of coal in a country's energy mix may indicate reliance on traditional and inefficient energy production methods. This reliance often stems from limited access to more advanced technologies or investment in cleaner, more efficient energy sources, signaling potential weaknesses in the energy infrastructure and contributing to energy poverty. Moreover, a significant dependence on coal can exacerbate environmental and public health issues, further deepening poverty. The associated health costs, as well as the need for environmental remediation, can place additional financial burdens on households, which further limits their capacity to escape energy poverty.

Per capita electricity consumption is an important indicator to measure the quality of life and access to energy services. If a country's residents' per capita electricity consumption is low, it may mean that it is difficult for some residents to get enough energy to meet their basic living needs, such as lighting, heating and cooling. This situation may be caused by factors such as insufficient energy infrastructure, unstable energy supply or limited ability of residents to pay. Low per capita electricity consumption may also affect education, health and economic activity, because energy is the foundation of the operation of modern society. Therefore, low per capita electricity consumption per person may reflect deeper poverty and social development problems.

Combining these two indicators, we can have a comprehensive understanding of the current situation of energy poverty in a country. A high coal ratio could mean an unstable and inefficient energy supply, while a low per capita electricity consumption reflects a lack of access to energy services. Together, these two indicators reveal national energy challenges, especially those in meeting people's basic energy needs. Contrasting these indicators across different countries provides a better understanding of the distribution and trends across global energy poverty.

In 2021, China's coal supply accounted for 61% of the total energy supply. This suggests that China remains highly dependent on coal as its main source of energy. Although this proportion is basically unchanged compared with the year before last, it shows that China's energy structure reform has a long way to go, and the dominant position of coal is still significant. In contrast, other countries may have a lower share of coal.

China's per capita electricity consumption has been growing in the past few years, indicating that China's energy poverty situation is constantly improving, and the corresponding supportive policies have achieved preliminary results. Compared with India and Mexico, China's per capita electricity consumption is significantly higher, and residents have more affordable modern energy services. But it may still be at low levels compared to developed countries. Per capita electricity consumption is an important measure of living standards and energy efficiency, and lower electricity consumption may mean energy poverty in some areas.

Taken together, the high proportion of coal in China's total energy supply and the median level of residential per capita electricity consumption may indicate that China is facing the challenge of energy poverty to some extent, but good progress has been achieved in alleviating energy poverty. China needs to continue to improve its energy efficiency, consistently promote clean energy and improve its energy infrastructure. At the same time, China can strongly support the coal industry to improve the level of science and technology and carry out intelligent construction, and gradually increase the proportion of clean energy in the energy mix.

5. The Causes of Energy Poverty

To effectively reduce and eliminate energy poverty, it is essential to understand and address the factors that influence energy consumption and contribute to energy poverty.

Current research highlights several key characteristics, such as income level, degree of infrastructure improvement, and other individual and community factors.

5.1. Low Income Level Leads to Energy Poverty

Income poverty, defined as insufficient income to meet basic societal needs [25], has long been identified as a primary driver of energy poverty [2,26]. In extreme cases, the poorest households may spend up to 80% of their income on cooking fuel alone [27].

Most studies on energy poverty focus on households with low incomes [18]. Halkos (2021) [28] assessed the impact of economic crises on European energy poverty, underscored energy prices, unemployment, and economic hardship as primary factors driving worsening energy poverty, with per capita GDP showing an inverse relationship.

However, conclusions regarding the relationship between income poverty and energy poverty remain contradictory. Shahidur et al. (2012) [29] analyzed this relationship in India, finding that while income poverty correlates with energy poverty in urban areas due to affordability challenges, this link is less pronounced in rural settings, where 57% of households experience income poverty, compared to 22% of households with poor incomes.

Moreover, energy poverty can exacerbate income instability. Deshwal et al. (2021) [30] found that energy poverty has a negative impact on fiscal positions. Batool et al. (2023) [31] discovered that energy shortages and rising prices prevent many low-income families from paying their electricity bills, hindering their ability to work remotely during the pandemic and thus worsening income poverty. Batool et al. argue that energy poverty is the root cause of income poverty, as current research shows that most residential areas are economically impoverished due to energy issues. Previous studies have also supported this argument [32] (Dong et al., 2022). This underscores how energy access directly impacts economic development and poverty alleviation efforts.

5.2. Imperfect Infrastructure Leads to Energy Poverty

Energy poverty can severely hinder government efforts to enhance energy efficiency, particularly in regions grappling with inadequate infrastructure or outdated equipment. For instance, Kazakhstan, despite being one of the coldest and energy-rich countries globally, faces significant energy inefficiencies and disparities. Kerimray et al. (2018) [33] highlighted that 28% of surveyed households in Kazakhstan spend more than 10% of their income on energy due to imperfect infrastructure, categorizing them as energy-poor households. Their research shows that there is an overwhelming reliance on coal in Kazakhstan: 40% of all surveyed households use coal for heating, cooking, and other needs. In general, liquefied petroleum gas is mainly used for cooking, coal, and firewood for heating, while electricity is rarely used for heating. This underscores how factors like gas and district heating infrastructure coverage, along with regional income disparities, contribute significantly to energy poverty in the country.

Similarly, in Mexico, despite its abundant energy resources, a substantial proportion of households experience energy poverty. The research of Miguel Ángel Marmolejo Cervantes and Lisa Reilly Solís (2024) [34] shows that 36.7% of Mexican households suffer from energy poverty. This discrepancy underscores challenges related to access and affordability, exacerbated by issues such as old equipment and inadequate maintenance personnel.

These examples illustrate how energy poverty can persist even in regions with abundant energy resources, highlighting the critical role of infrastructure investment, policy interventions, and effective governance in addressing energy access and affordability issues.

5.3. Other Individual and Community Factors Lead to Energy Poverty

Zhuang et al. (2024) [35] argue that energy intensity, population size, household size, education level, economic development, urbanization rate, and car ownership are important

factors influencing household energy consumption. Similarly, Clancy et al. (2003) [36] suggest that programs aimed at alleviating energy poverty should consider household sex ratios and demographic structures. Sen, K. K. et al. (2023) [37] find that experiencing economic shocks early in life increases the likelihood of energy poverty in adulthood, with probabilities ranging from 2.3% to 44%. They find life satisfaction, earnings, and financial inclusion to mediate the association between childhood economic shocks and energy poverty. The study further shows that the effect of these early life economic adversities on energy poverty is more pronounced in lower-middle-income countries and among males. Therefore, we can use cash transfers and other early life intervention programs for children to help redress the potential dangers these economic shocks can unleash in their future. Berti et al. (2023) [38] found that the Lombardy region could be one of the regions most affected by energy poverty. This aspect is due to a combination of factors such as the old building stock, energy demand, and the remarkable presence of vulnerable families, which cause a higher risk in the region compared to other Italian regions.

Low levels of education increase the susceptibility to energy poverty. Individuals with a limited education often lack knowledge about efficient energy management and conservation practices, which can result in energy inefficiencies and higher energy expenditures. Moreover, gender disparities in education exacerbate energy poverty. Acheampong et al. (2024) [39] conducted a study across 98 countries from 2000 to 2021, demonstrating a positive association between electrification rates and gender parity indices across all educational levels.

Individual housing conditions significantly influence energy poverty. Poorly maintained or inefficient housing can result in substantial energy losses, leading to higher energy consumption and costs, thereby increasing the risk of energy poverty. For instance, Grazini (2024) [40] conducted a questionnaire survey among 431 households residing in public housing in Viterbo, Italy, revealing that 71.23% of these households experienced severe energy poverty due to inadequate housing conditions.

Additionally, the adequacy of social security systems plays a crucial role in mitigating individual energy poverty. Individuals without robust social security measures may lack access to necessary financial assistance during periods of economic hardship, rendering them more susceptible to energy poverty. However, existing low-income household energy assistance programs often face challenges such as underfunding, leaving a significant number of eligible households without support. Moreover, even among assisted families, there can be inefficient allocation of public resources [41]. These factors underscore the complexity and multifaceted nature of addressing energy poverty comprehensively.

Despite the aforementioned factors, existing literature predominantly focuses on income levels as determinants of energy poverty. However, the impacts of income on energy poverty vary in effectiveness and mechanism across different endowments. Few studies have thoroughly examined these dynamics. Moreover, the current literature lacks comprehensive exploration of other influential factors such as cultural norms and customs, which also play significant roles in shaping energy poverty outcomes. Without delving into these factors, the assessment and understanding of energy poverty determinants may remain limited. Therefore, future research should adopt a more nuanced approach by investigating various factors comprehensively, emphasizing detailed analyses of their mechanisms, and thereby enhancing the depth and scope of research on energy poverty determinants.

6. The Impact of Energy Poverty

Energy poverty indeed has a profound impact across various domains, including health, education, environment, and income inequality.

6.1. Energy Poverty Harms Health

Energy deprivation, particularly in terms of access to modern energy sources, leads to a range of severe public health issues, with indoor air pollution (IAP) being the most significant concern. Many households without modern energy rely on the direct combustion of biomass such as wood, dung, and charcoal for cooking and heating, which poses substantial health risks akin to living in a constant cloud of harmful smoke. An energy-poor household, which is not adequately warm, can lead to severe health problems that can range from asthma to heart diseases and strokes, and it was shown that people who live in cold households are more likely to be hospitalized or need surgery [42].

Studies underscore the detrimental health effects associated with energy poverty. For instance, Awosusi et al. (2022) [43] found that energy poverty reduces household heating capacity and limits access to healthcare services due to financial constraints. In Mexico, Miguel Ángel Marmolejo Cervantes et al. (2024) [34] discovered that only 25% of households using firewood or coal for cooking had adequate ventilation systems, exposing approximately 12 million Mexicans to hazardous indoor air pollutants during meal preparation.

Polimeni et al. (2022) [44] demonstrate that energy poverty contributes to consumer vulnerability, significantly impacting individuals' health. These findings have far-reaching implications as extreme heat and cold temperatures become increasingly common, disproportionately affecting the most vulnerable households, particularly the elderly, women, and those living in poverty.

Consumer vulnerability due to energy poverty manifests in various ways, such as heat-related illnesses, respiratory conditions caused by indoor air pollution, and mental stress stemming from high energy costs. For instance, households experiencing energy poverty may be unable to afford adequate heating. During the cold season, prolonged exposure to low indoor temperatures can adversely affect residents. Children and the elderly, with relatively weaker immune systems, are more prone to severe respiratory diseases such as bronchitis and pneumonia. Exposure to cold temperatures increases cardiovascular strain, which can exacerbate conditions like heart disease and lead to serious outcomes such as myocardial infarction. Conversely, households unable to afford cooling equipment may suffer from heat stroke during hot weather. Excessive heat can lead to heavy sweating, dehydration, and electrolyte imbalances, which disrupt normal physiological functions.

Energy-poor households may resort to using low-quality fuels for economic reasons. In rural or impoverished areas, residents might use untreated coal or biomass (e.g., straw, firewood) for heating and cooking. These fuels release harmful gases during combustion, including sulfur dioxide, nitrogen oxides, and particulate matter. Long-term exposure to these pollutants can severely damage the respiratory system. Particulate matter, such as PM_{2.5} and PM₁₀, penetrates deep into the lungs, causing respiratory illnesses such as chronic obstructive pulmonary disease (COPD) and asthma. Acidic gases like sulfur dioxide can irritate the mucous membranes of the respiratory tract, weakening its defenses and increasing the risk of respiratory infections.

High energy costs impose a significant financial burden on energy-poor households. When energy expenses constitute a large proportion of household income, families face financial hardship that can lead to anxiety among members. Chronic financial stress may escalate into depression, adversely affecting mental health. Furthermore, this psychological strain can strain family relationships, increasing conflicts and tensions within households.

The adverse health impacts are particularly severe for vulnerable groups such as children and women. Each year, approximately 1.3 million people worldwide, predominantly women and children, die prematurely due to exposure to air pollution from inefficient biomass stoves [34]. The burden of collecting solid fuels falls disproportionately on women

and children in energy-poor households, reducing their time for productive activities or education and perpetuating cycles of poverty and inequality.

In summary, addressing energy poverty is crucial not only for improving access to modern energy services, but also for mitigating the severe public health risks associated with indoor air pollution and unsafe fuel usage. Efforts to promote clean cooking technologies and enhance energy access can significantly improve health outcomes, particularly for marginalized communities reliant on traditional solid fuels.

6.2. Energy Poverty Leads to Gender and Education Inequality

Energy poverty profoundly impacts both gender roles in society and the educational opportunities available to children and adults. Women in resource-scarce areas spend significant time collecting fuel, ranging from one to five hours daily [27]. Throughout Africa, women typically carry 20 kg of firewood over 5 km daily [45]. Zhang et al. (2022) [46] explored the gender inequality of the health impacts and found that women's health is more severely impaired and the effect of gender inequality is heterogeneous between urban and rural areas. We further investigated the historical origins of the intra-household division of labor and revealed that the root of gender inequality in the health effects of energy poverty is status inequality.

An adequately warm space and access to electricity can significantly improve standards of living, positively impact education [47]. Acheampong et al. (2024) [39] identified that female literacy, female health, female employment, information, and communication technologies are the potential transmission channels through which access to electricity and clean cooking fuels and technologies could contribute to gender equality at all levels of education.

The responsibility for energy harvesting is more distributed to women, and if they have enough energy, this time can be saved so that women can spend more time on education. Therefore, the lack of modern energy, i.e., energy poverty, can adversely affect girls' educational opportunities [48]. Energy services also enable schools to attract and retain qualified teachers, extend study hours with solar lighting, and provide better access to computers and the internet. For example, in Nicaragua, 72% of children from electrified homes attend school, compared to 50% in homes without electricity [27].

6.3. Energy Poverty Endangers the Environment

The environmental impacts of energy poverty include deforestation, land-use change, and greenhouse gas emissions. As billions of people rely on biomass for cooking and heating, about two million tons of biomass are burned every day. In densely populated or resource-scarce areas, new trees grow insufficiently to meet fuel needs, leading to deforestation, desertification, and land degradation. Even when entire trees are not cut down, the collection of feces, branches, shrubs, roots, twigs, leaves, and bark depletes nutrients needed by forest ecosystems and soil [49].

For example, in Bangladesh, trees and bamboo meet about 48% of domestic energy needs, followed by agricultural residues at 36% and feces at 13% [50]. People's inability to get clean fuels, their reliance on conventional energy sources and insufficient cooking devices all contribute to environmental degradation [51].

Firewood-driven deforestation has caused two major social and economic impacts. An increased burden on firewood collectors and farmers, and higher fuel prices. As fuel stocks run out, women and children must travel longer distances to collect fuel, requiring more time and effort. This collection also disrupts the viability of farms and other rural livelihoods that rely on trees for income [52]. Additionally, deforestation has led to a sharp rise in fuelwood prices. In Bangladesh, where timber demand exceeds supply, timber prices

have risen significantly, with 50% of annual household income in rural areas now spent on fuel [53].

Sovacool (2012) [54] noted that the large amount of greenhouse gases released during solid biomass combustion exacerbates global climate change, increasing government governance costs and negatively impacting public health. Rao et al. (2024) [55] assessed the relationship between energy poverty and environmental quality in South Asian economies, finding that energy poverty reduces environmental quality in most selected economies.

In summary, household energy poverty creates significant negative externalities due to a lack of access to minimal energy services. Although these externalities are difficult to quantify precisely, their impact is enormous. At the micro level, energy poverty affects population health; at the macro level, it affects educational equity and environmental quality. Addressing energy poverty is essential to mitigating these broad and profound impacts.

7. Policy Intervention

By providing economic support, building infrastructure, promoting the development of renewable energy, and strengthening energy management and regulation, the government can significantly improve energy poverty. These efforts can provide people with affordable and stable energy supplies, promote economic development, and enhance their quality of life.

First, the government can encourage the development of green finance and support the establishment of renewable energy projects. By building and promoting renewable energy projects, it can provide affordable and sustainable energy supplies, reducing dependence on traditional non-renewable energy sources. Santillán et al. (2020) [23] show that green finance has a positive impact on environmental production efficiency. Therefore, policy-makers are advised to develop precise plans to provide financial assistance to those in need, focusing on building and improving government financing risk-sharing and guarantee arrangements and utilizing flexible government financing platforms such as small loans.

Zeenat et al. (2024) [56] examined the impact of the fintech industry, energy efficiency, green finance, R&D, FDI, and GDP on energy poverty in European countries between 2013 and 2020. Using dynamic least squares (DOLSs) and fully modified least squares (FMOLSs), they estimated both long-term and short-term relationships. Their research highlights that renewable energy projects financed through green finance can play a crucial role in reducing energy poverty. Additionally, as European countries experienced economic growth, increases in per capita GDP positively contributed to alleviating energy poverty. Green financing has enhanced energy security and addressed the pressing environmental issue of energy poverty. By promoting the expansion of green finance and supporting renewable energy projects, governments can significantly advance sustainable development and mitigate energy poverty. This strategy not only strengthens energy security but also fosters environmental sustainability and economic resilience.

However, it remains challenging for non-European and low-income countries to address energy poverty through renewable energy projects financed by green funding. These countries often face economic constraints, including a weak financial base and limited fiscal revenues, which hinder their ability to make substantial investments in the early stages of renewable energy development. Furthermore, inadequate financial systems, low savings rates, and underdeveloped domestic capital markets limit their capacity to attract sufficient private investment, complicating the financing of renewable energy initiatives.

The effectiveness of green finance also varies based on a country's stage of development, existing infrastructure, and capacity to mobilize and manage green finance. In developed countries, residents typically exhibit a higher capacity for energy consumption, greater environmental awareness, and a stronger acceptance of clean energy. These

factors facilitate the rapid market expansion of renewable energy projects supported by green finance, achieving economies of scale, reducing costs, and ultimately benefiting energy-poor households. Well-established infrastructure further aids the integration of renewable and traditional energy sources. Through technologies such as smart grids, the optimal allocation of multiple energy sources can be achieved, enhancing energy efficiency. Moreover, financially robust countries can leverage their resources to innovate and create additional incentives for renewable energy projects underpinned by green finance.

Second, the government can provide economic support by lowering energy prices through subsidies to make energy services affordable for the poor. This can be achieved through direct subsidies on energy costs, low-cost loans, or tax breaks. Lin and Okyere Michael Adu (2023) [57] used the 2019 South African Comprehensive Household Survey (GHS) to demonstrate that housing subsidies can alleviate energy poverty, but addressing racial discrimination is a prerequisite. Without resolving systemic discrimination, government subsidies cannot effectively improve the energy poverty of non-white populations. The black community in South Africa has suffered from long-term discrimination in education, employment, and other areas, leading to persistently low economic income. Even with the gradual expansion of electricity infrastructure to historically underserved areas, the high costs of electricity access and consumption remain a heavy burden for poor black households. While the South African government is working to address inequalities in energy supply, achieving equitable access to energy across the country remains challenging due to historically significant gaps in infrastructure. Historically, black neighborhoods have had inadequate electrical infrastructure, necessitating massive investments to upgrade and expand the grid. This legacy of discrimination continues to hinder black communities' access to energy services.

Additionally, the government should prioritize support for individuals affected by unexpected disasters, those earning below the poverty line, and vulnerable groups such as the elderly and disabled by providing a comprehensive social safety net. In the capital development of emerging economies, establishing protective measures should take precedence to ensure vulnerable populations have access to essential energy for survival. Addressing structural inequalities requires studying the socio-economic structures of marginalized communities, including factors such as household income, employment status, and poverty levels. It is essential to analyze how these factors influence energy access and affordability. For instance, in some rural, marginalized communities, residents often depend primarily on agriculture for their livelihoods, leading to seasonal income fluctuations. Energy subsidy policies must account for such income instability to effectively support these populations.

Compared to high-income residents and those with higher education levels, low-income and less-educated residents have greater income elasticity and a larger gap between actual consumption and living energy demand. Energy subsidies for vulnerable groups can help fill this gap more quickly and accelerate the reduction in energy poverty. However, government subsidy programs can impose a significant financial burden on the government budget, leading to insufficient funding and many potentially eligible families not receiving assistance. Even those who do receive assistance may still overutilize public resources [41].

When selecting the policy targets for energy poverty alleviation and determining the proportion of investment, it is essential to differentiate from other policies that promote economic and social development, improve infrastructure construction, and enhance people's livelihoods. The implementation of energy poverty alleviation policies and capital investment should not be concentrated solely in economically poor areas but should fully consider the current energy poverty situation in various provinces and urban areas. According to Li (2015) [20], the southern coast, the Yangtze River, the middle reaches of the Yellow River, and the southwest region should address issues related to poor affordability

and efficiency, while the northeast region should focus on the problem of unclean energy consumption. By providing targeted economic support and addressing regional disparities in energy poverty, governments can create a more equitable and effective approach to alleviating energy poverty and improving living conditions for vulnerable populations.

Third, the government can invest in the construction of basic energy facilities, such as power transmission and distribution networks, gas pipelines, and clean fuel supply networks. These investments can provide a stable and reliable energy supply, making energy services more accessible and available. Szabó et al. (2013) [58] found that mixing different portfolios (micro-hydro, off-grid photovoltaic, and diesel), with a sufficient share of distributed local renewable energy options, offers an effective solution to energy poverty in Africa. From China's perspective, accelerating the construction of clean energy infrastructure in rural areas is also an important means to alleviate energy poverty. Increasing income alone is not sufficient to address energy poverty comprehensively. The rapid development of clean energy in rural areas allows residents to change their energy consumption patterns as their economic conditions improve, paving the way for clean energy to genuinely enter rural areas. By focusing on the development of basic energy infrastructure and integrating diverse energy sources, governments can create a more resilient and inclusive energy system. This approach not only addresses the immediate energy needs of rural populations but also supports long-term sustainable development and energy security.

Fourth, energy poverty calls for a concerted global response. Promoting international cooperative research can help countries share their experiences and achievements in addressing energy poverty and promote solutions to this global issue. Keevers Lynne (2022) [59] discusses a social development practice of international cooperation designed to reduce energy poverty by providing home solar lighting to indigenous people living in remote communities in the Remiscio area of East Timor. The results show that village-to-village transnational cooperation can effectively improve energy poverty in a region. However, international assistance cooperation must consider equity issues. Heerae and Huijoo (2024) [60] use the energy justice framework to examine the spatiotemporal pattern of energy assistance and the multidimensional energy poverty index (MEPI) over 20 years (2001–2020) in four African countries: Nigeria, Tanzania, Ethiopia, and the Democratic Republic of the Congo. The survey results show that energy assistance is mainly concentrated in provincial capitals or urbanized areas. The persistence of this model leads to the temporal continuity of regional energy imbalances, with many marginalized groups not receiving sufficient assistance. These findings highlight the importance of considering both spatial and temporal dimensions while pursuing energy justice and advocating for equitable aid distribution to ensure global energy justice. By addressing these issues, international cooperation can be more effective and inclusive, leading to substantial improvements in energy poverty and contributing to a fairer distribution of energy resources worldwide.

Fifth, the prevention of energy poverty through social workers is a critical but under-explored area. Scarpellini (2017) [61] highlights the mediating role of social workers at the local level in preventing energy poverty. Although social workers are not experts in energy consumption and insulation, they are public agents with first-hand knowledge of the practical problems faced by vulnerable families and the conditions of the buildings in which these families reside. However, the study's limitations are apparent, particularly due to the small sample size and its restriction to one area. Future research faces the challenge of analyzing larger samples and conducting comparative studies across different countries with varying socio-demographic characteristics and aid models. Such research will provide a more comprehensive understanding of the role social workers can play in mitigating energy poverty and how best to leverage their unique position within communities. By addressing these limitations and expanding the scope of research, we can develop more ef-

fective strategies to utilize social workers in the fight against energy poverty. This approach could significantly contribute to improving the living conditions of vulnerable populations.

By considering the above factors, the formulation and implementation of corresponding policies and measures can effectively address energy poverty and improve people's living conditions. Comprehensive strategies that integrate immediate and long-term solutions, as well as the development of robust indicators, are crucial in mitigating the impacts of energy poverty. Ensuring that policies are both actionable and responsive to the diverse and dynamic needs of communities will be essential in achieving substantial progress in this area.

8. Conclusions

Energy poverty is a complex, multi-dimensional challenge that encompasses income levels, infrastructure development, individual and community factors, and has significant implications for residents' health, educational equity, and environmental sustainability. In China, the largest developing country with notable regional disparities, energy poverty is particularly severe and multifaceted. The country faces both domestic and international pressure to address this issue, making it an urgent priority. This paper reviews the existing literature on energy poverty, clarifying current research gaps and suggesting directions for future investigation.

To effectively address energy poverty, it is critical to examine its root causes, which include income poverty, inadequate infrastructure, and a variety of individual and community factors. While the relationship between income levels and energy poverty is well-documented, the role of infrastructure—particularly outdated or insufficient energy systems—is often overlooked. Even regions rich in energy resources may still suffer from significant energy poverty due to inefficient distribution networks. Similarly, factors such as demographic characteristics, education, and social security systems exacerbate energy poverty, particularly among vulnerable populations.

Despite these recognized challenges, current measures of energy poverty are rudimentary and fail to fully capture its complexity. Existing indicators often provide limited information, which hinders the development of effective policies. Future research should prioritize large-scale, nationwide studies that incorporate diverse variables, including local natural conditions, cultural habits, and the specific developmental context of energy poverty.

Understanding local natural conditions is crucial, as factors like long-term temperature changes, precipitation, and meteorological disasters can severely impact energy infrastructure, further limiting access to energy. In parallel, research into human resource conditions, including education and skill levels, is essential. Limited technical knowledge can hinder residents' participation in energy projects, exacerbating the cycle of poverty. Additionally, cultural habits and preferences significantly influence energy consumption patterns. Even when efficient and clean energy technologies are available, cultural resistance to adopting them can impede progress. Consumer behavior studies and cultural surveys can provide valuable insights into these dynamics.

Furthermore, addressing deficiencies in current energy poverty statistics is vital. Comprehensive data collection—through collaboration with local governments, healthcare facilities, and community organizations—will provide a more complete understanding of the issue. For example, analyzing health data from hospitals in areas reliant on traditional biomass can help reveal the public health consequences of energy poverty, such as respiratory diseases caused by indoor air pollution.

There is also a gap between identifying energy poverty and implementing effective alleviation policies. Most existing studies focus on long-term governance measures, while

neglecting immediate, practical solutions. Policy frameworks must be operable and tailored to local realities, considering both financial support and incentive systems. The government should design immediate strategies that address both short-term relief and long-term structural improvements to ensure effective poverty alleviation.

In conclusion, future research must adopt a more holistic approach that encompasses both the technical and social dimensions of energy poverty. By examining the interplay between infrastructure, income, cultural habits, and social conditions, scholars can contribute to more effective and context-specific policies that address the root causes of energy poverty in China. This comprehensive approach will not only enhance understanding, but also guide the development of actionable solutions to ensure sustainable energy access for all.

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Abbreviations

The following abbreviations are used in this manuscript:

MEPI	Multidimensional Energy Poverty Index
EP	Energy poverty

References

- Berri, A. Measuring Energy Poverty: Uncovering the Multiple Dimensions of Energy Poverty; CIRED Working Paper. Available online: <https://ideas.repec.org/p/hal/ciredw/hal-01896838.html> (accessed on 5 January 2025).
- Boardman, B. *Fuel Poverty: From Cold Homes to Affordable Warmth*; Pinter Pub Limited: London, UK, 1991.
- Day, R.; Walker, G.; Simcock, N. Conceptualising Energy Use and Energy Poverty Using a Capabilities Framework. *Energy Policy* **2016**, *93*, 255–264. [[CrossRef](#)]
- Charlier, D.; Kahouli, S. From Residential Energy Demand to Fuel Poverty: Income-Induced Non-linearities in the Reactions of Households to Energy Price Fluctuations. *Energy J.* **2019**, *40*, 101–137. [[CrossRef](#)]
- Zhang, D.; Li, J.; Han, P. A multidimensional measure of energy poverty in China and its impacts on health: An empirical study based on the China family panel studies. *Energy Policy* **2019**, *131*, 72–81. [[CrossRef](#)]
- Nussbaumer, P.; Bazilian, M.; Modi, V. Measuring energy poverty: Focusing on what matters. *Renew. Sustain. Energy Rev.* **2011**, *16*, 231–243. [[CrossRef](#)]
- Best, R.; Hammerle, M.; Mukhopadhyaya, P.; Silber, J. Targeting Household Energy Assistance. *Energy Econ.* **2021**, *99*, 105311. [[CrossRef](#)]
- Legendre, B.; Ricci, O. Measuring fuel poverty in France: Which households are the most fuel vulnerable? *Energy Econ.* **2015**, *49*, 620–628. [[CrossRef](#)]
- Moore, R. Definitions of fuel poverty: Implications for policy. *Energy Policy* **2012**, *49*, 19–26. [[CrossRef](#)]
- Hills, J. Getting the Measure of Fuel Poverty: Final Report of the Fuel Poverty Review. *Case Rep.* **2012**, *72*, 237.
- Bardazzi, R.; Bortolotti, L.; Pazienza, M.G. To Eat and Not to Heat? Energy Poverty and Income Inequality in Italian Regions. *Energy Res. Soc. Sci.* **2021**, *73*, 101946. [[CrossRef](#)]
- Castaño-Rosa, R.; Sherriff, G.; Thomson, H.; Guzmán, J.S.; Marrero, M. Transferring the Index of Vulnerable Homes: Application at the Local-Scale in England to Assess Fuel Poverty Vulnerability. *Energy Build.* **2019**, *203*, 109458. [[CrossRef](#)]
- Heindl, P.; Schuessler, R. Dynamic Properties of Energy Affordability Measures. *Energy Policy* **2015**, *86*, 123–132. [[CrossRef](#)]
- Rizal, R.N.; Hartono, D.; Dartanto, T.; Gultom, Y.M. Multidimensional energy poverty: A study of its measurement, decomposition, and determinants in Indonesia. *Heliyon* **2024**, *10*, 24135. [[CrossRef](#)] [[PubMed](#)]
- Fizaine, F.; Kahouli, S. On the Power of Indicators: How the Choice of Fuel Poverty Indicator Affects the Identification of the Target Population. *Appl. Econ.* **2019**, *51*, 1081–1110. [[CrossRef](#)]

16. Bouzarovski, S.; Herrero, S.T. The Energy Divide: Integrating Energy Transitions, Regional Inequalities and Poverty Trends in the European Union. *Eur. Urban Reg. Stud.* **2017**, *24*, 69–86. [\[CrossRef\]](#)
17. Bonatz, N.; Guo, R.; Wu, W.; Liu, L. A Comparative Study of the Interlinkages between Energy Poverty and Low Carbon Development in China and Germany by Developing an Energy Poverty Index. *Energy Build.* **2019**, *183*, 817–831. [\[CrossRef\]](#)
18. Gouveia, J.P.; Palma, P.; Simoes, S.G. Energy Poverty Vulnerability Index: A Multidimensional Tool to Identify Hotspots for Local Action. *Energy Rep.* **2019**, *5*, 187–201. [\[CrossRef\]](#)
19. Alkire, S.; Fang, Y. Dynamics of Multidimensional Poverty and Uni-dimensional Income Poverty: An Evidence of Stability Analysis from China. *Soc. Indic. Res.* **2019**, *142*, 25–64. [\[CrossRef\]](#)
20. Li, K. *Research on the Comprehensive Assessment Method of Energy Poverty and Its Application*; Beijing Institute of Technology: Beijing, China, 2015; pp. 1–191.
21. Zhou, D.; Zhao, S.; Zhou, J.; Liu, X.; Ding, H. Study on provincial relative energy poverty measurement and hierarchical early warning in China. *J. Univ. Political Sci. Law Econ. Stud.* **2023**, *39*, 34–44.
22. Abbas, K.; Li, S.; Xu, D.; Baz, K.; Rakhmetova, A. Do Socioeconomic Factors Determine Household Multidimensional Energy Poverty? Empirical Evidence from South Asia. *Energy Policy* **2020**, *146*, 111754. [\[CrossRef\]](#)
23. Santillán, O.S.; Cedano, K.G.; Martínez, M. Analysis of Energy Poverty in 7 Latin American Countries Using Multidimensional Energy Poverty Index. *Energies* **2020**, *13*, 1608. [\[CrossRef\]](#)
24. Bollino, C.A.; Botti, F. Energy Poverty in Europe: A Multidimensional Approach. *PSL Q. Rev.* **2017**, *70*, 429–472.
25. Decerf, B. Combining Absolute and Relative Poverty: Income Poverty Measurement with Two Poverty Lines. *Soc. Choice Welf.* **2021**, *56*, 325–362. [\[CrossRef\]](#)
26. Howden-Chapman, P. Effect of Insulating Existing Houses on Health Inequality: Cluster Randomised Study in the Community. *Br. Med. J.* **2007**, *334*, 460. [\[CrossRef\]](#) [\[PubMed\]](#)
27. Masud, J.; Sharan, D.; Lohani, B.N. *Energy for All: Addressing the Energy, Environment, and Poverty Nexus in Asia*; Asian Development Bank: Manila, Philippines, 2007.
28. Halkos, G.E.; Gkampoura, E.C. Evaluating the Effect of Economic Crisis on Energy Poverty in Europe. *Renew. Sustain. Energy Rev.* **2021**, *144*, 110981. [\[CrossRef\]](#)
29. Shahidur, R.K.; Douglas, F.B.; Hussain, A.S. Are the energy poor also income poor? Evidence from India. *Energy Policy* **2019**, *47*, 1–12.
30. Deshwal, D.; Sangwan, P.; Dahiya, N. How will COVID-19 impact renewable energy in India? Exploring challenges, lessons and emerging opportunities. *Energy Res. Soc. Sci.* **2021**, *77*, 102097. [\[CrossRef\]](#)
31. Batool, K.; Zhao, Z.Y.; Sun, H.; Irfan, M. Modeling the impact of energy poverty on income poverty, health poverty, educational poverty, and environmental poverty: A roadmap towards environmental sustainability. *Environ. Sci. Pollut. Res.* **2023**, *30*, 85276–85291. [\[CrossRef\]](#)
32. Dong, K.; Dou, Y.; Jiang, Q. Income inequality, energy poverty, and energy efficiency: Who cause who and how? *Technol. Forecast. Soc. Change* **2022**, *179*, 121622. [\[CrossRef\]](#)
33. Kerimray, A.; De Miglio, R.; Rojas-Solórzano, L.; Ó Gallachóir, B.P. Causes of energy poverty in a cold and resource-rich country: Evidence from Kazakhstan. *Local Environ.* **2018**, *23*, 178–197. [\[CrossRef\]](#)
34. Cervantes, M.Á.M.; Solís, L.R. Energy poverty and social justice in Mexico: The rights of electricity consumers. *Electr. J.* **2024**, *37*, 107372. [\[CrossRef\]](#)
35. Zhuang, R.; Yang, J.; Mi, K.; Zhang, C.; Zhi, M. Spatiotemporal characteristics, influencing factors, and trend prediction of household energy consumption in China. *Adv. Geogr.* **2024**, *43*, 870–887.
36. Clancy, J.; Roehr, U. Gender and Energy: Is There a Northern Perspective? *Energy Sustain. Dev.* **2003**, *7*, 44–49. [\[CrossRef\]](#)
37. Sen, K.K.; Singha, B.; Karmaker, S.C.; Bari, W.; Chapman, A.J.; Khan, A.; Saha, B.B. Evaluating the relationship between energy poverty and child disability: A multilevel analysis based on low and middle-income countries. *Energy Sustain. Dev.* **2023**, *77*, 101331. [\[CrossRef\]](#)
38. Berti, K.; Bienvenido-Huertas, D.; Bellicoso, A.; Rubio-Bellido, C. Implications of energy poverty and climate change in Italian regions. *Energy Effic.* **2023**, *16*, 51. [\[CrossRef\]](#)
39. Acheampong, A.O.; Opoku, E.E.O.; Amankwaa, A.; Dzator, J. Energy Poverty and Gender Equality in Education: Unpacking the Transmission Channels. *Technol. Soc.* **2024**, *202*, 123274. [\[CrossRef\]](#)
40. Grazini, C. Energy Poverty as Capacity Deprivation: A Study of Social Housing Using the Partially Ordered Set. *Socio-Econ. Plan. Sci.* **2024**, *92*, 101843. [\[CrossRef\]](#)
41. Adams, J.A.; Carley, S.; Konisky, D.M. Utility assistance and pricing structures for energy impoverished households: A review of the literature. *Electr. J.* **2024**, *37*, 107368. [\[CrossRef\]](#)
42. Thomson, H.; Snell, C. Quantifying the prevalence of fuel poverty across the European Union. *Energy Policy* **2013**, *52*, 563–572. [\[CrossRef\]](#)

43. Awosusi, A.A.; Adebayo, T.S.; Kirikkaleli, D.; Altuntaş, M. Role of Technological Innovation and Globalization in BRICS Economies: Policy towards Environmental Sustainability. *Int. J. Sustain. Dev. World Ecol.* **2022**, *29*, 593–610. [\[CrossRef\]](#)
44. Polimeni, J.M.; Simionescu, M.; Iorgulescu, R.I. Energy Poverty and Personal Health in the EU. *Int. J. Environ. Res. Public Health* **2022**, *19*, 11459. [\[CrossRef\]](#)
45. Sagar, A.D. Alleviating energy poverty for the world's poor. *Energy Policy* **2005**, *33*, 1367–1372. [\[CrossRef\]](#)
46. Zhang, Z.; Linghu, Y.; Meng, X.; Yi, H. Is there gender inequality in the impacts of energy poverty on health. *Front. Public Health* **2022**, *10*, 986548. [\[CrossRef\]](#)
47. Sambodo, M.T.; Novandra, R. The state of energy poverty in Indonesia and its impact on welfare. *Energy Policy* **2019**, *132*, 113–121. [\[CrossRef\]](#)
48. Ozughalu, U.M.; Ogwumike, F.O. Extreme Energy Poverty Incidence and Determinants in Nigeria: A Multidimensional Approach. *Soc. Indic. Res.* **2019**, *142*, 997–1014. [\[CrossRef\]](#)
49. Alam, M.S.; Islam, K.K.; Huq, A.M.Z. Simulation of Rural Household Fuel Consumption in Bangladesh. *Energy* **1999**, *24*, 743–752. [\[CrossRef\]](#)
50. Miah, M.D.; Al Rashid, H.; Shin, M.Y. Wood fuel use in the traditional cooking stoves in the rural floodplain areas of Bangladesh: A socio-environmental perspective. *Biomass Bioenergy* **2008**, *33*, 70–78. [\[CrossRef\]](#)
51. Pereira, M.G.; Silva, N.F.D.; Freitas, M.A.V. Energy transition: The nexus between poverty and CO2 emissions in Brazil. *Int. J. Innov. Sustain. Dev.* **2019**, *13*, 376–391. [\[CrossRef\]](#)
52. Hiemstra-Van der Horst, G.; Hovorka, A.J. Reassessing the 'Energy Ladder': Household Energy Use in Maun, Botswana. *Energy Policy* **2008**, *36*, 3333–3344. [\[CrossRef\]](#)
53. Biswas, W.K.; Bryce, P.; Diesendorf, M. Model for Empowering Rural Poor through Renewable Energy Technologies in Bangladesh. *Environ. Sci. Policy* **2001**, *4*, 333–344. [\[CrossRef\]](#)
54. Sovacool, B.K. The political economy of energy poverty: A review of key challenges. *Energy Sustain. Dev.* **2012**, *16*, 272–282. [\[CrossRef\]](#)
55. Rao, J.; Ali, S.; Nazar, R.; Anser, M.K. From darkness to light: Unveiling the asymmetric nexus between energy poverty and environmental quality in South Asia. *Heliyon* **2024**, *10*, 27100. [\[CrossRef\]](#) [\[PubMed\]](#)
56. Zia, Z.; Zhong, R.; Akbar, W.A. Analyzing the impact of fintech industry and green financing on energy poverty in the European countries. *Heliyon* **2024**, *10*, 27532. [\[CrossRef\]](#)
57. Lin, B.; Okyere, M.A. Race and energy poverty: The moderating role of subsidies in South Africa. *Energy Econ.* **2023**, *117*, 106464. [\[CrossRef\]](#)
58. Szabó, S.; Bódis, K.; Huld, T.; Moner-Girona, M. Sustainable energy planning: Leapfrogging the energy poverty gap in Africa. *Renew. Sustain. Energy Rev.* **2013**, *28*, 500–509. [\[CrossRef\]](#)
59. Keevers, L. Working together to reduce energy poverty in Timor-Leste with environmentally sustainable community-based economic development: A transnational developmental social work approach. *Int. Soc. Work.* **2022**, *65*, 67–82. [\[CrossRef\]](#)
60. Heerae, L.; Huijoo, S. Spatial and Temporal Patterns of Energy Aid and Poverty in Four African Countries: Focusing on Distributive and Recognition Justice. *Renew. Sustain. Energy Rev.* **2024**, *192*, 114261.
61. Scarpellini, S.; Hernández, M.A.S.; Llera-Sastresa, E.; Aranda, J.A.; Rodríguez, M.E.L. The mediating role of social workers in the implementation of regional policies targeting energy poverty. *Energy Policy* **2017**, *106*, 367–375. [\[CrossRef\]](#)

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