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A Review of Literature on Measuring Energy Poverty

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Enerji Yoksulluğunun Ölçülmesine İlişkin Literatür İncelemesi

Öz

Bu makale, 2004-2022 yılları arasında enerji yoksulluğu ve ölçümü üzerine yapılan çalışmaları analiz etmektedir. Web of Science veri tabanında "energy poverty measurement" anahtar kelimesi ile yapılan aramada 195 makaleye ulaşılmış, bunlardan 69'u incelenmiştir. Çalışmada öncelikle enerji yoksulluğunun tanımı, yol açtığı sorunlar ve belirleyici kriterleri hakkında bilgi verilmiştir. Sonraki adımda enerji yoksulluğunun diğer belirleyicileri grafikler ve tablolar yardımıyla açıklanmıştır. Metodoloji bölümünde ise makaleler ülkelerin ekonomik gelişmişliklerine ve kullanılan ölçüm modellerine göre detaylı bir şekilde analiz edilmektedir. Son olarak, sonuçlar ve öneriler sunulmakta ve evrensel olarak kabul gören bir ölçüm modeli bulmak için gelecekteki çalışmalar önerilmektedir.

Anahtar Kelimeler: Enerji yoksulluğu, ölçüm modelleri, hanehalkı enerji erişimi

A Review of Literature on Measuring Energy Poverty

Abstract

This article analyzes the studies on energy poverty and its measurement between 2004 and 2022. A search of the Web of Science database with the keyword "energy poverty measurement" yielded 195 articles, among which 69 articles were found. In the study, first of all, information about the definition of energy poverty, the problems it causes and its determining criteria. In the next step, other determinants of energy poverty are explained with the help of graphs and tables. In the methodology section, the articles are analyzed in detail according to the economic development of the countries and the measurement models used. Finally, conclusions and recommendations are presented, and future work is suggested to find a universally accepted measurement model.

Keywords: Energy poverty, measurement models, access to household's energy

Makale Türü: Araştırma Makalesi

Paper Type: Research Article

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1. Introduction

People have basic needs for things like food, health care, and housing. Energy plays a crucial role in meeting these fundamental demands. Energy is regarded as one of the fundamental needs as a result. People cannot live healthy lives without energy. The literature provides broad definitions of energy poverty. Energy poverty is defined by Bouzarovski et al. (2012) as households' social and financial inability to access residential energy services.

In the literature, there is no agreed-upon definition of energy poverty, and there are various theories regarding how to measure it. The following definitions and metrics for energy poverty are provided by Barnes (2010).

1. Minimum physical energy requirements for cooking and lighting

2. Exceeding a threshold of a household's income on energy needs

3. Energy usage at the poverty line in terms of kind and volume

4. Maintaining a given level of income while keeping energy use and costs constant.

Following the oil crises of the 1970s, the phrase "energy poverty" was coined, and this issue has not yet been totally resolved. Particularly, the recent Russian-Ukrainian war and the surge in global energy costs brought on by the Covid-19 outbreak have increased the number of households living in energy poverty. Economic downturns have accelerated the pace of energy poverty, particularly in developing nations. People's salaries have decreased globally as a result of the Covid-19 pandemic issue, and initiatives to address energy poverty in developing nations have been abandoned. In particular, the rise in energy poverty in sub-Saharan Africa is anticipated to contribute to a 2% global increase in energy poverty in 2021. (IEA, 2021 as cited in Öcal and Arslan, 2022).

The 2019 Energy Progress Report estimates that 840 million people globally lack access to electricity, the most common form of energy poverty, despite the fact that international organizations have long worked to address challenges with energy infrastructure in Africa, Asia, and South America. Another example of energy poverty is the lack of access to modern cooking and clean energy sources. According to statistics, 3 million people in developing countries lack access to contemporary cooking techniques or clean fuels. (IEA, 2019, 1).

Energy poverty, which is a global problem, is carefully observed and the European Union and other international set-ups within the scope of the “Sustainable Development” goals of the United Nations produce solutions. To reduce energy poverty and draw attention to this problem, 2012 was declared the "Year of Sustainable Energy for All". 17 new global "Sustainable Development Goals" and 169 sub-targets were accepted by the United Nations in New York on September 25-27, 2015 and it is envisaged to achieve these goals by 2030 (Selçuk and Köktaş, 2018, 96). Within the scope of the sustainable improvement targets, Article 7 includes "Ensuring accessible, credible, sustainable and contemporary energy for all" and it is aimed to provide clean energy and cooking technologies to everyone in the world by 2030.

Based on these points, the significance of measuring energy poverty and studies on this issue is increasing. This study purposes to evaluate and examine the studies on the measurement of energy poverty in general, to interpret the results of the analyzed studies, and to reveal which perspective the literature offers. The studies analyzed in the article are taken from the Web of Science database. Considering that there is a large data source on energy poverty, we can say that the research area of our article is limited to this database.

2. Defining and Measuring Energy Poverty

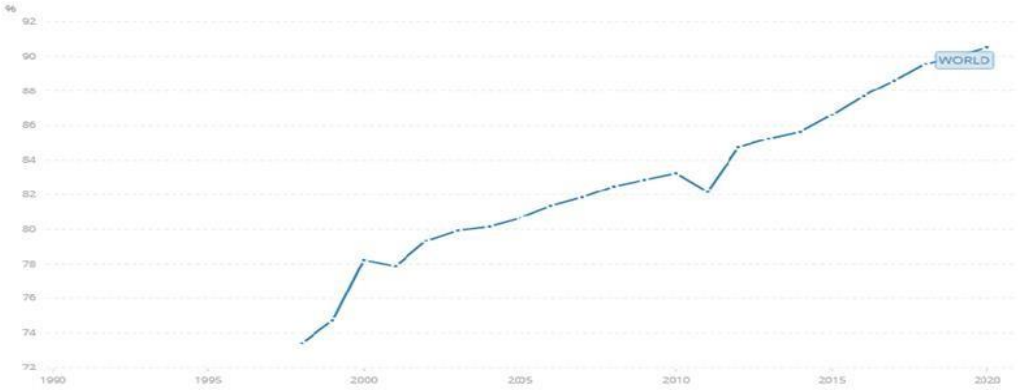
The world's energy poverty problem is squeezing the global energy market. Energy poverty is the problem of people not having attainment to enough quantities, purchasable prices, and high-quality energy (Day et al., 2016). World Economic Forum, WEF (2010) defines energy poverty as energy poverty is defined as the lack of access to sustainable contemporary energy services. Energy poverty encompasses most of the elements inherent in the term poverty and is one of the problems that threaten the future of humanity (Srivastava et al., 2012 as cited in Israel-Akinbo, 2019). There are two types of energy poverty depending on the economic progress of countries. While people in developed countries experience energy poverty due to high-energy prices, people in developing countries have difficulty accessing clean energy resources (Lin and Wang, 2020).

Energy poverty must be precisely measured for policies to be implemented as intended. Energy poverty is measured using unidimensional indicators, a panel of individual indicators, and the multidimensional energy poverty index (MEPI). The AFP Poverty After Fuel Cost (AFCP) index, the Minimum Income Standard (MIS) index, the Twice the National Median Indicators (2M), and the three arbitrary EU Statistics on Income and Living Conditions (EU-SILC) indicators are the most widely used single indicators. Energy poverty, according to Broadman (1991), is defined as a household's expenditure of more than 10% of its income on fuel according to Hills (2011), the definition of energy poverty is "low income and high expenditure" (LIHC), which means that a person is considered to be energy poor if their energy expenditure is higher than the median. Utilizing information on energy availability, the percentage of households unable to heat their houses, and the percentage of households unable to pay for energy expenditures, the MEPI indicator is a comprehensive measurement model that determines energy poverty.

3. Energy Poverty in the World and Turkey

People in industrialized, underdeveloped, and developing nations all struggle with energy poverty. People do not have access to clean energy sources in emerging and poor nations, whereas in industrialized nations, even when clean energy is available, it is not used as much as is necessary due to high costs.

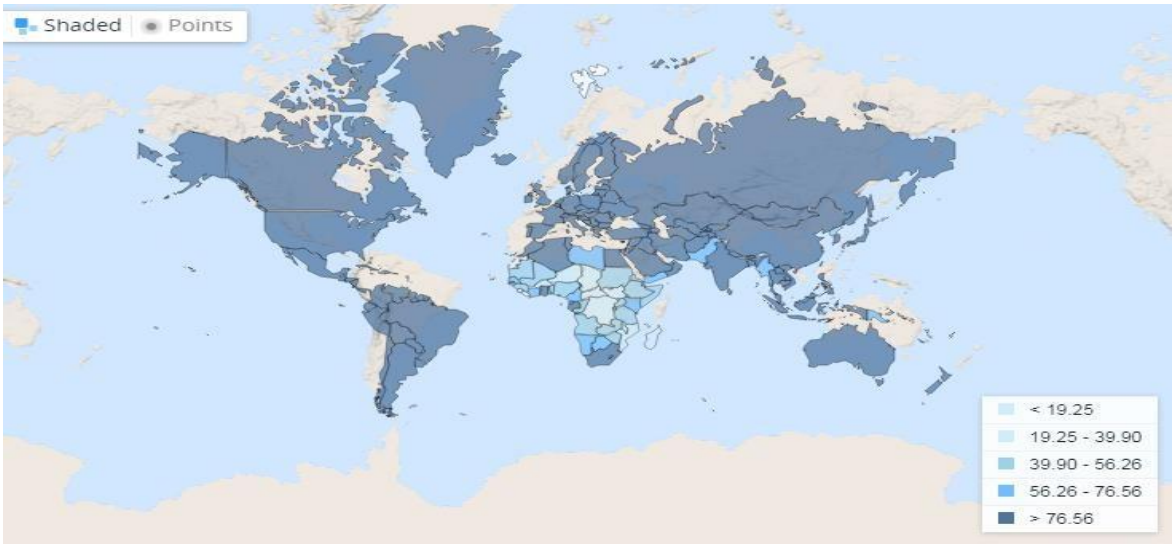
73% of people worldwide had access to electricity in 1995. (Shape 1). Over 90% of this amount was accomplished in 2020. All citizens of the nations that make up the European Union have had access to energy since the early 1990s. In the same year, 88.7% of Turkey's citizens had access to electricity. In Turkey, the rate of the population’s access to electricity has increased steadily since the 1990s, and as of 2018, every household has access to power (Selçuk and Köktaş, 2018).



Shape 1. Access to Electricity for The World's Population, 2020

Source: Worl Bank Global Electrification Database, 2020
https://data.worldbank.org/indicator/EG.ELC.ACCS.ZS?end=2020&start=1990&view=chart/ Retrieved from

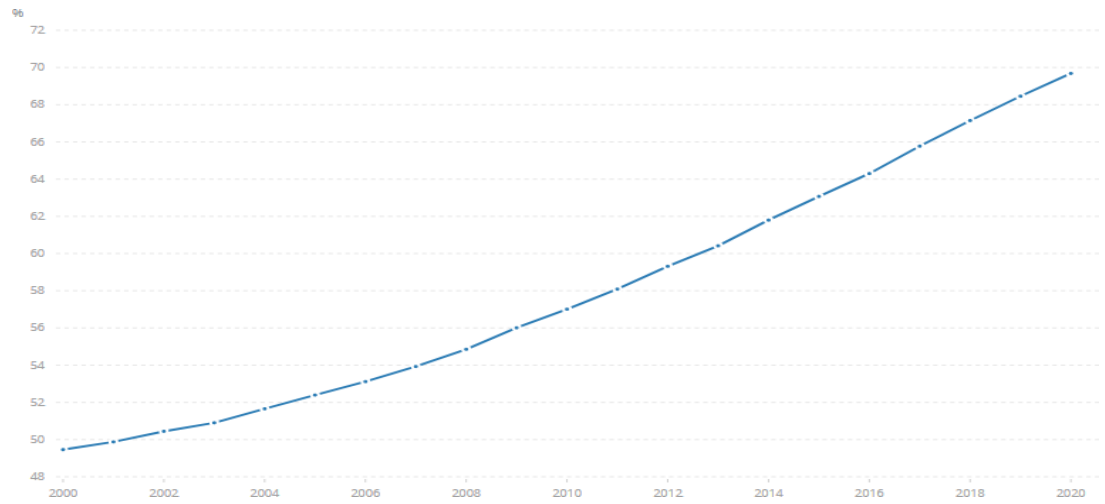
Depending on the countries' economic standing, different percentages of the world's population have access to electricity (Shape 2). Nearly every nation in Europe, Asia, and the Americas have an electrical availability rate of at least 90%. The north of the African continent, which includes Egypt, Libya, Algeria, and Morocco, has access rates to electricity that range from 90% to 100%. We observe that access to electricity is limited in other nations on the African continent because these nations have weak energy infrastructure and underdeveloped economies.



Shape 2. Countries' Access Rates to Electric Energy (2020)

Source: https://data.worldbank.org/indicator/EG.ELC.ACCS.ZS?type=shaded&view=map&year=2020

Due to financial disparity across nations, millions of people still lack access to clean water, energy, and food despite the expansion of the global economy and technological advancements. Millions of people still eat in traditional ways around the world, according to the International Energy Agency (IEA, 2020). 2.5 million individuals utilize biomass fuels, which are hazardous to their health and made from plant byproducts, bush waste, and wood pieces, in sub-Saharan Africa and developing Asian nations. According to the IEA (2020), 120 million people use kerosene to cook their food and 170 million people use coal to do so. There are 2.8 billion known users of non-clean fuels worldwide.



Shape 3. Access to Clean Fuels and Technologies for Cooking, 2020

Source: https://data.worldbank.org/indicator/EG.CFT.ACCS.ZS?end=2020&start=2000&view=chart

Worldwide, input to clean combustibles and technologies for cooking was 49% in 2000 and 70% in 2022 (Shape 3). This rate is over 95% in the Middle East, North Africa, North America, OECD, EU countries, 17% in sub-Saharan Africa and 60% in South Asia (World Bank Global Electrification Database, 2020). It was stated that more than 90% of the population worldwide would have access to electricity in 2022 (Shape 1). Compared to these two data, it can be said that the rate of people's access to clean combustibles and technology for cooking is low.

As in all countries around the world, Turkey has energy poverty. Our study tries to understand and compare energy poverty in Turkey. While there is no standard explanation for energy poverty in Europe, distinct terms are used, such as poor, low energy, poverty risk, or sensitive energy consumers. One data is not enough to measure energy poverty. Energy poverty in the country is associated with data such as high electrical energy prices, low household income, and the proportion of households unable to heat up their homes. According to Eurostat data, in 2021, the proportion of households in the EU countries that did not heat up their homes enough was 6.9%, the country with a minimum of Switzerland (0.2%), and the highest ratio was Bulgaria (22.5%). Enough of his home in Turkey the proportion of unheated households was 22.3% in 2016. Although there are no clear statistics, it may be stated that this rate was between 10% and 20% in 2021 (Europa.EU, 2021)

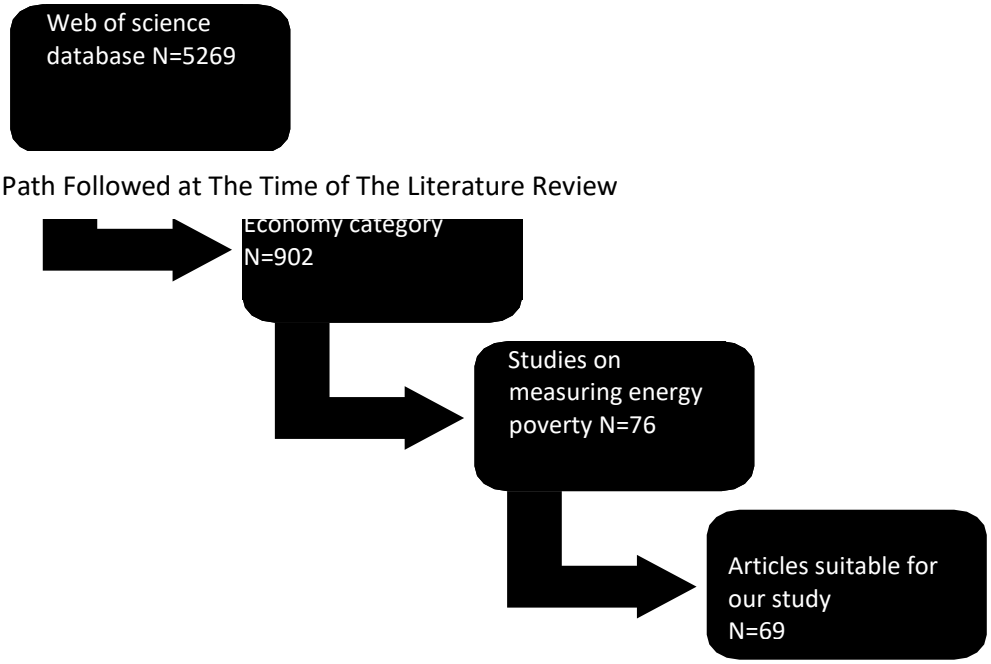
4. Method

In this article, studies on energy poverty and measurement were studied between 2004-2022. After the term energy poverty was first coined in 1977, it has not been widely and comprehensively researched for a long time. Although studies on energy poverty have been conducted in different years and topics, the articles on measuring energy poverty, which is the main topic of this paper, generally cover the period 2004 - 2022. The Web of Science database found 195 articles in the search with the keyword "energy poverty measurement", and 76 articles were found on the subject of our research. 7 of these 76 articles were excluded from coverage because they were not carried out by country, and 69 articles were examined in detail as a result. The study primarily contains information on the definition of energy poverty, the problems it causes, and the deterministic criteria. The literature review and evaluation time articles are classified according to the economic situation of the country in which they are being conducted and the measurement made. The stages of the literature scan are shown in Shape 4.

5. Discussion

All editions chosen for additional study were examined in accordance with the chosen categories. The author's name, publication date, case study location, article topic and conclusion, goal and main contribution of the study, and methodologies were all included in the content analysis. All studies were divided into two subcategories: those carried out in developing countries, and those carried out in developed countries. While research in developing countries has mostly focused on access to energy, studies in developed countries have typically focused on energy poverty. Based on economic and social factors, countries are divided into developed and developing countries. Here, economic factors include economic indicators such as national income per capita, unemployment rate, foreign trade volume. Social factors include social indicators such as human rights, education level and health services.

5.1 Studies on Energy Poverty in Developed Countries



Shape 4. The Path Followed at The Time of The Literature Review

When we examine the studies conducted in developed countries, we see that most of these studies have been conducted in developed countries located on the European continent. This is because the European continent is poor in terms of fossil fuel resources (except for the UK and Norway). Due to the high demand for energy and the inability to meet this demand with domestic production, these countries are forced to import natural gas and oil from countries with large oil and gas reserves such as the United Arab Emirates, Qatar, Azerbaijan, Kazakhstan, Russia (which was stopped after the Russia-Ukrania war started). Costs such as transportation and customs duties, as well as the maintenance of prices above a certain level by exporting countries, make the energy produced from these fuels expensive. This is why households in developed countries located on the European continent either pay large sums of money to meet their energy demand or are unable to meet their demand at all.

Table 1. Studies on Measuring Energy Poverty in Developed Countries

Author(s)	Method(s)	Country	Conclusion
Phimister et al(2015)	Expenditure-based energy poverty indicator	Spain	In contrast to subjective energy poverty, the result clearly demonstrates how lowering spending attitude lowers the amount and alters the dynamics of expenditure-based energy poverty.
Burlinson et al(2021)	LİHC, FP10, İHEAT	England	The findings show a statistically significant correlation between indices of fuel poverty and self-reported measures of present financial stress, with stronger implications for subjective indicators.
Aristondo and Onaindia(2018)	%10 indicator	Spain	The findings indicate that between 2004 and 2015, Spain's energy poverty increased. The Southern regions and rural communities in particular exhibit the highest levels of energy poverty.
Betto et al(2020)	Indicator of hidden energy poverty	Italy	The newly developed indicator makes use of data from the Italian National Institute of Statistics' 2018 Household Budget Survey, which assists in determining the percentage of Italian households that experience hidden energy poverty and provides policymakers with useful data for assisting vulnerable consumers.
Rodriguez-Alvarez et al(2021)	Stochastic boundary analysis	European countries	The findings demonstrate that measures to combat energy poverty include financial support for disadvantaged populations, lower energy costs, and increased energy efficiency. These elements may help to explain why, despite the financial crisis's detrimental effects on income, there has been a constant and general decrease in energy poverty throughout this period in almost all of the nations studied.
Streimikiene(2022)	energy expenditure indicator below half of the national median(M/2)	Lithuania	To fully understand the detrimental effects of the pandemic on energy vulnerability and energy poverty in Lithuania, attention was also given to energy prices as the primary indicator driving energy poverty during the COVID-19 pandemic.
Papada and Kaliampakos(2018)	Energy poverty indicator based on required cost	Greece	Sensitivity Analysis uses weighting factors too for the first time to quantify the effects of numerous characteristics on energy poverty. Energy poverty in Greece reached 70.4%, and income was the main determinant of energy poverty (63%).
	-	Spain	To determine local energy policies, the socioeconomic effects of energy poverty

Scarpellini et al(2019)			on households within a territory are assessed while taking into account the development, limitations, scope, and flexibility of the numerous interventions put in place throughout time.
Sanchez et al(2020)	High Energy demand index	Spain	The results show that 22.7% of homes are at risk of energy poverty and that assessments of energy poverty must effectively take into account the income levels and financial plans of households.
Papada Kaliampakos(2016)	%10 indicator	Greece	The results show that 58% of Greek families do not have enough energy. Nearly 90% of households living below the poverty line experience energy poverty. The present and new subjective indicators draw attention to other dimensions of energy poverty, including the degree of thermal comfort in the home, observable humidity problems, restrictions on other necessities to pay for energy, etc.
Karasek and Pojar(2018)	Percentage of household poverty indicator energy	Czech Republic	The paper's major conclusion outlines acceptable next measures and prospective initiatives aimed at reducing energy poverty in the Czech Republic.
Marchand et al(2019)	Index of Multiple Deprivation (IMD)	England	The outcomes have been utilized to create a classification matrix, which can be plotted using the Geographic Information System in the Lower Super Output Area, which identifies locations based on degrees of deprivation and energy poverty. The generated maps can be used to create successful local interventions that concentrate on the elements most likely to alleviate energy poverty in that region.
Delugas and Brau(2021)	MEPİ	Italy	The subjective indicator plays a clear extra role in identifying those who are energy poor, and there is only a small amount of overlap between MEPI and measures of affordability. Similar to this, as MEPI severity grows, econometric estimations show large and statistically significant negative effects on life satisfaction.
Longa et al(2021)	ML Model	Netherlands	Extensive sensitivity analysis shows that the results are independent of the precise placement of risk category boundaries. The study's conclusions show that machine learning can be used as a practical tool to track energy poverty and help develop and carry out successful policy measures.

Deller et al(2021)	LIHC and %10	England	Different definitions of energy poverty define not just the number of at-risk households but also households with different features, producing a fragile foundation for academic study and the creation of public policy. Using a large dataset from the UK to support and draw attention to these general difficulties, we show how three often-used indicators, two of which are based on official metrics, may reflect dramatically different targeting policies.
Chaton and Gouraud(2020)	Disposable income model	France 2006-2014	The model is put to the test using real numbers for the change in energy costs, the change in discretionary income, and the number of renovations that would actually be made to a home. The model is calibrated using the most recent two French national housing surveys, and it closely reproduces the number of people living in fuel poverty between 2012 and 2014.
Romero et al(2018)	LİHC and MİS	Spain	This essay seeks to advance this discussion by contrasting critically the various ways employed to gauge energy poverty in a real-world setting (Spain in 2015) and by putting up a fresh strategy that can address some of the major issues with the existing approaches.
Faiella and Lavecchia(2014)	LİHC	Italy	According to simulations, the measures that may be used to combat energy poverty in Italy would result in a slight decrease in the number of energy-hungry homes.
Carfora et al(2022)	DFA analysis	EU countries	The findings of this study imply that the negative effects of the pandemic on the EP level will be reversed very slowly, with notable differences between countries in any case, not before 2025, and that the gap between countries with low EP levels and countries with higher EP levels will continue to widen.
Okushima(2016)	energy consumption price index	Japan (2004 – 2013)	The findings demonstrate that over the past ten years, energy poverty among low-income and vulnerable households has gotten worse, as a result of both rising energy prices and declining earnings.
Spiliotis(2020)	Multi-Source measurement model	Greece	The framework was made available and put into use in Attica, Greece, to identify homes with insufficient energy.
Kelly et al(2020)	Home Heating Energy Poverty Risk Index	Ireland	In Ireland, the Index was created and used for a small-scale evaluation

Martin-Consuegra, F etal (2020)	MEPİ	Spain	To assess energy-poor households residing in inefficient homes, the index was created.
Okushima(2019)	MEPİ	Japan	The model based on energy service utilization is used to assess energy poverty in Japan.
Sanchez-Guevara et al (2019)	-	Spain vs England	Examined is the possibility of summertime energy poverty.
Charlier et al (2019)	MEPİ	France	The method is explained, and the suggested single indicators for determining energy poverty are contrasted with other well-known single indicators.

Different studies have been conducted on energy poverty and its measurement in the UK. Burlinson et al (2021) investigated the relationship between energy poverty and financial distress of households in the UK and found positive results. Marchand et al (2019) examined the relationship between the poverty of households in the UK and the energy poverty problem in their study. As a result, he concluded that energy poverty is an independent variable from multidimensional poverty. Deller et al (2021) examined the differences between the results of the indicators used to measure energy poverty in his study based on households in the UK and concluded that there are differences between the results of these indicators. Sanchez-Guevara et al (2019) examined the problems faced by socially vulnerable households due to summer heat in London and Madrid and concluded that the problem of energy poverty includes the problem of heating the house in winter as well as cooling the house in summer. When we examine the studies, we see that each of them has addressed different areas of the energy poverty problem in the UK. As can be seen, the aims of the studies in the UK are different.

Phimister et al (2015) conducted a study on measuring energy poverty in Spain. In this study, it was concluded that the expenditure-based energy poverty rate was 12.3% between 2007-2010. Aristondo and Onaindia (2018) measured how energy poverty rates changed in Spain between 2004 and 2015. While the measurement by Phimister et al. covers the average energy poverty for a 5-year period, the study by Aristondo and Onaindia calculates the energy poverty rate for each year in the 11-year period and examines how much this rate has changed compared to previous years. The study by Scarpellini et al (2019) aims to measure the social and economic impacts of energy poverty on the population. Although the study by Sanchez et al (2020) is similar to the study by Phimister et al and Aristondo and Onaindia, unlike the other two studies, this study was conducted to measure energy poverty at the province and district level, not at the country level. Romero et al (2018) used different methods of measuring energy poverty using data collected in Spain in 2015 and proposed a new methodology for solving the issue by comparing the results obtained from this measurement. Martin-Consuegra, F et al (2020) conducted a measurement in Madrid to identify neighborhoods facing energy poverty. It seems that the studies carried out by scientists in Spain are mainly aimed at measuring energy poverty and identifying the pros and cons of the measurement models used.

Betto et al (2020) calculated energy poverty in 5 different parts of Italy using the hidden energy poverty indicator to find hidden energy poverty in Italy. In contrast to Betto et al., Delugas and Brau (2021) aimed to measure energy poverty using the MEPI model. Faiella and Lavecchia (2014) tried to examine the energy poverty rates in Italy between 1997 and 2012 using the LİHC model. According to the results, the proportion of energy poor households was measured at 8% and remained broadly stable during this period. Although the three studies focus on measuring energy poverty in Italy, the measurement methods differ. Therefore, the

results obtained are also different.

In our review, we found three studies conducted to measure energy poverty in Greece. Two different studies were conducted by Papada and Kaliampakos in 2016 and 2018. The 2018 study used the "Stochastic Energy Poverty Model", while the 2016 study used the 10% measurement model. The application of different measurement models caused significant differences between the results. According to the results of the research conducted in 2016, 58% of households were energy poor, while this rate was 70.4% as a result of the research conducted in 2018. In his study, Spiliotis (2020) investigated how different measurement methods would yield results in Greece and tried to determine the pros and cons of these methods.

In the study conducted by Chaton and Gouraud (2020) to measure energy poverty in France between 2012 and 2014, the 10% indicator was used and it was found that 10.4% of households were energy poor. Unlike Chaton and Gouraud, Charlier et al (2019) tried to measure energy poverty using the MEPI indicator. It is not possible to make a comparison between these two studies as they are based on different indicators and years.

Streimikiene (2022) departed from the scope of the studies we have examined above and examined the relationship between energy poverty and Covid-19. Streimikiene tried to measure energy poverty in Lithuania before and after Covid-19 and compared the results. According to the data obtained, while the energy poverty rate in Lithuania tended to decrease before Covid-19, prices started to increase rapidly during the Covid-19 pandemic. This, in turn, led to an increase in the rate of energy poverty. As can be seen, Streimikiene's study is different from other studies and has made a significant contribution to the literature.

Kelly et al (2020) aimed to measure the risk index of households related to home heating problem using a different method of measuring energy poverty. They calculated a home heating risk index from 18641 households in Ireland and concluded that risk varies geographically.

The main purpose of the study by Karasek and Pojar (2018) is not to measure energy poverty like other studies, but to process and prepare programs to reduce this poverty. In the study, the proportion of households facing energy poverty in the Czech Republic was determined as 16%. In the following stages, it is seen that social programs for reducing energy poverty are necessary and the programs implemented have led to significant reductions in the energy poverty rate.

While studies on energy poverty have been conducted in different European Union countries, some studies focus on investigating the problem of energy poverty in the European Union in general. Rodriguez-Alvarez et al (2021) studied energy poverty in 30 European countries and found that vulnerable individuals living in these countries are negatively affected by energy price increases and decreases in energy efficiency. Carfora et al (2022), unlike Rodriguez-Alvarez et al, examined the impact of the Covid-19 pandemic on the energy poverty problem in European countries and emphasized that these effects will not disappear before 2025.

Energy poverty is increasingly gaining attention in developed countries such as the Netherlands. Although it affects only a small proportion of the population, it represents a serious problem that is difficult to measure and monitor, and therefore difficult to effectively address with appropriate policy measures. Research by Longa et al (2021) shows that machine learning can be used as an effective tool to monitor energy poverty and help design and implement appropriate policy measures.

We have already mentioned above that most of the studies on energy poverty are from developed countries located in Europe. One of the countries that is not located in Europe but has conducted studies on energy poverty is Japan. Okushima conducted two studies on energy poverty in 2016 and 2019. Okushima’s 2016 study differs from the other studies in that while the studies we included in our literature review were generally related to energy poverty and its different parts, this study by Okushima aimed to directly measure the impact

of the 2011 earthquake on energy poverty in Japan. As a result, it was found that the earthquake led to an increase in energy poverty among vulnerable households. Unlike his 2016 study, Okushima aimed to measure energy poverty regionally in his 2019 study. This study examines the regional characteristics of energy or fuel poverty in Japan through a new approach, namely by assessing energy poverty through direct measurement of energy service use. It also argues that the ongoing energy transition from fossil fuels to renewable energies should be carefully promoted, taking into account its detrimental effects on the energy poor.

To summarize, studies in developed countries have focused on the factors that cause energy poverty: Reduced household spending, according to Phimister et al (2015) and Sanchez et al (2020), reduces energy poverty. Papada and Kaliampakos (2016), Marchand et al (2019), and Papada and Kaliampakos (2018) all come to the conclusion that financial difficulties exacerbate energy poverty. According to Aristondo and Onaindia (2018), people who live in rural areas are more susceptible to energy poverty. In their respective studies, Betto et al (2020), Scarpellini et al (2019), Okushima (2016), Spiliotis (2020), and Rodriguez-Alvarez et al (2021) come to the conclusion that helping vulnerable populations reduce their access to energy. The Covid-19 epidemic, according to Streimikiene (2022) and Carfora et al (2022), has a detrimental effect on energy poverty. Studies by Karasek and Pojar (2018), Faiella and Lavecchia (2015) and Romero et al (2018) demonstrate the effectiveness of programs to combat energy poverty. Longa et al (2021) concluded that the population density of households has a negative impact on energy poverty, Delugas and Brau (2021), Chaton and Gouraud (2020), Kelly (2020) and Deller et al (2021) observed that a decrease in household income has a negative impact on energy poverty, Martin-Consuegra, F et al (2020) concluded that energy poverty levels are higher in inefficient households, Okushima (2019) argued that good energy services reduce energy poverty, Sanchez-Guevara, C et al (2019) concluded that energy poverty is lower in summer, Charlier, D et al (2019) compared the indicators used to measure energy poverty in his study.

5.2 Studies in Developing Countries

Studies on energy poverty in developing countries are shown in the Table 2. The studies were generally conducted in Asia, Africa and the Americas. Since there is no energy infrastructure in developing countries, people have problems accessing energy. In these articles, the rate of households' access to energy in developing countries has been tried to be measured.

Table 2. Studies on Measuring Energy Poverty in Developing Countries

Author(s)	Method(s)	Country(s)	Conclusion
Swierszcz(2017)	analytical-synthetic method	Poland	To assess it as a measure of the level of energy security, this research aims to quantify the effect of energy poverty on the social security of Polish households in terms of thermal energy.
Dogan et al(2021)	a multidimensional index (LIHC, 2M, 10%)	Türkiye	The findings also demonstrate the significance of wealth and health in influencing how financial inclusion impacts energy poverty. To reduce energy poverty, the findings emphasize the necessity for policies that support financial inclusion.
Selcuk et al(2019)	%10 indicator	Türkiye 2003-2017	The majority of homes in Turkey are in danger of energy poverty, and nearly half of those with the lowest

			income levels already experience it, according to the most recent data available. The rate for the wealthiest families is merely 3.48%.
Piwowar(2020)	Indicator that the house cannot be kept warm enough	Poland 2007-2017	According to the data, Poland's level of energy exclusion and poverty has decreased during the course of the study period. But a sizable portion of the populace still faces difficulties with energy poverty, such as paying for power and keeping their homes at a comfortable temperature.
Bouzarovski et al(2012)	-	Bulgaria	It investigates how policies are implemented in Bulgarian national state entities to alleviate energy poverty.
Piwowar(2021)	The ratio of households reporting that they cannot keep their homes warm enough	Poland and other European countries 2009-2018	The analysis' findings show that Poland is one of the nations where the number of households with earnings below 60% of the median income who claim they are unable to keep their homes warm enough has dramatically decreased over the study period. In the EU, this indicator's average level in 2018 was 7.3%.
Ye and Koch(2021)	-	South African countries	The result shows that energy poverty rates decline with income in all three poverty indices, and that lower income groups contribute more to overall poverty than higher-income groups.
Israel-Akinbo et al(2018)	MEPİ	South African countries	According to the research, low-income rural families use more energy inefficiently than urban households. According to the MEPI score over time, low-income urban and rural households experience a moderate level of energy poverty.
Ssennono et al(2021)	MEPİ	Uganda	According to the findings, 33% of Ugandans are severely energy poor, 66% of the population suffers from multidimensional energy poverty, and the average deprivation score is 51%.
Koomson and Danquah(2021)	Linear probability model (LPM)	Ghana	For individuals in the working category, an increase in financial inclusion is likely to result in the biggest decrease in energy poverty. It points to household net income and consumption poverty as two possible avenues via which financial inclusion could impact energy poverty.

Vermaak et al(2009)	Correlation analysis	South African countries	This study makes an effort to close this gap by creating trustworthy, theoretically sound energy-based metrics using information already available from the 2005 South African household survey. Using correlation analysis, the energy-based poverty indicator performs well when compared to other poverty variables after being modified for end-use and access.
Ogwumike and Ozughalu(2016)	MEPİ	Nigeria	Energy poverty is thought to afflict more than 75% of the population, according to estimates.
El-Katiri(2014)	-	Middle East and North Africa	A more in-depth examination of these nations paints an astonishing image of a region split between states with ample energy and a disproportionately high number of nations lacking access to power and a reliable supply of modern fuels.
Samarakoon(2019)	-	Countries of the South	The majority of the almost one billion people who lack access to electricity in the Global South reside in rural sub-Saharan Africa and the Indian subcontinent. Meanwhile, awareness of the crucial role energy availability plays in enhancing human well-being is expanding. The seventh Sustainable Development Goal of the UN, which has the audacious goal of ensuring that everyone has access to modern energy by 2030, is a perfect example of this.
Nduka(2021)	Contingent valuation method	Nigeria	The findings demonstrate that households in rural areas strongly choose renewable energy. Each home will save $60 as a result of the energy switch. Additionally, the cost-benefit analysis demonstrates that investing in the company is possible.
Zhao et al(2021)	D-H causality test	China (2002 – 2017) 30 State	In regions with significant levels of energy poverty, a bidirectional causal association between energy poverty and CO2 emissions was found.
Liang and Lu(2017)	Energy poverty is very dimension indicator (5 indicators)	China	The multifaceted nature of energy poverty is better understood in this research, which also offers a methodical framework for identifying energy poverty.
Nathan and Hari(2020)	Household income level analysis	India	The results indicate that the main source of energy poverty is a lack of access to cooking, and that the

			situation is more common in larger states. Unlike traditional measurements, we exclusively assess the degree and severity of energy poverty for the entire population.
Barnes et al(2011)	Measuring energy poverty by energy demand	Bangladesh	According to the data, 58 percent of rural Bangladeshi households lack access to energy, and 45 percent lack adequate income. The results also point to the possibility that strategies to promote rural electrification and increased usage of upgraded biomass cookstoves could be crucial in lowering energy poverty.
Pachauri et al(2004)	Two-dimensional measurement model of energy poverty	India 1983 -2000	According to the data, energy poverty has significantly decreased in a subcontinent that is quickly developing. The new metric is a useful addition to conventional monetary policies and is broad enough to be used in other emerging nations.
Jayasinghe et al(2021)	MEPİ	Shrilanka	The study's findings revealed significant disparities in energy poverty by gender, age, ethnicity, income level, and sub-national rank of the household head. There were also observable disparities in energy poverty according to sub-national status and income. When compared to other sociodemographic and geographic factors, there is a strong correlation between income and energy poverty in Sri Lanka, even if low-income households are not always low-energy households.
Gupta et al(2020)	Household energy poverty index	India	According to research on the geographic distribution of energy poverty, eastern and northeastern states are more susceptible to it, necessitating deliberate policy initiatives at all levels of governance.
Huang et al(2022)	Least squares regression and generalized system of moments estimation	China 1991-2015	The findings confirm that energy poverty has a significant negative influence on inclusive growth. People who have access to health insurance and water infrastructure in rural China experience less poverty than those who have not.
Nie et al(2021)	LİHC indicator	China 2012-2018	Using the 2012–2018 waves of the China Family Panel Studies, we investigate how energy poverty (EP) affects subjective well-being (SWB) among Chinese adults (18 years of age and older). In addition to

			establishing EP rates in the range of 13.2% to 35.3%, it also shows that EP leads to higher levels of depression (depending on the measure employed).
Sambodo and Novandra(2019)	%10 indicator	Indonesia	The study's three primary conclusions were provided. First, based on the criteria for expenditure, the range for energy poverty was around 53%, and based on total residential power use, it was about 22%. Non-energy-poor families spend more on both food (16.2%) and non-food (24.3%) than energy-poor households do.
Mohsin et al(2022)	Principal component analysis	Latin American countries	Energy poverty rates in Latin American nations are lower than average, at 17.54 percent, meaning that 17.45 percent of the population falls below the efficiency threshold of reasonable energy use. Results across all quantiles point to a relationship between rising energy poverty and a lack of financial growth.
Pereira et al(2011)	Lorenz Curve, Gap Poverty, Gap Quadratic, Gini Coefficient and Sen Index	Brazil	One of the study's key findings is that rural electrification significantly lowers the rate of energy poverty, which in turn improves energy equity.
Che et al(2021)	MEPİ	125 Country	The findings indicate a reduction in the world's energy poverty over time. However, there are significant spatiotemporal variations in the eradication of energy poverty across nations. The major obstacles to reducing energy poverty are access to and cost of energy.
Ampofo and Mabefam(2021)	Likert scale	1981 – 2014 Developing countries	The findings indicate a favorable correlation between religiosity and energy poverty. Particularly for people residing in developing economies and rural areas, high levels of religious activity engagement appear to be more closely related to high levels of energy poverty.
Pan et al(2021)	Generalized method of moments (GMM)	175 Country 2000-2018	The results show how energy poverty has a negative impact on public health. Additionally, we find that in countries with higher living standards, the negative effects of energy poverty on public health can be reduced, indicating that living standards may function as a conduit

			via which energy poverty influences health.
DSeuret-Jimenez et al(2020)	Energy access index	Mexico	It also lists the areas of Mexico and presents a tool for evaluating energy access.
Santillan (2020)	MEPİ	7 Latin American Countries	Results from measurements of energy poverty are contrasted. Energy poverty and the human development index (HDI) have been linked.
Ahmed and Gasparatos(2020)	MEPİ	Ghana	It was calculated and examined the MEPI index. No obvious links were discovered.
Mendoza et al (2019)	MEPİ	Philippines	The MEPI index was constructed for the Philippine provinces, and associations between household socioeconomic variables and energy poverty were found.
Pablo et al (2019)	MEPİ	Ecuador	To ascertain whether energy poverty exists in Ecuador is the goal of this study. Three indicators recommended by the European Union Energy Poverty Observatory were used to create a multidimensional energy poverty index (MEPI), which is based on measuring conditions related to energy poverty in areas related to utility bill payment delays, disproportionate expenditures, hidden energy poverty, and the 10% Boardman (1991) rule (EPOV).
Khanna.et al (2019)	Comprehensive Energy Poverty index	South and Southeast Asia.	In five developing Asian nations, the index has been introduced and used for micro-level evaluation.
Olang et al (2018)	MEPİ	Kenya	Links were found and MEPI was calculated.
Tait (2017)	Energy access index	South Africa	It revealed a framework for gauging emerging nations' access to electricity. The approach evaluated crucial energy access factors including security and dependability.
Sadath and Acharya (2017)	MEPİ	India	Energy insecurity and the socioeconomic underachievement of household members have been linked.
Nussbaumer,P et al(2013)	MEPİ	Developing countries	MEPI has been used in several developing nations.
Bazilian et Al (2012)	MEPİ	Developing African countries	In some African nations, the new composite index has been suggested and used to gauge energy deprivation.
Sokolowski (2020)	MEPİ	Poland	The index used to quantify energy poverty in Poland was created from five distinct indicators. Additionally, the major groups with the greatest

	risk of energy poverty were identified.

The issue of energy poverty is one of the most carefully monitored problems in Poland. Swierszcz (2017) examined how the energy poverty problem faced by households in Poland affects their social security and said that energy poverty threatens people's social security. Two of the studies on the problem of energy poverty in Poland belong to Piwowar. Piwowar tried to measure how the energy poverty problem developed in Poland between 2007 and 2017 in his study using the index of not being able to keep your home warm enough in 2020. Although Piwowar's 2021 study focuses on measuring energy poverty in Poland as in 2020, the difference from the previous study is that the results are compared with the energy poverty rates in other European countries. Although Sokolowski's study in 2020 was very similar to Piwowar's study, the methods used in the studies were different. However, as a result, both studies concluded that energy poverty rates in Poland have decreased in recent years.

In the last 20 years, China has made significant progress in terms of energy poverty. Studies on energy poverty have been conducted to analyze this progress and to fully address this problem in the future. In the study by Zhao et al (2021), energy poverty rates were measured in 30 provinces of China between 2002 and 2017, and then the impact of energy poverty on CO2 emissions was analyzed. As a result, it was observed that the rate of energy poverty in China decreased during this period and as a result of this progress, CO2 emissions decreased. The study by Liang and Lu (2017) is similar to the study by Zhao et al. and aims to measure energy poverty rates in China. Huang et al (2022) conducted a study that aims to measure the impact of energy poverty on people's incomes unlike other studies conducted in China. As a result, it was understood that a decrease in the energy poverty rate accelerates economic growth. The similar point of the study by Nie et al (2021) with the study by Huang et al is that they both aim to measure the impact of energy poverty on people's incomes and welfare. The study by Nie et al concluded that energy poverty negatively affects people's social welfare.

Energy poverty is a serious problem in India, the world's most populous country. Different studies have been conducted to investigate this problem. Nathan and Hari (2020) measured the rate of energy poverty in different states of India using the household income index and found that this problem is more widespread in large states compared to small states. The study by Pachauri et al (2004) also focused on measuring the energy poverty problem in India and found that energy poverty declined significantly between 1983 and 2000. Although Gupta et al (2020) used a different methodology than the others, the purpose of the study was the same as the others and focused on measuring the rate of energy poverty in India. The study by Sadath and Acharya (2017) measured the impact of energy poverty on people's social life unlike other studies conducted in India.

Turkey, which meets its energy needs with imported natural gas and oil, has an energy poverty problem. The reason for this poverty is that households spend too much money to heat their homes or they cannot heat their homes sufficiently. While Dogan et al (2021) measured the impact of financial coasters on energy poverty in Turkey, Selcuk et al (2019) calculated the proportion of energy-poor households in Turkey in 2003 and 2017 and compared these rates. These two studies, which examine the energy poverty problem from different perspectives, have contributed significantly to the literature.

Khanna. et al (2019) conducted a study on measuring energy poverty using data from India and ASEAN countries. The results show that the problem of energy poverty has decreased significantly in these countries since the beginning of the 21st century.

In the study by Bouzarovski et al (2012), measurement techniques were developed to

measure energy poverty across the European Union countries and then this measurement model was applied in Bulgaria to measure energy poverty.

The study by Barnes et al (2011) in Bangladesh was conducted to examine the relationship between energy poverty and income poverty and the findings show that households living in rural areas face both energy poverty and income poverty.

This study by Jayasinghe et al (2021) assesses the incidence, intensity, inequality and drivers of energy poverty in Sri Lanka by constructing a Multidimensional Energy Poverty Index (MEPI), using the latest (2016) data from the Sri Lanka Household Income and Expenditure survey. This study differs from others in that it reveals that the incidence of energy poverty varies due to differences in people's age, gender and ethnicity.

Mendoza et al (2019) analyzed the frequency with which energy poverty is measured in the Philippines using the MEPI indicator. Here, it was found that the rate of energy poverty varies across different regions of the country. Sambodo and Novandra (2019) tried to measure energy poverty in geographically close Indonesia using the 10% indicator. Both island states were found to have high energy poverty rates.

The problem of energy poverty is widespread in the African continent, which is generally composed of poor countries. For this reason, studies have been conducted on energy poverty covering different regions of the African continent. Ye and Koch (2021), Tait (2017) and Israel-Akinbo et al (2018) conducted studies on measuring energy poverty in low-income households in South Africa and concluded that higher income levels reduce energy poverty. Unlike other studies, Vermaak et al (2009) analyzed the effects of government policies on energy poverty. El-Katiri (2014) examined the problem of energy poverty in oil-rich countries in the Middle East and North Africa and emphasized that energy poverty is caused by problems in domestic distribution. Although the study by Samarakoon (2019) is similar to El-Katiri's study, Samarakoon associates energy poverty in sub-Saharan African countries with the lack of equitable distribution. Brazilian et al (2012) presented an innovation to the literature and examined the measurement methods used in measuring energy poverty and investigated the necessary regulations for the use of these methods in African countries.

Nduka (2021) examined policies for the development of the renewable energy sector in order to reduce energy poverty in Nigeria. The study by Ogwumike and Ozughalu (2016) is similar to the study by Nkuda. In this study, energy poverty was measured using the MEPI measurement model and then emphasized that the problem of energy poverty should be eliminated for sustainable development.

Koomson ve Danquah (2021) Gana'da finansal kapsayıcılığın enerji yoksulluğu üzerindeki etkilerini incelemiş ve finansal kapsayıcılıktaki bir standart sapmalık artışın enerji yoksulluğunda azalmaya yol açtığı sonucuna varmıştır. Ahmed ve Gasparatos (2020), Gana'da sanayi ürünlerinin kullanımının yaygınlaştırılmasının enerji yoksulluğu üzerindeki etkilerini analiz etmiştir.

Ssennono et al (2021) measured multidimensional energy poverty in Uganda using the MEPI measurement model commonly used in developing countries. The result shows that 66% of Ugandans are multidimensionally energy poor, 33% are severely energy poor and the average deprivation score is 51%. Olang et al (2018) used the same measurement model in Kenya, but unlike Ssennono et al, they aimed to develop policies that could be used to reduce energy poverty.

Some studies have been conducted to cover most developing countries. Che et al (2021) covered 125 countries and measured the rate of energy poverty in these countries and found that the energy poverty situation improved in these countries over time. Ampofo and Mabefam (2021) approached the issue of energy poverty differently from others and examined the relationship between religiosity and energy poverty. The study by Pan et al (2021) investigates the impact of energy poverty on public health using annual data for the

period 2000-2018 for a large panel of 175 countries. The study by Nussbaumer et al (2013) is similar to the study by Che et al and was conducted to measure energy poverty in developing countries and the same result was obtained.

Latin American countries belong to the group of developing countries. Due to the large population of these countries and the fact that they are still developing, their populations face energy poverty. Different studies have been conducted on energy poverty in Latin American countries. While Santillan et al (2020) was sufficient to measure energy poverty in 7 Latin American countries using the MEPI measurement model. Mohsin et al(2022) examined the effects of financial development on energy poverty in Latin American countries using econometric analysis.

Pereira et al (2011) analyzed whether policies to reduce energy poverty by the Brazilian government are effective. DSeuret- Jimenez et al (2020) and Pablo et al (2019) measured energy poverty in Mexico and Ecuador, respectively. While DSeuret- Jimenez et al used the energy access index in this measurement, Pablo et al used the MEPI measurement model in his study.

Swierszcz (2017), Santillan et al (2020), Nie et al (2021), Sambodo and Novandra (2019), Sadath and Acharya (2017, Mendoza et al (2019), Pan et al (2021) and Samarakoon (2019) concluded that energy poverty reduces the social security level of households. Energy poverty and financial development have been linked, according to Dogan et al (2021), Koomson and Danquah (2021), and Mohsin et al (2022). The findings show that financial progress lowers the incidence of energy poverty. Energy poverty, according to Ogwumike and Ozughalu (2016), Ahmed and Gasparatos (2020), and Bazilian et al. (2012), has a detrimental effect on economic growth. Selcuk et a l (2019), Ye and Koch (2021), Vermaak et al (2009), El-Katiri (2014), Nathan and Hari (2020), Jayasinghe et al (2021), Huang et al (2022), Olang et al (2018), Bouzarovski et al(2012), Tait (2017), Ssennono et al (2021) and Piwowar (2020) conclude that low-income households are more likely to face energy poverty. Israel-Akinbo et al (2021), Sokolowski (2020), Barnes et al (2011) and Nduka (2021) explain that rural households are more affected by energy poverty than other households. Zhao et al (2021) found a positive relationship between high energy poverty and CO2 emissions. Liang and Lu (2017) applied a multidimensional indicator to measure energy poverty. Pachauri et al (2004) concluded that policies are effective in reducing energy poverty. Gupta et al (2020) concluded that geographical terrain affects energy poverty. Pereira et al (2011) conclude that the installation of power lines in rural areas reduces energy poverty. Che et al (2021) conclude that energy poverty reduction programs vary across countries. Ampofo and Mabefam (2021) found a positive relationship between energy poverty and religiosity. Seuret-Jimenez (2021) measured energy poverty in different areas of Mexico and found different results. Pablo et al (2019) calculated energy poverty in Ecuador by creating a new index. Khanna,R.A. et al (2019) tried to solve the problem of energy poverty by conducting micro-level research in developing Asian countries. Nussbaumer et al (2013) tried to develop the MEPI methodology for measuring energy poverty in developing countries.

6. Conclusion and Recommendations

This article offers a thorough examination of energy poverty. 69 publications from the Web of Science database that were published between 2004 and 2022 were taken out and thoroughly examined. The publications were divided into two subcategories—studies from rich nations and studies from developing countries—for a more thorough examination. Energy access issues were used as the basis for estimates of energy poverty in emerging nations. The MEPI, the most widely used indicator, was used in more than half of the studies in the subcategory that were chosen for additional analysis. The subcategory of energy

poverty assessment received twenty indices. It was rather popular to develop indices out of specific indicators (10%, LIHC, AFC, etc.) or to compare evaluation results to those indices.

According to our research, energy poverty has recently spread to other parts of the world. Energy poverty was a concern for individuals in developing nations in the early 2000s, but in recent years, the wealthiest nations in the world—the European Union—have also experienced it as a result of the consequences of the Covid-19 outbreak and the Russian-Ukrainian war. Increasing the usage of renewable energy sources, in our opinion, is the best method to combat energy poverty. Since non-renewable resources like oil and gas are only found in a few nations, political and economic crises there have an impact on the global energy supply. Energy poverty will decrease and cease to be a global issue if nations use renewable energy sources domestically to lessen their reliance on imported energy, as we have previously stated.

When we look at the studies, it becomes clear that there is no widely used model for calculating energy poverty. New measurement models were developed by the authors for some papers, while MEPI, LIHC, 2M, and 10% markers were utilized in others. Measure energy poverty, none of these indicators, however, offers definite conclusions. The MEPI model can be used to quantify energy poverty in underdeveloped nations, but when employed in developed nations, it is impossible to get accurate findings. This is because energy prices are not taken into account by the MEPI model, although citizens in industrialized nations frequently experience energy poverty as a result of high energy prices. The LIHC, 2M, and 10% indicators are useful for quantifying energy poverty in industrialized nations, but because they lack multidimensional measurement models, they do not take into account all the elements that contribute to it. The degree of energy poverty must be correctly and impartially determined to address the issue. To achieve this, it is essential to create a more thorough measurement model for calculating energy poverty that takes into account all variables affecting energy poverty, applies to all nations, and is widely recognized. To create such a model, it might be deemed necessary to undertake group studies. Thanks to the model that will be developed, energy poverty can be precisely measured in all nations, and measures can be taken to lessen it by the findings.

Statement of Research and Publication Ethics

This article does not require ethics committee approval

Authors' Contributions to the Article

Shahlar ISAZADE's contribution to the article is 50%, Prof. Dr. Meral ALTAN's contribution to the article is 50 %.

Declaration of Interest

The study does not present any conflicts of interest for the authors or other stakeholders.

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