

Review

Coping with Energy Poverty: Measurements, Drivers, Impacts, and Solutions

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Abstract: Energy is required for socioeconomic development, and the world's energy needs have significantly increased in the last decades. The lack of energy can have severe impacts on a person's well-being; therefore, energy access should be ensured for everyone in the world. Energy poverty usually refers to a situation where a household cannot be kept adequately warm, but it is a complex issue with many more aspects. This paper aims to present a comprehensive review of the energy poverty problem, particularly presenting various definitions given in the literature that capture the multi-dimensional nature of the problem and analyzing the different ways of measuring energy poverty (expenditure approach and consensual approach). In addition, the impacts of the problem are identified, including health, socioeconomic, and environmental impacts, as well as the drivers that can worsen energy poverty conditions, such as several household characteristics and various socioeconomic and environmental factors. The situation occurring currently in the world is also presented, including studies that focus on different world regions, and the different solutions that can help address the problem are discussed, including changes to the living environments and the use of new technologies.

Keywords: energy poverty; energy social impacts; inclusion; affordability; world regions



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1. Introduction

Human existence and prosperity rely significantly on every known form of energy [1]. Energy use is found in the core of almost every daily activity that takes place in the modern, technologically advanced world, and these activities largely comprise the areas of mobility, communications, health, and food security. Basic human needs require energy to be accomplished; energy use is therefore important for economic and social development and welfare [2].

In the last decades, energy needs have significantly increased. The total final energy consumption was at 6,267,177 kilotonnes of oil equivalent (ktoe) in 1990 and reached 9,937,703 ktoe in 2018 [3]. Taking also into consideration the increase of the worldwide population, i.e., from 5.28 billion people in 1990 to 7.59 billion in 2018 [4], it is obvious that energy consumption per capita has increased and that energy has reached extremely high levels of usage in the world.

Fossil fuels are used to cover most of the world's energy needs: according to the World Bank database, fossil fuels covered 79.7% of the total world energy consumption in 2015, while renewable sources only accounted for 18.05% the same year [5,6]. The sectors with the biggest energy consumption worldwide include the industry and transport sector, while the residential sector follows [7].

The residential sector's final consumption, the third biggest energy consumer, was accounted for 2,109,205 ktoe in 2018. In a household, energy is required for space heating, air-conditioning, water heating, lighting and for the operation of devices, such as refrigerators, cooking appliances, washers and dryers, televisions and electronics, with space heating requiring the most amount of energy among these [8]. It is therefore obvious that a

household can be significantly affected if it has limited or no access to the energy that is necessary to perform basic daily tasks and to cover basic human needs.

In 2016, approximately 1.1 billion people did not have access to electricity, according to IEA's World Energy Outlook 2017, while approximately 1.2 billion people in developing countries have gained access to electricity since 2000 [9]. This energy-related poverty that is observed around the world is usually mentioned as "energy poverty" [10]. The goal that the United Nations set in 2015, as a part of their 17 Sustainable Development Goals (7th SDG) was to "ensure access to affordable, reliable and modern energy for all" by 2030 [11].

Since energy is vital for good conditions of living, welfare, and development, the concept of energy poverty has been an issue studied in the recent literature. Most of the population that is affected by energy poverty is located in rural areas and in developing countries, but this does not mean that developed countries are not affected as well: studies have shown that the people who suffer from energy poverty are located in European countries as well [12]. This universal effect that energy poverty has makes its examination significantly important, as this would allow us to deeply understand the issue and therefore eradicate it.

This paper aims to contribute to the existing literature by providing a comprehensive review on the problem of energy poverty. Since energy is one of the most important elements of everyday life, the examination of problems that are related to this is extremely valuable, especially when it comes to access to energy services, energy efficiency, and ability to keep a household warm. Thus, this paper's aim lies mainly on the in-depth examination of the existent literature that focuses on the issue of energy poverty all around the world, in order to increase knowledge on the problem and assist in its mitigation. A deeper understanding of what energy poverty means and the impacts it has on people's well-being is very important, in order to specifically identify and clarify the problem. To that end, it is equally important to explore the ways that energy poverty can be measured. Based on this, it is then possible to review the energy poverty conditions that occur worldwide and in different world regions. The identification of the factors that are causing or worsening energy poverty conditions, may provide important insights on the problem's driving forces, while the suggestion of actions that can help mitigate the problem may provide valuable assistance to policy makers, in order to successfully address energy poverty.

Different definitions of energy poverty provided in the literature are presented in Sections 2 and 3, where the impacts of energy poverty are discussed. The different ways of measuring energy poverty, based on the literature, are also presented in Section 4, while Section 5 analyzes the situation occurring currently in the world. Drivers of energy poverty are identified in Section 6, while Section 7 suggests certain actions that can be undertaken in order to mitigate the problem. Section 8 concludes the paper.

2. Energy Poverty Definitions

Poverty is a concept difficult to define and measure. It can refer to a person having less than a specific minimum, which is an absolute minimum and is objectively defined. It can also refer to a person having relatively less of something compared to others in a society, or to a person feeling that they do not have enough to get along. These different approaches can lead to different understandings of the concept and to the identification of different determinants and indicators that define and cover the issue of poverty [13].

Energy poverty, often mentioned as fuel poverty, refers to every energy-related aspect of poverty. Since the definition of poverty is not simple and easy to determine, energy poverty is also difficult to define and conceptualize [14]. Most of the definitions provided in the literature mainly define energy poverty as the inability to keep a household adequately warm, but energy poverty is a much more complex and multidimensional concept. Table 1 presents various definitions that have been given in the literature for energy poverty or fuel poverty.

It has been argued that there is a difference between the terms "energy poverty" and "fuel poverty". More specifically, fuel poverty seems to focus more on issues related to

low energy affordability, while energy poverty is a broader term that captures all the problems related to inadequate energy access [15,16]. Based on this, fuel poverty is related to the interactions between energy prices, low levels of income, and energy inefficiency of households [17]. Despite the distinctions, many scientists in the literature use the two terms to describe the same thing; based on this, in this paper, we consider the two terms as synonyms as well.

The definitions presented in Table 1 all seem to focus on the problems related to non-affordable and inadequate heating of a dwelling and the inability to meet basic energy needs. According to Okushima [18], energy poverty is divided into the two concepts of availability and affordability. In the World Energy Outlook 2010, the definition of energy poverty does not only include the lack of access to electricity, but also refers to the traditional use of biomass for cooking and the reliance on it, expanding thus its definition [19]. The definition of energy poverty is a complex issue but an important one as well since, based on the chosen definition, the appropriate measurement is going to be developed, that will capture every aspect of the problem.

Table 1. Definitions of energy/fuel poverty.

No	Source	Year	Definition
1	Boardman [20]	1991	“the inability to afford adequate warmth because of the energy inefficiency of the home”
2	Reddy [21]	2000	“the absence of sufficient choice in accessing adequate, affordable, reliable, high-quality, safe, and environmentally benign energy services to support economic and human development”
3	Modi et al. [22]	2006	“the inability to cook with modern cooking fuels and the lack of a bare minimum of electric lighting to read, or for other household and productive activities after sunset”
4	Buzar [23]	2007	“the inability to heat the home up to a socially—and materially—necessitated level”
5	Chakravarty and Tavoni [24]	2013	“lack of access to reliable energy”
6	Bouzarovski et al. [25]	2014	“problems of inadequate access to energy in developing countries, involving a host of economic, infrastructural, social equity, education and health concerns”
7	Bouzarovski and Petrova [26]	2015	“problems of energy deprivation in the home”
8	González-Eguino [10]	2015	“a level of energy consumption that is insufficient to meet certain basic needs”
9	Pye et al. [27]	2015	“the situation where individuals are not able to adequately heat (or provide necessary energy services) in their homes at affordable cost”
10	Scarpellini et al. [28]	2019	“when [a household] cannot afford to purchase enough energy to satisfy domestic needs”

It is observed that all these definitions include the concept of access to energy services and/or adequate heating, which can be considered as the core of energy/fuel poverty, although some of them are more inclusive, since they seem to incorporate additional dimensions of the problem, taking into consideration its complexity. These dimensions include the ability to meet basic or domestic needs (Definitions 8 and 10), achieve certain activities in the household (Definition 3) or support human development (Definition 2). In addition, the issue of affordability is included in a few of these definitions (Definitions 2, 9 and 10), while Definition 2 includes also the issues of quality, reliability, safety and environmental protection. Definition 6 includes several socioeconomic and environmental concerns that are raised due to the problem of energy poverty.

3. Impacts of Energy Poverty

Energy poverty can significantly impact various aspects of everyday life and lead to unmet basic needs [29]. Energy is an important element of everyday life, both at the individual and collective levels, since it can assist in the achievement of meeting basic needs [2]. An adequately warm space and access to electricity can significantly improve standards of living, lead to better health conditions, positively impact education and income, and can even increase job opportunities and improve productivity, thereby creating a positive impact on people's welfare [30]. Studies have shown that energy-poor households are more likely to report problems regarding poor health and emotional well-being [31].

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 to need surgery [32]. In addition, the usage of traditional biomass as the main fuel for cooking and heating, a common situation mainly in least developed countries and rural areas, can also lead to significant health problems, such as respiratory and lung disease, even premature deaths [33]. Indoor air pollution is one of the main causes of morbidity and mortality, and the usage of traditional solid fuels can significantly impact the indoor air's quality [34]. The lack of electricity could also prevent some other basic services, such as water treatment and purification, services that prevent illnesses and protect human health [35] (Table 2).

Table 2. Health impacts of energy poverty.

Health Impacts	Source
Asthma, heart diseases, strokes	Thomson and Snell [32]
Need for hospitalization or surgery	Thomson and Snell [32]
Respiratory and lung disease, premature deaths	Kaygusuz [33]
Morbidity and mortality due to indoor air pollution	Sovacool [34]
Illnesses and health problems due to lack of water treatment and purification	García Ochoa and Graizbord [35]

The economy is also a sector affected by energy poverty. Economic development is significantly affected, especially in poor or developing countries, both in the short run and the long run [36]. All production sectors are affected; in the agricultural sector, which is usually the most important economic sector in poor countries, lower energy inputs equal lower productivity, making it more difficult for poor countries to develop [10]. Energy is an important factor for the eradication of general poverty [37], and its usage is vital for the promotion of the manufacturing sector and the support of new employment opportunities. Energy poverty thus prevents social and economic progress and development of modern societies [38].

Household members' education is also affected by energy poverty. A household that does not have access to electricity cannot provide sufficient light for studying at night, while the absence of electric appliances negatively impacts children's familiarization with ICTs and their learning progress in general. Electricity and improved energy conditions in the household are proven to improve students' educational progress and the quality of their education [39] (Table 3).

Table 3. Socioeconomic impacts of energy poverty.

Socioeconomic Impacts	Source
Affects economic development in the short run and the long run	Amin et al. [36]
Lowers the productivity in the agricultural sector, leading to lower development	González-Eguino [10]
Prevents poverty eradication and socioeconomic progress	Vera et al. [37]; Acharya and Sadath [38]
Produces negative impacts on children's education and learning progress	Kanagawa and Nakata [39]

Energy poverty has also a negative impact on the environment, since the usage of traditional biomass in poor households and its exploitation is often linked to increased levels of deforestation, degradation of the land, and desertification, although there are studies that do not support the existence of this causality [10]. It is, however, supported that with proper government actions and regulations, a transition towards cleaner (renewable) energy sources would not only help to tackle climate change but would also lead to energy poverty mitigation as well [40].

4. Measuring Energy Poverty

The main approaches that are proposed and followed in the literature concerning the measurement of energy poverty, are the expenditure approach and the consensual approach. These approaches have been used in order to evaluate energy poverty conditions in various countries, regions, and income levels. The choice of the approach depends on the author and on how the author defines energy poverty.

4.1. Expenditure Approach

The expenditure approach takes into consideration the household's expenditure on energy, using an expenditure indicator, such as the household's expenditure on energy, its share on income, etc. [12]. This indicator is often compared to a certain critical threshold, and it is assessed whether a household is energy poor or not, depending on whether its expenditure metric is above or below the threshold. Table 4 presents the different kinds of expenditure-based metrics that have been identified by Trinomics [41].

Table 4. Expenditure-based metrics (Identified by [41]).

Metric	Description
High share of energy costs	A household has high energy expenditures
Low available income	After energy costs, little income is left in the household
Insufficient energy spending	A household's energy costs are less than a minimum level of basic and necessary energy services

In addition, different options on the choice of the threshold were also proposed in the literature, although there is a debate regarding which threshold is better to be set and at what level. Table 5 presents the different options of thresholds that can be used for the expenditure-based approach, also as identified by Trinomics [41].

Table 5. Threshold options for the expenditure-based approach (Identified by [41]).

Threshold	Description
10% of income	If a household's energy expenditures are more than 10% of total household income, the household is energy poor.
Above the median share	If a household's energy expenditures are above the national median (as a % of income) and if its income, after energy costs, is below the poverty line, the household is energy poor.
Twice the national median	If a household's energy expenditures are above the national median multiplied by two (as a % of income or in euros), the household is energy poor.
Minimum Income Standard	If a household's income is lower than the minimum income that is necessary for someone's integration in society or if a household's income is lower than the necessary energy and housing costs, the household is energy poor.
No threshold	On a scale of severity of energy expenditure for households with low income, a household with higher levels of expenditure is energy poor, and very low expenditures could indicate hidden energy poverty.

In addition to the choice of the threshold, the expenditure approach requires a decision of whether a household's actual energy expenditures or estimated required expenditures are going to be used for the calculations. While the actual energy expenditure data are much easier to collect, it is possible that they can provide misleading results, since a household's

low expenditures could either mean energy poverty or could simply be a choice of the specific household. This is why the usage of estimated required expenditures is proposed in the current literature.

It is also important to examine whether energy poverty is an issue of certain income groups or a more generalized problem across all income levels, where households are energy poor without being poor in general and vice versa. There are several studies that follow the expenditure-based approach and focus on low income groups in order to evaluate energy poverty [41].

One of the main advantages that come with the usage of the expenditure approach to evaluate energy poverty is that the data required are measurable and objective, making them comparable across time and countries, but the identification of the optimal metric and threshold can be proven a quite sensitive procedure and can lead to different results.

In addition, the expenditure approach mainly takes into consideration pure monetary indicators to assess energy poverty. However, energy poverty is a much more complex concept with a multidimensional nature, and the expenditure approach, which does not cover this plurality, could provide misleading results [42,43]. This is why the development of composite indicators that can capture and imprint more aspects of energy poverty is significantly important, as this can help us to have a better understanding of the issue and design more appropriate policies to successfully eliminate the problem.

4.2. Consensual Approach

In the consensual approach, various measures and metrics are used that can capture the energy situation occurring in a household, such as thermal comfort and adequate warmth, energy affordability, dwelling efficiency, etc. Such metrics can be used as proxies, and they can be combined and evaluated jointly, in order to identify whether a household is energy poor or not. The necessary data used in the consensual approach are collected via surveys; this means that the information provided are subjective assessments that the households perform regarding their energy conditions [41].

Focusing on the European level, the consensual approach is easier to be implemented, due to the European Union Statistics on Income and Living Conditions (EU-SILC). EU-SILC is a project launched in 2003 that provides multidimensional data on issues such as income, poverty, social exclusion and living conditions, comparable over time and place. It is thus feasible to monitor poverty and social inclusion, which are issues included within the Europe 2020 strategy, a European agenda for growth and jobs [44]. Among other indicators, EU-SILC also provides data on the three main indicators proposed in the literature to measure energy poverty (Table 6) [32].

Table 6. Main indicators used for the consensual approach in the EU and reasons of inclusion (Identified by [32]).

Indicator	Reason of Inclusion
Inability to keep home adequately warm	The definitions of energy poverty mainly focus on a household's ability to provide adequate heat
Arrears on utility bills	Arrears on bills may indicate a difficulty to afford basic electricity services
Presence of leak, damp, rot in the dwelling	Such problems may lead to inefficient heating

The main advantage of the consensual approach is that it can capture the multidimensional nature of energy poverty and its wider elements. The subjectivity of the indicators used, however, could lead to false results, a risk that comes with the usage of composite measurements. Thus, it is important that the selection of the indicators that are used in a composite index is carefully made [43]. In addition, the problem of subjectivity could be an issue present in the database as well: since the consensual approach is based on surveys, people might have different understandings on what each indicator (e.g., inadequacy of warmth) means. The different assessment of the peoples' living conditions could

make the comparability much more difficult and is one of the main weaknesses of this approach [41,45].

4.3. Other Approaches

In addition to the two main approaches used to measure energy poverty, a few more have been proposed in the literature. Table 7 presents these approaches, their description, and their weaknesses, as identified by Trinomics [41].

Table 7. Other approaches for measuring energy poverty (Identified by [41]).

Approach	Description	Weaknesses
Temperature-based approach	Internal temperature measurements	Lack of data
Outcome-based approach	Metrics based on outcomes that could be associated with energy poverty	Lack of national statistics and causality problems

It should be noted that it is not an easy task to track changes between energy poverty rates during a specific period of time using either one of the previously mentioned approaches. This is because other factors, such as economic growth, social development, and environmental conditions, can have a significant impact on energy poverty as well [46]. Therefore, it is important to take into consideration and examine all these factors that might have an influence, when evaluating energy poverty and assessing these rates over time.

5. Energy Poverty in the World

The 7th Sustainable Development Goal that the United Nations established in 2015 focuses on the accessibility to affordable and reliable energy for all [11]. Access to electricity and to clean fuels for cooking, as well as energy efficiency are the key factors that need to be ensured everywhere in the world in order to ensure good living conditions for everyone.

In 2018, 89.6% of world’s population had access to electricity, according to the World Bank database while, in 2016, only 59.34% had access to clean fuels and technologies for cooking. More specifically, 100% of population in North America and the European Union had electricity access while in Sub-Saharan Africa, only 47.7% of population had the same access. In addition, high percentages of population had access to clean fuels and technologies for cooking in the EU, North America, Middle East, and North Africa, but Sub-Saharan Africa faces significantly low percentages of access (Figure 1) [47,48].

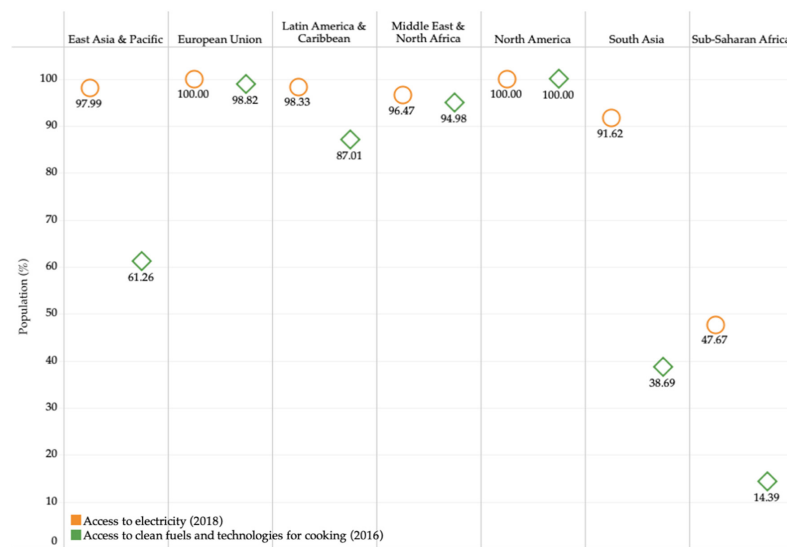


Figure 1. Percentage of population with access to electricity (2018) and to clean fuels and technologies for cooking (2016) in different world regions (Data source: [47,48]).

These data make it obvious that the main focus should be given on the increase of the African electrification rate and on the development of the necessary facilities that can provide access to electricity as well as to cleaner fuels for cooking to more people in the area, thereby improving their living standards, health, and welfare. In addition, improvements on access to clean fuels should be done in South and East Asia, as well as in Latin America.

Currently, a universal approach of a composite measurement to measure energy poverty in the world as a whole, does not exist. Several approaches in the literature focus on different continents, countries, or parts of the world and examine energy poverty, based on the availability of data, by proposing different composite measurements.

5.1. Europe

The evaluation of energy poverty in Europe has been a subject of various studies in the recent literature that focus both on the EU as a whole and on individual countries as well. The European Commission's Member States Reports on Energy Poverty 2019 presented a detailed overview of the energy poverty conditions in EU member states, including each country's performance on certain indicators [49]. In addition, various methods of assessment were presented, including the usage of the EU-SILC indicators, which facilitate the evaluation process.

The countries that are usually identified with the highest energy poverty levels among the EU states are Eastern and Southern European countries, while the lowest levels are observed mainly in Scandinavia. More specifically, Bulgaria, Cyprus, and Romania are the countries that had the worst levels of fuel poverty for 2007, based on Thomson and Snell's research, which used the EU-SILC indicators and provided different scenarios for their evaluation [32]. Thomson and Snell's methodology was also used by Halkos and Gkampoura to assess the impact of economic crisis on energy poverty. The authors found that energy poverty conditions were worsened during the time-period when the impacts of economic crisis were visible, and they found that the studied Balkan countries and especially Bulgaria, suffered from high levels of energy poverty during the years 2004–2019 [50].

The Energy Poverty Multidimensional Index (EPMI), developed by Bollino and Botti [12], also led to similar results regarding the European countries with higher levels of energy poverty. Following a fuzzy set approach, the EMPI focuses on two main dimensions of energy poverty, affordability and efficiency, using EU-SILC data in order to capture the situation occurring in the EU. Central European and Mediterranean countries, such as Greece, Bulgaria, Cyprus, Hungary, Lithuania, Latvia, and Portugal were identified with significant levels of energy poverty for the years 2012 and 2014. Contrariwise, in Scandinavian and northern countries, such as Denmark, Norway and Iceland, low levels of energy poverty were observed.

5.2. Africa

The Multidimensional Energy Poverty Index (MEPI) is a composite index developed by Nussbaumer, Bazilian, and Modi [51] that aims to capture energy poverty, using a set of six indicators that identify several energy deprivations that could possibly affect a person. These indicators cover the dimensions of cooking, lighting, household appliances, entertainment/education, and communication—all of them representing basic needs that require energy to be achieved.

The MEPI was initially used to evaluate energy poverty in selected African countries, for which data were available. Data were selected from the Demographic and Health Surveys, which capture the incidence and the intensity of the problem. The degree of energy poverty for most of the studied countries ranges from moderate energy poverty to acute energy poverty. Ethiopia was the country with the highest MEPI and was characterized with acute energy poverty, while Niger, Rwanda, Burkina Faso, Malawi, Mozambique, and Uganda followed with significantly high levels of MEPI. The country that had the lowest

levels of energy poverty among the studied countries was Egypt, and Morocco also had a notably low MEPI.

These results highlight the urgent need to implement a set of development policies that can reduce these high levels of energy poverty and provide access to electricity for more people in order to improve their living conditions [51].

5.3. Latin America

Energy poverty has also been examined for 7 Latin American countries (Colombia, Dominican Republic, Guatemala, Haiti, Honduras, Mexico, and Peru), based on the evaluation methodology of the Multidimensional Energy Poverty Index. Santillán, Cedano, and Martínez collected data from 2 databases that provided information based on surveys concerning the same five dimensions covered in the MEPI. The estimated results showed that Haiti was the country where the problem of energy poverty was the most intense, while Guatemala and Honduras also suffered from it at a significant level. Among the 7 Latin American countries that were examined, the Dominican Republic and Mexico were the countries least affected by energy poverty, but they still have a severe problem concerning their population's access to energy services. These results indicate that actions need to be undertaken immediately in order to provide access to affordable and reliable energy services and mitigate energy poverty in Latin America [52].

5.4. Asia

An adjusted MEPI was also used to examine energy poverty in 6 countries of South Asia. Afghanistan and Bangladesh were found to be the countries most affected by energy poverty among the studied countries, as India and Nepal followed, while the Maldives and Pakistan were the countries least affected by energy poverty issues, among those six [53]. Focusing on the case of India, it was shown that a significant share of population does not have access to modern energy services, despite the fact that the country has made progress during the past years in reducing energy poverty [38].

China is also an Asian country that has managed to mitigate its total energy poverty levels from the beginning of the century and increase the availability of energy services. The country's economic development led to an improvement in infrastructure and living standards, leading thus to the reduction of high energy poverty. The overall situation in the country is significantly improved, especially in the northern coast and northwest regions, although there are specific regions in the country that still suffer from energy related issues (e.g., middle reaches of Yellow River region) [54].

Despite the improvements that have been achieved in Asia, it is equally important to promote and implement policies and strategies that aim to mitigate even more energy poverty and provide access to basic energy services for as many people as possible.

6. Drivers of Energy Poverty

Energy poverty could be a result of various socioeconomic and environmental factors, while specific household characteristics can also have a significant influence. In the literature, the main factors that could increase the number of energy poor households in a country were identified, and Tables 8–10 present these characteristics that can be viewed as energy poverty drivers.

More specifically, a household's income can be considered as a key driver to energy poverty, since high energy costs, as a share of income, can lead to energy poverty in a household. Additionally, income can determine more household characteristics, such as size, tenure, building quality, etc., which can potentially influence energy poverty [12,41]. In addition, a household's location may influence energy poverty conditions: households in rural areas (based on EU studies) report higher levels of energy poverty. Available fuel sources and/or higher levels of poverty in rural areas might also explain this influence [32].

Table 8. Household characteristics viewed as energy poverty drivers.

Household Characteristics	Source
Household's income	Trinomics [41]; Bollino and Botti [12]
Household's location	Thomson and Snell [32]
Energy inefficient household	European Commission [55]; Thomson and Snell [32]
Number of rooms	Thomson and Snell [32]
Insufficient information	European Commission [55]

Table 9. Socioeconomic factors viewed as energy poverty drivers.

Socioeconomic Factors	Source
Economic and political systems	Bouzarovski et al. [15]; Thomson and Snell [32]
Energy market system	Trinomics [41]
Energy/electricity prices	Halkos and Gkampoura [50]; European Commission [55]; IEA [56]
State of the economy (i.e., economic crisis)	Trinomics [41]; Halkos and Gkampoura [50]

Table 10. Environmental factors viewed as energy poverty drivers.

Environmental Factors	Source
Climate conditions	Trinomics [41]
Climate change	Sumiya [57]

A household that is poorly insulated and has energy losses, uses older equipment and domestic appliances, has inefficient heating system or has damages and leaks, is energy inefficient and is more likely to be energy poor, which shows that a household's energy inefficiency is a potential energy poverty driver [32,55]. A higher number of rooms can have an impact on the household's ability to keep the dwelling adequately warm [32]. In addition, insufficient information is also important, since the lack of access to the necessary information on how to improve energy related issues (e.g., switch energy suppliers, energy saving, subsidies, etc.) could increase energy poverty levels in households [55] (Table 8).

Regarding the socioeconomic factors that can worsen energy poverty conditions, the current economic and political systems can play a key role in energy poverty. Studies have shown that former socialist states in the EU report higher levels of energy poverty, mainly due to their slow restructuring process from their reliance on fossil fuels, state-owned energy enterprises, and inefficient heating systems and stocks in households [15,32]. In addition, the energy market system might have an influence on the problem: the level of liberalization and competition of energy market systems can have a significant impact on energy poverty, since these characteristics can influence products and tariffs of energy services [41].

High energy or electricity prices, which can be affected by movements that occur in commodity markets or by policy decisions, can play a key role in an increase of energy poverty levels [50,55,56]. In addition, the economic state of a country and a potential economic crisis can influence a household's income and have severe consequences in energy poverty due to austerity measures, high energy prices, etc. [41,50] (Table 9).

Several environmental factors may also have an impact on energy poverty. Climate conditions in each area can determine the energy demand for a dwelling's heating and cooling and thus affect energy poverty, although some studies for the EU pointed out that Southern European countries face higher levels of energy poverty, despite their milder climate, due to inefficient housing and heating systems and economic recession [41]. In addition, changes in climatic conditions (climate change) could lead to energy poverty,

since they cause natural disasters, changes in energy needs and energy demand, and changes in energy service prices [57] (Table 10).

7. Tackling Energy Poverty

Energy poverty is a social issue with great influence on people's welfare. It is therefore important to focus on the development of tools and the implementation of policies that aim to eradicate the problem and provide access to modern, affordable, and reliable energy for as many people in the world as possible. In the literature, various actions are suggested that could help address the problem.

Changes made to the living environments and high efficiency standards in buildings is a key to the energy poverty mitigation process. Architects, designers, engineers, and building specialists should focus on the construction of energy-efficient buildings, such as passive houses, etc. [58]. In addition, new technologies such as solar PV or smart technologies (smart grid technology, web-based geospatial information, intelligent communication technologies, etc.) could improve access to electricity and, at the same time, cleaner energy, in developed and developing countries [59,60].

On a wider level, and according to a few studies, energy transition could potentially assist on the process of tackling energy poverty. Renewable energy sources are not only alternative solutions better for the environment, but they could also be used to provide electricity in nonelectrified regions and mitigate energy poverty, especially in developing countries [61].

Actions for tackling energy poverty should be promoted in a national, continental, and universal level through policies and legislations. For instance, the European legislation recognizes energy poverty as a significant problem and promotes the development of national action plans, including social policies and energy efficiency improvements [27]. In addition, financial schemes, such as funding for the implementation of innovative and energy efficient solutions in houses, for research and innovation on energy-related issues, for energy-saving and/or sustainable energy investments, for sustainable and affordable housing for vulnerable populations, etc., have already been or could be developed by countries in order to address and mitigate energy poverty [62] (Table 11).

Table 11. Actions that can help tackle energy poverty.

Action	Source
Changes to the living environments	Ürge-Vorsatz and Herrero [58]
New technologies	Obeng et al. [59]; Oldfield [60]
Energy transition	Bhide and Monroy [61]
Policies and legislation	Pye et al. [27]
Financial schemes	Lakatos and Arsenopoulos [62]

Energy poverty is not a problem easy to eradicate, and its multidimensional nature makes it more difficult to address it efficiently. It is therefore necessary to implement not only one but a series of different actions, that are targeted to certain areas or regions based on their characteristics, in order to eradicate energy poverty. In addition, policy makers should not focus on short-term solutions but on actions that help to effectively address the problem in the long run.

8. Conclusions

Energy is vital for good living conditions and people's welfare, since it is required for the achievement of most of the basic everyday-life activities. However, a significant number of people in the world still face energy-related difficulties: approximately 1.1 billion people did not have access to electricity in 2016, while an also notable number of people cannot

meet the basic energy needs. This problem is referred to as energy poverty and is an issue that concerns researchers and policy makers around the world the last decades.

A universal definition of energy poverty does not yet exist; despite this, several definitions have been given to capture the many dimensions of the problem, while always keeping at its core the issue of energy services access and adequate heating. Many researchers in the current literature have tried not only to define the problem but also to provide measures in order to evaluate it. The tools and measures developed are significantly important, since they provide the necessary knowledge on the topic and assist the development of policies and strategies to mitigate it. The most used approaches of measuring energy poverty in the current literature are based on the expenditure approach and the consensual approach.

Energy poverty can impact various aspects of everyday life: it can cause severe health problems and worsen indoor air, affect education and communication, prevent social and economic progress and development, and have a negative environmental impact. Energy poverty can be driven by specific household characteristics, such as income, location, energy inefficiency, number of rooms and insufficient information, as well as by socioeconomic and environmental factors, such as economic, political and market systems, energy prices, state of the economy and climate conditions and climate change.

A large number of people in the world experience energy-related problems. Even though the overall situation has improved during the last few years, energy poverty is evident in many parts of the world: in African and Latin American countries, in Asia and in Southern Eastern Europe. It is therefore an urgent need to develop plans and strategies in order to mitigate the problem. Such actions include changes to the living environments and the adoption of new technologies, the use of renewable sources, financial schemes, and proper policies and legislations.

It is an urgent need to undertake a set of actions in order to help eradicate the problem of energy poverty in the long run and to achieve the 7th Sustainable Development Goal that the United Nations have set, ensuring access to affordable, reliable, and modern energy for all by 2030. The eradication of energy poverty and the improvement of electricity access and clean fuels access can also contribute to the eradication of poverty in general (1st SDG), it can provide better health and well-being (3rd SDG), improve the household conditions that affect the quality of education (4th SDG), reduce inequalities (10th SDG), promote sustainability of cities and communities (11th SDG), and contribute to the great challenge of tackling climate change (13th SDG).

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