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JUST TRANSITION AS A TOOL FOR ENERGY POVERTY ALLEVIATION IN POST MINING AREAS

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Purpose: The EU is currently facing an energy transition that is a process affecting entire regions and changing many aspects of reality. The European Green Deal assumes that the transition, which in its consequences may cause so-called "territorial stress," should be fair, and that citizens and regions affected by the swap will not be left behind". Energy poverty understood as a situation in which households are unable to access essential energy services and products, is most likely to affect less developed regions – especially coal mining areas in the near future post-mining areas. The goal of this paper is the analysis of adequate energy poverty indicators tailored for post-mining areas- based on the SITRANS project results.
Design/methodology/approach: To begin, the review was performed using both the standard method of critical literature review, web-based literature research and a study of academic multidisciplinary databases such as Scopus and Google Scholar. The next step of the research was the mapping of the literature flow around energy transformation. For this mapping, the methodology of VOS-viewer has been used. The last part of the research was focused on indication analysis of adequate energy poverty indicators tailored for post-mining areas.
Findings: It was shown that one of the most common approaches to defining energy poverty is to precise it as a situation in which households are unable to access essential energy services and products Additionally it was pointed out, that the ambitious goal of the EU is to be climate-neutral by 2050, an economy with net-zero greenhouse gas emissions requires multilevel and multidimensional changes, what it can cause so-called "territorial stress". The transition to a decarbonized economy in the EU-27 is expected to result in the loss of approximately 76,000 jobs in coal mines and plants by 2025; the number is expected to double with more than 154,000 job losses projected by 2030. As such the negative effects of energy transformation can contribute to an increase in the level of energy poverty. The performed review indicated that to make sure that no one in this process would be left behind a Just Transition has been set up. At that point correlation between energy transformation, Just Transition and energy poverty has been indicated. It was indicated that energy transformation will affect less developed regions – especially coal mining areas in the near future post-mining areas. The finding of the paper is the proposal of energy poverty for the post-mining areas.

Practical implications: The outcomes of the project are going to be used in the SITRANS project. The empirical research is to be conducted in coal regions of Western Macedonia in Greece, Silesia, Poland and Stara Zagora, Bulgaria. The results will allow us to estimate the level of energy poverty and as such will be a base for creating Roadmap for Energy Poverty Alleviation.
Originality/value: The paper brings new to the science, as it introduces the energy poverty indicators for post-mining areas.

Keywords: Energy Transformation, Energy Poverty, Energy Poverty Indicators.

Category of the paper: Research paper.

1. Introduction

The EU is currently facing an energy transition that is a process affecting entire regions and changing many aspects of reality. The European Green Deal assumes that the transition, which in its consequences may cause so-called "territorial stress," should be fair, and that citizens and regions affected by the swap will not be left behind. This is one of the main tenets of Just Transition. What needs to be strongly underlined, energy transformation can be highly risky for energy-poor households, who enter the transition at a disadvantage, as from its nature energy poverty affects less developed regions – especially coal mining areas – as well as the most vulnerable in society: unemployed people, low-skilled workers and those aged above 60. Understanding this starting point is critical in ensuring the energy poor are able to participate in a Just Transition and are not subject to further disadvantage. Energy poverty is understood as the lack of an adequate level of domestic energy services, such as space heating and cooling, water heating, lighting, cooking, and use of household appliances. Even access to information and communication technologies is considered essential to guarantee a decent standard of living for the population, and even necessary to realize their full potential. Energy poverty can be observed in many regions of the world. Due to its multidimensional nature, it is not exclusively the domain of poor or developing countries. However, it should be emphasized that if energy poverty is defined as a limitation of choices, this means that those suffering from this type of poverty are *a priori* excluded not only from the ability to meet basic needs such as heating or cooling their homes and cooking at home. Even more disturbingly, they are excluded from other important elements that are essential for individual development. These primarily include health, education, access to information and political participation. Energy poverty can affect home heating or cooling, as well as health, education, access to information and political participation. Energy poverty is a contributing factor to other types of poverty and can be seen as one of the major challenges of the 2st century.

With the transformation towards renewable energy in EU coal, most member states developed energy plans, with a plan for coal-ban. It could create additional energy poverty in the post-mining area. Therefore, it is important to choose the proper indicators or composite indicators which can inform in advance about possible energy poverty problems. Nowadays, there have already been proposed many indicators but not focusing on this area. In the SITRANS project (Life-2021-CET-Coal Regions, available at https://sitrans-project.eu/project/), which takes a meso-level approach to explore various factors influencing the emergence and effectiveness of governance, the positive socio-economic impact, we identify and analyse the changes of poverty connected with decarbonization of the energy system. The SITRANS project addresses two main objectives:

a) the necessity to assess the economic and social consequences of the energy transition at both regional and intra-regional levels,
b) the requirement to develop an efficient governance model for a fair transition that incorporates a location-based approach.

The project encompasses various aspects, including the formulation of new governance policies and structures, and policy development, with a primary focus on aligning local and regional strategies with the clean energy transition and bolstering the fair transition by leveraging support from the Just Transition Mechanism. The main goal of the paper is a baseline review of the energy poverty indicators and a proposal of those indications which will have the best application for the SITRANS project purposes, i.e. post-mining areas.

2. Materials and Methods

To begin, the review was performed using both the standard method of critical literature review, web-based literature research and a study of academic multidisciplinary databases such as Scopus and Google Scholar. The keywords such as “Energy transformation”, “Just Transition”, “Energy Poverty” and “Energy Poverty Indicators”. It was shown that one of the most common approaches to defining energy poverty is to precise it as a situation in which households are unable to access essential energy services and products Additionally it was pointed out, that the ambitious goal of the EU is to be climate-neutral by 2050, an economy with net-zero greenhouse gas emissions requires multilevel and multidimensional changes, what it can cause so-called “territorial stress”. The transition to a decarbonized economy in the EU-27 is expected to result in the loss of approximately 76,000 jobs in coal mines and plants by 2025; the number is expected to double with more than 154,000 job losses projected by 2030. As such the negative effects of energy transformation can contribute to an increase in the level of energy poverty. The performed review indicated, that to make sure, that no one in this process would be left behind a Just Transition has been set up. At that point correlation between energy transformation, Just Transition and energy poverty has been indicated.

The next step of the research was the mapping of the literature flow around energy transformation. For this mapping, the methodology of VOS-viewer has been used. VOS-viewer is a special tool that uses the software for visualizing and constructing bibliometric networks, which include for example journals, researchers, or individual publications, and they can be constructed based on citation, bibliographic coupling, co-citation, or co-authorship relations. To perform the mapping "Energy Poverty Indicator" and "Energy Poverty Indicators" terms were used.

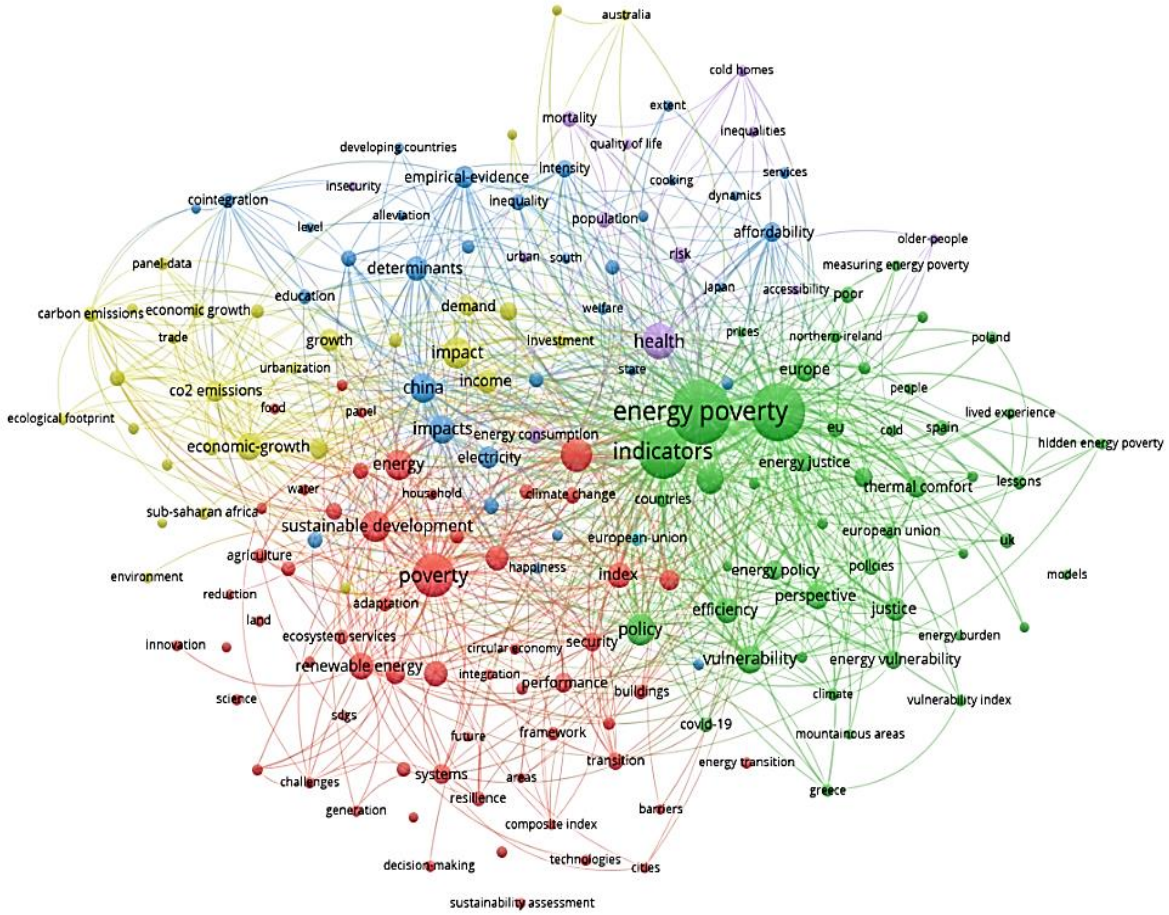

Figure 1. Literature review of the energy poverty indicators.

Source: VOS viewer.

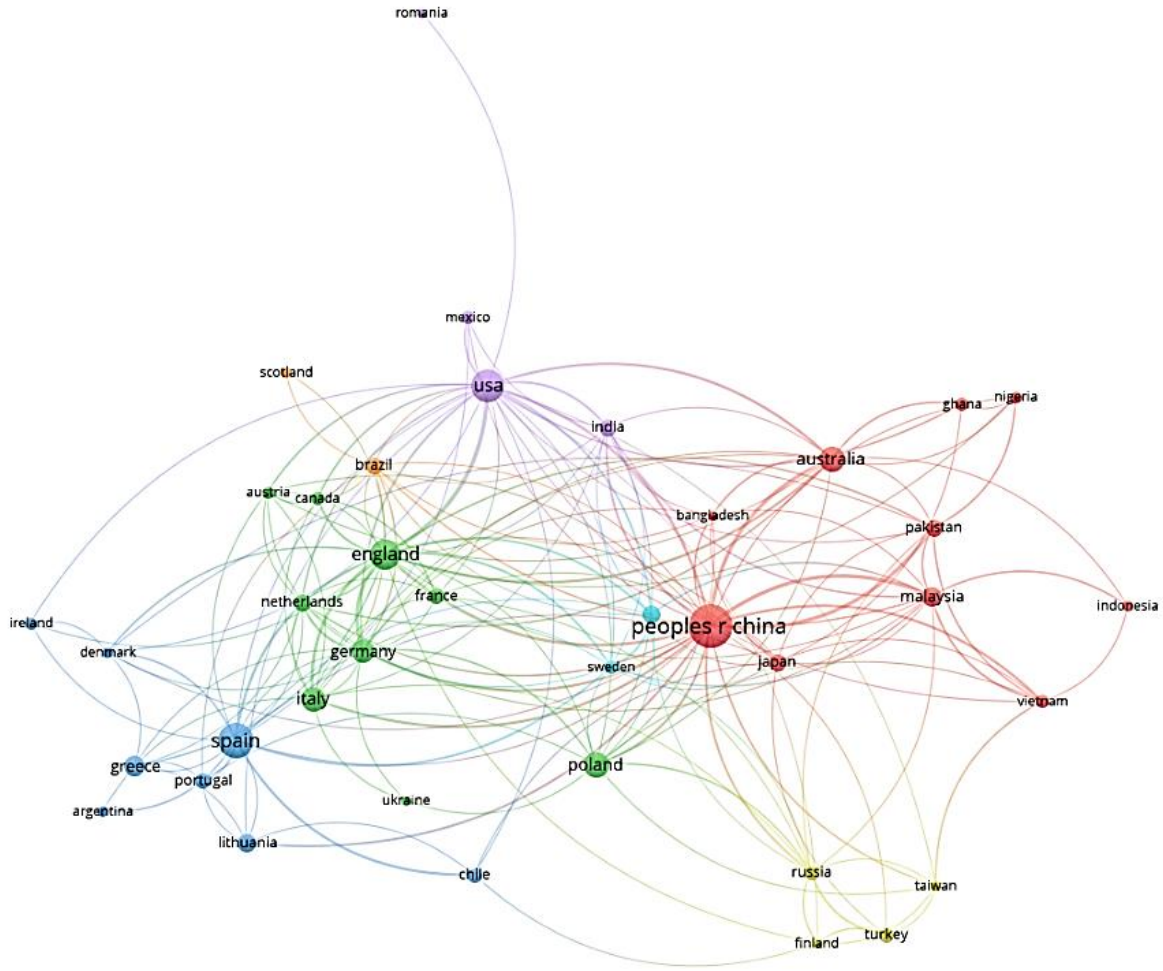

Figure 2. Literature review of the energy poverty indicators by the authors origin.
Source: VOS viewer.

The results of mapping indicated that literature can be structured into three groups adequate to the frequency of term occurrence in the literature. The major flow of literature related to the indicated terms was for articles related to energy justice, energy policy, vulnerability, policy, and efficiency. The next group was related to terms such as poverty, sustainable development, renewable energy, buildings, and households. The last group showed links to such terms as affordability, intensity, electricity, and education. Additionally, a literature review of the energy poverty indicators by the authors of origin has been performed. The VOS-viewer has been used. The last part of the research was focused on indication analysis of adequate energy poverty indicators tailored for post-mining areas.

3. Energy Poverty Literature Review

Schislyaeva and Saychenko indicate that globalization, bilateral trade, and the level of bureaucracy may contribute to energy poverty. The study's potential remedy was that bilateral commerce be evaluated to determine whether conditions of energy demand and supply are met in order to maintain energy pricing in an affordable range, particularly for low-income households in European countries (Schislyaeva, Saychenko, 2022). Stefan Stefan Bouzarovski perceives the main causes of energy poverty in the EU include high energy costs, low household incomes, inefficient structures and equipment, and specific household energy demands (Bouzarovski, 2014). La Paz, Tarrega, ZhenyuSu and Paloma Monllor reveal the unobserved relationships between energy poverty indicators and home characteristics, which are influenced by other factors as household type, poverty, and tenancy of housing (Taltavull et al., 2022). Eisfeld and Seebauer suggested taking self-restriction in energy use into account in addition to the energy poverty combination of high energy costs, low income, and poor housing conditions (Eisfeld, Seebauer, 2022). Middlemiss and Gillard mentioned six challenges to energy vulnerability for the fuel poor: quality of dwelling fabric, energy costs and supply issues, stability of household income, tenancy relations, social relations within the household and outside, and ill health (Middlemiss, Gillard, 2015). According to Karpinska and Smiech energy transition, can create energy poverty by increasing heating cost (Karpinska, Smiech, 2019). Nagaj and Korpysa claims that pandemic COVID-19 had a negative impact on the average disposable income of Polish households, which, with the increase in prices and expenditure on energy carriers, led to an increase in the proportion of disposable income spent on energy carriers (Nagaj, Korpysa, 2019). Aristondo and Onaindia focused on three indicators: *the ability to keep the home adequately warm*, *the arrears on utility bills (electricity, water, gas)* and *the presence of a leaking roof, damp walls or rotten windows* (Aristondo, Onaindia, 2018). Guzmán-Rosas claims energy poverty, and this could be accentuated in subgroups of the indigenous population (Guzmán-Rosas, 2022).Taylor introduced the "10%" indicator (at least 10% of a household's income spent on energy), and various other single indicators sought to combine the key variables of income and energy expenditures (Taylor, 2007). According to Butkiene energy poverty depends on households' individual characteristics e.g., household income, habits, specific energy needs, available technologies, and external conditions e.g., energy prices, climatic conditions, indicators of energy performance of the building (Butkiene, et al., 2021). According to Marz Fuel poverty was broken down into three vulnerability dimensions heating burden, socio-economic and building vulnerability (Marz, 2018). Fabbri claims that fuel poverty depends on family income and energy prices. Building energy performance also influences required energy consumption and is a contributing cause of fuel poverty (Fabbri, 2015). Brunner indicates that there are relevant factors in causing fuel poverty among those, bad housing conditions, outdated appliances, financial problems are prominent

(Brunner et al., 2012). Thomson and Snell points out, fuel poverty in Europe as a result of the influx of many former social states and growing fuel costs (Thomson, Snell, 2013). O'Sullivan shows that deregulated electricity market continues to lead to increases in the real price of residential electricity and in the number of people in fuel poverty (O'Sullivan et al., 2011). Simoesa, concluded that in Southern European countries, due to future climate change the occurrence of heat waves with significant impact on public health will increase and with it most probably the share of potential fuel poor (Simoesa et al., 2016). Heindl and Schuessler includes measures used in practice, such as the low income/high-cost measure and the double median of expenditure share indicator (Heindl, Schuessler, 2015). Berangere and Ricci focused on probability of being fuel vulnerable is higher for those who are retired, living alone, rent their home, use an individual boiler for heating, cook with butane or propane and have poor roof insulation (Berangere, Ricci, 2015). According to Thomson insufficient energy services in households that vary over time and space causes energy poverty, which requires statistical indicators for effective research and policymaking (Thomson et al., 2017). Igawa and Managi indicates that country's economic development level and income inequality, as well as household-level socioeconomic factors, affect households' energy poverty (Igawa, Managi, 2022). According to Njiru and Letema energy poverty has negative impact on indicators of standards of living, caloric intake, life expectancy and literacy levels (Njiru, Letema, 2018). Ogwumike and Ozughalu claims that determinants of energy poverty include household size, educational level, gender and age of household head, general poverty, region of residence and proportion of working members in the household (Ogwumike, Ozughalu, 2015). Riva deals with energy poverty and factors related to household composition, dwelling characteristics, urban/rural location, and province of residence (Riva et al., 2021). Meyer draw on a set of complementary indicators with the aim of grasping the multifaceted nature of energy poverty: excessive energy bills compared to available income (*measured* energy poverty), restriction in energy consumption below basic needs (*hidden* energy poverty) and self-reported difficulties to heat the housing correctly (*perceived* energy poverty) (Meyer et al., 2018). Streimikiene shows that the main social indicators of just low carbon transition were selected to address state of energy poverty, vulnerability and justice in just low carbon transition and include such state indicators as inability to keep home adequately warm; arrears on energy bills, dwellings with leakages and damp walls or rot (Streimikiene et al., 2021). According to Alexandri and Androutsopoulos energy upgrade of existing dwellings, placing emphasis on whether they can constitute an efficient means of dealing with energy poverty (Alexandri, Androutsopoulos, 2019). Charlier and Kahouli claims that under the impulse of economic crises and environmental and energy policies, many households have experienced reductions in real income and higher energy prices (Charlier, Kahouli, 2019).

4. Energy Poverty

In the forthcoming decades, the energy sector will confront three significant transformations related to energy security, climate change, and energy poverty. Various interpretations of energy poverty not only identify different numbers of households at risk but also pinpoint households with distinct characteristics, creating an unclear foundation for both scholarly research and policy development (Brunner, Spitzer, Christanell, 2012). Energy poverty is generally defined in energy studies in two primary ways: the absence of access to electricity and the household's reliance on inefficient and polluting methods to fulfil their energy requirements by burning solid biomass (Bouzarovski, 2014). A household experiences energy poverty when it cannot meet its energy needs. This is manifested through a high percentage of income spent on energy bills, an increased likelihood of electricity cut-offs, and the inability of a household to maintain comfortable indoor temperatures or access desired services such as air conditioning, heating, or computer usage (Boardman,1991). Adequate domestic energy services encompass space heating, cooling, water heating, lighting, cooking, home appliance usage, and even the use of information and communication technology (Aristondo, Onaindia, 2018). These services are deemed essential to ensure a decent standard of living for citizens and are prerequisites for realizing their full potential in their lives. According to the Commission Recommendation (EU) 2020/1563 from October 2020, energy poverty is a situation where households cannot access essential energy services (EU 2020/156, 2020). Energy poverty can be observed in multiple regions worldwide; it is not confined solely to poor or developing countries (Igawa, Managi, 2022). Even in developed, industrialized, and highly electrified European nations, energy poverty challenges may exist. It is crucial to emphasize that if energy poverty is defined as a limitation of choice opportunities, it signifies that those experiencing this type of poverty are inherently excluded not only from meeting basic needs like home heating, cooling, and cooking but also from other vital aspects required for personal development (Charlier, Kahouli, 2019). These encompass health, education, access to information, and engagement in politics. Energy poverty can impact not only a household's ability to heat or cool their home but also their overall well-being, educational prospects, access to information, and participation in political processes (Guzmán-Rosas, 2022). Energy poverty is a contributing factor to other forms of poverty and is considered one of the major challenges of the 21st century. According to the European Economic and Social Committee, in 2022 up to 42 million people in the EU cannot afford to heat their homes adequately (The European Economic and Social Committee, Press Realis, 2023).

As per the United Nations Sustainable Development Goals (SDGs), ensuring access to clean, sustainable, and affordable energy for all is a top priority for governments worldwide (UN, SGD, 2015). This emphasis arises from the intrinsic connection between human development and energy usage: energy is a vital requirement for meeting essential human needs

such as clean air, health, food and water, education, and basic human rights (Njiru, Letema, 2018). Additionally, energy plays a fundamental role in the advancement of every sector of the economy. Energy poverty typically exists in countries where there is insufficient or inconsistent data regarding key economic indicators.

When energy poverty is understood as the inability to access adequate energy services, then the social group who would be especially and most likely experience energy poverty would be all those who are on a low income. On the other hand, people could be energy poor without being income poor. As such social groups that are more likely to experience energy poverty can not only be narrowed to poverty, as in the category of energy poor elderly people living on, they own, family living in single homes, residents of high poverty urban areas, families, living in the countryside, single parents, migrants (Middlemiss, 2022; Carrere, Peralta, 2021).

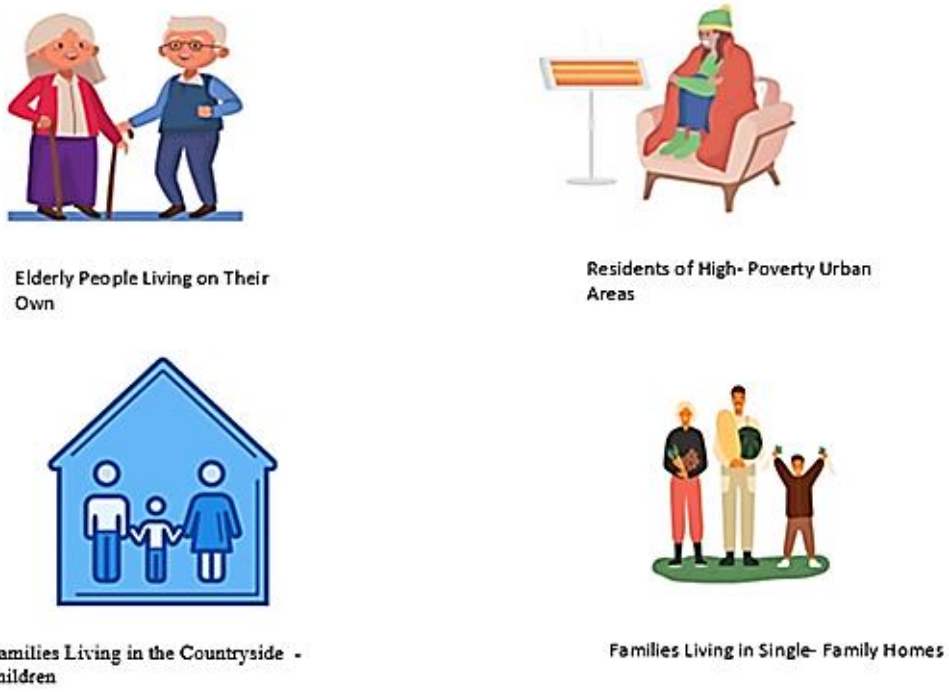

Figure 3. Social groups who suffer energy poverty the most.

Source: Own study.

Energy poverty results in unmet basic needs and depressed economic and educational opportunities that are particularly pervasive among women, children, and minorities (Christian, Casillas, Kammen, 2010). Energy poverty is caused by the interplay of three main factors:

- Low incomes.
- High energy need.
- High energy prices.

Table 1.
Review of energy poverty definitions by international institutions

Institution	Definition of Energy Poverty
The International Energy Agency (IEA, 2007)	a lack of access to modern energy services, including electricity, clean cooking facilities, and forms of mechanical power for productive uses such as agriculture, industry, and transportation
The World Bank	the lack of access to modern energy services, such as electricity, clean cooking facilities, and access to modern fuels, which affects health, education, livelihoods, and overall well-being
European Union (EU, 2020)	energy poverty is a situation in which households are unable to access essential energy services
The United Nations Development Programme (UNDP, 2022)	the inability to access or afford the energy services necessary for a decent standard of living, including access to electricity, clean cooking facilities, and modern fuels for heating and transportation

Source: Own study.

Hence, it can be affirmed that energy poverty constitutes the condition where individuals struggle to fulfil their basic energy requirements within their place of residence at an affordable cost. This encompasses maintaining an adequate level of warmth and supplying various forms of energy to adequately support the fundamental biological and social needs of household members (Laurence, Bart, Middlemiss, Maréchal, 2018). Energy poverty manifests through aspects such as insufficient heating of living spaces, which can lead to the proliferation of harmful microorganisms. Consequently, it increases the risk of respiratory illnesses, allergies (Ballesteros-Arjona, Oliveras et al., 2020) especially in overly damp and mold-infested dwellings), hormonal imbalances, cardiovascular complications, a decline in mental well-being (including stress, anxiety, and mood disorders), and a general weakening of the body's immune system (Polimeni, Simionescu et al., 2022). Notably, energy poverty is intricately intertwined with economic poverty, which is characterized by a lack of access to material goods and resources. In Europe, economic poverty is meticulously examined through various methodologies, encompassing a wide range of quantitative and qualitative approaches. These methods aim to comprehend economic poverty in its multifaceted nature and, importantly, to devise social safety nets and policies to combat it effectively (Hayati, Karami, et al., 2006). Likewise, the issue of energy poverty warrants comparable attention from researchers and policymakers, necessitating thorough investigation and the development of strategies to alleviate its impact.

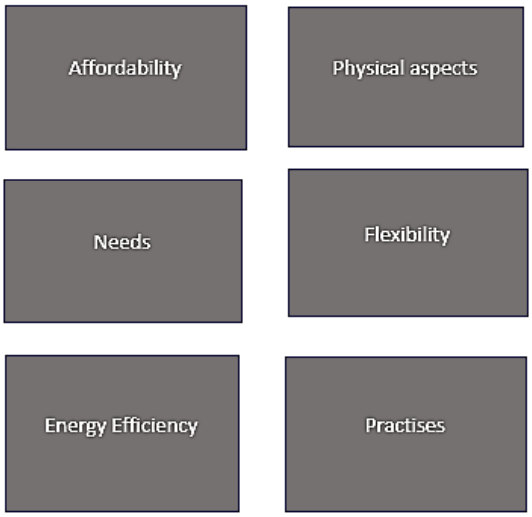

Figure 4. Key challenges to get access to energy.

Source: Own study.

Among the causes of energy poverty (González-Eguino, 2015), there are three types mostly indicated:

- Technical reasons - occur when a residence has a low level of energy efficiency, making it take more effort to maintain an optimal standard of heat. Another reason is the malfunctioning of heating systems, inadequate to heat a given apartment. Greater energy consumption for heating entails greater expenditures and thus depletes a household's disposable resources, which can be used for other purposes (often including basic expenses). Low energy efficiency of buildings and installations can also result in insufficient reheating of the dwelling, so that the optimal standard of heat cannot be maintained. Also, energy inefficient household appliances, e.g.: light bulbs, consumer electronics and household appliances can lead to a marked increase in expenditures from the household budget and thus a reduction in disposable income after paying energy fees (Pachauri, Spreng, 2011).
- Economic causes - occur when there is deprivation of economic resources, which can consequently lead to energy arrears and cutting off energy sources or saving on heating to reduce the cost of energy bills. This group of causes also includes mismanagement of the household budget, which affects the difficulty of covering housing expenses. One can imagine a situation in which a household operates in a building with optimal energy efficiency and with efficient heating and electrical appliances, but due to material deprivation is unable to maintain an optimal standard of heat and cover other necessary energy expenses. This group of causes most closely approximates energy poverty to economic poverty in its characteristics (Sovacool, 2012).

- Causes related to attitudes toward efficient energy use - occur when improper use of appliances leads to significant energy losses and consequently increased energy expenditures beyond what the household can afford. The group of these causes has cognitive, behavioral and emotional dimensions (Nguyen, Ali Nasir, 2021). Examples of such actions include ventilating the apartment while the radiators are turned off, leaving appliances consuming electricity unnecessarily. In this area, the main moderator of behavior is knowledge of the efficient use of heating and electrical appliances or knowledge of investments in higher energy efficiency equipment (energy-saving light bulbs, thermal insulation of buildings, etc.)

Economic poverty and household energy poverty often overlap but are not identical. Therefore, addressing deprivation in one area does not fully resolve the issue in the other. Consequently, efforts to combat household energy poverty cannot rely solely on measures designed to alleviate economic poverty. The challenge of energy poverty is multifaceted, and its resolution cannot be confined to a single sector-specific policy. A comprehensive solution should address the various underlying causes of this problem (Aristondo, Onaindia, 2018). This necessitates an integrated package of measures, including enhancing the energy efficiency of buildings, providing financial support to low-income households to meet their ongoing energy expenses, and equipping them with the knowledge and skills to effectively manage energy usage and consumption within their homes. As a result, the development of a complementary set of public policies targeted at this demographic should be a collaborative effort involving representatives from the relevant ministries responsible for these areas (Middlemiss, Gillard, 2015). This integrated approach is essential to comprehensively tackle the complex issue of energy poverty and ensure that vulnerable households receive the support they need to improve their energy security and overall well-being.

5. Energy Poverty Indicators

The battle against energy poverty must adopt a comprehensive approach that includes ensuring fair access to clean and affordable energy services, leveraging advanced financial tools, and promoting sustainable energy alternatives. Our aim should be to create a future where every individual and household has access to these essential services for their well-being, development, and empowerment by embracing a holistic approach and implementing targeted strategies (Siksnelyte-Butkiene et al., 2021). In Europe, millions of people, particularly low-income individuals and vulnerable groups, grapple with the complex issue of energy poverty (Halkos et al., 2021). The European Union (EU) acknowledges the significance of energy poverty as a policy concern and is actively taking steps to address it through various measures. The lack of accessible energy services not only affects public health but also raises social justice

concerns, as it can lead to higher rates of illness and mortality. One of the primary approaches employed by the EU to tackle this problem is the establishment of energy poverty indicators. The impact of energy poverty on an individual's health, well-being, and overall quality of life can be profound. The challenging task at hand is to explore the numerous indices of energy poverty in Europe and conduct a critical analysis of their interrelationships. Existing literature identifies three primary measurement methods, as highlighted by (Thomson et al., 2017).

Table 2.
Three main methods of energy poverty measurement

Expenditure	where examinations of the energy costs faced by households against absolute or relative thresholds provide a proxy for estimating the extent of domestic energy deprivation
Consensual approach	based on self-reported assessments of indoor housing conditions, and the ability to attain certain necessities relative to the society in which a household resides
Direct measurement	where the level of energy services (such as heating) achieved in the home is compared to a set standard

Source: Thomson et al., 2017.

Several metrics can be utilized to gauge the extent of energy poverty in Europe. An illustrative example is the proportion of household income allocated to energy expenses. Another vital indicator of energy poverty is the energy efficiency of buildings. Buildings consume 40% of the energy consumed in the EU and are responsible for 36% of the region's total greenhouse gas emissions, according to a European Environment Agency report from 2013. Enhancing the energy efficiency of buildings can thus contribute to sustainability and a reduction in energy poverty (Romero et al., 2021). Importantly, these indicators are interconnected, so improvements in one area can have positive ripple effects elsewhere. For instance, boosting a building's energy efficiency can reduce household energy costs, subsequently decreasing the proportion of households experiencing energy poverty. Efforts to combat energy poverty can also align with environmental sustainability. For instance, the promotion of renewable energy sources can lower household energy expenditures while simultaneously aiding the EU in achieving its climate objectives. However, it's crucial to recognize that certain indicators of energy poverty may involve trade-offs. For example, higher energy consumption could potentially undermine energy efficiency if policies aimed at reducing household energy expenses are implemented without due consideration.

Bouzarovski and Simcock argue that it's viable to perceive energy poverty as a matter of social justice intertwined with broader socioeconomic disparities and exclusion (Bouzarovski, Simcock, 2017). They propose that addressing energy poverty necessitates a social approach that takes into consideration the needs and perspectives of the affected communities and stakeholders. A pivotal tactic for mitigating energy poverty and its adverse repercussions is to enhance the energy efficiency of buildings. Contend that increasing building energy efficiency can have multiple benefits, including stimulating local economies, generating employment opportunities, improving building quality, enhancing urban environments, and reducing household energy expenses and consumption (Lee et al., 2019).

Furthermore, apart from the direct reduction in household energy costs, the promotion of renewable energy sources aligns with the EU's efforts to attain its climate objectives (European Commission, 2019; Sovacool, 2018). However, it's essential to acknowledge that there can be trade-offs among different approaches to address energy poverty, and initiatives aimed at lowering household energy expenses may inadvertently lead to increased energy consumption, potentially undermining energy efficiency (Burchell et al., 2016). Hence, it's imperative to implement a comprehensive and well-balanced strategy that considers the various facets of energy poverty and their interdependencies. Combatting energy poverty requires a systematic approach that involves the collaboration and engagement of all stakeholders while considering the socioeconomic and environmental implications of the issue (Sovacool, 2018).

Given the intricate nature of Europe's energy poverty challenge, a multifaceted strategy is essential. By comprehending the diverse indicators of energy poverty and their interconnections, policymakers can craft effective policies that simultaneously address energy poverty and advance sustainability (Baker, 2019). The EU's Energy Poverty Observatory plays a pivotal role in achieving this objective by providing valuable data on energy poverty in Europe and facilitating evidence-based policy development. To tackle the multifaceted issue of energy poverty, cooperation among energy providers, governments, and other stakeholders is imperative (Carley, 2020). By addressing the various dimensions, it becomes possible to enhance the well-being of countless households, reduce greenhouse gas emissions, and promote inclusive and sustainable development both within Europe and beyond.

According to EPOV guidebook they organized and identified secondary indicators:

Primary indicator:

- Energy expenditure ratio.
- Energy affordability.
- Energy intensity.
- Overheating.

Secondary indicator:

- Housing quality.
- Income.
- Vulnerability (age, health status, disability).
- Housing tenure.
- Energy efficiency of Appliances.
- Energy performance of Buildings.
- Fuel type.
- Quality of Fuel.
- Energy debt.
- Energy insecurity.
- Access to energy tariffs.

- Access to energy advice.
- Energy use behaviours.
- Comfort level.
- Outdoor air pollution.
- Indoor air quality.
- Thermal discomfort.
- Social isolation.
- Satisfaction with energy supply.

EPOV provides four different primary indicators for energy poverty, of which two are based on self-reported experiences of limited access to energy services (based on EU-SILC data) and the other two are calculated using household income and/or energy expenditure data (based on HBS data).

Table 3.
Primary energy poverty indicators

Consensual-based indicators – EU-SILC Target variables	Ability to keep home adequately warm (HH050)1 Format of the question: Can your household afford to keep its home adequately warm? Arrears on utility bills (HS021)2 Format of the question: In the past twelve months, has the household been in arrears, i.e., has been unable to pay the utility bills (heating, electricity, gas, water, etc.) of the main dwelling on time due to financial difficulties?
Expenditure-based indicators (long list) – HBS	Absolute (equivalized) energy expenditure below half the national median Share of (equivalized) energy expenditure (compared to equivalized disposable income) above twice the national median

Source: Energy Poverty Observatory, EPOV Indicator Dashboard Methodology Guidebook.

6. Conclusion – energy poverty alleviation in post-mining areas

Energy transition which is based on reducing reliance on coal is crucial, at the same time it's not as simple as substituting a renewable energy source for fossil fuel. Beyond the financial aspects, there are complex challenges facing coal mining areas and power stations. These challenges include potential job losses, economic hardships in mining communities and regions, and the necessity to address employment shifts through retraining and welfare support, as well as identifying new regional economic drivers. The results of transition apart from the financial aspects, there are complex challenges facing coal mining areas and power stations. These challenges include potential job losses, economic hardships in mining communities and regions, and the necessity to address employment shifts through retraining and welfare support, as well as identifying new regional economic drivers – in its consequences may cause so-called "territorial stress". The European Union's efforts to reduce carbon emissions are anticipated to lead to the displacement of around 76,000 jobs in coal mining and power plants by the year 2025. This figure is predicted to double, resulting in more than 154,000 job cuts by 2030.

As coal is phased out, its impact will vary across different regions, emphasizing the importance of ensuring a fair transition, commonly referred to as a 'just transition,' for both workers and communities. Within the EU, coal-related infrastructure spans 108 regions, and it currently supports approximately 237,000 jobs, with the majority (185,000 jobs) being in coal mining. At that point energy poverty is most likely to affect less developed regions – especially coal mining areas in near future post mining areas. The concept of a "Just Transition" has gained global recognition as it encompasses not only the imperative of shifting towards new energy sources but also emphasizes the importance of engaging with and providing support to affected workers and communities during this transition. In this context, there is an argument that sustainability transitions, up to the present day, have not sufficiently considered the wider consequences of these disruptions on local coal-dependent communities and their future employment opportunities.

SITRANS is an EU-funded project which will promote a place-based governance approach and tailor-made transformative policies in areas that are intensely experiencing the phase-out of coal. By assessing the socio-economic impact of the energy transition, SITRANS will develop an effective governance model based on the principle of “leaving no one behind”. The results of these actions will lead to the creation of a Just Energy Transition Observatory (JETO), the aim of which will be to design, host and monitor evaluation models based on predefined indicators and criteria. The main objective of SITRANS is to promote the place-based governance approach and tailor-made transformative policies in areas that are intensely experiencing the phase-out of coal. The project addresses the complex nature of decarbonization in coal regions. To do this, it will consider the socio-economic and environmental factors at play in this process and develop a robust framework to involve residents in decision-making. The aim is a just transition. Such an endeavour requires improved governance at all levels by empowering public and private stakeholders, especially through participative governance models.

SITRANS aims to achieve the following objectives:

- Shift to a low-carbon economy: SITRANS aims to enable people and regions involved in the project to address the shift to a low-carbon economy.
- Economic and social impacts of such a transition: SITRANS aims to align local/regional strategies with the clean energy transition to mitigate social, employment, economic and environmental impacts of the transition.
- Bottom-up and just transition governance approach with local stakeholders and citizens: SITRANS encourages a place-based approach and strong citizen engagement in the governance structure and decision-making processes.
- Building capacity and understanding amongst key stakeholders & citizens: SITRANS invests in building capacity and understanding amongst key stakeholders with a view to fostering a participative decision-making culture at the local/regional level.

- Transition towards an energy-efficient, renewable energy-based economy: SITRANS addresses key pillars of the energy transition: energy efficiency and renewable energy. In regions and localities, they can foster fairer energy, solidarity, and community solutions. They can also help to protect vulnerable consumer groups from energy poverty.
- An inclusive, consumer and community-centered approach: SITRANS works on detailing and tailoring on national energy poverty measures through the National Energy and Climate Plans of each member state.
- Implementing the sustainable energy-related elements of their local and/or regional transition plans: SITRANS brings together evidence-based and place-based policies supported by the regional authorities to accelerate impact investment.
- Combining the support provided by the Just Transition Mechanism and/or other sources of available funding: SITRANS promotes local coordination to support transformative projects which seek to attract private and community-based funding.

The project seeks to support the shift away from coal by helping to ensure a fair distribution of the costs, benefits, and risks among key stakeholders. Ultimately the aim is for society to benefit and to minimize any negative effects of change. The result will be a sustainable development apparatus for improved inclusive and place-based governance at all levels, by empowering the public and private stakeholders and by involving civil society. SITRANS will promote a Just Energy Transition through an inclusive and place-based approach to governance in areas that are intensely experiencing the phase-out of coal. In this respect, the project's outcome is Public and Citizen engagement for Deliberative Democracy & Impact Investing (https://sitrans-project.eu/)**.**

To full fill the ambitious requirements of the project energy poverty indicators for post-mining regions have been designated. Selection of the indicators has been based on data availability on a European level and results in the selection of two energy poverty indicators:

- 1.M/2: Absolute (equivalized) energy expenditure below half the national median.
- 2.2M: Share of (equivalized) energy expenditure (compared to equivalized disposable income) above twice national median.

Additionally, to corelated energy poverty indicators with social indicators, which can influence and are corelated with energy poverty. qualified for these:

- 1.SDG 01-10 People at risk of poverty or social exclusion.
- 2.SDG 08-40 Long-term unemployment rate by sex.

The empirical research is to be conducted in coal regions of Western Macedonia in Greece, Silesia, Poland and Stara Zagora, Bulgaria. The results will allow us to estimate the level of energy poverty and as such will be a base for creating Roadmap for Energy Poverty Alleviation.

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