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Energy transition versus energy poverty in post-mining regions. Case Study Poland, Greece, and Bulgaria

Introduction

A key ambition of the European Union is to achieve climate neutrality by 2050, meaning an economy with net-zero greenhouse gas emissions. This objective is central to the European Green Deal and aligns fully with the EU's dedication to international climate action, as outlined in the Paris Agreement (Paris Agreement 2015). 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,

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there are complex challenges facing coal mining areas and power stations (Boardman 1991). 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 (Karpinska and Śmiech 2021). 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 (Ceglia et al. 2022). At that point, energy poverty is most likely to affect less developed regions – especially coal mining areas in the near future post-mining areas. Energy poverty, inherently connected to its wide-ranging impacts, spans various sectors, including economic, social, health, and environmental realms. Defining energy poverty as a restriction of options means those afflicted are pre-emptively deprived of meeting not only basic needs like home heating, cooling, and cooking, but also of crucial elements vital for personal growth, such as health, education, information access, and political participation. In essence, energy poverty can perpetuate poverty itself (Bouzarovski 2014). Globally, this issue is underscored by the 789 million people without electricity and almost 3 billion lacking cooking facilities, exposing them to harmful health conditions from indoor air pollution (Max Roser 2021). The energy poverty issue is also entwined with climate change since historical reliance on conventional energy sources like coal and oil, while propelling economies, has also imposed significant anthropogenic pressures (Brunner et al. 2012). Additionally, global carbon reduction efforts clash with the energy poor's dilemma of choosing between accessible, cheap, yet environmentally harmful energy sources and forsaking energy access altogether. This presents a worldwide ethical and practical challenge: balancing energy availability with sustainable development. As the European Union navigates through an energy transition under the European Green Deal, it emphasizes that the resultant transformation, which might induce "territorial stress," should be equitable, ensuring that no citizen or region is marginalized in the process. This forms a cornerstone of a just transition. Crucially, it's pivotal to note that the energy transition may pose substantial risks for energy-poor households, especially as energy poverty typically affects underdeveloped regions and vulnerable societal groups (Eisfeld et al. 2022). Recognizing this context is vital to ensure that the energy poor are not further marginalized during a just transition. Addressing energy poverty necessitates a blend of strategies and cooperative efforts on local, national, and global scales, with a focus on renewable energy sources and decentralized energy solutions, like home solar systems and mini-grids, that offer a pathway to electrify distant and isolated areas without requiring expansive grid infrastructure. A comprehensive and multifaceted approach to battling energy poverty is imperative (März 2018). It's vital to craft appropriate international policies and collaborations that are inclusive and consider regional variations, socioeconomic status, and cultural contexts to devise effective interventions. International cooperation should be pivotal in mobilizing resources, sharing knowledge, and transferring technology (Taltavull et al. 2022). Moreover, aligning global

initiatives to tackle energy poverty with frameworks like the UN Sustainable Development Goals, especially Goal 7, which advocates for universal access to affordable, reliable, sustainable, and modern energy, is crucial. The main thesis of the paper is that energy transition may contribute to the deepening phenomenon of energy poverty, especially in post-mining regions. The paper explores energy transition models in Poland, Greece, and Bulgaria. Additionally to identify the potential vulnerable customers in those countries paper analyses data such as; people at risk of poverty or social exclusion and long-term unemployment rate by gender.

1. Methods and methodology

To begin, the baseline 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 key words such as "Energy Transition", "Just Transition", "Energy Poverty" and "Energy Poverty Indicators". It was shown that one of the most common approaches to define energy poverty is to perceive 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,

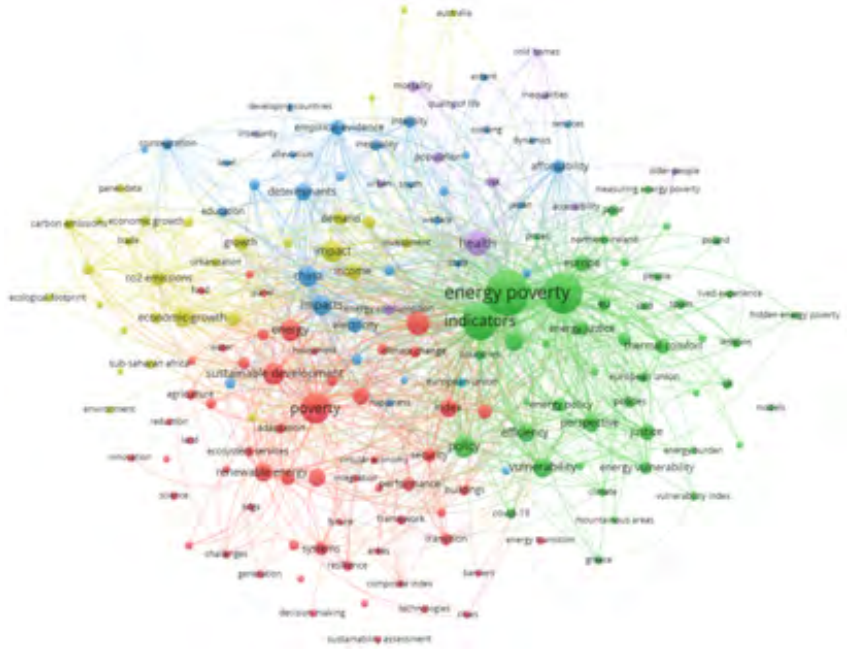

Fig. 1. Literature review of the energy poverty
Source: VOS viewer

Rys. 1. Przegląd literatury dotyczący ubóstwa energetycznego

an economy with net-zero greenhouse gas emissions requires multilevel and multidimensional changes, which can cause so-called "territorial stress". The next step of the research was the mapping of the literature flow around Energy Transition. 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). 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, education. Additionally review the number of scientific publications on energy poverty, just transition and energy poverty in the EU in the years 2013–2023 has been performed (Table 1).

The subsequent section of the research focused on the energy transition models in Poland, Greece, and Bulgaria, for which national strategic documents were reviewed. The regions of Stara Zagora in Bulgaria, Western Macedonia in Greece, and Silesia in Poland

Table 1. Number of publications on energy poverty, just transition and energy poverty in EU in years 2013–2023

Tabela 1. Liczba publikacji dotyczących ubóstwa energetycznego, sprawiedliwej transformacji i ubóstwa energetycznego w EU w latach 2013–2023

Years	Energy Poverty	Just Transition	Energy Poverty in EU
2013–2014	189	702	1
2014–2015	176	690	6
2015–2016	260	801	9
2016–2017	271	773	12
2017–2018	312	816	17
2018–2019	461	871	8
2019–2020	481	999	23
2020–2021	607	1,139	30
2021–2022	735	1,234	49
2022–2023	793	1,184	34
Total	4,279	9,200	188

Source: Web of Science.

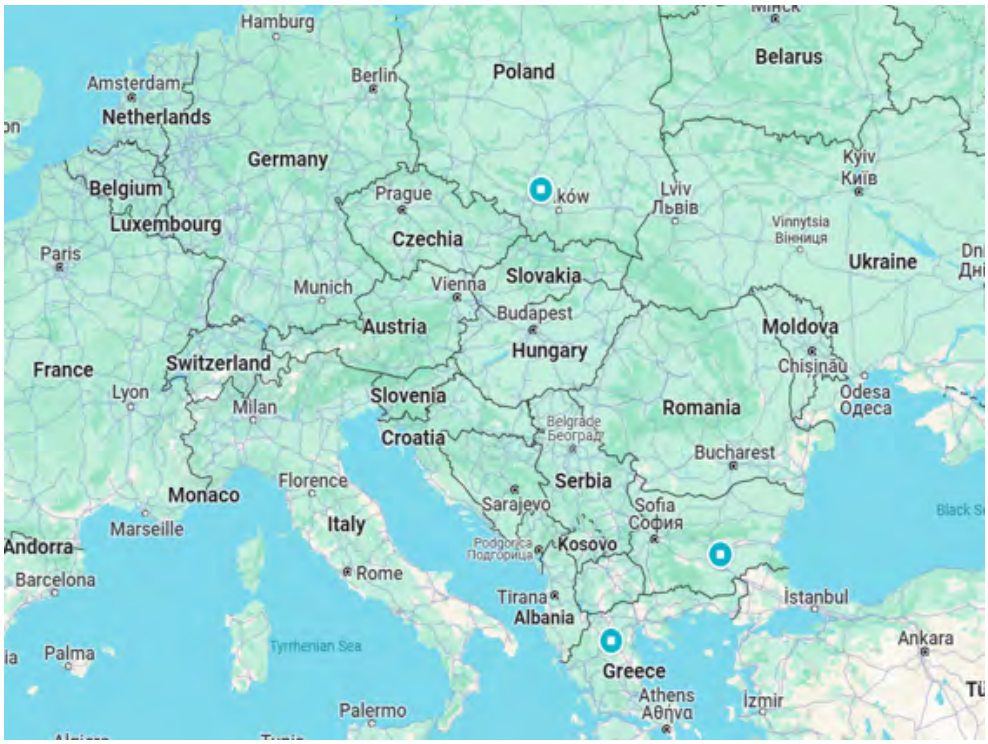

Fig. 2. Map of analysed regions
Source: https://www.google.com/maps

Rys. 2. Mapa analizowanych regionów

were selected based on their post-mining characteristics (Figure 2). The final part of the study concentrated on identifying potentially vulnerable customers in these countries. This involved analysing data on people at risk of poverty or social exclusion and the long-term unemployment rates, differentiated by gender.

2. Energy transition in Poland, Greece and Bulgaria

The energy transition in the European Union (EU) is the shift from reliance on fossil fuels to a greater use of renewable energy sources. This shift is propelled by a blend of policy measures, advancements in technology, and societal demands. The EU aims to achieve a renewable energy share of 32% in its total energy mix by 2030. A critical motivator for this transition in the EU is the urgent requirement to lower greenhouse gas emissions to address climate change. The EU has pledged to cut its emissions to at least 40% below the levels of 1990 by 2030 and aims for a reduction of 80–95% by 2050. Moreover, the EU's energy

transition is also influenced by the need to lessen its reliance on imported fossil fuels, which are often expensive and can lead to political challenges. Boosting the proportion of renewable energy not only mitigates this dependence but also fosters job creation and economic growth.

Poland's journey towards energy transition has been extensive, evolving through various stages. Historically, the mining sector has been and continues to be, a pivotal part of Poland's economy. This sector is notably accountable for a substantial portion of the nation's CO_2 emissions. Poland remains at the forefront in Europe as the leading producer of hard coal and ranks second in brown coal production. The mining industry not only serves as a significant source of employment but also plays a crucial role in the national economy, particularly through its coal-based electricity production. In recent years, Poland has embarked on various legislative measures to advance its energy transition and augment the utilization of renewable energy sources. A key legal instrument in this shift is the 2015 Act on Renewable Energy Sources (OZE). This act introduces numerous incentives to foster renewable energy growth, such as tax breaks, lower grid access fees, and the option to sell surplus energy back to the grid. Poland has also aligned with the European Union's objective to boost the proportion of renewables in its energy portfolio to 15% by 2020 and at least 32% by 2030, as mandated by the Renewable Energy Directive. These commitments are encapsulated in the National Energy and Climate Plan (NECP), which delineates the nation's strategy to achieve these goals and enhance energy efficiency. Further, the Polish government has actively supported the expansion of offshore wind energy, particularly with the enactment of the Offshore Wind Energy Act in 2018. This legislation establishes a regulatory framework for the development of offshore wind projects, including planning, construction, environmental, and safety guidelines. Overall, Poland's legislative endeavours in energy transition aim to bolster renewable energy adoption, improve energy efficiency, and curb greenhouse gas emissions.

In 2018, Poland unveiled its Strategy for the coal sector, outlining its vision until 2030. The following year, the country approved the National Energy and Climate Plan (NECP) for 2021–2030, setting targets for enhanced energy efficiency and decarbonization. Furthermore, in February 2021, Poland introduced the Energy Policy 2040, anticipating a reduced role for coal in energy generation and heating. This policy also highlights initiatives related to Just Transition and efforts to reduce energy poverty. Coal has been the predominant energy source in Poland's power sector. However, the country's significant reliance on imported natural gas and crude oil has made energy security, transformation, and clean air critical elements of Polish energy policy for many years. Additionally, Poland was a net importer of coal last year, further emphasizing the need for a strategic shift in its energy landscape.

The most important documents are as follows:

- 1997 The act of 10 April,
- 1997 The Energy Law (it has been often updated in last years as the consequence of the amendment of other legal in scope adopted primarily due to the need to adjust the Polish legal order to EU law requirements),

- 1990 Foundation of the energy policy of Poland for 1990–2010,
- 1995 Establishment of an energy policy until 2010,
- 2000 Assumptions of Poland's energy policy until 2020,
- 2002 Evaluation of the implementation and correction of the assumptions of energy policy until 2020,
- 2005 Energy policy of Poland until 2025,
- 2009 Energy policy of Poland until 2030,
- 2021 Energy policy of Poland until 2040,
- Principles for the update of the Energy Policy of Poland until 2040 (EPP2040).

Poland's Energy Policy up to 2040 serves as a strategic framework for the country's energy transition, aligning with EU climate policies. This policy acknowledges the magnitude of challenges involved in adapting Poland's national economy to comply with EU regulatory standards, particularly concerning the 2030 climate and energy targets, the European Green Deal, and the economic recovery strategies post-COVID-19 (Energy Policy of Poland until 2040). It also considers Poland's role in achieving climate neutrality, contributing to the objectives set by the Paris Agreement. While this policy has been regularly updated, it has predominantly focused on aspects like energy security, the shift towards Renewable Energy Sources (RES), and minimizing environmental impacts. However, there has been a noted lack of emphasis on social aspects within the policy. This observation underscores the argument that a "Just Transition" approach is necessary, one that incorporates social challenges more prominently into Poland's energy policy framework. Poland is actively working to enhance its renewable energy usage and lessen its reliance on coal. The government has aimed to produce 15% of its energy from renewable sources by 2020 and aims to cut greenhouse gas emissions by 40% by 2030. Developments in this direction include offshore wind farms, biomass power plants, and investments in solar energy. Despite these efforts, coal continues to be Poland's primary energy source, and transitioning away from coal necessitates substantial changes in politics, economy, and infrastructure. Coal has been a major component of Poland's energy landscape, contributing about 80% to the primary energy mix in recent years. The government's ambitious targets to increase renewable energy's share in the energy mix – 15% by 2020 and 20% by 2030 – have faced challenges. Achieving these goals has been difficult due to limited political backing and opposition from the coal sector.

According to the Principles for the update of the Energy Policy of Poland until 2040 (EPP2040), the current international situation is significantly impacting various aspects of energy policy. This necessitates a shift in approach to ensure greater energy security through increased diversification and independence. In light of these considerations, the following modifications to the EPP2040 are proposed:

- increasing technological diversification and extension of capacity based on national resources,
- further development of renewable energy sources,
- improved energy efficiency,
- further diversification of supplies and providing alternatives for hydrocarbons,

- adjustment of investment decisions related to gas production capacity to fuel availability,
- use of coal units,
- implementation of nuclear energy Nuclear energy based primarily on large nuclear reactors,
- grid and energy storage development,
- negotiations on amendments to the EU regulations Poland (EPP2040).

Bulgaria's energy transition is intimately connected to its political and economic development. The country's focus on heavy industry led to a significant increase in energy demand, driving substantial investments in large-scale energy projects. Despite undergoing economic reforms, Bulgaria's energy sector has seen little change. Even after joining the EU in 2007, which necessitated the decommissioning of some of its oldest nuclear power units, Bulgaria continues to rely heavily on fossil fuels. The nation has encountered considerable obstacles in aligning with EU objectives for greenhouse gas emission reductions, compounded by its strong dependency on energy. Bulgaria's energy infrastructure is still predominantly based on coal and nuclear energy, though there has been a recent push towards embracing renewable sources like wind and solar power. To further this transition, the government has implemented various policies and initiatives aimed at enhancing energy efficiency and reducing energy consumption, including the National Program for Energy Efficiency and the National Program for Energy Development. Bulgaria's energy transition is largely shaped by its obligations as a member of the European Union and the directives of the EU's Climate and Energy Package. The primary legal frameworks guiding this transition are the Bulgarian Energy Act and the Renewable Energy Act. These key legislative instruments have been established to support the shift towards more sustainable energy practices. Introduced in 2011, the Renewable Energy Act focuses on encouraging the utilization of renewable energy sources. This act established an ambitious goal for Bulgaria, aiming to generate 16% of its total energy from renewable sources by the year 2020. A significant legislative step in Bulgaria's energy policy is the National Energy Strategy 2020, adopted in 2011. This strategy outlines a comprehensive roadmap for the nation's energy sector, focusing on reducing reliance on imported fossil fuels and enhancing energy efficiency (COMMISSION STAFF WORKING DOCUMENT 2023 Country Report). This initiative represents a key part of Bulgaria's efforts to modernize and make its energy infrastructure more sustainable and self-reliant. Adopted in 2019, the National Energy and Climate Plan (NECP) of Bulgaria serves as a strategic guide for achieving the country's energy and climate objectives, aligning with the European Union's Energy Union goals and the Paris Agreement. The NECP prioritizes several crucial areas:

- Renewable Energy: The plan aims to boost the share of renewable energy in Bulgaria's total energy consumption to 27% by 2030. This goal involves expanding capacities in wind, solar, and other renewable sources, along with endorsing energy efficiency initiatives.

- Energy Efficiency: The NECP underscores the need for enhanced energy efficiency in buildings, industries, and transportation. It seeks to diminish energy usage and promote conservation through various strategies and incentives.
- Decarbonization of the Energy Sector: A key objective is to lower greenhouse gas emissions in the energy sector by transitioning to cleaner and low-carbon energy options. This includes decreasing the reliance on coal for electricity generation and fostering the use of natural gas and renewable energies.
- Sustainable Transport: The plan stresses the development of sustainable, low-emission transport systems. Bulgaria's strategy includes boosting the use of electric vehicles, upgrading public transport, and encouraging alternative transport methods to lessen emissions.
- Innovation and Research: Recognizing the role of innovation and research, the NECP aims to support activities in clean energy technologies and foster collaboration with other EU states, thereby aiding Bulgaria in meeting its energy and climate targets.

In July 2021, Bulgaria's National Recovery and Resilience Plan (RRP) was approved, structured around four fundamental pillars:

- Innovation: Focusing on advancing technological and creative advancements to drive economic growth and modernization.
- Climate Transition and Nature Protection: Prioritizing the shift towards environmentally sustainable practices and the preservation of natural ecosystems.
- Connectivity: Enhancing the infrastructure and networks to improve national and international linkages in various sectors.
- Social Fairness: Concentrating on equitable social policies to ensure that the benefits of economic and technological progress are shared broadly across society.

Bulgaria is dedicated to transforming its energy sector, shifting from a fossil fuel-based mix to one predominantly powered by renewable sources. This commitment includes setting significant goals to lower greenhouse gas emissions, contributing notably to the European Union's collective climate change mitigation efforts. As of 2020, Bulgaria's total installed energy capacity was about 14 GW, with coal-fired power plants accounting for approximately 40% of this. Yet, the Bulgarian government has established an objective to achieve a 27% share of renewable energy in its gross final energy consumption by 2030. This target also envisages a substantial decrease in fossil fuel usage. The National Recovery and Resilience Plan outlines three strategic aims to boost economic growth and demographic recovery, including setting a deadline for coal phase-out by 2038. However, there has been some societal pushback regarding the revision of this deadline and the intermediate goal of reducing emissions by 40% by 2026.

A significant aspect for Greece in aligning with the existing European energy policy is addressing Climate Change. Historically, Climate Change was not a top priority for Greece, primarily because lignite, the country's only domestic fossil fuel, was strategically chosen despite its adverse environmental impacts (International Energy Agency, Greece 2023 Energy Policy Review). However, the present goals of Greece's energy policy, now in line

with those of the EU, are encapsulated in the updated National Energy and Climate Plan (NECP) of December 2019. This document represents Greece's commitment to transitioning towards cleaner energy forms. The main objectives of Greece's national energy planning, aligned with the European Union's energy policy, are comprehensive and multifaceted. They aim to:

- Establish an integrated model of sustainable development across all economic sectors.
- Merge energy sector growth with environmental preservation and implement decisive actions to combat climate change.
- Select energy policies that offer the most favourable cost-benefit ratio for transitioning to renewable energy.
- Implement waste management and utilization using modern circular economy technologies.
- Transform Greece into a pivotal energy hub contributing significantly to the EU's energy security and supply.
- Diversify energy imports while modernizing and developing energy infrastructure, including addressing the energy isolation of islands.
- Create an attractive investment environment that supports energy transition, focusing on innovation and new technologies.
- Maximize the utilization of Community resources and mechanisms.
- Foster extroversion and innovation to drive growth and create new job opportunities.

In 2019, Greece prepared the Long-Term Energy Strategy for 2050 in addition to the National Energy and Climate Plan (NECP). This strategy serves as a roadmap for climate and energy issues, aiming for a climate-neutral economy by 2050. The NECP details the country's energy and climate goals, policy priorities, and implementation measures while exploring the optimal energy system structure and evolution up to 2050. For the period 2030–2040, Greece plans to adopt mature technological solutions and continue successful policies and measures at an intensified pace to meet its 2050 targets. To facilitate decarbonization, the Greek Government enacted several laws, including:

- Law 4759/2020 for modernizing spatial and urban planning.
- Law 4872/2021 for "Just Transition Development" and specific delignification issues.
- Law 4956/2022 establishing a programmatic agreement between the Ministry of Development and Investments, PPC, and METAVASI S.A.
- Establishment of the Monitoring Committee of the "Just Development Transition" 2021–2027.

Greece announced a lignite phase-out by 2028 and aims for climate neutrality by 2050. The NECP for 2030 and the Long-term Strategy to 2050 focus on promoting natural gas and renewables, interconnecting islands to the mainland grid, and decommissioning lignite power units. This transition, particularly reducing lignite mining and power generation, has significant social implications in lignite-producing areas, especially Western Macedonia.

This shift formalizes Greece's move away from lignite-based electricity production, a process that began in the early 2010s with a gradual reduction in lignite activities. Data from the Public Power Corporation (PPC) indicate a yearly decrease of about 10% in costs related to lignite activities in Western Macedonia and Megalopolis from 2011 to 2019.

3. Energy poverty

The concept of energy poverty, which is subject to various interpretations, poses significant challenges in both scholarly research and the development of policies (Thomson et al. 2017). In the field of energy studies, it is typically characterized in two main ways: the absence of electricity access and dependence on inefficient, harmful energy sources like solid biomass combustion (Bouzarovski 2014). A household is considered to be experiencing energy poverty if it struggles to sufficiently fulfill its energy requirements (Meyer et al. 2018). This situation often leads to a large proportion of income being allocated to energy expenses, regular disruptions in electricity supply, and the inability to ensure comfortable temperatures indoors or use essential services such as heating, cooling, or electronic devices (Ogwumike et al. 2016). Essential domestic energy services cover a range of needs such as space heating, cooling, water heating, lighting, cooking, household appliances, and access to information and communication technologies (Sovacool 2012). These services are crucial for maintaining a satisfactory quality of life and enabling individuals to reach their full potential. The Commission Recommendation (EU) 2020/1563, dated October 2020, defines energy poverty as a condition where households are unable to afford necessary energy services (EU 2020/156, 2020). Notably, energy poverty is not exclusive to low-income or developing nations; it also occurs in advanced, highly electrified regions, including Europe (Igawa Managi 2022). This phenomenon leads to unfulfilled basic needs and limits economic and educational opportunities, disproportionately affecting women, children, and minority groups (Charlier Kahouli 2019). Energy poverty arises due to the interaction of three primary factors:

- low incomes,
- high energy need,
- high energy prices.

Energy poverty can be seen as a complex and multifaceted issue that affects millions of people worldwide (Christian et al. 2010) Various definitions and frameworks have been proposed to characterize and understand energy poverty from different perspectives. There are different approaches to defining energy poverty (Table 2) that explores those methods.

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

Table 2. Different approaches to defining energy poverty.

Tabela 2. Zróżnicowane podejścia w definiowaniu ubóstwa energetycznego

Basic Energy Needs Approach	According to this approach, energy, poverty should be perceived in terms of access to basic energy services for essential needs such as cooking, heating, lighting, and access to modern energy sources. Energy poverty is seen as the lack of access to reliable and affordable energy services required for a decent standard of living. This definition emphasizes the importance of meeting basic energy needs to alleviate poverty.
Multi-dimensional Approach	Energy poverty is defined as a multi-dimensional problem that encompasses not only the availability and affordability of energy but also factors like health, education, and social well-being. This approach recognizes that energy poverty is interconnected with other dimensions of poverty and social inequality.
Energy Access Metrics	Some definitions of energy poverty rely on specific metrics, such as the percentage of the population without access to electricity or clean cooking fuels.
Fuel Poverty Approach	Energy poverty is synonymous with "fuel poverty", which is the inability to afford adequate heating or cooling to maintain a comfortable indoor temperature. This definition often considers factors like energy efficiency, household income, and energy prices.
Energy Expenditure Approach	Energy poverty can also be defined in terms of the percentage of a household's income spent on energy-related expenses. High energy costs relative to income can lead to energy poverty, as it may force households to make trade-offs between energy consumption and other essential needs.
Environmental Sustainability Perspective	Energy poverty can be viewed through an environmental lens, highlighting the need for sustainable energy solutions that reduce greenhouse gas emissions and promote cleaner technologies. In this context, energy poverty may be defined as the reliance on dirty or inefficient energy sources.
Cultural and Social Context	Definitions of energy poverty can vary based on cultural and social contexts. What is considered adequate energy access may differ from one community or region to another, considering local customs, traditions, and preferences.
Dynamic Approach	Energy poverty is not static; it can change over time due to factors like economic fluctuations, policy interventions, and technological advancements. Therefore, some definitions of energy poverty consider its dynamic nature and the need for adaptive solutions.

Source: own study.

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). The 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 and Spreng 2011).

- Economic causes occur when there is deprivation of economic resources, which can consequently lead to energy arrears, 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, behavioural, and emotional dimensions (Nguyen and Ali Nasir 2021). Examples of such actions include ventilating the apartment while the radiators are turned off, and leaving appliances consuming electricity unnecessarily. In this area, the main moderator of behaviour 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.).

4. Vulnerable customer

Energy poverty is a significant worldwide problem impacting the lives and well-being of countless individuals (Middlemiss 2022). This issue is marked by a lack of access to consistent, affordable, and clean energy, leading to a myriad of social, economic, and environmental difficulties (Polimeni et al. 2022). Energy poverty, understood as the inability to obtain sufficient energy services, predominantly affects those with lower incomes. Yet, it's crucial to recognize that energy poverty can occur independently of income poverty. The groups most vulnerable to energy poverty extend beyond those in financial hardship to include older individuals living alone, single-parent households, inhabitants of impoverished urban areas, rural families, and migrants (Thomson et al. 2019). In this context, vulnerable customers are those individuals or households particularly prone to the adverse effects of insufficient or expensive energy services, due to factors like low income, age, health issues, or social isolation. As such vulnerable customer is a person who is at risk of experiencing difficulties in securing sufficient energy services without compromising their well-being or spending a disproportionate amount of their income, due to personal characteristics, socioeconomic status, or unforeseen hardships (Halkos Gkampoura 2021). The main factors of vulnerability are; low income, elderly age, physical or mental health challenges, residing in energy-inefficient housing, and more (O'Sullivan et al. 2011). Energy poverty can have an impact on vulnerable customers, such as health, quality of life, and social exclusion (Table 3).

Table 3. Consecuences of energy poverty

Tabela 3. Konsekwencje ubóstwa eneregtycznego

Health	Lack of adequate heating or cooling, especially for elderly individuals or those with health conditions can lead to exacerbated health issues.
Quality of Life	The constant struggle to manage energy expenses can adversely impact overall life quality, causing stress and limiting access to other necessities.
Social Exclusion	Energy poverty can limit participation in social activities or access to educational and work opportunities, further entrenching disadvantage.

Source: own study.

Vulnerable customers can include various groups such as low-income households, elderly individuals, people with disabilities, single-parent households, and those living in substandard housing (Streimikiene et al. 2021). These individuals or groups are more susceptible to the adverse effects of energy poverty. Gaining access to energy encounters numerous challenges across different spectrums, including technological, economic, social, and political factors. Key challenges to get access to energy are: affordability, needs, energy efficiency, physical aspects, flexibility, practises (Figure 3).

Fig. 3. Key challenges to get access to energy
Source: own study

Rys. 3. Kluczowe wyznania związane z ubóstwem energetycznym

5. Identification of potential vulnerable customers

In order to identify potentially vulnerable customers, the following data was analysed:

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

The number of people at risk of poverty or social exclusion from 2010 to 2020 has been diverse. In 2014, 10.1% of what was compared to the rest of the data was deviation. In general, trend indicates decline from 49.2% in 2010 to 32.1% in 2020 (Figure 4).

In the case of the long-term unemployment rate, it declined from 6.3% in 2011 to 2.3% in 2020 (Figure 5).

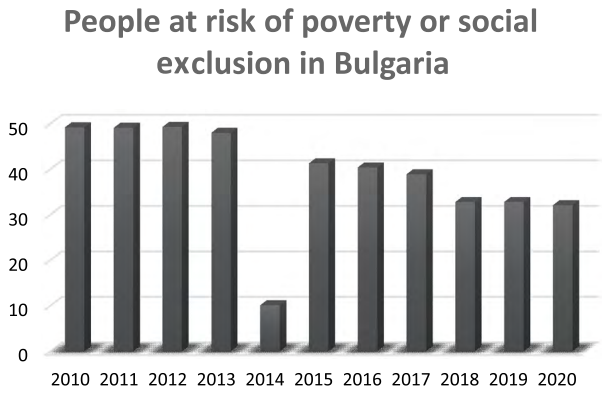

Fig. 4. People at risk of poverty or social exclusion in Bulgaria
Source: Eurostat

Rys. 4. Osoby zagrożone ubóstwem lub wykluczeniem społecznym w Bułgarii

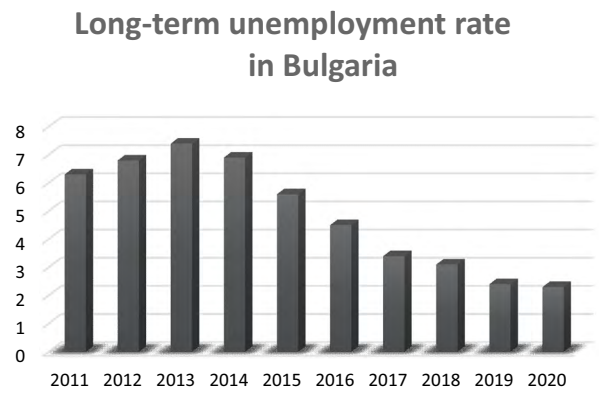

Fig. 5. Long-term unemployment rate in Bulgaria
Source: Eurostat

Rys. 5. Stopa długotrwałego bezrobocia w Bułgarii

The number of people at risk of poverty or social exclusion is divers the lowest percentage was in 2010 – 27.7%, the highest in 2016 – 36%. In 2020 28.8% (Figure 6)

In Greece, long-term unemployment rate by sex was the highest in 2014 – 19.5%, and lowest in 2011 – 8,9%. In 2020 was at 10.9 % (Figure 7).

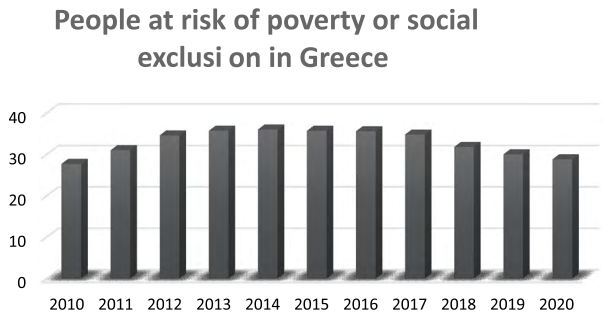

Fig. 6. People at risk of poverty or social exclusion in Greece
Source: Eurostat

Rys. 6. Osoby zagrożone ubóstwem lub wykluczeniem społecznym w Grecji

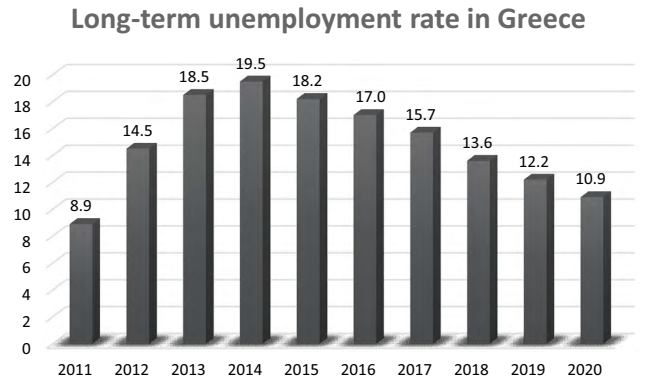

Fig. 7. Long-term unemployment rate in Greece
Source: Eurostat

Rys. 7. Stopa długotrwałego bezrobocia w Grecji

The number of people at risk of poverty or social exclusion in 2010 was 27.8% and in 2020 – 17.3% (Figure 8).

In the case of the long-term unemployment rate, it declined from 3.6% in 2011 to 0.6% in 2020 (Figure 9).

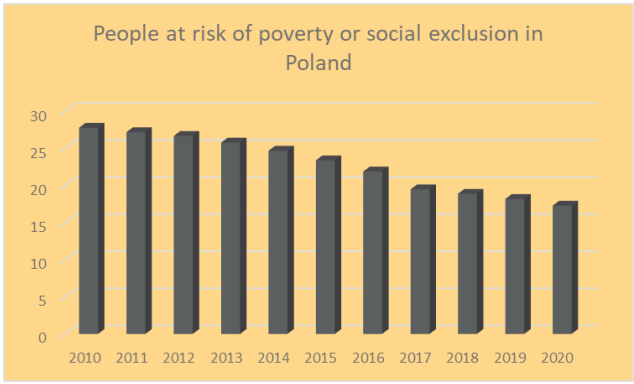

Fig. 8. People at risk of poverty or social exclusion in Poland
Source: Eurostat

Rys. 8. Osoby zagrożone ubóstwem lub wykluczeniem społecznym w Polsce

Fig. 9. Long-term unemployment rate in Poland
Source: Eurostat

Rys. 9. Stopa długotrwałego bezrobocia w Polsce

Conclusions

The research conducted in this paper indicates that energy transition in post-mining regions involves complex socio-economic challenges such as energy poverty while shifting towards sustainable energy sources (Hills 2012; Koirala et. al. 2017; Hargreaves 2018). Each case of the conducted study highlights unique local contexts and responses shaped by historical, political, and economic factors. The analysis of the literature on energy poverty

in post-mining regions underscores the complex interplay of economic, social, and environmental factors contributing to this issue (Walker and Day 2012; Sovacool et.al. 2015; Jenkins et.al 2016). That brings us the to conclusion that effective solutions require an integrated approach, combining regulatory frameworks, market innovations, and community engagement to ensure equitable access to affordable energy for all.

The process of transitioning to new energy sources brings with it various outcomes, especially noticeable in areas with mining activities. This shift will require alterations in job markets, potentially leading to both employment losses and economic challenges in these regions. The concept of "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. The energy transition that awaits us may additionally hit energy-poor households hard, as there is already a significant increase in energy prices.

Table 4. Factors of future energy poverty level corelated with energy transition

Tabela 4. Czynniki przyszłego poziomu ubóstwa energetycznego powiązane z transformacją energetyczną

Policy Framework and Implementation	To be successful, the energy transition should be based on social equity, thus it can help fight energy poverty. This means that policies should be developed at the local, national as well as EU levels to support vulnerable populations, such as subsidies for renewable energy installations in low-income homes or support for energy efficiency measures that reduce overall energy bills.
Social guarantees	For the transformation to be effective, it should provide a social guarantee that translates into job creation: The renewable energy sector can be a source of new jobs, which can help raise the economic status of many households. However, the potential loss of jobs in the fossil fuel industry must be taken into account, and mechanisms for retraining and employment must be provided.
Energy Efficiency	For transformation to contribute to reducing energy poverty, it should decisively increase energy efficiency, which can directly reduce energy bills and thus alleviate energy poverty.
Costs of Renewables	The cost of renewable technologies should fall which could potentially lower energy costs for consumers in the long run. On the other hand, the transition to decentralized renewables may require updates to grid infrastructure. The costs associated with these upgrades may be passed on to consumers, potentially increasing energy prices in the short term.
Initial Investment	Although renewables can have lower ongoing expenses, the upfront costs, such as those for solar panels or home energy improvements, can be challenging for households with limited income. Without financial support or payment plans, this might intensify energy disparities.
Global Market	Changes in global demand and supply for fossil fuels can influence their prices. As certain nations move towards alternative energy sources, this might decrease worldwide demand, possibly leading to lower prices. Such a scenario could temporarily make fossil fuels more financially appealing, complicating the shift away from them.

Source: own study.

In the paper transition models in in Poland, Greece and Bulgaria have been analysed. The main thesis of the paper is that energy transition may contribute to the deepening phenomenon of energy poverty, especially at post-mining regions. To identify the potentially vulnerable customer in those countries paper analyse data such as; people at risk of poverty or social exclusion and long-term unemployment rate by sex.

The research indicated that the relationship between energy transition and energy poverty is complex. To avoid protentionally risks of the increases in the phenomenon of energy poverty in post-mining regions factors should be taken under consideration, social guarantees, energy efficiency, cost of renewables, initial investments, and global market (Table 4).

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ENERGY TRANSITION VERSUS ENERGY POVERTY IN POST-MINING REGIONS. CASE STUDY POLAND, GREECE, AND BULGARIA

Keywords

energy transition, energy poverty, energy poverty indicators, post-mining regions

Abstract

The European Union's primary goal is to attain climate neutrality by 2050, aiming for an economy with zero net greenhouse gas emissions. This objective is a core element of the European Green Deal and aligns seamlessly with the EU's commitment to global climate action as articulated in the Paris Agreement. It is crucial to emphasize that the transition to sustainable energy carries significant risks for households experiencing energy poverty, particularly impacting underdeveloped regions and vulnerable social groups. Acknowledging this context is imperative to prevent further marginalization of the energy poor during a just transition. Effectively addressing energy poverty requires a combination of strategies and collaborative efforts at local, national, and global levels. The focus should be on renewable energy sources and decentralized solutions, such as home solar systems and mini-grids, providing a means to electrify remote and isolated areas without the need for extensive grid infrastructure. The central thesis of this paper posits that the energy transition may exacerbate the issue of energy poverty, particularly in post-mining regions. The study delves into various energy transition models, specifically examining Poland, Greece, and Bulgaria. To identify potentially vulnerable populations in these countries, the paper analyses data related to individuals at risk of poverty or social exclusion, as well as the long-term unemployment rate categorized by gender. Research indicates that potentially vulnerable customers are most likely to be identified in Bulgaria, where 32.1% of the population was at risk of poverty or social exclusion in 2020, and the long-term unemployment rate was 2.3% in the same year. In Greece, 28.8% of the population faced the risk of poverty or social exclusion in 2020, with a long-term unemployment rate of 10.9%. The situation in Poland is relatively better, with 17.3% of the population at risk of poverty or social exclusion in 2020 and a long-term unemployment rate of 0.6%.

TRANSFORMACJA ENERGETYCZNA A UBÓSTWO ENERGETYCZNE W REGIONACH POGÓRNICZYCH. STUDIUM PRZYPADKU POLSKI, GRECJI I BUŁGARII

Słowa kluczowe

transformacja energetyczna, ubóstwo energetyczne,
wskaźniki ubóstwa energetycznego, regiony pogórnicze

Streszczenie

Głównym celem Unii Europejskiej jest osiągnięcie neutralności klimatycznej do 2050 r., co oznacza dążenie do gospodarki o zerowej emisji gazów cieplarnianych netto. Cel ten jest kluczowym elementem Europejskiego Zielonego Ładu i doskonale wpisuje się w zaangażowanie UE w globalne działania na rzecz klimatu, wyrażone w porozumieniu paryskim. Należy podkreślić, że przejście na zrównoważoną energię niesie ze sobą znaczne ryzyko dla gospodarstw domowych doświadczających ubóstwa energetycznego, szczególnie w regionach słabo rozwiniętych i wrażliwych grupach społecznych. Uznanie tego kontekstu jest niezbędne, aby zapobiec dalszej marginalizacji ubogich energetycznie podczas sprawiedliwej transformacji. Skuteczne przeciwdziałanie ubóstwu energetycznemu wymaga połączenia strategii i wspólnych wysiłków na poziomie lokalnym, krajowym i globalnym. Należy skupić się na odnawialnych źródłach energii i zdecentralizowanych rozwiązaniach, takich jak domowe systemy solarne i minisieci, zapewniając środki do elektryfikacji odległych i odizolowanych obszarów bez potrzeby rozbudowanej infrastruktury sieciowej. Teza artykułu zakłada, że transformacja energetyczna może wpłynąć na wzrost ubóstwa energetycznego w regionach pogórniczych. Badania przeprowadzone w artykule koncentrują się na różnych modelach transformacji energetycznej ze szczególnym uwzględnieniem Polski, Grecji i Bułgarii. W celu identyfikacji potencjalnych odbiorców wrażliwych w artykule przeanalizowano dane dotyczące osób zagrożonych ubóstwem lub wykluczeniem społecznym, a także stopę długotrwałego bezrobocia w analizowanych krajach. Badania wskazują, że potencjalni odbiorcy wrażliwi są najczęściej identyfikowani w Bułgarii, gdzie w 2020 roku 32,1% ludności było zagrożonych ubóstwem lub wykluczeniem społecznym, a długotrwała stopa bezrobocia wynosiła 2,3% w tym samym roku. W Grecji w 2020 roku 28,8% ludności było zagrożonych ubóstwem lub wykluczeniem społecznym, a długotrwała stopa bezrobocia wynosiła 10,9%. Sytuacja w Polsce jest stosunkowo lepsza – w 2020 roku 17,3% ludności było zagrożonych ubóstwem lub wykluczeniem społecznym, a długotrwała stopa bezrobocia wynosiła 0,6%.