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OLGA JULITA JANIKOWSKA[1]

Advancing energy transition in Silesian Coal Region: aligning with SDGs 7 and 13

Introduction

Amid escalating economic inequalities, deepening social injustices, and an intensifying migration crisis fuelled by climate change, the transition to sustainable energy systems has become an urgent necessity (UNHCR 2023). The effects of climate change are magnifying a broad spectrum of global challenges: glaciers are melting at unprecedented rates, sea levels are rising, hurricanes and wildfires are becoming more frequent and severe, and extreme heat waves are pushing communities to their limits (Bondaruk 2019). Additionally, accelerated land degradation and widespread deforestation are depleting vital natural resources and disrupting ecosystems essential to global biodiversity and human well-being (Kryszk et al. 2023). These environmental disruptions are not isolated; they have profound ripple effects on society. Climate change exacerbates existing socio-economic vulnerabilities, driving forced migration as communities face the loss of arable land, water shortages, and uninhabitable living conditions (Kuchler 2017). According to the UNHCR,

✉ Corresponding Author: Olga Julita Janikowska; e-mail: olgajan@min-pan.krakow.pl

[1] Mineral and Energy Economy Research Institute, Polish Academy of Sciences, Kraków, Poland; ORCID iD: 0000-0003-2692-7122; e-mail: olgajan@min-pan.krakow.pl

over 21.5 million people annually have been displaced by climate-related disasters since 2008. This growing trend of climate-induced migration poses significant challenges to global governance, resource distribution, and social cohesion (Kumar 2015). The urgency for an energy transformation lies not only in mitigating greenhouse gas emissions but also in addressing the root causes of these cascading crises (Bouzarovski 2014). By shifting toward renewable energy sources, enhancing energy efficiency, and fostering a just transition for affected communities, the world can simultaneously reduce its environmental footprint and create pathways for economic equity, resilience, and sustainable development (Jenkins 2018). Reducing greenhouse gas emissions is critical not only to safeguard current resources and ecosystems but also to ensure a sustainable and prosperous future for generations to come. The International Energy Agency (IEA 2021) emphasizes that the energy transition entails a progressive shift from reliance on fossil fuels such as coal, oil, and natural gas to energy systems dominated by renewable sources, including wind, solar, hydropower, and geothermal energy. This transformation goes beyond a simple switch in energy sources – it involves enhancing energy efficiency, decarbonizing vital sectors like transportation and industry, and integrating advanced clean technologies into energy grids for optimal performance and reliability (Gawlik and Mokrzycki 2019). The energy transition has a dual purpose: mitigating climate change by significantly reducing greenhouse gas emissions and fostering a more sustainable, resilient, and equitable energy system. Among its broader advantages are increased energy security through reduced dependency on non-renewable resources, minimized environmental degradation, and improved quality of life for communities worldwide (EU 2020). For instance, according to the World Resources Institute (WRI 2023), transitioning to renewable energy systems could avoid 70–90% of annual CO_2 emissions from electricity generation by 2050, contributing significantly to global climate goals. Moreover, this transformation requires systemic change, encompassing institutional restructuring, innovative solutions, and phased adaptation to evolving technological, environmental, and economic conditions. (Tsoukas and Chia 2002) underline the importance of continuous adaptation and reorganization to align with dynamic objectives and challenges (IEA2021). For example, investments in energy storage technologies, such as battery systems and hydrogen, play a crucial role in ensuring the reliability of renewable energy grids, while the electrification of transportation is a key step toward decarbonizing urban environments. Adopted on September 25, 2015, by the United Nations General Assembly, the Sustainable Development Goals (SDGs) highlight SDG 7 (Affordable and Clean Energy) and SDG 13 (Climate Action) as central to advancing the global energy transition (United Nations General Assembly 2015). These goals aim to address the interrelated challenges of ensuring universal access to energy, fostering sustainability, and mitigating the far-reaching impacts of climate change (IEA 2021). The energy transition transcends being merely a technological evolution; it represents a profound socio-economic transformation, essential for addressing the complex and interwoven challenges of the 21st century (IPCC2023). The purpose of this article is to examine the interconnections between the energy transition trilemma, SDG 7 (Affordable and Clean Energy), and SDG 13 (Climate Action) within the context of Silesia –

a historically coal-dependent region that is now navigating a complex and transformative energy transition (WRI 2023). As one of Poland's key industrial and mining hubs, Silesia faces unique challenges in balancing economic stability, environmental sustainability, and social equity during its transition (IPCC 2023). This study highlights the region's pivotal role in achieving national and EU climate goals, given that coal still accounts for over 70% of Poland's energy mix (IEA 2023). Moreover, the analysis considers the socio-economic implications for Silesian communities, where energy restructuring must address issues such as job losses in coal industries, the adoption of renewable energy technologies, and the promotion of green employment opportunities (IRENA 2023).

This study presents a case analysis of the Silesian coal region, a historically significant coal mining centre in Europe, and its ongoing transition toward sustainable energy. While energy transitions and their implications have been extensively examined in coal-dependent regions, this research provides novel insights by directly linking the trilemma of Silesia's energy transformation with Sustainable Development Goal (SDG) 7 (Affordable and Clean Energy) and SDG 13 (Climate Action). Although numerous studies explore energy transition frameworks, few explicitly align their findings with the SDG agenda, particularly in regions with deep-rooted coal dependence. By integrating the SDG framework, this study underscores how Silesia's energy transition contributes to global sustainable development objectives, thereby enriching the discourse on balancing decarbonization efforts with economic and social justice considerations. Furthermore, this research advances the existing body of literature by offering a region-specific analysis of Upper Silesia while situating its findings within the broader global sustainable development agenda. Its emphasis on the intersection of SDGs, just transition strategies, financial mechanisms, and policy interventions positions it as a valuable contribution to discussions on the transformation of coal-reliant economies toward clean energy. A key contribution of this study is its focus group research, which has the potential to inform the development of regional policies aimed at mitigating energy poverty.

1. Method and methodology

The research adopts a mixed-methods approach to comprehensively analyze the energy transition in the Silesia region within the context of Sustainable Development Goals (SDG) 7 (Affordable and Clean Energy) and SDG 13 (Climate Action). This approach integrates qualitative and quantitative methods to provide a robust understanding of the region's energy trilemma, its socio-economic challenges, and pathways for achieving a just energy transition. The research design consists of the following key components:

- Desk-based research: extensive literature review and analysis of secondary data sources.
- Focus group studies: structured group discussions with key stakeholders to assess administrative knowledge, data accessibility, and key challenges.

- Case study analysis: Silesia as a focal region for in-depth exploration of energy transition challenges and opportunities.

The study began with a systematic review of existing literature and publicly available data sources, including reports, policy documents, and academic publications. Key databases and materials included:

- International Energy Agency reports on coal reliance and energy transitions;
- European Commission policies, particularly the European Green Deal;
- statistical data: Poland's energy poverty metrics sourced from Statistics Poland and Eurostat;
- relevant publications by the United Nations, World Resources Institute, and World Energy Council.

To address gaps in administrative knowledge and stakeholder collaboration, focus group discussions were conducted with representatives from:

- local government authorities (municipalities and regional offices);
- energy sector stakeholders (utility providers, renewable energy firms);
- non-governmental organizations (NGOs) engaged in energy poverty alleviation;
- community leaders and grassroots organizations.

Focus group objectives:

- assess administrative awareness of energy poverty levels and causes;
- identify data accessibility challenges and interdepartmental cooperation gaps;
- examine current tools, policies, and strategies addressing energy poverty;
- highlight community perceptions and barriers to the energy transition.

The Silesia region was selected as a case study due to its historical dependence on coal mining and industrial activities, its central role in Poland's energy transition, and its EU climate goals. Despite the valuable insights gained, certain limitations of this study highlight potential directions for future research. While focus groups provide rich qualitative data, they do not yield statistically generalizable findings. However, they are instrumental in identifying key themes and perspectives that can inform subsequent quantitative analyses. The main limitations of this method include the small, non-representative sample, which restricts the broader applicability of the findings, the potential for social conformity effects or dominance by more vocal participants, and the necessity of an experienced moderator to ensure a balanced and constructive discussion. Given the exploratory nature of this study, the emphasis was on depth of understanding rather than statistical validation. Nonetheless, the thematic analysis of discussions allowed for the identification of recurring patterns and critical insights. Future research could incorporate survey-based or statistical methods to quantitatively validate these findings on a larger scale. Additionally, broadening the participant selection beyond key stakeholders to include a wider range of affected populations could enhance the study's applicability and its relevance for policy development.

2. Energy trilemma in the context of SDGs 7 and 13 in the Silesia Region

Silesia, located in southern Poland, is a historically significant region known for its rich industrial heritage, particularly in coal mining and heavy industry. As one of Poland's most urbanized and densely populated areas (McCauley 2017), the region has been a cornerstone of the nation's economy, driven by its abundant natural resources, including coal, zinc, and lead (Wójcik and Wójtowicz 2021). The final coal mine in Silesia is set to close by 2049, though coal mining will phase out much earlier in other towns across the region. For decades, mining served as the backbone of the local economy, reshaping villages into industrial hubs driven by the presence of coal operations (Bondaruk 2023). While Silesia is often synonymous with mining and coal extraction, the decline of its coal industry began as early as the 1990s. In 1990, the region boasted 71 operational mines employing nearly 400,000 people (Mazurkiewicz 2019). However, the political transformation in 1989, which marked Poland's shift from a centrally planned economy to a market-oriented system, brought profound challenges to industries that had been the backbone of the socialist economy (IEA2023). The mining sector, heavily reliant on state support, faced significant restructuring pressures as it struggled to adapt to the demands of a competitive market (WRI 2023). Poland's accession to the European Union in 2004 added further impetus for change. Compliance with EU environmental standards and labour regulations necessitated the closure of many mines and the modernization of those that remained operational (Jenkins et al. 2017). Between 2004 and 2020, Poland's coal production capacity decreased by nearly 50%, reflecting these shifts (IEA 2023). Additionally, stricter EU climate policies, such as the Green Deal, placed increasing pressure on coal-dependent regions like Silesia to accelerate their transition toward cleaner energy sources. To address these challenges, eight government restructuring programs were implemented between 1990 and 2012, focusing on reducing overcapacity, improving efficiency, and enhancing profitability (Sovacool et al. 2017). These reforms included significant job cuts and severance packages, with the mining workforce shrinking by more than 70% by 2020 (Górnictwo w Polsce 2023). Alongside workforce reductions, technological upgrades, and the consolidation of smaller mines into larger entities aimed to make the sector more competitive in a rapidly changing energy market. Despite these efforts, the transition has been socially and economically disruptive (IPCC 2023).

The energy transition necessitates a holistic approach, recognizing the intricate interdependencies between social, political, and environmental dimensions, particularly in relation to its long-term consequences. By definition, transformation often entails structural and fundamental change, typically requiring sustained effort and time. This process is seldom immediate, as it is characterized by several inherent attributes:

- Complexity: the transition involves multiple interrelated factors, including technological advancements, societal adaptation, and environmental considerations, necessitating effective coordination among these elements.

- Adaptation: individuals, institutions, and broader societal systems must undergo a period of adjustment to align with new conditions, a process that inherently requires time and flexibility.

The energy transition demands the gradual restructuring of existing systems, institutions, and governance frameworks through successive stages of adaptation, reorganization, and innovation (Topaloglou et al. 2024). This transformation must be tailored to evolving socio-economic and environmental objectives. At its core, the concept of transformation is understood as a fundamental shift within a societal system, encompassing technological advancements, economic restructuring, and social adaptation. The energy transition in Silesia is not solely a technological phenomenon; rather, it represents a profound socio-economic transformation with far-reaching implications for the region's workforce, communities, and cultural identity. For this transition to be both effective and socially acceptable, it must be inclusive, participatory, and responsive to the specific needs of local residents. This entails safeguarding employment opportunities, fostering economic diversification, engaging communities in the decision-making process, and preserving the region's cultural heritage. The future trajectory of Silesia hinges upon the successful integration of traditional industrial foundations with contemporary low-carbon economic models while ensuring sustainable and equitable development. The transition from a coal-dependent economy to one driven by renewable energy sources and low-emission technologies presents both opportunities and challenges (Pepłowska et al. 2024). The closure of coal mines and the contraction of the mining sector raise significant concerns regarding job losses, demographic shifts, and potential regional socio-economic decline. Silesia, a region historically characterized by strong mining traditions, has long relied on coal as the foundation of its economic and social fabric. The phasing out of coal necessitates a comprehensive strategy that mitigates the adverse socio-economic impacts of the transition, ensuring that local communities are adequately supported through reskilling programs, alternative employment opportunities, and targeted social policies. One of the principal challenges of the energy transition lies in the preservation of employment stability for individuals affected by the decline of the coal industry (Kowalik et al. 2024). The implementation of upskilling and reskilling initiatives, alongside strategic investments in emerging economic sectors – such as renewable energy, green technologies, and the digital economy – is imperative to prevent systemic unemployment and its subsequent socio-economic ramifications. The expansion of small and medium-sized enterprises (SMEs), as well as the development of localized entrepreneurial initiatives, will play a critical role in fostering economic resilience and labor market diversification within the region. One of the unintended socio-economic consequences of the energy transition is the risk of energy poverty, particularly affecting low-income households and vulnerable social groups. Energy poverty, defined as the inability to afford adequate energy services, can emerge as a result of rising energy costs, the phasing out of subsidized fossil fuels, and the financial burden of transitioning to renewable energy sources (Hubert et al. 2023).

Several factors contribute to the potential exacerbation of energy poverty during the energy transition:

- Higher energy prices: the shift to renewable energy and the implementation of carbon pricing mechanisms may initially lead to an increase in electricity and heating costs, disproportionately affecting low-income households.
- Lack of access to affordable alternatives: the transition towards sustainable energy systems often requires upfront investments in energy-efficient housing, smart grids, and decentralized energy sources, which may be financially inaccessible to economically disadvantaged communities.
- Disparities in infrastructure modernization: many households in Silesia, particularly in older urban and rural areas, rely on outdated heating systems and poorly insulated buildings, exacerbating the cost burden as energy efficiency standards rise.
- Job loss and economic vulnerability: the decline of coal-related industries can lead to income instability, making it more difficult for affected workers and their families to cope with increasing energy expenses.

The coal industry has played an integral role in shaping Silesia's cultural and social identity. Consequently, the energy transition must not only address economic concerns but also safeguard the region's industrial heritage and cultural continuity. Initiatives aimed at repurposing historical mining sites, promoting industrial tourism, and supporting cultural programs linked to Silesia's mining legacy will be essential in maintaining a sense of historical continuity while facilitating economic transformation. A fundamental tenet of the energy transition is the principle of social justice, ensuring that the benefits of the transformation are equitably distributed across all segments of society. The transition should not exacerbate existing social inequalities; rather, it must be inclusive, participatory, and transparent. This requires the implementation of comprehensive support mechanisms, including European funding programs, national policy interventions, and locally driven initiatives. These mechanisms must be tailored to foster socio-economic resilience, protect vulnerable populations, and promote sustainable regional development.

The trilemma of energy transition refers to the challenge of balancing three key, often competing, objectives during the shift from fossil fuels to sustainable energy systems (Table 1, Figure 1).

Achieving energy security requires a strategic diversification of energy sources, transitioning from a heavy reliance on fossil fuels – often imported – to locally sourced renewable energy. This shift enhances resilience by reducing dependence on fossil fuel-exporting nations, improving energy independence, and mitigating risks associated with geopolitical disruptions (Van de Graaf 2020). Equally important is ensuring system stability, which necessitates the integration of renewable energy sources like wind and solar. To support this transition, advancements in energy storage technologies and the modernization of energy grids are critical to managing variability and ensuring a reliable energy supply (Tol 2023). Environmental sustainability is a cornerstone of the energy transition, emphasizing the urgent need to reduce greenhouse gas emissions, as the energy

Table 1. The trilemma of energy transition

Tabela 1. Trilemat transformacji energetycznej

Energy security	Ensuring a reliable and uninterrupted supply of energy to meet current and future demands. This involves maintaining stable energy systems, reducing dependency on imports, and increasing the resilience of energy infrastructure (WEC 2023).
Environmental sustainability	Reducing greenhouse gas emissions, minimizing the ecological footprint of energy systems, and transitioning to renewable and cleaner energy sources to combat climate change and protect ecosystems.
Economic equity and affordability	Providing energy that is accessible and affordable to all sectors of society, while supporting economic growth and minimizing negative impacts, such as job losses in traditional energy industries or high costs for consumers.

Source: World Energy Council (2019) World Energy Trilemma Index 2019: Balancing energy security, equity, and sustainability. [Online:] https://www.worldenergy.org/publications [Accessed: 2024-11-28].

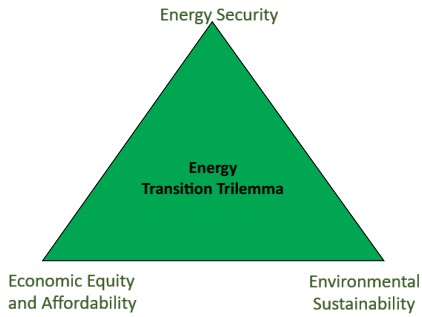

Fig. 1. The trilemma of energy transition
Source: own study

Rys. 1. Trilemat transformacji energetycznej

sector contributes over 70% of global emissions. Shifting to renewable energy sources such as solar, wind, and biomass is essential to meet the objectives of the Paris Agreement. Beyond emission reductions, replacing fossil fuels minimizes environmental degradation by curbing extraction activities and the combustion of harmful resources (Stephens 2018). This shift plays a vital role in safeguarding ecosystems, promoting biodiversity conservation, and reducing the negative impacts of industrial activities on natural habitats (UNECE 2023). From the perspective of social justice and affordability, the energy transition must prioritize equitable access to affordable energy for all, particularly vulnerable populations at risk of energy poverty (IPCC 2023). Ensuring fairness in the transition involves addressing the socio-economic impacts of moving away from traditional industries like mining

(Rutkowski et al. 2018). Worker retraining programs and the creation of new employment opportunities in the renewable energy and green technology sectors are essential to mitigate job losses and support economic stability. Additionally, investments in energy efficiency – such as modernizing residential buildings and adopting energy-saving technologies – are critical to reducing energy consumption and lowering costs for households, particularly in low-income communities (Day et al. 2016).

The energy trilemma poses significant challenges, as it highlights tensions between short-term priorities, such as ensuring supply stability and affordable energy, and long-term objectives, including sustainable development and economic transformation (Cappellano 2024). Addressing these challenges requires a multifaceted approach:

- Technological integration: advancing energy storage technologies and implementing smart grid systems are critical to stabilizing the variability of renewable energy sources (RES). These innovations can enhance energy reliability and efficiency, ultimately contributing to more stable and affordable energy prices (Vakulchuk 2020).

Table 2. The energy trilemma is closely connected to Sustainable Development Goals (SDG) 7 and 13

Tabela 2. Trilemat energetyczny jest ściśle powiązany z Celami Zrównoważonego Rozwoju (SDG) 7 i 13

Energy security and SDG 7	Access to energy: SDG 7 aims to ensure universal access to affordable, reliable, and modern energy by 2030 (IRENA 2023). This aligns with the energy trilemma, which emphasizes energy security by advocating for resilient energy systems capable of meeting demand without disruptions. Transition to renewable energy: both the energy trilemma and SDG 7 stress the importance of transitioning to renewable energy sources. Greater reliance on renewables enhances energy security by reducing dependency on unstable fossil fuel imports. Modern infrastructure: achieving SDG 7 requires investments in infrastructure, such as smart grids and energy storage technologies, which are also critical for balancing the energy trilemma.
Environmental sustainability and SDG 13	Climate change mitigation: SDG 13 prioritizes actions to combat climate change, directly aligning with the trilemma's focus on environmental sustainability. The energy sector accounts for over 70% of global greenhouse gas emissions, making the shift to cleaner energy sources essential for reducing emissions and achieving climate goals (Kuchler et al 2018). Decarbonization of energy systems: transitioning to renewable energy supports SDG 13 by reducing fossil fuel combustion, cutting pollution, and slowing global warming. Ecosystem protection: replacing fossil fuels with renewable energy sources helps conserve biodiversity and minimizes environmental degradation, a shared objective of SDG 13 and the energy trilemma (Rogala and Cieślik 2020).
Social equity and SDGs 7 and 13	Affordability: the energy trilemma underscores the need to maintain affordable energy prices, especially for vulnerable communities. SDG 7 supports this by promoting equitable access to clean and affordable energy solutions. Just transition: both SDG 13 and the energy trilemma highlight the importance of a fair energy transition, ensuring that the shift to clean energy does not disproportionately affect low-income communities or workers in traditional energy sectors. Energy poverty: tackling energy poverty is a shared priority, requiring tailored programs to enable access to energy-efficient technologies and renewable energy solutions, thereby reducing social inequalities.

Source: own study.

- Climate and economic policy: developing comprehensive legislative and financial frameworks is essential to balancing the costs of the energy transition. Such policies should aim to encourage investments in renewable energy and efficiency measures while fostering public acceptance by demonstrating tangible benefits.
- Equitable transition: ensuring a fair energy transition is vital. This includes implementing robust support programs for workers and communities impacted by the shift away from traditional energy industries. Addressing energy poverty must also be a priority, with targeted initiatives to improve energy access and affordability for vulnerable populations (Bouzarovski et al. 2017).

3. Balancing energy trilemma in the context of SDGs 7 and 13 in the Silesia Region in the light of focus study – focus group research

The energy transition in the Silesia region must be understood within a multi-level policy framework that encompasses global, European Union (EU), national, and regional levels. Achieving a just transition requires balancing energy security, sustainability, and affordability in line with Sustainable Development Goals (SDG) 7 and 13. This process necessitates coordinated governance, strategic financial investments, and cross-sectoral collaboration. Addressing energy poverty in the region demands an integrated policy approach that combines financial instruments, regulatory measures, and socio-economic restructuring to mitigate the adverse effects of coal phase-out while ensuring inclusivity (IEA 2022). At the global level, transitioning to a low-carbon and sustainable energy system is essential for meeting the United Nations' SDGs, particularly SDG 7 on affordable and clean energy and SDG 13 on climate action (WEC 2022). Countries striving for decarbonization face the challenge of balancing energy security, affordability, and sustainability, often referred to as the energy trilemma. Achieving this transition requires a multi-sectoral approach that integrates policy reforms, technological advancements, economic transformation, and social inclusion (UNDP 2021). At the supranational level, the European Green Deal (EGD) is the EU's primary strategy for decarbonization, establishing legally binding commitments to achieve climate neutrality by 2050 (EC 2019). This objective necessitates a reduction in coal dependency in historically fossil fuel-reliant regions such as Silesia. The Just Transition Mechanism (JTM) was introduced as a targeted financial and policy instrument to assist coal-dependent regions in mitigating the socio-economic impacts of energy transition. The mechanism consists of three key financial instruments: the Just Transition Fund (JTF), which provides grants for workforce reskilling, economic diversification, and clean energy investments; the InvestEU program, which facilitates private investment in energy efficiency and sustainable projects; and financial support from the European Investment Bank (EIB) for infrastructure modernization and renewable energy deployment. Despite these mechanisms, the effectiveness of EU funding depends on the administrative capacity of regional authorities to allocate resources efficiently and implement energy transition programs.

At the national level, Poland's Polityka Energetyczna Polski 2040 (PEP 2040) serves as a strategic roadmap for progressive decarbonization, energy diversification, and the expansion of renewable energy sources. The strategy emphasizes a gradual reduction in coal dependency for electricity generation, the promotion of nuclear energy and offshore wind as alternative baseload power sources, improvements in energy efficiency across residential and industrial sectors, and the enhancement of regulatory measures to address energy poverty (KEPIK 2023). Poland's draft National Energy and Climate Plan (KPEiK) aligns national priorities with EU climate and energy targets for 2030, balancing energy security, sustainability, and affordability while addressing socio-economic challenges associated with the transition from coal. The KPEiK is structured around five key dimensions: decarbonization through reductions in greenhouse gas (GHG) emissions and increasing the share of renewables in the energy mix; energy efficiency by implementing savings measures across industries, buildings, and transport; energy security through reduced dependence on imported fossil fuels and ensuring a stable energy supply; the development of an integrated internal energy market with strengthened interconnectivity within the EU; and investments in research, innovation, and competitiveness to support technological advancements in clean energy (EC 2020). A key priority of the KPEiK is the expansion of renewable energy sources to reduce coal dependency and enhance energy security. The plan sets a goal of increasing the share of renewables in Poland's electricity generation to at least 32% by 2030, with significant investments in onshore and offshore wind energy, targeting 18 GW of installed offshore wind capacity by 2040; the deployment of over 20 GW of solar photovoltaic capacity by 2030; and the development of biogas and biomass facilities to enhance rural energy security. These initiatives contribute directly to SDG 7.2, which aims to increase the share of renewables in the global energy mix. Despite progress in renewable energy deployment, energy affordability remains a critical challenge, particularly for low-income households in historically coal-dependent regions. The KPEiK proposes several measures to address this issue, including energy efficiency upgrades through retrofitting programs for residential buildings, incorporating heat pumps, insulation, and smart metering to reduce household energy consumption; targeted subsidies and social tariffs to provide financial assistance for vulnerable consumers; and community energy initiatives aimed at strengthening energy cooperatives and promoting decentralized renewable energy generation.

Poland remains one of the most coal-dependent economies in the EU, with coal accounting for over 60% of electricity generation as of 2023. The KPEiK outlines a gradual coal phase-out, aiming to reduce coal-fired power capacity to 30% by 2030. Key measures include accelerating mine closures in unprofitable coal basins, investing in gas-fired power plants as a transitional energy source, with a long-term shift towards green hydrogen and energy storage solutions, and expanding Carbon Capture, Utilization, and Storage (CCUS) technologies to mitigate emissions from industrial sectors. These efforts align with SDG 13.2, which calls for integrating climate measures into national policies. Beyond emissions reduction, the KPEiK prioritizes climate adaptation strategies, recognizing the increasing

frequency of extreme weather events, heatwaves, and water scarcity. Key initiatives include investments in resilient energy infrastructure, such as flood-proof substations and enhanced grid flexibility, the deployment of decentralized energy systems, including microgrids and battery storage to improve climate resilience, and the electrification of transport, with a target of one million electric vehicles (EVs) on Polish roads by 2030. These measures contribute to SDG 13.1, which seeks to strengthen resilience and adaptive capacity to climate-related disasters. Poland's energy transition under the KPEiK is closely integrated with broader EU energy and climate policies, particularly the European Green Deal, which targets climate neutrality by 2050; the EU Fit for 55 Package, which mandates a 55% reduction in GHG emissions by 2030; and the Just Transition Mechanism, which provides financial support to coal-dependent regions such as Silesia to facilitate their transition to sustainable economic activities. At the regional level, Silesia, a historically coal-mining hub, is undergoing structural economic transformation through investments in renewable energy manufacturing, workforce reskilling, and clean technology innovation. These efforts aim to ensure that the transition is both socially inclusive and economically viable, aligning with SDG 7 and SDG 13.

The Just Transition Fund (JTF) plays a pivotal role in supporting the energy transition in the Silesian Coal Region, directly contributing to advancing SDG 7 and SDG 13. This relationship is reflected in multiple dimensions, including financial support for renewable energy, workforce reskilling, economic diversification, and socio-environmental sustainability. The JTF provides financial incentives and grants to facilitate the deployment of renewable energy infrastructure, which is essential for reducing coal dependency and enhancing energy security while ensuring long-term affordability and sustainability. Investments include wind, solar, and biomass projects, enabling the development of large-scale offshore wind farms, photovoltaic installations, and biomass power plants, all of which contribute to increasing the share of renewables in the energy mix. The fund also supports decentralized energy systems, encouraging community-led renewable energy cooperatives to foster localized energy production and reduce reliance on centralized fossil fuel-based power generation. The modernization of energy transmission networks and the integration of battery storage solutions are crucial for stabilizing intermittent renewable energy supply. The JTF provides financing for smart grids and digital infrastructure to optimize energy distribution, improving grid stability while reducing transmission losses. A major barrier to energy transition in Silesia is the region's high employment dependency on coal mining. The JTF addresses these challenges through reskilling initiatives, training coal sector workers for jobs in the renewable energy sector, including solar panel installation, wind turbine maintenance, and energy efficiency auditing. Additionally, JTF-funded institutions offer STEM-based education and technical certification programs to facilitate a smooth labor transition. Investments in clean energy startups, smart manufacturing, and circular economy projects further contribute to alternative employment opportunities. The economic resilience of Silesia depends on diversifying beyond coal-based industries, with the JTF stimulating private investments in renewable energy technology hubs, the

development of wind turbine and photovoltaic panel manufacturing industries, and green hydrogen production. Sustainable industrial parks are being established by repurposing decommissioned coal sites into clean technology innovation zones. These measures ensure a just and inclusive transition, preventing economic stagnation while contributing to SDG 8 on decent work and economic growth and SDG 9 on industry, innovation, and infrastructure.

According to Article 5gb of the Energy Law, energy poverty is defined as a situation in which a household – whether run by a single person or multiple individuals living together in an independent residential unit or single-family house where no business activity is conducted – cannot ensure a sufficient level of heating, cooling, and electricity for powering appliances and lighting (EL 2023). A household is considered to be experiencing energy poverty if it meets all of the following criteria:

1. Low income.
2. High energy-related expenses.
3. Living in a dwelling or building with low energy efficiency.

The report *The Four Faces of Energy Poverty: Polish Households During the 2021–2023 Crisis* by Kamil Lipiński and Adam Juszczak, published by the Polish Economic Institute, analyzes the phenomenon of energy poverty in Poland in the context of the energy crisis caused, among other factors, by rising energy prices and Russia's invasion of Ukraine.

The authors identify four main categories of energy poverty:

1. Fuel (income-based) poverty – affects households where energy costs constitute a significant portion of the budget. In 2022, between 16% and 30% of Polish households experienced this type of energy poverty, depending on the expenditure threshold used.
2. Structural poverty – occurs when high energy costs relative to household income deepen financial hardship. In 2022, between 8% and 12% of households were affected by this issue.
3. Communal poverty – concerns households that cannot meet their basic energy needs due to a lack of adequate infrastructure or living in buildings with low energy efficiency. In 2022, this problem affected between 3% and 5% of households.
4. Hidden energy poverty – involves extreme reductions in energy consumption for financial reasons, leading to a deterioration in living conditions. In 2022, between 13% and 16% of households experienced this type of poverty.

The absence of a unified definition of energy poverty at the European Union level results in significant discrepancies in estimates of its scale. In Poland, depending on the measurement method used, the percentage of households affected by energy poverty in 2022 ranged from 3% to 40%. Moreover, the report indicates that in 2023, 68% of households feared rising energy prices – an 18-percentage-point increase compared to the previous five years (Lipiński Juszczak 2023). Despite protective measures such as programs supporting thermal modernization and the replacement of heating sources, energy poverty in Poland remains a significant social and economic challenge.

The *Healthy Buildings Barometer 2024*, prepared by the Velux Group and the Buildings Performance Institute Europe, highlights that:

- 70% of buildings in Poland have low energy efficiency,
- 15% of buildings are in the worst technical condition,
- up to 40% of households experience energy poverty,
- 1.5 million Poles are unable to ensure adequate thermal comfort.

More extensive data on building energy efficiency is presented in the *National Building Renovation Plan*, developed by the National Energy Conservation Agency S.A., the National Energy Conservation Agency S.A., and the Institute for Reform Foundation. Key findings include:

- Only 2.13% of single-family houses in Poland have a confirmed energy standard.
- One in three apartments in Poland is heated with solid fuels.
- Over 60% of single-family houses in Poland rely solely on solid fuels for heating.
- One in five apartments is in a building without external wall insulation.
- One in four single-family houses remains uninsulated.
- One in three apartments is in a building where the ceiling above the top floor or attic is not insulated.
- The average annual consumption of heating fuels in households is:
  - coal: 3.3 tons,
  - wood: 9 m^3,
  - pellets: 4.1 m^3,
  - gas: 1,261 m^3,
  - district heating: 29 GJ.
- More than 40% of residential buildings have insulation that is only 5–12 cm thick, while only 25% of apartments are in buildings with insulation exceeding 12 cm.
- 41% of surveyed households indicate the need to insulate attics or top floors, and 30% see the need for wall insulation and heating system modernization.
- Nearly 50% of households in uninsulated buildings report problems with insufficiently heated rooms during the heating season (Velux 2024).

The energy transition in Poland is a crucial element in efforts to reduce greenhouse gas emissions and reduce the national economy's dependence on imported fossil fuels. In the context of the European Union's climate policy and global commitments to carbon neutrality, renewable energy sources (RES) play a key role in shaping a modern power system. According to data from the Energy Market Agency (2023), the total installed capacity of renewable energy sources in Poland at the end of 2023 amounted to 28.77 GW, accounting for approximately 30% of the country's total power system capacity (OZE.pl, 2023). Compared to previous years, there has been an intensification of investments in this sector, driven by both increasing environmental awareness and the implementation of support mechanisms such as the auction system and guaranteed tariffs. The dominant technologies in the Polish renewable energy sector remain photovoltaic (PV) and wind energy.

Photovoltaics (PV):

The dynamic growth of solar energy in Poland is primarily due to the increasing number of prosumer micro-installations and large-scale solar farms. According to the Institute of Renewable Energy (2024), the total installed capacity in this technology reached 17.08 GW, representing nearly 59% of total RES capacity (IEO, 2024). This growth has been facilitated by the availability of government subsidies through programs such as *Mój Prąd* ("My Electricity") and *Czyste Powietrze* ("Clean Air").

Wind energy:

Wind power plays a significant role in Poland's energy mix, although its development has been hindered in recent years by restrictive regulations regarding turbine location. According to a report from *Rynek Elektryczny* (2025), the total installed capacity of onshore wind farms reached 9.43 GW (Rynek Elektryczny 2025). In the long-term perspective, the development of offshore wind energy could be of particular importance, with Poland's Baltic Sea offshore potential estimated at approximately 11 GW by 2040.

The expansion of the RES sector in Poland has significant economic implications at both the macroeconomic level and in relation to specific industrial sectors.

- Energy security and economic independence: the increasing share of renewable energy sources in the national energy mix reduces Poland's reliance on energy imports, particularly coal and natural gas. As noted by the Ministry of Climate and Environment (2024), investments in RES serve as an economic stimulus, boosting the competitiveness of the Polish economy within the European market (MKŚ 2024).
- Job creation: the growth of renewable energy investments has led to an increased demand for highly skilled labor in low-emission technology sectors. Estimates from *Wysokie Napięcie* (2023) suggest that the number of jobs related to the RES sector has increased by 25% in recent years, contributing to the development of the national labor market (Wysokie Napięcie 2023).

Despite its numerous benefits, the further expansion of renewable energy sources in Poland faces significant challenges. The most critical issues include:

- Grid infrastructure limitations: in April 2024, due to an oversupply of electricity, it was necessary to temporarily shut down wind farms with a total capacity of 1.9 GW. This issue highlights the limited flexibility of Poland's power system and the urgent need for investments in grid infrastructure and energy storage technologies.

Regulatory barriers:

Regulations introduced in 2016 regarding the minimum distance of wind turbines from residential areas have significantly constrained wind energy development. To accelerate the energy transition, legislative changes are needed to enable the implementation of new projects in alignment with sustainable development principles. The development of renewable energy sources in Poland is a key component of the country's energy and economic transition. The increase in installed RES capacity brings numerous benefits, including enhanced energy

security, improved economic competitiveness, and reduced greenhouse gas emissions. However, further expansion of this sector requires addressing infrastructure challenges, regulatory obstacles, and the integration of RES into the national power system.

To balance the energy trilemma in the context of SDGs 7 and 13 in the Silesia Region, it is crucial to implement a policy on energy poverty alleviation, as it disproportionately affects low-income households, limiting access to affordable and reliable energy, while facilitating the clean energy transition through energy efficiency, renewable energy access, and job creation, addressing structural inefficiencies, reducing fossil fuel dependence, accelerating decarbonization, and ensuring environmental justice, all of which are essential to overcoming regional economic and environmental challenges and achieving energy security, sustainability, and affordability.

To support research on combating energy poverty in the Silesia region, a focus group study was conducted. Focus groups are a robust qualitative research method in social sciences, facilitating an in-depth exploration of complex perspectives, interactive discourse, and the socio-cultural meanings underlying behaviours and opinions. This method is particularly valuable in policy development, as it enables the systematic collection of public opinions on various policy issues and social challenges. The focus group approach involves a structured yet flexible discussion, moderated to examine participants' attitudes, beliefs, and behavioral patterns in a dynamic and interactive setting. The insights generated through this method contribute to a more nuanced understanding of public perceptions and social phenomena (Hennink et al. 2011). A fundamental characteristic of focus groups is that they do not seek to achieve consensus among participants. Instead, they are designed to elicit a diversity of viewpoints, fostering a deeper understanding of individual and collective attitudes, behaviours, and perspectives on the subject matter. The interactive nature of focus groups encourages participants to engage with alternative perspectives and articulate thoughts that might not surface in one-on-one interviews. Furthermore, the group dynamic provides valuable observational data that enriches qualitative analysis, offering a more holistic understanding of the studied phenomenon.

The preparation for the focus group study encompassed:

- Desk research, which included a comprehensive review of strategic policy documents, research reports, and relevant academic literature.
- Stakeholder mapping, identifying key policymakers, stakeholders, and representatives from civil society organizations engaged in energy poverty discourse.

The study engaged six participants, selected through stakeholder mapping, representing a diverse spectrum of expertise and institutional affiliations. The participants included high- and mid-level administrative officials, academic researchers specializing in energy poverty, and a trade union representative from the Silesia region. The focus group discussion was conducted online via the Webex platform and was systematically recorded for subsequent analysis.

The primary objectives of the study were to assess:

- the level of administrative knowledge regarding the scale of energy poverty at local, regional, and national levels,

- interdepartmental cooperation in measuring energy poverty,
- primary sources of information on energy poverty,
- the most representative indicators of energy poverty in the silesia region, and
- tools and strategies to alleviate energy poverty.

This methodological approach provides a rigorous framework for examining the socio-economic and policy dimensions of energy poverty, offering insights that can inform targeted policy interventions and interdisciplinary cooperation. The findings contribute to the broader discourse on energy justice and the equitable distribution of energy resources within the region.

1. Administrative knowledge on energy poverty in Silesia

The research revealed fragmented knowledge about energy poverty at the administrative level. Although data on general poverty is collected at the regional level, the lack of thorough analysis and coordination inhibits comprehensive solutions. The participants emphasized insufficient collaboration between research centers and administrative bodies, which limits the practical application of findings from scientific studies.

Recommendation:

- Define and enhance administrative expertise for assessing energy poverty.
- Identify specific administrative units responsible for addressing energy poverty.
- Establish dedicated administrative bodies and implement a training system to increase awareness and understanding of energy poverty at the local level.

2. Accessibility and transparency of energy poverty data

The study highlighted significant gaps in data availability and transparency. A lack of standardized methods for collecting and sharing energy poverty data, particularly regarding sensitive indicators such as income, emerged as a key issue.

Recommendation:

- Introduce legislation to improve data collection and ensure interdepartmental cooperation.
- Establish a national-level administrative unit to coordinate data collection efforts across regions, creating a comprehensive and accessible database.

3. Interdepartmental cooperation in energy poverty measurements

Participants noted fragmentation and limited interdepartmental communication regarding energy poverty measurements. This lack of coordination impedes the flow of critical information and the development of unified strategies.

Recommendation:

- Create enduring interdepartmental cooperation mechanisms to facilitate data exchange and analysis.
- Establish coordinating units at both local and national levels to harmonize energy poverty measurements and enhance public awareness, citizen training, and the energy transition process.

4. Main sources of information on energy poverty

Statistics Poland was identified as the primary source of energy poverty data, supplemented by Eurostat and ministry websites. However, the data collection system was perceived as unclear and fragmented.

Recommendation:

- Develop a holistic and transparent system for measuring energy poverty, integrating diverse data sources.
- Ensure a comprehensive understanding of energy poverty to guide effective, evidence-based policies.

5. Representative energy poverty indicators

The most commonly cited indicator was the low-income, high-cost measure. Other key indicators included a household's ability to maintain adequate heating in winter and cooling in summer, housing quality, and energy efficiency.

Recommendation:

- Conduct further research to develop tailored energy poverty metrics specific to Silesia's socioeconomic and environmental context.
- Engage local experts, NGOs, and administrative personnel in defining these indicators to support effective strategies.

3.1. Challenges in reducing energy poverty in Silesia

The focus group identified several challenges related to energy poverty reduction, exacerbated by the region's reliance on coal, aging infrastructure, and economic vulnerability linked to the energy transition. The closure of coal mines – a significant employment source – poses a risk of increasing energy poverty. Participants also highlighted a lack of accessible information on alternative heating methods and energy efficiency.

Key challenges identified:

- Dependence on coal and high energy consumption.
- Social and economic vulnerability due to the energy transition.
- Outdated housing infrastructure.
- Insufficient public awareness regarding efficient heating solutions.

Recommendation:

- Train independent energy specialists to provide reliable guidance on heating options.
- Establish local energy advisory centers staffed with specialists to offer impartial advice and energy audits.
- Develop online platforms to provide information, comparisons of heating systems, and expert consultations.
- Monitor the environmental and economic impacts of heating solutions and conduct localized research on energy efficiency.

Tools to alleviate energy poverty in Silesia

1. Financial instruments:
   - Subsidies and grants: support low-income households with energy bills and energy efficiency improvements.
   - Microfinance loans: assist vulnerable consumers and entrepreneurs in adopting energy-efficient technologies.
   - Energy service companies (ESCOs): provide services such as energy audits and efficiency upgrades based on achieved savings.
   - Public-private partnerships (PPP): leverage resources and expertise from multiple stakeholders.
   - Social impact investing: attract capital for renewable energy projects targeting underserved populations.
2. Social policy instruments:
   - Energy affordability and weatherization assistance programs.
   - Community-based initiatives (e.g., cooperatives, awareness campaigns).
   - Inclusive energy planning, ensuring marginalized communities' participation.
   - Regulatory protections, safeguarding consumers from unfair practices.
   - Capacity-building programs to enhance local job opportunities in the energy sector.
3. Education and awareness programs:
   - Launch educational campaigns on energy-saving practices and clean energy benefits.
   - Involve schools, communities, and media in spreading awareness.
4. Data and monitoring tools:
   - Develop systems for real-time energy data collection and analysis to inform targeted interventions.

3.2. Strategic recommendations for short- and long-term action

Short-term actions:

- Establish a robust energy poverty measurement system.
- Improve interdepartmental cooperation and data transparency.
- Focus on capacity building, community engagement, and financial support.

Long-term actions:

- Facilitate the energy transition with community participation.
- Implement renewable heating systems and energy audits.
- Foster collaboration between scientific and governmental institutions.
- Invest in infrastructure improvements and energy efficiency.
- Develop sustainable energy solutions and economic diversification to mitigate job losses.

The focus group research underscores the need for a coordinated, multi-dimensional approach to energy poverty alleviation in Silesia. Implementing financial, social, and

educational tools alongside policy reforms and robust data systems will be crucial in addressing the region's unique socioeconomic and environmental challenges. Despite the collection of data on poverty, the study reveals a fragmented understanding and insufficient cooperation between research centres and administrative bodies, hindering comprehensive solutions. Moreover, the research highlights challenges such as limited data accessibility, unclear methodologies, and inadequate interdepartmental cooperation in measuring energy poverty. The report further identifies key indicators of energy poverty in the region, including low-income, high-energy costs, and inadequate housing conditions. It emphasizes the most pressing challenges, particularly those associated with Silesia's dependence on coal, aging infrastructure, and the socioeconomic impacts of the energy transition. Recognizing the need for coordinated action, the study proposes targeted short-term and long-term recommendations, including financial support, policy reforms, data monitoring tools, capacity-building initiatives, and community engagement. By addressing these areas, this research aims to establish a holistic framework for energy poverty alleviation in Silesia, balancing the energy trilemma – security, sustainability, and affordability – while ensuring a just and inclusive energy transition.

Conclusions

To address the energy trilemma (security, sustainability, and affordability) in the context of SDGs 7 and 13 in the Silesia region, a comprehensive policy approach to alleviating energy poverty is crucial. This approach should focus on reducing socioeconomic inequality while advancing a clean energy transition. Based on the findings of the focus group study, several strategic recommendations can be made. Enhance administrative capacity and knowledge; short-term: establish dedicated units for energy poverty alleviation, provide training for local officials, and incorporate expertise from research centres; long-term: foster continuous capacity-building initiatives for local governments to prioritize energy poverty. Improve data collection and transparency; short-term: introduce legislation for standardized energy poverty data collection and establish a national-level administrative unit; long-term: create a unified, transparent data system with real-time energy data for informed interventions. Foster interdepartmental cooperation; short-term: develop mechanisms for better communication and collaboration between ministries; long-term: establish interdepartmental units focusing on energy poverty to streamline decision-making and enhance public awareness. Develop tailored energy poverty indicators; short-term: conduct localized research to create specific metrics for energy poverty in Silesia, considering unique factors like coal dependency; long-term: continuously monitor and adjust policies based on these refined indicators. Support transition to clean energy solutions; short-term: provide targeted financial support for low-income households to adopt energy-efficient technologies; long-term: promote renewable energy infrastructure and ensure access for energy-poor communities. Address coal dependence and employment; short-term: assist workers transitioning from coal industries,

and establish renewable energy training centers; long-term: promote economic diversification and job creation in green sectors to mitigate coal mine closures' social impacts. Strengthen public awareness and education; short-term: launch educational campaigns on energy-saving practices and alternative heating options; long-term: develop energy literacy programs to build a culture of energy efficiency in vulnerable communities. Implement financial and social policy instruments; short-term: provide direct financial support to energy-poor households and expand access to microfinance loans for clean energy technologies; long-term: foster public-private partnerships and community-based energy cooperatives. Monitor and evaluate the impact of heating solutions; short-term: implement pilot programs to assess alternative heating solutions and their impacts; long-term: continuously monitor and expand successful programs that address heating challenges and reduce fossil fuel dependency. Leverage financial and social policy instruments for long-term change, short-term: provide financial assistance for energy bills and upgrades, and implement community-based initiatives; long-term: develop inclusive energy planning processes and sustainable energy solutions that align with social and environmental goals. To balance the energy trilemma and achieve SDGs 7 (Affordable and Clean Energy) and 13 (Climate Action), Silesia must adopt a multifaceted approach that addresses energy poverty, promotes energy efficiency, and ensures equitable access to clean energy. By implementing the above short- and long-term strategies, the region can reduce energy poverty while advancing a sustainable, secure, and affordable energy future. Through coordinated efforts, Silesia can become a model for just energy transitions that benefit all citizens, particularly the most vulnerable.

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ADVANCING ENERGY TRANSITION IN SILESIAN COAL REGION: ALIGNING WITH SDGS 7 AND 13

Keyworlds

energy transformation, coal region, SDGs 7 and 13,
energy poverty, energy transition trilemma

Abstract

The Silesia region of Poland, historically reliant on coal mining, faces a critical juncture in advancing its energy transition amidst socio-economic and environmental challenges. This study examines the interplay of the energy trilemma – security, sustainability, and affordability – and Sustainable Development Goals (SDGs) 7 (Affordable and Clean Energy) and 13 (Climate Action) in the region. By employing a mixed-methods approach, including desk-based research, focus group discussions, and case study analysis, the research identifies key barriers and opportunities for a just energy transition. Findings reveal the pervasive impact of energy poverty, exacerbated by coal dependency, aging infrastructure, and economic vulnerabilities linked to the energy transition. Limited administrative knowledge, fragmented data systems, and insufficient interdepartmental cooperation hinder comprehensive strategies for alleviating energy poverty. The study highlights the importance of developing tailored energy poverty indicators, fostering interdepartmental collaboration, and promoting public awareness and education. Short-term recommendations include enhancing administrative capacities, establishing mechanisms for data collection, and supporting vulnerable households with financial aid and energy-efficient technologies. Long-term strategies emphasize economic diversification, renewable energy adoption, and systemic reforms to ensure equitable access to clean energy. Silesia's energy transition holds transformative potential for balancing the energy trilemma while meeting national and EU climate goals. This research underscores the need

for coordinated, multidimensional policies to support vulnerable communities and drive sustainable development. The findings aim to guide Silesia and similar coal-dependent regions in navigating complex energy transitions and achieving a just, inclusive, and sustainable energy future.

TRANSFORMACJA ENERGETYCZNA ŚLĄSKIEGO REGIONU GÓRNICZEGO W KONTEKŚCIE REALIZACJI CELÓW ZRÓWNOWAŻONEGO ROZWOJU 7 I 13

Słowa kluczowe

transformacja energetyczna, regiony górnicze, Cele Zrównoważonego Rozwoju 7 i 13, ubóstwo energetyczne, trylemat transformacji energetycznej

Streszczenie

Region Śląska w Polsce, historycznie uzależniony od górnictwa, stoi przed kluczowym wyzwaniem w zakresie transformacji energetycznej, mierząc się z problemami społeczno-ekonomicznymi i środowiskowymi. W niniejszym artykule analizowane są współzależności pomiędzy trylematem energetycznym – bezpieczeństwem, zrównoważonym rozwojem i przystępnością cenową – a Celami Zrównoważonego Rozwoju (SDG) 7 (Czysta i dostępna energia) oraz 13 (Działania na rzecz klimatu) w regionie. Wyniki wskazują na rozległy wpływ ubóstwa energetycznego, pogłębianego przez uzależnienie od węgla, starzejącą się infrastrukturę i wrażliwość gospodarczą związaną z transformacją energetyczną. Ograniczona wiedza administracyjna, rozdrobnione systemy danych oraz niewystarczająca współpraca międzyresortowa utrudniają opracowanie kompleksowych strategii przeciwdziałania ubóstwu energetycznemu. W artykule podkreślono znaczenie opracowania dostosowanych wskaźników ubóstwa energetycznego, wspierania współpracy międzyresortowej oraz promowania świadomości społecznej i edukacji. Przestawiono krótkoterminowe rekomendacje, które obejmują wzmocnienie zdolności administracyjnych, ustanowienie mechanizmów zbierania danych oraz wsparcie finansowe dla gospodarstw domowych w trudnej sytuacji, umożliwiając dostęp do technologii energooszczędnych. Natomiast proponowane w artykule długoterminowe strategie koncentrują się na dywersyfikacji gospodarczej, przejściu na odnawialne źródła energii oraz systemowych reformach zapewniających sprawiedliwy dostęp do czystej energii. Transformacja energetyczna Śląska ma potencjał równoważenia trylematu energetycznego przy jednoczesnym osiąganiu krajowych i unijnych celów klimatycznych. Badanie podkreśla potrzebę skoordynowanej, wielowymiarowej polityki wspierającej społeczności oraz promującej zrównoważony rozwój. Wyniki mają na celu wspieranie Śląska i innych regionów uzależnionych od węgla w nawigowaniu złożonymi procesami transformacji energetycznej i osiąganiu sprawiedliwej, inkluzywnej oraz zrównoważonej przyszłości energetycznej.