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Review

Energy Poverty Alleviation in the Era of Energy Transition—Case Study of Poland and Sweden

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Abstract: The energy transition, aimed at significantly reducing greenhouse gas emissions to combat climate change, presents both opportunities and challenges in addressing energy poverty. This article explores the differing approaches of Poland and Sweden in energy poverty alleviation within the context of this transition. Poland, with its historical dependence on coal, faces considerable obstacles as it seeks to shift towards cleaner energy sources while minimizing the impact on vulnerable populations. Conversely, Sweden, supported by its advanced energy infrastructure and strong welfare systems, has implemented effective strategies that have largely mitigated energy poverty, though challenges persist for low-income households, especially in rural areas. The article delves into the definitions, drivers, and alleviation strategies of energy poverty in both countries. Through a comprehensive literature review and the analysis of key initiatives such as Poland's Clean Air Program and Sweden's Warm Rent scheme, the study underscores the potential for policy interventions to address energy poverty. It concludes with recommendations on how both countries can further reduce energy poverty, highlighting the critical role of energy efficiency, social support systems, and the integration of renewable energy in achieving a fair and equitable energy transition.

Keywords: energy transition; energy poverty; energy poverty alleviation; Poland; Sweden; warm rent

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Citation: Janikowska, O.; Generowicz-Caba, N.; Kulczycka, J. Energy Poverty Alleviation in the Era of Energy Transition—Case Study of Poland and Sweden. *Energies* **2024**, *17*, 5481. https://doi.org/10.3390/en17215481

Academic Editor: Marco Casazza

Received: 4 October 2024
Revised: 24 October 2024
Accepted: 30 October 2024
Published: 1 November 2024

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1. Introduction

In an era of the Anthropocene where climate changes generate social injustice, economic inequality, and a deepening migration, energy transition seems to be the only alternative [1]. The world is at a critical juncture, grappling with the existential threat of climate change while simultaneously confronting entrenched disparities in access to energy services and economic opportunities [2]. The energy transition, defined as the shift to clean and sustainable energy sources, offers the potential not only to mitigate the impacts of climate change but also to reduce poverty and promote social equality [3]. This transition demands a holistic approach, recognizing the intricate interconnections between social, political, and environmental systems, especially when considering its far-reaching consequences [4]. These consequences will be especially pronounced in countries historically dependent on the coal industry [5]. The transition away from coal mining and extraction in former coal-producing regions will bring about significant changes in the labor market, potentially leading to what is known as "territorial stress" due to profound economic and social shifts [6]. Consequently, special attention must be given to vulnerable groups who are already at risk of energy poverty [7]. In energy studies, energy poverty is generally defined in two primary ways: as a lack of access to electricity and as reliance on inefficient and polluting energy sources, such as solid biomass [8].

Energy poverty arises when a household is unable to meet its energy needs adequately [9]. This situation can result in a significant portion of income being spent on energy bills, frequent disruptions in electricity supply, and an inability to maintain comfortable indoor temperatures or access essential services like heating, cooling, and the use of

electronic devices [10]. For millions of people worldwide, energy poverty remains a severe and persistent issue, depriving them of essential services such as electricity, heating, and cooking fuel [11–13]. This deprivation traps individuals in a continuous cycle of poverty and hardship. Energy poverty significantly impacts health, well-being, social integration, and overall quality of life [14–16]. Its effects are far-reaching, influencing physical and mental health, contributing to economic strain through debt accumulation, and reducing living standards [2,13,17]. Additionally, energy poverty affects educational outcomes, exacerbates emissions, leads to inefficient resource use, and perpetuates intergenerational poverty, thereby impacting entire communities [2,14,18]. People affected by energy poverty experience inadequate comfort and poor sanitary conditions [3,4,19,20]. They may also face significant psychological stress, such as that caused by unpaid energy bills [21,22]. The impact of energy poverty extends beyond the individuals directly affected [5,7,23]. Toxic fumes not only harm those using inappropriate fuels to heat their homes but also affect their immediate and distant neighbors [24,25]. Increased greenhouse gas emissions contribute to climate change on a global scale [26–28]. Additionally, the costs of treating health issues arising from poor air quality are borne by society as a whole, and social care services are funded by public money [2,9,12,29]. Furthermore, the Energy Poverty Advisory Hub introduced new indicators for energy poverty, including metrics related to deaths caused by energy poverty, such as those from overheating, freezing, and poisoning from harmful fumes [30].

It is important to recognize that energy poverty has both local and global dimensions [31]. It creates disparities not only within local communities but also reinforces global divisions between the affluent North and the impoverished South [32]. Developed countries, which make up 16% of the world's population, consume over 40% of global energy [33,34]. In contrast, developing countries, which are home to more than 80% of the global population, use less than 60% of global energy [35]. Furthermore, approximately 759 million people around the world lack access to electricity, primarily in sub-Saharan Africa and South Asia [5]. Additionally, higher-income households typically consume significantly more energy and resources compared to lower-income households [23]. This disparity is often due to greater access to modern conveniences, larger homes, and higher rates of vehicle ownership. As a result, there is a significant variation in energy access between wealthier urban areas and poorer rural regions [36]. The selection of Poland and Sweden is based on Poland's traditional reliance on the extractive industry, which presents significant challenges during the energy transition. This shift has the potential to exacerbate issues related to energy poverty. By contrast, Sweden is widely recognized for its effective management of energy poverty issues. The aim of the paper is to study the strategies and effectiveness of energy poverty alleviation efforts within the context of the ongoing energy transition, with a particular focus on Poland and Sweden [3,37].

2. Materials and Methods

This paper argues that effective energy poverty alleviation in the context of energy transition requires a multifaceted approach that balances the urgency of transitioning to renewable energy with the need to ensure affordable and equitable access to energy for all. The goal of the paper is to assess the scope and impact of energy poverty in Poland and Sweden.

The review was conducted through a combination of traditional critical literature review methods, web-based research, and an analysis of academic multidisciplinary databases such as Scopus and Google Scholar. Key terms like 'Energy Transition', 'Just Transition', 'Energy Poverty', and 'Energy Poverty Indicators' were used to guide the research. A prevalent approach to defining energy poverty emerged, characterizing it as a condition where households lack access to essential energy services and products. Moreover, the review highlighted the European Union's ambitious objective to achieve climate neutrality by 2050. Reaching this goal, which requires a net-zero greenhouse gas emissions economy, will necessitate extensive, multilevel, and multidimensional transitions,

potentially leading to what is termed 'territorial stress'. The next phase of the research involved mapping the literature flow surrounding energy transitions. For this purpose, the VOSviewer_1.6.18_exe tool was utilized, a specialized software designed to visualize and construct bibliometric networks, which include entities such as journals, researchers, and publications. These networks are based on relationships such as citation, bibliographic coupling, co-citation, or co-authorship. The terms 'Energy Poverty Indicator' and 'Energy Poverty Indicators' were employed in the mapping process (Figure 1). The results revealed that the literature could be grouped into three main clusters, determined by the frequency of term occurrence. The primary cluster centered around topics like energy justice, energy policy, vulnerability, policy, and efficiency. The second cluster focused on terms related to poverty, sustainable development, renewable energy, buildings, and households. The final cluster highlighted terms such as affordability, intensity, electricity, and education. Additionally, the review included an analysis of the number of scientific publications on energy poverty, just transition, and energy poverty within the EU from 2013 to 2023.

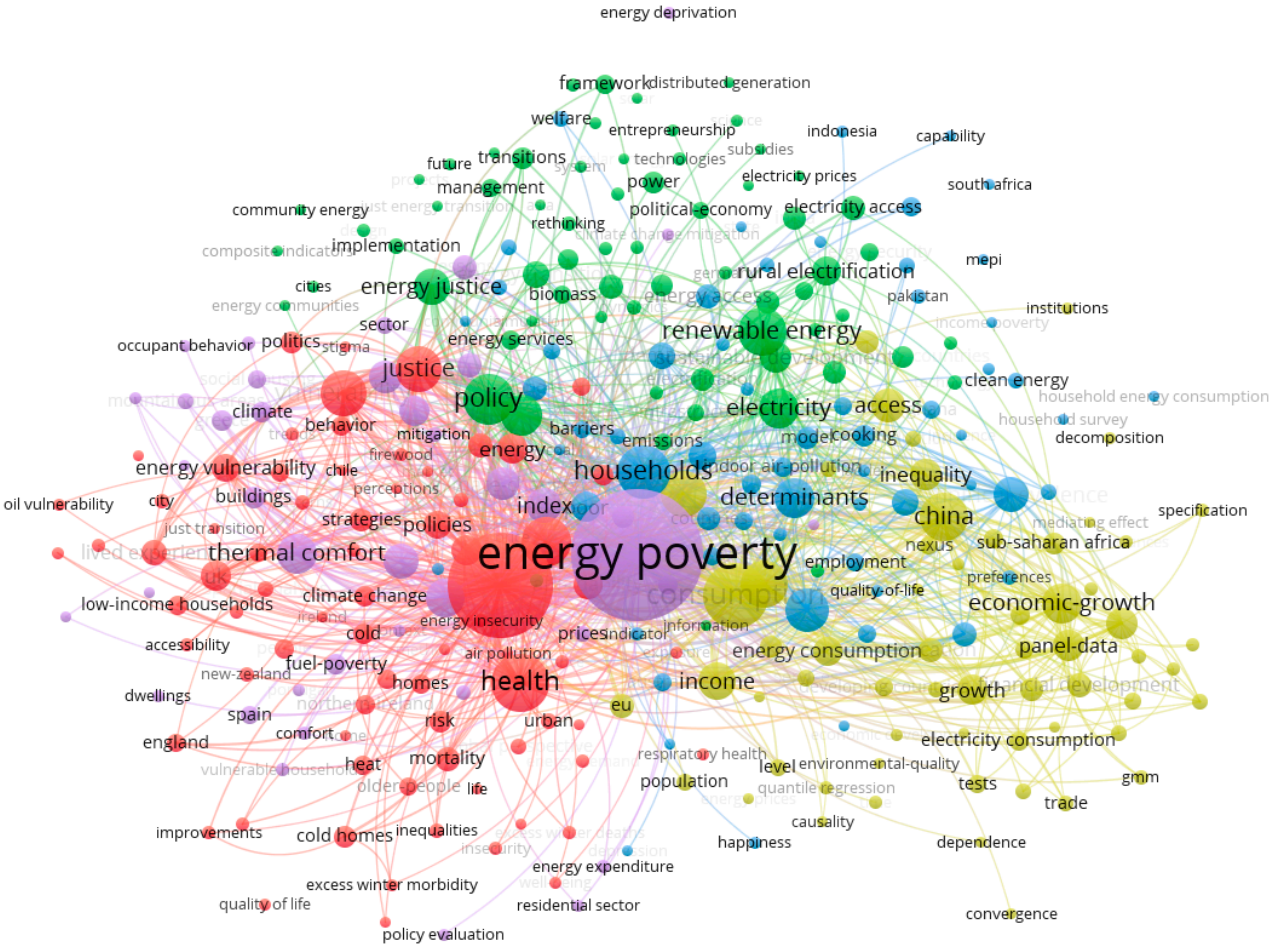


Figure 1. Literature review of the energy poverty (Source: VOS viewer).

The review of the literature on energy poverty definitions reveals several categories that have evolved over time. The basic access definition was prominent in the early stages of defining energy poverty, focusing primarily on whether households had access to electricity and clean cooking facilities. This approach correlates energy poverty with access to basic energy services. The affordability-based definition is commonly used in the European context, with the '10% rule' widely accepted. This rule identifies households as energy-poor if they spend more than 10% of their income on energy services required to maintain adequate heating. Physical and infrastructural definitions form another significant group, concentrating on the energy efficiency of dwellings and the excess energy needed to main-

tain appropriate levels of heating, lighting, and power. These definitions emphasize the physical aspects of energy consumption and infrastructure quality. The multidimensional definition of energy poverty addresses multiple forms of deprivation, viewing energy poverty as not merely a function of income and energy prices. It also encompasses energy needs, consumption patterns, socioeconomic status, and housing characteristics, making it a more comprehensive approach. The capability approach emphasizes the importance of having access to adequate, affordable, and reliable energy services to meet basic human needs and social functions. This approach defines energy poverty as the inability to secure essential energy services. Finally, the relational definition highlights energy poverty as a result of social and spatial relationships that affect energy access, affordability, and use. This approach recognizes the complex interplay of infrastructural, economic, and social factors in shaping energy poverty. The next step involved a comprehensive review of the literature on strategies for alleviating energy poverty in Poland and Sweden. Using VOS-viewer, it was found that there are 196 academic papers related to energy poverty in Poland (Figure 2). These publications are predominantly associated with key terms such as poverty, sustainable development, fuel poverty, vulnerable consumers, renewable energy, and policy.

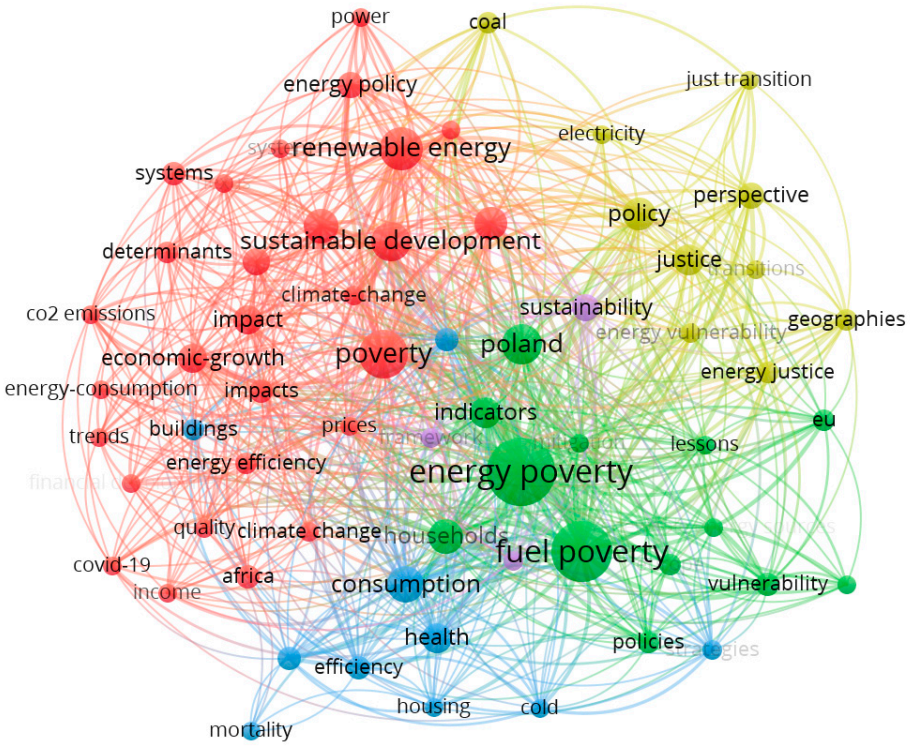


Figure 2. Literature review of energy poverty in Poland (Source: VOS viewer).

The literature review revealed a total of 214 papers focused on energy poverty in Sweden. The most frequently referenced terms in these studies include poverty, sustainable development, renewable energy, and the Sustainable Development Goals (SDGs) (Figure 3).

The second part of the research focused on analyzing national policies aimed at alleviating energy poverty and assessing how these efforts align with the current realities on the ground.

The selection criteria for the paper were based on several key factors:

- Geographical Focus: Poland and Sweden were chosen as case studies due to their contrasting approaches to energy transition and poverty alleviation. Poland, heavily reliant on coal for its energy needs, presents a sharp contrast to Sweden, which has developed a highly advanced renewable energy infrastructure. These differences provide a rich basis for analyzing energy poverty across varying contexts.

- Economic and Social Indicators: The countries were selected due to their distinct energy production models. Poland's economy has long depended on coal as a primary energy source, while Sweden is recognized for its extensive use of renewable energy, making these economic and social factors critical to the study's framework.
- Energy Poverty Alleviation Policies: The paper examines the national policies in Poland and Sweden that specifically target energy poverty reduction, allowing for a comparative analysis of their effectiveness and outcomes.
- Sources and Literature: The literature and studies included in the review were selected based on their relevance to energy poverty, the impacts of policy interventions, and their empirical approach to measuring the outcomes of energy transitions in these two countries.

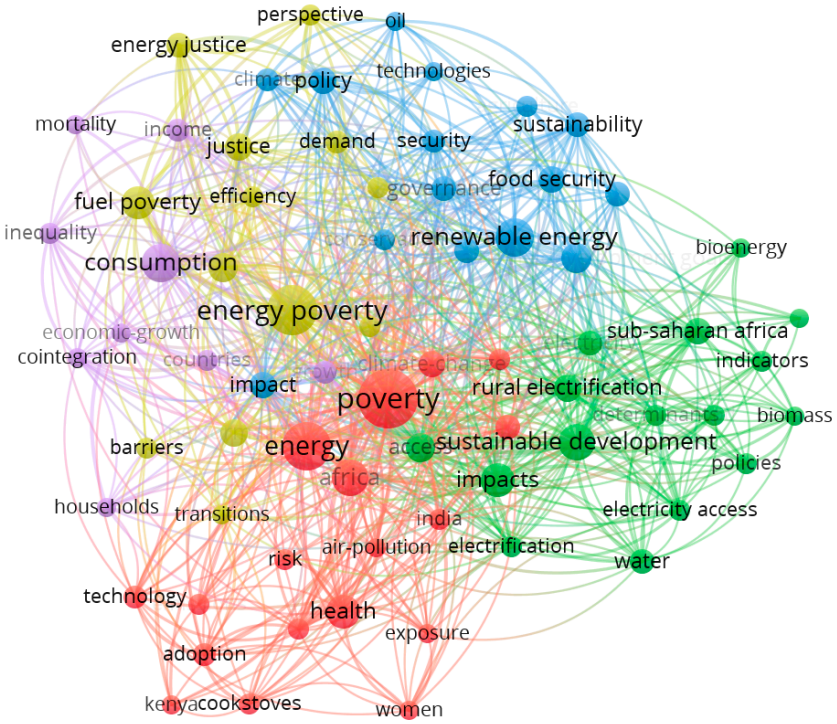


Figure 3. Literature review of energy poverty in Sweden (Source: VOS viewer).

3. Results

The 1973 oil crisis marked a turning point in recognizing energy and fuel poverty as significant issues. The concept of energy poverty was formally introduced by Isherwood and Hancock in 1979. However, it was Boardman's influential 1991 book on fuel poverty in the UK that brought widespread attention to the issue, which had been largely overlooked in academic and policy debates. In her work, Boardman defined fuel poverty as a situation where a household spends more than 10% of its income on energy services needed to maintain adequate indoor temperatures. By 1997, the UK government officially incorporated the term "fuel poverty" into its policy framework. It is important to note that while the terms "energy poverty" and "fuel poverty" are often used interchangeably, they carry distinct meanings. Energy poverty generally refers to the broader inability to access essential energy services, while fuel poverty is more specific to the affordability of energy, particularly in the context of maintaining adequate household heating. Fuel poverty, primarily recognized in the UK and several European countries, refers to the condition where a household is unable to afford sufficient fuel to keep their home at a comfortable, healthy temperature [7,8]. In the UK, fuel poverty is specifically defined as a household spending more than 10% of its income on fuel to maintain an adequate level of warmth—typically 21 °C in main living areas and 18 °C in other rooms. This definition underscores the interplay between fuel costs, household income, and the energy efficiency of the home. Harrison and Popke (2011)

used the term 'energy poverty' to describe a condition commonly referred to as fuel poverty, while Foster et al. (2000) employed 'fuel poverty' to refer to what is more broadly known as energy poverty. Buzar (2007) argued that the two terms are essentially synonymous, noting that in the UK and Ireland, energy poverty is typically referred to as fuel poverty [9–11]. Bouzarovski et al. (2012) expanded on Buzar's perspective, discussing energy poverty policies in the UK, which the UK government refers to as fuel poverty policies [12]. While 'fuel poverty' is the term commonly used in the UK, 'energy poverty' is a broader concept used internationally. Energy poverty encompasses a wider range of energy needs beyond just heating. It is characterized by insufficient access to modern energy services, such as electricity and clean cooking facilities, which are essential for maintaining a basic standard of living. The core issue lies in the inability to secure or afford enough energy for essential activities like lighting, cooking, and powering appliances. This issue is particularly severe in many developing countries. Fuel poverty, on the other hand, is a subset of energy poverty, focusing primarily on heating and the financial strain households face in affording fuel. Energy poverty, in contrast, includes a lack of access to all critical energy services.

Energy poverty remains one of the most critical global challenges, with approximately 759 million people still lacking access to electricity. The issue is particularly acute in regions like sub-Saharan Africa and South Asia, where large populations remain disconnected from modern energy infrastructure. Recent research published in Joule titled "Lost in the Dark: A Survey of Energy Poverty from Space" utilized night-time satellite imagery to analyze energy usage across 115 developing countries [13]. The study revealed that 1.18 billion people in these regions experience energy poverty, meaning they have limited or unreliable access to electricity that fails to meaningfully improve their quality of life [14]. This includes households with electrical connections that are underutilized due to frequent outages, unreliable supply, or prohibitively high costs [13]. This figure significantly surpasses the official estimate of 733 million people lacking access to electricity, highlighting the deeper extent of the issue. Energy poverty occurs when a household is unable to sufficiently meet its energy needs, resulting in a large share of income being spent on energy bills, frequent disruptions in electricity, and an inability to maintain comfortable indoor temperatures or access essential services like heating, cooling, and the use of electronic devices [15]. Adequate domestic energy services encompass various critical aspects, including space heating, cooling, water heating, lighting, cooking, the operation of home appliances, and access to information and communication technologies [16]. Energy poverty occurs when a household is unable to sufficiently meet its energy needs, resulting in a large share of income being spent on energy bills, frequent disruptions in electricity, and an inability to maintain comfortable indoor temperatures or access essential services like heating, cooling, and the use of electronic devices [2]. Adequate domestic energy services encompass various critical aspects, including space heating, cooling, water heating, lighting, cooking, the operation of home appliances, and access to information and communication technologies [17]. These energy services are fundamental for ensuring a decent quality of life and empowering individuals to reach their full potential. According to the Commission Recommendation (EU) 2020/1563, energy poverty is defined as a condition where households lack access to essential energy services necessary for a basic standard of living [18]. This issue is not confined to developing or impoverished nations; it also affects developed and highly electrified regions, including Europe [19]. Energy poverty leads to unmet basic needs and limits economic and educational opportunities, disproportionately affecting vulnerable groups such as women, children, and minorities [20]. In González-Eguino's 2015 study, three key drivers of energy poverty are identified: technical factors, economic factors, and behavioral and attitudinal factors [21].

Energy transition refers to the global shift from conventional energy sources such as fossil fuels (coal, oil, and natural gas) to renewable and sustainable alternatives like wind, solar, and hydropower. This transition is driven by the urgent need to reduce greenhouse gas emissions, mitigate climate change, and transition toward a more sustainable, low-carbon energy system. However, the energy transition should be recognized as a challenge,

particularly for mining regions. The shift to renewable energy requires substantial investments, often leading to higher initial costs for infrastructure and technology. These financial burdens can disproportionately affect low-income households already struggling with high energy costs. Additionally, energy price volatility may arise as traditional energy sources are phased out while renewable sources are still being established. Technical disparities could emerge, with the benefits of the energy transition unevenly distributed across different groups, creating inequalities in access to new technologies. During the transition period, there is also the potential for increased energy costs, further straining household budgets. Infrastructure gaps are another concern, as transitioning to new energy systems requires significant upgrades, which may cause temporary disruptions. Furthermore, policies and regulations designed to facilitate the energy transition could unintentionally benefit certain groups more than others, leading to inequities. Finally, the disruption of traditional energy services during the phase-out of fossil fuels may result in temporary service interruptions as new systems are implemented.

Energy Poverty Alleviation in Poland and Sweden

In Poland, according to Article 5 of the Energy Law of 24 August 2024, energy poverty is defined as a situation in which a household, whether run by a single person or multiple people living together in an independent residential unit or a single-family home, where no business activity is conducted, is unable to ensure an adequate level of heating, cooling, and electricity for powering devices and lighting. This occurs when the household meets the following conditions:

- It has a low income;
- It incurs high energy-related expenses;
- It resides in a dwelling or building with low energy efficiency [22].

Based on the high costs and low income index, energy poverty affects about 10% of the population in Poland (https://www.gov.pl/web/klimat/badania-statystyczne, accessed on 1 September 2024). This issue impacts both rural and urban regions, including single-family houses as well as multi-family buildings. It is especially prevalent in buildings lacking central heating, older structures in need of insulation, or homes heated by inefficient energy sources. Vulnerable individuals are particularly affected, as they often receive social housing that is poorly insulated and electrically heated, making it difficult to afford, which traps them in a cycle of energy poverty. Poland's national efforts, outlined in the Energy Policy until 2040 (PEP2040), focus on reducing energy poverty to 6% by 2030. The policy emphasizes the importance of establishing appropriate legal frameworks, including clarifying the definition of energy poverty, developing metrics to assess it, and identifying key areas for action. Poland's energy policy until 2040 defines the framework for energy transition and is a response to the EU climate policy. The policy takes into account the scale of the challenges related to the adaptation of the national economy to the EU regulatory conditions related to the 2030 climate and energy goals, the European Green Deal, the COVID economic recovery plan, and the pursuit of climate neutrality in line with national opportunities, as a contribution to the implementation of the Paris Agreement.

Poland's efforts to alleviate energy poverty involve a range of programs, as outlined in Table 1. These initiatives are designed to assist households struggling with energy poverty by offering solutions such as enhancing the energy efficiency of residential buildings, providing financial aid, and encouraging the adoption of renewable energy sources.

Sweden does not have an official, specific definition of energy poverty. According to the data around 2.3% of the Swedish population struggling to keep their homes warm comes from recent energy poverty assessments [23]. Energy poverty in Sweden is comparatively lower than in many other EU nations, primarily due to robust social welfare programs and proactive energy efficiency policies. However, it persists in certain segments of the population, particularly among low-income households, residents of rural or remote areas, and those living in older, less energy-efficient homes. These groups face higher energy costs, especially during Sweden's long, cold winters, which can strain household budgets despite

broader national efforts to mitigate the issue. Over the last 20 years, the cost of living in Sweden has been gradually rising, especially in cities such as Stockholm, Gothenburg, and Malmö. Housing costs, rent, energy prices, and basic consumer products have become increasingly expensive, particularly affecting people on low incomes, retirees, migrants, and people living alone. High heating costs, especially in winter, put additional pressure on the budgets of households that have limited financial resources. In the early 2000s and during the 2008 financial crisis, many families in Sweden experienced financial difficulties, which affected their ability to pay their energy bills. The COVID-19 pandemic in 2020 also contributed to higher costs of living, including energy, and reduced incomes for many households. As a result of the pandemic, many people lost their jobs or had reduced incomes, which further deepened the problem of energy poverty. To combat energy poverty, Sweden has introduced the programs shown in Table 2.

Table 1. Key programs and initiatives aimed at alleviating energy poverty in Poland.

Tools to Support the Struggle Against Energy Poverty	Description
Energy Policy until 2040	Poland's national efforts, outlined in the Energy Policy until 2040 (PEP2040), focus on reducing energy poverty to 6% by 2030. The policy emphasizes the importance of establishing appropriate legal frameworks, including clarifying the definition of energy poverty, developing metrics to assess it, and identifying key areas for action. Poland's energy policy until 2040 defines the framework for energy transition and is a response to the EU climate policy [6].
Clean Air Clean Air Plus	The Clean Air program is one of Poland's flagship initiatives aimed at improving air quality and addressing energy poverty by modernizing heating systems and enhancing the energy efficiency of single-family homes. The program provides financial support for replacing outdated, inefficient heating sources, such as coal-fired stoves, with more eco-friendly alternatives, and for implementing thermal upgrades to buildings. Its scope includes upgrading heating systems, improving insulation, and installing renewable energy technologies. The program is primarily targeted at owners and co-owners of single-family houses. Additionally, it offers special assistance to low-income households through the Clean Air Plus initiative, which provides even higher levels of financial aid. Beneficiaries can receive support in the form of grants or low-interest loans to fund these improvements [38].
Warm Apartment	The Warm Apartment program is a Polish government initiative designed to enhance energy efficiency in multi-family apartment buildings. It provides financial support for upgrading old, inefficient heating systems to modern, eco-friendly alternatives, such as gas boilers or heat pumps, and for improving insulation to lower energy usage and costs. The program offers grants, with additional assistance for low-income households, to promote cleaner, more efficient heating and better living conditions, particularly in older apartments. It plays a key role in reducing energy poverty and air pollution while supporting Poland's climate goals [39].
ASSIST in Poland	ASSIST in Poland is part of a European initiative focused on combating energy poverty by offering direct support to vulnerable households. The program trains Vulnerable Consumers Energy Advisors (VCEA) to assist low-income families and seniors in managing energy use, cutting costs, and improving energy efficiency in their homes. The project provides personalized guidance, runs awareness campaigns on energy-saving strategies, and collaborates with local governments and NGOs [40].
The Consumer Stock Ownership Plan (CSOP)	The Consumer Stock Ownership Plan (CSOP) empowers consumers, particularly those without savings or access to capital credit, to acquire ownership stakes in the renewable energy installations they use, transforming them into 'prosumers'. This consumer-focused investment model in public utilities provides both financial participation and a voice in management decisions. By shielding consumer shareholders from personal liability, CSOP enables co-investment opportunities for municipalities, small and medium-sized enterprises (SMEs), and other local stakeholders, fostering broader community engagement in sustainable energy projects [41].
The Energy Shield Allowance (Energy Supplement)	The Energy Shield Allowance (Energy Supplement) is a direct financial support program designed to help households facing difficulties in paying their energy bills. It targets low-income individuals, with the amount of the allowance determined by household size and income. This initiative is part of a wider social policy aimed at alleviating the effects of rising energy costs [42].

Table 1. *Cont.*

Tools to Support the Struggle Against Energy Poverty	Description
The Thermomodernization and Renovation Fund	The Thermomodernization and Renovation Fund is a support program for housing cooperatives and associations aimed at enhancing the energy efficiency of multi-family buildings. By reducing heating costs, thermomodernization helps to alleviate energy poverty. The program covers a range of energy-saving measures, including window replacement, upgrades to heating systems, and other improvements designed to increase energy efficiency [43].

Source: Own study.

Table 2. Key programs and initiatives aimed at alleviating energy poverty in Sweden.

Tools to Support the Struggle Against Energy Poverty	Description
Energy Efficiency Law (Energilagen)	Key regulations on energy consumption and energy management in the building sector are defined in this law. It imposes an obligation on building owners and property managers to strive to reduce energy consumption and CO_2 emissions, which has a direct impact on reducing energy poverty [44].
Climate strategy	Sweden is aiming for climate neutrality by 2045 as part of its climate policy, and the building sector plays a key role in this transition. This includes requirements for energy retrofits of existing buildings [45].
Boverket—Sweden's National Council for Building, Planning and Housing	This council administers standards that set minimum requirements for energy efficiency. These must be met by new buildings, as well as by retrofitting existing buildings. The standards address high thermal insulation and mandate the use of energy-efficient technologies [46].
Mandatory energy certificates (Energideklaration)	Sweden requires an energy certificate for every residential building. These certificates assess the building's energy efficiency based on energy consumption and recommend improvement measures. Owners of buildings with low efficiency are required to make improvements [47].
Grants for thermomodernization	Building owners can apply for subsidies for measures to improve insulation, replace windows, and upgrade heating systems. This effectively reduces energy demand [48].
Support for renewable energy in buildings	The government offers subsidies and tax breaks for owners who choose to install renewable energy sources, such as photovoltaic panels and heat pumps. Renewable energy sources reduce energy costs, which helps in the fight against energy poverty. Wind and hydroelectric power plants: The high share of renewables in Sweden's energy mix contributes to stable and relatively low energy prices compared to fossil fuel-dependent countries [49].
Warm rent rules	Public housing often has a "warm rent" policy, which means that all energy charges are included in one rent. This gives financial stability to tenants, who do not have to worry about sharp increases in energy prices [50].
Subsidy for heating costs	People with low incomes can apply for energy allowances to help cover rising heating costs, especially during the winter months [51].
Housing benefits	Social support for people who have difficulty paying their rent often includes covering part of the cost of energy [52].

Source: Own study.

When analyzing the influence of policies on energy poverty in Poland, it is essential to highlight that this issue is particularly pressing due to the country's climatic conditions, the large number of old, uninsulated buildings, and rising energy costs. Additionally, Poland's ongoing energy transition presents significant challenges for vulnerable consumers (Figure 4). Between 2000 and 2010, energy poverty was a relatively understudied phenomenon in Poland, largely due to the absence of clear indicators for measuring its extent. Furthermore, following the political transformation, when Poland shifted from a centrally planned to a market economy, the country faced difficulties in accessing modern energy sources. This resulted in high energy costs, especially for households dependent on outdated heating systems like coal stoves. The low energy efficiency of older buildings further compounded heating costs. From 2010 to 2015, interest in addressing energy

poverty in Poland began to rise. During this period, Poland gradually introduced various programs aimed at reducing energy poverty, particularly through improving energy efficiency measures, such as building thermal insulation projects. Despite these efforts, energy poverty remained widespread, particularly in rural areas, where access to modern heating systems and electricity was more limited. The increasing prices of energy and gas also posed significant financial challenges for many households. However, during this period, support programs like subsidies for energy and heating costs were introduced, and there was growing promotion of renewable energy sources, including solar panels. Between 2015 and 2020, the Polish government increased its investment in energy efficiency initiatives, notably through programs such as "Clean Air", designed to reduce air pollution and improve building energy efficiency. According to data from this period, approximately 12–15% of households in Poland were affected by energy poverty. The primary causes included rising energy prices and the low energy efficiency of older residential buildings. While the thermal modernization programs began to yield positive results, the pace of progress was slow. Modernizing buildings and providing financial assistance to the most disadvantaged households helped mitigate the issue of energy poverty, but it remained a significant problem. The period from 2020 to 2023 saw the COVID-19 pandemic exacerbate energy poverty in Poland, primarily due to job losses and decreased income for many households. Moreover, lockdowns resulted in people spending more time at home, leading to increased energy consumption. Energy poverty in Poland in 2022 ranged from 3% to 40%, depending on the indicator used. In the past 12 months, 65% of households reported reducing energy consumption. In addition, 25% of households stated that they sometimes use poor-quality fuels for their energy needs, such as coal dust, biomass, or waste. In total, 66% of households saving energy indicated economic necessity as the reason for doing so, and 7% of households in single-family homes admitted to burning waste [53]. Another major factor contributing to the rise in energy poverty during this time was the sharp increase in energy prices, especially in 2021 and 2022. These price hikes were driven by the European Union's climate policies, rising costs of CO_2 emission certificates, and global disruptions in the supply of energy resources, such as coal and gas. The ongoing conflict in Ukraine and the sanctions imposed on Russia in 2022 further contributed to the rising costs of energy resources, leading to higher household bills for heating and electricity in Poland. Poland is currently facing the challenge of transitioning away from coal and toward renewable energy sources. However, this transition entails significant costs, which may disproportionately affect low-income households unless adequate support mechanisms are put in place. The government continues to implement programs like "Clean Air" and "Stop Smog", which aim not only to combat air pollution but also to lower energy costs for the poorest households by modernizing buildings. Rising energy prices and inflation pose a risk of worsening energy poverty in the future. Nevertheless, increased awareness of energy efficiency and further investments in renewable energy technologies could play a key role in mitigating this issue.

Energy poverty in Sweden, while relatively low at present, has undergone marked changes over the past 20 years. Rising energy prices and the cost of living have been significant challenges, especially for low-income households. This situation has necessitated measures to reduce energy poverty, including improving the energy efficiency of buildings and supporting households affected by high energy costs.

In the early 2000s and during the 2008 financial crisis, many families in Sweden experienced financial difficulties, which affected their ability to pay their energy bills. The COVID-19 pandemic in 2020 also increased the cost of living, including energy, and reduced income in many households. As a result of the pandemic, many people lost their jobs or had their incomes reduced, further exacerbating the problem of energy poverty.

Sweden is the country with the world's most developed energy mix, the only country to have developed both nuclear and renewable energy in parallel, while reducing the share of fossil energy. The Swedes are also very determined to become independent of traditional fossil fuels in transportation by 2030. The share of non-fossil fuels in the primary energy

balance is 41% in Sweden today. In fulfillment of the tasks imposed by the EU's climate policy—the so-called Climate strategy—Sweden has decided to voluntarily raise the share of non-fossil fuels to 50% by 2020. It is worth taking into account the short—for such ambitious measures—period of introducing huge changes. The changes in Sweden, thanks to the determination and help of lawmaking politicians, took 28 years.

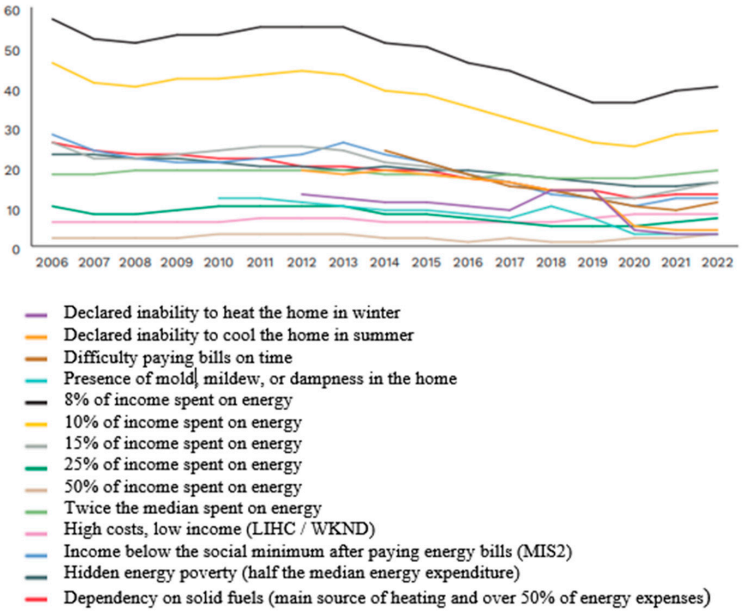


Figure 4. The percentage of households affected by energy poverty in Poland from 2006 to 2022 [53].

In 1980, the share of fossil fuels in heat production was 95% (similar to today in Poland). The changes began with legislative processes and taxing what was energy inefficient and used imported fuels. The principle of not rewarding what was "clean and economical" and penalizing what was "dirty and wasteful" was applied.

Thus, the energy generator pays for the following:

- combustion of fossil fuels,
- Nox and SO_2 emissions
- In turn, the end customer pays for the following:
- energy tax (close to the price of energy),
- a fee for ordered power,
- a fee for the energy consumed,
- an additional small fee for the promotion of green energy,
- and finally VAT on the total amount

As a consequence of the fees imposed, per capita heating energy consumption in Sweden is half that in Poland, not only because of energy recovery from ventilation or better energy efficiency of buildings (mandatory energy certificates (Energideklaration)) but mainly because the average Swede simply does not pay to waste energy.

Over the years, Sweden has relied on extensive investment in renewable energy sources (Boverket—Sweden's National Council for Building, Planning and Housing, Karlskrona, Sweden) and modernization of energy infrastructure (Grants for thermomodernization), which has helped stabilize energy prices and reduce energy poverty. The development of technologies such as wind and solar power and better management of energy transmission, especially between regions of the country, have improved the situation for low-income households [54].

With the introduction of new policies, such as support for vulnerable consumers and educational programs, public energy awareness has also improved. Sweden has reduced the scale of energy poverty over the past two decades, although the challenges of high

energy prices, especially in the context of global economic and geopolitical crises, are still present [55].

Energy poverty in Sweden, although currently relatively low, has changed markedly over the last 20 years. Rising energy prices and the cost of living are significant challenges, especially for low-income households. This situation forces actions aimed at reducing energy poverty, including improving the energy efficiency of buildings.

Ensuring energy affordability in Sweden is a complex challenge that requires an integrated approach. Here are some key strategies that can help achieve this goal:

- Strengthen financial support policies: It is important for the government to continue and expand support programs for households, especially low-income households that are most vulnerable to energy poverty. These could include subsidies for improving the energy efficiency of homes, which would reduce heating and electricity costs.
- Education and awareness: Increasing public awareness of energy saving and available sources of support is key. Education about how to use energy efficiently can help lower energy bills.
- Energy price dynamics: Allowing more flexible energy prices that reflect supply and demand can help stabilize costs. At the same time, efforts should be made to avoid a situation where households with limited resources cannot take advantage of dynamic pricing models.
- Promoting renewable energy sources: Investment in renewable energy can help lower overall energy costs, as well as improve energy security. The government should promote renewable energy installations at the local level.
- Crisis interventions: With energy prices rising due to global crises, it is important for the government to have intervention programs ready to quickly support the neediest households.

As a part of energy transition the development of electric vehicles should be taken under consideration [56,57] (Table 3). It can have significant implications for energy poverty, particularly due to the contrasting energy landscapes of these two countries.

Table 3. Impact of electric vehicles implementation for energy poverty in Poland and Sweden.

Impact in Poland	Impact in Sweden
Energy Prices—As Poland shifts towards decarbonization, its coal-dependent energy system is likely to face rising costs, which could result in higher energy prices. This would disproportionately affect households already at risk of energy poverty. Moreover, the growing demand for electric vehicles could further strain the electricity grid, potentially driving energy costs even higher and worsening the burden on vulnerable consumers.	Affordable Electricity—Sweden's energy grid, primarily powered by renewable sources like hydropower and wind, offers long-term cost efficiency. As a result, the widespread adoption of electric vehicles (EVs) is unlikely to cause significant increases in energy prices. This allows lower-income households to potentially benefit from reduced transportation costs without facing higher energy bills, making the EV transition more accessible and economically advantageous for a broader population.
Dependence on Fossil Fuels—Since Poland's energy grid is still largely reliant on coal, the environmental and economic advantages of transitioning to electric vehicles (EVs) could be undermined unless substantial investments are made in renewable energy sources. Without such investments, the shift to EVs may result in higher electricity bills for households, perpetuating the cycle of energy poverty rather than alleviating it. For many families, the cost burden could grow, especially if clean energy alternatives are not adopted at scale.	Accessibility—Sweden's energy grid, predominantly powered by renewable sources like hydropower and wind, ensures long-term cost stability. Consequently, the widespread adoption of electric vehicles (EVs) is unlikely to significantly increase energy prices. This stability allows lower-income households to benefit from reduced transportation costs without a corresponding rise in energy bills, making the EV transition more affordable and accessible across all income levels, while also enhancing overall economic efficiency.
Rural and Poorer Communities—The initial deployment of EV charging infrastructure is likely to be concentrated in urban areas, potentially leaving rural and economically disadvantaged regions underserved. This disparity in access could exacerbate energy inequality, as rural households may struggle to benefit from the transition to electric vehicles due to limited availability and higher costs of charging stations in their areas.	Policy Support—Sweden has implemented forward-thinking policies to promote the adoption of electric vehicles (EVs) and expand renewable energy usage, increasing the likelihood that this transition will ease, rather than exacerbate, energy poverty. Financial incentives and subsidies for EV purchases make EV ownership more accessible to low-income households, while the country's robust renewable energy grid ensures these benefits reach a broader segment of the population. This comprehensive approach helps ensure that the shift to EVs is both environmentally sustainable and socially inclusive.

Source: Own study based on [56,57].

4. Discussion

Energy poverty is one of the key social and economic challenges affecting many European countries. Although both Poland and Sweden face this problem, there are significant differences in the nature, scale, and ways to address energy poverty. Sweden, as a country with advanced infrastructure and high energy efficiency standards, has traditionally handled this challenge better than other European Union countries [50]. One solution that may be a good example to replicate is the use of the "warm rent" method in Sweden [57]. Warm rent is a model for accounting for housing fees [58]. It relies on the fact that all costs associated with the operation of the apartment, including utilities such as heating, water, and energy, are included in the rent payment [59]. Tenants do not pay separately for these services, which means there are no separate bills for energy or heating [60]. This model provides predictability in housing costs, which is particularly beneficial for households with limited financial resources [57]. This model eliminates cost fluctuations associated with seasonality or energy price increases, providing financial stability for households, especially for those with low incomes.

In Poland, the energy payment system works quite differently. Energy costs are separated from rent payments, and utility charges depend directly on energy consumption and current market prices. In practice, this means that households, especially those with low incomes, are exposed to greater fluctuations in energy costs, which can lead to a situation where they are unable to cover the cost of heating or electricity during periods of high demand or increases in energy prices. Sweden has been investing in improving the energy efficiency of buildings for decades, a key component of its policy against energy poverty. Stringent building standards and subsidy programs support the retrofitting of existing buildings and the installation of modern heating systems. As a result of these measures, Swedish buildings have low energy consumption for heating, which, combined with a warm rent system, significantly reduces the risk of energy poverty. In Poland, despite growing awareness of the need for energy modernization of buildings, progress in this area has been slower. Older buildings, especially in the residential sector, have low energy efficiency, which increases heating costs. Support programs, such as Clean Air ("Czyste Powietrze"), aim to improve the insulation of buildings and promote efficient technologies, but their effectiveness is limited due to complicated procedures and the lack of sufficient funding for the poorest social groups. Sweden has an extensive social support system that includes housing and heating allowances, which helps the poorest households cope with energy costs. In addition, financial support in energy retrofitting of buildings and the promotion of renewable energy sources, such as solar panels, supports citizens' long-term energy stability. In Poland, support for those in energy poverty is less developed. Although there are social programs and subsidies for energy retrofits, in practice they are not always used effectively by those most in need. As a result, many households, especially in rural areas, continue to face poor heating quality and high energy costs. It is also worth noting that there is greater environmental awareness in Sweden, which translates into broad acceptance of policies aimed at reducing energy consumption and transitioning to renewable energy sources. In Poland, on the other hand, the energy transition is more complicated due to a heavy reliance on coal and historical economic conditions. Energy costs are often seen as a barrier to household development, with the result that policies promoting energy conservation do not always meet with broad public support.

5. Conclusions

The energy transition poses distinct challenges for both Poland and Sweden in their efforts to address energy poverty. In Poland, the primary challenge is to strike a balance between alleviating energy poverty and transitioning to cleaner energy sources, given the country's heavy reliance on affordable coal. Additionally, overcoming economic and social resistance from coal-dependent communities remains a significant hurdle. However, opportunities exist, such as EU support through initiatives like the Just Transition Fund, as well as the growing potential for renewable energy development in solar and wind. In

Sweden, the key challenge in addressing energy poverty during the energy transition lies in maintaining energy affordability while achieving high levels of renewable energy integration. For both countries, there are also shared opportunities, including job creation in the green energy sector, technological innovations to reduce energy poverty, and the potential for cross-border collaboration on renewable energy projects among EU member states. In Poland, accelerating the energy transition will require a balanced approach that protects vulnerable populations. This can be achieved through subsidies, retraining programs for coal workers, and incentives for adopting renewable energy sources. Additionally, improving energy efficiency in housing should be prioritized through state-sponsored renovation initiatives. In Sweden, efforts should focus on continuing to support vulnerable groups with targeted welfare programs and expanding access to renewable energy in remote areas. Sweden can also play a key role in sharing best practices with other EU countries, including Poland, to help balance energy transition efforts with poverty reduction. Sweden can be an excellent model for Poland in addressing energy poverty. The "warm rent" system, which standardizes housing fees while channeling community budget surpluses toward thermal upgrades and maintaining building energy efficiency, could prove to be a highly effective tool in Poland's efforts to combat energy poverty.

Author Contributions: Conceptualization, O.J. and N.G.-C.; methodology, O.J. and N.G.-C.; software, O.J. and N.G.-C.; validation, O.J., N.G.-C., and J.K.; formal analysis, J.K.; investigation, O.J. and N.G.-C.; resources, O.J.; data curation, O.J. and N.G.-C.; writing—original draft preparation, O.J. and N.G.-C.; writing—review and editing, O.J., N.G.-C., and J.K.; visualization, O.J. and N.G.-C.; supervision, J.K.; project administration, J.K.; funding acquisition, J.K. All authors have read and agreed to the published version of the manuscript.

Funding: This research was funded by statutory of MEERI PAS and statutory of AGH and co-funded by the Sitarns project (Energy transition in coal regions).

Conflicts of Interest: The authors declare no conflict of interest.

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