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Energy/Fuel and human poverty: public policy and Recommendations in Southern Europe

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Table of contents

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List of Figures

List of Tables

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1. Introduction

Energy poverty is the inability to access sufficient, clean, and affordable household energy. It is a severe issue of global concern, affecting significantly high proportions of people worldwide. It is directly associated with human poverty.[1] Macroeconomically, economic growth is undoubtedly a key factor of energy poverty. Furthermore, inequality, high energy prices, low energy efficiency, and weak policy implications deteriorate the phenomenon. At the same time, energy poverty is associated with severe social impacts, hindering prosperity and development in the short and long run and favoring inequality. Physical and mental health, educational attainment, environmental quality, and other fundamental prosperity indicators, such as food security and transportation, are highly affected by energy poverty.

Identifying vulnerable households and accurately measuring energy poverty presents significant challenges. While indicators are designed to capture the extent of the problem and highlight areas of need, notable gaps and shortcomings still require attention. The chosen measurement methods must consider historical trends and regional variations, ensuring they are both straightforward and precise while offering meaningful insights for effective policy action. Societies require effective and inclusive means of addressing energy poverty. Collaboration between multidisciplinary academic fields is needed to cooperate with authorities and policymakers to apply sustainable and just policy. EU member states are required to evaluate and address energy poverty within their territories, incorporating findings into their National Energy and Climate Plans (NECPs). The 29 indicators introduced by the European Platform for Addressing Energy Poverty (EPAH) offer a more comprehensive framework for understanding and addressing this issue. These indicators provide a foundation for greater collaboration between academic researchers, government authorities, and policymakers, helping to safeguard a more coordinated and effective response to energy poverty across Europe.

The EFPORE-SE project investigates energy poverty concerns and provides targeted insights into South European countries (Greece, Italy, Spain, Portugal). Through the collection and analysis of data from each partner country, the project findings will reveal similarities and disparities between and within the nations involved. Its primary goals are to:

- develop strategies to assess energy poverty,
- identify vulnerable households in Southern Europe, and

[1] In this project, human poverty is proxied by the components of the AROPE (At Risk of Poverty or Social Exclusion) indicator, as defined in the EU-SILC dataset. The AROPE indicator combines three major dimensions: (i) relative income poverty, using the EU's at-risk-of-poverty threshold; (ii) enforced lack of socially perceived necessities, expressed by the severe material and social deprivation indicator; and (iii) weak labour market attachment, concerning population living in (quasi-)jobless households.

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- enhance public policies and approaches to address energy poverty issues.

This report (Deliverable D2.1) initially analyses the definitions and drivers of energy poverty in cross-country analysis. Next, it focuses on the severe social impacts of the subject and continues with the analysis of existing energy poverty indicators. The research team recognizes the emerging challenges following the initial energy poverty synergies analysis. In the next step, the European status is investigated, starting with the statistical analysis of the fundamental economic indicators. The European framework is thoroughly described in chronological order, aiming to capture the Union trends and the obligations of member states. Previous European energy poverty studies are presented, alongside an overview of its current state across the EU. Subsequently, a cross-country statistical comparative analysis focused on the EU-27 average and the Southern European countries occurred. This approach aims to provide a comprehensive overview of Southern Europe, which includes Greece, Italy, Spain, Portugal, Cyprus, and Malta, offering more holistic data for the region. Then, the report focuses on Southern European countries, providing a statistical investigation of energy poverty in all the South European countries, the specific status of each partner country, and previous works. Finally, the research gaps are identified.

2. Energy Poverty - definition and drivers

It is well known that energy poverty is a complex and multidimensional issue of global concern, affecting social welfare. It is perceived as unable to access sufficient, clean, affordable household energy. Developing countries struggle for sufficient access to modern energy, while developed nations cannot mitigate energy costs (Che et al., 2021; Faiella & Lavecchia, 2021). Regardless of a nation's level of development, energy remains the fundamental and essential requirement for meeting basic human needs. Simultaneously, energy poverty could be described as the inability to have socially and materially required levels of domestic energy services. It refers to a situation in which sufficient domestic warmth and other household energy needs cannot be satisfied.

According to the revised Energy Efficiency Directive (EU) 2023/1791, the official definition of energy poverty is as follows: "*'energy poverty' means a household's lack of access to essential energy services, where such services provide basic levels and decent standards of living and health, including adequate heating, hot water, cooling, lighting, and energy to power appliances, in the relevant national context, existing national social policy and other relevant national policies, caused by a combination of factors, including at least non-affordability, insufficient disposable income, high energy expenditure and poor energy efficiency of homes*". The 2030 Agenda for Sustainable Development adopted by the UN General Assembly in 2015 includes SDG 7, a stand-alone goal dedicated to energy. SDG 7 calls to "ensure access to affordable, reliable, sustainable and modern energy for all".

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Energy is central to the 2030 Sustainable Development Agenda and the Paris Climate Change Agreement.

The lack of sufficient, affordable, safe energy services leads to social injustice. A World Bank Voices Blog (2024) session dedicated to energy poverty clearly states that to end poverty, we first have to combat energy poverty. A simple and worrying fact concluded, argues that poor households are the least likely to have access to power, and if they stay unconnected, they are more likely to remain trapped in poverty. Even when electricity is unavailable, the power supply is not continuous, sustainable, and affordable. One-third of developing countries experience power outages and severely high electricity prices compared to the global average. Economic activity prerequisites are adequate, reliable, and affordable modern energy; otherwise, economic growth is not inclusive, and poverty cannot be addressed (World Bank Voices Blog, 2024).

Identifying people who experience poverty and combining the poverty gaps of various individuals to create a comprehensive index reflecting the overall severity of poverty consists of two respected challenges in poverty research. A plethora of poverty definitions are identified in poverty research and policy implication, which can all be categorized into one of the following groups:

i. Poverty is living with less than a clearly defined, absolute minimum standard (*absolute definition*). This approach can be subdivided as follows:

    - The basic needs approach assesses the absolute minimum expenditure in needs such as food, housing, and clothing and adds them up to determine a poverty threshold based on income.

    - Food/Income ratio: the proportion of income spent on food decreases as income rises. Being at the absolute minimum is represented by this ratio, such as 1/3.

    - The ratio of fixed costs to total household income. This definition is supported by the observation that many low-income households have faced substantial increases in fixed costs, primarily due to rising energy prices. As a result, even with stable income levels or social benefits, their net disposable income has dropped significantly. The ratio in Dutch policy is 0.50.

    - Total Expenditure/Income Ratio: defines poverty when current income cannot pay total expenditure (when the ratio is above one).

ii. Poverty is having less than others in society possess (*relative defi*nition). This second approach concerns what individuals or households possess in comparison to society.

These relative definitions encompass two types of definitions grounded in theories of relative deprivation: based on income or various commodities common in society.

iii. Poverty is experiencing a sense of insufficiency in managing daily life (absolute, relative, or a combination). This approach refers to the insufficiency in managing daily life, which is either income- or consumption-oriented. Definitions like the Subjective Minimum Income identifies poverty if actual income is less than the consensual "just sufficient" income. Definitions such as the Subjective Minimum Consumption examine the required amount to meet the self-reported essential needs and compare it with the actual expenditure (Hagenaars & De Vos, 1988).

Extreme poverty rose in 2020 due to the COVID-19 pandemic, reversing global progress by three years. However, by 2022, extreme poverty declined to pre-pandemic levels in upper-middle and high-income regions, contrary to low-income and low-middle countries. If current trends remain as they are, 590 million people will remain in extreme poverty by 2030 (UN SGDs report, 2024).

Globally, **economic growth** is undoubtedly a key factor of energy poverty. Regional economic levels are consistently associated with the phenomenon; high-income regions like Europe, Oceania, and North America are less affected by energy poverty than low-income regions like Sub-Saharan Africa, South Asia, and Central America (Che et al., 2021). According to the International Renewable Energy Agency, noticeable improvements have been observed globally from 2010 to 2019; people without access to electricity fell from 1.2 billion to 759 million, and access to clean cooking decreased from 3 billion people to 2.6 billion. However, the report suggests that efforts should increase significantly to reach 2030 targets (IRENA, 2021). Energy poverty is still a challenging problem worldwide, even within developed nations. In the USA, 27% of households experienced difficulties in meeting their energy needs in 2020 (EIA, 2020). Furthermore, in the EU, approximately 7% of its population had arrears on their utility bills, and 15% lived in dwellings with leakages, damp, or rot in 2020. Over 41 million people in the EU (9.3 % of its population) could not warm their homes adequately in 2022. In 2018, the poorest European households (i.e., the lowest 10 % income bracket) spent 8.3% (European Parliament research service, 2023).

Developing countries struggle with energy poverty primarily because of a lack of modern infrastructure that requires advanced technologies and high upfront costs, surpassing their financial and technological capabilities. Energy poverty convergence improves in Middle Eastern European countries, South America, the Caribbean, and Southeast Asia. These societies are characterized by transitioning economic structures, a shift toward cleaner energy consumption, and significant technological advancements. However, Central Asia, South Asia, and Africa present with lower improvements. Access to clean energy and modern cooking technologies is a severe problem in Sub-Saharan

Africa, Central Asia, and South Asia. In these countries, the key factors contributing to high energy poverty are insufficient power generation capacity, inadequate transmission and distribution infrastructure, high supply costs to remote areas, unaffordability of electricity, ineffective policies and inadequate regulations, insufficient planning and institutional support, and a lack of financing for off-grid entrepreneurship (Salman et al., 2022). Sub-Saharan African nations especially attract global interest in research due to increased worrying data; in 2019, more than 700 million people lived without access to electricity. Regional disparity is significant since urban areas have developed better electrification than rural regions (Ben Cheikh et al., 2023).

The fact that energy poverty is geographically unevenly distributed in developed and developing societies suggests that **inequality** is a critical factor influencing its occurrence. Apart from economic status, income inequality is also a major driver of energy poverty. The phenomenon is highly and differently affected by accessibility, reliability, and affordability, depending on income level. For example, accessibility and reliability impact more substantial energy poverty in cases of low-income countries. The effect of affordability worsens energy poverty in middle-income countries with high-income inequality. Furthermore, as economic growth improves, lower-income households experience less energy poverty under the accessibility dimension. On the other hand, as economic growth and income inequality increase, lower-income households suffer more profoundly from energy poverty under the affordability dimension (Igawa & Managi, 2022). Similarly, data from Catalonia (Belzunegui and Valls, 2020) show a close linkage between poverty and energy poverty. Concretely, the risk of energy poverty is up to five times higher among people at poverty risk.

Another critical determinant of energy poverty lies in high **energy prices**. Increasing energy costs can make it unaffordable for many households, especially in developing regions. As electricity prices rise, more households, especially low-income households, face incredible difficulty meeting their energy needs, pushing them further into energy poverty. This demonstrates the vulnerability of low-income households to energy price fluctuations, highlighting the need for policies that address energy affordability (Chai et al., 2021). More specifically, high energy prices significantly contribute to energy poverty by increasing the financial burden on households, particularly those with lower incomes, while affecting their economic stability and posing risks to their health and well-being. Addressing this issue requires comprehensive policies to reduce energy costs and support vulnerable communities.

Furthermore, **weak governance and lack of incentives** can negatively affect energy poverty. Insufficient support and poorly implemented policies may hinder energy access and affordability. Countries that have achieved or are close to achieving SDG 7 perform better in combating energy poverty than others. OECD nations have tried to alleviate this phenomenon, which is linked to policy areas. A range of horizontal projects

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and global initiatives in the OECD agenda help identify economic, social, and energy policy associations. All developed OECD countries have included vulnerable populations in their framework, and some of them, like the UK, Slovakia, Ireland, France, and Portugal (2024), have legislated energy poverty (Salman et al., 2022). Nevertheless, addressing price rises in the short run and accounting for energy risks is of questionable value in the long run.

Another key factor is **energy efficiency**. As highlighted earlier, energy plays a central role in the 2030 Agenda and is a core focus of the Paris Agreement on Climate Change (UN SGDs report, 2024). While there have been improvements in access to electricity for underprivileged populations, the growth rate of renewable energy adoption has not kept pace. Although energy efficiency has advanced in high-income nations, progress is also evident in the developing world. Decoupling economic growth from increasing energy demand requires the global implementation of energy efficiency technologies (World Bank Voices Blog, 2024). The European Commission argues that energy efficiency contributes to the overall reduction of energy consumption and is vital in meeting the EU's climate ambition without compromising present and future energy security and affordability. The revised Directive sets the "energy efficiency first" principle in the EU and its member states' policy agendas. Apart from complying with the commitment to the Global Pledge (double the global energy efficiency from 2% to more than 4% by 2030), the revised Energy Efficiency Directive contributes significantly to combating energy poverty (EU 2023/1791).

Furthermore, **several social and demographic factors** like gender inequality, lack of education, and limited awareness may impact energy poverty. Given that energy poverty can influence all aspects of life, it is essential to consider inequality, gender disparities, social progress, environmental factors, and ethnicity (Shahzad et al., 2022). Additionally, certain demographic factors such as gender, occupation, social class, and household size highlight vulnerability issues (Betto et al., 2020). The geographical dimension is also important (Bardazzi et al., 2021; Castaño-Rosa et al., 2020).

Concluding, improving economic conditions, alleviating poverty and inequality, investing in infrastructure, advanced technologies, and energy efficiency, and adopting supportive and inclusive policies are vital to ensure that all households have access to reliable and affordable energy.

3. Impacts on social life and challenges

According to UN statistics in Figure 1, globally, 685 million people lacked electricity access in 2022. People with no access increased for the first time in a decade by 10 million more compared to the previous year. Furthermore, 2.1 billion people use polluting and harmful fuels for cooking. Without faster progress, 660 million people will still have no access to electricity, and 1.8 billion will lack clean cooking technologies by 2030 (UN SGDs report,

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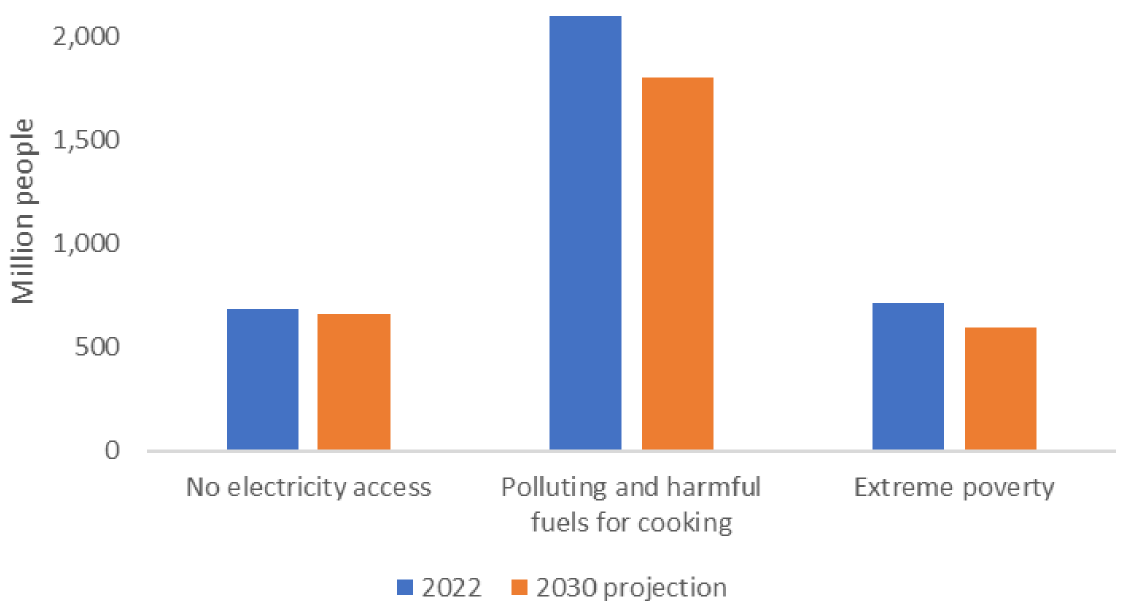
2024). Relying on polluting and harmful fuels for cooking leads to significant health risks, such as premature deaths and serious health concerns in the poorest countries in the world (IEA, 2023).

Figure 1: People with no electricity access, people with no clean fuels and technologies for cooking, and people in extreme poverty (globally): facts for 2022 and projections for 2030 if no progress is witnessed.



Source: (UN SGDs report, 2024)

Energy deprivation devastates societal and individual well-being, hindering overall prosperity and development. When essential human needs such as lighting, cooking, and adequately warming homes are mitigated, populations are exposed to severe hazards (Betto et al., 2020). The socioeconomic impacts of energy poverty are intertwined with economic progress in both the short and long run (Tundys et al., 2021). Energy poverty impacts all production sectors and constrains development potential. The agricultural sector is greatly affected in poor nations with low energy input. Progress is mitigated in all aspects of life and growth. Even a slight improvement could have significant benefits. Access to information and communication provides access to free, high-quality online training and promotes societal empowerment, which can foster micro-business growth. Even though the impact of energy infrastructure on development is challenging to measure, it is evident that the opportunities created by energy and new technologies cannot be utilized without it. The national human development index (HDI) and gross domestic product (GDP) are associated with energy consumption (González-Eguino, 2015). Energy poverty is highly associated with development and vice versa. Similarly, energy poverty and income inequality are bi-directionally related (Nguyen & Nasir, 2021).

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At this point, it should be pointed out that the existence of energy resources in a nation with high extraction and exporting activity should not be confused with reducing poverty and energy poverty. Whether the subsidies truly reach the poorest segments of society and can be sustained over time is doubted. For example, increased income from natural energy products resources in oil-exporting sub-Saharan Africa exists alongside overall poverty and energy poverty. Angola's oil revenues share of national GDP is high; nevertheless, most of its population (91%) rely on biomass, and just 9% of people living in rural areas access electricity. Even in countries like Gabon, which has some of the highest per capita GDP and HDI levels in Africa, access to modern energy sources remains significantly lower than in developed countries (González-Eguino, 2015).

Beyond insufficient income levels or limited energy consumption because of unaffordability, energy poverty hinders development by depriving vulnerable populations of the fundamental right to make choices and achieve overall prosperity. Energy is necessary to deliver essential human needs. It is linked to income generation and social justice. While electricity access may not be the primary factor in explaining poverty, greater access can offer poor households better opportunities to enhance their quality of life and surpass the poverty line. Access to energy can enhance human potential, enabling individuals to perform better in generating income and improving health and education (Sambodo & Novandra, 2019). Basic human needs such as cooking and keeping the home adequately warm are the apparent impacts of energy poverty. However, energy deprivation undermines several fundamental rights like health, prosperity, access to education, communication, information, and participation in politics, leaving vulnerable populations with no choices, which leads to restricted interaction with institutions and mitigates equal development (González-Eguino, 2015).

Energy poverty is negatively associated with education (González-Eguino, 2015; Oum, 2019; Sule et al., 2022) as it has deteriorating impacts on years of school attendance, school outcomes, and dropouts. Furthermore, the factors are interrelated since a low level of educational attainment generates poverty and creates educational inequality. Lower education impacts people's income (Katoch et al., 2024), while energy poverty severely affects health (Batool et al., 2023; Nawaz, 2021; Oliveras et al., 2021). The risks of reparatory and respiratory diseases, chronic illnesses, and asthma exacerbations are increased. Lacking modern energy and dependence on traditional fuel consumption are associated with injuries from fuelwood collection.

Furthermore, it leads to air pollution, which is related to premature deaths (IEA, 2023). Insufficient energy consumption is related to reduced life expectancy at birth, increased maternal and child mortality, malnutrition, and regular hospital visits. Moreover, not only physical health is undermined, but mental health too; energy poverty is associated with depression and other mental disorders (González-Eguino, 2015; Katoch et al., 2024; Nawaz, 2021; Oliveras et al., 2021). It is argued that psychological distress,

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substance abuse, and social capital are key mechanisms through which the impact of energy poverty contributes to physical violence (Lee & Yuan, 2024).

Additionally, energy poverty negatively affects further fundamental prosperity indicators such as food security and transportation(Owusu & Asumadu-Sarkodie, 2016). Environmental quality is also hindered since energy poverty accounts for significant greenhouse gas emission increases (Hassan et al., 2022). Energy poverty contributes to the rise in CO_2 emissions. In areas with severe energy poverty, there is a two-way causal relationship between energy poverty and CO_2 emissions. On the contrary, in regions with lower levels of energy poverty, the causality is one-directional, with energy poverty driving an increase in CO_2 emissions (Zhao et al., 2021).

4. Measuring energy poverty

Measuring energy poverty is challenging, complex, and multifaceted (Simcock et al., 2016). Energy poverty indicators are mandatory to identify vulnerable populations, understand various aspects of energy poverty, and capture the depth of persistence of the problem and the hidden energy poverty issue. Several indicators are employed in academic research, which can be categorized mainly into three distinct approaches: the objective, the subjective, and the direct methods. Objective indicators are income and energy expenditure oriented. The subjective approach lies in self-reported considerations concerning indoor energy services' conditions and the level of necessities that are met. The direct, scarcely employed approach compares the energy services achieved at home with standards (Herrero, 2017). Although these indicators have been widely used in literature and policy implications, academic research has recognized insufficiencies and gaps between them. All types of measuring energy poverty feature their advantages and disadvantages. Considerable gaps have been located in existing literature between energy poverty indicators. Classifying vulnerable populations according to one measuring tool does not necessarily coincide with different indicators. Policymakers and authorities must utilize comprehensive, unbiased, and inclusive metric approaches that provide robust data and thorough analysis that express the real problem to address energy poverty effectively and adequately. Further analysis of this aspect will be presented in Deliverables D.2.3 and D.3.1. That report will include a dedicated section covering and analyzing thoroughly the trends of energy poverty indicators.

5. Respected challenges

Energy poverty is associated with fundamental principles for human progress like prosperity and development, economic activity and growth, equality, access to education, health status, income generation and social justice, and environmental quality. Even though existing academic research has identified the major drivers that impact energy poverty occurrence, as well as the severe impacts of the problem, it is observed that the

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associations may be bi-directional. The causes of energy poverty lead to severe social impacts, which may generate new or deteriorate existing energy-poor instances. For example, high energy prices and low energy efficiency pose high risks of energy poverty, which worsens households' affordability, leading to less available income to meet other human needs. Furthermore, energy poverty is highly affected by inequality in several dimensions, resulting in further inequality between and within societies.

If recognizing the synergies of energy poverty is complicated, identifying vulnerable households and computing is an even more serious challenge. Although energy poverty indicators aim to capture the problem and illustrate the needs, some insufficiencies and gaps must be addressed. Investigating energy poverty and addressing the measurement should include thorough and targeted analysis with specific factors. First, the problem's historical development should be considered fundamental before proceeding to further analysis, which will reveal underlying factors. Secondly, data consolidation (aggregation and simplification) helps a more comprehensive and actionable process. Furthermore, regional and local investigation and innovative ways of presentation contribute to better understanding and reveal different aspects. These dimensions help provide concrete actions to address energy poverty through relevant policies and initiatives, concluding in a comprehensive framework.

The EU mandates EU member states to investigate and evaluate energy poverty in their territory and include it in their National Energy and Climate Plans. Additionally, in societies where energy poverty is a severe issue, national authorities must provide measures and policies to alleviate it. The 29 indicators introduced by EPAH contribute to a more holistic approach, which should be the foundation for greater collaboration between academic research, authorities, and policymakers.

The connections between energy poverty and several policy sectors, such as healthcare, employment, climate action, and social welfare, are increasingly acknowledged. However, the degree of integration across these areas differs significantly among European countries, shaped by national disparities and EU-level directives. Furthermore, recent progress highlights the connection between energy poverty and factors such as vulnerable populations, governance structures, and institutional accountability. This underscores the need to address systemic issues and promote equitable practices, like preventing unjust energy disconnections. Energy poverty arises from both infrastructural disparities and policy-driven influences. Effectively addressing the structural causes of energy poverty requires coordinated efforts and implementing consistent, integrated policies across various sectors (Stojilovska et al., 2022).

Consequently, capturing and measuring energy poverty in Southern European countries and providing practical policy recommendations is multidimensional. The research team must comprehend the structural differences through macro indicators and recognize trends and specific needs at a national or local level through previous studies. Then, the indicators' specifications should be adequate for the countries involved in the project. Alternatively, it may be concluded that differentiated measuring approaches should be adopted in each region, depending on each society's profile. Table 1 provides a comprehensive summary of the prominent and widely acknowledged challenges associated with investigating energy poverty, highlighting critical aspects that shape the discourse and research in this field, emphasizing critical barriers and complexities that influence both the understanding and mitigation of energy poverty across diverse contexts.

Table 1: Summary of respected challenges

Challenges	
High energy prices and low energy efficiency	Policy and governance challenges
Inequality in multiple dimensions	Integration across policy sectors
Difficulty in identifying vulnerable households	Structural and infrastructural disparities
Insufficient indicators and data gaps	National and local measurement differences
Need for historical analysis	Need for adaptable measurement approaches
Data consolidation challenges	EU directives and national policy gaps
Regional and local differences	Challenges in addressing vulnerable populations and institutional accountability
Lack of innovative presentation methods	Developing targeted, effective indicators

6. Energy poverty in Europe

6.1 A general picture of Europe

According to the European Commission, energy poverty occurs when a household is forced to reduce its energy usage to a level that adversely affects the health and well-being of its members. The condition is primarily driven by three underlying root causes:

- a high proportion of household expenditure is spent on energy
- low income
- low energy performance of buildings and appliances (European Commission-Energy poverty, 2024).

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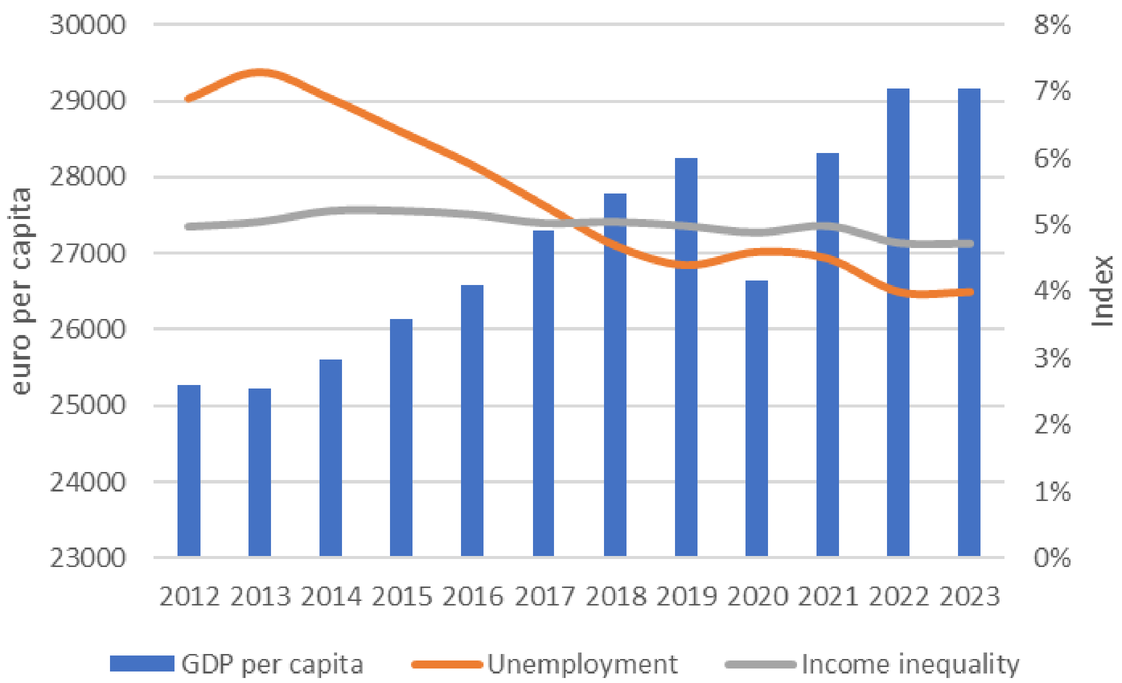
As observed in Figure 2, from 2012 to 2023, Europe experienced severe challenges, such as the economic and the COVID-19 pandemic crises, which had notable impacts on key economic indicators.

Figure 2: Economic indicators for EU-27 for 2012-2023.



Source: Eurostat 2024

After the first years of the deep economic crisis and up to 2019, the GDP of the EU-27 displayed a steady upward trend. However, in 2020, economic growth declined due to the pandemic effect, which eventually rebounded in 2021 and 2022, recovering its growth momentum. Similar considerations are derived from the unemployment rate, which is declining from 6.9% in 2012 to 4% by 2023. At the beginning of the period, the unemployment rate increased, reflecting the effect of the 2008 financial crisis on many EU-27 member states, which were still struggling with economic recovery and unemployment issues. Labor conditions gradually improved from 2015 up to 2019. Economic activity increased job creation, particularly in service-oriented sectors, providing beneficial conditions for the EU labor market. In 2020, with the onset of the COVID-19 pandemic, employment was affected by widespread lockdowns and economic disruptions. However, the labor market rebounded quickly in the following years.

Regarding income inequality, a modest decline is demonstrated from 2012 to 2023, with fluctuations caused by the financial crisis and the pandemic. More specifically, the aftermath of the economic crisis is depicted in the first years of the period examined and up to 2015 with an upward trend, showing the delayed impact of economic challenges

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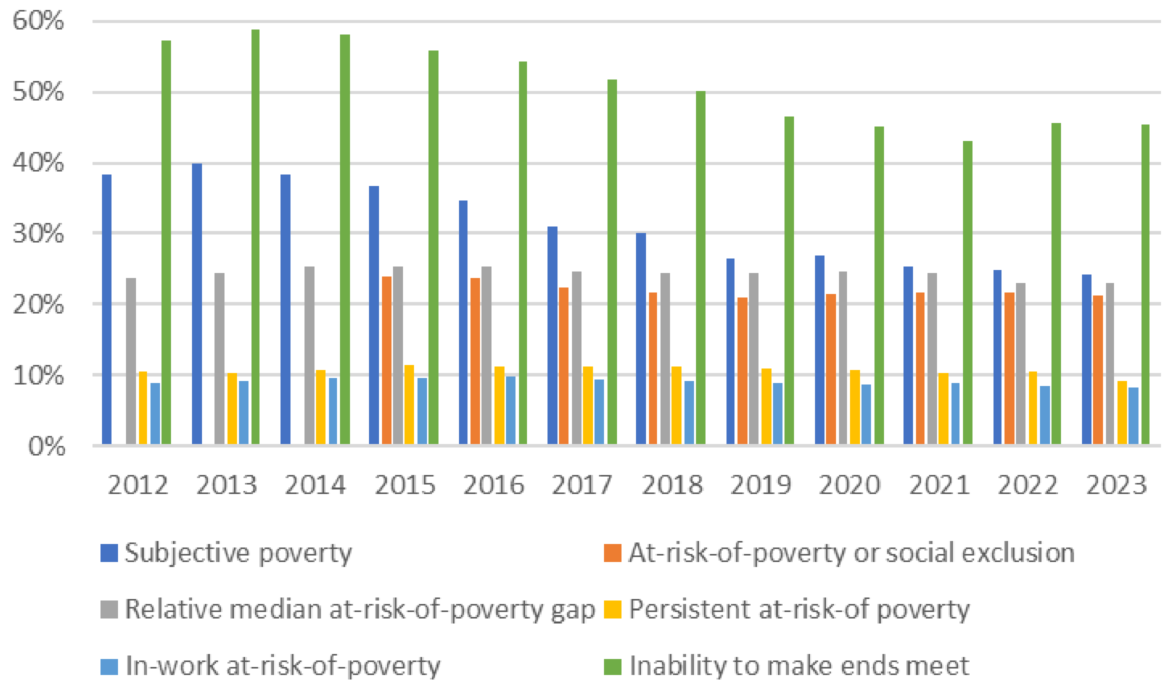
on income distribution across the EU. During this period, the gap between higher and lower income groups worsened, probably due to uneven recovery between member states. After 2015 and up to 2020, income distribution indicated signs of improvement, with an exception in 2018 with a slight increase. In 2021, the year after the pandemic, income inequality increased again, showing disparities in recovery from the economic shock of COVID-19. However, in the following years, income inequality was improved. Several indicators illustrating poverty status across the EU are presented in Figure 3.

Figure 3: Poverty indicators for EU-27, 2012-2023, Eurostat.



Source: Eurostat 2024

First, the "at-risk-of-poverty or social exclusion" is examined, which refers to people who are at risk of poverty (*disposable income below the risk-of-poverty threshold, which is set at 60 % of the national median equivalized disposable income*), or are severely materially deprived (*living conditions severely constrained by a lack of resources, experiencing at least seven out of thirteen deprivation items*), or living in households with very low work intensity (*aged 0-64 living in households where the adults (aged 18-64) worked a working time equal or less than 20% of their total combined work-time potential during the past year*). Persons in more than one of the three sub-indicators are only counted once. The indicator improved from 24% in 2015 to 21.1% in 2019. After experiencing minor negative and positive fluctuations in the subsequent years, the indicator stabilized at similar levels in 2023. The "Persistent at-risk-of-poverty rate" indicates the percentage of the population whose income was below the 'at-risk-of-poverty threshold' for the current year and at least 2 out of the preceding 3 years. Until

2015, the persistent poverty rate was increasing, remaining stable for the next three years and demonstrating the immense impact of the financial crisis. However, after 2015, the indicator presented a descending slope.

The indicator "Relative median at-risk-of-poverty gap" refers to the distance between the median income of persons below the at-risk-of-poverty threshold and the at-risk-of-poverty threshold, expressed as a percentage of the at-risk-of-poverty threshold. This threshold is set at 60% of the national median income of all people in a country and not for the entire EU. Up to 2016, the indicator shows an increasing trend, reaching the highest value of 25.4%. This value shows a severe income shortfall for people already at risk of poverty since the median income was 25.40% lower than the national poverty threshold. From 2017 to 2021, the indicator is relatively stable; from 2022, it presents a decrease to reach 23% in 2023 finally. The indicator "In-work-at-risk-of-poverty" considers the share of employed people whose income is below the risk-of-poverty threshold. A similar picture is illustrated here: the indicator increases up to 2016 and decreases the years after, with a slight exception in 2021.

Regarding consensual indicators, the subjective poverty metric presents a declining slope, starting with 38.9% of the people perceiving themselves as poor in 2013, which falls to 24.1% in 2023. Similar improvement rates are observed in the examination of the inability to make ends meet, with a gradual but consistent decline from 57.2% in 2012 to 45.4% in 2023. Nevertheless, the fact that almost 45% of the population still have difficulty, some difficulty, or great difficulty in making ends meet reveals that many households remain vulnerable to economic shocks and/or high living conditions.

6.2 EU Policy Framework

Energy poverty is a crucial concern in the current EU policy framework, and several regulations have been developed to combat it. In 2021, 6.9% of Europeans could not warm their homes. The proportion increased to 9.3% in 2022 and reached 10.6% in 2023 (European Commission-Energy Poverty, 2024). The EU approach is multifaceted, addressing short-term relief for low-income households and long-term strategies targeting improved energy efficiency of the building stock and equipment renewable energy integration while pursuing a just transition through structural reforms. EU policies emphasize energy efficiency while ensuring vulnerable consumers' protection and access to affordable energy in transitioning to a climate-neutral economy. Table 2 presents the EU framework and policies addressing energy poverty.

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Table 2: EU framework and policies addressing energy poverty

Year	EU policy	Basic description and association with energy poverty
2009	Directive (2009/72/EC)	The first EU law that introduced the concept of energy poverty.
2010	Energy Performance of Buildings Directive (EPBD) (2010/31/EU) recast of 2002 Directive	Aiming the energy efficiency improvement of buildings, it establishes standards for the energy performance of new or existing buildings, promotes energy-efficient renovations, and encourages nearly zero-energy buildings. It is undergoing further revisions to strengthen its role in meeting the EU's climate neutrality target by 2050 as part of the European Green Deal and the "Fit for 55" package.
2016	Winter package	Aiming to modernize the European energy system, it focused on affordable energy and better consumer protection (lower consumption, lower bills).
	Energy Poverty Observatory (EPOV) initiative	It aims to enhance knowledge about energy poverty in Europe. It collects data, shares best practices, and provides policy recommendations. and support strategies to mediate it. It also supports the development of indicators.
2017	European Pillar of Social Rights	A broader key social principles' framework (fair and improved well-being systems and labor markets, equal opportunities, education, and social inclusion). It recognizes energy as an essential need for everyone, including the support against forced evictions.
2019	European Green Deal	The main objective is to make Europe the first climate-neutral continent by 2050 while ensuring the transition is just, equitable, and inclusive.
	Clean energy for all Europeans package	The target is to decarbonize the energy systems in Europe to meet the Paris Agreement and achieve net-zero emissions by 2050. This energy rulebook introduces "energy efficiency first", emphasizing buildings' energy performance, explicitly focusing on vulnerable populations who should be prioritized in energy efficiency measures and programs. It also specifies member-states' obligation to submit their National Energy and Climate Plans.
	Renewable Energy Directive (2018/2001) (part of the package)	Promotes the use of renewable energy, contributing to lower energy expenditure.

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Year	**EU policy**	**Basic description and association with energy poverty**
	Electricity Directive (2019/944) (part of the package)	Requires member states to define energy poverty, evaluate its extent, and implement national plans to alleviate it. It also recommends measures for consumer protection (i.e., rules for disconnections and affordable pricing models).
	National Energy and Climate Plans (NECPs)	NECPs must include how member states will identify, monitor, and combat energy poverty, particularly enhancing energy efficiency and supporting vulnerable populations.
	EU Regulation 2018/1999	Defines that energy transition and climate targets included in national plans must include energy poverty alleviation
	The Just Transition Mechanism (part of the European Green Deal)	Provides financial support to regions and industries heavily dependent on fossil fuels, ensuring social fairness and shared prosperity and protecting vulnerable groups from energy transition disproportionate impact.
2020	Renovation Wave Strategy (part of the European Green Deal)	The initiative focuses i) on addressing energy poverty and worst-performing buildings, ii) on renovating public buildings, and iii) on decarbonizing heating or cooling. Particular focus is on the renovation of low-income households living in low-efficiency homes.
	Recommendation on energy poverty (EU/2020/1563) (as part of the Renovation Wave)	The Commission's first Recommendation on energy poverty supports energy poverty indicators, sharing good EU member states' practices and informing about EU funding programs pursuing measures for vulnerable populations.
	Fit for 55 package	Targets EU ambitious climate goals as part of the European Green Deal (55% minimum reduction of greenhouse gas emissions by 2030, compared to 1990, aiming for carbon neutrality by 2050).
2021	Launch of the Energy Poverty Advisory Hub (EPAH)	EPAH is the leading EU initiative aiming to alleviate energy poverty. It builds on the 'EU Energy Poverty Observatory' project (2016-2020) and drives forward a fair energy transition. The EPAH provides a platform for collaboration and knowledge-sharing among local and regional authorities. Also, it provides online resources and knowledge tools for diagnosing, measuring, and planning initiatives to address energy poverty at the local level, incorporating national and EU perspectives, including publications, interactive databases, courses, calls for assistance.

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Year	EU policy	Basic description and association with energy poverty
	Recommendation on energy poverty	Fit for 55 package specifies measures to recognize the key drivers of energy poverty vulnerability risk, highlighting inequalities and concrete solutions for those needing support.
	Tackling rising energy prices: a toolbox for action and support (EU/2021/660)	Aiming to confront the surge in energy prices. The communication involves various objectives concerning short- and medium-term initiatives at the state level, focusing on the groups that need support.
	Commission Energy Poverty Vulnerable Consumers Coordination Group (Decision EU/2022/589)	In order to develop collaboration between EU countries and exchange experiences on the ways they address energy poverty vulnerability.
2022	Social Climate Fund (Regulation EU/2023/955) (part of the Fit for 55 Package)	Aiming to provide funding to the EU countries concerning the support of vulnerable groups (households and micro-enterprises) This initiative involves investments that contribute to energy efficiency. It targets the social impacts of the EU Emissions Trading System (ETS), providing financial support for investments in energy efficiency, renewable energy, and clean transportation.
2023	Revised Energy Efficiency Directive on Energy Efficiency and amending Regulation (EU) 2023/955 (recast) ((EU) 2023/1791)	The Directive strengthens previous legislation to ensure 2030 and 2050 targets. It also introduces energy poverty definition and specifies means of identification and alleviating measures. It emphasizes increasing the energy efficiency of residences and public buildings, focusing on vulnerable groups. The regulation includes requirements for Member States to identify the most energy-poor and prioritize them in affiliated measures and programs.
	Recommendation on energy poverty (C/2023/4080) together with a guidance document (SWD 2023 647) and the renewed, Joint Declaration on enhanced consumer protection for the winter.	It addresses energy poverty by encouraging EU countries to adopt measures that safeguard affordable, accessible, and sustainable energy. The protection of vulnerable populations and enhanced energy efficiency to address energy poverty in the EU are fundamental principles. Detailed suggestions for EU nations on assessing, monitoring, and addressing energy poverty are provided. Implementing policies targeting decreasing energy poverty and promoting social inclusion, emphasizing vulnerable populations is provoked.

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Year	EU policy	Basic description and association with energy poverty
		Focusing on consumers' protection during winter, considering increased energy prices and high cost of living. It propagates particular support of vulnerable groups, accounting for safeguards against disconnections, transparent billing, and access to assistance programs.
2024	Energy Performance of Buildings Directive (EU/2024/1275)	It includes significant provisions addressing energy poverty, particularly for vulnerable households and those living in social housing. In their National Building Renovation Plans, specific measures refer to member states' plans for reducing people affected by energy poverty.
	The Electricity Market reform (Directive (EU) 2024/1711 and Regulation (EU) 2024/1747),	Aim to strengthen consumer rights, safeguarding clearer information and enhanced rights for the most vulnerable and those facing gas disconnection.

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The revised Energy Efficiency Directive (2023) strongly focuses on alleviating energy poverty. Its goal is to empower consumers by imposing stricter requirements on member states to enhance awareness, provide information about energy efficiency, and adopt specific measures to tackle energy poverty.

The recommended changes require member states to prioritize energy efficiency improvements for vulnerable groups, individuals facing energy poverty, and residents of social housing. Revenue from extending the EU Emissions Trading System to buildings and transport will be directed to the Social Climate Fund to minimize potential negative impacts. Under the energy savings obligation, each member state is responsible for securing some of its savings from vulnerable customers and those experiencing energy poverty. The criteria for setting these targets will be determined by each country, providing flexibility to develop solutions tailored to their specific national circumstances. It highlights the importance of establishing one-stop shops, offering technical and financial advice, and supporting consumer protection through out-of-court dispute resolution mechanisms. Additionally, it includes enhanced regulations aimed at identifying and eliminating barriers related to split incentives for energy efficiency renovations between tenants and owners or among multiple property owners.

All the above-mentioned policies and regulations are interconnected and part of a broader effort of the EU to address energy poverty, upgrade energy efficiency, and safeguard a just transition to a low-carbon society. The standard orientation of all these policies accounts for reducing energy consumption and bills while ensuring a fair transition. However, the EU strategy has faced criticism concerning effectiveness and implementation. Some analysts worry that the current economic system and transition could increase energy poverty (Bouzarovski & Tirado Herrero, 2017; Chester, 2014; Stojilovska et al., 2022). Low energy efficiency is considered a significant driver of energy poverty; however, high energy efficiency is critical to addressing it.

Nevertheless, although sustainable buildings decrease energy consumption and renewable energy mitigates greenhouse gas emissions, their cost is higher than conventional practices. Therefore, questioning how the energy transition will safeguard vulnerable households is a legitimate inquiry. Furthermore, energy poverty is differently expressed across European regions because of systematic inequalities and path dependencies. Consequently, it is important to examine the connection between energy poverty and other relevant policies in various European regions and establish how these policies combat all the aspects of energy poverty (Stojilovska et al., 2022).

6.3 Descriptive analysis of energy poverty indicators in Europe

Proceeding to energy poverty indicators, which are included in the EU-SILC survey and are available through the Eurostat database, the analysis delves into the different energy

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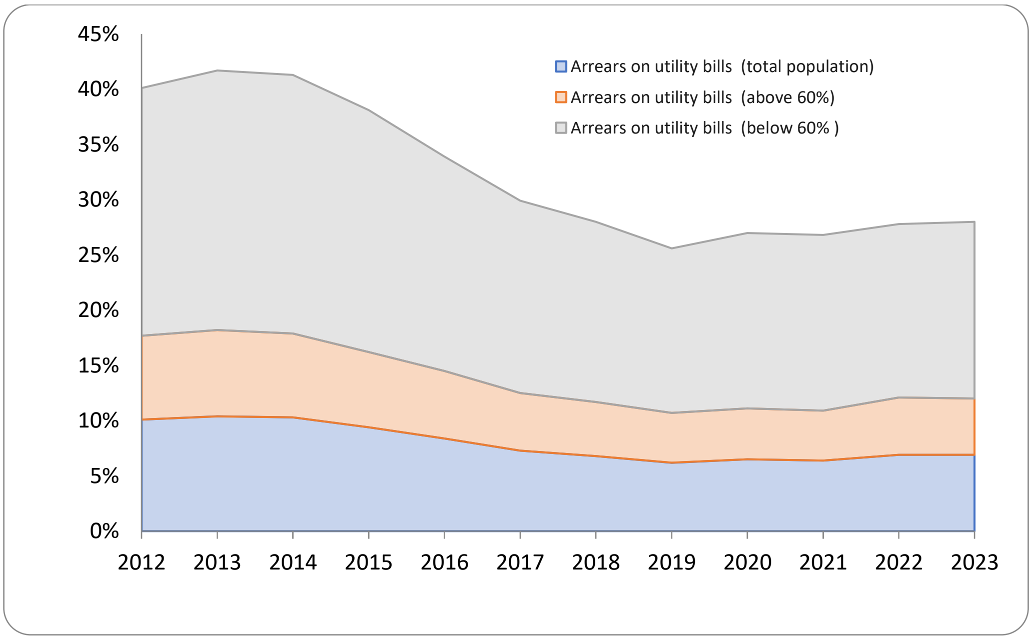
poverty occurrences between the three indicators "Arrears in utility bills", "Dwellings with damp, leakages, or rot", and "Inability to keep home adequately warm". Furthermore, to shed light on the economic determinant of energy poverty, each indicator is examined on the total population of EU-27, the people who are below the poverty line, and the people who are above the poverty line (i.e., this is important according to close linkages between energy poverty and poverty).

As observed in Figure 4 concerning the arrears indicator, 8% of the EU-27 population had utility bill arrears for 2012-2023. More than 18.5% of the people with arrears are below the poverty line, and almost 6% are above the poverty line. For all three subgroups, the indicator shows improvement until 2021, although it rises after that.

Figure 4: "Arrears in utility bills" for EU-27 for the total population, people below the poverty threshold, and people above the poverty threshold, 2012-2023.



Source: Eurostat 2024

The indicator "Living in dwellings with leakages, damp, or rot, " presented in Figure 5.[2] The indicator identifies a higher proportion of households in energy poverty. The mean value for the total population is almost 15%, while the value for people below the poverty line is more than 23%, and for those above the poverty line is approximately 13%. The indicator demonstrates a relatively stable trend from 2017-2019 for all income sub-groups, with a slight decrease.

[2] Linear interpolation was applied only to the macro data for the years 2021 and 2022.

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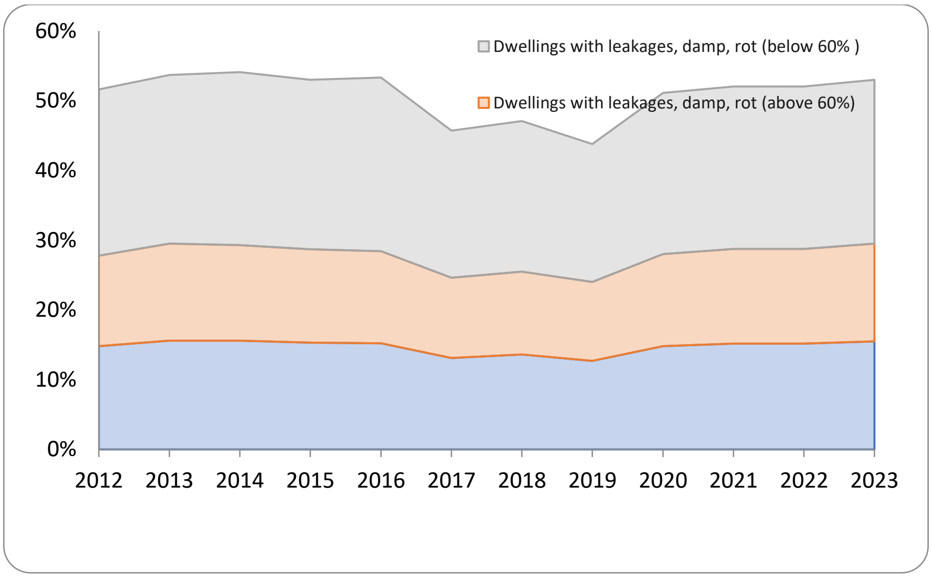
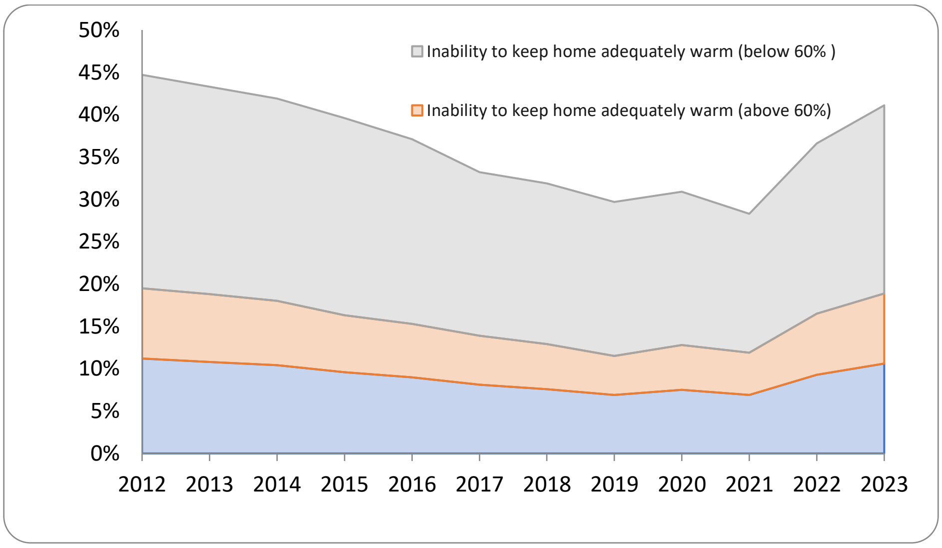
Figure 5: "Living in dwellings with leakages, damp, or rot" for EU-27 for the total population, people below the poverty threshold, and people above the poverty threshold, 2012-2023.



Source: Eurostat 2024

According to the average values of the indicator "Inability to keep home adequately warm", presented in Figure 6, 9% of the total EU-27 population could not keep their home warm, 21% are below the poverty line, and 6.5% are above. Even though the indicator presented a declining trend during the period examined, after 2020, it started increasing.

Figure 6: "Inability to keep home adequately warm" for EU-27 for the total population, people below the poverty threshold, and people above the poverty threshold, 2012-2023.



Source: Eurostat 2024

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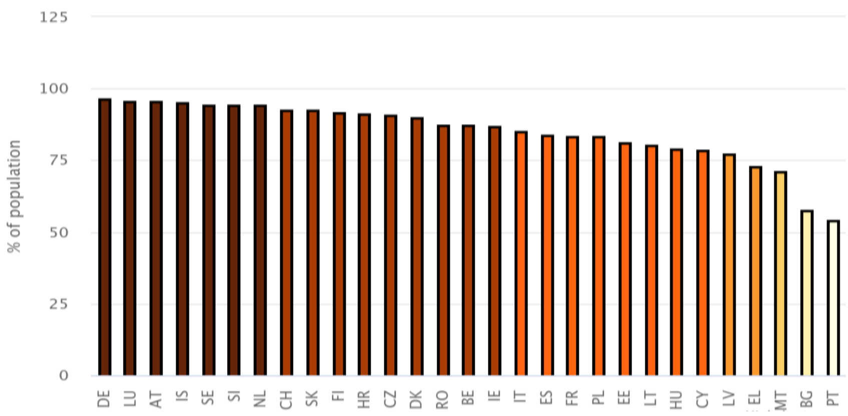
Significant information can also be retrieved from the EPAH (EPAH dashboard). The indicator concerning the percentage of people living in homes comfortably warm (for 2012) is presented in Figure 7 and demonstrates that Portugal (54.0%) and Bulgaria (57.7%), are least comfortable during warm, followed by Malta (71.1%) and Greece (72.8%), showing vulnerability in the South of Europe. On the other hand, in Germany, Luxemburg, and Austria, more than 95% of their populations dwell in warm residences despite colder climatic conditions.

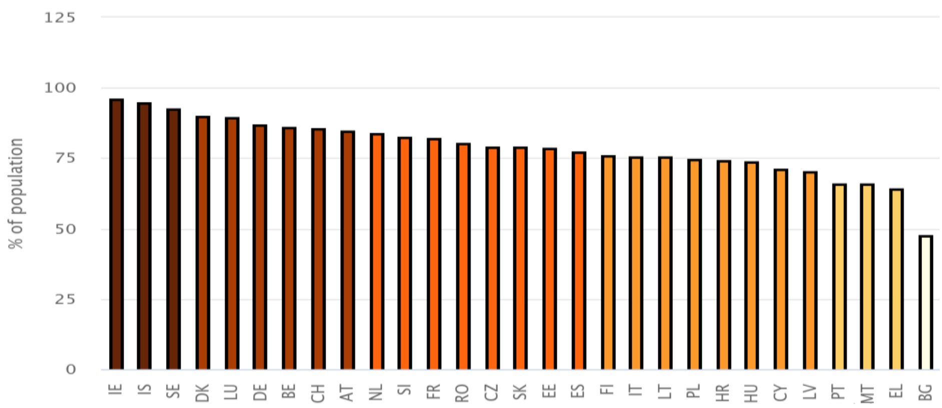
Figure 7: Population living in dwellings comfortably warm in winter (2012).



Source: EPAH dashboard, 2024

Another critical aspect of energy poverty is the ability to keep homes adequately cool during the summer months. This is particularly significant in Southern European countries, where higher summer temperatures exacerbate the challenge. Figure 8 presents the proportions of people living comfortably cool during summer. It is observed that Bulgaria has the lowest record (47.1%), followed by Greece (64.1%), Malta (65.9%), and Portugal (66.0%).

Figure 8: Population living in dwellings comfortably cool in summer (2012).



Source: EPAH dashboard, 2024

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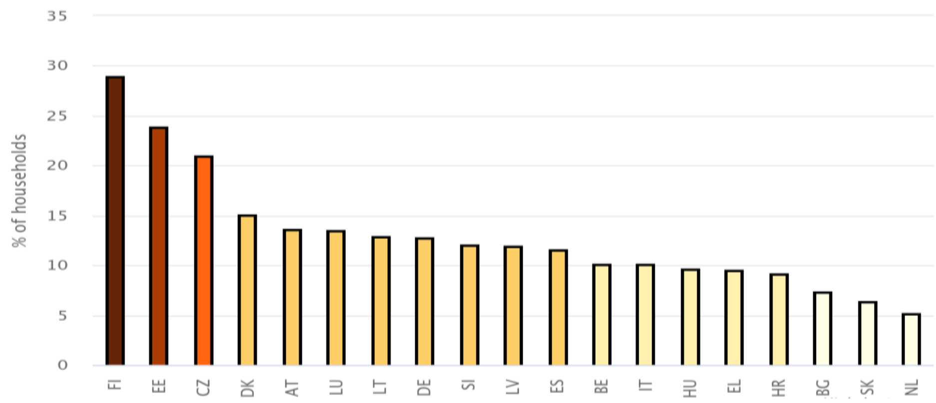
An analysis of the objective indicators related to energy expenditure, as shown in Figure 9, reveals that Finland (29.0%), Estonia (23.9%), and the Czech Republic (20.9%) have the highest proportions of low absolute energy expenditure (M/2). In contrast, the Netherlands (5.2%), Slovakia (6.4%), Bulgaria (7.4%), Croatia (9.1%), Greece (9.5%), and Hungary (9.7%) exhibit the lowest proportions.

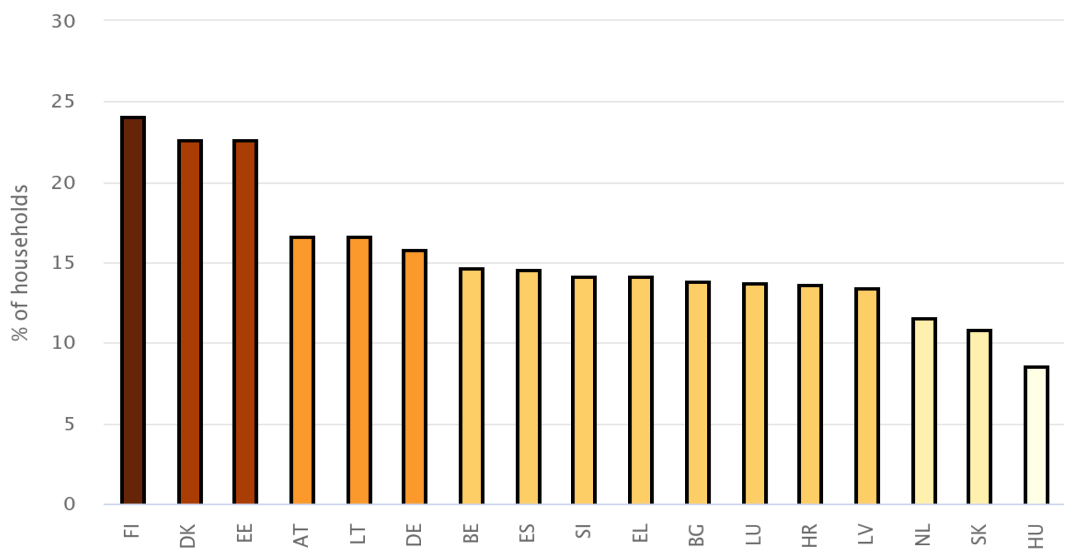
Figure 9: Population with low energy expenditure (M/2) (2020).



Source: EPAH dashboard, 2024

Regarding the indicator for populations with high energy expenditure relative to income (2M), Figure 10 shows that Finland (24.1%), Estonia (22.6%), and Denmark (22.7%) have the highest proportions, while Hungary (8.6%), Slovakia (10.9%), and the Netherlands (11.5%) have the lowest.

Figure 10: Population with high energy expenditure in income (2M) (2020).



Source: EPAH dashboard, 2024

The fact that Finland and Estonia rank among the highest proportions for both indicators demonstrates the complexity of energy poverty, influenced by economic inequality, energy pricing, and climatic demands. The high ratios in the 2/M indicator could be attributed to relatively efficient energy systems or lower energy costs, enabling the population to maintain energy expenditures below a specific threshold. However, it may also suggest economic disparities where a notable group cannot afford more energy, potentially reflecting constrained energy use despite harsh winters. The data concerning the 2M indicator illustrate that cold climates require extensive heating, which, alongside energy pricing structures, may disproportionately impact certain income groups. The finding indicates energy affordability challenges, particularly for vulnerable populations, even in relatively wealthy countries like Finland.

7. Energy poverty in Southern Europe

7.1 A general picture of South European countries

To provide a more precise context for analyzing energy poverty in Southern European countries, Table 3 presents a comparative overview of key socioeconomic indicators: GDP, income inequality, unemployment rate, jobless households, tertiary education attainment, and the in-work at-risk-of-poverty rate—for Southern Europe and the EU-27. This comparison highlights regional disparities and underlying structural factors that influence energy poverty. First, analyzing economic growth, it is observed that EU-27 has a high mean GDP per capita (mean value at 27,119 € with low deviation), indicating a more consistent economic performance across its member states. Southern Europe has a lower economic dynamism (mean value 21,886 €), probably due to economic challenges and slower recovery from the financial crisis, with much higher deviation, showing more significant variability in economic conditions and regional disparities. Similar indications are revealed from the income inequality measure. The EU presents lower income inequality at 5% with a slight deviation, compared to 5.5% in the South, with more significant variability between the countries of the group. Therefore, it could be concluded that Southern Europe faces higher and more uneven income inequality, which may be linked to economic instability and regional differences in wealth distribution.

Furthermore, EU-27 shows relative stability in labor markets, with an unemployment rate of 5.4%. In comparison, South European countries have a significantly higher unemployment rate at 7.8%, with a wide deviation, reflecting more severe and varying unemployment issues. This could be attributed to more significant structural problems and slower economic growth. The associated indicator of jobless households is similar in both groups (approximately 10%), which is a worrying proportion. However, the standard deviation is much more prominent in the southern countries, indicating that some countries' labor market faces significant challenges.

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Concerning the fact that working people are still at risk of poverty, the EU-27 rate is 9.12% with a slight deviation. South European rates are higher with wider deviations, reflecting disparities in labor market conditions such as wages, job security, and policies. People who have attained tertiary education are 28.5% of Europeans and 27.5% of citizens in southern countries. However, the deviation for the southern countries is much higher, showing unequal access to higher education, which may impact labor market outcomes.

Table 3: Socioeconomic factors of EU-27 and South European countries (2012-2023).

	EU 27		**South European countries**	
Variables	***Mean***	***St. Dev.***	***Mean***	***St. Dev.***
GDP per capita	27,119	1,424.83	21,866	3,923
Income inequality	5.00%	0.16%	5.44%	0.81%
Unemployment rate	5.41%	1.21%	7.74%	3.67%
Jobless households	9.72%	1.11%	10.05%	3.65%
Tertiary education	28.51%	2.66%	27.56%	8.92%
In-work at-risk-of-poverty rate	9.12%	0.47%	10.04%	2.55%

Source: Eurostat 2024

Overall, Southern Europe has lower economic growth, educational attainment, unemployment, unequal income distribution, and a higher risk of in-work poverty than the broader EU-27 mean. Additionally, more significant variability is observed within Southern Europe, implying that some countries face much worse economic and social stability than others. Figure 11 illustrates the growth rate trends for the EU-27 and Southern Europe from 2012 to 2023, highlighting regional variations and overall patterns of economic development during this timeframe. The growth rate reveals that the EU follows more stable patterns, with fewer extreme changes during downturns and recoveries. Southern Europe experiences a more unstable growth rate, with sharper contractions during shocks but more substantial recoveries afterward. As a result of the financial crisis, both regions experienced negative economic growth in 2012, although Southern Europe was more severely affected. Although during 2013, there was a slight improvement in economic contraction, both regions still had negative growth. 2014-2019 depicts a recovery period with positive growth, peaking in 2017 for both regions. However, with higher growth rates, the EU experienced steadier growth than the South European countries.

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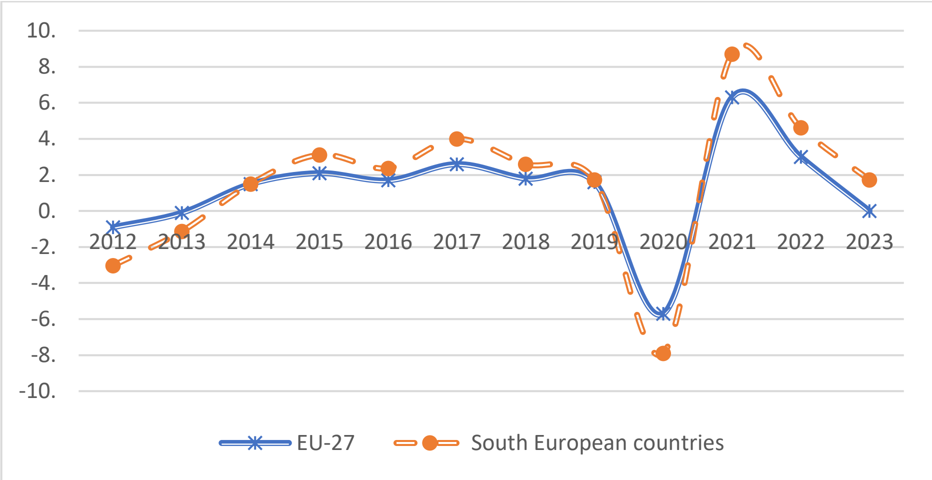
However, in 2020, both regions faced severe contractions. EU-27 shrank by -5.7% and South Europe by almost -8%. However, the rebound from the pandemic was substantial the year after, with 6.3% growth for the EU and almost 9% for the southern countries. Afterward, both regions continued to grow but at slower rates.

Figure 11: Growth rate in EU-27 and Southern European countries (2012-2023).



Source: Eurostat 2024

Overall, it is demonstrated that Southern European countries may be more resilient in recovery phases; they seem more vulnerable to economic shocks, probably due to structural differences and challenges. Consequently, exploring the incidence of poverty across the EU and the Southern European countries is expected to shed light on regional disparities.

As observed in Figure 12, the average percentage of people at risk of poverty is 22% for the EU and 24% for the southern countries. Up to 2018-2019, the indicator has been descending, showing a recovery from the economic crisis. However, 2020 and 2021 depict the pandemic effect, with an increasing trend in both regions. The proportion of people living in poverty has slightly declined in the years after.

The indicator "Relative median at-risk-of-poverty gap" is similar for both regions, standing at about 24%, showing that in both areas, the income of people at risk of poverty is 24% lower than the poverty line. The "Persistent at-risk-of-poverty rate" indicator demonstrates that, on average, 10.8% of the European population is vulnerable to poverty, while the value for the southern countries is higher (12%). 2015 was the year with the highest value for both areas.

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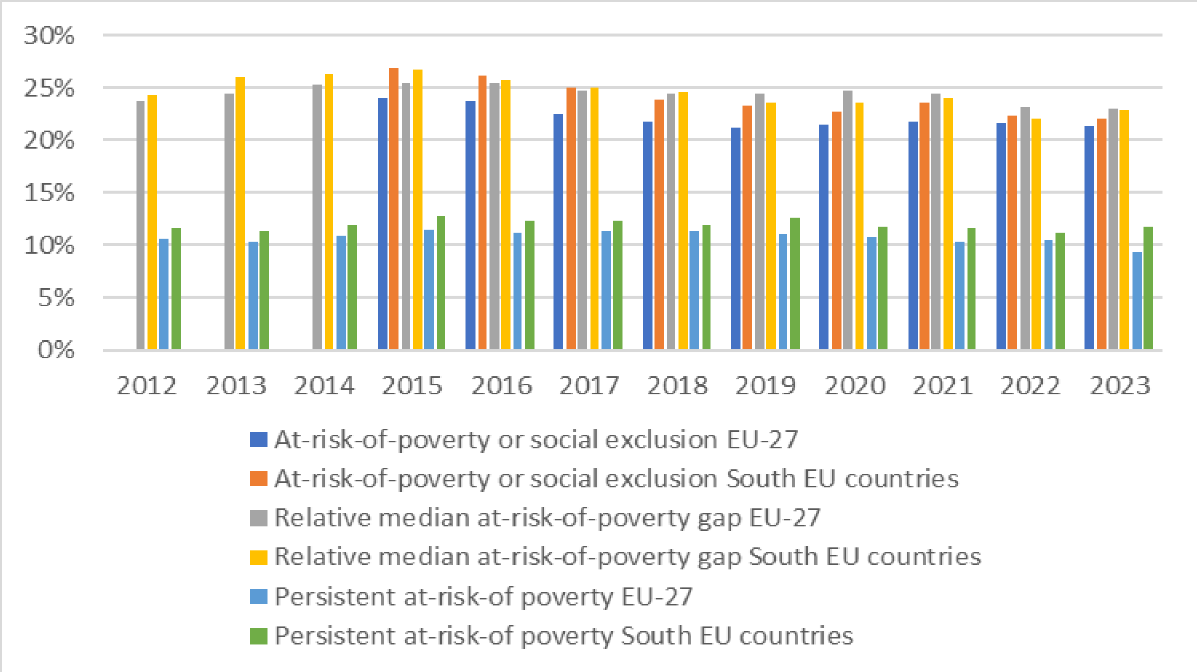
Figure 12: Poverty indicators for the EU-27 and Southern European countries (2012-2023).



Source: Eurostat 2024

The consensual-based poverty indicators in Figure 13 present higher proportions of people who perceive themselves to experience poverty. Furthermore, more significant differences are observed between the two regions. According to the subjective poverty indicator, 31.4% of EU citizens and 38.5% of Southern Europeans perceive their living conditions as poverty. During 2012-2015, the relative proportions were almost 40% for EU-27 and almost 50% for South Europe, indicating a significant percentage, approximately half of the population, experience severe poverty risk.

The second indicator refers to the inability to make ends meet, being that 51% of the EU-27 population finds it difficult to make ends meet, while the value for the southern countries is considerably higher, reaching 69% of their population. This outcome indicates the more critical financial strain Southern European economies face compared to the EU-27 average. This also highlights the contrast between the financial situation in Southern Europe and the broader EU-27. It reflects the region's deeper economic issues and structural weaknesses, like lower economic growth, salaries, unemployment, and inequality. It is clearly demonstrated that it is harder for a large portion of the population in Southern Europe to cover their essential needs.

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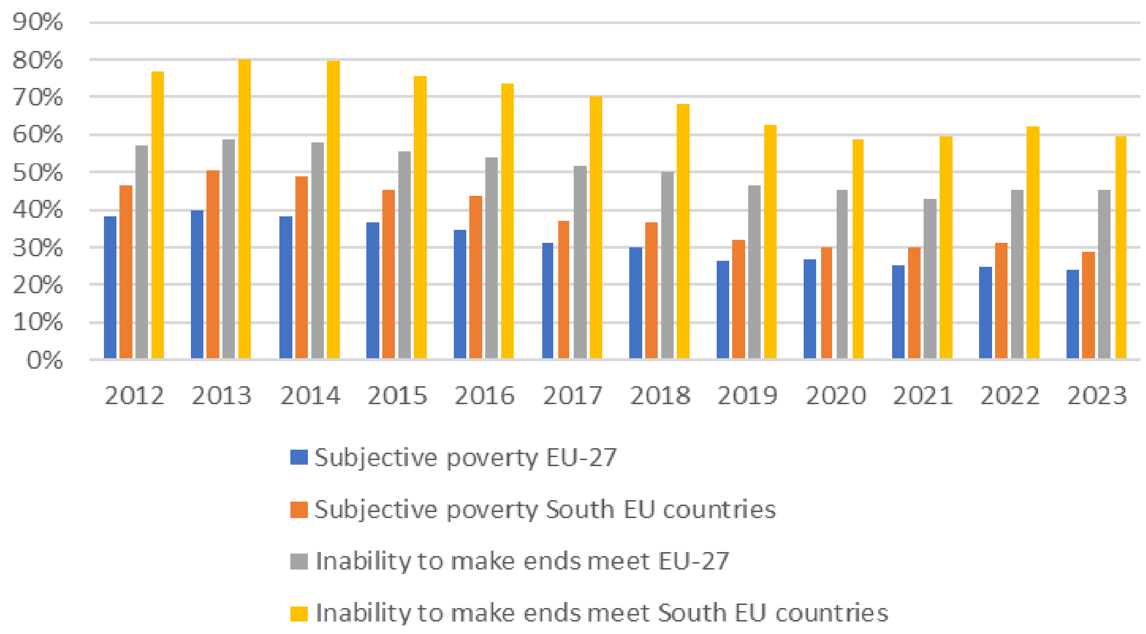
Figure 13: Consensual poverty indicators for the EU-27 and Southern European countries (2012-2023).



Source: Eurostat 2024

Apart from the socioeconomic determinants that shape energy poverty occurrence, some general energy parameters reveal households' habits and needs. Energy cost and energy consumption are essential considerations when investigating energy poverty. The electricity prices are quite similar for both regions. However, energy expenditure and energy consumption differ. The average consumption for 2012-2022 is 566 kilograms of oil equivalent per capita for EU-27 and 350 kilograms per capita for southern countries. Consequently, energy consumption expenditure is higher for the broader EU region, at 689 € per capita and 493 € per capita for the southern countries.

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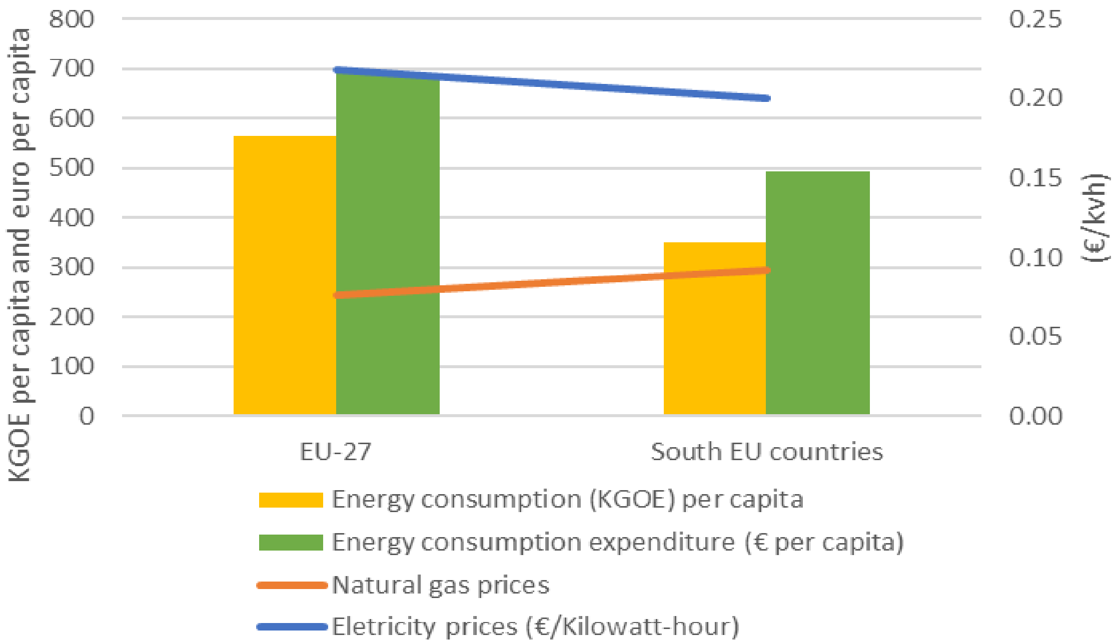
Figure 14: Electricity prices, energy consumption, and energy expenditure for EU-27 and South European countries (2012-2022).



Source: Eurostat 2024

This outcome is reasonable since central and northern European countries have colder climates, and their energy needs are higher compared to southern countries for the winter months. However, it should be considered that Southern Europe faces hotter climatic conditions during the summer, with significant added needs for air conditioning. These considerations are illustrated in Figure 15. The average heating degree days value for the EU-27 is almost 3,000, while for the Southern part of Europe, the value is lower than half (1,200 days). On the contrary, the average cooling degree days for the EU-27 value is almost 105, and the respective value for South Europe is more than 4 times higher (425).

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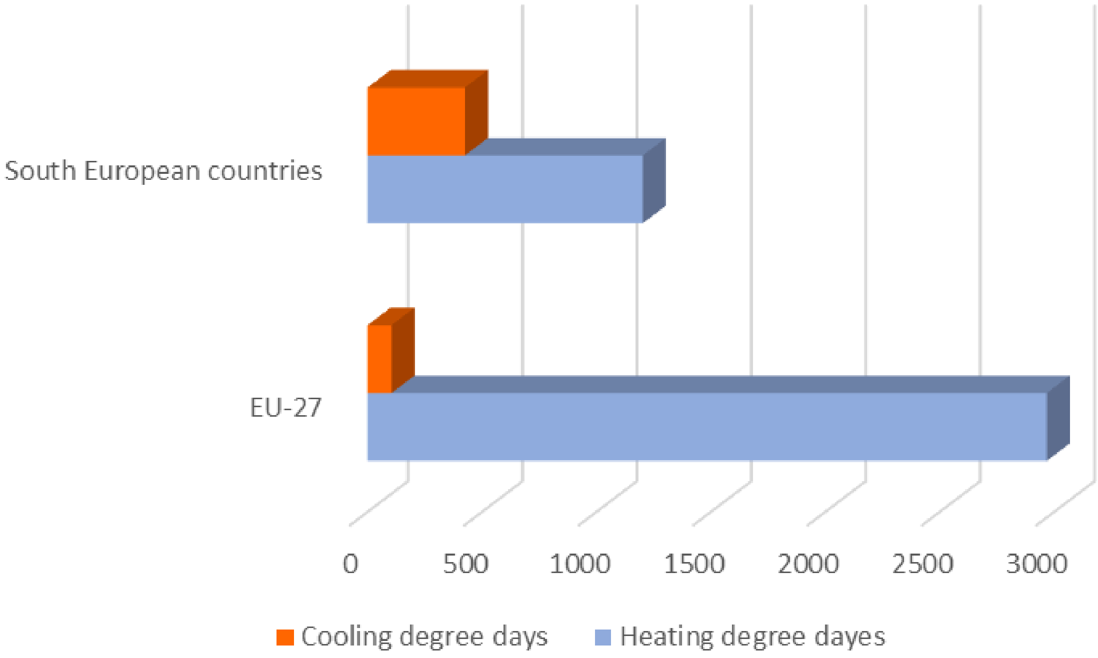
Figure 15: Average heating and cooling degree days for EU-27 and South European countries (2012-2023), Eurostat.



Source: Eurostat 2024

Therefore, it is profound that Southern European countries have different energy needs than the rest of Europe. Parameters like energy efficiency and intensity should be examined to shed further light on the energy sector. As illustrated in Figure 16, EU-27 and Southern European countries have similar energy efficiency indexes (final energy consumption index, 2005=100). The EU-27 score is 92.7, and the average for Southern European countries is slightly lower at 91.8, indicating a marginal difference in energy efficiency. The spatial analysis reveals that Greece is the least energy-efficient country at 75.9, significantly below the EU-27 average and the southern countries. This indicates that Greece lags significantly behind and implies that there is enough room for improvement. Spain and Italy have similar scores (83.40 and 83.60 respectively), and Portugal reaches 85. All these countries are also below the EU-27 average, suggesting potential areas for improvement. Consequently, the broader southern countries of Europe present similar energy efficiency with the EU; however, Greece, Spain, Italy, and Portugal need to prioritize energy efficiency improvements more than others.

Interesting findings are derived concerning households' energy efficiency while examining the percentage of the population living in dwellings whose energy efficiency has improved during the last 5 years. Almost a quarter of the residences across the EU have been upgraded with better energy performance in the past 5 years. Unfortunately, the average for Southern European countries is significantly lower, at 15.5%. Like its

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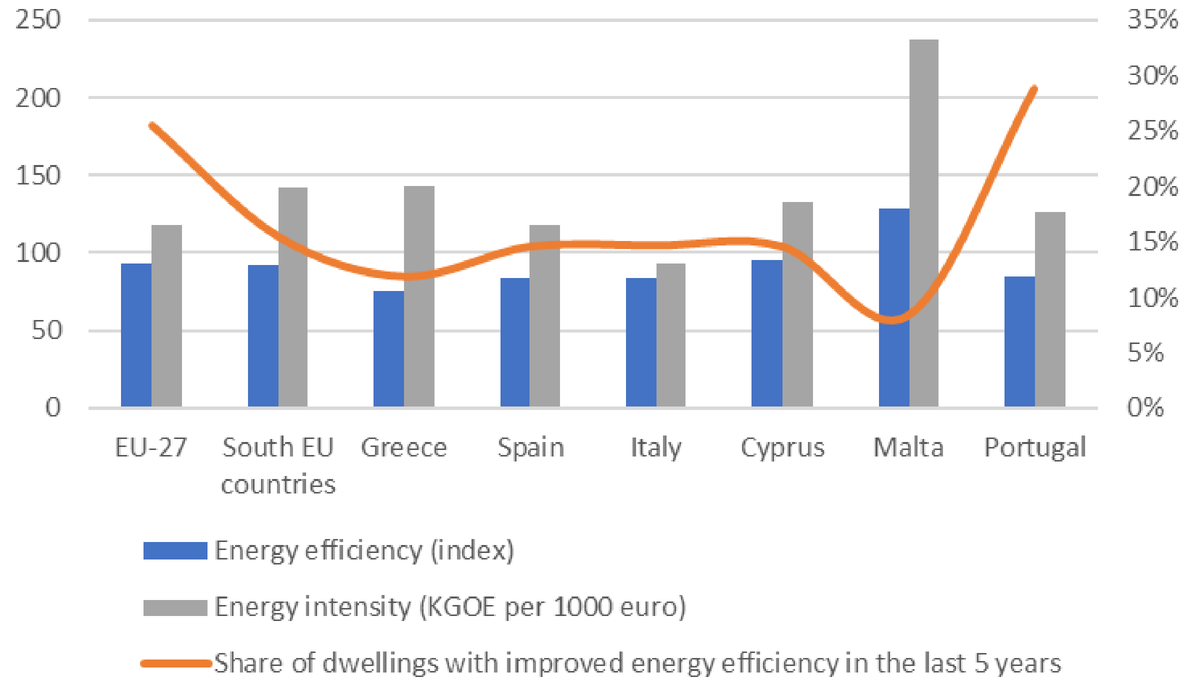
energy efficiency index, Greece has the lowest share, with only 11.9% of dwellings having improved their energy efficiency, highlighting a delay in adopting energy efficiency measures. Spain and Italy present similar figures (14.6% and 14.7% respectively), also below the average of southern countries and well below the EU-27 average. On the other hand, Portugal stands out, with 28.8% of its dwellings having improved their energy efficiency, exceeding both the EU-27 and southern countries. This demonstrates that Portugal has been more proactive in improving its building stock energy efficiency.

Figure 16: Energy efficiency, percentage of dwellings that have improved energy efficiency in the last 5 years, and energy intensity.



Source: Eurostat 2024

As far as energy intensity (*energy intensity of GDP in chain-linked volumes 2015 measured in kilograms of oil equivalent per thousand euro*) is concerned, it is demonstrated that the average EU-27 is 117.6. The respective value for the average for Southern European countries is significantly higher at 141.8, implying that these regions use more energy relative to their economic output. Southern Europe exhibits higher energy intensity, suggesting a higher need for energy to produce the same economic output as the EU-27. Greece is again in the worst situation among this group of countries since its energy intensity is 142.9, above the average values of the southern countries and well above the EU-27 average. The second worst observation is for Portugal, at 126.6, which is higher than the EU-27 average but lower than the Southern European average. Spain's energy intensity is 118, close to the EU-27 average. Italy has the lowest energy intensity

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at 93.3, far below the Southern European average and the EU-27, reflecting efficient energy use.

7.2 Literature review focused on Southern European countries

As mentioned, Southern and Eastern European countries are greatly affected by energy poverty compared with the rest of the continent. Although significantly milder winter climatic conditions characterize South European regions, these societies seem to suffer deeper in meeting their energy needs. The highest levels of energy poverty are observed in the Balkans. In some cases, like Greece, energy poverty has become a severe social concern, where for the period 2011-2016, the country presented the highest increase among all European countries. Despite the reduction noticed between 2017 and 2019, energy poverty levels in 2019 (before the COVID-19 pandemic and after the financial crisis) were still higher than in 2004 (Halkos & Gkampoura, 2021). This situation is similar to that of Spain, where (according to data from Eurostat) in 2011, 6.5% of Spanish households could not maintain adequate warmth at home. However, this percentage increased to 14.2% in 10 years, which implies a much higher level than those targeted by the Spanish government for 2025, according to the Spanish National Strategy against Energy Poverty (MITERD, 2019).

Additionally, this negative situation tends to worsen in counter-cyclic periods (Costa et al., 2024), which generates extra difficulties when there are sharp declines in GDP levels. Similarly, (Bollino & Botti, 2017) revealed that Eastern and Southern European countries suffer significantly from energy poverty. The most significant determinants lie in low incomes, the type of dwellings, the location of the residence, and low population density. Furthermore, gender, age, and migration background influence the phenomenon. The analysis of (Karpinska & Śmiech, 2021) reveals that Bulgaria and Greece are in the EU group with the highest risk of permanent energy poverty, with a retention rate of 80%, while Italy, Malta, and Spain have the lowest retention rate group at 30%, while the European average is 51.5%. As in international literature, academic research on Southern European countries argues that noticeable gaps have been found between the energy poverty indicators. An analysis concerning the Iberian context highlighted that both subjective and objective approaches could benefit from broadening their scope and improving inclusivity. Hidden energy poverty, depth of vulnerability, and persistent energy poverty should be further investigated (Palma et al., 2024).

Hidden energy poverty is a critical issue that needs to be addressed, especially for southern European countries. The main drivers of energy poverty are low income, increased energy costs, and buildings with low energy efficiency, which lead vulnerable consumers to two difficult conditions. The first is derived from increased consumption, forcing them to deal with high energy bills beyond their financial capability. On the other hand, sometimes vulnerable households prefer to reduce consumption due to

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unaffordability. The second condition involving low-energy bills is a severe social phenomenon, which refers to hidden energy poverty. This subcategory of energy-poor households is often challenging to measure, especially in cases where expenditure-based indicators are employed.

Furthermore, data concerning disconnections or power reductions may not reveal the actual situation because households suffering from hidden energy poverty may reduce their consumption proactively before reaching the point of disconnection. These households have to struggle with cold homes during winter. This challenge is more common in Mediterranean countries than in Northern Europe because milder winters in Southern Europe make it easier to endure lower indoor temperatures than the harsher climatic conditions in the Northern European countries (Betto et al., 2020).

Table 4 presents an overview of representative and recent studies on the energy poverty field in Southern European countries, offering insights into each region's unique challenges and specific needs. Key contributions to the literature are summarized while reflecting the diversity of research in this area.

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Table 4: Overview of recent studies on Energy Poverty in Southern European Countries.

Author(s), Year	Title	Time	Region	Objective	Key Findings
(Karpinska & Śmiech, 2021)	Escaping Energy Poverty: A Comparative Analysis of 17 European Countries	2015–2018	17 European countries	Examination of the dynamics of energy poverty based on the EU SILC data. Investigation of households' probabilities of transitioning in and out of energy poverty in each country.	The probability of staying in energy poverty is 51.5%. Much heterogeneity across countries is found. Bulgaria, Greece, Romania, and Lithuania are quite close to the energy poverty trap. Demographic, technical, and socio-economic factors are the determinants of escaping energy poverty.
(Atsalis et al., 2016)	Fuel poverty in Greece: Quantitative analysis and implications for policy	2003-2014	Greece	Implementing a preliminary assessment of energy poverty (subjective and objective approaches employed) and analyzing the potential effects of energy poverty on public health in quantitative terms through statistical analysis.	According to objective approaches, 20–25% of Greek households were in fuel poverty in 2013. Under the subjective measures, the proportions reach 29.5%, twice as high as in 2010. The increased levels of fuel poverty after 2010 had significant negative impacts on public health (1–2.7% of deaths, 2.7–7.4% of cardiovascular diseases and 3.1–8.5% of respiratory infections were attributed to fuel poverty.
(Papada & Kaliampakos, 2016)	Measuring energy poverty in Greece	2015	Greece	Aiming to highlight the great vulnerability of Greek households on energy poverty, in the middle of a severe economic crisis, the study employs a primary survey recording objective and subjective data.	According to the objective expenditure approach, 58% of the Greek population and 90% of households under the poverty line are energy-poor. Existing and new subjective indicators introduce the fact that the level of thermal comfort at home, damp problems, and restriction of other essential needs to meet energy payments play a vital role. Households identified as energy-poor do not coincide when examined by objective and subjective indicators. Different indicators complement each other by capturing different aspects and providing a more holistic aspect.
(Papada & Kaliampakos, 2017)	Energy poverty in Greek mountainous areas: A comparative study	2015	Greece	Explore energy poverty in the mountainous areas of Greece in comparison to national conditions, employing primary surveys based on objective and subjective approaches.	According to the objective approach, 73.5% of the population in mountainous areas of Greece suffer from energy poverty. Based on the subjective approach, dwellings with dampness and mold are a severe issue. Furthermore, it was revealed that the vulnerable population cannot cover other essential needs after meeting energy needs.
(Boemi et al., 2017)	Domestic energy deprivation in Greece: A field study	2015-2016	Greece	The study explores energy poverty, its key drivers, and the role of education in shaping household energy use. The survey was conducted using questionnaires in North Greece.	The level of education may influence how individuals respond to energy poverty during a financial crisis.
(Papada & Kaliampakos, 2018)	A Stochastic Model for energy poverty analysis	2012-2016	Greece	The study addresses the weakness of actual versus required energy consumption by developing the "Stochastic Model of Energy Poverty". The study models energy consumption at the household level and then the transition to country level through stochastic analysis.	Energy poverty reaches 70.4%. Income is the decisive determinant affecting energy poverty at 63%.
(Ntaintasis et al., 2019)	Comparing different methodological approaches for	2017	Greece	Employ and comparatively evaluate objective, subjective and composite energy poverty indicators through 451 households.	The classical objective and subjective indicators lead to different results, with little relevance to each other. Composite indicators adjusted to local conditions provide a more coherent approach. According to the two composite indicators

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Author(s), Year	Title	Time	Region	Objective	Key Findings
	measuring energy poverty: Evidence from a survey in the region of Attika, Greece				developed in the study, it was revealed that energy poverty levels in Attica range between 37% and 43.5%. Approximately 27.5% of households are energy-poor with both composite indicators. 11.5% of households are identified to suffer from high energy poverty intensity.
(Spiliotis et al., 2020)	A multi-sourced data based framework for assisting utilities identify energy poor households: a case-study in Greece	2018	Greece	Present a framework designed to help utility companies accurately identify energy-poor households. The framework is based on an enhanced version of the 10% rule and involves weather, income, and energy-related variables. It is demonstrated in the Attica region.	The proposed framework effectively identifies energy-poor households. Energy poverty is a multidimensional issue influenced by income, building characteristics, and weather.
(Papada & Kaliampakos, 2020)	Being forced to skimp on energy needs: A new look at energy poverty in Greece		Greece	Aiming to unfold the invisible "under-consumption condition due to unaffordability", the study develops a new index: the "Degree of Coverage of Energy Needs" (DCEN). The index is expressed as the ratio of actual / required energy expenditure, quantifying "compression of energy needs", "satisfaction of energy needs" and "energy wastage". There were two case studies: Greece and the mountainous areas of Greece.	According to the findings, 45–51.5% of the two samples reduce their energy consumption and 34.5–38% waste energy. Only a small proportion (14- 17%) can adequately meet their energy needs.
(Damigos et al., 2021)	Does Energy Poverty Affect Energy Efficiency Investment Decisions? First Evidence from a Stated Choice Experiment		Greece	Emphasizing energy efficiency, as typically involved in the National Energy and Climate Plans of EU Member States to address energy poverty, the study focuses on the need to move towards more localized or even personalized actions gradually. Following a labeled choice-based experiment involving a hypothetical selection between three alternative energy interventions, the research integrates the preferences of households from the choice experiment. Establish a connection between energy poverty and energy efficiency investment decisions with energy poverty indicators.	Qualitative and quantitative dimensions of energy vulnerability and sociodemographic characteristics influence households' preferences. Vulnerable people are more prone to the "discounting gap". Without tailor-made assistance, vulnerable households may suffer from permanent energy poverty.
(Kalfountzou et al., 2022)	Predicting energy poverty in Greece through statistical data analysis	2003-2020	Greece	Time-series data were analyzed using objective indicators like 10%, 2M, 2M EXP, M/2, M/2 EXP, and subjective indicators to understand energy poverty drivers and impacts. Chi-square tests of Independence and binary logistic regression	Based on the 10% rule, the logit model presented the highest performance (32%). Based on this model, households affected mainly by energy poverty were single families with dependent children and households in Macedonia, increasing the relative probability of fuel poverty by 7.0 and 6.5 times per unit, respectively.

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Author(s), Year	Title	Time	Region	Objective	Key Findings
				models were employed to predict energy poverty based on critical socio-economic factors.	
(Lyra et al., 2022)	From measuring fuel poverty to identification of fuel poor households: a case study in Greece	2010-2019	Greece	The study aims to develop approaches and algorithms to recognize energy-poor populations through the EU-SILC survey dataset. Furthermore, the formulation of composite indicators is incorporated.	It is found that 4 out of 10 households experience energy poverty. The problem for 1 in 3 of them has more structural characteristics. Specific factors like dwelling types, tenure status, location, income, and the level of education are significant determinants.
(Halkos & Kostakis, 2023)	Exploring the persistence and transience of energy poverty: evidence from a Greek household survey	2017-2020	Greece	The study employs four rounds of household panel data to analyze the consensual approach of energy poverty, using dynamic Probit random effects and Wooldridge conditional maximum likelihood (WCML) estimators.	Poverty persistence (10-12%) effects are detected. Approximately 9–10% of the households are chronically energy poor. Factors like education, income, dwelling characteristics, migration background, and employment status impact the chances of suffering and exiting from energy poverty.
(Sardianou, 2024)	Understanding Energy Poverty among the Elderly: Insights from a Household Survey in Greece	2022	Greece	The study investigates the determinants of energy poverty among older people through the EU-SILC dataset.	Household size and work-related pensions positively influence the ability to meet heating needs. Older people with higher education levels are less likely to suffer from energy poverty. Older individuals are more likely to face difficulties covering utility payments as their perceived health status decreases.
(Kalfountzou et al., 2024)	Identifying Energy-Poor Households with Publicly Available Information: Promising Practices and Lessons Learned from the Athens Urban Area, Greece	2017-2021	Greece	The study explores objective and subjective established indicators and novel approaches, using the Athens urban area as a case study. It uses the official NEPI indicator and newly developed ones.	According to the subjective approach, detached and semi-detached houses, houses with one or two rooms, tenants, and those struggling to make ends meet are more vulnerable. The objective metrics revealed the following percentages of energy poverty: 2M indicator: 4%, M/2: 11%, NEPI (official indicator) and modified NEPI: 10%, modified LIHC: 22%, and modified LILEE: 6.4%. The innovative indicators (the modified LIHC and modified LILEE) eliminate the need for primary surveys or complex models, making it easier to identify vulnerable populations.
(Papada & Kaliampakos, 2024)	Artificial Neural Networks as a Tool to Understand Complex Energy Poverty Relationships: The Case of Greece		Greece	This study examines using artificial intelligence (ANNs) to predict energy poverty in Greece. The analysis involves seven energy poverty indicators using socio-economic and geographical factors as input variables, with three models investigated for each indicator.	ANNs presented strong predictive accuracy for energy poverty, recording from 61.71% to 82.72%. The strong relationships confirm their potential as an assessing tool for understanding energy poverty.
(Aristondo & Onaindia, 2018b)	Inequality of energy poverty between groups in Spain	2005, 2008, 2012, 2016	Spain	The study assesses the evolution of energy poverty and analyzes different household classifications and characteristics of the primary breadwinner, such as gender, type of house, and education, under subjective indicators.	Energy poverty deteriorated between 2005 and 2016. Thinly populated regions and households in which the primary breadwinner has been born outside of Europe are greatly affected.

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Author(s), Year	Title	Time	Region	Objective	Key Findings
(Aristondo & Onaindia, 2018a)	Counting energy poverty in Spain between 2004 and 2015	2004-2015	Spain	Analysis of energy poverty for three different types of areas (depending on population share) and regions, using subjective indicators.	Energy poverty deteriorated between 2004 and 2015. Rural areas and Southern regions present the highest energy poverty values.
(Castaño-Rosa et al., 2020)	Energy poverty goes south? Understanding the costs of energy poverty with the index of vulnerable homes in Spain		Spain	A case study in a working-class district of Seville. The study defines the Index of Vulnerable Homes to evaluate the vulnerability to energy poverty (before and after intervention). Additionally, the costs to the National Health Service are also assessed.	The Index of Vulnerable Homes can support the development of a comprehensive and coordinated social housing strategy to tackle energy poverty while also aiding in monitoring the effectiveness of ongoing projects in Seville.
(García Alvarez & Tol, 2021)	The impact of the Bono Social de Electricidad on energy poverty in Spain	2008-2011	Spain	The Bono Social de Electricidad (BSE) is a discount on electricity prices available to vulnerable households who apply for it. The analysis employs differences-in-differences and propensity score matching methods on household data to evaluate its impact.	No statistically significant impact of the intention to treat on the two indicators "ability to keep home adequately warm" and "the presence of damp, rots and leaking roofs" was found. The indicator "arrears on utility bills", presents a statistically significant deterioration. The BSE has not meditated on energy poverty.
(Barrella et al., 2022)	Proposing a Novel Minimum Income Standard Approach to Energy Poverty Assessment: A European Case Study	2014-2019	Spain	The study employs the reference budgets method and compares the Minimum Income Standard (MIS) indicator to one derived using the Integration Minimum Income (RMI, in Spanish) as a threshold. The analysis critically examines MIS indicators calculated with various income thresholds, aiming to establish a disproportionate expenditure metric based on an absolute income threshold determined through an objective methodology.	The reference budget MIS indicators are higher than those derived from the RMI, with the latter failing to recognize energy poverty in specific household types. The lack of scientific objectivity associated with the RMI underscores the greater accuracy of the reference budget MIS in determining an adequate minimum income.
(Costa et al., 2024)	Determinants of energy poverty: Trends in Spain in times of economic change	2006–2022	Spain	Aiming to provide valuable insights into the spatial variation of energy poverty, the study employs empirical analysis with a sample of more than 300,000 households from the HBS survey.	Energy poverty is asymmetrically distributed across the country. Non densely populated regions are greatly affected. Significant regional heterogeneity in the incidence of energy poverty drivers is also detected.
(Betto et al., 2020)	A new measure of Italian hidden energy poverty	2018	Italy	The study defines a new measure of hidden energy poverty to identify which households decrease energy consumption due to unaffordability. A new indicator concerning hidden energy-poor households, based on factors like poor energy efficiency of buildings, poverty, low energy consumption, and	The newly identified indicator facilitates the evaluation of the percentage of Italian households experiencing hidden energy poverty, providing valuable insights for policymakers aiming to support vulnerable consumers.

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Author(s), Year	Title	Time	Region	Objective	Key Findings
				sensitivity to the climate, is employed. The study uses data from the HBS survey.	
(Faiella & Lavecchia, 2021)	Energy poverty. How can you fight it, if you can't measure it?	2014-2016	Italy	The study reviews the existing definitions, measures and policies of energy poverty. It presents an indicator developed in a previous work, which the Government has adopted as the official measuring tool in Italy. The study also introduces a new indicator, which depends on the heating expenditure required to achieve a minimum comfort level.	According to the existing indicator adopted as the official metric in Italy, more than 2.2 million energy-poor households or 8.6% of the total population, were energy-poor in 2016. According to the new measure introduced in the study, approximately 3 million households were identified as energy-poor in 2014–2016 (11.7% of total households).
(Bardazzi et al., 2021)	To eat and not to heat? Energy poverty and income inequality in Italian regions	2004-2015	Italy	Investigation of the relationship between economic inequality and energy poverty under consensual approach, expenditure-based approach, and a combination of them. Variables that contribute to regional variations in energy poverty are also incorporated.	Income inequality is significantly associated with energy poverty indicators when Italian regions are the units of analysis.
(Vurro et al., 2022)	Climate Change Impact on Energy Poverty and Energy Efficiency in the Public Housing Building Stock of Bari, Italy	2017-2018	Italy	The study quantifies the impact of climate change on the energy demand of public housing building stock, using a neighborhood in Bari as a representative example of typical late 1970s construction in Italy. Energy models were developed and calibrated using real-time data obtained from utility bills.	A medium to strong association between age and energy consumption was found, but there was no correlation between the number of tenants and energy consumption. An energy penalty of approximately 7 kWh/m^2 in heating energy consumption was calculated for every 10-year increase in the average age of tenants. Additionally, the analysis of future weather scenarios revealed an average annual energy penalty of 0.3 kWh/m^2.
(Berti et al., 2023)	Implications of energy poverty and climate change in Italian regions	2000-2019	Italy	Analysis of the risk of energy poverty disaggregated by the Italian regions with different climate change scenarios.	The region of Lombardy could be mostly affected by energy poverty, probably because of the old building stock, energy demand, and the remarkable presence of vulnerable families. Furthermore, a significant risk was identified in the Southern regions, which have the lowest incomes in the country and are particularly impacted by the increase in cooling degree days projected in future scenarios.
(Simoes et al., 2016)	Mapping Fuel Poverty in Portugal		Portugal	This study assesses the potential fuel poverty of residential buildings at the LAU2 level by combining data on income, education level, unemployment rate, and the number of inhabitants over 65 years old, alongside the estimated space heating and cooling gap for each household typology. An indicator is created to represent the share of potentially fuel-poor inhabitants in each LAU2 region.	On average, 22% of inhabitants are potentially fuel-poor in space heating and 29% in space cooling. However, there is considerable variation across the country.

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Author(s), Year	**Title**	**Time**	**Region**	**Objective**	**Key Findings**
(Gouveia et al., 2017)	Daily electricity consumption profiles from smart meters - Proxies of behavior for space heating and cooling	2014	Portugal	This study explores daily electricity consumption profiles from smart meters as indicators of active behavior related to space heating and cooling. It investigates how environmental air temperature influences electricity consumption, specifically multiple maximum and minimum daily thresholds. The analysis involved 19 households in southwestern Europe, which experiences hot, dry summers and cool, wet winters.	The study identifies significant differences in consumers' electricity consumption patterns in response to temperature thresholds for space heating and cooling. It also assesses statistical clusters of households exhibiting active and non-active behavior regarding energy use for space heating. The paper highlights the value of widespread smart meter data in understanding how thermal comfort is achieved through the active climatization behavior of occupants, particularly in regions lacking automatic HVAC systems.
(Gouveia et al., 2018)	Mining households' energy data to disclose fuel poverty: Lessons for Southern Europe	2014	Portugal	The analysis combines daily electricity smart meters' registries and socio-economic data (collected from door-to-door surveys), to explore the scope and determinants of energy consumption in two contrasting consumer groups, fuel poverty and fuel obesity groups. The analysis examines the quantity and annual patterns of electricity consumption, supplemented by building energy simulations for relevant building typologies within these groups, to identify gaps in heating and cooling thermal performance.	Socio-economic factors like income and consumer behavior are key determinants of electricity consumption. A significant lack of thermal comfort was observed in households from both groups, with 98% of fuel poverty and 87% of fuel obesity households experiencing inadequate cooling and 98% and 94%, respectively, facing insufficient heating. A key conclusion is that electricity consumption alone cannot accurately segment consumer groups.
(Palma et al., 2019)	Mapping the energy performance gap of dwelling stock at high-resolution scale: Implications for thermal comfort in Portuguese households	2013	Portugal	Using a high geographical resolution scale, the study estimates and examines the energy poverty gap concerning thermal comfort in Portugal's occupied residential dwelling stock. A building typology approach was employed to estimate the theoretical final energy consumption (TFEC) required for heating and cooling (H&C) to achieve thermal comfort. In contrast, a statistics-based approach was used to calculate the real final energy consumption (RFEC) for H&C. The energy poverty gap was defined as the percentage difference between TFEC and RFEC.	Under nominal conditions, every civil parish exhibits an energy poverty gap exceeding 60% for heating and cooling, attributed to the poor energy efficiency of the buildings and low H&C energy consumption levels. The scenarios indicated a reduction in the energy poverty gap for several civil parishes, probably due to variations in temporal space climatization patterns. However, high and persistent energy poverty gaps suggest that civil parishes in the northern and central regions are the most vulnerable during the winter and summer seasons.
(Gouveia et al., 2019)	Energy poverty vulnerability index: A multidimensional tool to identify hotspots for local action		Portugal	A high-resolution spatial scale composite index was developed to map energy-poor regions and identify hotspots for targeted local action, focusing on space heating and cooling. The proposed index (Energy Poverty Vulnerability Index -EPVI) integrates population socio-	A higher prevalence of significant EPVIs in inland regions and on the islands, especially in rural civil parishes, is revealed. Although cooling-related EPVIs are generally more pronounced, heating emerges as a potentially more critical issue due to its impact on energy demand and associated health risks.

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Author(s), Year	Title	Time	Region	Objective	Key Findings
				economic indicators with building characteristics and energy performance metrics.	
(Horta et al., 2019)	Energy poverty in Portugal: Combining vulnerability mapping with household interviews	2018	Portugal	The study integrates an Energy Poverty Vulnerability Index (EPVI) and mapping—based on a comprehensive quantitative analysis of all 3,092 civil parishes—with qualitative data from interviews conducted with 100 households in ten identified hotspots nationwide.	The findings highlight the extent and variability of vulnerability to energy poverty across Portugal. Furthermore, many households perceive cold in winter and hot in summer as normal and acceptable.
(Oliveira Panão, 2021)	Lessons learnt from using energy poverty expenditure-based indicators in a mild winter climate	2015-2016	Portugal	A thorough analysis of the performance of energy poverty expenditure-based indicators in Portugal is employed, using national statistics raw data.	Moderate heating costs, calculated as the difference between households with and without central heating, range from €116 to €202. The Minimum Income Standard is the most reliable indicator, identifying 27.8% of households as energy-poor.
(Palma et al., 2022)	It Starts at Home: Space Heating and Cooling Efficiency for Energy Poverty and Carbon Emissions Reduction in Portugal		Portugal	The paper uses the Energy Poverty Vulnerability Index to examine the regional impact of replacing space heating and cooling equipment on energy poverty levels. It also investigates the effect on carbon emissions.	Improving equipment efficiency to meet regulation standards effectively reduces winter energy poverty, lowering municipal vulnerability by approximately 18%. A more substantial "deep change" in heating and cooling equipment significantly reduces both winter (47.8%) and summer (26.3%) energy poverty and meditates potential carbon dioxide emissions by 3,554 kilotons. Improvements in building energy performance should accompany this transformation and address financial investment and social justice challenges, which require attention from authorities at various levels.
(Palma et al., 2024)	Comparative analysis of energy poverty definition and measurement in Portugal and Spain		Portugal and Spain	The study analyzes and compares the definition and measurement of energy poverty in the national policy strategies of Portugal and Spain. The analysis is supported by a systematic literature review of indicators within the Iberian context.	Definitions should expand their scope to include a broader range of energy services and vulnerability. Measurement can be improved using available data and indicators to enhance comprehensiveness, reduce redundancy, and address depth and persistence. To more effectively identify energy-poor households, there is a need for greater intersectionality of indicators and the inclusion of alternative measures.

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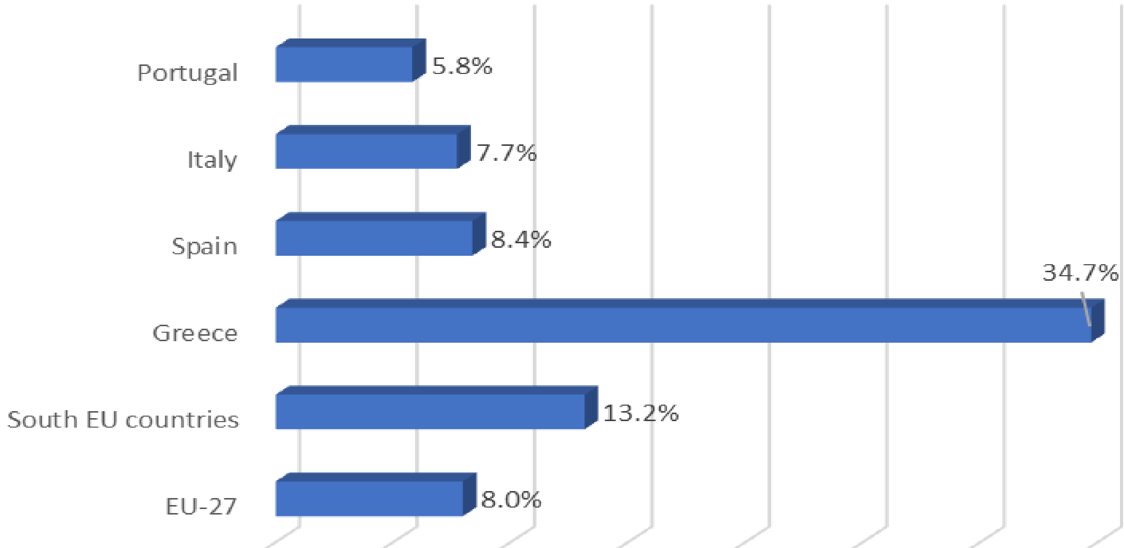
7.3 Data for energy poverty in Southern European countries

The official subjective energy poverty indicators reveal that the average values for the Southern European countries are significantly higher than the average EU-27, indicating the need for further investigation. More specifically, the indicator "Arrears on utility bills" presented in Figure 17 reveals that almost 8% for the EU-27, in contrast to more than 13% for South Europe, indicates more significant difficulties in paying utility bills. In Greece, the average value is primarily influenced by the alarmingly high percentage of people experiencing significant financial distress, with nearly 35% of Greek citizens falling behind on utility payments. This extremely high percentage shows that over a third of Greek households are behind on utility bills. This value is more than four times the mean EU-27. Spain is slightly above the EU-27 average, at 8.4%, but far below the South Europe average. Similarly, Italy is almost matching the EU-27 average. Portugal has the lowest percentage (5.8%), below the regional average and lower than the EU-27 average, indicating that Portuguese households face less difficulty meeting their utility bills. Three main reasons justify that: 1) the existence of an automatic social energy tariff that provides around 33% discount on energy tariffs reaching out to over 800 thousand families, 2) high reported levels of thermal discomfort and underconsumption as a coping strategy (e.g., Palma et al., 2019), and high use of wood in fireplaces as one of the primary fuels being used for space heating. This highlights the importance of issuing a varied set of indicators from different areas better to understand the context of a country or region and promote a broader understanding of the energy poverty problem.

Figure 17: Average proportions of households with arrears on utility bills for EU-27 and South European countries (2012-2023).



Source: Eurostat 2024

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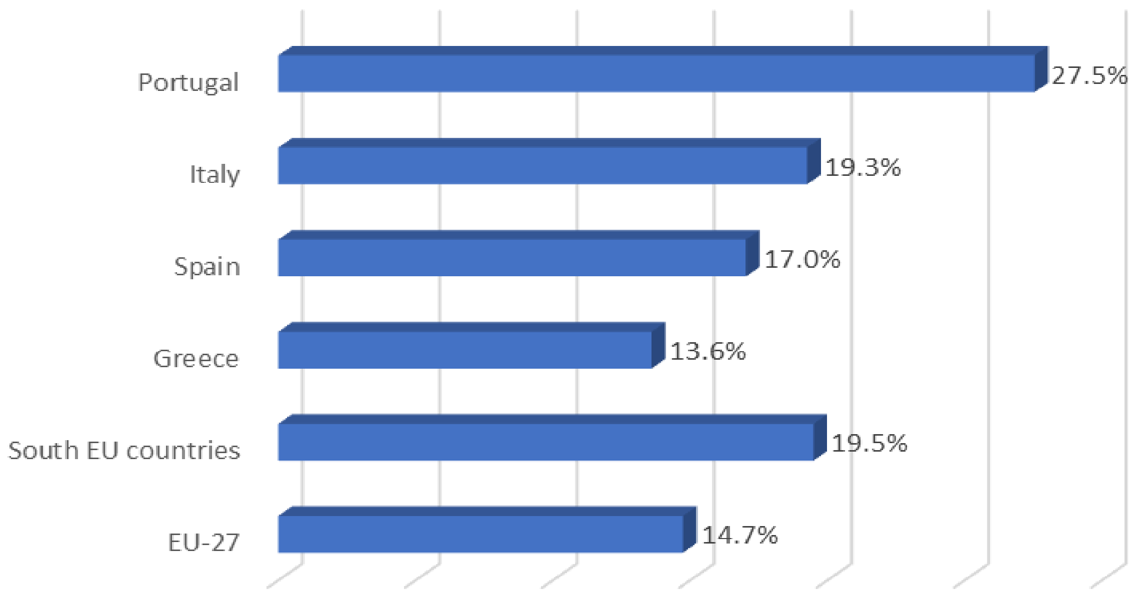
The indicator referring to households living in dwellings with leakages, damp, or rot demonstrates a different picture in Figure 18. Although the EU-27 average is significantly lower (approximately 15%) than the average for southern countries (19.5%), the variation across southern countries differs from the previously analyzed indicator. In this case, Greece has the lowest portion (14%), below the South of Europe and EU-27. This is an unexpected finding since Greece presented the worst performance in dwellings' energy efficiency improvement in the last 5 years. Spain reports 17%, above the EU-27 but below the South Europe average. Italy's percentage is almost 19.3%, close to the South European average and above the EU-27. Surprisingly, Portugal has the highest percentage, with over a quarter of its dwellings experiencing housing issues, at 27.5%, significantly above all regions. This outcome contradicts Portugal's performance in improving energy efficiency measures for dwellings.

Figure 18: Average proportions of people living in dwellings with leakages, damp, or rot, for EU-27 and South European countries (2012-2023).



Source: Eurostat 2024

The third subjective indicator, shown in Figure 19, reflects the percentage of households unable to warm their homes adequately. Approximately 8% of EU households face this challenge. Despite Southern Europe experiencing significantly fewer heating degree days, the regional average indicates that nearly 18% of residents struggle to keep their homes warm during winter. Greece reports a notably higher rate, with 24% of its population unable to heat their homes, far exceeding the EU-27 and Southern European averages, highlighting severe energy poverty. Portugal follows closely at 22%, indicating similar energy challenges. Meanwhile, Italy (14%) and Spain (11.4%) report lower rates below the regional average but still above the EU-27 average.

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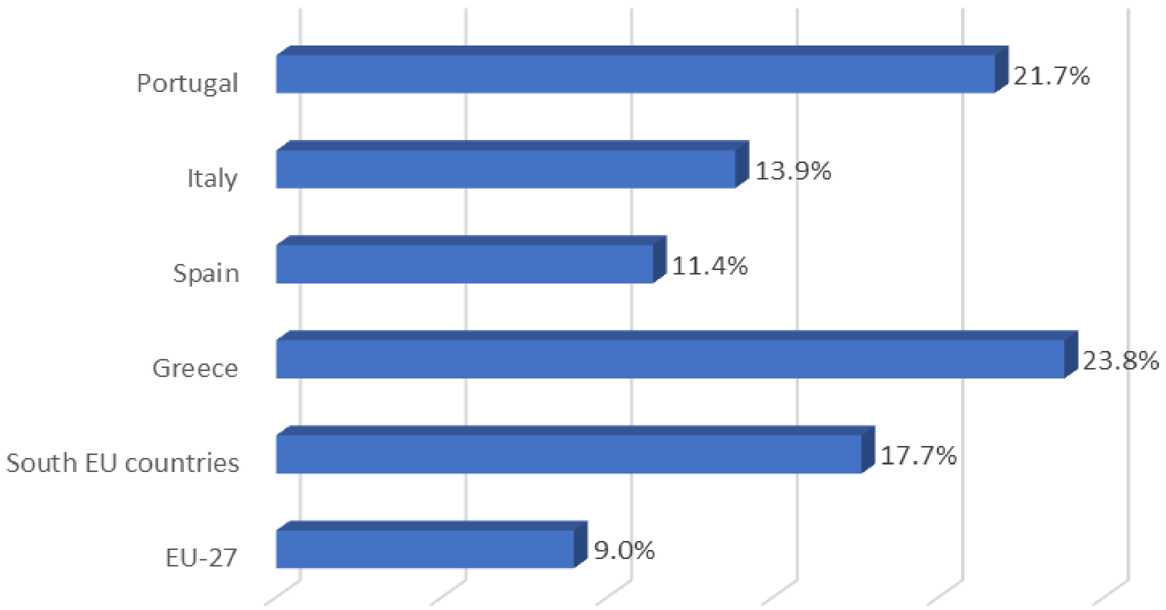
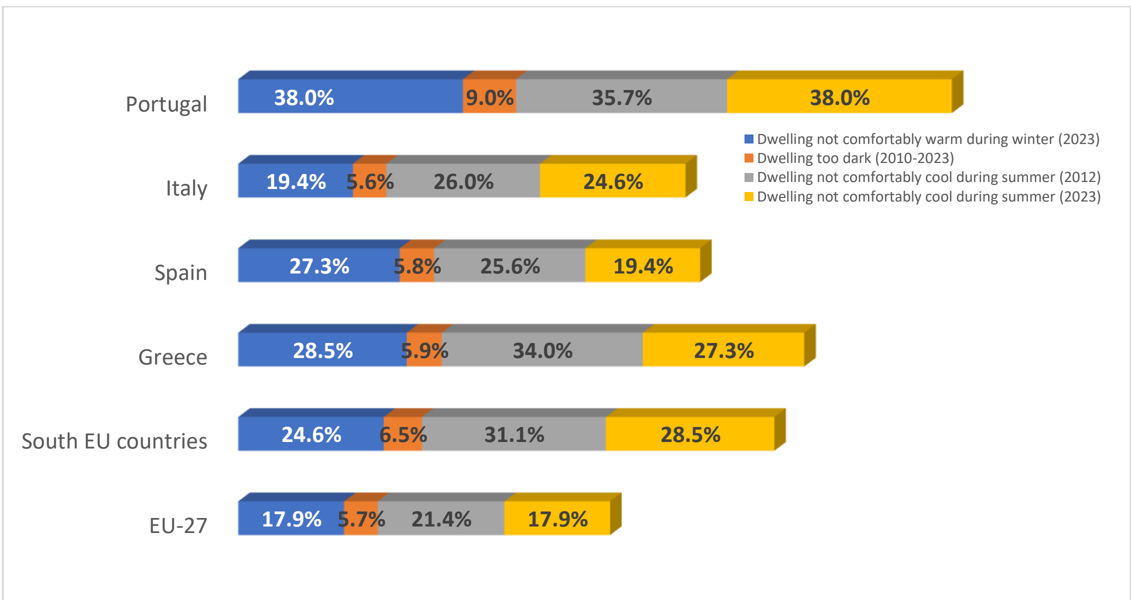
Figure 19: Average proportions of households unable to keep their home adequately warm, for EU-27 and South European countries (2012-2023).



Source: Eurostat 2024

Other key aspects of housing conditions associated with energy poverty, such as homes that are insufficiently warm in winter, inadequately cool in summer, or too dark, are anticipated to offer additional insights.

Figure 20: Average proportions of households dwelling not comfortably warm (2023), too dark (2010-2023), not comfortably cool (2012), for EU-27 and South European countries.



Source: Eurostat 2024

As shown in Figure 20, the proportion of dwellings not comfortably warm during winter is lower for the EU-27 average (18%) compared to other regions despite harsher winter conditions. Southern Europe reports a significantly higher average (24.6%), with Greece (28.5%) and Spain (27.3%) showing similar rates. However, notable regional differences exist due to varying climate conditions. Portugal stands out with an exceptionally high rate of 38%, while Italy performs relatively better at 19.4%, though challenges remain.

The opposite metric, which reflects the proportion of households not comfortably cool during summer, reveals significant discomfort in Southern Europe (31.1%) during hot months, compared to 21.4% across the EU. Portugal (35.7%) and Greece (34%) exceed the Southern European average, while Spain and Italy, at approximately 26%, fall below the regional average but remain above the EU-27 average. Regarding inadequate lighting, the EU-27, Greece, Spain, and Portugal report similar rates, around 5.8%. However, Portugal has the highest rate of poorly lit dwellings at 9%, indicating multiple housing deficiencies despite achieving the highest energy efficiency improvements over the past five years.

8. Research gaps

Despite the EU's focus on unity and cohesion, significant disparities in energy poverty persist between EU-27 member states and Southern Europe. Despite milder winters than in central and northern EU countries, all energy poverty indicators show that Southern European countries face higher energy poverty levels. This highlights the need for further spatial analysis to understand the region's unique factors influencing energy poverty. This project aims to comprehensively understand conditions in Greece, Spain, Italy, and Portugal by analyzing demographic, socioeconomic, energy, and poverty-related data. These insights will inform the advanced econometric investigations in subsequent steps. Although South European countries share similar climatic conditions, they differ significantly in political systems, socioeconomic structures, demographic characteristics, and approaches to meeting energy needs.

Energy poverty is a multidimensional phenomenon influenced by social, fiscal, macroeconomic, and household-level factors. This research will try to utilize a combination of objective and consensual indicators to capture hidden and persistent energy poverty, providing more inclusive and reliable results. Advanced research tools and interdisciplinary methods will link economic, environmental, social, and behavioral sciences, offering a robust framework for analyzing energy poverty. The project's findings will inform targeted and efficient policy recommendations tailored to Southern Europe. These insights will motivate stakeholders to invest in energy-efficient solutions and improve the welfare of vulnerable households. Dissemination through the project website, scientific journals, and conferences will raise awareness of energy poverty's significance and guide future research. This work lays the foundation for formulating research questions detailed in Deliverables 2.3 and 3.1, focusing on the synergies of energy poverty, its measurement, and its policy implications in Southern Europe both at the country and the regional level of analysis.

9. Conclusions

Studying energy poverty literature and interpreting available data, leads to the conclusion that the causes of energy poverty result in severe social impacts which may generate new or deteriorate existing energy-poor instances. Additionally, identifying vulnerable households and measuring energy poverty is challenging. Although indicators aim to capture the problem and illustrate the needs, some insufficiencies and gaps must be addressed. The selected measuring approaches should account for historical trends and regional particularities, be accurate and straightforward, and provide practical policy implications.

The EU mandates EU member states to investigate and evaluate energy poverty in their territory and include it in their National Energy and Climate Plans. Furthermore, in societies where energy poverty is a severe issue, national authorities must provide measures and policies to alleviate it. The 29 indicators introduced by EPAH contribute to a more holistic approach, which should be the foundation for greater collaboration between academic research, authorities, and policymakers.

As far as the official subjective energy poverty indicators are concerned (according to all EU-SILC indicators), all three indicators reveal that the incidence of energy poverty for people above the poverty line is closer to that of the total population. In contrast, the proportions concerning the population below the poverty line are far higher. Furthermore, the average values for the Southern European countries are significantly lower than the average EU-27, indicating the need for further investigation. However, disparities are observed between the countries of south Europe. For example, Greece has a significantly higher proportion of people with arrears than the EU-27 average and South group, while Portugal has the lowest, below both groups. On the contrary, the indicator concerning dwellings with leakages, damp or rot, classifies Greece at the lowest ratio (between the South Europe group) and Portugal at the highest. Finally, the inability to maintain a warm home identifies Greece and Portugal as the most vulnerable. These arguments reveal that energy poverty is differently expressed across societies and probably within them. The research team must comprehend structural differences through macro indicators and recognize trends and specific needs at a national or local level through previous studies. Then, the indicators' specifications should be adequate for the countries involved in the project. Alternatively, it may be concluded that differentiated measuring approaches should be adopted in each region, depending on each society's profile.

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