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A Critical Review of the Energy Poverty Paradigm and its Measurement Indicators

Trabajo Fin De Grado

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Table of Contents

ABSTRACT	3
1. INTRODUCTION	4
2. LITERATURE REVIEW OF ENERGY POVERTY	6
2.1 WHAT IS ENERGY POVERTY?	6
2.2 DEFINING THE RELATED CONCEPTS OF ENERGY POVERTY	10
2.3 THE DIFFERENT DIMENSIONS OF ENERGY POVERTY	11
3. A CRITICAL REVIEW OF MEASUREMENT APPROACHES	14
<i>TABLE 1: SUMMARY OF MEASUREMENT APPROACHES</i>	15
3.1 THE EXPENDITURE APPROACH	15
3.2 LOW-INCOME HIGH-COST (LIHC) INDICATOR	18
3.3 TWICE MEDIAN (2M) INDICATOR	19
3.4 SELF-REPORTED DEPRIVATION INDICATORS.....	21
3.4.1 <i>The Inability to Keep the Home Adequately Warm</i>	21
3.4.2 <i>Arrears on Utility Bills</i>	22
3.4.3 <i>Economic Hardship Measures</i>	23
3.5 MULTIDIMENSIONAL ENERGY POVERTY INDEX (MEPI)	25
3.6 EUROPEAN DOMESTIC ENERGY POVERTY INDEX (EDEPI)	29
4. METHODOLOGY	30
4.1 DATA SOURCE	30
4.2 CONSTRUCTION OF INDICATORS	34
4.3 SPAIN AS THE MEASURED COUNTRY	37
5. RESULTS AND DISCUSSION	40
5.1 ENERGY POVERTY INDICATORS.....	40
5.1.1 <i>National Energy Poverty Indicators</i>	41
FIGURE 1: <i>PERCENTAGE PROPORTION OF NATIONAL ENERGY POVERTY INDICATORS</i>	41
FIGURE 2: <i>ENERGY POVERTY RISK COMPARED AGAINST MEDIAN INCOME AND ENERGY PRICES IN SPAIN</i>	44
5.2 DRIVERS OF ENERGY POVERTY	45
5.2.1 <i>National Income Perspective</i>	45
FIGURE 3: <i>MEDIAN INCOME OF HOUSEHOLDS EXPERIENCING ENERGY POVERTY BETWEEN 2020 AND 2023</i>	46
FIGURE 4: <i>PERCENTAGE PROPORTION OF ENERGY POVERTY INDICATORS BETWEEN 2020 TO 2023</i>	46
5.2.2 <i>Regional Income Perspective</i>	48
FIGURE 5: <i>THE MEDIAN ANNUAL INCOME BY REGION IN SPAIN IN 2020</i>	48
FIGURE 6: <i>THE MEDIAN ANNUAL INCOME BY REGION IN SPAIN IN 2023</i>	49
5.1.2 <i>Regional Energy Poverty Indicator Perspective</i>	51
FIGURE 7: <i>PERCENTAGE PROPORTION OF SEVERE ENERGY POVERTY IN SPAIN IN 2020</i>	52
FIGURE 8: <i>PERCENTAGE PROPORTION OF SEVERE ENERGY POVERTY IN SPAIN IN 2023</i>	52
5.2.3 <i>Energy Cost</i>	54
FIGURE 9: <i>THE PRICE PER kWh (€) BETWEEN 2020 AND 2023 (EUROPEAN COMMISSION, 2025)</i>	55
FIGURE 10: <i>PERCENTAGE PROPORTION OF ENERGY POVERTY INDICATORS BETWEEN 2020 AND 2023</i>	55
5.2.4 <i>Energy Efficiency in the Home</i>	56
5.3 COMPARISON OF INDICATORS	57
5.4 STRENGTHS AND CRITICISMS OF ECV	57
6. CONCLUSIONS	59
7. FURTHER RESEARCH	62
8. DECLARATION OF AI	63
9. BIBLIOGRAPHY	63
9. APPENDICES	73

Abstract

This dissertation critically evaluates the conceptual paradigms and measurement indicators of energy poverty, an increasingly prominent socio-economic challenge that has been accelerated by rising energy prices and economic instability. Due to the multidimensional complexity of energy deprivation, relying on a single measurement approach often fails to capture the true extent of household vulnerability.

Focusing on Spain as a case study, this research analyses EU-SILC (Encuesta de Condiciones de Vida, ECV) microdata from 2020 to 2023 to compare how different metrics—specifically self-reported thermal deprivation and utility arrears help to identify distinct vulnerable populations. The analysis reveals an upward trend in energy poverty across the period, with thermal deprivation capturing a growing segment of "hidden energy poverty" where households deliberately under-consume energy to manage costs. On the other hand, utility arrears are shown to be more responsive to immediate economic fluctuations. Regional analysis further highlights a stark North-South divide, with severe, multidimensional energy poverty concentrated in lower-income southern regions like Andalucía, Extremadura, and Murcia. The study concludes that energy poverty cannot be completely explained by income or affordability alone, emphasising the need for a multidimensional measurement framework to inform public policy decisions, and expand the ECV to account for more variables to facilitate more rigorous analysis.

Keywords: Energy poverty, Spain, Thermal deprivation, ECV, Regional inequality

Esta tesis evalúa de forma crítica los paradigmas conceptuales y los indicadores de medición de la pobreza energética, un reto socioeconómico cada vez más relevante que se ha visto agravado por el aumento de los precios de la energía y la inestabilidad económica. Debido a la complejidad multidimensional de la privación energética, basarse en un único enfoque de medición a menudo no permite captar el verdadero alcance de la vulnerabilidad de los hogares.

Tomando a España como caso de estudio, esta investigación analiza los microdatos de la EU-SILC (Encuesta de Condiciones de Vida, ECV) correspondientes al periodo 2020-2023 para comparar cómo diferentes indicadores —concretamente, la privación térmica declarada por los propios encuestados y los atrasos en el pago de las facturas de servicios públicos— ayudan a identificar distintos grupos de población vulnerables. El análisis revela una tendencia al alza de la pobreza energética a lo largo del periodo, y la privación térmica capta un segmento creciente de “pobreza energética oculta”, en el que los hogares consumen deliberadamente menos energía para gestionar los costes. Por otro lado, se observa que los atrasos en el pago de los servicios públicos responden mejor a las fluctuaciones económicas inmediatas. El análisis regional pone aún más de relieve una marcada división entre el norte y el sur, con una pobreza energética grave y multidimensional concentrada en las regiones meridionales de menores ingresos, como Andalucía, Extremadura y Murcia. El estudio concluye que la pobreza energética no puede explicarse completamente solo por los ingresos o la asequibilidad, y subraya la necesidad de un marco de medición multidimensional que sirva de base para las decisiones de política pública, así como de ampliar el ECV para tener en cuenta más variables y facilitar un análisis más riguroso.

Palabras clave: Pobreza energética, España, Privación térmica, ECV, Desigualdad regional

1. Introduction

Energy poverty has become an increasingly important socio-economic issue in Europe in recent years, due to energy price surges, increasing geopolitical tensions, and general economic instability with higher inflation as a result (Campagna et al., 2024). As these crises threaten the wellbeing of households, it becomes essential for national governments to be able to identify who is impacted and design effective targeted interventions.

It is mainly defined as a household's inability to securely access domestic energy services, including heating, electricity, and cooling systems to maintain a certain living standard (Bouzarovski et al., 2012). Energy poverty is a multi-faceted concept that goes beyond affordability implications, capturing housing inefficiency, regional climatic conditions, tenure status, thermal deprivation, and differing energy needs. By extension of these factors, individuals' physical and mental wellbeing are also diminished (Healy and Clinch, 2002), making it an area of concern for academics and policymakers alike. These different indicators capture different dimensions of energy poverty and in doing so identify different households as being energy poor. A household may appear energy poor under one indicator while being overlooked by another. Furthermore, because each indicator measures energy poverty differently, it emphasises that measurement is not a neutral technic but rather one that is based off of theoretical assumption. It highlights that the measurement indicators used can have a drastic impact on how policy frameworks target households. The recent push by international organisations to encourage the energy transition to more renewable sources of energy, due to recent increases in climate change and the insufficient supply of finite resources (Energy Transitions Commissions, 2021), further intensifies the need for a better measurement and definition of energy poverty to ensure all can be equally captured under public policy.

Spain was chosen as a valuable case study for this dissertation as it offers unique regional and geographical examples for analysing energy poverty that will add to current energy poverty literature. Strong regional income inequalities (Díez-Minguela et al., 2016), an ageing housing stock (Phimister et al., 2015), and exposure to recent external shocks, such as the COVID-19 pandemic and the Russo-Ukraine war have led to energy poverty fluctuations (Sun et al., 2024) (Wang, Yang, & Li, 2021). These conditions make Spain an appropriate case study in which to examine the measurement and impact of energy poverty.

The dissertation will address the following research question:

How do different measurement indicators capture energy poverty in Spain, and what do they fail to capture?

The general objective is to critically evaluate the main approaches used to measure energy poverty and to analyse how they are used to identify different forms of deprivation in Spain.

The specific objectives are:

To define energy poverty conceptually and distinguish it from monetary poverty and broader energy vulnerability.

To critically compare expenditure-based, self-reported, and multidimensional measurement approaches.

To apply specific indicators using the Spanish ECV data between 2020 and 2023 and assess which dimensions of energy poverty are captured and which are not.

The dissertation is organised into four chapters. Chapter 1 presents the theoretical and conceptual framework. Chapter 2 reviews the principal measurement approaches and their limitations. Chapter 3 explains the dataset, variables, and operationalisation strategy. Chapter 4 presents the empirical results and discusses the strengths and weaknesses of each indicator. The dissertation concludes by summarising the main findings and reflecting on implications for future research and public policy.

2. Literature Review of Energy Poverty

2.1 What is Energy Poverty?

The concept of energy poverty has rapidly become a prominent socio-economic challenge faced by a growing number of households (González-Eguino, M., 2015).

Energy poverty is conceptualised as a household's inability to access energy services, such as heating, electricity, appliance use, and lighting- that would be necessary to achieve an adequate standard of living in both social and material terms (Bouzarovski et al., 2012). Despite the growing body of academic research surrounding the concept, there is still no universally agreed upon definition, resulting in considerable ambiguity amongst academics, institutions, and policymakers (Thomson et al., 2017).

The discussion regarding energy poverty gained prominence during the 1970s and 1980s, through Brenda Boardman's pioneering work the early academic work *Fuel Poverty: From Cold Homes to Affordable Warmth* (1991). Her research on fuel poverty helped lay the groundwork for the definition of energy poverty. Boardman regarded fuel poverty as a condition in which a household spending more than 10% of their income on energy services is deemed to be fuel poor (Phimister et al., 2015). This definition was eventually adopted by UK policymakers and became the foundation of future energy deprivation research (Liddell et al., 2012). The expenditure approach focused primarily on the affordability element, linking low-income households and high utility costs to insufficient energy access. Furthermore, her work emphasised the importance of housing efficiency, and how a lack of, can result in higher fuel costs and therefore exacerbate the effect of fuel poverty.

Although Boardman's work provided valuable insights that catapulted the concept of fuel poverty, and later energy poverty, into both academic and political discussions, critics argued that her definition was too broad and failed to capture the true complexity of energy poverty (Thomson et al., 2017).

Future studies introduced the "Consensual" (Thomson et al., 2017) and "Multidimensional" (Nussbaumer et al., 2013) approach. The consensual approach introduced the idea of self-reporting measures, allowing households to have their own say in whether they experience energy deprivation. These revealed dimensions of energy poverty that would have largely gone unnoticed under the expenditure approach, such as coping strategies to reduce energy consumption. The multidimensional approach built on the consensual perspective by considering other dimensions of energy poverty, such as access to clean cooking fuels and energy efficiency, rather than simply focusing on affordability (Nussbaumer et al., 2013). Consequently, energy poverty cannot be measured as a single variable but instead requires different theoretical assumptions to capture the full extent of energy deprivation. However, these assumptions are subjective and depending on the social or economic context, can lead to varying interpretations as to its perceived meaning.

To understand these subjective interpretations, it is important to look at the precedent of the concept itself. Guevara et al. (2025) categorise this evolution into five key schools of thought, providing a necessary framework to see how theoretical assumptions drive measurement indicators. According to Zeus Guevara et al. (2025), the theory of energy poverty has progressed and evolved through several key schools of thought. The first was referred to as “Traditional Fuel Poverty”. This directly corresponds to Brenda Boardman’s expenditure-based approach and other metrics that heavily focused on affordability and expenditure indicators, such as Hill’s Low-Income-High-Cost metric (Hill, 2011) and the twice median (2M) metric (Hills, 2012). Guevara et al. (2025), argued that Brenda Boardman’s work dominated the early field of energy poverty and is still seen as an influential paper, even though the concept has developed far beyond expenditure-based measures.

The second school of thought, “Energy Poverty in the Developing World”, also tied into the more traditional characterisation of energy deprivation. Historically, developing countries, who tended to have lower incomes, weaker infrastructure and lack access to modern energy services, are commonly associated with being more susceptible to energy poverty (Pachauri & Spreng, 2011). However, this idea doesn’t account for households in the global north who also struggle to securely access energy services.

The final three schools of thought reflect a more multidimensional view on energy poverty. “Energy and Fuel Poverty Merging” draws a clear distinction between the fuel poverty and energy poverty perspectives, thereby, clearly defining them as separate concepts and reducing overall ambiguity. The fourth school of thought is concerned with “Broad Energy Justice”. It essentially links energy poverty with the idea of distributing both the benefits and costs of energy services equally (van Bommel & Höffken, 2021). This is where policy frameworks can be particularly influential.

The last school of thought, “Traditional Fuel Poverty meets Energy Justice” attempts to build on the traditional stance of energy poverty by including more justice-orientated concepts. It recognises that energy deprivation is not determined solely by household expenditure, but rather social inequality, health outcomes, or possibly even environmental

sustainability (Guevara et al., 2025). Similar to “Broad Energy Justice”, government invention can play an important role in reducing energy deprivation. For instance, government subsidies used to upgrade the energy efficiency rating of the home or for transitioning to renewable energy technologies, such as solar panels. These initiatives can reduce the carbon footprint of the household and can provide some form of long-term energy security. This can provide greater stability to vulnerable households by reducing their exposure to rising energy costs.

This demonstrates a shift away from the more traditional expenditure-based indicators towards a more modern multidimensional approach which places greater emphasis on accessibility rather than affordability. Moreover, these approaches bring greater acknowledgment to inequalities associated with distribution and the role of public policy. Importantly, these latter schools of thought realise the importance of environmental sustainability efforts, something that wasn’t taken into consideration by earlier expenditure-based indicators.

The main observation from both traditional and contemporary perspectives on energy poverty is that energy has increasingly become an essential component in the home and therefore is seen as a necessity for individuals to achieve an adequate standard of living (Pye & Dobbins, 2015).

It could be argued that as the scope of energy poverty widens, so has policy frameworks, with different governments and institutions prioritising varying elements of energy poverty that they deem to be more significant than others (Bouzarovski et al., 2012). These conceptual differences can greatly influence public policy as they dictate which households are identified as energy poor and the type of assistance that is implemented. Consequently, these multiple definitions and measurement indicators end up creating differing levels of policy response and therefore create greater inequality at the international level. This lack of coherence and direction could disorientate the implementation of international goals.

2.2 Defining the Related Concepts of Energy Poverty

It is important to understand the different concepts of energy poverty before examining its dimensions. In previous academic literature, energy poverty has been used interchangeably with other concepts such as energy vulnerability, fuel poverty, and monetary poverty (Castaño-Rosa et al., 2019). Despite having some similarities between them, they are distinctly different concepts.

Monetary poverty refers to ‘a level of household consumption or income that meets a minimum standard of living, allowing individuals to satisfy their basic needs’ (Evans et al., 2020). Even though this concept does align with that of energy poverty, energy poverty is specifically related to a household’s access to energy services and is not only affected by income related factors. Monetary poverty can be applied to a wider range of scenarios, such as lack of food, clothing, and health care services.

Energy vulnerability is defined as; “the propensity of an individual to become incapable of securing a materially and socially needed level of energy service in the home” (Bouzarovski et al., 2014). It refers to the risk of households being unable to meet their energy needs as a result of external factors. Middlemiss and Gillard (2015) went a step further and identified six factors that directly influence energy vulnerability including energy efficiency, household income, and supply issues such as market volatility. A recent example can be seen by the war in Ukraine, which significantly increased energy prices for most European countries in 2022 (Sun et al., 2024).

In such cases, lower income households will face greater financial strain in the form of higher energy bills. In addition, by having a poor energy efficiency rating it means that the household will require greater energy usage to maintain an adequate standard of living, again resulting in increased costs for the household. In both instances, these factors could exacerbate the risk of households being unable to afford necessary energy services.

Fuel poverty and energy poverty have continuously been misconstrued. Both definitions focus on the energy consumption of households. Fuel poverty has been an issue of concern since the early 1970s (Li et al., 2014). Fuel poverty is characterised as a

household's inability to afford energy services. It was later redefined by Brenda Boardman's definition which incorporated the 10% threshold of income expenditure (Boardman, 1991). Energy poverty, however, is defined as a lack of access to modern energy services (Li et al., 2014). Nevertheless, this interpretation of the definition demonstrates how energy poverty is closely linked to development. Access to basic energy sources such as electricity can have a drastic impact on employment opportunities, the health of individuals, and improvements in education levels (Li et al., 2014).

Similarly, another reason for the confusion between the two terms could be indicative of the fact that both have similar root causes. Low incomes often play a big role in both concepts. If a family has a low income; they may not be able to invest in improving the energy efficiency of their home to keep it adequately warm. This could leave them exposed to higher fuel costs and ultimately creates a poverty trap that many low-income families struggle to escape (Li et al., 2014). By having access to energy resources, such as electricity, it helps households maintain a decent standard of living and remain out of poverty, especially those in rural areas (Li et al., 2014).

Nevertheless, it can be argued that energy poverty is a far more complex issue that cannot be explained solely by low income or high expenditure costs. Instead, it is a multidimensional problem that varies depending on the household's circumstances. Energy poverty cannot be solved using a one-fits-all approach as there is no single measure that can entirely capture the true extent of the problem.

2.3 The Different Dimensions of Energy Poverty

Although there is still no well-rounded definition that encapsulates the complexity of the issue, there has been extensive research completed to further understand the other dimensions of energy poverty that may not be as obvious to recognise (Castaño-Rosa et al., 2019) (Thomson et al., 2017). By identifying these different conditions, energy poverty can be better understood and defined. It can be conceptualised through the following dimensions:

Affordability: Lower income households tend to be more vulnerable as they spend a greater proportion of their income on energy expenditure, compared to wealthier households, leaving them more exposed to energy market fluctuations (Halkos & Gkampoura, 2021).

Differing energy needs: Households will have differing energy needs depending on the size of the household, the ages of the individuals, health status or disability. Households with elderly or sick members may require greater energy usage, such as higher indoor temperatures, to attain a satisfactory level of comfort (Sequiera et al., 2024). Since the Covid-19 pandemic in 2020, there has been a surge in the number of people working from home, resulting in households having greater energy needs as people are spending more time at home (Shi et al., 2023).

Climate and Geographical Location: can also be a factor in determining a household's energy needs. Urban areas usually have better infrastructure while rural households are often faced with; "limited grid connection, unreliable energy services and dependency on inefficient energy sources like biomass" (Wang et al., 2024). They may have greater dependency on these expensive fuels as they have few alternatives to choose from. Moreover, many rural dwellings are often detached properties and can be found in higher-altitude areas, thus making them more difficult and expensive to heat (Halkos & Gkampoura, 2021). Climate can also have an impact on the amount of energy used. Countries with colder winters or warmer summers will cause households to consume a vastly larger amount of energy from heating or cooling systems to sustain a satisfactory level of comfort (Thomson et al., 2017).

Thermal Deprivation: is the inability to keep the indoor temperature of the home at an adequate level of satisfaction (Healy and Clinch, 2002). It is influenced by several factors including, inadequate housing efficiency, such as poor insulation or insufficient heating systems, high energy costs, or even deliberate underconsumption to reduce expenditure. Long-term exposure to inadequate temperatures can negatively impact both the health and wellbeing of the household.

Housing Quality: The quality and efficiency of the home is a crucial indicator of energy poverty. There has been notable research indicating that a vast majority of people live with some sort of inefficiency in the home, such as damp, poor insulation, or rot (Healy and Clinch, 2002). This is often seen in older housing stock, which can result in larger bills, as greater amounts of energy are used to ensure a satisfactory indoor temperature. Moreover, these older buildings are less capable of being adapted to support renewable energy technologies, such as solar panels or heat pumps (Energy Poverty Advisory Hub, 2025).

Tenure Status: Sequeira et al. (2024) argue that; “households living in the private-rented sector are the hardest group to reach in energy policies”. Landlords may have little incentive to invest in energy-efficient upgrades that could reduce tenant’s energy bills. This is because landlords are not directly impacted by the cost of poor energy efficiency, creating a split incentive problem (Sequeira et al., 2024). At the same time, it could be argued that the tenant is not pushed to attempt to invest in energy performance either due to differing circumstances, including their level of income, the type of contract, and the duration of the rental (Sequiera et al., 2024).

Energy poverty is not seen as a permanent state. Instead, it is seen as something that varies over time (Eisfeld, K., & Seebauer, S., 2022). For instance, in countries with colder winters, they may struggle to heat their homes during the winter months. Whereas, in summer they may be able to afford their energy services without any issues. Therefore, certain households may end up being classified as energy-poor under the expenditure-based indicators due to their high energy expenditure during that part of the year. Also, large one-off payments such as purchasing a car or an expensive medical procedure may put a household temporarily behind on other expenses, which could include energy bills.

Again, categorising some families as being energy-poor when in reality it is only a temporary situation. Some metrics don’t account for households that move in and out of energy poverty. Conversely, more subjective indicators under the Consensual or Multidimensional approach, allow households to directly report on the severity and extent

of the deprivation they experience. Consequently, capturing a greater proportion of the households facing energy deprivation.

When trying to come up with an accurate measurement of energy poverty at an international level, legislators may be prejudiced by their own assumptions as to what they think defines being in energy deprivation (Thomson et al., 2017) (Tirado Herrero, 2017). However, these theoretical assumptions can differ by person or by context, emphasising the discrepancies in these measurement indicators, especially in relation to a country's level of economic development. For instance, in warmer Mediterranean countries like Italy or Spain, energy deprivation may be associated with not having access to cooling systems while in lower income countries, it may be seen as having limited or even no access to electricity. Furthermore, if there is no data available on certain dimensions, such as thermal comfort, or housing efficiency, it becomes increasingly difficult to determine which dimensions of energy poverty should be prioritised in public policy. This emphasises that energy poverty is in fact a multi-dimensional problem and that the actions taken to measure energy poverty are not merely technical but rather theoretical.

3. A Critical Review of Measurement Approaches

As mentioned above, energy poverty is not only difficult to define but even harder to measure. The prevalence of this issue across the European Union has meant that there is a greater need to find a single definition for energy poverty that will allow for cross-country comparisons (Bouzarovski et al., 2012). However, the main challenge of measuring energy poverty is that there is no single indicator that completely captures every incidence of energy poverty, making it more difficult for international organisations and governments to implement policies that effectively alleviate energy poverty for all households, equally (Castaño-Rosa et al., 2019). From this, several measurement approaches have emerged, each capturing different dimensions of energy deprivation, ranging from affordability-based metrics to self-reporting and multidimensional indicators. These approaches provide valuable insights into certain aspects of energy

poverty, but none fully encompass the complexity of the concept. To summarise this section, the table below depicts the different indicators based on the type of measure, what it captures, and what it leaves out.

Indicator	Type of measure	Captures	Misses
10% rule	Expenditure-based	Households facing affordability issues	Households deliberately under consuming energy
LIHC	Expenditure-based	The income and energy costs of lower and higher-income households	Hidden energy poverty/coping strategies used
2M indicator	Expenditure-based	Households spending more than twice the median income on energy	Hidden energy poverty of people spending just below the threshold
Inability to keep the home warm in winter	Self-reported/consensual approach	Lived experiences of households in relation to thermal comfort/discomfort	Subjective measure, people over or under-reporting energy deprivation
Arrears on utility bills	Self-reported/consensual approach	Households facing affordability pressures/financial strain	Hidden energy poverty
Economic hardship indicators	Self-reported/consensual approach	Hidden energy poverty and household's response to financial pressure	Overstated or understated self-reporting, miss certain households when compared against other countries
MEPI	Mixed approach	Multiple energy poverty dimensions at once	Affordability pressures, household income

Table 1: Summary of Measurement Approaches

3.1 The Expenditure Approach

Before the rise of energy poverty as a separate concept, it used to be grouped in with a different type of deprivation, known as fuel poverty. Isherwood and Hancock's publication, titled 'Household Expenditure on Fuel: Distributional Aspects' (1979), is often cited as the first publication to mention the concept of fuel poverty (Liddell et al., 2012). Yet, fuel poverty wasn't seen as an issue for concern until after the oil crisis of 1973-74 and the reduction in subsidies for gas and electricity industries in the UK (Koh et al., 2012).

Despite earlier references to the concept of fuel poverty, it wasn't until Brenda Boardman's publication on fuel poverty in 1991 that a measurable definition was popularised. Boardman stated that fuel poverty is "the inability to afford adequate warmth because of the inefficiency of the home" (Boardman, 1991). One of the defining characteristics of Boardman's publication was the use of an energy expenditure threshold which classified households as energy poor when they would spend more than 10% of their household income on energy needs (Phimister et al., 2015). The 10% threshold was chosen as it was twice the median level of energy expenditure at the time (Phimister et al., 2015).

The assumption that underlines this indicator is that energy poverty can be identified through relatively high energy expenses in comparison to income, indicating financial stress and potential deprivation. On the surface, Boardman's definition was attractive as it was quantifiable and easy to understand (Schuessler, 2014). It identified lower-income households and those that spend a large proportion of their income on energy bills. Furthermore, it could reflect households that experience poor housing efficiency. For example, poorer insulated homes may require greater energy usage to maintain an adequate level of warmth in the home. The first instance of fuel poverty being recognised in legislation didn't come until 2001, with the introduction of the UK Fuel Poverty Strategy (Liddell et al., 2012). It was seen as the first time that government strategy had been utilised in a way to address the issue of fuel poverty (Liddell et al., 2012).

However, more recent literature offers criticisms of this definition, mainly concerning its oversimplification. Liddell et al. (2012) investigated the impact of fuel poverty in different regions of the UK. They discovered that different regions had varying average fuel expenditures, with Northern Ireland spending around 1.6% more of their annual income on their fuel bill (Liddell et al., 2012). This demonstrates that applying the same expenditure threshold to all regions is not representative of all households and does not allow for cross-country comparisons.

Another criticism of Boardman's definition is its rigidity, leaving no scope for ranging circumstances. According to her definition, a household is either seen to be fuel poor or not fuel poor and hence doesn't consider the severity of fuel poverty relative to each

household. Families who are spending close to the 10% threshold on energy, are being grouped alongside households who spend a proportionally larger amount of their income on energy (Koh et al., 2012). Another example is homeowners who choose to live in larger homes. Large homes normally require greater energy costs to maintain, such as heating and electricity (Koh et al., 2012). As a result, large homeowners appear as though they are struggling to afford their energy needs as they are spending a higher amount on energy bills (Koh et al., 2012), and consequently, end up being placed in the same category alongside smaller households who genuinely experience hardship related to fuel poverty. This creates policy implications for governments as it becomes more difficult to accurately determine which households are in actual need of assistance.

Moreover, there is even further criticism regarding income equivalisation. This is when household incomes are adjusted so it reflects factors such as the size of a family or the ratio of children to adults in a household (Koh et al., 2012). Therefore, a person earning £35,000 but has a family of 6 and is the sole earner would be seen in a similar light as a single person earning the same amount. (Koh et al., 2012) explains that despite many other government surveys implementing income equivalisation, the current fuel poverty measure at the time didn't take adjusted incomes into account. This potentially could have led to a misinterpretation of data, as larger low-income families would have been deemed better off than they were.

Lastly, this definition fails to consider households who are deliberately undercutting their energy usage to keep their energy costs as low as possible to avoid paying higher energy bills (Healy & Clinch, 2004). According to Brunner et al. (2012), the standards by which we define a reasonable quality of life in relation to energy consumption has increased in recent decades. For example, setting higher room temperatures or taking more showers. This has forced lower income households to take certain cost cutting measures in order to try and keep up with these current standards.

Despite the many criticisms that Boardman's expenditure paradigm faced, it still served as a valuable resource that paved the way for further research into the field of both fuel and, later, energy poverty (Thomson et al., 2017). Furthermore, Boardman's work finally

brought recognition to the issue of fuel poverty and provided a useful starting point for legislative change in the UK and later across Europe.

3.2 Low-Income High-Cost (LIHC) Indicator

To counteract some of the limitations found in Boardman's proposal, the Low-Income High-Cost (LIHC) indicator was created. It was first coined by John Hills in 2011, as part of an extensive research project to investigate possible recommendations to help alleviate and better measure fuel poverty in the UK. It states that a household should be considered fuel poor when their required energy costs exceed the national median and, by spending this amount, are left with a residual income that is below the official poverty line, which was defined as 60% of median income (Hill, 2011). In addition, Hills recommends that incomes should be equivalised to consider other aspects of the home that aren't as easy to measure under Boardman's approach (Hills, J., 2011).

Mathematically, a household i is defined as energy poor if it meets two simultaneous conditions:

High Cost: Their required energy expenditure (E_i) is greater than the median required energy expenditure of the population (E_m). $E_i > E_m$

Low Income: Their equivalised disposable income (Y_i) minus their energy expenditure (E_i) falls below the official poverty line threshold (P). $Y_i - E_i < P$

Therefore, the LIHC threshold can be expressed as:

$$LIHC_i = \begin{cases} 1, & \text{if } E_i > E_m \text{ and } (Y_i - E_i) < P \\ 0, & \text{otherwise} \end{cases}$$

Both the LIHC and 2M indicators rely entirely on the expenditure paradigm, requiring continuous, quantitative variables representing exact household energy expenditure (E_i).

The ECV data does not capture actual energy consumption costs or specific energy billing amounts. Instead, the survey provides a general, binary indicator for utility arrears, which groups electricity and heating together with other expenses such as broadband or water. Without exact monetary data for energy costs, calculating the precise thresholds required for LIHC ($E_i > E_m$) and 2M ($\frac{E_i}{Y_i} > 2S_m$) is mathematically impossible.

The main benefit of this metric compared to the 10% threshold, was that it accounted for a wider range of households' situations. As a result, this indicator helped identify not only lower-income households with large energy needs, but also the wealthier households with high energy needs that weren't financially constrained. By identifying and avoiding these wealthier households, it can assist governments in creating legislative policies that better target the most vulnerable groups. It can also offer a wider perspective as to how the population responds to increases and decreases in energy costs. Lastly, the concept of the LIHC indicator can be applied at national level, allowing for more precise country comparisons.

On the contrary, Hill's paper drew criticisms surrounding its accuracy, mainly, it doesn't consider households that are taking strategic measures to reduce their energy costs, such as only heating one room, or avoiding the use of appliances (Eisfeld & Seebauer, 2022). Therefore, on paper, some households who are suffering from energy poverty may appear as though they are sustaining an adequate standard of living as their energy costs are not greater than the national median nor are they left with an income below the poverty line. As a result, these vulnerable households are overlooked and won't receive the necessary support they require.

3.3 Twice Median (2M) Indicator

The final metric of note is that of the twice median (2M) indicator (Hills, 2012). It is represented as "double the median share of household energy spending relative to income" (Schuessler, 2014). This indicator helps identify specific households who are stuck paying substantially higher energy costs than higher income households. It identifies households that have extremely high energy requirements, such as elderly individuals, or it could point to homes with inefficient housing conditions, requiring them

to consume more energy. It is based on the assumption that a household spending more than the national median of income on energy will likely be experiencing some form of energy poverty or financial strain. Similarly, to the LIHC metric, which is based off of the national median, it can be easily applied to different countries for comparative analysis.

The 2M indicator identifies households that spend a disproportionately large share of their income on energy compared to the national average. A household is considered energy poor if the share of their income spent on energy exceeds double the national median. It is more flexible than Boardman’s 10% threshold as it accounts for changes in national energy costs and income patterns.

Let S_i be the share of income spent on energy for household (i), calculated as total energy expenditure (E_i) divided by total household income (Y_i):

$$S_i = \frac{E_i}{Y_i}$$

Let (S_m) be the median energy expenditure share for the entire population. The 2M formula is expressed as:

$$2M_i = \begin{cases} 1, & \text{if } \frac{E_i}{Y_i} > 2S_m \\ 0, & \text{otherwise} \end{cases}$$

Schuessler et al. (2014), criticised Hill’s LIHC metric by questioning why is it only when a household is spending the median amount of their income on energy that it is deemed unreasonable. He uses a simple yet effective analogy: consuming five steaks in one sitting is clearly excessive, but that doesn’t necessarily mean that eating four steaks is okay either. In the same way, even though Hill’s threshold is helpful in theory at identifying lower income households, it doesn’t fully account for other households who would still be disproportionately burdened by energy costs, even if on paper, they aren’t spending above the median. The obvious drawback of this indicator is that it doesn’t differentiate between lower-income and higher-income households. For example, a large household

with energy costs above twice the median could still be financial capable of covering this expenditure (Schuessler, 2014). It also doesn't consider households that are intentionally cutting back on their energy consumption to reduce energy costs.

3.4 Self-Reported Deprivation Indicators

Self-reported deprivation indicators are regarded as subjective as they are based on; “a households' direct assessment of their own living conditions and circumstances” (Tirado Herrero, 2017). They take into account basic goods such as heating or cooling systems and attributes of the home that are deemed essential such as being free from damp or rot (Tirado Herrero, 2017). These indicators give governments or international organisations a detailed first-hand account of the lived experiences of households and their strategies for coping with energy poverty (Middlemiss & Gillard, 2015). It also provides households the opportunity to draw attention to struggles they face as a result of not being to access essential energy services. These indicators are based on the assumption that households can identify and report accurately on their lived experiences in relation to energy deprivation.

The most common self-reported indicators include the inability to keep the home adequately warm, arrears on utility bills, and energy hardship measures. These are the variables taken by the EU-SILC, which is a database that is used to compare deprivation indicators across EU countries (Eurostat, 2025). Despite being recognised as one of the main sources for cross-country comparison, it still has its weaknesses, namely that it only surveys individuals living in private housing, thereby ignoring people in collective housing, institutions, and those who don't live in houses such as the Roma community (Thomson & Snell, 2013).

3.4.1 The Inability to Keep the Home Adequately Warm

According to the WHO, the recommended temperature for an indoor environment is 18°C-20°C and is often cited as the respective threshold for a satisfactory level of thermal comfort (Tirado Herrero, 2017). This baseline temperature increases by 2-3 °C for those who are sick or elderly as they are often more vulnerable and lower temperatures may

exacerbate ill health or even cause damage to the cardiovascular or respiratory system (Healy and Clinch, 2002). As part of the consensual approach, households are asked if they can afford to keep their homes adequately warm in line with or above the mentioned threshold. This gives a much more detailed insight as to the extent in which a household can be suffering from deprivation and if their energy needs are being met. These surveys or interviews conducted can also reveal the hidden side of deprivation and the coping strategies used to manage it.

The main limitation of this indicator is that people have different perceptions of warmth. Some individuals who are used to lower living temperatures may deem it adequately warm whereas others may find it unsatisfactory. Therefore, it is not only a subjective measure but also a culturally specific one (Thomson et al., 2017). In addition, some people may feel embarrassed or are aware of stigmas and instead see deprivation as weakness or even failure (Eisfeld & Seebauer, 2022). This bias means that some people may not classify themselves as living in energy poverty and will not receive the support needed to alleviate their burden.

Consequently, there has also been criticisms that this metric disproportionately focuses on the heating aspect and doesn't give the same weighting to other energy services such as lighting or appliance usage (Tirado Herrero, 2017). Lastly, this metric follows a binary threshold. This is limiting as it doesn't allow for any scope in determining the severity of energy poverty in a household and makes it more difficult to identify the most vulnerable households (Tirado Herrero, 2017).

3.4.2 Arrears on Utility Bills

As our standards of living have increased so has our reliance on energy services. Nowadays having access to basic energy services is not viewed as a luxury, but rather a necessity (Pye & Dobbins, 2015) (Brunner et al., 2012).

However, these services come at a price, with many households facing financial hardship to meet these expenses. This metric assesses whether households can pay their utility bills

on time. It is assumed that if a household cannot consistently pay their energy bills on time, it reflects financial difficulties which can, in turn, exacerbate energy poverty through future accumulated debt or restricted access to important energy services, such as heating or electricity.

One of the main strengths of this metric is that it is based on empirical evidence, making it less subjective and easier to measure than indicators such as thermal comfort. It can also be used as a means to identify lower income households, as they are more likely to be subject to payment difficulties (Thomson & Snell, 2013). In addition, when applied to a large sample, it could provide useful insight into general economic trends, particularly in relation to the financial situation of the household. In depth interviews and survey responses could also give academics or policy makers a clearer idea of the underlying factors causing households to fall behind on utility bill payments, such as, unemployment, high mortgage repayments, or medical expenses. This can be used as a guideline for policymakers to see what other areas need to be tackled in order to alleviate the financial burden on households.

However, this metric doesn't consider households that only occasionally experience arrears due to temporary financial difficulties. In addition, some datasets, such as the ECV mention arrears in a general sense rather than specifically related to energy (Thomson et al., 2017). This could include telecommunications, water, or broadband charges, which can reduce the accuracy of the metric. Furthermore, some households that are deliberately cutting back on consumption to prioritise their utility bill payments, are not included even though they may be experiencing another dimension of energy poverty such as poor housing efficiency or thermal discomfort (Eisfeld & Seebauer, 2022).

3.4.3 Economic Hardship Measures

Economic hardship indicators have been popularised in the academic works of (Middlemiss & Gillard, 2015) and (Bouzarovski et al., 2014). It has aspects similar to the consensual approach, in that it looks at the household at an individual level, but they place greater emphasis on the lived experience of the household, in particular, the coping

strategies and behaviours utilised by individuals to manage energy costs and alleviate financial strain. These indicators are much more useful in identifying examples of hidden energy poverty which has always been a challenging element to measure. Hidden energy poverty is referred to as; “scarcity and deprivation in home energy services that is severely experienced by those affected, but insufficiently reflected in established indicators” (Eisfeld & Seebauer, 2022). These measures go a step beyond looking at the binary measures of energy affordability, but instead how they act when put under these constraints, reiterating the point that energy poverty is not a static condition but rather a dynamic process influenced by adaptive capacity (Eisfeld & Seebauer, 2022).

This perspective is shared by Middlemiss and Gillard’s (2015) vulnerability framework, which offers a more in-depth analysis compared to other approaches, such as Boardman’s expenditure approach, and explores the reasoning behind what makes people vulnerable to fuel poverty by analysing their ‘lived experiences’ (Middlemiss, 2020). This framework identifies three areas in relation to their vulnerability research; “the likelihood of a household being subject to fuel poverty, the sensitivity of that household to fuel poverty, and the capacity that household has to adapt to changes in fuel poverty” (Middlemiss and Gillard, 2015). It shifts the focus away from simply income-based indicators towards more detailed measures, based on a household’s capabilities to access and afford basic energy services.

As mentioned previously, the benefit of using this type of measurement indicator is that it accounts for households that are suffering from hidden energy poverty. This is often an overlooked group as it is difficult to measure when using expenditure-based metrics. This means an entire new group can be identified and better targeted by policymakers at the legislative level. Furthermore, it better details the lived experience of each household and captures the true deprivation in which they face, whether that be financial hardship, health implications, or thermal discomfort.

The limitations of this metric are related to how it is implemented across different countries. For instance, certain countries may suffer from inability to keep their home adequately cool rather than warm, especially in the Mediterranean countries that are known for having warmer summers (Blue Green Atlas, n.d.). This makes it difficult to

capture and compare different countries under one metric, as each country is context specific. This could suggest it is more challenging for EU policy frameworks to be implemented equally across these alternate countries.

In addition, as this metric relies heavily on qualitative data, it should be used with caution due to its subjectivity. Some individuals could misconstrue or over exaggerate the extent to which they are facing economic hardship. Contrary to this, they may do the opposite and talk down or not report whether they do take part in self-rationing strategies as they may feel embarrassed for having less than others or worried that they will face stigmatisation (Eisfeld & Seebauer, 2022). This may in turn skew the data and not reliably capture the true number of people facing energy poverty.

It should be noted that the work of Middlemiss and Gillard (2015) focuses on the concept of fuel poverty vulnerability, not necessarily energy poverty. However, the idea of addressing any form of deprivation by exploring the real lived experiences of households, makes it applicable to the wider concept of energy poverty.

3.5 Multidimensional Energy Poverty Index (MEPI)

The MEPI is a composite index, which are referred to as “single numerals calculated from a number of variables that represent the aggregated value of a dimension that in itself might be elusive” (Nussbaumer et al., 2013). It is a multi-criteria framework that allows the analysis of multiple energy poverty deprivation indicators at once. It looks at a households’ deprivation in relation to their access to energy services. In addition, it captures the prevalence and intensity of energy poverty, emphasising its usefulness in policy-making (Nussbaumer et al., 2013).

Each indicator corresponds to a specific weighting, and a household’s deprivation score is calculated by summing up the different weights of the reported deprivation indicators. Examples of these indicators could include if a household does not have access to modern cooking fuels, such as electricity, kerosene, LPG, and natural gas or they don’t have access to electricity or any means of telecommunication (Nussbaumer et al., 2013). The score ranges from 0 to 1, with values closer to 1 indicating a greater severity of energy

poverty. For example, if access to electricity is given a 0.3 weighting and access to modern cooking fuels is assigned a weighting of 0.4, then the total deprivation score of the household will be 0.7. The MEPI measures energy poverty across d variables with a n population of households (Robles-Bonilla & Cedan, 2024). A household is identified as energy poor if they exceed a pre-determined threshold. From the previous example, if the threshold was set at 0.5, then that household would be deemed energy poor.

To form the MEPI, it has to follow the following structure:

1. As mentioned above, energy poverty is measured in d variables across a population of n individuals.
2. Firstly, $Y = [y_{ij}]$, represents the achievement matrix of $n \times d$ for $i =$ individuals and $j =$ variables
3. $y_{ij} > 0$ represents household i 's outcome in relation to the variable j
4. Weightings can be applied. The weighting factor is made up of the element w_j which is the weight that is applied to the variable j . It is defined as

$$\sum_{j=1}^d w_j = 1$$

5. The variable z_j is the deprivation cut-off in in the variable j that is then used to identify all individuals deprived in any variables
6. $g = [g_{ij}]$, this is the deprivation matrix. It is defined by $g_{ij} = w_j$ when $y_{ij} < z_j$ and $g_{ij} = 0$ when $y_{ij} \geq z_j$.
7. The weighted deprivation score for each household is calculated using the following formula:

$$c_i = \sum_{j=1}^d w_j g_{ij}$$

It represents the sum of weighted deprivations experienced by person or household i

8. A household will be identified as energy poor if it exceeds a predetermined threshold

$$c_i > k$$

9. $c_i(k)$ is equal to zero when $c_i \leq k$ and equals c_i when $c_i > k$

10. The headcount ratio H represents the proportion of people that are considered energy poor.

$$H = \frac{q}{n}$$

Where:

q = the number of energy poor households

n = the total number of households

11. The intensity of multidimensional energy poverty A , is represented by the following formula:

$$A = \sum_{i=1}^n c_i(k) / q$$

12. Therefore, MEPI is defined as $H \times A$ (Nussbaumer et al., 2013).

There are major drawbacks of using the classic MEPI calculation in a developed country like Spain. The original index measures absolute, physical deprivations, such as cooking with firewood, lacking a basic lightbulb, or not owning a radio (Nussbaumer et al., 2013). Those metrics are irrelevant to a developed country like Spain. Other authors, such as Sokołowski et al. (2020), have utilized the Alkire-Foster (AF) method (Alkire & Foster, 2011) to adapt the MEPI to both objective monetary indicators (like "low income, high costs") and subjective self-reported indicators (like "inability to keep the home adequately

warm") to map energy poverty in Poland. However, the ECV survey lacks data corresponding to these diverse dimensions, including critical factors like the age of the housing stock and the ability to cool the home during summer. Therefore, calculating an aggregated deprivation score (C_i) that accurately satisfies the multidimensional criteria ($c_i \geq k$) could not be achieved.

What distinguishes the MEPI from the other measurement approaches is that it identifies different energy poverty dimensions by using a multi-criteria framework focusing on multiple household needs including access to modern cooking fuels, electricity, and household appliance ownership (Nussbaumer et al., 2013). It is a more dynamic assessment that shifts away from the more traditional single-indicator measures such as the expenditure approach, which tended to underestimate the complexity of energy poverty.

Similar to the other measurement approaches, one of its main strengths is that it offers detailed information across several criteria. This can provide a detailed breakdown as to the habits and concerns of each household and can be used with regard when creating public policy frameworks (Nussbaumer et al., 2013). Moreover, it captures a much broader range of deprivation indicators, such as electricity, heating, and access to cooking fuels. This can assist governments or policy makers in understanding which dimensions of energy poverty have a greater impact on the average household and therefore, should have greater emphasis in public policy frameworks.

In regards to limitations, the weightings of the indicators should be questioned. It is a subjective task to determine which indicators should be given a stronger weighting than others, and can have a significant impact on the results. Similarly, the dimensions which are selected or even the threshold which is set, can ultimately skew the results and may be misleading to reaffirm a certain hypothesis. Furthermore, this approach is based off of a household's energy needs and fails to consider other aspects of energy poverty, such as affordability indicators. For example, a household may obtain a low deprivation score of 0.1, meaning they have access to most modern energy services, yet it doesn't take into consideration whether they are paying their energy bills on time, if the household is failing

to cover all of their expenses, or if they are implementing self-rationing strategies to keep their energy costs low. A further point of note is that the MEPI leans into the idea that energy poverty is a static issue rather than a dynamic one (Phimister et al., 2015). Even though it makes a better effort to capture the multidimensional complexity of the issue, it still doesn't take into consideration temporary energy poverty or its long-term implications on the household.

3.6 European Domestic Energy Poverty Index (EDEPI)

The EDEPI is a composite index that measures four metrics: share of energy expenditure, the inability to keep homes adequately cool in summer and warm in winter, and the share of the general population living in homes with poor housing conditions, such as, leaks or damp (Saheb et al., 2019). Therefore, it presents a multidimensional approach by measuring several dimensions of energy poverty at the same time. What sets it apart from the MEPI is that it specifically considers energy expenditures not general utility arrears. Furthermore, it considers cooling in summer, an indicator that is largely ignored by datasets such as the EU-SILC.

For countries with warmer climates, like Spain or Italy, this is particularly relevant, as households may have a greater need for cooling systems than for heating. A weakness of this index, is that even though it is accounting for multiple energy poverty dimensions, it may be taking too broad of a perspective, by combining the various circumstances of the household into a simple composite score. It may overlook hidden energy poverty or regional inequalities that exist.

Overall, the complexity of energy poverty means that there is no single measurement approach that can provide a complete picture of household deprivation. Every indicator, as mentioned above, whether it's based on expenditure, subjective experience, or multidimensional criteria have their trade-offs. The main question is identifying what each indicator successfully captures and what dimensions of vulnerability it leaves out.

The Expenditure Approach captures the objective financial reality of households and measures the financial burden energy costs place on a household's income. It is quantifiable and very useful for governments when establishing limits on financial aid. However, it leaves out 'hidden' energy poverty, households that deliberately restrict their energy use to save money.

Self-Reported Deprivation Indicators capture the lived experiences of households and what they may be suffering from, including, thermal discomfort or the stress of not being able to pay their bills. This allows us to identify households that might be self-rationing by restricting their energy use. But, because it is subjective, it's more difficult to use for targeting policies.

The Multidimensional Approach is much broader by combining several energy poverty indicators. It provides a better understanding of the factors that contribute to energy deprivation and can identify households that have been overlooked by expenditure-based metrics. However, this wider scope makes the measure more complex and relatively incomplete due to its wide scope.

Given the inherent limitations and trade-offs of each measurement approach discussed above, it is important that the energy poverty indicator selected fits with the context of the population being measured. Particularly to the specific socio-economic, infrastructural, and climatic realities of the population under study. The following chapter will establish the data sources, variables, and specific measurement frameworks selected to assess energy deprivation within the national context of Spain.

4. Methodology

4.1 Data Source

This analysis will focus on interpreting EU-SILC (Encuesta de Condiciones de Vida, ECV) microdata for Spain between the periods 2020-2023. The ECV is a national survey that collects data relating to the income and living conditions in Spain and is part of the

wider European Union Statistics on Income and Living Conditions (EU-SILC) dataset, making it particularly useful for comparison with other EU countries (Thomson & Snell, 2013).

The ECV is conducted by the Instituto Nacional de Estadística every year and covers mainland Spain, the island regions, and the autonomous communities. Its purpose is to have a detailed overview of the socio-economic factors that directly impact households such as income inequalities, deprivation, and social exclusion (INE, 2024b). It can help policymakers clearly observe and understand what factors are negatively impacting households, and therefore, better design and implement new policies that will best target the most vulnerable.

The chosen data is longitudinal as it emphasises the changes to the household overtime, and therefore can better establish a trend. This will provide a broader picture of the overall socio-economic situation in Spain. The period of 2020-2023 is the chosen timeframe for this analysis as it some of the most recent data, allowing for a more accurate representation of the current socio-economic situation in Spain and because it aligns with recent economic shocks such as the COVID-19 pandemic and the energy crisis in relation to the war in Ukraine.

A clear distinction between the level of variables used in the ECV dataset is necessary in order to have a better understanding of which variables are being measured in this study of energy poverty.

For the purposes of this analysis, household level data will be the main measured variable. Key indicators include thermal deprivation, arrears on utility bills, and household disposable income. The ECV also provides individual level data, such as the age of the individual, employment status, and education level, however, this analysis is focusing on the comparison at the regional level between households. Therefore, the household level variable is more appropriate for the study as thermal comfort and the payment of utility bills often impact the entire household, rather than individual members. At the dwelling level, the ECV has limited data surrounding dwelling characteristics, such as energy

efficiency rating or the age of the house. To make up for this, self-reported indicators, particularly thermal warmth, can be used as indicators of poor energy efficiency in the home.

Although the ECV applies a survey weight to each Spanish household, these were not applied to the study. The analysis is focused on identifying and comparing regional patterns of energy deprivation with the use of binary indicators rather than producing adjusted national estimates (Phimister et al., 2015) (Solon et al., 2013).

The household income data was used without including equivalisation. This is due to the understanding that residential energy demand, particularly heating, is dependent on the physical characteristics of the home itself, rather than the number of people in the household (Heindl, 2013). Also, Brabo-Catala et al, (2024) review how different academics and policymakers measure fuel and energy poverty, and found that 51.19% of the publications did not equivalise incomes, compared to only 47.62% that did.

In regards to missing values, if households chose not to respond to one or more of the primary indicator questions they were removed from the sample. This marginally reduced the sample size of each region but not enough to directly impact the overall results of the analysis.

The study will consist of a quantitative comparative analysis of measurement indicators and comparison at the regional level. The ECV data will be analysed to identify if there are any energy deprivation patterns amongst households across different regions of Spain. The analysis will be comparing yearly thermal deprivation and utility arrears figures from the ECV and contrasting them against energy poverty drivers, including energy prices, household income, and energy efficiency. The same type of indicators will be used at the regional level, with the results being displayed in charts or tables to identify patterns or differences between them.

This paper adapts the theoretical principles of these indicators by constructing the following binary metrics:

Thermal deprivation

Generalized utility arrears

to evaluate energy vulnerability within the constraints of the available data.

Although the ECV contains a variety of variables concerning household characteristics, there are only a select few that can be applied to the concept of measuring energy poverty. Both thermal deprivation and payment difficulties will be interpreted by region to observe if there are regional inequalities present. As the ECV contains data that spans several years, it is possible to observe the changes or trends in different socio-economic indicators across different regions of Spain. This not only gives us a detailed breakdown of the prevalence of energy poverty across Spain, but it also serves as a guide to identify regions that require better public policy frameworks.

The disposable income of the household is important as it evidently has one of the strongest ties to energy poverty in academic literature (Brabo-Catala et al., 2024).

If a household is financially disadvantaged, there is an increased likelihood that they will defer on their energy payments and struggle to keep their home adequately warm. It doesn't consider every dimension of energy poverty, but it can strongly indicate which households are more vulnerable to energy poverty.

The ability to keep the home adequately warm during winter is an example of a self-reported metric. It provides a first-hand account as to whether households are experiencing thermal discomfort. This is the strongest indicator of energy poverty, as a household who is not able to keep themselves warm means they are not receiving or meeting their energy needs and are therefore struggling to maintain a sufficient level of comfort in their home. This has the added risk of deteriorating the health or wellbeing of individuals, emphasising the severity of their situation (Healy and Clinch, 2002). This holistic approach is more detailed but subjective, meaning that people's perceptions of inadequate warmth in the home may cause inconsistencies in the results.

Arrears on utility bills is an extension of the affordability indicator. It expresses if households face challenges in meeting their energy payments. Households experiencing arrears could be under extreme financial strain, leaving them exposed to economic shocks and more vulnerable to losing access to important energy services.

Other potential energy poverty dimensions, such as, actual energy consumption, energy efficiency ratings, cooling ability, and indoor temperature were not included in the analysis as there was no corresponding data available in the ECV survey. Therefore, the variables chosen were based on academic literature and could be observed in the ECV dataset.

4.2 Construction of indicators

As previously discussed, there are multiple variables that can be used to determine energy poverty, yet they are not all measured in the same way. To be able to compare and contrast these variables, they need to be converted into binary indicators that reflect affordability, thermal deprivation, and financial capabilities.

The thermal deprivation variable is operationalised by establishing if the household is able to adequately heat their home during winter. The responses from participants were categorised into a binary indicator:

0 = Household is able to keep their home adequately warm during winter

1 = Household cannot keep their home adequately warm during winter

A value of 0 means that the household is not experiencing thermal discomfort whereas, a value of 1 is perceived as experiencing thermal discomfort, and therefore energy deprivation. Binary coding makes it easier to draw comparisons between the data. It considers first-hand experience of energy deprivation yet its subjectivity is dependent on households' perceptions rather than quantifiable evidence. Furthermore, this indicator only takes into account a household's ability to keep warm in winter, ignoring the ability

to keep cool in summer, which arguably, is just as important of a dimension, especially in relation to warmer countries like Spain.

The presence of arrears on utility bills is operationalised by noting whether a household has experienced arrears on utility bills in the last 12 months. It was recoded into the binary form below:

0 = no arrears on utility bills in the last 12 months

1 = arrears on utility bills in the last 12 months

A value of 1 indicates that the household is facing financial difficulties in meeting their utility payments. The household can be viewed as vulnerable to energy poverty as they are at risk of losing access to basic energy services. It is compared alongside the thermal deprivation indicator to identify the type of energy vulnerability that is present. For instance, if a household is not experiencing arrears on their utility bills but they are reporting inadequate heating, this could be a sign of deliberate underconsumption to reduce energy costs. On the other hand, if a household has arrears but are adequately warm, they could be intentionally not reporting thermal deprivation due to stigma or embarrassment.

Disposable household income is not necessarily a direct measure of energy poverty as other factors can contribute to energy poverty, including climate conditions, poor energy efficiency, and economic shocks. Instead, it is used as a means of assessing whether a household is experiencing thermal deprivation or arrears on utility bills as these are the more central indicators relating to the concept. For this indicator, the median household income was used for both the national and regional analysis.

For this analysis, the median was chosen as the most efficient method for measuring a standardised value of household income. The median is often cited as being a more reliable measure than the mean as it disregards the extreme values which lie outside the range of household incomes (Liddell,2012). For example, in the ECV, there are various households who report having negative household incomes, possibly due to high

mortgage repayments, sudden unemployment, or large medical expenses. As the extremes of household income are ignored, it allows for a more representative dataset that accurately depicts the true financial situation of the Spanish household. (Liddell,2012), (Schuessler, 2014).

As this analysis is comparing the thermal deprivation and utility arrears indicators both individually and against each other, four categories of energy vulnerability were introduced. The four sub-groups corresponded to the outcomes of their answers to the survey questions regarding their ability to keep their home warm during winter and whether they had any late utility bills in the last 12 months. It is also used as a measure for the severity of energy vulnerability, not just those who are the worst off. It can also help identify households that may be facing hidden energy poverty. In this sense, the variables are observing and measuring different dimensions of energy poverty, drawing a parallel between affordability pressures and thermal comfort. The four groups are displayed below:

(0,0) No Risk: The largest group throughout the period, indicating that most households remain relatively energy secure and can meet both thermal and financial needs.

(0,1) Arrears Only (Financial Strain): This group identifies households that are experiencing some form of financial strain but not necessarily related to energy costs. While this metric highlights households needing financial support, it fails to capture those prioritizing bills over warmth.

(1,0) Thermal Deprivation Only (Hidden Energy Poverty): It captures households that are unable to keep their homes adequately warm but do not have arrears, providing strong evidence of "hidden energy poverty". These households likely adopt self-rationing coping strategies to reduce energy costs and avoid late payments. While it captures lived experiences missed by affordability metrics, it is a subjective, perception-based measure.

(1,1) Severe Multidimensional Poverty: This group experiences both thermal deprivation and arrears. It represents the most severe, multidimensional form of energy

vulnerability, as households are constrained by physical and financial pressures, putting them at high risk of losing access to domestic energy services. This group is highly relevant for targeted policy intervention, though relying only on this strict combined metric would underestimate total deprivation.

4.3 Spain as the measured country

Spain offers a valuable insight into energy deprivation in a European country, making it an appropriate case study for analysing the impact of energy poverty; as it combines climatic inequalities, aging housing stocks, and recent exposure to economic fluctuations.

Spain is known for having contrasting climatic conditions across its regions, particularly between the north and south. Northern regions such as Cantabria, Asturias, and Galicia are viewed as having a maritime climate, with mild winters and a high level of rainfall, while southern regions including Andalucía, Murcia, and Extremadura are renowned for having extremely hot and dry conditions for prolonged periods of the year (Blue Green Atlas, n.d.). This makes Spain a convincing choice for analysis as different climatic conditions can have a direct implication on the energy needs of households. Families in colder regions may have greater heating requirements while in southern regions, cooling systems may be more necessary, especially during the summer months. This correlates with both the thermal comfort and affordability dimensions of energy poverty. Even though it has been established that cooling needs are important to Spanish households, the ECV data is only concerned with the ability to keep the home adequately warm during winter, neglecting a dimension of energy poverty that is just as important when attempting to measure energy deprivation.

Spain is also known for having a relatively older housing stock compared to other European countries. Many of these homes were built long before strict building quality standards and energy efficiency ratings were introduced (Ibarloza et al., 2018).

Therefore, older dwellings may likely suffer from poor insulation, unsealed windows, and inadequate heating systems, contributing to poor thermal comfort and potentially

generating higher energy costs. Interestingly, Spain has the fourth highest incidence of winter deaths related to energy poverty in the EU (European Energy Poverty Observatory [EPOV], 2019), which could be attributed to the disconnect between housing efficiency and thermal comfort in Spain.

Subsequently, some families may resort to using coping strategies to reduce their energy usage, making Spain a useful indicator for identifying hidden energy poverty. Moreover, these houses are not adaptable to modern forms of renewable technology, making it more difficult for certain Spanish households to transition to cleaner and more stable energy services (Bouzarovski & Tirado Herrero, 2017). By using the ECV data, these variables can be isolated from affordability metrics, making it easier to identify the multiple dimensions of energy poverty.

Lastly, Spain has experienced several economic crises over the last number of years including the COVID-19 pandemic in 2020. Consequently, this led to high unemployment, fluctuating energy prices, rising inflation, and general financial insecurity within the country (Bienvenido-Huertas, 2021) (Wang et al., 2021).

These external shocks tie in directly to the affordability dimension of energy poverty and showcase the general response of households to economic change. If households are facing greater financial strain in the home, they may be more likely to default on energy payments, thereby worsening the effect of energy poverty as they could lose access to domestic energy services. What sets Spain apart is that it is known for having a lower average income than other EU countries (Pyou ES, n.d.), potentially making Spain more vulnerable or susceptible to energy poverty.

Spain also has a history of regional inequalities, with northern regions like the Basque country and Navarra attaining far higher incomes than the poorer regions of Andalucía, Extremadura, and the island regions, such as the Canaries (Eurostat, 2023). As can be seen in various energy poverty literature, disparities in incomes can result in the unequal distribution of energy poverty (Bouzarovski & Tirado Herrero, 2017). By identifying energy poverty dimensions, policymakers and governmental organisations may be able

to identify gaps in public policies whilst at the same time, bridging the gap between inequalities at a regional and international level.

Spain was selected as it has an abundance of energy poverty related data. It is one of the only EU countries that has publicly available EU-SILC data. This gives a far more detailed breakdown of energy deprivation and social inequality at various levels. The dataset contains information on a majority of the energy poverty dimensions already mentioned including, thermal deprivation, arrears on utility bills, geographical location, and disposable income, making it a valuable source of information for this analysis.

The Bono Social Eléctrico is a discount on electricity bills for low-income households that meet a set of vulnerability criteria (Ministerio para la Transición Ecológica y el Reto Demográfico, n.d.). It also includes additional benefits, such as extended payment periods which immediately reduce household financial stress and lower the likelihood of experiencing arrears (Ministerio para la Transición Ecológica y el Reto Demográfico, n.d.).

Similarly, the Bono Social Térmico provides aid to vulnerable households to reduce the cost of hot water, cooking, or heating. During times of economic uncertainty, energy poverty has been addressed through emergency supports (Ministerio para la Transición Ecológica y el Reto Demográfico, n.d.). For example, during the COVID-19 pandemic, the Spanish government introduced a temporary ban on the disconnection of electricity, gas, or water supply from vulnerable households (Ministerio para la Transición Ecológica y el Reto Demográfico, n.d.).

These policies lean into Spain's National Strategy Against Energy Poverty, which aims to reduce long-term energy poverty by implementing a timeline which introduces short-term financial measures, the encouragement of structural improvements relating to energy efficiency, the identification of vulnerable households, and increased involvement of autonomous communities in the implementation of the strategy (Rodríguez Cabrero & Marbán, 2020).

The development of these support measures highlights a shift in how energy poverty is viewed by the Spanish government. Rather than being seen as a temporary or singular issue, energy poverty is being recognised as a long-term structural problem that requires a multifaceted policy response.

5. Results and Discussion

Here, we examine whether the selected indicators capture different aspects of energy poverty, based on analysis of the ECV data between 2020 and 2023. The two main indicators used are thermal deprivation, defined as the inability to keep the home adequately warm in winter, and payment difficulty, measured through arrears on utility or housing-related bills over twelve months. Our analysis compares how these indicators change over time and where they overlap or diverge and the scope will include both national and regional levels. This helps identify different types of energy vulnerability and gives an indication of how severe the problem is for different groups. The results are also considered alongside wider economic factors, including median income and changes in energy costs in Spain. This makes it easier to explore how household financial circumstances and energy prices interact, and how they relate to energy poverty. However, this does not assume that income or prices alone explain energy deprivation but instead considers how they contribute to the overall picture.

We examine the strengths and limitations of the ECV dataset, particularly in terms of how accurately it captures different forms of energy deprivation. We highlight areas for further research that could improve understanding of energy poverty, particularly in the Spanish context. The aim here is to support the research question by showing how the choice of indicators influences how energy poverty is measured and understood.

5.1 Energy Poverty Indicators

5.1.1 National Energy Poverty Indicators

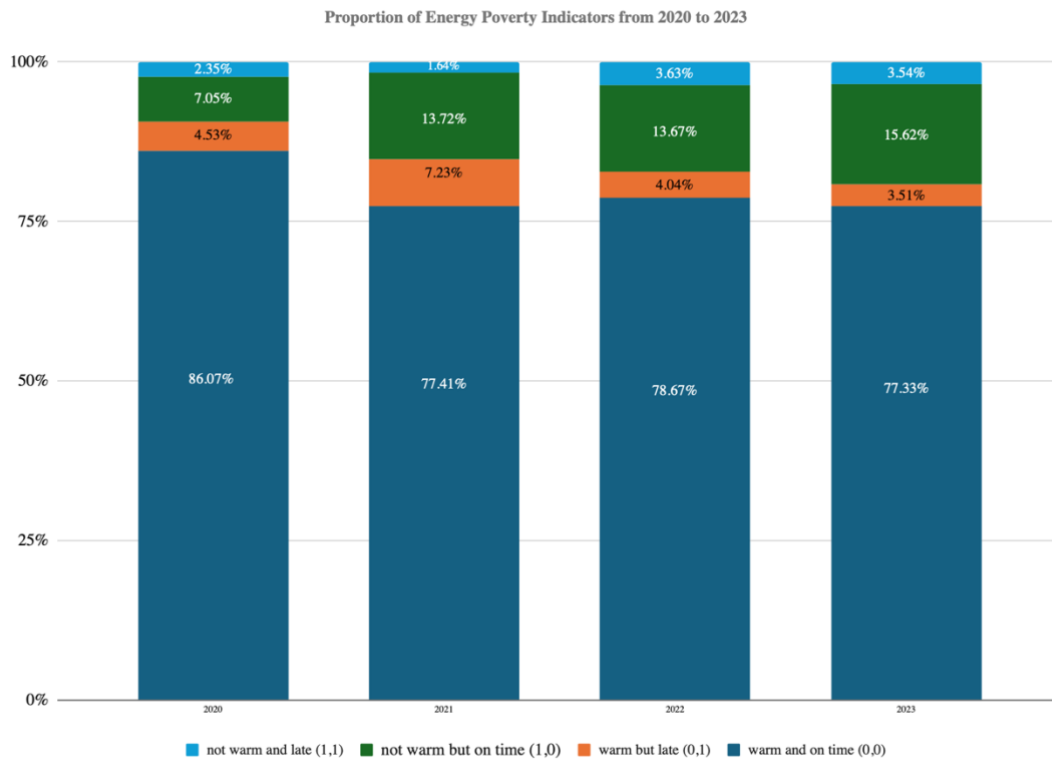


Figure 1: Percentage proportion of National Energy Poverty Indicators

From the chart provided, the (0,0) group remained the largest throughout the period, indicating that the majority of households were relatively energy secure.

There was an evident increase in the (1,0) category which suggests that the rise in energy poverty is occurring through an expansion of less visible forms of energy deprivation. In contrast, the (0,1) group saw a slight decrease over this period and the (1,1) group, which represents the combined condition of both thermal discomfort and arrears on utility bills, is seen to be gradually rising, emphasising its persistence and growth over time.

In regards to the general trend over the four years, even though these groups maintained the same overall position there was an evident shift in the number of households reporting some form of energy deprivation, whether that be lack of warmth, arrears, or both over the course of the studied period. However, this period also marked the start of a sharp rise

in inflationary pressures and energy prices (INE, 2024b). This may explain why, despite some financial aid, many household incomes were not able to keep up with rising living costs, leading some to deliberately reduce their energy consumption or to fall behind on utility payments.

There is an exception for 2021, where the proportion of households experiencing the most severe category appear to decline while both of the moderate deprivation groups increased substantially. It is likely due to extensive welfare efforts introduced by the Spanish government because of the pandemic, such as the IMV or Bono Social Eléctrico, which may have helped protect the most severely affected households, which could help explain this temporary decline. However, after 2021, the broader trend suggests that severe energy poverty is on the rise again.

In 2020, the percentage of Spanish households facing some type of energy deprivation - (1,0), (0,1), and (1,1) - was 13.93%. This figure increased substantially to 22.59% in 2021, before slightly decreasing to 21.34% in 2022. However, in 2023, this figure increased again to 22.67%, which indicates that the number of Spanish households experiencing some degree of energy deprivation has increased over the period. By the end of 2023, the likelihood of a household experiencing energy deprivation had increased by approximately 9–10 percentage points compared to 2020, indicating a clear upward trend over the period.

The purpose of these deprivation indicators is to capture the different forms of vulnerability experienced by households, which could allow for a more detailed understanding of both the severity of energy poverty and how it varies between Spanish households.

The graph allows for a clear distinction to be seen amongst the different groups of energy deprivation. Between 2020 and 2023, the proportion of households within the category (1,0) increased substantially. This provides strong evidence of the growing proportion of Spanish households experiencing hidden energy poverty within the general population. It can be assumed that if a household is able to pay their utility bills in full, and on time,

that it seems counterintuitive that they cannot keep their home satisfactory warm. This pattern suggests that these households may be resorting to coping strategies in order to reduce their energy consumption to avoid paying higher energy costs.

In relation to heating, if a home shows obvious signs of poor housing characteristics such as poor insulation, cracks, or unsealed windows and doors, it is likely experiencing inadequate thermal warmth, due to heat loss. Parallels can also be drawn between energy inefficiency and the group (0,1). Some households may resort to leaving the heating on for extended periods of time, driving their energy costs up and resulting in them being unable to pay their bills.

Across the four years, it can be observed that all groups containing some form of energy deprivation - (0,1), (1,0), and (1,1) - show an overall increase. However, the proportion in which they experience hardship differs considerably, emphasising that relying on a single indicator to measure energy poverty will overlook or diminish the severity of some vulnerable households.

While the combined use of these indicators provides a more complete picture of energy poverty, it doesn't necessarily explain why households fall into each of the different categories. Therefore, it is important to analyse the drivers of energy poverty, including household income, energy prices, and energy efficiency, which can impact a household's ability to access energy services.

Of the two indicators, the inability to keep the home adequately warm appears to be the more robust measure of energy poverty, because it directly captures whether households are meeting their energy needs. By contrast, payment difficulties are more dependent on assumptions, since arrears may reflect wider financial problems rather than energy poverty alone. However, using both indicators together provide a more comprehensive picture of energy poverty, as each identifies different vulnerable groups. For this reason, both are included within the official monitoring framework (European Commission, 2023). Using them together allows for a clearer distinction between households

experiencing hidden energy poverty, those under financial pressures, and those facing more severe, multidimensional hardship.

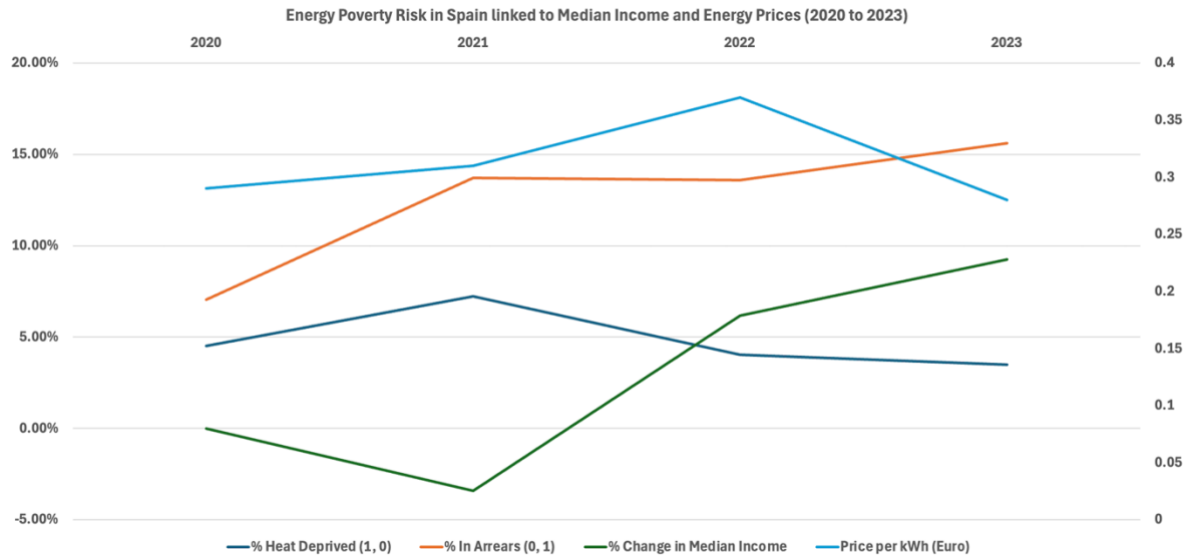


Figure 2: Energy poverty risk compared against median income and energy prices in Spain

Figure 2 above highlights the relationship between how thermal deprivation and arrears respond to changes in the median income and electricity prices between 2020 and 2023.

Between 2020 and 2021, the line graph follows the expected trend, as median income decreases, the number of households experiencing energy poverty increases. External shocks strongly correlate with the subsequent rising energy costs between 2021 and 2022.

The arrears indicator peaks in 2021 before slowly declining, in line with the fall in energy prices. However, thermal deprivation sees a steady increase over the period, despite signs of economic recovery, as seen by the increase in median income in 2022. This emphasises the persistence of the issue and that it may not be concurrent with short-term economic improvements. This divergence also highlights different indicators measure multiple aspects of energy poverty. Arrears captures the specific problem of payment difficulty and may react quicker to economic instability, such as changing energy prices. In contrast, thermal deprivation covers a broader group of households, including those who are prioritising their bills by under consuming energy to keep their energy costs low. The upward trend of thermal deprivation, despite improving economic conditions and decreasing electricity prices, may show that energy poverty is not entirely captured by

financial indicators. Instead, it could be the result of more challenging factors, including housing inefficiency or climatic conditions.

This reiterates the point that energy poverty cannot be merely defined by simply affordability metrics. It is a multidimensional phenomenon that requires context specific public policy frameworks. The upward trend since 2020 could suggest that an increasing proportion of households in Spain are experiencing some form of energy deprivation. This emphasises the ever-growing need for efficient policy intervention by the Spanish government to try and relieve the financial pressure faced by vulnerable households.

A limitation of the chart is that thermal deprivation and arrears are compared only against electricity prices. It doesn't consider other forms of energy such as heating oil or gas, which are often more expensive. Electricity was selected as it is the leading source of energy used by Spanish households (IDAE, 2022).

Even though these findings show that energy poverty is actually increasing in both size and complexity, the reasons behind these trends, especially in relation to why thermal deprivation continues to rise despite arrears remaining relatively stable. To get a better understanding of the causes, it is necessary to investigate key drivers in relation to household income and energy costs. The following section examines if changes in these two factors impact the rise in energy deprivation in Spain between 2020 and 2023.

5.2 Drivers of Energy Poverty

5.2.1 National Income Perspective

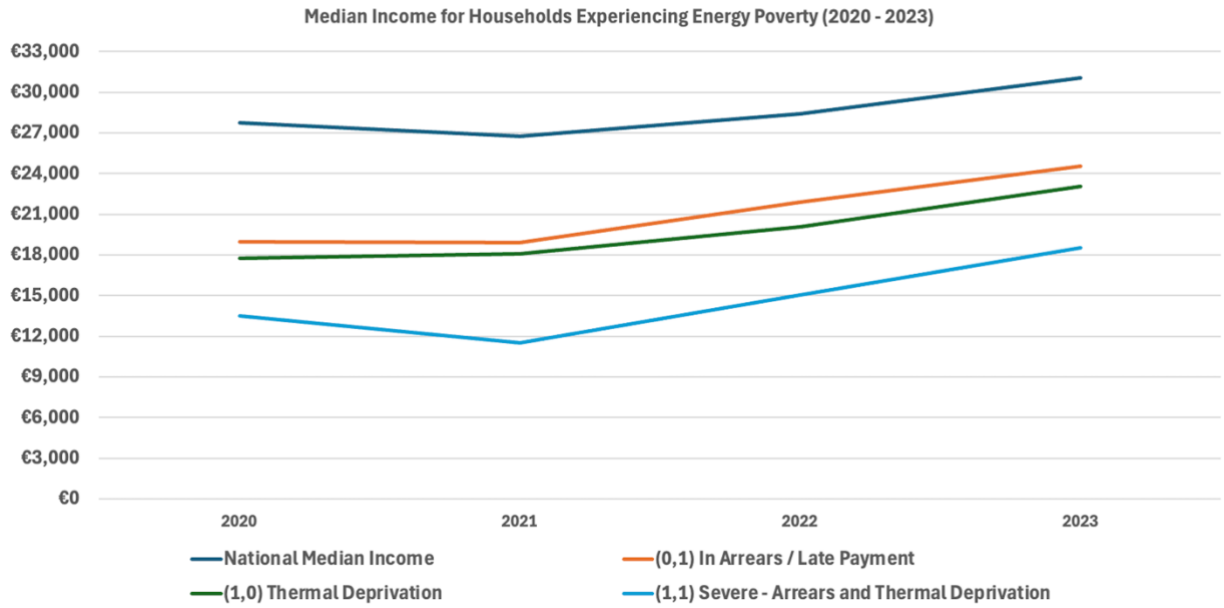


Figure 3: Median Income of households experiencing energy poverty between 2020 and 2023

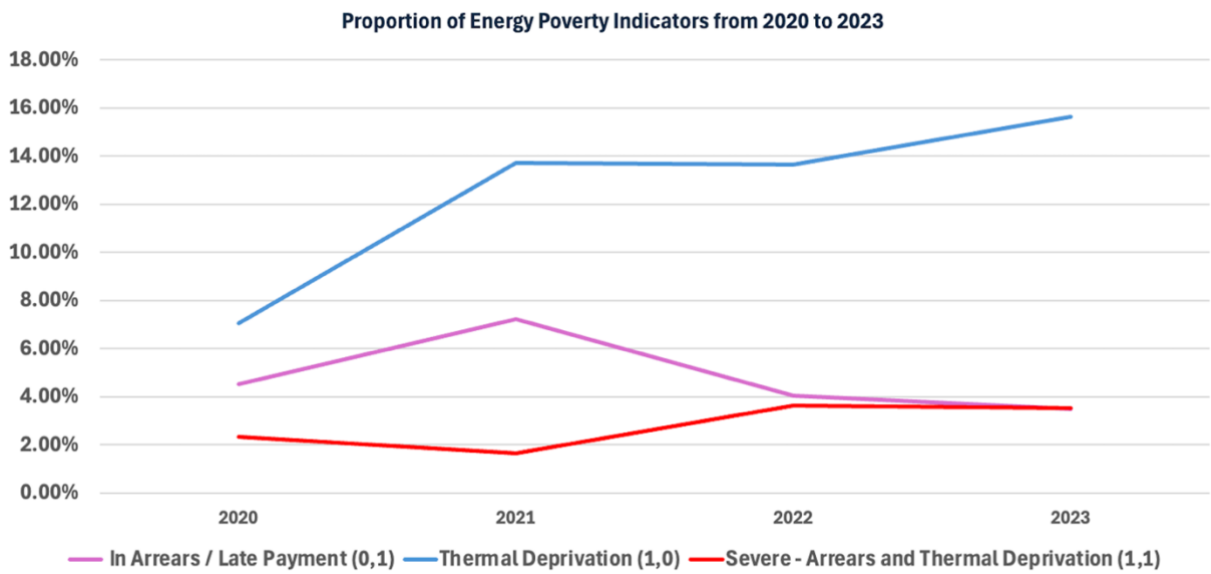


Figure 4: Percentage proportion of energy poverty indicators between 2020 to 2023

Comparing energy poverty indicators against median income trends highlights a disparity between rising income and self-reported measures in Spain between 2020 and 2023.

At a national level, the median income of Spain saw an overall increase between the years of 2020 and 2023. However, between 2020 to 2021, the median income dipped from €27,722.70 to €26,772.80. This dip is consistent with the implications of the COVID-19 pandemic, with high inflation, rising unemployment, and general economic slowdown accelerating this decline (Halkos & Gkampoura, 2021). From 2021 onwards, the median income increases, indicating economic recovery. However, this increase is likely to have a nominal effect when inflation is considered. Many households are actually left worse off as their purchasing power is reduced. This could help explain why energy poverty indicators do not improve when incomes rise. For instance, thermal deprivation rises significantly from around 7% in 2020 to approximately 16% in 2023, even though income is increasing. This suggests that rising energy costs and inflation are offsetting income gains.

On the contrary, the proportion of households with arrears initially increase from about 4.5% in 2020 to 7% in 2021, before dipping to around 4% by 2022. This shows a significant contrast between the two indicators. There is strong evidence to suggest that hidden energy poverty is occurring. Some households may prioritise paying energy bills at the expense of thermal comfort.

The indicator representing severe energy poverty increased from 2% in 2020 to about 3.5% by 2022. This indicates that this group is not only facing multiple dimensions of deprivation, but that more people are falling into this category overtime despite increases to median income since 2021. This is likely influenced by continued inflationary pressure and increasing energy prices as a result of the war in Ukraine.

The graphs also depict a clear inequality between income and deprivation groups. Households who suffer from thermal deprivation and arrears consistently have the lowest levels of median income, while those who experience no deprivation have the highest median incomes. It suggests that income is a determining factor in explaining energy poverty yet the steady increase in thermal deprivation despite median income increases, shows that income alone is insufficient in capturing the true extent of energy poverty.

It should be noted though, that the number of respondents differed considerably from year to year, which can impact the reliability of the results.

5.2.2 Regional Income Perspective

The previous section focused on national-level trends, which can overlook the more subtle differences of energy poverty. Energy poverty doesn't affect everyone equally; it is impacted by varying economic conditions and the severity of vulnerability. To gain a better understanding of where these factors overlap and diverge, the analysis will now be refined to a regional level, with a narrower scope. This will allow for a clearer consensus of how regions are linked to specific forms of energy deprivation.

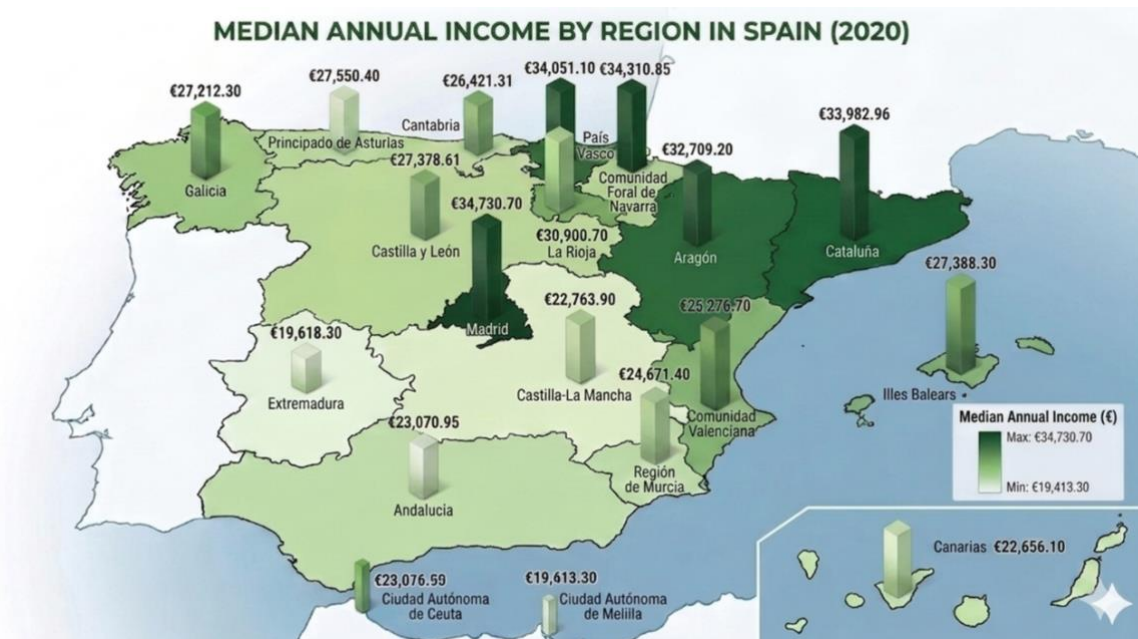


Figure 5: The median annual income by region in Spain in 2020

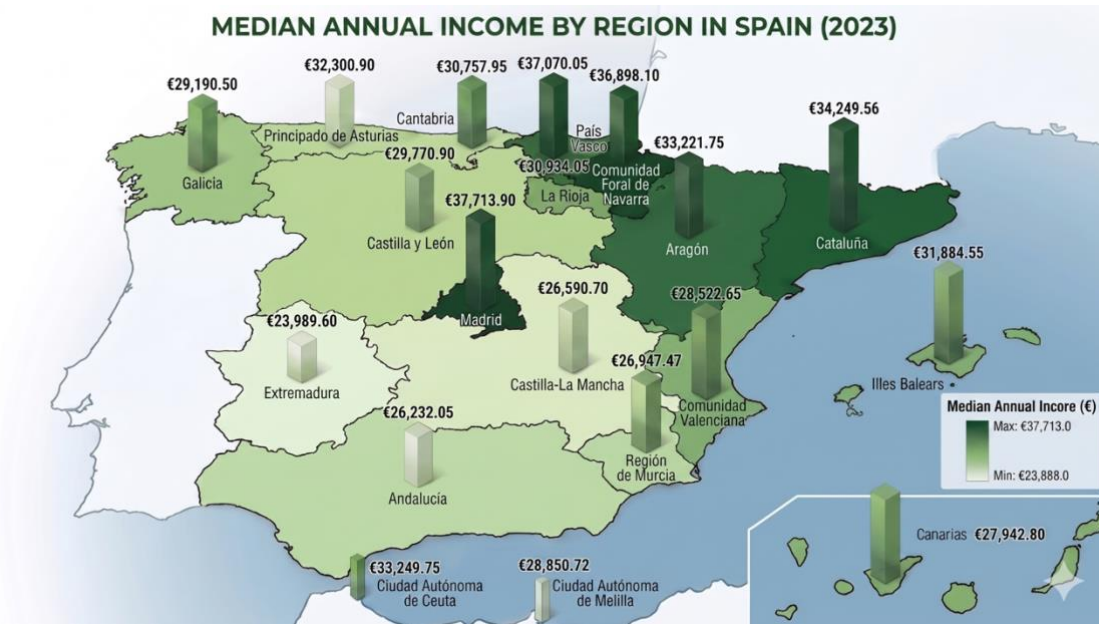


Figure 6: The median annual income by region in Spain in 2023

The heat maps above show the regional median income in Spain for 2020 and 2023. The varying shades of green indicate how each region compares relative to others. Immediately a clear pattern emerges: northern regions, including the Basque country, Navarra, Cataluña, and Aragón have relatively higher median incomes compared to southern regions such as Extremadura, Andalucía, Murcia and the autonomous communities of Ceuta and Melilla.

The north-south divide has a long-standing history of inequality. Northern regions have experienced earlier economic development, in part due to their proximity to European markets (Díez-Minguela et al., 2016). This gap became particularly prominent during the period of industrialisation, for instance in Barcelona and Vizcaya, which led to better infrastructure, higher employment, and higher wages. Díez-Minguela et al. (2016) argue that these disparities are a long-standing feature of Spain's economic history.

In contrast, southern regions such as Andalucía have one of the highest unemployment rates in Europe at 16% in 2024 (Tapia & Venturi, 2025). There is also a clear divide between economic sectors. The south is dependent on agriculture and tourism, which promote lower productivity, temporary contracts, and overall lower wages (Castejón et al. (n.d.). There are less high-paying opportunities in southern regions, leading to more

migration or ‘brain drain’ of skilled individuals to northern regions that have diversified economies in sectors like manufacturing, finance, and technology Castejón et al. (n.d.).

Although it appears that median income increases across most regions between 2020 and 2023, the data reflects nominal income and does not account for inflation. The cumulative inflation rate for Spain is approximately 15.4% (INE, 2024b), with many regions experiencing a decline in real income. This means household purchasing power decreases despite salary increases.

This is evident in higher-income regions such as the Basque country and Navarra. Despite recording some of the highest nominal income growth in Spain, both experienced declines in their real income between 2020 and 2023, indicating that households’ salaries were lagging behind rising inflation. This helps explain why energy deprivation has increased in these regions, with more households experiencing thermal discomfort or late payments by 2023.

In lower-income regions such as Extremadura, Andalucía, and the Canary Islands, the picture is more mixed. Some regions experienced modest real income growth, partly due to income supports such as the Ingreso Mínimo Vital, which improved their purchasing power to some extent (Gorjón, 2021). However, southern regions still have significantly lower incomes, meaning energy costs still take up a large share of household income, which, in turn can cause additional financial strain or encourage hidden energy poverty strategies.

Andalucía experienced a decline in real income in 2023, suggesting that households are particularly vulnerable due to lower incomes, high unemployment, and reliance on temporary contracts, especially during the summer season Castejón et al. (n.d.). This contributed to continued financial strain despite policy supports.

Overall, about two thirds of the regions saw a real decline in median income after inflation was taken into consideration. The fact that the same regions consistently ranked in the same positions over the course of the analysis highlights persistent regional inequalities.

Higher-income regions continue to experience lower energy poverty, while lower-income regions remain more vulnerable, indicating limited progress in reducing disparities. Intensive public policy intervention is necessary to try and relieve some of the financial strain that many of these households have become accustomed to.

Over the four years, Ceuta recorded the highest proportion of households facing energy deprivation. However, this should be interpreted with caution due to the small sample size of the region, which can reduce reliability. Lastly, while more detailed regional breakdowns would be useful, they are limited by the small sample sizes, so overall regional median income provides a more robust comparison.

5.1.2 Regional Energy Poverty Indicator Perspective

While regional income differences help explain economic inequality in Spain, they do not reflect the lived-experience of households. Income levels vary by region and are affected by inflation. However, energy poverty depends on more than just income. By looking at direct measures of deprivation- thermal deprivation and arrears on utility bills- households experiencing the most severe forms of energy poverty can be identified.

Percentage of Severe Energy Poverty, 2020

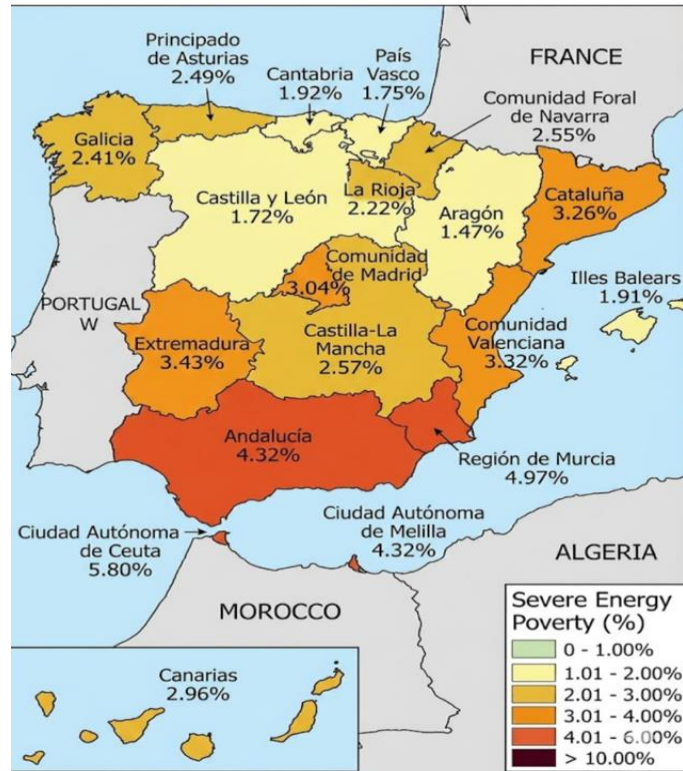


Figure 7: Percentage proportion of severe energy poverty in Spain in 2020

Percentage of Severe Energy Poverty, 2023

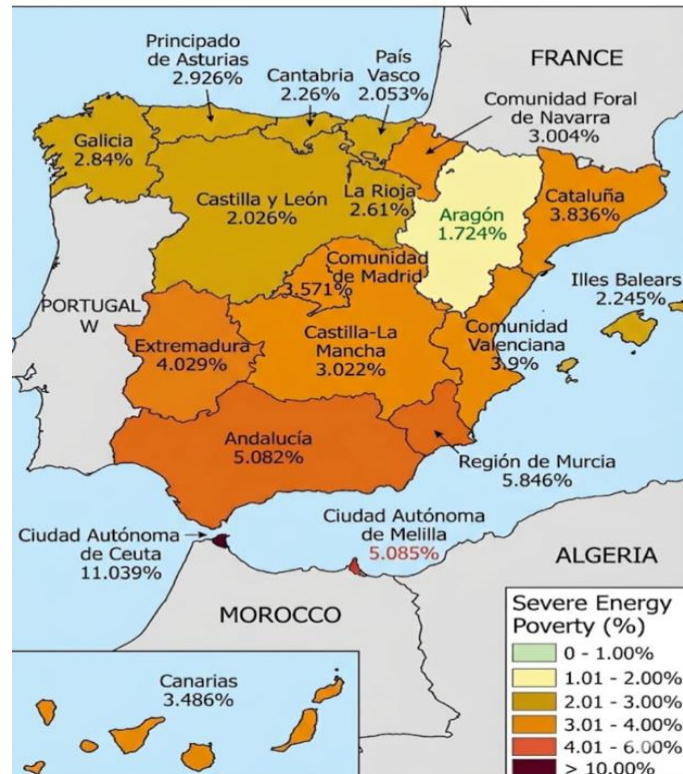


Figure 8: Percentage proportion of severe energy poverty in Spain in 2023

The two heatmaps above highlight the percentage of households facing severe energy poverty. From analysing the two charts, there is a clear increase in the proportion of households experiencing severe energy poverty between 2020 and 2023. Most regions show a notable rise, which aligns with wider external pressures such as post-pandemic inflation and the 2022 energy price shock.

A clear regional divide becomes apparent in both periods, as higher levels of severe energy poverty are concentrated in Extremadura, Murcia, and Andalucía. These regions record some of the biggest increases in severe energy poverty figures in both years, increasing from 3.43% to 4.02% in Extremadura, 4.97% to 5.84% in Murcia, and 4.32% to 5.08% in Andalucía. These same regions were among the highest levels in 2020, indicating existing regional inequalities have not changed but rather intensified. Although most regions retain similar rankings between 2020 and 2023, the darker shading in 2023 indicates a general increase in severity across the country.

Several structural factors may explain why these regions continue to experience higher levels of energy poverty. Firstly, unemployment is higher in southern regions such as Andalucía (Tapia & Venturi, 2025), which negatively impacts household income and increases affordability pressures. In addition, lower income households tend to live in homes with inadequate energy efficiency (Phimister et al., 2015), which increases the likelihood of higher energy costs and thermal discomfort.

Climate also plays an important role. Southern regions are notoriously warmer than other parts of Spain, especially during the summer (Castejón et al., n.d.). This could increase the demand for cooling systems. Poor energy efficient homes could further exacerbate the effect of energy poverty as more cooling is required to maintain an adequate level of comfort in the home.

In contrast, northern regions maintain relatively lower levels of severe energy poverty. Regions such as Aragón (1.47% to 1.72%), Cantabria (1.92% to 2.26%), and the Basque Country (1.75% to 2.05%) remain among the lowest across the period. This may reflect the implementation of stronger housing or energy efficiency measures. For example, the

Opengela programme in the Basque Country provides technical and financial guidance to local residents in relation to collective building retrofitting and energy efficiency improvements (European Climate, Infrastructure and Environment Executive Agency, 2025), which can help reduce household energy demand and exposure to deprivation.

The Canary Islands show visible indications of severe energy poverty, rising from 2.96% in 2020 to 3.49% in 2023. This may be partly due to geographical and structural factors, as the islands are dependent on imported fossil fuels and only a small percentage of renewable energies are generated on the islands, making them more vulnerable to price fluctuations (Uche-Soria & Rodríguez-Monroy, 2020). Higher energy costs increase the risk of arrears and reduced energy consumption, particularly for lower income households.

The autonomous cities of Ceuta and Melilla also expressed extremely high levels of energy poverty across the period with 5.085% in Melilla and 11.039% in Ceuta in 2023. Both of these regions experience economic hardship, with the lowest level of GDP per capita and the highest levels of unemployment out of all of the Spanish regions (Leiva, 2022). Ceuta stands out as an extreme value but given the small sample size of the region (164 respondents in 2021), it should be interpreted with caution as it is less statistically reliable.

5.2.3 Energy Cost

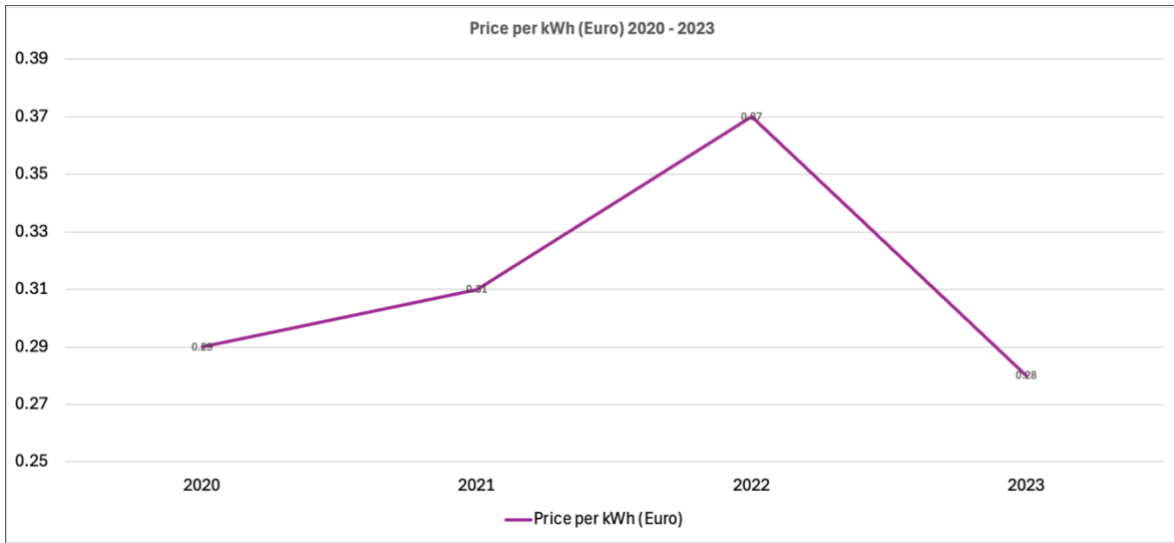


Figure 9: The price per kWh (€) between 2020 and 2023 (European Commission, 2025)

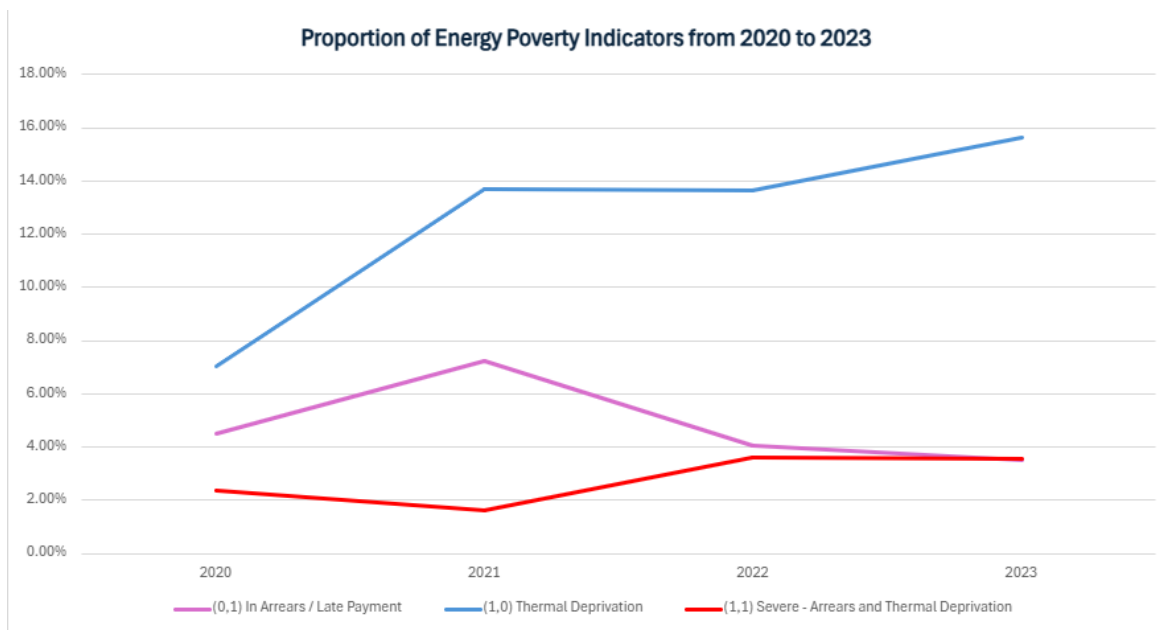


Figure 10: Percentage proportion of Energy Poverty Indicators between 2020 and 2023

It has already been established that rising income alone does not necessarily mean people are better off. This suggests that there could be other factors, such as energy prices, which are contributing to rising energy deprivation across Spanish households. Examining Spanish electricity prices over the same period could provide a greater indication as to its impact on energy poverty. Figure 9 and Figure 10 show a correlation between electricity prices and national energy poverty indicators between 2020 and 2023. Electricity prices

increased between 2020 and 2021 before peaking in 2022 at €0.37 kWh. In 2023, the price fell drastically to €0.28 kWh (European Commission, 2025).

The energy poverty indicators follow this trend to an extent. For instance, thermal deprivation increases from 7% in 2020 to around 13.6% by 2021. It could suggest that as energy prices increased, households struggled to keep their homes adequately warm.

In relation to the arrear's indicator, it didn't seem to follow the same trajectory as thermal deprivation. It increased from 4.5% in 2020 to about 7.2% in 2021, before declining to about 4% in 2022 and 2023. This could correlate with the implementation of several protective measures by the Spanish government to reduce financial strain during periods of economic uncertainty. This aligns with the decline in the severe energy poverty group between 2020 and 2021.

Overall, the graph suggests that the rise in electricity prices contributed to exacerbating the effect of energy poverty. However, the relationship isn't immediate. For example, even after energy prices decreased in 2023, thermal deprivation remained high, which could suggest that households continue to experience the effect of earlier price increases long after they have occurred.

5.2.4 Energy Efficiency in the Home

Another important factor that influences energy poverty is the energy efficiency within the home. While the analysis does not directly measure efficiency, due to a lack of data from the ECV, it remains a key component of energy deprivation. Households with inadequate heating systems or poor-quality insulation may require additional energy needs to maintain a satisfactory level of thermal comfort. Spain is known for having older housing stock which may not meet certain energy efficiency standards, thereby increasing energy consumption and overall vulnerability to energy poverty. For lower income households the cost of making improvements to the home make act as a barrier to overcoming energy poverty. This can create a cycle where lower income households

remain in inefficient homes, resulting in higher energy costs even when incomes rise or energy prices decrease, highlighting the persistence of the issue. Overall, this shows how income, energy prices, and energy efficiency interact and influence energy poverty in Spain, all the while reinforcing the notion that a multidimensional approach is needed to capture the various dimensions of energy deprivation together.

5.3 Comparison of Indicators

Overall, the indicators overlap in identifying households experiencing energy deprivation but particularly the (1,1) group, who represent the most severe form of energy poverty. However, they diverge in the type of households they capture. The thermal deprivation indicator (1,0) observes households experiencing hidden energy poverty whereas the arrears indicator (0,1) captures more obvious financial pressures. The (1,1) group is the most restrictive as it may potentially underestimate total deprivation experienced by households. This emphasises that each indicator only captures part of the problem, reinforcing the importance of using a multidimensional approach.

5.4 Strengths and Criticisms of ECV

Throughout this analysis we found there were various strengths and weaknesses of using the ECV data. The first strength is that the ECV has a very detailed dataset that helps identify vulnerable groups and obvious inequalities, which allows the Spanish government and regional departments to put together a more comprehensive picture of which households need to be targeted by public policies.

More specifically, in relation to energy poverty, the ECV is one of the only publicly available datasets of its size that offers any sort of information regarding the energy vulnerability of the household. The ECV offers large sample sizes which make it representative of the population and helps to improve its reliability as a source of data. Both the questions regarding thermal deprivation and arrears on utility bills help identify different dimensions of energy poverty and allow the different intensities of energy deprivation to be seen and measured, rather than being solely grouped into a single category. For instance, it can identify the use of hidden energy poverty, particularly by

analysing the (1,0) groups of each region. It can also identify the financial situation or burden experienced by many households by analysing the (0,1) groups. Lastly, as the ECV is part of the wider collection of EU-SILC data, this means these energy deprivation indicators can be compared across different countries, allowing for a much broader investigation into energy poverty at the European level.

However, there were a series of limiting factors within the ECV data. As mentioned before, the sample sizes varied considerably from year to year. For example, there were only 5,180 participants in 2020 but more than triple that in 2021 with 19,604 participants. This can negatively impact the results by reducing its accuracy and creating outliers that don't fit within the range of results. For example, nationally, the group experiencing extreme energy poverty (1,1) in 2021 actually decreased from 2020, even though median incomes declined and the other energy deprivation groups (1,0) and (0,1) increased. This could be explained by the drastic change in sample size, as far more respondents were taken into account in the 2021 survey, hence the (1,1) group may have made up a smaller proportion of the population than was stated in the 2020 survey.

There were also many other indicators that were not included, for instance, there is no mention of the age of the house. This is quite important as an older house usually has lower energy efficiency compared to newer builds. Also, countries such as Spain have been known to have an older housing stock compared to other European countries, emphasising the importance of this variable when trying to assess the overall energy poverty of the country. Similarly, there is no mention of the energy efficiency ratings of the household, or the energy consumed. With this information, we could gather more insight in relation to the binary variables created. It would offer some explanation as to why some households are in the (1,0) or (0,1) category, adding a further dimension of energy poverty that can be clearly identified and measured. Furthermore, the indicator related to payment on arrears doesn't specify electricity or heating costs. Therefore, it could contain any form of expenditure, such as gas, mobile phone bills, or broadband. This makes it harder to isolate if households are specifically enduring energy poverty or are just behind on one specific expenditure. Lastly, there is also no indicator in relation to cooling the home. Spain is known for having a warm Mediterranean climate and tends

to have very warm summers. It could be argued that an indicator related to cooling deprivation is just as important as a thermal indicator. Cooling equipment, such as electric fans and air conditioning units can use large quantities of energy, leading to higher energy costs. Therefore, in some regions, particularly the south of Spain, where it is warmer, the actual extent of energy deprivation may be worse than what is seen in the data as it has not factored in a household's ability to keep adequately cool in the summer.

The limited number of variables associated with energy deprivation constrained the dissertation. The narrow scope didn't allow for in-depth critical analysis, and many of the observed trends were based on assumptions rather than quantitative evidence. However, there were still several conclusions that could be drawn from the results.

6. Conclusions

The aim of this paper is to examine different self-reporting energy poverty indicators. We focus on what they measure and what they fail to capture. This study is based on the ECV data for Spain 2020 to 2023.

When we examine our results dataset, there are several conclusions that can be drawn. Firstly, we have identified a clear upward trend across thermal deprivation and the combined indicator (thermal deprivation and late payment) groups. This shows an obvious increase in energy poverty across the measured period, where the proportion of households experiencing some form of poverty rises significantly. When we observe the overall trend, it strongly suggests that energy poverty has become more persistent and widespread in Spain.

When we look more closely at the trend of each indicator, we can see that different indicators seem to capture different aspects of energy poverty and identify different household groups. The thermal deprivation group, rose steadily with time and appeared to be more persistent, which points to a more sustained indicator of hardship. In contrast, the late payment of utility bills indicator showed much more volatility where we observed an increase when the economic situation worsened and then declined as economic

conditions improved. This suggests that difficulty in paying bills is more affected by immediate financial pressure whereas, thermal deprivation is more closely associated with longer-term and possibly structural forms of hardship. If we look at the group experiencing both thermal deprivation and arrears, they represent a much smaller but increasing group. They are the most severely affected population because they are facing both financial strain and poor living conditions.

An important point to highlight is the divergence between the indicators, in particular the arrears and thermal deprivation groups. As the arrears indicator declines with improving financial conditions, the thermal deprivation indicator continues to increase which illustrates the presence of hidden poverty, which suggest they are coping by reducing energy consumption to keep up with bill payments. This means these households are not identified as energy poor by only affordability measures like arrears. This illustrates the weakness in relying on a single indicator.

From the analysis, there are some dimensions of energy poverty that have been captured effectively while others have not received adequate attention (Thomson et al., 2017), due to limitations in the data available within the ECV. Without these necessary variables, it is difficult to identify the underlying causes of energy poverty and the particular households who are affected.

The aspect of affordability has been defined and measured effectively through both the analysis conducted and the academic research referenced. A clear correlation between affordability and energy deprivation can be seen from the data. From analysing the median income of Spain at both a regional and national level, it was determined that households who tended to have no experience of energy deprivation, often had far superior median incomes compared to the those who suffered from mediate to severe energy poverty deprivation.

However, energy poverty in Spain cannot be explained by income alone. For example, while lower income households are more likely to experience energy poverty, rising median income over the period did not translate into a reduction in deprivation levels. This can partly be explained by rising inflation and energy prices, particularly during 2021-2022, which impacted purchasing power of households. Interestingly, thermal

deprivation remained high even though there was a reduction in energy prices which suggests that the effects of economic shocks, like between 2021-2022 can have lasting effects. This seems to suggest that energy poverty is complex and is shaped by several drivers that interact. These include, but are limited to, energy costs, wages and wider economic conditions.

The most logical explanation for this is that when households have higher salaries, they can pay their bills on time and often have enough left over to cover any increased payments as a result of increased usage or external shocks. Furthermore, households with higher incomes can afford to make the change towards implementing new technologies, such as heat pumps, better insulation, or solar panels which overtime will help further reduce their energy bills. Households with lower incomes can't afford to make these improvements, and as a result become socially excluded due to their financial situation.

At a region level, the analysis reinforces this point by showing clear inequalities across Spain. For example, the north-south divide became apparent across the four years when the southern regions of Andalucía and Murcia consistently ranked in the highest category for the greatest proportion of people suffering from extreme energy deprivation. Meanwhile the northern region of Navarra and the Basque country frequently ranked as having the lowest number of people suffering from extreme energy poverty. These differences are reflected by long term economic differences illustrated by the disparity in income between the regions. Other factors such as variations in unemployment and housing conditions most likely play an important part. This regional divide indicates that energy poverty is not evenly distributed and is most likely linked to geographical and structural factors. Even though the combined indicator is a more stringent test of energy poverty, it still captures these regional disparities and reflects the unequal distribution of income at the regional level.

In summary, we can see from the trends illustrated in our datasets that no one indicator can fully capture the complexity of energy poverty. Each indicator can capture a specific aspect of energy poverty but then overlook another. This reinforces the need to adopt a multi-dimensional approach to measuring and understanding energy poverty.

7. Further Research

If future research was to be conducted using the ECV data from the EU-SILC database, there are several investigations that could be of interest. For instance, using a larger range of data, such as a ten or even twenty-year period to get a greater scope as to the changing situation regarding energy deprivation over the years and how it correlates and reacts to external shocks such as the 2007 financial crisis, COVID-19, or the dot.com bubble burst in 2001.

It would also be useful to track a select sample of individual households from each region over several years, to try and identify temporary energy poverty, as this is a dimension of energy poverty that still doesn't appear to be widely defined or measured.

If there were additional deprivation metrics added to the ECV such as the age of the home, its energy efficiency rating (CER), and the ability to keep the home adequately cool in summer, it would be favourable to repeat the same analysis and see if further conclusions could be drawn. In particular, examining the relationship between energy efficiency and the age of the home, as this could provide valuable insight for future policy frameworks aimed at improving building performance.

Future research should examine whether the push for sustainability and renewable energy inadvertently worsens energy poverty for low income households who cannot afford green upgrades. It would also be beneficial to try and predict the future of energy poverty due to possible rising global temperatures and unpredictable weather patterns where some countries, like Spain, are going to see more extreme heat in the summers. Some research should also be applied to anticipate fluctuating energy prices, due to increasing geopolitical tensions, again adding to the instability that households may have to face.

Finally, as society grows ever more reliant on technology not only for heating and cooling, but also for communication, employment and education, future research may need to identify emerging forms of hidden energy poverty among households who lack the capability or resources to adapt. If energy poverty and its various dimensions cannot

be defined or measured accordingly by policymakers and government bodies, there is a serious risk of households deteriorating even further.

8. Declaration of AI

Por la presente, yo, Maeve Searles, estudiante de Grado en Administración y Dirección de empresas mención internacional nombre del título de la Universidad Pontificia Comillas al presentar mi Trabajo Fin de Grado titulado " A Critical Review of the Energy Poverty Paradigm and its Measurement Indicators" declaro que he utilizado la herramienta de Inteligencia Artificial Generativa ChatGPT y Gemini.

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9. Appendices

The relevant calculations are in the files provided.

Figure 1, Proportion of Energy Poverty Indicators from 2020 to 2023

	2020	2021	2022	2023
warm and on time	86.07%	77.41%	78.67%	77.33%
warm but late	4.53%	7.23%	4.04%	3.51%
not warm but on time	7.05%	13.72%	13.67%	15.62%
not warm and late	2.35%	1.64%	3.63%	3.54%

Figure 2, Energy Poverty Risk in Spain Linked to Median Income and Energy Prices (2020 to 2023)

	Arrears	Thermal Deprivation		
Year	% 0,1	% 1, 0	% Change in Median Income	Price per kWh (Euro)
2020	4.52%	7.05%	0.00%	0.29
2021	7.23%	13.70%	-3.43%	0.31
2022	4.03%	13.60%	6.16%	0.37
2023	3.50%	15.60%	9.24%	0.28

Figure 3, Median Income for Households Experiencing Energy Poverty (2020-2023)

		Arrears	Thermal Deprivations	Severe
Year	National Median Income	(0,1) In Arrears / Late Payment	(1,0) Thermal Deprivation	(1,1) Severe - Arrears and Thermal Deprivation
2020	€27,722.70	€18,963.10	€17,737.80	€13,472.00

2021	€26,772.80	€18,919.74	€18,085.00	€11,515.23
2022	€28,421.60	€21,882.00	€20,073.40	€15,020.83
2023	€31,046.80	€24,531.50	€23,040.96	€18,515.50

Figure 4, Full Regional Data for % population that suffered severe Energy Poverty between 2020 and 2023

		2020	2020	2020	2023	2023	2023
		1,1	Total	%	1,1	Total	%
ES11	Galicia	4	349	1.146%	29	1021	2.840%
ES12	Principado de Asturias	4	173	2.312%	17	581	2.926%
ES13	Cantabria	2	193	1.036%	12	531	2.260%
ES21	País Vasco	1	242	0.413%	17	828	2.053%
ES22	Comunidad Foral de Navarra	4	108	3.704%	14	466	3.004%
ES23	La Rioja	4	190	2.105%	13	498	2.610%
ES24	Aragón	0	273	0.000%	13	754	1.724%
ES30	Comunidad de Madrid	13	608	2.138%	66	1848	3.571%
ES41	Castilla y León	7	404	1.733%	23	1135	2.026%
ES42	Castilla-La Mancha	7	255	2.745%	22	728	3.022%
ES43	Extremadura	9	239	3.766%	28	695	4.029%
ES51	Cataluña	6	536	1.119%	149	3884	3.836%
ES52	Comunidad Valenciana	22	373	5.898%	50	1282	3.900%
ES53	Illes Balears	3	147	2.041%	11	490	2.245%
ES61	Andalucía	13	564	2.305%	99	1948	5.082%
ES62	Región de Murcia	8	173	4.624%	38	650	5.846%
ES63	Ciudad Autónoma de Ceuta	1	115	0.870%	17	154	11.039%
ES64	Ciudad Autónoma de Melilla	3	27	11.111%	6	118	5.085%
ES70	Canarias	10	179	5.587%	19	545	3.486%

Fig 5. Proportion of Energy Poverty Indicators from 2020 to 2023

	2020	2021	2022	2023
In Arrears / Late Payment	4.53%	7.23%	4.04%	3.51%
Thermal Deprivation	7.05%	13.72%	13.67%	15.62%
Severe - Arrears and Thermal Deprivation	2.35%	1.64%	3.63%	3.54%

Fig 6. Price of Energy

Year	Price per kWh (Euro)
2020	0.29
2021	0.31

2022	0.37
2023	0.28

Figure 7: Master Sheet data for national and regional calculations for Spain between 2020-2023

2020

Region ES11				Region ES21				Region ES24				Region ES42			
warm and on time	0.0	301	0.802484183	warm and on time	0.0	294	0.820819820	warm and on time	0.0	219	0.840564946	warm and on time	0.0	214	0.839215689
warm but late	0.1	6	0.016209648	warm but late	0.1	5	0.020671077	warm but late	0.1	9	0.022961931	warm but late	0.1	10	0.026828209
not warm but on time	1.0	39	0.111478913	not warm but on time	1.0	17	0.044982777	not warm but on time	1.0	6	0.021878022	not warm but on time	1.0	19	0.024028084
not warm and late	1.1	4	0.011603158	not warm and late	1.1	2	0.004132231	not warm and late	1.1	0	0.000000000	not warm and late	1.1	7	0.021760908
total from region		349		total from region		342		total from region		273		total from region		258	
median income		28,360.30		median income		34611.10		median income		38,363.70		median income		19,760.00	
		27028.36				34611.10				32790.26				2776.96	

National results

national levels 2020				national levels 2021				national levels 2022				national levels 2023			
(I,0)	4431	0.80722611	(I,1)Median	13472	18,472.00	(I,0)	10288	0.78966205	(I,1)Median	18014.86	15020.83				
(I,1)	203	0.04620096	(I,1)Median	13472	18,472.00	(I,1)	786	0.04039313	(I,1)Median	18014.86	15020.83	5,441.50	37,43690618		
(I,0)	963	0.07052821	(I,0)Median	29629.16	29,629.40	(I,0)	2656	0.13068777	(I,0)Median	30863.76	30863.76	4,865.25	13,88722299		
(I,1)	121	0.02394274	(I,0)Median	29629.16	29,629.40	(I,1)	708	0.03632008	(I,1)Median	21,873.82	21,882.00	5,468.40	29,36439177		
no energy poverty risk	4431	86.67%	(I,0)Median	18,098.25	18,063.10	no energy poverty risk	78.67%	(I,0)Median	30863.76	30863.76	20073.40				
energy poverty risk	717	13.33%	(I,0)Median	17,718.10	17,727.80	energy poverty risk	21.34%	(I,0)Median	30863.76	30863.76	20073.40				
blanks	32		totals	13472		blanks	170		totals	18434					
totals	5148		totals	13472		totals	18434		totals	18434					

2021

Region	ES52	ES53	ES54	Region	ES52	ES53	ES54	Region	ES79		
warm and on time	0,0	754	0.74418047	warm and on time	0,0	321	0.30824776	warm and on time	0,0	279	0.85503686
warm but late	0,1	79	0.87181919	warm but late	0,1	45	0.0875	warm but late	0,1	45	0.10595111
not warm but on time	1,0	146	0.154334038	not warm but on time	1,0	95	0.197915667	not warm but on time	1,0	65	0.15979516
not warm and late	1,1	23	0.824312896	not warm and late	1,1	14	0.022916667	not warm and late	1,1	18	0.044226441
total from region		948		total from region		480		total from region		407	
median income	8414,71	24156,255		median income	8350,8	23582,2		median income	71289,73	21318,2	
Region	ES53	ES53	ES54	Region	ES53	ES53	ES54	Region	ES53		
warm and on time	0,0	296	0.795132041	warm and on time	0,0	81	0.112902228	warm and on time	0,0	81	0.112902228
warm but late	0,1	31	0.875094833	warm but late	0,1	14	0.112902228	warm but late	0,1	14	0.112902228
not warm but on time	1,0	55	0.148306122	not warm but on time	1,0	22	0.177419355	not warm but on time	1,0	22	0.177419355
not warm and late	1,1	10	0.825510204	not warm and late	1,1	5	0.040322681	not warm and late	1,1	5	0.040322681
total from region		392		total from region		122		total from region		122	
median income	8448,8	14899,05		median income	8718,8	27906,85		median income	8718,8	27906,85	
Region	ES51	ES51	ES54	Region	ES54	ES54	ES54	Region	ES54		
warm and on time	0,0	1049	0.700748803	warm and on time	0,0	79	0.87181919	warm and on time	0,0	79	0.87181919
warm but late	0,1	139	0.888843355	warm but late	0,1	21	0.189354829	warm but late	0,1	21	0.189354829
not warm but on time	1,0	275	0.882864729	not warm but on time	1,0	15	0.130987742	not warm but on time	1,0	15	0.130987742
not warm and late	1,1	42	0.828056112	not warm and late	1,1	9	0.072880641	not warm and late	1,1	9	0.072880641
total from region		1497		total from region		124		total from region		124	
median income	8448,8	22152,85		median income	8114,5	21787,25		median income	8114,5	21787,25	

Region	ES51	ES51	ES51	Region	ES51	ES51	ES51	Region	ES51		
warm and on time	0,0	583	0.828113371	warm and on time	0,0	341	0.87798452	warm and on time	0,0	440	0.88183136
warm but late	0,1	32	0.845303889	warm but late	0,1	25	0.8488676	warm but late	0,1	29	0.89724018
not warm but on time	1,0	86	0.1488039	not warm but on time	1,0	49	0.17688216	not warm but on time	1,0	31	0.89797214
not warm and late	1,1	4	0.89887796	not warm and late	1,1	3	0.8488676	not warm and late	1,1	2	0.89822188
total from region		707		total from region		639		total from region		592	
median income	25.946,49	39846,86		median income	11.561,39	39846,86		median income	8204,8	39846,86	
Region	ES51	ES51	ES51	Region	ES51	ES51	ES51	Region	ES51		
warm and on time	0,0	323	0.78398054	warm and on time	0,0	383	0.83073986	warm and on time	0,0	1120	0.81739476
warm but late	0,1	26	0.86038796	warm but late	0,1	27	0.87877201	warm but late	0,1	49	0.89291545
not warm but on time	1,0	41	0.1488039	not warm but on time	1,0	27	0.87877201	not warm but on time	1,0	254	0.1324896
not warm and late	1,1	2	0.89887796	not warm and late	1,1	6	0.81748271	not warm and late	1,1	14	0.81004082
total from region		412		total from region		343		total from region		1372	
median income	30441,58	30441,58		median income	28.126,59	30441,58		median income	30441,58	30441,58	
Region	ES51	ES51	ES51	Region	ES51	ES51	ES51	Region	ES51		
warm and on time	0,0	341	0.80856672	warm and on time	0,0	330	0.87012161	warm and on time	0,0	740	0.8530489
warm but late	0,1	28	0.88820711	warm but late	0,1	29	0.89770449	warm but late	0,1	37	0.89297884
not warm but on time	1,0	40	0.131112184	not warm but on time	1,0	27	0.87248106	not warm but on time	1,0	80	0.89372051
not warm and late	1,1	4	0.89847872	not warm and late	1,1	2	0.898277045	not warm and late	1,1	5	0.895767013
total from region		413		total from region		378		total from region		907	
median income	30441,58	30441,58		median income	27.823,13	30441,58		median income	28.461,72	30441,58	

2022

Region ES52				Region ES62				Region ES70			
warm and on time	0,0	1026	0.746181818	warm and on time	0,0	499	0.727405248	warm and on time	0,0	495	0.756880734
warm but late	0,1	72	0.052963636	warm but late	0,1	28	0.040816327	warm but late	0,1	42	0.064220183
not warm but on time	1,0	226	0.164363636	not warm but on time	1,0	125	0.182215743	not warm but on time	1,0	92	0.140672783
not warm and late	1,1	51	0.037090909	not warm and late	1,1	34	0.049562682	not warm and late	1,1	25	0.0382263
total from region		1375		total from region		686		total from region		654	
median income		25.583.50		median income		24016.6		median income		31000.40	
		25583.50				24051.40				29158.16	

Region ES53				Region ES63				Region ES70			
warm and on time	0,0	437	0.81988743	warm and on time	0,0	118	0.719612195	warm and on time	0,0	495	0.756880734
warm but late	0,1	20	0.03752452	warm but late	0,1	8	0.048780488	warm but late	0,1	42	0.064220183
not warm but on time	1,0	65	0.12195122	not warm but on time	1,0	19	0.115853959	not warm but on time	1,0	92	0.140672783
not warm and late	1,1	11	0.020673959	not warm and late	1,1	19	0.115853959	not warm and late	1,1	25	0.0382263
total from region		533		total from region		164		total from region		654	
median income		28.552		median income		30326.44		median income		31000.40	
		28502.50				30316.42				29158.16	

Region ES61				Region ES64				Region ES70			
warm and on time	0,0	1484	0.730674545	warm and on time	0,0	93	0.69924812	warm and on time	0,0	495	0.756880734
warm but late	0,1	102	0.050221596	warm but late	0,1	11	0.07744391	warm but late	0,1	42	0.064220183
not warm but on time	1,0	343	0.168823234	not warm but on time	1,0	14	0.102531158	not warm but on time	1,0	92	0.140672783
not warm and late	1,1	102	0.050221596	not warm and late	1,1	13	0.097744361	not warm and late	1,1	25	0.0382263
total from region		2031		total from region		133		total from region		654	
median income		23.528.85		median income		25.776.65		median income		31000.40	
		23531.20				25986.60				29158.16	

2022 Region EB11				Region EB21				Region EB24				Region EB29			
warm and on time	0,0	839	0.77978777	warm and on time	0,0	713	0.86512941	warm and on time	0,0	713	0.88918907	warm and on time	0,0	597	0.745118362
warm but late	0,1	29	0.02324201	warm but late	0,1	21	0.02437931	warm but late	0,1	29	0.03218097	warm but late	0,1	35	0.04389381
not warm but on time	1,0	174	0.161710037	not warm but on time	1,0	74	0.09101747	not warm but on time	1,0	54	0.06914498	not warm but on time	1,0	139	0.17331084
not warm and late	1,1	38	0.039319893	not warm and late	1,1	22	0.02828736	not warm and late	1,1	14	0.01748203	not warm and late	1,1	30	0.037493184
total from region		1076		total from region		879		total from region		807		total from region		801	
median income		27126.71		median income		30423.6		median income		31378.13		median income		24.538.65	
		27216.44				30446.40				31314.30				24638.60	

Region EB12				Region EB22				Region EB30				Region EB33			
warm and on time	0,0	498	0.80062087	warm and on time	0,0	424	0.80982592	warm and on time	0,0	1575	0.821167883	warm and on time	0,0	551	0.728835978
warm but late	0,1	15	0.024115756	warm but late	0,1	25	0.045337255	warm but late	0,1	63	0.028649715	warm but late	0,1	31	0.04100591
not warm but on time	1,0	95	0.146302251	not warm but on time	1,0	38	0.07450804	not warm but on time	1,0	221	0.115294192	not warm but on time	1,0	142	0.18782088
not warm and late	1,1	18	0.02838907	not warm and late	1,1	16	0.031372548	not warm and late	1,1	59	0.03078123	not warm and late	1,1	32	0.04232042
total from region		622		total from region		518		total from region		1918		total from region		756	
median income		29280.6		median income		30902.4		median income		34328.8		median income		21114.8	
		29220.61				30929.30				34331.40				21276.79	

Region EB13				Region EB23				Region EB41				Region EB51			
warm and on time	0,0	480	0.82474288	warm and on time	0,0	431	0.85116873	warm and on time	0,0	1031	0.864932888	warm and on time	0,0	3234	0.786169154
warm but late	0,1	17	0.02920922	warm but late	0,1	12	0.02389924	warm but late	0,1	29	0.02489933	warm but late	0,1	295	0.04880869
not warm but on time	1,0	77	0.133204091	not warm but on time	1,0	52	0.103174603	not warm but on time	1,0	108	0.09064027	not warm but on time	1,0	652	0.142620232
not warm and late	1,1	6	0.013745794	not warm and late	1,1	9	0.017897143	not warm and late	1,1	23	0.020973154	not warm and late	1,1	180	0.042643923
total from region		582		total from region		504		total from region		1192		total from region		1421	
median income		28818.1		median income		29770.10		median income		27009.6		median income		21.184.65	
		28826.40				29770.08				27272.35				21099.20	

2023

Region ES52				Region ES62				Region ES70			
warm and on time	0,0	953	0.743369735	warm and on time	0,0	442	0.88	warm and on time	0,0	390	0.71559633
warm but late	0,1	39	0.030421217	warm but late	0,1	24	0.05397892	warm but late	0,1	37	0.067889908
not warm but on time	1,0	240	0.187207488	not warm but on time	1,0	136	0.209230769	not warm but on time	1,0	99	0.181651276
not warm and late	1,1	50	0.0390156	not warm and late	1,1	38	0.054461538	not warm and late	1,1	19	0.03482385
total from region		1382		total from region		650		total from region		545	
median income		28020		median income		28042.4		median income		30.548.11	
		28522.65				26947.47				27942.80	

Region ES53				Region ES63				Region ES70			
warm and on time	0,0	407	0.839612245	warm and on time	0,0	101	0.651644156	warm and on time	0,0	390	0.71559633
warm but late	0,1	13	0.026530912	warm but late	0,1	13	0.084415584	warm but late	0,1	37	0.067889908
not warm but on time	1,0	72	0.148381776	not warm but on time	1,0	23	0.149356549	not warm but on time	1,0	145	0.19978284
not warm and late	1,1	11	0.02244898	not warm and late	1,1	17	0.11038991	not warm and late	1,1	22	0.0302978
total from region		490		total from region		154		total from region		714	
median income		31811.4		median income		33074		median income		31.938.80	
		31884.56				33249.75				29888.6	

Region ES61				Region ES64				Region ES70			
warm and on time	0,0	1397	0.717145791	warm and on time	0,0	88	0.745762712	warm and on time	0,0	390	0.71559633
warm but late	0,1	88	0.045174538	warm but late	0,1	9	0.076271186	warm but late	0,1	37	0.067889908
not warm but on time	1,0	364	0.186888316	not warm but on time	1,0	15	0.127118644	not warm but on time	1,0	99	0.181651276
not warm and late	1,1	99	0.050821355	not warm and late	1,1	6	0.050847458	not warm and late	1,1	19	0.03482385
total from region		1948		total from region		118		total from region		545	
median income		28820.19		median income		28820.42		median income		30.548.11	
		28232.05				28850.72				27942.80	

2023 Region EB11				Region EB21				Region EB24				Region EB29			
warm and on time	0,0	778	0.76199041	warm and on time	0,0	703	0.88933814	warm and on time	0,0	639	0.847480106	warm and on time	0,0	538	0.739010889
warm but late	0,1	19	0.01869297	warm but late	0,1	26	0.03140996	warm but late	0,1	29	0.03481339	warm but late	0,1	29	0.03193407
not warm but on time	1,0	393	0.33889204	not warm but on time	1,0	82	0.08920346	not warm but on time	1,0	73	0.086816978	not warm but on time	1,0	145	0.19978284
not warm and late	1,1	29	0.02403326	not warm and late	1,1	17	0.02093401	not warm and late	1,1	13	0.01741379	not warm and late	1,1	22	0.0302978
total from region		1301		total from region		828		total from region		734		total from region		724	
median income		28.180		median income		37.070.05		median income		33211.2		median income		28666.70	
		28180.00				37070.05				33211.76				28666.70	

Region EB12				Region EB22				Region EB30				Region EB33			
warm and on time	0,0	480	0.79179382	warm and on time	0,0	401	0.88019091	warm and on time	0,0	1480	0.80885001	warm and on time	0,0	506	0.728835978
warm but late	0,1	10	0.01711704	warm but late	0,1	12	0.025751973	warm but late	0,1	45	0.02430649	warm but late	0,1	39	0.03813229
not warm but on time	1,0	84	0.141790517	not warm but on time	1,0	39	0.08090987	not warm but on time	1,0	217	0.130892964	not warm but on time	1,0	136	0.19978284
not warm and late	1,1	17	0.02938987	not warm and late	1,1	14	0.03042918	not warm and late	1,1	86	0.03714288	not warm and late	1,1	28	0.04028777
total from region		591		total from region		466		total from region		1848		total from region		800	
median income		32.207.21		median income		36894.4		median income		37711.6		median income		21.938.80	
		32008.90				36896.19				37713.90				21988.6	

Region EB13				Region EB23				Region EB41				Region EB51			
warm and on time	0,0	423	0.79810389	warm and on time	0,0	409	0.821285141	warm and on time	0,0	956	0.842290749	warm and on time	0,0	2982	0.767861591
warm but late	0,1	7	0.01338274	warm but late	0,1	15	0.02120482	warm but late	0,1	23	0.020264517	warm but late	0,1	179	0.04726991
not warm but on time	1,0	89	0.16790286	not warm but on time	1,0	61	0.12248396	not warm but on time	1,0	131	0.117406517	not warm but on time	1,0	583	0.10502967
not warm and late	1,1	12	0.0229987	not warm and late	1,1	13	0.022104419	not warm and late	1,1	23	0.020264517	not warm and late	1,1	149	0.03826213
total from region		531		total from region		498		total from region		1135		total from region		1364	
median income		30.745.18		median income		30007.8		median income		29.763.15		median income		24840.11	
		30747.85				30074.045				29770.90				24249.655	

