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# Proposing a Novel Minimum Income Standard Approach to Energy Poverty Assessment: A European Case Study

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**Abstract:** Energy deprivation can be identified as a manifestation of general poverty. Indeed, the former should be studied in connection with economic poverty since energy vulnerability is closely linked to a low-income level. To explore this connection, this paper proposes a novel Minimum Income Standard (MIS) approach to energy poverty indicators. In particular, this work applies the reference budgets method to the case of Spain and compares the obtained MIS indicator with one calculated using the Integration Minimum Income (RMI in Spanish) as a threshold. The results of the MIS indicator calculated with different income thresholds were critically analysed to establish a disproportionate expenditure metric based on an absolute income threshold obtained with an objective methodology. The outcomes show that the reference budget MIS indicators are generally higher than those obtained with the RMI, with the latter unable to identify energy poverty amongst certain household typologies. This result, together with the lack of scientific objectivity associated with the RMI, indicates that the reference budget MIS is more accurate when measuring an adequate minimum income. Eventually, this work might contribute to the measurement of (energy) poverty in Spain and the EU and inform policymakers to adequately target assistance programs.

**Keywords:** energy poverty; minimum income standard; indicators; reference budgets; Spain



**Citation:** Barrella, R.; Romero, J.C.; Mariño, L. Proposing a Novel Minimum Income Standard Approach to Energy Poverty Assessment: A European Case Study. *Sustainability* **2022**, *14*, 15526. https://doi.org/10.3390/su142315526

Academic Editor: Oihana Aristondo

Received: 19 October 2022
Accepted: 19 November 2022
Published: 22 November 2022



## 1. Introduction

The debate around poverty and the reasons behind it has been present in all societies throughout history. A first step would be to define poverty as the lack of resources to satisfy basic needs. This definition has been broadened in recent years to take into account new dimensions. Thus, when talking about poverty, access to basic services such as water or sanitation, education, health or adequate food must be taken into account.

Nowadays, energy can be considered among the essential commodities in our daily lives and is indispensable when carrying out the most basic tasks, such as heating a home or staying connected. A lack of access to affordable energy can hinder economic and human development, particularly affecting the most vulnerable households. Consequently, this paper focuses on the dimension of poverty related to energy affordability, i.e., energy poverty. In Spain (the paper's case study), energy poverty is officially defined as a situation in which a household is unable to meet its basic energy needs as a result of an insufficient level of income [1]. This last issue is the focus of this paper. However, according to the literature, there are two other main reasons behind this phenomenon: low household energy efficiency and high energy prices. Manifestations of energy poverty can range from the inability to maintain an adequate temperature at home to a household's energy expenditure being disproportionately high compared to the level of income.

According to official data from the Ministry for Ecological Transition and the Demographic Challenge [2], in 2020 (the year of the COVID lockdown [3]), 16.8% of Spanish households had an energy expenditure in excess of income greater than twice the national

median (2M indicator) and 10.3% had an absolute energy expenditure below the national median (M/2 indicator). More recently, the medium-term economic consequences of the COVID-19 pandemic and rising energy prices have aggravated the situation faced by many families affected by energy poverty.

Therefore, reliable indicators are necessary to be able to diagnose the energy poverty situation in Spain and thus be able to address it with appropriate policies. If defining energy poverty is already a complicated task, measuring it in all its dimensions presents a similar or even greater challenge. There is a wide variety of indicators, each of them reflecting the situation from a different point of view [4–8].

Within this context, this paper aims to provide more clarity on the definition of a Minimum Income Standard (MIS) indicator. This metric has been identified as one of the most consistent energy poverty estimation approaches [9,10]. This is because it addresses the problem at its economic root by identifying households with disproportionate energy expenditure through the use of a minimum income standard as an absolute threshold, unlike the most commonly used indicators, which use a relative one. For example, the 2M, proposed as the primary objective indicator by the European Energy Poverty Observatory (EPOV), estimates that 'the proportion of households whose share of energy expenditure in income is more than twice the national median' [11]. However, the following limits on the application of this indicator have been identified in the literature [12,13]: (1) there are difficulties in investing the 2M with normative meaning; (2) income and expenditure do not follow the same trend; and (3) there are no good arguments why twice the national median is an appropriate threshold. A 2014 study, [12], proposed that, to become more acceptable, the 2M could be linked to 'adequate energy services', as in [14]. However, giving the abovementioned 2M shortcomings (some of them shared by other officially used indicators, e.g., LIHC), the MIS indicator is considered a more fit-for-purpose metric.

In recent years, the European Union has been paying special attention to minimum income schemes. In Spain, great progress has been made through the implementation of a regional Integration Minimum Income (RMI is the Spanish acronym). Regarding energy poverty studies, the first report in this country was published by the Environmental Sciences Association in 2012 [15]. Since then, several studies have continued the work of developing energy poverty indicators in the country, such as [16,17].

However, an in-depth study of the methodology of the minimum income standard and its applications to the MIS indicator has not yet been carried out. Therefore, this paper aims to lay the foundations for the definition of a Minimum Income Standard (MIS) methodology to obtain absolute and objective indicators of energy poverty in Spain.

The rest of the article is organized as follows. Section 1.1 explores the state-of-the-art research on the definition of a minimum income standard and its use for energy poverty metrics. Section 2 describes the methodology and data used to define alternative absolute income thresholds and their application to the MIS indicator in Spain. Section 3 compares the MIS results by using different income threshold approaches, and Section 4 discusses these. Finally, Section 5 provides concluding remarks and details on further work.

### *1.1. Literature Review*

A Spanish study [9] carried out a vulnerability analysis based on an econometric methodology proposed by Legendre in 2015 [18]. This study identified four main variables that can increase the probability of a household being energy poor: income level, the configuration of the household, the tenure status of the housing and the occupation of the main breadwinner. The analysis of energy consumption considered the configuration of the household (household composition) and the occupation of the main breadwinner but it lacked an analysis of the household income level. However, defining and measuring an adequate household income level (the 'monetary' approach) is not an easy task. In this sense, there are two main methodologies that have been used in the literature to characterize 'overall' poverty [19]: (1) the 'indirect approach' [20], which defines the inputs (income levels) necessary to achieve a certain level of wellbeing, and the (2) 'direct approach' [21],

which focuses on the 'actual standard of living of people' (outcomes). The former measures poverty in terms of income (which is the approach analysed in this paper), the latter in terms of 'consumption'. Among the 'monetary' and 'indirect' approaches (which are the most commonly used ones), another distinction can be made depending on the threshold type: 'absolute' and 'relative' [21]. The former, which is the one applied in this paper, means that the analysis should 'define poverty on the basis of a normative judgment' of basic needs [21]. Several studies on living standard conditions have been carried out (e.g., [22], and the studies reviewed in [23]), but no single standard has emerged.

The Organisation for Economic Co-operation and Development (OECD) identified three main equivalence scales that assign a value in proportion to household needs [24]: the 'OECD equivalence scale', the 'OECD-modified scale', and the 'Square root scale'. The value is commonly dependent on the size of the household and the age of its members but differs depending on the scale used. For the calculation of the equivalent income in Spanish households, the main energy poverty reports carried out in Spain, [16,17,25], applied the 'OECD-modified scale' [26], which is the one recommended in the Eurostat guidelines. This scale assigns a value of 1 to the household breadwinner, 0.5 to each additional adult member, and 0.3 to each child. These values can be applied to the minimum living costs, which cover the costs of items other than housing and energy costs.

In the literature, the income level that allows households to meet the minimum living costs is usually called the Minimum Income Standard (MIS) [27]. The main technical difficulty in this calculation is represented by the level of uncertainty in the determination of an objective minimum income [9]. A 2013 study, [28], identified three main issues that should be considered when determining household income: (1) whether or not to consider the housing cost in the measure; (2) 'what benefits should be included as disposable income'; and (3) 'whether income should be equivalised'. The first and third of these define the core of the methodology, i.e., the definition of an MIS. Taking into account the third point, it is necessary to categorize the income standard depending on the household composition.

One of the oldest tools for calculating living standards are reference budgets [23]. This methodology is based on the selection of commodities (goods and services) that are deemed necessary to maintain a specific, predefined standard of living [27]. By pricing this "basket" of commodities, a budgetary benchmark standard for a given standard of living can be obtained.

There are different approaches to defining these reference budgets. Christopher Deeming [29] classifies them according to the actor leading the budget definition:

- Expert-led: This is the most normative approach. It consists of developing reference budgets by applying the knowledge of scientists and research findings (related to health and well-being).
- Citizen-led: In this approach, researchers use qualitative techniques to determine household budget needs. For this purpose, interviews are conducted through focus groups, where an attempt is made to reach a citizen consensus.
- Survey-led: this approach examines statistical data from social surveys to determine indicative budget norms.

There is an overlap with regards to the research processes of the different approaches, as all the methodologies involve a mix of expert knowledge, public reasoning and databases to form a budget norm [29]. This combination of information sources (at different weights for each approach) attempts to leverage the strengths of each with the aim of building robust baseline budgets.

Finally, in this context, it is worth mentioning the debate on the Universal Basic Income (UBI), a concept that is closely related to the MIS approach investigated here. The UBI is usually intended as an 'unconditional cash payment provided to people regardless of their financial situation' [30]. In contrast, the minimum income is usually designed as support for low-income households. A book published in 2017, [31], reviewed the pioneering proposals of Paine, Mill and Galbraith and presented an integrated defence of this radical concept. A more recent study, [32], proposed the application of the UBI to the United States and, more

generally, to developed countries. One of the final remarks of that work was that 'a UBI large enough to increase transfers to low-income families would be enormously expensive'. Finally, that study concluded that the UBI pilot works carried out to date were ineffective at addressing certain major outstanding questions. Conversely, pilot studies such as the one developed in Finland, [33], have proven more promising.

In any case, this study has not attempted to enter the theoretical discussion surrounding UBI. Our aim has been to explore the potential of an MIS approach to measure energy poverty. It remains for future researchers to delve deeper into the relationship between the two approaches, which are very close to each other.

#### 1.1.1. European Projects Defining a Minimum Income

In recent years, various initiatives have emerged at the international level to try to define a methodology for calculating an adequate minimum income. The most relevant European projects carried out in this field are presented below.

##### The Minimum Income Standard in the United Kingdom

In 2008, the Joseph Rowntree Foundation published the first report on the Minimum Income Standard (MIS) [27]. This study combined two budget methodologies, expert-led and citizen-led, reconciling the views of experts with those of citizens. As a result, the report compiled budgets from different household types and calculated the first minimum income standard (MIS) in England.

MIS budgets are based on detailed lists of the different types of households need, including food, clothing, shelter, utilities, fuel, household items, personal goods and services, transport and social and cultural activities. The lists are determined by consensus regarding the members of the two groups (citizens and experts), who negotiate in detail what a household needs to achieve an acceptable standard of living.

Since its first report, the foundation has continued to consolidate its methodology, updating the MIS annually and helping other countries to adapt it to their context. France, Ireland, Portugal and Mexico are among the countries that have calculated the MIS following the UK methodology [22,34,35].

##### The Reference Budget Approach in EU Projects

The ImPRove project was launched in 2014 as an EU initiative to build internationally comparable reference budgets. Until that time, reference budgets had been developed independently, which did not allow for cross-country comparisons. Therefore, this pilot project aimed to create a common methodology to promote transnational learning and the contextualisation of EU social indicators. To this end, the feasibility of developing a common theoretical framework and methodology in six countries (Belgium, Greece, Spain, Hungary, Finland and Italy) was explored by drawing on their (inter)national standards, scientific bases and focus group discussions [36].

These budgets were designed to correspond to the minimum income necessary for adequate social participation. Adequate social participation was defined as the ability of individuals to adequately perform the different social roles they have to assume as members of society [36].

The work was carried out by national teams in each country, coordinated by the Belgian one. They applied a mixed method approach, which involved many rounds of discussions in focus groups (initially composed of people experiencing poverty and then of general population). Their theoretical framework was based on the theory of human need [37], together with a range of international references, to unpack the 'relation between the individual and society, and the central importance of health and autonomy for being able to participate adequately in society' [36]. Moreover, the project analysed the relationship between these central needs and a more tangible set of 'intermediate needs' (mentioned thereafter), including their related functions.

As a result, the ImPRove project presented the reference budgets of four hypothetical households (a single woman, a couple, a single parent with a child aged around 10 and a couple with two children aged around 10 and 14) based in six cities (Antwerp, Athens, Barcelona, Budapest, Helsinki and Milan), which cover the following intermediate needs: 'healthy food, clothing, housing, personal care and health care, safety in childhood, mobility, rest and leisure and maintaining social relations' [36].

Section 2.2 describes how the outcome of the baskets that made up the baseline budgets for Barcelona in 2014 were updated in the context of this paper.

In 2015, the European Commission, with the purpose of continuing the work of the IMPRove project, funded the "Pilot project on developing a common methodology on reference budgets in Europe" to determine the minimum financial resources required to run an adequate social life. This project had three main objectives [38]:

1. To establish a reference budget network composed of key experts and representative stakeholders, at national and EU level, to share experiences and knowledge on reference budgets.
2. To develop a common theoretical framework and methodology for developing nationally comparable reference budgets in European Member States.
3. To develop comparable food baskets for the capital of a maximum number of Member States and as many other baskets as possible for the capital of a selection of countries.

The methodology used follows a mixed methods approach to develop reference budgets based on baskets of goods and services. This approach is based on a review of the relevant scientific literature in each country and institutionalised social expectations. Where comparable data are available, they are given a preference in terms of measuring the cost of baskets. In addition, focus groups are organised to assess overall acceptability. Finally, it should be noted that due to the normative nature of the reference budgets, they face a challenge of robustness. They are therefore essentially illustrative rather than prescriptive [38].

The project resulted in a food basket for 26 EU Member States and a health care, personal care and housing basket for eight EU Member States, including Spain (and, in particular, for the city of Madrid).

#### 1.1.2. The Minimum Income Standard in Energy Poverty Indicators

In line with the above-mentioned approaches, an alternative measure of the ability of a household to afford energy expenditure was proposed by Moore in 2012 [39]. This methodology is based on the definition of a Minimum Income Standard (MIS) 'needed by different household types in different locations to participate in society'. This new metric was inspired by research carried out at Loughborough University and the University of York (described in Section 1.1). According to the MIS-based indicator, a household is considered energy poor if Equation (1) occurs.

$$\text{Actual household energy expenditure} > \text{Net household income} - \text{Housing costs} - \text{Minimum living costs (MIS)} \quad (1)$$

Spain does not have a specific methodology to define a Minimum Income Standard, as other countries do (including the United Kingdom, Ireland, France and Portugal). In the literature [9,40], the value of the Spanish regional Integration Minimum Income (RMI) is used as a reference for the MIS threshold. However, the RMI is determined by regional government policies and lacks social objectivity. In addition, it has been considered insufficient because it does not allow the household to cover its basic needs. One of the mentioned studies, i.e., Romero et al. [9], proposed a MIS-based energy poverty indicator for Spanish households that uses the following Equation (2).

$$\begin{gathered}[\text{Actual household energy expenditure}] > [\text{Net household income}] - \\ [\text{Housing costs}] - [\text{MIS}_{\text{eq.}} - \text{Average energy expenditure} - \text{Average housing costs}]\end{gathered} \quad (2)$$

As can be deduced from Equations (1) and (2), the minimum living costs ($MIS_{eq.}$ in Equation (2)) cover all items other than housing and energy expenditure. The drawback of this methodology lies precisely in the difficulty of objectively determining the $MIS_{eq.}$, as shown in the minimum income literature review (Section 1.1.2). As mentioned above, this metric requires a complex previous calculation of the different income items necessary to meet the household's needs. Nevertheless, several studies identified various advantages in using the MIS [4]. The two main improvements introduced by the MIS indicator are as follows: (1) the MIS equivalisation of household incomes is more accurate compared to the OECD scale [10], and (2) the MIS-based indicator results are 'robust when measuring objective income-based energy poverty', especially if combined with a sensitivity analysis [9].

More recently, Rodriguez-Alvarez et al. [41] studied the connection between energy poverty and well-being in Spain by using the MIS methodology of Romero et al. [9]. Llorca et al. [42] and Cadaval et al. [43] applied the same metric approach to estimate the influence on energy poverty on self-reported health and the impact of the social electricity tariff, respectively, both taking Spain as a case study. A more local study, i.e., [40], mapped energy poverty in the city of Valencia by using, among other indicators, the Romero et al. [9] MIS metric. To the best of the authors' knowledge, in all the studies carried out in this country, the equivalent MIS is approximated by using the regional RMI (assigned to the households depending on its Autonomous Community or nationally weighted) or similar income support references.

On the other hand, to the best of the authors' knowledge, all the studies carried out until now for Spanish case studies have considered a relative energy expenditure threshold, which is usually the national average of household energy costs (as shown in Equation (2)). Several shortcomings could be pointed out for this approach: (1) this threshold does not consider regional climate differences, which have been pointed out as essential in defining household energy expenditures in Spain [8,14]; (2) household characteristics are not taken into account when defining it, while they have been included as key features in the literature when estimating Spanish household energy needs [44]; and (3), as discussed in previous studies [8], using relative thresholds focuses the assessment on energy inequality rather than energy poverty, with the latter being the actual research goal of the MIS indicator. Therefore, a potential contribution to filling these additional gaps could be the inclusion of an absolute energy expenditure threshold that considers households' locations and characteristics.

## 2. Materials and Methods

As mentioned above, to the best of our knowledge, no in-depth study of the basic needs of the population as a whole has been carried out in Spain in order to define a Minimum Income Standard for energy poverty (or other) studies. For this reason, to achieve an objective and a robust result, previous experiences from European projects in this field have been taken into account in the methodological approach of this work. Table 1 shows the considered resources and methodologies for the MIS threshold calculation. Two approaches are proposed for the minimum income threshold: (1) thresholds based on public income support references (used as a basis for comparison) and (2) the updating of the reference budgets proposed in European projects such as the EU pilot project and the ImPRoVe project.

**Table 1.** Approaches, resources available and methodologies for the MIS threshold calculation.

| Project/Program | Approach | Resources Available | Methodology |
|---|---|---|---|
| Integration minimum income (RMI) | Public income references | • RMI for each region | National weighted and regional RMI |
| EU pilot project | Expert-led | • 4 Budgets, 3 hypothetical families, Madrid 2015<br>• Inflation data | Projection of baskets to the present |
| ImPRoVe project | Expert-led | • 8 Budgets, 4 hypothetical families, Barcelona 2014<br>• Inflation data | Projection of baskets to the present |

### *2.1. Thresholds Based on Public Income References*

As mentioned above, in Spain, the Integration Minimum Income (RMI) has been used as the equivalent of the minimum income standard threshold in the calculation of the MIS indicator [9,40]. This threshold will be used as a basis for comparing the results obtained in this paper.

First, a weighted calculation of the RMI of each region (autonomous community) with the total number of households in each community was made to obtain a national RMI [17]. Table A1 (Appendix A) shows the RMI values by autonomous community and the corresponding national RMI for 2014, 2015 and 2019.

In order to obtain more robust results, in addition to calculating the indicator with the national average RMI, this was calculated with the RMI of the autonomous community associated with each household (shown in Table A1, retrieved from [17]).

### *2.2. Update of the European Reference Budgets (ImPRoVe and EU PILOT Project)*

Tables 2 and 3 show the results of the reference budgets obtained in the European projects. As can be seen, these budgets are divided by basket and by household type and are compared to a specific Spanish city. The aim was to update these values using consumer price indices.

**Table 2.** Reference budgets for Barcelona in 2014, ImPRove Project (Retrieved from Figures 2 and 3 of [36]).

| Household Type | Food | Clothing | Rest and Leisure | Personal and Health Care | Maintaining Social Relations | Safe Child-hood | Mobility without Car | Totals without Housing | Totals Private Market | Totals Reduced Rent | Totals Outright Owner |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Single | 138 | 47 | 52 | 45 | 89 | 0 | 50 | 422 | 979 | 831 | 560 |
| Couple | 302 | 92 | 69 | 72 | 119 | 0 | 101 | 755 | 1377 | 1363 | 921 |
| Single + child | 265 | 105 | 66 | 62 | 108 | 101 | 58 | 765 | 1353 | 1258 | 938 |
| Couple + 2 children | 571 | 201 | 107 | 130 | 170 | 214 | 157 | 1551 | 2218 | 2274 | 1787 |

**Table 3.** Reference budgets for Madrid in 2015, EU Pilot Project (Retrieved from Tables 22, 23 and 24, and Figure 47 of [38]).

| Household Types | Healthy Food + Kitchen Equipment | Total Food (Incl. Social Functions) | Personal Care | Health Care | Totals without Housing | Totals Private Market | Totals Reduce Rent | Totals Home Owner |
|---|---|---|---|---|---|---|---|---|
| Single | 174 | 199 | 19 | 20 | 411 | 1040 | 637 | 555 |
| Single woman + 2 children | 458 | 501 | 53 | 64 | 1076 | 1778 | 1453 | 1291 |
| Couple + 2 children | 647 | 702 | 66 | 73 | 1487 | 2227 | 1923 | 1736 |

The Consumer Price Indices (hereinafter CPI) published by the Spanish National Statistics Institute (INE) was used to update the baskets. The objective of these indices is to measure the evolution of prices of consumer goods and services acquired by Spanish households. Among its applications, its use as a measure of inflation in the country stands out.

In this paper, three reference budget assumptions are calculated: total without housing costs, total owner-occupied housing and total rented housing [38]. First, the national index disaggregated by ECOICOP consumption groups [45] was used to update the food, clothing and footwear, leisure and culture, transport and health baskets. Secondly, to update the housing costs of a homeowner, the ECOIPOP housing group was used. Finally, the Rented Housing Price Index (IPVA is the Spanish acronym) [46] was used to update the prices of rented housing. The IPVA is an experimental index published by the INE in 2022 that reflects the evolution of prices using data from personal income tax returns (see Tables A3 and A5).

To obtain the INE data for Consumer Price Indices, the CPI variations tool (founded on the INE website: https://www.ine.es/varipc/index.do, accessed on 1 March 2021) was used, along with a 2021 CPI base system. Table A2 shows the CPI variations taking December 2014 as the start period (the year in which the ImPRoVe project baskets were made). Likewise, Table A4 shows the variations in the CPI taking December 2015 as the start period (the year in which the baskets of the EU pilot project were carried out). It should be noted that the CPI is a weighted index and, therefore, each of the products has a specific weight. The last column shows the weights of each group for the 2021 base system.

The CPI changes are then used to calculate the updated price baskets according to the Equation (3):

$$\text{Basket}_t = \text{Basket}_{\text{base year}} \times (1 + \Delta\text{CPI}) \quad (3)$$

In some cases, a weighted combination of indices from the ECOIPOP groups is used. For example, the "Personal care and health" basket of the ImPRoVe project combines group 06 (health, medical and hospital services, etc.) and group 12 (personal care).Tables 4 and 5 show the results of the updated total baskets by household type, and the full tables can be found in Appendix A. Firstly, Table 4 shows the updated reference budgets from the ImPRoVe project, carried out in 2014 for the city of Barcelona (consisting of eight baskets).

**Table 4.** Reference budgets (total baskets) updated from the ImPRoVe project for the city of Barcelona (own elaboration from [36]).

| Household Type | Total Baskets | 2014 | 2015 | 2016 | 2017 | 2018 | 2019 |
|---|---|---|---|---|---|---|---|
| One-person household | No housing costs | 421.7 | 424.4 | 430.1 | 435.5 | 440.2 | 447.4 |
| | Rental | 979.2 | 979.7 | 986.0 | 996.4 | 1009.4 | 1025.0 |
| | Owner | 560.0 | 559.5 | 566.3 | 573.4 | 581.5 | 581.7 |
| Two adults | No housing costs | 755.3 | 760.4 | 770.9 | 781.1 | 789.4 | 803.0 |
| | Rental | 1377.4 | 1374.9 | 1375.5 | 1381.1 | 1390.4 | 1399.8 |
| | Owner | 921.5 | 922.7 | 934.6 | 946.7 | 959.2 | 964.3 |
| One adult and one minor | No housing costs | 764.7 | 770.5 | 780.5 | 788.7 | 797.5 | 808.8 |
| | Rental | 1353.0 | 1350.7 | 1351.3 | 1356.6 | 1365.4 | 1374.2 |
| | Owner | 938.3 | 940.1 | 951.5 | 961.8 | 974.9 | 977.4 |
| Two adults and two minors | No housing costs | 1550.6 | 1561.4 | 1583.0 | 1600.3 | 1617.8 | 1641.9 |
| | Rental | 2217.8 | 2215.1 | 2215.8 | 2221.8 | 2231.8 | 2241.8 |
| | Owner | 1787.0 | 1792.4 | 1815.9 | 1836.0 | 1859.4 | 1871.4 |

**Table 5.** Reference budgets (total baskets) updated from the EU Pilot project for the city of Madrid (own elaboration from [38]).

| Household Type | Total Baskets | 2015 | 2016 | 2017 | 2018 | 2019 |
|---|---|---|---|---|---|---|
| One-person household | No housing costs | 237.6 | 239.5 | 243.1 | 246.3 | 250.1 |
| | Rental | 866.6 | 869.2 | 878.4 | 891.0 | 904.2 |
| | Owner | 381.6 | 384.7 | 390.1 | 397.0 | 393.2 |
| One adult and two minors | No housing costs | 618.0 | 623.0 | 632.1 | 640.2 | 649.9 |
| | Rental | 1320.0 | 1325.7 | 1341.1 | 1359.8 | 1380.0 |
| | Owner | 833.0 | 839.7 | 851.6 | 865.3 | 863.6 |
| Two adults and two minors | No housing costs | 840.6 | 847.4 | 860.1 | 871.2 | 884.6 |
| | Rental | 1580.6 | 1588.1 | 1607.5 | 1629.7 | 1654.2 |
| | Owner | 1089.6 | 1098.4 | 1114.3 | 1131.9 | 1132.1 |

Secondly, Table 5 shows the updated reference budgets for the European pilot project, carried out in 2015 for the city of Madrid (four baskets).

### *2.3. MIS Indicator*

The MIS indicator considers households to be energy poor if, after deducting actual housing costs from their net disposable income, they do not have sufficient resources to cover their total energy bill. In other words, a household is energy poor if the condition in Equation (4) is met:

$$\text{Household energy expenditure} > \text{Household net disposable income} - [\text{MIS}_{eq} - \text{Energy component of MIS}_{eq}] \quad (4)$$

Following Equation (4) and using the data provided by the Spanish Household Budget Survey (HBS), the indicator was calculated as follows:

1. The calculation of household income: household income was calculated from the HBS variable IMPEXAC ("Exact amount of total net monthly household income"). It was multiplied by 12 to calculate its annual value.
2. The calculation of household energy expenditure: For the calculation of household energy expenditure, the expenditure reported in COICOP category 04.5 ("Electricity, gas and other fuels") of the HBS was used.
3. Sample selection: Once the HBS household and expenditure database was obtained, the sample to be used for each threshold (for each type of basket) was selected. It is important to remember that the reference budgets calculated for a given household type cannot be extrapolated to other conditions (geographical, cultural, etc.) or family types (single person, 2 × 2 family, etc.). Table A6 shows the conditions required for each type of basket and the approximations that have been made to compose the selected sample of the HBS.
4. The weighting of the threshold: the threshold must be weighted to obtain its annual value by multiplying the monthly value by 12. Likewise, in the case of the RMI threshold, its equivalence is also calculated according to its size. For this purpose, the variable UC2 of the HBS was used.
5. The calculation of the national average of energy expenditure from the HBS data.
6. The calculation of the MIS indicator: the indicator is calculated following Equation (4). If the energy expenditure of the household is higher than the 'national average energy expenditure', the household is considered energy poor.

Finally, an approximation of the calculation of the MIS indicator with an absolute energy expenditure threshold ('absolute energy MIS') was carried out, following the methodology of [8]. For this purpose, half of the required energy expenditure (RENE/2) calculated

by autonomous community in [8] for 2019 (shown in Table A7) is used as threshold. The chosen threshold was proposed in a previous study to find out whether the actual energy expenditure of a household is objectively too low to reach a necessary level of energy services [8]. The authors of this study found that the required energy expenditure threshold (RENE) overestimated actual household expenditure, while halving this expenditure (RENE/2) brought the threshold more in line with the national median (in particular that of the five highest income deciles). In this way, the MIS indicator (Equation (4)) was recalculated by replacing the average energy expenditure with this regional absolute energy expenditure threshold as 'Energy component of $MIS_{eq}$', as shown in Equation (5).

$$\text{Household energy expenditure} > \text{Household net disposable income} - [MIS_{eq} - \text{Regional absolute energy expenditure}] \quad (5)$$

Eventually, this regional threshold can be replaced by the household's (i.e., the households' RENE/2), as applied in [8] for an underspending indicator. However, for the purpose of clarity, the simplified version of the methodology (i.e., Regional RENE/2) was applied.

## 3. Results

In this section, the results of the MIS indicator are presented according to the different methodologies chosen. In addition, an analysis of the results is carried out using the methodology of the public income reference threshold (RMI) as a basis for comparison. The objective of comparing the MIS calculated with the RMI threshold with the one computed with the reference budget methodologies (or baskets of products and services) is to determine the objectivity of the indicator used in previous studies carried out for Spain, in other words, to determine whether energy poverty is being accurately estimated or not, on the basis that the reference budget methodology has a more objective basis for calculating an adequate minimum income than the RMI definition. Therefore, the final aim of this analysis was determining whether the methodology currently used to calculate the MIS indicator needs to be updated to better estimate the number of households that have a disproportionate energy expenditure with respect to their income.

### *3.1. MIS Indicator with RMI Threshold*

Table 6 shows the results of the MIS indicator and the values of the national average RMI used as $MIS_{eq}$ threshold in the period 2014 to 2019. These values will be used as the basis for the MIS analysis. As mentioned in Section 2, two different thresholds were used: the national RMI (weighted by the households of the regions) and the RMI of the region where the HBS household lives.

**Table 6.** Results of the MIS indicator with the RMI threshold. Period 2014–2019.

| | **2014** | **2015** | **2016** | **2017** | **2018** | **2019** |
|---|---|---|---|---|---|---|
| *MIS with national RMI* | 9.2% | 8.4% | 7.9% | 7.8% | 7.6% | 7.7% |
| *MIS with regional RMI* | 9.3% | 8.2% | 7.6% | 7.4% | 7.4% | 7.9% |
| *National RMI* | €418.0 | €421.6 | €424.0 | €454.7 | €477.7 | €505.6 |

Several observations can be made from Table 6. On the one hand, there was an improvement in the indicator between 2014 and 2016, with it remaining stable thereafter. It is also interesting to note that the weighted average of the RMI has been increasing over the years, reflecting the increase in minimum incomes in the autonomous communities. However, this increase in the RMI has not led to a rise in the indicator. This could be due to several factors. One of them is the fact that, in those years, the national minimum wage level in Spain also increased.

On the other hand, there is not a large discrepancy between the two national minimum income thresholds used, with the maximum difference occurring in 2017, with a value of

0.4%. In order to examine the behaviour of the indicator in more detail, Figure 1 presents the MIS by autonomous community for 2019. The autonomous cities of Ceuta and Melilla (not shown in the map) have an MIS indicator value of 8.8 and 13.2, respectively. These results show large differences between regions, with the MIS ranging from 2.6% in Cantabria to 14.2% in Canarias. A general trend of higher MIS values in the southern regions can also be deduced from Figure 1.


**Figure 1.** RMI-based MIS indicator by autonomous communities in Spain for the year 2019.

### *3.2. MIS Indicator with Reference Budgets*

Regarding the results of the ImPRoVe project, firstly, the MIS indicator was calculated for 2014 with the original data of the project. To do this, a sample of the HBS was chosen to collect households in Barcelona that met the conditions for geographical and household type. Table 7 shows the results of this calculation.

**Table 7.** MIS result with ImPRoVe threshold for specific households in Cataluña provincial capitals compared to the RMI MIS for Cataluña, both for 2014.

| Reference | Indicator [%] | $MIS_{eq}$ [€/month] | Average Energy Expenditure [€/year] | Sample Size |
|---|---|---|---|---|
| ImPRoVe | 21.2% | €422–€2218 | €696.1–€1290 | 0.27 M |
| RMI Cataluña | 6.97% | €423.7 | €1020.7 | 2.94 M |

In order to be able to compare the two types of methodologies (reference budgets and fixed threshold) more accurately, the indicator for Catalonia was calculated with the RMI of the autonomous community. As can be seen, the indicator calculated with the ImPRoVe baskets is much higher than those based on the RMI. As a result, it can be seen that, for 2014, the indicators based on the RMI indicate that only 6.97% of the population of Catalonia were in energy poverty. However, the indicator based on the ImPRoVe project baskets determines that, in 2014, 21.2% of the population of Catalonia was in energy poverty.

The difference between the results is mainly due to the value of the income threshold ($MIS_{eq}$) used in Equation (4). The MIS indicator for Catalonia uses the RMI of the autonomous community (€423.7) as the threshold for all households in the community. However, for the calculation of the MIS indicator based on the ImPRoVe results, the threshold varies in a range from €422 to €2218 per month. This range in terms of equivalent

MIS presents higher values for most of the household categories than those of the RMI of Cataluña and makes it possible to consider the type of household and the type of housing expenditure, as shown in the Table 8:

**Table 8.** ImPRoVe project's equivalent MIS ($Mis_{eq}$ [€/month]), 2014.

| Basket | Woman Alone | Couple | Family 1 × 1 | Family 2 × 2 |
|---|---|---|---|---|
| No housing costs | 421.7 | 755.3 | 764.7 | 1550.6 |
| Rental | 979.2 | 1377.4 | 1353.0 | 2217.8 |
| Owner | 560.0 | 921.5 | 938.3 | 1787.0 |

This significant difference in the results of the indicator indicates that the RMI is not able to reflect the real needs of citizens and, consequently, governments might be unable to implement measures in line with reality.

The MIS indicator calculated with the ImPRoVe baskets updated for 2019 is presented in Section 3.3. However, it is considered that the most reliable interpretation of the results should be made for 2014, the year of ImPRoVe data collection. This is because, since 2014, it is not only prices that should be updated for inflation but also the items that make up the baskets of goods and services.

On the other hand, the European pilot project calculated four baskets of goods and services for three types of households in the city of Madrid in 2015. The baskets included make up the bulk of a household's expenditure; however, compared to the ImPRoVe project, which proposes eight baskets, its baseline budgets are less adjusted to reality. In other words, the baseline budgets of the pilot project are incomplete. Still, it is interesting to compare the results of the MIS indicator using the EU pilot baskets as $MIS_{eq}$ with the one using the RMI, which are shown in Table 9.

**Table 9.** MIS results with EU pilot project threshold for Madrid (capital city of Comunidad de Madrid) compared to the RMI MIS for Comunidad de Madrid, both for 2015.

| Reference | Indicator [%] | $MIS_{eq}$ [€/month] | Average Energy Expenditure [€/year] | Sample Size |
|---|---|---|---|---|
| EU Pilot project | 5.42% | €237–€1580 | €1005.4–€1319.7 | 0.3 M |
| RMI Madrid | 4.2% | €375.6 | €1182 | 2.9 M |

Table 9 presents the results of the MIS indicator using as income threshold, respectively, the EU pilot project baskets or the equivalent RMI of the Comunidad de Madrid. For the former indicator, the sample of HBS households from Comunidad de Madrid that met the conditions of the reference budget households was taken. Concerning the latter indicator, the whole HBS sample of households from the autonomous community of Madrid was selected. In this case, the results of the MIS indicator obtained with the reference budgets are very close to those obtained with the RMI of the community.

For further analysis, the MIS indicator disaggregated by household type was calculated using the same data sample for both thresholds (the data sample that meets the conditions of the reference budgets was used). Table 10 presents the results of the MIS indicator disaggregated by household type, showing that the EU pilot reference budget indicators measure a higher level of energy poverty than the RMI indicators. This table clearly shows the shortcomings of using a single equivalent MIS as a threshold for all types of households. For example, if we look at the single parent household with two minor children (Family 1 × 2), the pilot project indicator indicates that there is 10.6% energy poverty in this type of household; however, the RMI-based indicator does not identify any household to be in energy poverty.

**Table 10.** MIS indicators for the city of Madrid disaggregated by household type (2015).

| Indicator | EU Pilot Baskets | RMI Madrid |
|---|---|---|
| Total | 5.5% | 2.3% |
| One-person household | 2.6% | 1.3% |
| Family 1 × 2 | 10.6% | 0.0% |
| Family 2 × 2 | 9.3% | 4.0% |

As with the results of the ImPRoVe project, the results of the EU pilot project's baseline budgets for 2019 were updated and are given in Section 3.3. However, it is considered that the most reliable interpretation of the results is for the year of their realisation in 2015. Furthermore, it should be taken into account in the analysis of results that the baseline budgets of the pilot project are incomplete (only four baskets were calculated) and therefore the indicator would have been higher.

### *3.3. Comparison of 2019 MIS Results Using Different Thresholds*

This section presents the different results of the MIS indicator calculated for 2019. Firstly, Table 11 shows the results of the indicator for 2019 calculated by using the national average energy expenditure as the 'energy component' ('relative energy MIS'). The values of the MIS indicator using the ImPRoVe or EU Pilot reference budgets are, respectively, slightly lower or much higher than those obtained with the RMI for the respective regions. The comparison between the two methodologies in the case of the Madrid region is more accurate than for Cataluña, because in the former's capital city there are half of the inhabitants of the corresponding region (Comunidad de Madrid) compared to a quarter of the total regional inhabitants in the case of the Cataluña's capital cities.

**Table 11.** Comparison of 'relative energy MIS' results using different thresholds for 2019.

| *MIS Methodology* | Indicator's Result |
|---|---|
| *RMI (National) for Spain* | 7.75% |
| *RMI (Regional) for Spain* | 7.92% |
| *RMI (Regional) for Cataluña* | 10.80% |
| *RMI (Regional) for Comunidad de Madrid* | 2.80% |
| *ImPRoVe (Barcelona) for Cataluña capital cities* | 9.68% |
| *EU Pilot (Madrid) for Madrid city* | 6.96% |

Table 12 shows the results of the MIS indicator with the different thresholds using half of the required energy expenditure (RENE/2) for 2019.

**Table 12.** Comparison of 'absolute energy MIS' results using different thresholds for 2019.

| *MIS Methodology* | Indicator's Result |
|---|---|
| *RMI (National) for Spain* | 8.00% |
| *RMI (Regional) for Spain* | 8.24% |
| *RMI (Regional) for Cataluña* | 11.39% |
| *RMI (Regional) for Comunidad de Madrid* | 2.81% |
| *ImPRoVe (Barcelona) for Cataluña capital cities* | 9.68% |
| *EU Pilot (Madrid) for Madrid city* | 6.16% |

Finally, Figure 2 compares the main 2019 MIS regional results obtained with the two energy cost component's methodologies, i.e., the relative energy threshold approach typically used in the literature and the absolute energy threshold one introduced in this paper.

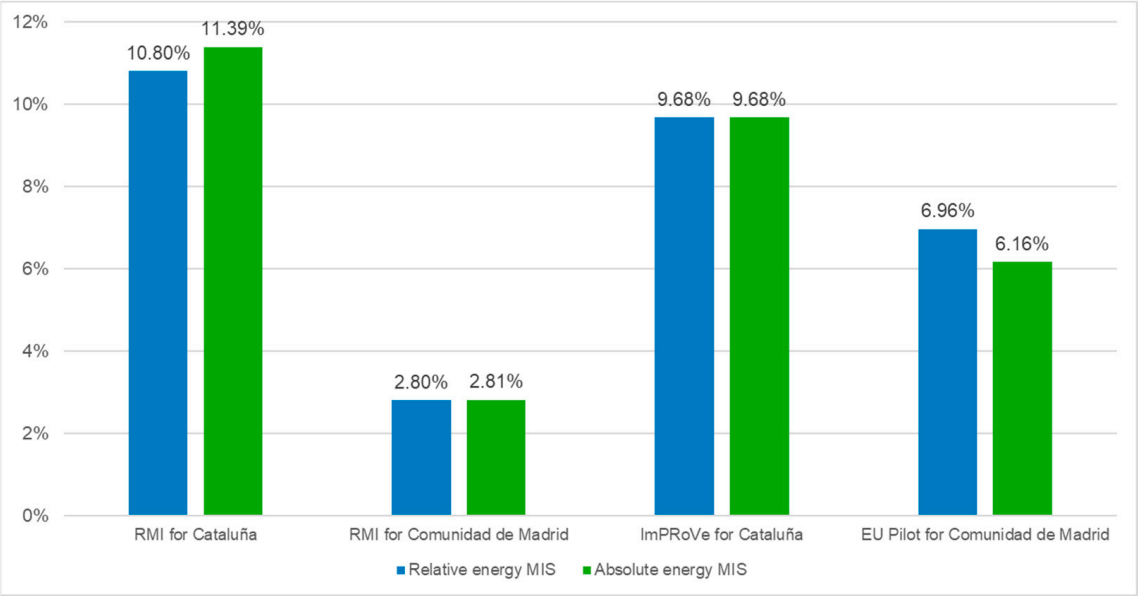


**Figure 2.** Comparison of MIS regional results using different income and energy expenditure thresholds for 2019.

## 4. Discussion

First, the MIS indicator was calculated using two thresholds: the nationally weighted minimum insertion income (RMI) and the RMI of the autonomous community associated with the HBS household. Initially, no substantial differences were found in the results. However, the analysis was deepened by calculating the MIS indicator disaggregated by autonomous community in 2019. In this case, large differences were found between regions. While the national indicator showed that 7.7% of the Spanish population was in energy poverty in 2019, the disaggregated indicator showed that the MIS ranged from 2.6% in Cantabria to 14.2% in the Canary Islands. As a first glance, it is worth noting the large difference in the indicator between autonomous communities. It would therefore be appropriate for each region to calculate its own indicator in order to be able to formulate policies more appropriate to its situation.

Secondly, the results of the MIS indicator based on European budgets were compared with the results of the RMI. The aim of this comparison was to find out whether there is a difference between the results of the two methodologies, assuming that reference budgets are a more 'scientifically objective' methodology for calculating an adequate minimum income. On the one hand, the MIS indicator was calculated for 2014 using the baseline budgets of the ImPRove project as a threshold. Since this project was developed in 2014 in the city of Barcelona, the MIS indicator of the provincial capitals of Cataluña (as an approximation to the city of Barcelona) was used for comparison. As a result, it was found that the indicator based on reference budgets is much higher than the one based on the RMI, with the former showing a percentage of energy poverty in Barcelona of 21.2% compared to 6.97% (2014). The main reason for this difference lies in the value used as the equivalent MIS, i.e., the RMI in Cataluña in 2014 was €423.7, whereas the ImPRoVe benchmark budgets ranged from €422 to €2218.

The MIS indicator was also calculated for 2015 based on the baskets of the European pilot project. In this case, the difference between the Madrid indicators was not so clear. It should be recalled that the European pilot project calculated four baskets for three types of households in the city of Madrid (instead of eight baskets, as in the ImPRoVe project),

even though these baskets correspond to most household expenditures. To deepen the analysis, the indicator disaggregated by the household types of the pilot project were calculated using the same database for the reference budgets and the RMI of Madrid. The results presented by this calculation are very interesting, as it confirms one of the major shortcomings of the RMI threshold methodology. For example, if one looks at the typology of a single parent household with two minor children, the pilot project indicator detects that there is 10.6% of energy poverty in this type of household; however, the RMI-based indicator is not able to identify vulnerable households.

In order to try to make a comparison between all the methodologies, the indicators were calculated for the year 2019. To do this, the baskets of European projects had to be updated using the CPI values of each sub-category taking into account inflation. However, this update is only an approximation, as the elements that make up the baskets should be updated as well. As a result, it can be observed that, generally speaking, the reference budget indicators are higher than those obtained with the RMI threshold.

Additionally, comparing the 2019 MIS results for Madrid (shown in Table 11) with the results of another disproportionate expenditure indicator such as the 2M (Comunidad de Madrid: 12,74% [2]), the latter gives values that are much closer to the estimate of the MIS indicator that uses the EU pilot's reference budgets as a threshold. This finding might be connected with the abovementioned issue, i.e., the inability of the RMI-based MIS indicator to identify energy poverty amongst certain household typologies. Indeed, as mentioned before, the RMI threshold does not adequately take into account household composition. Given the above, it could be hypothesized that the MIS indicator based on the minimum insertion income excluded potentially vulnerable households and, therefore, is not measuring energy poverty correctly.

On the other hand, Tables 11 and 12 and Figure 2 indicate that the 'absolute energy MIS' results are close to those calculated with the average national energy expenditure of the HBS, confirming the conclusions of [8], i.e., the RENE/2 threshold better represents the statistical values of energy expenditures in the case study than the total RENE. Nevertheless, it should be pointed out that this is a particular conclusion for this 2019 Spanish case study, but, if the calculation was replicated for other years or countries, significant differences might emerge between the results of the two energy threshold approaches. Moreover, the flexibility of the RENE model, when used for setting the absolute threshold, could make it possible to calculate a specific 'energy component' for each household in further applications. Eventually, temperature increases due to climate change (which could lead to a significant variation in heating and cooling needs, as pointed out in [47,48]) and energy price variability (such as the those due to the ongoing energy crisis, which is notably affecting household finances [49]) might also be considered in future studies analysing the MIS indicator with the absolute energy expenditure approach proposed in this work.

## 5. Conclusions

This paper shows that it is necessary to continue addressing the problem of energy poverty through the definition of its indicators. In particular, an absolute income threshold metric to identify households who are spending too much on energy compared with their income (disproportionate expenditure) is missing for Spain. Therefore, this work explored the use of the reference budget methodology in the definition of an equivalent minimum income standard for an MIS indicator.

The main conclusions of the application of different income threshold methodologies to this metric can be summarised as follows:

- It was found that the results of the indicators based on reference budgets are higher or almost equal to those based on the Integration Minimum Income (RMI). Based on the assumption (confirmed in this paper) that the reference budget approach is more accurate when measuring an adequate minimum income, it was concluded that the relative threshold might not reflect the real situation of energy poverty in Spain. This

is particularly evident in the case of Madrid where the MIS based on the RMI detects 4% fewer energy poor households than the reference budgets MIS.

- A great disparity was observed among different autonomous regions. This gap should be taken into account when formulating appropriate policies for each region.
- Overall, it was observed that the MIS indicator is sensitive to its income threshold. This highlights the importance of defining an appropriate income standard.
- On another level, it was found that when the MIS indicator is disaggregated by household typologies (family types), the RMI threshold presents a clear deficiency, since it is not able to identify vulnerable households composed of large families.
- Finally, significant differences in order of magnitude were detected when comparing the results obtained from the MIS indicator with other energy poverty indicators used in official reports. One example is the 2M indicator, which shows higher values than any of those obtained from the MIS. This might reveal that the share of energy poor households identified by the 2M might be overestimated. Further work should therefore be done to refine the identification of vulnerable households.

Lastly, it can be concluded that the proposal of this paper complements the primary indicators suggested by the EPOV (which are currently used as official metrics in Spain) by establishing a disproportionate expenditure indicator based on a threshold obtained with an objective methodology, as opposed to the official proposal, which uses a relative threshold, with all the issues that this entails.

This work demonstrates the need for further research into the issue of energy poverty and, in particular, for a comprehensive approach to the indicators that measure this phenomenon. In this sense, the income threshold of the MIS indicator is crucial for the correct identification of vulnerable households with a disproportionate energy expenditure. The calculation methodology and the application of the threshold (e.g., applied absolutely or by household type) is also crucial.

The following areas of research are therefore recommended as proposals for future studies:

- The updating of the reference budgets of European projects by considering both the change in needs of households and inflation.
- The implementation of a Minimum Income Standard pilot project using the UK methodology.
- The deepening of the study of a disaggregated MIS indicator: calculating an equivalent MIS threshold by type of household and by autonomous community.

In addition, an improvement in the measurement of the 'housing basket', so that it includes various alternatives, such as ownership without loan or mortgage in progress, ownership with loan or mortgage in progress, renting or reduced rent (old rent, semi-free or free of charge), is desirable. On the other hand, climate change and energy price variability might be considered for defining the absolute energy expenditure threshold in further studies analysing future years.

Eventually, this work might contribute to energy poverty measurements in Spain (which could be potentially replicable for other EU countries) and inform policymakers to adequately target assistance programs.

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

**Funding:** This research was funded by the Chair of Energy and Poverty of Comillas Pontifical University (CATEDRA EYP). The Open Access fee was funded by the Institute for Research in Technology (IIT) of Comillas Pontifical University.

**Institutional Review Board Statement:** Not applicable.

**Informed Consent Statement:** Not applicable.

**Data Availability Statement:** Further data are available through the corresponding author upon reasonable request.

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

## Appendix A

**Table A1.** Regional RMI and National RMI (both in [€/month]) weighting in 2014, 2015 and 2019.

| Autonomous Community | 2014 | 2015 | 2019 |
|---|---|---|---|
| *Andalucía* | 400.09 | 402.13 | 419.52 |
| *Aragón* | 441.00 | 573.30 | 491.00 |
| *Asturias* | 442.96 | 442.96 | 448.28 |
| *Islas Baleares* | 426.86 | 429.20 | 457.31 |
| *Canarias* | 472.16 | 472.16 | 486.90 |
| *Cantabria* | 426.01 | 426.01 | 430.27 |
| *Castilla y León* | 426.00 | 426.00 | 430.27 |
| *Castilla la Mancha* | 372.76 | 372.76 | 546.00 |
| *Cataluña* | 423.70 | 423.70 | 644.00 |
| *Comunidad Valenciana* | 385.18 | 385.18 | 630.00 |
| *Extremadura* | 426.00 | 426.00 | 537.84 |
| *Galicia* | 399.38 | 399.38 | 403.38 |
| *Madrid* | 375.55 | 375.55 | 400.00 |
| *Murcia* | 300.00 | 300.00 | 430.27 |
| *Navarra* | 548.51 | 648.60 | 623.63 |
| *País Vasco* | 665.90 | 619.29 | 667.05 |
| *Rioja* | 372.76 | 399.38 | 430.27 |
| *Ceuta* | 300.00 | 300.00 | 300.00 |
| *Melilla* | 387.18 | 458.64 | 458.64 |
| *National* | 417.98 | 421.63 | 505.62 |

**Table A2.** CPI change [%] with a December 2014 base period 2021 base system (Estimated with: https://www.ine.es/varipc/index.do).

| ECOIPOP Groups | 2015 | 2016 | 2017 | 2018 | 2019 |
|---|---|---|---|---|---|
| Food and non-alcoholic beverages | 1.8 | 2.6 | 4.4 | 5.8 | 7.5 |
| Alcoholic beverages and tobacco | 1.3 | 2.2 | 3.9 | 5.3 | 5.8 |
| Clothing and footwear | 0.5 | 1.4 | 1.9 | 2.8 | 3.8 |
| Housing | −2.3 | −1.5 | −0.3 | 2.2 | −2.9 |
| Kitchenware | 0.1 | 0.1 | −0.3 | 0.0 | 0.6 |
| Medicine | 0.5 | 0.4 | 0.8 | 1.7 | 2.2 |
| Transport | −2.8 | 1.7 | 3.7 | 4.0 | 8.2 |
| Communications | 0.5 | 3.8 | 4.0 | 6.4 | 7.1 |
| Leisure and culture | 0.2 | 0.6 | 0.0 | 0.0 | 0.1 |
| Teaching | 0.5 | 1.5 | 2.2 | 3.3 | 4.2 |
| Hotels, cafes and restaurants | 0.9 | 2.4 | 4.3 | 6.2 | 8.3 |
| Other | 1.7 | 3.6 | 4.3 | 5.5 | 6.9 |

**Table A3.** Rental Housing Price Index (IPVA) with a base period 2014 (retrieved from [46]).

| Rental Housing Prices | 2015 | 2016 | 2017 | 2018 | 2019 |
|---|---|---|---|---|---|
| IPVA | −0.4 | −0.3 | 0.6 | 2.1 | 3.6 |

**Table A4.** CPI variation [%] with a December 2015base period and 2021 base system(Estimated with: https://www.ine.es/varipc/index.do).

| ECOIPOP Groups | 2016 | 2017 | 2018 | 2019 |
|---|---|---|---|---|
| Food and non-alcoholic beverages | 0.8 | 2.5 | 3.9 | 5.6 |
| Alcoholic beverages and tobacco | 0.9 | 2.6 | 4.0 | 4.4 |
| Clothing and footwear | 0.9 | 1.3 | 2.3 | 3.2 |
| Housing | 0.8 | 2.1 | 4.7 | −0.6 |
| Kitchenware | 0.0 | −0.5 | −0.1 | 0.5 |
| Medicine | −0.1 | 0.3 | 1.1 | 1.7 |
| Transport | 4.7 | 6.7 | 7.0 | 11.3 |
| Communications | 3.3 | 3.5 | 5.9 | 6.6 |
| Leisure and culture | 0.5 | −0.1 | −0.2 | 0.0 |
| Teaching | 0.9 | 1.7 | 2.7 | 3.6 |
| Hotels. Cafes and restaurants | 1.4 | 3.3 | 5.2 | 7.3 |
| Other | 1.9 | 2.6 | 3.7 | 5.2 |

**Table A5.** Rental Housing Price Index (IPVA) with a 2015 base period (retrieved from [46]).

| Rental Housing Prices | 2016 | 2017 | 2018 | 2019 |
|---|---|---|---|---|
| IPVA | 0.1 | 1.0 | 2.5 | 4.0 |

**Table A6.** Sample of households in the HBS by threshold.

| Threshold | Conditions | Sample of the HBS |
|---|---|---|
| RMI | None | Total households |
| Barcelona reference budget (ImPROve) | - Geographical<br>- Household type | - City of Barcelona: CAAC = 9 (Catalonia); CAPROV = 1 (Yes)<br>- Single woman: TIPHOGAR4 = 3<br>- Pair: TIPHOGAR3 = 5<br>- Family 1 × 1: TIPHOGAR3 = 9 + NNINOS = 1<br>- Family 2 × 2: TIPHOGAR3 = 7 |
| Madrid reference budget (EU Pilot Project) | - Geographical: city of Madrid<br>- Household type | - City of Madrid: CAAC = 13 (Madrid), CAPROV = 1 (Yes)<br>- One-person household: TIPHOGAR7 = 1<br>- Family 1 × 2: TIPHOGAR3 = 9 + NNINOS = 2<br>- Family 2 × 2: TIPHOGAR3 = 7 |

**Table A7.** Absolute energy expenditure thresholds [€/year] by autonomous community.

| Autonomous Community | RENE | RENE/2 |
|---|---|---|
| *Castilla—La Mancha* | € 2713 | € 1357 |
| *Castilla y León* | € 2514 | € 1257 |
| *Aragón* | € 2252 | € 1126 |
| *Navarra, Comunidad Foral de* | € 2250 | € 1125 |
| *Extremadura* | € 2235 | € 1118 |
| *Galicia* | € 2159 | € 1080 |
| *Madrid, Comunidad de* | € 2155 | € 1078 |
| *Rioja, La* | € 2145 | € 1073 |
| *Murcia, Región de* | € 2028 | € 1014 |
| *Andalucía* | € 1946 | € 973 |
| *Comunitat Valenciana* | € 1945 | € 973 |
| *Balears, Illes* | € 1916 | € 958 |
| *Cataluña* | € 1860 | € 930 |
| *Asturias, Principado de* | € 1852 | € 926 |
| *Cantabria* | € 1794 | € 897 |
| *País Vasco* | € 1785 | € 893 |
| *Ceuta* | € 1262 | € 631 |
| *Melilla* | € 1055 | € 528 |
| *Canarias* | € 861 | € 431 |

## References


1. Ministerio para la Transición Ecológica. *Estrategia Nacional Contra La Pobreza Energética 2019–2024*; Ministerio para la Transición Ecológica: Madrid, Spain, 2019.
2. Ministerio para la Transición Ecológica y el Reto Demográfico. *Actualización de Indicadores de La Estrategia Nacional Contra La Pobreza Energética. Noviembre de 2020*; Ministerio para la Transición Ecológica y el Reto Demográfico: Madrid, Spain, 2020.
3. Cuerdo-Vilches, T.; Navas-Martín, M.Á.; Oteiza, I. Behavior Patterns, Energy Consumption and Comfort during COVID-19 Lockdown Related to Home Features, Socioeconomic Factors and Energy Poverty in Madrid. *Sustainability* **2021**, *13*, 5949. [CrossRef]
4. Rademaekers, K.; Yearwood, J.; Ferreira, A.; Pye, S.; Hamilton, I.; Agnolucci, P.; Grover, D.; Karásek, J.; Anisimova, N. *Selecting Indicators to Measure Energy Poverty. Under the Pilot Project 'Energy Poverty—Assessment of the Impact of the Crisis and Review of Existing and Possible New Measures in the Member States*; Trinomics B.V.: Rotterdam, The Netherlands, 2016.
5. Thomson, H.; Bouzarovski, S.; Snell, C. Rethinking the Measurement of Energy Poverty in Europe: A Critical Analysis of Indicators and Data. *Indoor Built Environ.* **2017**, *26*, 879–901. [CrossRef]
6. Siksnelyte-butkiene, I. A Systematic Literature Review of Indices for Energy Poverty Assessment: A Household Perspective. *Sustainability* **2021**, *13*, 10900. [CrossRef]
7. Antepara, I.; Papada, L.; Gouveia, J.P.; Katsoulakos, N.; Kaliampakos, D. Improving Energy Poverty Measurement in Southern European Regions through Equivalization of Modeled Energy Costs. *Sustainability* **2020**, *12*, 5721. [CrossRef]
8. Barrella, R.; Romero, J.C.; Linares, J.I.; Arenas, E.; Asín, M.; Centeno, E. The Dark Side of Energy Poverty: Who Is Underconsuming in Spain and Why? *Energy Res. Soc. Sci.* **2022**, *86*, 102428. [CrossRef]
9. Romero, J.C.; Linares, P.; López, X. The Policy Implications of Energy Poverty Indicators. *Energy Policy* **2018**, *115*, 98–108. [CrossRef]
10. Moore, R. *The Hills Fuel Poverty Review Proposal for a New Definition of Fuel Poverty: An Analysis. A Report to Consumer Focus from Richard Moore*; Consumer Focus: London, UK, 2011.
11. National Indicators. Available online: https://energy-poverty.ec.europa.eu/observing-energy-poverty/national-indicators_en (accessed on 16 November 2022).
12. Schuessler, R. *Energy Poverty Indicators: Conceptual Issues–Part I: The Ten-Percent-Rule and Double Median/Mean Indicators*; Discussion Paper No. 14-037; Zentrum für Europäische Wirtschaftsforschung (ZEW): Mannheim, Germany, 2014; Available online: https://nbn-resolving.de/urn:nbn:de:bsz:180-madoc-368880 (accessed on 16 November 2022).
13. Heindl, P. Measuring Fuel Poverty: General Considerations and Application to German Household Data. *FinanzArchiv* **2015**, *71*, 178. [CrossRef]
14. Barrella, R.; Linares, J.I.; Romero, J.C.; Arenas, E.; Centeno, E. Does Cash Money Solve Energy Poverty? Assessing the Impact of Household Heating Allowances in Spain. *Energy Res. Soc. Sci.* **2021**, *80*, 102216. [CrossRef]
15. Tirado-Herrero, S.; López Fernández, J.L.; Martín García, P.; Ruiz Mediavilla, L. *Pobreza Energética En España, Potencial de Generación de Empleo Directo de La Pobreza Derivado de La Rehabilitación Energética de Viviendas*; Asociación de Ciencias Ambientales: Madrid, Spain, 2012.

16. Romero, J.C.; Linares, P.; López, X.; Labandeira, X.; Pérez, A. *Pobreza Energética En España. Análisis Económico y Propuestas de Actuación*; Economics for Energy: Vigo, Spain, 2015.
17. Romero, J.C.; Barrella, R.; Centeno, E.; Mariño, L. *Informe de Indicadores de Pobreza Energética En España 2020*; Cátedra de Energía y Pobreza (Universidad Pontificia Comillas): Madrid, Spain, 2022; Available online: http://hdl.handle.net/11531/65128 (accessed on 1 June 2022).
18. Legendre, B.; Ricci, O. Measuring Fuel Poverty in France: Which Households Are the Most Fuel Vulnerable? *Energy Econ.* **2015**, *49*, 620–628. [CrossRef]
19. Eurostat, What Can Be Learned from Deprivation Indicators in Europe. In *Methodologies and Working Papers*; Office for Official Publications of the European Communities: Luxembourg, 2009; Available online: https://ec.europa.eu/eurostat/web/products-statistical-working-papers/-/ks-ra-09-007 (accessed on 1 June 2022).
20. Ringen, S. Direct and Indirect Measures of Poverty. *J. Soc. Policy* **1988**, *17*, 351–365. [CrossRef]
21. Boarini, R.; Mira D'ercole, M. Measures of Material Deprivation in OECD Countries. 2006. Available online: http://www.oecd.org/els/workingpapers (accessed on 4 April 2019).
22. Gilles, L.; Covolo, C.; Concialdi, P.; Math, A. *ONPES REFERENCE BUDGETS. Study Conducted at the Request of the French National Observatory on Poverty and Social Exclusion (ONPES)*; CRÉDOC: Paris, France, 2014.
23. Deeming, C. The Historical Development of Family Budget Standards in Britain, from the 17th Century to the Present. *Soc. Policy Adm.* **2010**, *44*, 765–788. [CrossRef]
24. OECD. *OECD Framework for Statistics on the Distribution of Household Income, Consumption and Wealth*; OECD: Paris, France, 2013.
25. Tirado Herrero, S.; Jiménez Meneses, L.; López Fernández, J.L.; Irigoyen Hidalgo, V.M. *Pobreza Energética En España 2018. Hacía Un Sistema de Indicadores y Una Estrategia de Actuaciones Estatales*; Asociación de Ciencias Ambientales: Madrid, Spain, 2018.
26. Hagenaars, A.; de Vos, K.; Zaidi, M.A. *Poverty Statistics in the Late 1980s: Research Based on Micro-Data*; Statistical Office of the European Communities: Luxembourg, 1994.
27. Bradshaw, J.; Middleton, S.; Davis, A.; Oldfield, N.; Smith, N.; Cusworth, L.; Williams, J. *A Minimum Income Standard for Britain: What People Think*; The Joseph Rowntree Foundation: York, UK, 2008.
28. Thomson, H. *Fuel Poverty Measurement in Europe: A Rapid Review of Existing Knowledge and Approaches Conducted for Eaga Charitable Trust*; The University of York: Heslington, UK, 2013.
29. Deeming, C. Defining Minimum Income (and Living) Standards in Europe: Methodological Issues and Policy Debates. *Soc. Policy Soc.* **2017**, *16*, 33–48. [CrossRef]
30. Q&A: Adequate Minimum Income. Available online: https://ec.europa.eu/commission/presscorner/detail/en/qanda_22_5722 (accessed on 16 November 2022).
31. Van Parijs, P.; Vanderborght, Y. *Basic Income: A Radical Proposal for a Free Society and a Sane Economy*; Harvard University Press: Cambridge, MA, USA; London, UK, 2017.
32. Hoynes, H.; Rothstein, J. Universal Basic Income in the United States and Advanced Countries. *Annu. Rev. Econom.* **2019**, *11*, 929–958. [CrossRef]
33. Kangas, O.; Jauhiainen, S.; Simanainen, M.; Ylikännö, M. *The Basic Income Experiment 2017–2018 in Finland: Preliminary Results*; Ministry of Social Affairs and Health: Helsinki, Finland, 2019.
34. Valadez-Martínez, L.; Padley, M.; Fernanda Torres Penagos, M.; Padley MJPadley, M.; María Fernanda Torres Penagos, L. A Dignified Standard of Living in Mexico: Results of a Pilot Study of the Minimum Income Standard Approach. *Soc. Indic. Res.* **2017**, *140*, 695–714. [CrossRef] [PubMed]
35. Pereira, E.; Pereirinha, J.; Branco, F.; Amaro, M.I.; Costa, D.; Nunes, F. Development of a Conceptual Framework Suitable for the Determination of the Minimum Acceptable Standard of Living in Portugal. In Proceedings of the VII Congress of Sociology Portuguese, Lisbon, Portugal, 19–22 June 2012.
36. Goedemé, T.; Storms, B.; Stockman, S.; Penne, T.; Van den Bosch, K.; Kanavitsa, E.; Karakitsios, A.; Matsaganis, M.; Elena Carillo Alvarez, B.; Cussó Parcerisas, I.; et al. Towards Cross-Country Comparable Reference Budgets in Europe: First Results of a Concerted Effort. *Eur. J. Soc. Secur.* **2015**, *17*, 3–30. [CrossRef]
37. Doyal, L.; Gough, I. *A Theory of Human Need*; Red Globe Press: London, UK, 1991.
38. Goedemé, T.; Storms, B.; Penne, T.; Van den Bosch, K. *Pilot Project for the Development of a Common Methodology on Reference Budgets in Europe. The Development of a Methodology for Comparable Reference Budgets in Europe—Final Report of the Pilot Project*; Publications Office of the European Union: Luxembourg, 2016.
39. Moore, R. Definitions of Fuel Poverty: Implications for Policy. *Energy Policy* **2012**, *49*, 19–26. [CrossRef]
40. Calero-pastor, M.; Pellicer-sifres, V.; Lillo-rodrigo, P.; Alfonso-solar, D. Fuel Poverty Map of Valencia (Spain): Results of a Direct Survey to Citizens and Recommendations for Policy Making. *Energy Policy* **2021**, *151*, 112162. [CrossRef]
41. Rodriguez-Alvarez, A.; Orea, L.; Jamasb, T. Fuel Poverty and Well-Being:A Consumer Theory and Stochastic Frontier Approach. *Energy Policy* **2019**, *131*, 22–32. [CrossRef]
42. Llorca, M.; Rodriguez-Alvarez, A.; Jamasb, T. Objective vs. Subjective Fuel Poverty and Self-Assessed Health. *Energy Econ.* **2020**, *87*, 104736. [CrossRef]
43. Cadaval, M.; Regueiro, R.M.; Calvo, S. The Role of the Public Sector in the Mitigation of Fuel Poverty in Spain (2008–2019): Modeling the Contribution of the Bono Social de Electricidad. *Energy* **2022**, *258*, 124717. [CrossRef]

44. Barrella, R. *Addressing Energy Poverty in an Integrated Way. An Interdisciplinary Characterisation of Spanish Vulnerable Households and Proposal for Implementing Feasible Technical and Policy Solutions*; Universidad Pontificia Comillas: Madrid, Spain, 2022.
45. Eurostat Glossary:Classification of Individual Consumption by Purpose (COICOP)–Statistics Explained. Available online: https://ec.europa.eu/eurostat/statistics-explained/index.php?title=Glossary:Classification_of_individual_consumption_by_purpose_(COICOP) (accessed on 7 September 2022).
46. INE (Spanish National Statistics Institute) Estadística Experimental. Menu Principal. Available online: https://www.ine.es/en/experimental/ipva/experimental_precios_vivienda_alquiler_en.htm (accessed on 7 September 2022).
47. Castaño-Rosa, R.; Barrella, R.; Sánchez-Guevara, C.; Barbosa, R.; Kyprianou, I.; Paschalidou, E.; Thomaidis, N.S.; Dokupilova, D.; Gouveia, J.P.; Kádár, J.; et al. Cooling Degree Models and Future Energy Demand in the Residential Sector. A Seven-Country Case Study. *Sustainability* **2021**, *13*, 2987. [CrossRef]
48. Dokupilová, D.; Palma, P.; Stojilovska, A.; Gouveia, J.P.; Paschalidou, E.G.; Barrella, R.; Feenstra, M.; Horta, A.; Sánchez-Guevara, C.; Kádár, J.; et al. *The Urban/Rural Divide: Exploring Energy Poverty Determinants for Eight Countries in Europe and the Middle East*; IIT-21-214WP; Universidad Pontificia Comillas: Madrid, Spain, 2021.
49. Menyhert, B. *The Effect of Rising Energy and Consumer Prices on Household Finances, Poverty and Social Exclusion in the EU*; Publications Office of the European Union: Luxembourg, 2022.