Conceptualizing and Measuring Energy Poverty in Bulgaria

Monica Robayo-Abril
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Abstract

Addressing energy poverty has emerged as one of the main challenges for Bulgaria's poverty and social inclusion policy, particularly in the context of the European Green Deal and the current crisis in Ukraine. To tackle the adverse impacts of energy poverty effectively, a crucial initial step involves accurately defining and measuring this issue. Identifying households affected by energy poverty is essential for shaping and implementing targeted policies. This study explores various definitions of energy poverty within the Bulgarian context by (1) systematically reviewing current methodologies and measures employed in the EU context; (2) assessing the feasibility of implementing these measures in Bulgaria based on data availability, comparing the incidence of energy poverty using alternative measures, and presenting characteristics of energy poverty to inform potential policy instruments; and (3) providing policy recommendations for the measurement and monitoring of energy poverty. The way energy poverty is measured and the overlap with income poverty shape the types of policy solutions perceived to be possible and appropriate to address it. The evaluation supports the need to shift from single indicators to multidimensional approaches in measuring energy poverty. Additionally, enhancing the granularity, quality, and frequency of expenditure and income surveys can contribute to easier operationalization of these concepts and a better understanding of the demographics of energy poverty. The study proposes exploring alternative data generation methods, such as smart meters, further to enhance insights into the dynamics of energy poverty.

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Conceptualizing and Measuring Energy Poverty in Bulgaria\(^1\)

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1. Introduction

Energy poverty is a pressing social inclusion challenge in Bulgaria, gaining heightened significance after the European Green Deal and Russia’s invasion of Ukraine. The European Green Deal, introduced by the European Commission in December 2019, aims to ensure an equitable transition towards a climate-neutral Union by 2050. This transition, however, poses economic and social challenges, particularly with the potential disproportionate impact of rising fossil fuel prices on vulnerable groups who allocate a significant portion of their income to energy expenses. In response to the social and distributional consequences stemming from the cost impacts of decarbonization measures, the European Commission established a Social Climate Fund in 2021. Recent developments, such as the war in Ukraine, have led to steep increases in energy prices across most EU countries, including Bulgaria. Consequently, energy poverty, broadly understood as the inability of a household to attain a socially and materially required level of energy service, has emerged as a foremost and urgent concern in Bulgaria’s social and economic inclusion efforts.

Several directives in the EU legislative framework call for measures to address energy poverty; moreover, EU Member States are mandated to evaluate and tackle it within their national Energy and Climate Plans (NECPs). If many households face energy poverty, Member States must include policies in their NECPs to mitigate it. Directives like the Recast Electricity Directive and Directive 2009/73/EC require measures to combat energy poverty, protect vulnerable customers, and assess affected households. The Energy Efficiency Directive prioritizes energy poverty considerations in energy efficiency obligations. The revised Energy Performance of Buildings Directive mandates national measures to alleviate energy poverty in long-term renovation strategies. Strategies for achieving 2030 and 2050 energy efficiency targets should prioritize shielding energy poor households. The EU legislative framework ensures that addressing energy poverty aligns with smooth market operations, emphasizing the importance of fair retail markets for a smooth transition. The European Pillar of Social Rights underscores universal energy access, aligning with the December 2019 European Green Deal’s goal of a fair transition to a climate-neutral Union by 2050. The Renovation Wave initiative, adopted concurrently, reinforces the call to combat energy poverty within the ‘Clean Energy for All Europeans’ legislative framework. Regulation (EU) 2018/1999 and the Recast Electricity Directive

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2 The Social Climate Fund is a financial tool established to address the social challenges and disparities arising from the transition to a green economy, including those exposed to energy poverty.
3 This includes the following directives: 1) The recast Electricity Directive and Directive 2009/73/EC, which are regulatory instruments within the EU framework addressing energy policy and market functioning; 2) The Energy Efficiency Directive, which aims to enhance energy efficiency and reduce energy consumption across the EU, and 3) the revised Energy Performance of Buildings Directive, which focuses on improving the energy performance of buildings within the EU.
4 Energy and Climate Plans (NECPs) are strategic documents outlining each EU Member State’s energy and climate policies and targets.
5 The recast Electricity Directive and Directive 2009/73/EC are regulatory instruments within the EU framework addressing energy policy and market functioning.
6 The Energy Efficiency Directive aims to enhance energy efficiency and reduce energy consumption across the EU.
7 The revised Energy Performance of Buildings Directive focuses on improving the energy performance of buildings within the EU.
8 As shown in section II, access to energy can be measured at the extensive margin (having access to energy or not - a binary indicator) and the intensive margin (characteristics related to quality and reliability).
Directive mandate the Commission to guide the measurement of energy poverty and define a 'significant number of households in energy poverty.\(^9\)

**To tackle energy poverty, EU Member states must formulate a national definition and criteria tailored to their context; the Bulgarian government has recently published an official definition.** To meet its legal obligations, the Bulgarian government established an inter-ministerial working group\(^10\) to work on changes to the Energy Act\(^11\). The group has recently published an official definition of energy poverty and criteria for identification and assessment, endorsed by the Council of Ministers and the European Commission. These tools encompass short-term measures shielding energy-vulnerable households from rising prices and policies to enhance medium-term energy efficiency. Moreover, within the Bulgaria Recovery and Resilience Plan's (RRP) Low Carbon Economy Chapter,\(^12\) approved by the European Commission in April 2022, Reform 3 focuses on defining energy poverty. This definition aims to facilitate electricity market liberalization and ensure priority treatment for energy poor households in energy efficiency measures and projects. The RRP allocates 59 percent of its funds to climate and clean energy support, covering decarbonization measures and interventions promoting energy efficiency.

**The challenge in measuring energy poverty begins with the absence of a common definition.** The EU introduced the concept through the Directive on Common Rules for the Internal Electricity Market (2009/72/EC) and expanded it within a fair energy transition context. In 2020, the European Commission defined energy poverty as households unable to access essential energy services.\(^13\) According to the EC, it arises when energy bills constitute a significant share of household income or when households curtail energy consumption, negatively impacting health and well-being (European Commission, 2023). The 2023 Social Climate Fund regulation and the revised Energy Efficiency Directive further define energy poverty as a lack of access to essential energy services, encompassing heating, hot water, cooling, lighting, and energy for appliances, tailored to the national context and existing social policies. Factors contributing to energy poverty include affordability issues, insufficient disposable income, high energy expenditure, and poor home energy efficiency. Alternative definitions, like the one used by the United Nations (United Nations, 2018), emphasize the lack of access to high-quality energy services. More recently, scholars have incorporated sustainability aspects, introducing energy efficiency and access to renewable energy into the concept of energy poverty (Siksnelyte-Butkiene, 2021).

**Measuring energy poverty presents challenges, yet there is a critical demand for accurate indicators at the country level.** The complexity of energy poverty requires indicators that can capture the multifaceted nature of the issue. The urgency for precise measures has grown, propelled by the rising impact of climate change and the heightened push for a rapid, eco-friendly transition, particularly in light of the recent Ukraine crisis. The initial step involves defining SMART (Specific, Measurable, Achievable, Relevant, and Time-bound) indicators to monitor energy poverty and assess policy

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\(^10\)The group includes the Minister of Labor and Social Policy, the Minister of Energy and the Minister of Regional Development and Public Works.

\(^11\) See updated Energy Act: [https://dv.parliament.bg/DVWeb/showMaterialDV.jsp?idMat=201222](https://dv.parliament.bg/DVWeb/showMaterialDV.jsp?idMat=201222)

\(^12\) The Low Carbon Economy Chapter of the Bulgaria Recovery and Resilience Plan (RRP) focuses on climate goals and the use of clean energy, directing a significant portion of funds to related measures.

interventions promoting cleaner and more efficient energy use. A robust approach to measuring energy poverty enables policymakers to pinpoint those most in need and track progress over time.

Furthermore, energy poverty has multiple drivers, including low income, poor energy efficiency, and high energy prices. As explored further in section 2, energy poverty manifests in various forms, including a lack of energy access due to power shortages or the inability to adequately heat one's home. Thomson et al. (2017) define energy poverty as inadequate access to home energy services, encompassing heating, cooling, lighting, and appliance use. The Energy Poverty Advisory Hub (EPAH)14(2022) categorizes the drivers of energy poverty into contextual and individual factors, identifying low income, low energy efficiency, and high energy prices as overarching causes. The consequences of energy poverty on human welfare can be severe in both the short and long term (ibid). Specific population groups may experience varying impacts based on socio-demographic characteristics, household composition, health, energy literacy, and cultural factors.

This paper systematically reviews existing literature on energy poverty measurement, assesses the suitability of potential measures for Bulgaria, and constructs feasible measures based on the availability and quality of existing micro datasets. This involves analyzing measures previously established in academic literature, white papers, and policy reports, focusing on the EU context. Then, utilizing available household-level microdata, we analyze the feasibility of implementing these indicators in Bulgaria. The examination involves several indicators using household expenditure data from the Household Budget Surveys and income and housing conditions from the European Living Condition Survey (EU-SILC). When selecting appropriate indicators, Palma and Gouveira (2022) recommend considering three key factors—context, scale, and availability. Additionally, we experiment with the potential use of big data, including satellite data. Subsequently, we compare these measures, highlighting their respective strengths and limitations. The main objective is to inform the Bulgarian government's efforts in measuring, operationalizing, and addressing energy poverty.

Additionally, the paper examines the correlation between energy poverty and income poverty,15 considering its policy implications. Our analysis involves characterizing energy poverty and identifying overlaps with monetary poverty to understand potential intersections between these vulnerable groups. Recognizing these overlaps is crucial for designing effective instruments to mitigate energy poverty. This includes measures to protect the energy poor and vulnerable populations in the face of rising energy prices or other forward-looking policy interventions addressing energy inefficiencies.

Our results suggest substantial variations in the incidence rates of energy poverty depending on the chosen definition. Notably, the so-called 10 percent threshold, which defines the energy poor population as all those reporting an energy expenditure share in household income or expenditure of more than 10 percent, exhibits a significant deviation from other expenditure-based indicators, resulting in an incidence rate of approximately five times higher. This deviation could be attributed to measurement issues, and considerable criticism can be found in the existing literature on this indicator. Although this criticism is valid, the 10 percent measure is one of the few monetary measures of energy poverty that allow for comparisons across countries and over time. The remaining monetary-based measures show fluctuations ranging from 7.9 to 9.9 percent. Consensual measures, which rely on self-
reported energy deprivations, demonstrate a wide variation, between 11 and 47 percent, depending on the metrics used.

Our analysis also reveals that, except for one measure, the monetary poor and energy poor only overlap partially; this finding has important implications for policymaking. While the 10 percent measure has a considerable overlap of the income and energy poor, this relationship is not necessarily valid for the other expenditure-based measures. Depending on the measure employed, between 3.1 and 5.3 percent of the population experiences monetary and energy poverty. This finding has implications for policy interventions targeting poverty. The existing social protection scheme, which often relies on monetary definitions of poverty to develop targeting schemes, might not necessarily cover those who are energy poor. Separate targeting schemes should be developed to address energy poverty.

Furthermore, we identify that different population subsets face distinct dimensions of energy poverty, further making the case for targeted interventions. We show that different population subsets differ in different aspects of energy poverty. For example, the population reporting leakages, one important indicator of energy efficiencies and energy poverty, does not generally coincide with the population reporting arrears on utility bills. Consequently, the government may need to consider different population segments for short- and long-term interventions targeting energy poverty through different types of policy interventions.

Based on this assessment and recommendations established in the existing literature, we recommend an approach that moves away from relying on single poverty indicators and instead tracks a set of indicators, as done in other European countries with national Energy Observatories (Belgium, France). One possibility would be to adopt the approach used by previous initiatives, such as the Belgium Energy Observatory and the French National Energy Poverty Observatory (ONPE), which monitor multiple indicators. This also aligns with recommendations in the recent academic literature and the European Commission.

Finally, multisector approaches are needed to measure and tackle energy poverty, given its multidimensional nature. Given its multidimensional nature, addressing energy poverty involves many stakeholders, including energy, transport, infrastructure, and social sectors, such as social protection, health, and education. It also requires interconnected approaches at different geographic levels, ranging from EU-wide policies and comparisons to monitoring at the local level. Given the multidimensionality of energy poverty, this note informs several public policies, including energy, social, and housing policy instruments. As such, a broad list of stakeholders is required to define and monitor energy poverty. The operationalization of energy poverty measures should involve a collaborative effort among various ministries, academic institutions, and local communities. Including marginalized and poor population groups in consultations that flow into developing a system that tracks, measures, and analyzes energy poverty is crucial.

The paper is organized as follows. Section 2 presents the different concepts and related measurements of energy poverty in the EU. Section 3 constructs some of these measures for Bulgaria, based on data availability, and characterizes the energy poor. Section 4 concludes and provides policy recommendations.
2. Overview of Approaches for Measuring Energy Poverty in the EU

2.1. Conceptualizing Energy Poverty

There is currently no consensus in the literature on how to best measure energy poverty due to a lack of a common understanding of energy poverty and a lack of a standardized set of metrics. There is no consensus on how to best measure energy poverty. The inexistence of a common measure has several reasons. First, there is no consensus on the basket of basic energy services (Culver, 2017). Second, the absence of such a measure might be partly related to the fact that energy usage varies significantly by country context and culture. Next, while the literature agrees that energy poverty should reflect a lack of energy services, it is unclear how to translate this concept into a common metric (ibid). Partly, this problem is related to the fact that energy services cannot be substituted for each other and that the poverty level for each energy service is arbitrary (ibid).

Nevertheless, measures of energy poverty should be evidence-based and well-thought-through. What most papers agree on, however, is that energy poverty measures should not be chosen arbitrarily without reflecting on the shortcomings of each metric and the aspect of energy poverty, which is a specific indicator measure (Herrero, 2017). In the case of the European Union, Pye et al. (2017) conclude that the concept of energy poverty varies significantly across member states. They recommend that the European Commission take a leading role in achieving greater harmonization and less fragmentation in the EU concerning measuring and approaching energy poverty.

Gouveia et al. (2022) divide energy poverty measures in the EU into three types: expenditure-based, consensual indicators, and direct measures. Gouveia et al. (2022) take stock of energy poverty measures in the European Union and categorize them into three types: expenditure-based measures, consensual approaches, and direct measures (see Figure 1). Expenditure-based measures assess households’ energy costs and compare them to absolute or relative thresholds. Consensual approaches are self-reported assessments of indoor housing conditions and/or the ability to meet necessities, such as keeping one’s home warm in winter. These are then compared to relative values in the place of residence of a given household. Finally, direct measures measure the level of energy services (physical variables) and compare them to previously set standards, such as the reference comfort temperature by the World Health Organization (WHO) (Palma and Gouveira, 2022), or other indicators to determine the adequacy of energy services (e.g., room temperature).

![Figure 1: Types of energy poverty measures in the EU](source)

When looking at factors that relate to energy poverty and vulnerability, Thomson et al. (2017) take a vulnerability approach to energy poverty and divide energy vulnerability into six factors. Thomson

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16 Gouveia et al. (2022) limit their assessment to data from EUROSTAT, EU-SILC (European Union Statistics on Income and Living Conditions), HBS (Household Budget Survey), and BSO (Building Stock Observatory).
et al. (2017) approach energy poverty through a vulnerability lens and develop six factors that relate to energy poverty and vulnerability (Figure 2). First, households might face poor access to energy. However, in the context of EU countries, access to energy is usually not the main problem. Second, they might face constraints based on the limited affordability of energy. This constraint may be particularly binding in the current inflationary context because of the Ukraine conflict. Third, they might be subject to poor flexibility, which is the inability to switch to energy sources that are more appropriate to their needs. Fourth, energy efficiency is a potential vulnerability factor because households might experience high energy losses due to poor energy efficiency at home. Fifth, some households might not be able to meet their energy demands from a cultural or socioeconomic perspective. Lastly, households might suffer from a lack of or limited policies addressing energy poverty. With respect to measurement possibilities, Thomson et al. (2017) detail the same categories presented in Figure 1.

Figure 2: Energy poverty through a vulnerability lens

In Table 1, we summarize different indicators measuring energy poverty gathered by Gouveia et al. (2022) and add several indicators identified from our review of the relevant literature. The table reveals that energy poverty indicators in the EU mainly rely on three different types of data sources: EU-SILC (European Union Statistics on Income and Living Conditions), HBS (Household Budget Survey), and BSO (Building Stock Observatory) (Gouveia et al., 2022). We add several indicators from our literature review, which we outline in the next subsections. Most indicators can be classified into three different measurement types (expenditure, consensual, and direct measurement), and some additional ones are more related to the building stock features and energy prices.

Table 1: Different indicators measuring energy poverty

<table>
<thead>
<tr>
<th>Type of Measure</th>
<th>Indicator</th>
<th>Definition</th>
<th>Source</th>
<th>Availability – Bulgaria</th>
</tr>
</thead>
<tbody>
<tr>
<td>Expenditure-Based</td>
<td>M/2 measure</td>
<td>Absolute (equivalized) household energy expenditure below half the median</td>
<td>HBS</td>
<td>Yes</td>
</tr>
<tr>
<td></td>
<td>2M measure</td>
<td>Share of household energy expenditure (compared to disposable income/expenditure) above twice the national median</td>
<td>HBS</td>
<td>Yes, when using HBS income</td>
</tr>
<tr>
<td>Consensual</td>
<td>Consumption expenditure on electricity, gas, and other fuels as a share of income-by-income quintile</td>
<td>EUROSTAT based on Harmonized HBS</td>
<td>Yes, but only for 2005, 2010, 2015, and 2020</td>
<td></td>
</tr>
<tr>
<td>---------------------------------------------------------------------------</td>
<td>------------------------------------------------------------------------------------------------</td>
<td>-----------------------------------</td>
<td>-------------------------------------------</td>
<td></td>
</tr>
<tr>
<td>Ability to keep home adequately warm</td>
<td>Share of the population unable to keep home adequately warm</td>
<td>EU-SILC</td>
<td>Yes</td>
<td></td>
</tr>
<tr>
<td>Arrears on utility bills</td>
<td>Share of population with arrears of utility bills</td>
<td>EU-SILC</td>
<td>Yes</td>
<td></td>
</tr>
<tr>
<td>Dwellings comfortable cool in the summertime</td>
<td>Share of the population able to keep home comfortably cool</td>
<td>EU-SILC</td>
<td>Not available for BGR18</td>
<td></td>
</tr>
<tr>
<td>Dwellings comfortable warm in wintertime</td>
<td>Share of the population able to keep home comfortably warm</td>
<td>EU-SILC</td>
<td>Not available for BGR</td>
<td></td>
</tr>
<tr>
<td>Presence of leak, damp, rot.</td>
<td>Share of population reporting leakage</td>
<td>EU-SILC</td>
<td>Yes</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Energy Prices</th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Biomass prices</td>
<td>Average household price per kWh generated from biomass</td>
<td>BSO</td>
<td>No</td>
</tr>
<tr>
<td>Coal prices</td>
<td>Average household price per kWh generated from coal</td>
<td>BSO</td>
<td>No</td>
</tr>
<tr>
<td>Fuel oil prices</td>
<td>Average household prices per kWh generated from fuel oil</td>
<td>BSO</td>
<td>No</td>
</tr>
<tr>
<td>Household electricity price 19</td>
<td>Electricity price for household consumers (consumption band 2500-5000 kWh)</td>
<td>EUROSTAT</td>
<td>Yes</td>
</tr>
<tr>
<td>Household gas price</td>
<td>Gas price (consumption band 20-200 GJ)</td>
<td>EUROSTAT</td>
<td>Yes</td>
</tr>
<tr>
<td>District heating price</td>
<td>Average household price per kWh generated from district heating</td>
<td>BSO</td>
<td>No</td>
</tr>
</tbody>
</table>

17 https://ec.europa.eu/eurostat/web/household-budget-surveys/methodology

18 Information on ability to keep home cool is particularly important in the context of climate change and the increasing likelihood of heat waves. The World Bank rapid surveys collected in June 2023 collect information to construct this indicator in Bulgaria. This information could potentially be collected through specific ad hoc modules of the national EU-SILC, as recommended by the latest EC recommendation on energy poverty in October 2023. https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=OJ:L_202302407

19 Household electricity and gas price are considered complementary indicators, as they affect affordability but do not indicate affordability per se.
<table>
<thead>
<tr>
<th>Building Stock Features</th>
<th>Share of dwellings in densely populated areas</th>
<th>BSO</th>
<th>Yes</th>
</tr>
</thead>
<tbody>
<tr>
<td>Dwellings in densely populated areas</td>
<td>Share of dwellings in densely populated areas</td>
<td>BSO</td>
<td>Yes</td>
</tr>
<tr>
<td>Dwellings in an intermediate population area</td>
<td>Share of dwellings in intermediately populated areas</td>
<td>BSO</td>
<td>Yes</td>
</tr>
<tr>
<td>Dwellings with energy label A</td>
<td>Share of dwellings with energy label A</td>
<td>BSO</td>
<td>Yes</td>
</tr>
<tr>
<td>Excess winter mortality/deaths</td>
<td>Share of excess winter mortality/deaths</td>
<td>BSO</td>
<td>Yes</td>
</tr>
<tr>
<td>Equipped with heating</td>
<td>Share of population living in dwelling with heating</td>
<td>EU-SILC</td>
<td>Not available for BGR</td>
</tr>
<tr>
<td>Equipped with air conditioning</td>
<td>Share of the population living in dwellings with air conditioning</td>
<td>EU-SILC</td>
<td>Not available for BGR</td>
</tr>
<tr>
<td>Number of rooms per person</td>
<td>Average number of rooms per person in rented/owned/all dwellings</td>
<td>EU-SILC</td>
<td>Yes</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Additional Indicators based on literature review</th>
</tr>
</thead>
<tbody>
<tr>
<td>10 percent measure</td>
</tr>
<tr>
<td>(Boardman, 1991)</td>
</tr>
<tr>
<td>Energy deprivation</td>
</tr>
<tr>
<td>Low-Income High Costs</td>
</tr>
<tr>
<td>(Hills, 2011)</td>
</tr>
</tbody>
</table>

\textsuperscript{20} Energy needs of a dwelling, or data on indoor temperature (see Palma and Gouveira (2022)).
<table>
<thead>
<tr>
<th>Consensual</th>
<th>Theoretical energy demand</th>
<th>Disposable household income before energy expenditure for adequate space heating</th>
<th>BSO</th>
<th>Requires standard on adequate space heating</th>
</tr>
</thead>
<tbody>
<tr>
<td>Type of dwelling</td>
<td>Type of dwelling</td>
<td>EU-SILC</td>
<td>Yes</td>
<td></td>
</tr>
<tr>
<td>Children exposed to leakages.</td>
<td>Share of children (aged 0 to 17) living in a dwelling with a leaking roof, damp walls, floors, or foundation, or rot in window frames or floor</td>
<td>EU-SILC</td>
<td>Yes</td>
<td></td>
</tr>
<tr>
<td>Ability to afford to keep home adequately warm</td>
<td>Share of the population able to afford to keep home adequately warm</td>
<td>Eurobarometer</td>
<td>Yes</td>
<td></td>
</tr>
<tr>
<td>Risk of falling behind with paying utility bills on time</td>
<td>Share of the population at risk of falling behind with paying utility bills on time</td>
<td>Eurobarometer</td>
<td>Yes</td>
<td></td>
</tr>
<tr>
<td>Dwelling is leaking, damp, or rotting.</td>
<td>Share of the population who report leaking, damp, rotting</td>
<td>Eurobarometer</td>
<td>Yes</td>
<td></td>
</tr>
<tr>
<td>Energy usage and efficiency of housing and households</td>
<td>Energy-related data for housing units occupied as primary residences and their households</td>
<td>Residential Energy Consumption Survey (United States)</td>
<td>No</td>
<td></td>
</tr>
<tr>
<td>Energy efficiency of housing</td>
<td>Collects information about people's housing circumstances and the energy efficiency of housing</td>
<td>English Housing Survey (England)</td>
<td>No</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Several</td>
<td>Several indicators of energy efficiency and affordability</td>
<td>Several</td>
<td>European Quality of Life Survey</td>
<td>Yes</td>
</tr>
<tr>
<td></td>
<td>Several indicators of energy efficiency and affordability</td>
<td>Several</td>
<td>Generation and Gender Programme Survey</td>
<td>Yes</td>
</tr>
<tr>
<td></td>
<td>Multidimensional energy poverty indicators</td>
<td>Combination of several indicators</td>
<td>Several (see main text)</td>
<td>Yes</td>
</tr>
<tr>
<td></td>
<td>Energy consumption</td>
<td>Approximation of energy consumption, compared to a norm</td>
<td>Direct meters, Satellite data, and other big data (see main text)</td>
<td>Yes</td>
</tr>
</tbody>
</table>

Source: Compilation of findings by Gouveia et al. (2022) and additional literature (as shown in this section).
Our review reveals that direct measures of energy poverty are less used in the European Union, although the recent introduction of smart meters could change that. Given the limited availability of datasets on temperature or energy services, direct measures are more challenging to implement. Gathering this data involves visiting households and taking stock of indoor temperatures, for example, a procedure that might be burdensome. In addition, it is challenging to select appropriate standards, given that they might be subjective by nature. Also, standards can vary by context and individual factors (Palma and Gouveira, 2022). One potential solution to the lack of reliable data on energy consumption is the introduction of smart meters (European Commission, 2023b). Although smart meters potentially increase access to timely and more accurate information on energy usage, they are still subject to shortfalls, such as energy sources that are not metered (e.g., wood, heating oil, coal) (Frei et al., 2021). Research to date has mainly relied on temperature sensor deployment (ibid).

Based on our review, energy poverty indicators are mainly only available at aggregated levels; generating them at disaggregated levels would be useful as tackling energy poverty requires local policy engagement. The European Commission recommends a local approach to tackle energy poverty, meaning that solutions must be adapted to national and local conditions. Therefore, it is worth generating more data and information on local (disaggregated) energy poverty. The geographical distribution and identification of energy poverty are critical for tackling energy poverty. The Energy Poverty Advisory Hub (2022) advises tackling energy poverty via a three-step process at the local level. Given the local approach towards energy poverty, there is a need for indicators at the disaggregated geographic level. Palma and Gouveira (2022) review the literature on subnational analyses around energy poverty. They found that studies mainly focused on Southern Europe. While they do not mention any studies on Bulgaria, some generated insights could serve as inputs to generate geographically disaggregated analyses in Bulgaria.

Although there is consensus that the geographical (subnational) distribution and identification of energy poverty is vital for mitigation, most subnational analyses rely on census data, and energy poverty indicators are often not collected as part of the population census. According to the review by Palma and Gouveira (2022), most subnational studies rely on data collected as part of the national census, although energy poverty indicators are often not included. While other studies take advantage of HBS or EU-SILC for regional analyses, the data is usually only representative at the NUTS 1 or NUTS-2 level (depending on the country). Therefore, direct estimates for higher disaggregation levels are unreliable (ibid). Small-area estimates of energy poverty are needed but not necessarily available. Alternatively, many studies incorporating subnational indicators included in the review by Palma and Gouveira (2022) rely on new surveys collected by researchers. Nevertheless, the increasing usage of big data and satellite data generates new opportunities for subnational analyses of energy poverty. National research institutes, for example, might be able to share meteorological data and facilitate the creation of subnational energy poverty indicators based on climate data.

21 The first step is an energy poverty diagnosis. During this first phase, policy makers should try to understand local energy poverty more closely. The second step is the design of a Local Climate Plan, which is a plan of how to best tackle energy poverty by taking an integrated approach at the local level. It involves setting up a detailed strategy and defining short- and long-term goals. The last step is the implementation of the Local Climate Plan.

22 In this context, the World Bank is exploring the development of a methodology for small-area estimates of energy poverty, under a DG Regio Trust Fund. The project aims to establish a methodology to measure energy poverty at the sub-national level using small-area estimation techniques and assess data availability across selected member states. The methodology will use a specific indicator of energy poverty (e.g., utility arrears, the share of energy expenditures within the household budget) and will then develop and apply an appropriate empirical methodology to project estimates of energy poverty from survey data into census data.
Based on the conceptualization of energy poverty, we describe these approaches in more detail but rely on approaches we can feasibly measure and monitor with the available data in Bulgaria. As we are ultimately interested in recommending a measure of energy poverty in Bulgaria that can be operationalized for monitoring and evaluation purposes, we rely on those approaches that we can feasibly measure and monitor through household expenditure surveys and the EU-SILC (see Column 4 in Table 1). We also explore the potential of big data sources. This leaves us with the following approaches: the access-based approach, the consensual-based approach, the outcome-based approach, the big data approach, and the expenditure-based approach. Finally, we analyze the strengths and weaknesses of each of these approaches.

2.2. Access-Based Approach

The most straightforward approach to measuring energy poverty is to analyze the share of the population without access to energy. The worst form of energy poverty is not having access to energy, which has important implications for overall well-being and monetary poverty. Previous research shows a significant relationship between access to electricity, for example, and poverty rates (Asghar et al., 2022). A common approach to measuring this aspect of energy poverty is to look at the share of the population without access to certain energy services, such as electricity, natural gas, or other forms of energy. There are binary access-based approaches (e.g., having access to electricity or not) and those using a threshold (e.g., having more than 50 kWh of electricity per capita) (Nussbaumer et al., 2012). Others have constructed composite measures such as the Energy Access Index (EAI), which measures access to six essential energy services: lighting, cooking, water heating, space heating/cooling, information/communication, and mobility (Practical Action, 2010).

Access to energy services can be measured at the extensive but also the intensive margin and can, additionally, refer to access to clean and sustainable energy. Most measures focusing on energy access measure households’ access to energy at the extensive margin, meaning that they analyze whether households have access to energy. Moreover, quality aspects in households’ energy access and reliability also play a role in energy poverty (the intensive margin). Bhatia and Angelou (2015) present a multi-tier framework to analyze the quality of energy access in the case of electricity. They measure reliability (the number of disruptions per week), legality, the health and safety aspects of the available energy source, peak capacity, and duration, among other factors. Another aspect one can measure with access-based approaches to energy poverty is access to certain types of energy, such as clean energy (Ullah et al., 2021).

Access-based measures are helpful in identifying the most deprived populations and improving energy poverty around lack of access, but they also suffer from limitations. While access-based approaches are helpful in detecting the most deprived populations as they lack access to energy altogether, they abstract from other important aspects of energy poverty, such as variations in energy needs and preferences or the affordability and sustainability of energy services. Measures at the extensive margin also abstract from the quality and reliability of energy services.

2.3. Expenditure-Based Approaches

The discussion on how to best measure energy poverty does not stop with the type of approach one should best use but extends to questions around how to best construct each metric within a given context.

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23 By extensive margin, we refer to having access to energy or not (a binary description). By intensive margin, we refer to various characteristics of energy poverty related to its quality and reliability. For example, how many hours per day the household receive electricity, the number of blackouts per month, etc. This is more difficult to quantify.
approach. This problem is especially apparent within the literature using expenditure-based approaches. Often, even if researchers use the same metric, approaches on how to construct this metric deviate; this problem is especially apparent within the literature relying on expenditure data focusing on the affordability aspect of energy poverty. We identify the following inconsistencies in the literature:

- **On scaling energy expenditure and measuring energy costs:** While some scholars divide energy expenditure by adult equivalents, others scale it by the number of household members (Schulte and Heidl, 2016) or the OECD equivalence scale (Hills, 2012). A third possibility is to use absolute values altogether (Thema and Vondung, 2020). The rationale behind this debate is that residential energy use is subject to important economies of scale (Schulte and Heidl, 2016). There is no consensus in the literature on how to address this point. Moreover, different researchers consider different components of energy costs. For example, one could include transport-related energy costs or abstract from them. Finally, there is debate on whether theoretical energy needs for a household with certain characteristics at current prices or actual energy expenditures reported by households should be used.

- **On using household income or expenditure:** In addition, there is variation in the literature on defining the denominator of the energy spending share. Several papers relate energy expenditure to household income (e.g., Thema and Vondung (2020); Hills (2012); Saghir (2005)) while others relate it to household expenditure (e.g., Freund and Wallach (1995); Schulte and Heindl (2012); Laderchi et al. (2013)). At the same time, several measures abstract from scaling household energy spending altogether and use absolute energy costs (Thema and Vondung, 2020). When using income as the denominator, there is again an inconsistency with respect to whether to consider disposable income before or after housing costs (Herrero, 2017).24

- **The threshold used to define energy poverty.** Lastly, there is no consensus in the literature to date on the threshold one should use to define those who are energy poor. While energy poverty is multidimensional, in practice, most definitions of energy poverty specify a resource threshold in terms of a maximum acceptable proportion of household income devoted to energy consumption. The threshold can be based on an absolute or relative measure. In an absolute measure, the threshold is a fixed percentage of the income/expenditure spent on energy, whereas a relative threshold is based on a median or average energy burden. The most used thresholds are the 10-percent measure, the twice median (M2) threshold, the half median (M/2) threshold, and the Low-Income High Costs (LIHC) measure (Thomson et al., 2022). In some cases, researchers and policymakers also use thresholds for subgroups of the population, such as households with a similar composition or the same number of rooms, or might apply several thresholds simultaneously, such as a threshold for energy expenditure and income (King Baudouin Foundation, 2018).

- **National vs. subnational threshold.** Using a consistent nationwide threshold may also be problematic, as it overlooks the variations in energy requirements between households living in different regions. Using the same threshold can lead to lower energy poverty rates in warmer zones and higher rates in colder zones. The rationale behind this pattern lies in the higher energy needs for domestic heating services prevalent in colder regions, thus leading to increased domestic energy usage. Conversely, individuals residing in warmer regions exhibit lower heating energy needs, resulting in decreased domestic energy usage. Consequently, applying a uniform national threshold indicates a higher likelihood of surpassing the threshold.

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24 For example, the Energy Poverty Barometer developed in the case of Belgium relates energy expenditure to disposable income after deduction of housing costs (King Baudouin Foundation, 2018).
for those in colder regions and vice versa. This underscores the necessity to appropriately consider variations in energy needs due to climatic and circumstantial factors when establishing levels of ‘adequate energy services’ (Boardman, 1991, p.227) or a socially and materially necessitated level of domestic energy services’ (Bouzarovski and Petrova, 2015, p.31).

In summary, while expenditure-based measures might seem straightforward at first, there is a lot of discussion about how exactly to measure these indicators. In addition, these types of indicators might simplify the concept of energy poverty and reduce it to the affordability aspect of energy poverty. In the following, we explore four expenditure-based measures in more detail.

**Ten Percent Measure**

The 10-percent measure relies on an absolute threshold, defining energy poverty as the share of households that spend a significantly high portion of their household budgets (10 percent or more) on energy. For monitoring progress over time, it is recommended to use absolute thresholds instead of relative thresholds, or in other words, a fixed standard of what households should be able to count on to meet their basic energy needs, rather than a cutoff point about the overall distribution of energy spending in a country. A common approach used is to rely on a threshold of 10 percent to define the energy poor. Under this definition, energy poverty is the share of households that spend a significantly high portion of their household budgets (10 percent or more) on energy. Ten percent is a threshold related to a minimum level of energy consumption to maintain an adequate level of warmth, originally measured as 10 percent for the UK. A broad set of studies uses this definition because it allows tracking progress over time and comparing energy poverty rates across countries. This measure has also been used in several World Bank studies on energy prices and was used in a World Bank report across a large set of countries in Europe and Central Asia (Olivier & Ruggeri Landerchi, 2017).

The 10-percent measure has been widely used in the literature despite being criticized for several reasons. The measure was originally developed for the UK and, therefore, lacks strong empirical justification for other countries, and it also fails to account for households in precarious situations that restrict their energy usage and consume less energy than needed. While many reports rely on a threshold of 10 percent (hereinafter: 10-percent measure), this measure was originally developed for the UK context (Hills, 2012). It originally was the 2M measure (twice the national median) of the energy expenditure ratio (energy expenditure (modeling consumption and prices) and total UK people’s income) in 1990 (King Baudouin Foundation, 2018). The application of this measure to other countries' contexts has been highly criticized to date (see, for example, Thomson et al. (2017) and Schuessler (2014)). More recently, experts have even recommended moving away from this definition in the UK, where the measure was originally developed (Hills, 2012). This method is also problematic as it leads to a binary distinction of energy poor/non-poor, while energy poverty may also be a continuum. Additionally, it does not capture vulnerable households that limit their energy use and under-consume energy (or the "hidden" energy poor). This shortfall can be overcome by using theoretical energy needs instead of actual energy bills, but calculations of theoretical energy bills are data-intensive and may require additional modeling tools. The 10-percent measure can be beneficial in comparing energy

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25 A similar approach is used to track changes in income poverty over time based on absolute measures.
26 Energy poor households may go unnoticed as they limit their residential heating to save energy. These households may tolerate colder room temperatures to prevent high energy bills. However, under this definition, they are no considered energy poor and therefore, may not meet eligibility criteria for social policies designed to protect them.
poverty incidence rates across countries, as they are compared against a fixed standard, although this comparison still suffers from limitations.

To estimate this measure, one can divide the household’s overall energy expenditure by the household income or household expenditure. The measure can be estimated as a share of household expenditure or income. Still, income measures are usually not captured accurately in household budget surveys, as the instruments are generally designed to capture consumption and expenditure patterns rather than income sources. Therefore, it is recommended that these measures work appropriately and are reliable when deciding how to scale energy expenditure in the case of the relative measures.

Measure M/2 and 2M

Another relative expenditure-based measure, next to the 10-percent measure, is the so-called 2M measure. The "2M" indicator captures abnormally high energy expenditure. It represents the percentage of households whose energy expenditure share (in income or consumption) is more than twice the national median share (Energy Advisory Hub, 2022). This metric gauges the burden of energy bills on households in relation to their incomes or overall expenditure, using the national median as a reference. Therefore, poor households that limit their energy consumption due to budgetary constraints may not be captured in this measure.

In contrast, the M/2 measure follows the concept of hidden energy poverty and measures abnormally low absolute energy expenditure. M/2 is an indicator that captures abnormally low energy expenditure, consisting of the share of households whose absolute energy expenditure is below half the national median. The M/2 measure draws from the "hidden" energy poverty concept, which argues that households might decrease their energy consumption so much that it becomes abnormally low and could result in negative health outcomes (Nguyen, 2022). Notice that households living in highly efficient buildings that technically require less energy may be considered energy poor under this definition.

Both of these are relative measures, as the thresholds moved with the distribution, which makes it challenging to compare them over time. Relative thresholds are a cutoff point in relation to the overall distribution of income or consumption in a country (in this case, they are linked to the median of the distribution). Consequently, if the entire distribution moves up or down, the M2 and M/2 measures might still not improve. It might, therefore, be difficult to use these measures to track progress over time. Moreover, they might suffer from measurement errors, and it might be difficult to compare these measures across countries as it requires harmonizing income, expenditure, and the approach toward measuring energy expenditure.

Low-Income-High-Cost Measure

The expenditure-based indicator "Low Income-High Costs (LIHC)" identifies energy poor households as those pushed into energy poverty due to high fuel costs and low incomes. This measure was officially adopted in England to measure energy poverty and replace the original 10 percent measure. Based on this indicator, a household is considered energy poor if two conditions are met: 1) if they have an energy expenditure above the national median, and 2) if the remaining income after they spend that amount (in equivalized terms) is below the official at-risk-of-poverty (AROP) threshold (Hills, 2012) (Figure 3). This approach directly considers households affected by the problem.

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27 In the case of the application at hand, the overall household expenditure is harmonized following World Bank ECAPOV Harmonization Guidelines.

28 This is equivalent to having an income threshold equal to the AROP plus the energy expenditure. This includes the income poor (those with incomes below AROP) and the vulnerable that fall into poverty because of their
specifically those with low income and high costs. To be more precise, it includes households with energy costs exceeding a 'reasonable level' (the median) and whose residual equivalized income would fall below the official poverty line if they were to spend that amount. Notice that two types of households meet these conditions: 1) Households that are income poor and have relatively high energy expenditures; and 2) Households that are just above the poverty line and would fall into income poverty after considering energy expenses (households vulnerable to poverty), with relatively high energy expenditures. This definition excludes income-poor households with relatively low energy expenditures and households above the poverty line that do not fall into poverty when energy expenses are taken into account. Similarly to the M/2 and the 2M metrics, the “LIHC” also uses relative thresholds, making comparisons over time difficult unless the thresholds are anchored.

A similar definition is the after-fuel-costs poverty (AFCP) indicator, developed by Hills (2011). Still, it considers only one condition: household equivalized income (possibly subtracting housing costs and domestic energy costs) is below the standard threshold of 60% of equivalized national income (Figure 4). In addition to the incidence of energy poverty, the energy poverty gap can also be estimated. The depth of energy poverty is defined as the amount by which the assessed energy requirements of fuel-poor households exceed the threshold for reasonable costs.

The energy expenditure can be the observed energy expenditure, for example, from the HBS, or it can be modeled. In the UK, the energy cost is modeled rather than based on observed spending. This ensures that one does not overlook households with low energy bills simply because they actively limit their energy use at home, for example, by not heating their home. It is calculated by combining the fuel requirements of the household with corresponding fuel prices. This approach is data intensive, as these required costs capture four areas of energy requirements: a. Space heating; b. Water heating; c. Lights and appliances; and d. Cooking. The modeling ensures that the household achieves adequate warmth, subject to various characteristics concerning the dwelling and its occupants.

Figure 3: Low Income-High Costs (LIHC) Measure
The income and expenditure measures used in this indicator must use the same scale and reference period. The at-risk-of-poverty threshold (AROP) is set at 60% of the national median equivalized disposable income after social transfers. Household members are made equivalent by weighting each according to age, using the so-called modified OECD equivalence scale. Therefore, when comparing energy expenditures and income to this threshold, they must be in the same unit (equivalized with the same equivalent scale). The reference period should also be the same. For example, the reference period for household incomes in the SILC surveys is the last 12 months, so expenditures must also be annualized compared to annual incomes. Moreover, the AROP line is a relative measure that adheres to EU standards for officially measuring poverty, using a relative poverty line. This standardized approach is employed across all EU countries for national and EU poverty monitoring purposes. However, to monitor changes over time, fixing or anchoring the relative poverty (AROP) lines at a
specific point in time is recommended, effectively converting them into an absolute measure. These are referred to as anchored AROP poverty lines.

In the case of Bulgaria, we construct the low-income-high-cost measure drawing from both observed expenditure and income information gathered as part of the HBS. We estimate overall household energy expenditure and subtract this amount from the net total household income reported in the household budget survey (HBS). We then compare the remaining household income (the net disposable household income after subtracting energy expenditures) to the official at-risk-of-poverty line (from the EUSILC survey). Income poverty lines and rates are usually estimated using the EU-SILC survey, but this survey does not collect expenditure information. Therefore, we rely on use income and expenditures from the HBS and the official poverty line from the SILC. Note that the at-risk-of-poverty line differs from the official one reported by Eurostat, which relies on data from EU-SILC.

2.4. Consensual Approaches

The set of indicators often denoted as consensual approaches rely on self-reported information by households. We next explore consensual approaches toward measuring energy poverty. Thema and Vondung (2020) define consensual measures as those that rely on self-reported assessments of housing conditions or the inability to cover basic energy needs because of a lack of access or affordability. Examples of such metrics are the share of households that cannot keep their home adequately warm/cool or those reporting leakages.

Consensual approaches are direct and personal measures but are subjective. Consensual approaches are easy to measure and might reflect different energy needs and demands. They also intrinsically capture some of energy poverty’s negative social and psychological effects. However, they also suffer from important flaws. First, they are subjective measures, and it might be difficult to compare them across different households, regions, or countries. Next, they might also be influenced by household expectations, preferences, and social norms. These factors might significantly influence the reliability and comparability of consensual approaches.

2.5. Outcome-Based Approaches

Another possibility for measuring energy poverty is to focus on the outcomes that occur because of energy poverty (Thema and Vondung, 2020). Energy poverty leads to unfavorable health, socioeconomic, and environmental impacts (Halkos and Gkampoura, 2021), and measuring these impacts can then again shed light on the severity of energy poverty experienced by the population of interest. Examples of such measures are the number of cold- or heat-related mortalities or arrears on energy/utility bills.

Outcome-based approaches might be easy to measure but, at the same time, could be confounded by other factors, such as lack of appropriate public infrastructure or income. While it might be easy, conceptually speaking, to measure the number of cold-related deaths, these measures might be influenced by other factors that we might not be able to observe, such as the development of the public infrastructure or the available income at the household level.

2.6. Multidimensional Measures

Given the multidimensional nature of energy poverty, several scholars propose multidimensional indicators to measure energy poverty. Given the multidimensional nature of energy poverty and the

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30 As shown later, the AROP estimate based on the HBS is significantly below the estimate from the EU-SILC.
31 The at-risk of poverty rate constructed for this measure is equal to 60 percent of the median value of the equivalized household income after social transfers in the HBS.
difficulty of capturing it with single indicators, several scholars propose to create multidimensional indicators. A recent review by Siksnelyte-Butkiene (2021) for 1994 to 2020 identified 34 indicators. For example, Day et al. (2016) embark on energy poverty from a capability framework. Similarly, Sokolowski et al. (2020) constructed a multidimensional indicator based on five dimensions of energy deprivation in Poland. Bollino and Botti (2017) generated a multidimensional energy poverty indicator based on five indicators from EU-SILC data, which is in line with this methodology. Similarly, Bouzarovski and Herrero (2016) constructed an energy poverty index for EU countries using three indicators from the EU-SILC (European Union, 2016). Pelz et al. (2018) evaluate several additional indicators that try to capture the multidimensional nature of energy poverty and evaluate their strengths and weaknesses. Further work exploring multidimensional energy poverty indicators in the EU is by Maxim et al. (2016) and Herrero and Bouzarovski (2014), among others. Other practical examples are from the Philippines (Mendoza et al., 2019), several countries in Asia (Lan et al., 2022), Africa (Nussbaum et al., 2012), and Uganda (Ssennono et al., 2021), among others.

While multidimensional measures of energy poverty have gained increasing attention in the literature, these measures are also subject to downfalls. Nussbaum et al. (2012) evaluate composite energy poverty metrics and conclude that these measures are useful but might be subject to important methodological shortfalls. While they help incorporate multidimensionality into one metric, there needs to be a consensus around which indicators to include, how to weigh them, and which thresholds to use for each subdimension to define energy poverty.

2.7. Big Data

More recently, big and open-source data started to play a significant role in direct measures of energy consumption, which can also shed light on energy poverty and vulnerability. Access to satellite data has facilitated the measurement of direct indicators without the necessity of implementing time-consuming home visits to employ sensors or meters. Xinyi et al. (2018) use freely available satellite data to construct a residential building stock model for energy consumption. Similarly, Fehrer and Krarti (2018) use nighttime light data to generate US electricity and fuel consumption maps. Sun et al. (2022) developed a building energy efficiency prediction algorithm to predict the energy efficiency of buildings by combining data from the Energy Performance Certificate (EPC) database and Google Street View (GSV) building façade images in the case of Glasgow. Another example is by Berger and Worlitschek (2018), who generate energy end-use data for heating in the residential sector by combining data on population, norm temperatures, energy supply, consumption data, and buildings. Table 2 summarizes this evidence.

Table 2: Measurement strategies for energy consumption of buildings using open-source and satellite data – 4 examples

<table>
<thead>
<tr>
<th>Authors/Source</th>
<th>Summary</th>
<th>Data</th>
<th>Place</th>
</tr>
</thead>
<tbody>
<tr>
<td>Xinyi et al. (2018)</td>
<td>Definition of representative buildings of a built-up residential building stock, using satellite images and cluster analysis methods, to generate energy Use Intensity (EUI) indicators</td>
<td>- Satellite data (Google Earth)</td>
<td>People’s Republic of China (Districts)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>- Ground survey</td>
<td></td>
</tr>
<tr>
<td>Sun et al. (2022)</td>
<td>Application of deep learning-based framework using street</td>
<td>- Energy Performance Certificate (EPC)³²</td>
<td>Glasgow, UK</td>
</tr>
</tbody>
</table>

³² This type of information is also gathered in Bulgaria, at least for new buildings and old buildings that undergo major renovations (iBroad, 2018).
Big data sources might also help generate new insights into energy spending, consumption patterns, and related social norms and behaviors. For example, Fergus and Chalmers (2021) use data from smart meters, consumer access device (CAD) data, and machine learning algorithms to detect and monitor fuel poverty. They also generate new insights into energy consumption, behavior, social norms, and expectations of energy sobriety.

Big data approaches are promising but require advanced data science skills and tools. Big data approaches allow for real-time tracking and extremely granular measurement of energy poverty. At the same time, they require advanced data science skills and tools. In addition, they might raise concerns about data privacy, ethics, and security. Lastly, they might still abstract from the multidimensionality of energy poverty, especially considering quality, affordability, or differences in energy demands and needs.

### 2.8. Summary

In summary, there are a variety of approaches to measuring energy poverty. Each approach highlights different aspects of energy poverty, including strengths and weaknesses. Having these strengths and weaknesses in mind when designing operational measures of energy poverty and having clarity of what aspect of energy poverty one would want to measure can result in more effective and impactful measuring strategies. We summarize each of the measures and their respective strengths and weaknesses in Table 3.

#### Table 3: Summary of energy poverty measures and strengths and weaknesses of each approach

<table>
<thead>
<tr>
<th>Name</th>
<th>Summary</th>
<th>Strengths</th>
<th>Weaknesses</th>
</tr>
</thead>
<tbody>
<tr>
<td>Access-based measures</td>
<td>Lack of access to a minimum level of energy services, such as electricity and clean cooking fuels</td>
<td>Useful to improve energy access; useful to identify the most deprived population/region</td>
<td>Abstracts from quality and reliability; does not factor in variations in energy needs and preferences; does not account for sustainability and affordability.</td>
</tr>
<tr>
<td>Expenditure-based measures</td>
<td>Energy poverty is spending more than a certain percentage of income or expenditure</td>
<td>Easy to calculate and simple measure</td>
<td>Abstracts from quality and quantity of energy services and different household realities; no consensus in</td>
</tr>
<tr>
<td>Consensual approaches</td>
<td>Self-reported perception of energy deprivation</td>
<td>Direct and personal; incorporates different energy demands and necessities.</td>
<td>Subjective and personal; lower comparability and higher measurement errors</td>
</tr>
<tr>
<td>-----------------------</td>
<td>-----------------------------------------------</td>
<td>-------------------------------------------------</td>
<td>----------------------------------</td>
</tr>
<tr>
<td>Outcome-based approaches</td>
<td>Measures outcomes based on energy poverty, such as cold-related deaths or arrears on utility bills</td>
<td>Direct and observable</td>
<td>This might be confounded by other factors, such as low savings, low public infrastructure, and low awareness.</td>
</tr>
<tr>
<td>Multidimensional measures</td>
<td>A combination of multiple indicators that reflect different aspects of energy deprivation</td>
<td>Nuanced and holistic, it captures the complexity and multidimensionality of energy poverty.</td>
<td>Subjective choices on the inclusion of indicators and weighting require more data.</td>
</tr>
<tr>
<td>Approaches that use big data</td>
<td>Measures that use big data, such as satellite, mobile phones, social media, etc.</td>
<td>Innovative, real-time, and granular analysis</td>
<td>Abstracts from quality, affordability, and reliability; require advanced data science skills and tools; may raise ethical and data privacy concerns</td>
</tr>
</tbody>
</table>

*Source: Own compilation based on literature (2023).*

### 3. Energy Poverty Measures in Bulgaria

We next explore several energy poverty measures in Bulgaria. We start by looking at purely expenditure-based measures. We then explore consensual and outcome-based approaches and the potential of big data sources. We mainly rely on data from the household budget survey (2021) and the EU-SILC (2020), the most recent data for this study.

#### 3.1. Expenditure-based measures

We start by exploring expenditure-based measures of energy poverty using survey data from 2021. We explore the three expenditure-based approaches detailed previously and also analyze the sensitivity of these measures to varying some of the underlying parameters.

For the relative measure, we start by defining energy spending shares as follows:

\[
ES = \frac{E}{I}
\]

where \(E\) is the total energy spending category reported in the household budget survey (electricity, natural gas, town gas, liquified energy sources, liquid fuels, coal, other solid fuels, and heat energy). We divide it by total household expenditure and alternatively disposable household income and then compare both measures. Importantly, we rely on net income, the total income from all sources,
including non-monetary components minus income taxes. We do not consider imputed rent. We scale the nominator and denominator by the same measure (e.g., the number of total household members or the adult equivalent), which means they cancel each other out. We also explore the possibility of only scaling the denominator, but estimates are significantly higher than benchmarks from the literature, which is why we discard this approach.

The average energy expenditure shares are close to each other, but the income-based measure is significantly less dispersed; the energy poverty rates show similar proximity across the three measures: the 2M, M/2, and equivalized M/2. While the average energy expenditure shares are close to each other (13.5 percent versus 12.7 percent using expenditure and income, respectively), the distribution depicted in Figures 5 and 6 looks different, which could impact energy poverty measures based on energy shares. Figures 7 and 8 reveal that measures 2M and 10 percent have significant differences, likely due to the differences in the distributions. M/2 measures do not vary, as they are absolute measures that do not rely on the shares. The graphs also show that the 10 percent measure is significantly above the other expenditure-based measures, probably related to the methodological shortfalls detailed previously. While the 10-percent measure results in an energy poverty incidence rate above 50 percent, the incidence rates of the other measures fluctuate between 8 and 10 percent.

Figure 5: Energy expenditure share (energy over expenditure) (2021)  
Figure 6: Energy expenditure share (energy over income) (2021)

Source: Own estimates based on HBS (2021)

33 Rent is treated separately in the income aggregate due to the complexity of its inclusion. When rent is included, it can create a situation where a tenant appears less economically disadvantaged than a homeowner with similar characteristics living in the same area, even if their incomes in other categories are identical. To address this disparity and treat these individuals equally, one option is to exclude rents altogether, or alternatively, to devise a method for measuring the utility flow generated by owner-occupied housing. In alignment with World Bank ECAPOV guidelines (World Bank, 2022), imputed rent is not included in the income aggregate.

34 These values are similar to estimates of the energy poverty share reported previously in the literature (Laderchi et al., 2013).

35 Two notable effects can explain this result. First, the 10 percent measure, relying on actual energy expenditures, fails to account for the concept of “hidden poverty,” which pertains to individuals who curtail their usage and consume less energy, thus resulting in an undercounting of energy poverty. Second, the choice of a 10 percent threshold is arbitrary and based on UK standards. According to Thomson (2017), researchers risk producing invalid results by using a 10 percent actual expenditure threshold that is not grounded in the specific context of the country under consideration. In the case of Bulgaria, this threshold seems exceptionally low, leading to a higher proportion of individuals being classified as energy poor. These two effects operate in opposing directions, with the dominance of the second effect resulting in a relatively high incidence of energy poverty. Moreover, our estimate of energy poverty using the p10 measure is close to previous estimates (Laderchi et al., 2013).
Note: Energy includes electricity, natural gas, town gas, liquified energy sources, liquid fuels, coal, other solid fuels, and heat energy

Figure 7: Energy spending share (over expenditure) and energy poverty incidence rates, by definition (2021)

Figure 8: Energy spending share (over income) and energy poverty incidence rates and, by definition (2021)

Notes: The energy spending share is the average expenditure on energy divided by the average household income (on the right) and by the average household expenditure (on the left). We consider the following measures of energy poverty: (1) A household is considered energy poor as soon as the share of energy expenditure (compared to equivalised disposable income) is above twice the national median of energy spending shares (2M); (2) a household is energy poor as soon as absolute energy expenditure is below half the median of absolute energy expenditure (M/2); (3) a household is energy poor as soon as equivalized energy expenditure is below half the median of absolute energy expenditure (M/2 (equ.)); (4) A household is considered energy poor as soon as the share of energy expenditure is above 10 percent. Source: Own estimates based on HBS (2021).

An additional measure of energy poverty that is increasingly used, the low-income-high-cost measure (LIHC), is below the 2M and (equivalized) M/2 measures in Bulgaria. This measure is close to the newly announced official measure but uses observed energy expenditures from the household budget survey rather than modeled energy expenditures. The energy poverty rate resulting from the low-income-high-cost measure is 7.1 percent (Figure 9), below the 2M and M/2 measures. However, it is important to note that the at-risk of poverty rate using income reported in the HBS 2021 results in slightly higher rates than the official measures from the EU-SILC survey (25 percent versus 22.1 percent).36 The difference in the estimates reflects differences in the income distribution generated by the household budget survey compared to the EU-SILC.

36 We create the LIHC measure of energy poverty by utilizing the official poverty line from the European Union Statistics on Income and Living Conditions (EU-SILC) rather than the poverty line derived from the Household Budget Survey (HBS). The purpose is to align our measure more closely with the official definition, which relies on the poverty line from the SILC as a benchmark. Using the poverty line from the HBS could potentially result in a higher incidence of energy poverty. This is because the HBS poverty line is higher than the one estimated using SILC, leading to higher income poverty rates.
Notes: The at-risk-of-poverty rate is calculated using household income from the 2021 household budget survey and, therefore, does not correspond to the official poverty estimate. The resulting estimate is slightly above the official poverty estimate from the EU-SILC (22.9% in the 2022 survey year and 2021 income reference year). A household is considered energy-poor if two conditions are met: 1) if they have an energy expenditure above the national median, and 2) if the remaining income after they spend that amount (in equivalized terms) is below the official at-risk-of-poverty threshold. By the definition of the LIHC, all monetary income poor are also energy-poor if they have energy spending shares above the national median.

Source: Own estimates based on HBS (2021).

The overlap between energy and monetary poverty varies considerably between the different measures. By construction, all monetary poor are energy poor in the low-income-high-costs (LIHC) measure only if they have energy spending above the national median37 (see Figure 10). An additional share of vulnerable households falls below the threshold (AROP poverty line) when subtracting their household energy expenditure from their available household income. Still, some have energy spending shares below the national median, so these households remain unaffected by energy poverty. The P10 measure highlights the most significant intersection between households facing energy and monetary challenges. Specifically, it reveals that 20% of all Bulgarian households experience both energy and monetary poverty. Additionally, a striking 80% of those classified as income poor also fall into the category of energy poverty. The overlap is significantly lower among other measures. For example, only 14.3% of income poor households are also energy poor under the LIHC measure. The overlap between the different measures and at-risk of poverty rates only varies slightly when using income or expenditure as the denominator (compare Figures 11 and 12)38. The limited overlap in the LIHC, the 2M, and M/2 measures means that policies targeting the energy poor

37 Households are considered poor when their income falls below the AROP poverty line. The at-risk-of-poverty threshold is set at 60% of the national median equivalized disposable income after social transfers. Household members are made equivalent by weighting each according to their age, using the so-called modified OECD equivalence scale. Therefore, when subtracting energy expenditures from their income, the remaining income will always fall below the AROP poverty line for these households that have energy spending above the median (condition 2).

38 Note that the M/2 measures are the same in both figures, as they, by definition, do not rely on the denominator.
using these definitions must go beyond income-support measures designed to target the income poor, as they will not reach a large share of this group.

**Figure 11:** Overlap of energy and monetary poor using expenditure-based measures (over expenditure, when applicable)

**Figure 12:** Overlap of energy and monetary poor using expenditure-based measures (over income, when applicable)

Notes: Monetary poverty is the at-risk poverty rate using the income measure reported in the HBS 2021 and, therefore, does not correspond to the official poverty measure. The resulting poverty estimate is slightly above the estimate from the EU-SILC.

Source: Own estimates based on HBS (2021).

In summary, the large differences in the incidence of energy poverty between the alternative expenditure-based measures demonstrate how sensitive these measures are to the underlying definition; the most effective public policies that address energy poverty will, therefore, be highly conditioned by the definition adopted by the government. The differences in energy poverty incidence rates between the measures confirm the challenge of identifying sound and precise indicators. If policymakers plan to target those who experience low income and high costs, the low-income-high-costs measure might be most appropriate. If they want to generate indicators that can be compared across countries, the 10 percent measure might be most appropriate. Suppose the goal is to capture those that under-consume energy in absolute terms or abnormally high energy expenditure relative to the distribution. The M2 and (equivalized) M/2 measures might be best suited in that case. Finally, since these expenditure-based measures rely on data from the Household Budget Survey (HBS), and this data is only representative at the national, urban, and rural levels, additional geographical disaggregation (NUTS2 and below) is not possible.

Characterizing energy affordability within the group experiencing income poverty or estimating the intersection between official income poverty and energy poverty poses challenges. In particular, the above indicators rely exclusively on the Household budget survey, the main source of energy expenditures among households, but use the income reported in this survey. However, official income poverty in Bulgaria, as in other EU countries, relies on the EUSILC survey. A different approach to this problem involves the statistical matching of these datasets (Rude and Robayo-Abril, 2024). Using

---

39 Through data fusion, they create a unique dataset incorporating details on energy spending shares, income-based poverty indicators, inequality measures, and additional variables related to households' living conditions
imputation methods, energy shares can be imputed into the EU-SILC survey. Utilizing the resulting synthetic dataset, one can overlay energy poverty with official monetary poverty. The findings reveal a substantial portion of the energy-poor population (using the LIHC measure) that does not fall under the category of official income poverty. Consistent with the findings in this paper, the results vary significantly depending on the energy measure used. This research contributes to the expanding body of literature exploring the potential of statistical matching to enhance the current data landscape in the European Union.

3.2. Consensual Approaches and Outcome-based Metrics

We next explore consensual and outcome-based measures in Bulgaria and rely on those indicators mentioned in Table 1, which are included in the EU-SILC and available in Bulgaria. Two aspects of the main EU indicators for material and social deprivation (MSD) and severe material and social deprivation (SMSD) are directly applicable to the monitoring of energy poverty using this approach. They are commonly employed as proxies for assessing energy poverty in the EU: the inability to adequately heat one’s home and the incidence of arrears on utility bills.40 Both factors are integral components of the AROPE headline indicator, which has been fundamental to the EU2020 poverty and social exclusion target. It continues to play a key role in supporting the 2030 EU poverty and social exclusion reduction target.

Figure 13 shows that the energy poverty incidence rate fluctuates between 11.0 percent and 46.5 percent, depending on the indicator used. Consequently, the overlap between monetary and energy poor differs significantly by indicator (Figure 14). Not surprisingly, the leakage and type of dwelling indicators41 report relatively low overlaps. At the same time, nearly half of the monetary poor are also energy poor in the case of the affordability indicators. A high share of households are only energy poor on the building indicator (40.2 percent). These measures can be disaggregated at the NUTS3 level, as the SILC survey is representative at this level.

40 Arrears on utility bills are captured in the SILC survey question: “During the last 12 months, did your household face some problems with payment on time of the expenditure on the dwelling you are living in? Ability to keep the home warm is captured in the SILC survey question: “Can you afford adequate heating of your dwelling?”

41 Privately-owned inefficient multi-family apartment blocks with insufficient maintenance may have high energy poverty rates.
Notes: Monetary poverty is defined via the at-risk-of-poverty measure using income measures reported in the EU-SILC. Income refers to the year 2019.

Source: Own estimates based on EU-SILC (2020).

Overlapping the different consensual measures confirms findings from the previous literature on households experiencing different dimensions of energy poverty. For example, only half of households that report arrears on their utility bills also report an inability to keep their home warm (EU-SILC, 2020). Similar observations can be made when overlapping households that report leakages with those unable to keep their home warm (EU-SILC, 2020). These results show that various population segments encounter distinct aspects of energy poverty. Efficient targeting strategies must consider which part of the population is affected by what type of energy poverty.

3.3. Multidimensional Measures

Given the multidimensional nature of energy poverty, one approach would involve using a comprehensive array of indicators to construct a thorough understanding of energy. Among the wide range of multidimensional measures identified in the literature, we construct a multidimensional energy poverty index following the methodology developed by Bouzarovski and Tirado Herrero (2017) and Rodriguez-Alvarez et al. (2021). The advantage of this index is its simplicity and the fact that all the dimensions can be measured with one data source, the EUSILC, and, therefore, can easily be constructed and tracked over time. Tirado Herrero (2017) emphasizes that the suggested index operates under the assumption that relying solely on consensual measures (like self-reported inability to maintain warmth) may not adequately grasp the intricate nature of energy poverty. They suggest integrating indicators describing the population’s housing and financial circumstances to comprehensively understand them.

The multidimensional energy poverty index is constructed as a composite index using three indicators from the EU-SILC and weighting them accordingly as follows:

\[
\text{Energy Poverty Index} = (0.5 \times \text{Inability} + 0.25 \times \text{Arrears} + 0.25 \times \text{Leakages}) \times 100
\]

Where:
- Inability indicates the percentage of the total population who cannot keep their homes adequately warm.
- Arrears is the percentage of the total population with arrears on utility bills (heating, electricity, gas, water) on time due to financial difficulties.
- Leakages capture the percentage of the population living in a dwelling with a leaking roof, damp walls, floors, or foundation, or rot in window frames or floors.

In this case, the higher the value of the EP index, the higher the degree of energy poverty. The researchers give the inability to keep the home adequately warm a higher value as they argue that this indicator has greater importance, as proposed in the literature (Thompson and Neil, 2013; Bouzarovski and Tirado Herrero (2017)). According to this indicator, nearly half of the population is affected by at least some dimension of energy poverty (Figure 15). In this case, a significant share (seven out of 10) of the poor based on the at-risk of poverty are also energy poor (Figure 16).

**Figure 15: Multidimensional energy poverty rate (2019/20)**

**Figure 16: Overlap of at-risk of poverty and multidimensional energy poverty rate (2019/20)**

Source: Own estimates based on EU-SILC (2020)

### 3.4. Big Data

We lastly experiment with big data to explore the potential of this data type to measure energy poverty. We note that this approach is experimental and should be cautiously taken. Nighttime lights have been used to measure urbanization dynamics (Zhou, 2012), population, local economic activity, and energy use (Goldblatt, 2016; Shi et al., 2014; N. Zhao, 2017; Amaral et al., 2005; Townsend et al., 2010, Coscieme et al., 2014; Shi et al., 2014; Fehrer and Krarti (2018)). We follow the approach of Fehrer and Krarti (2018) and argue that nighttime light satellite data could be used as a proxy for building energy use intensity. The methodology presented in this study offers a replicable approach globally, providing opportunities for geospatial energy analysis without the challenges associated with disaggregated building energy use data collection. 42 We use the data made available by Li and Zhou (2017). Applying zonal statistics, we calculate the mean nighttime light data per municipality and plot it in Figure 17.

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42 The study addresses the challenge of limited data for geospatial analysis of energy use in buildings by proposing the use of satellite-derived information, specifically nighttime light imagery from the VIIRS instrument aboard the SUOMI NPP satellite. Researchers evaluated this imagery as a predictor of building energy use intensity across states, counties, and cities in the United States. The findings indicate that nighttime lights can explain a significant portion of the variability in energy consumption, reaching up to 90%, depending on conditions and geospatial scale. The results are applied to generate detailed electricity and fuel consumption maps for the United States at a resolution of less than 200 square meters.
Overall, using nighttime light data to measure energy poverty can provide valuable insights into the spatial distribution and dynamics of energy usage and can help policymakers and practitioners better understand and address the challenges faced by vulnerable communities. These types of maps could be helpful in identifying areas with the most significant demands for interventions while also indicating areas with low population density or limited energy use. The map in Figure 17 indicates a significant variation of nighttime light data across municipalities. Given Bulgaria's very high electrification rate (effectively 100%), darker areas (with low levels of nighttime light intensity) can be indicative of low population density, energy usage, or economic activity. Similarly, areas that report the highest values could experience high energy usage. Therefore, more detailed studies are required when using these types of datasets, and overlaying nighttime light data with data on income levels, population density, housing conditions, or access to basic services can be particularly useful in understanding energy poverty patterns at the local level.

Combining big data with traditional data sources can increase the informativity of these sources. Another possibility to use these maps is to scale them by population or square meters of the ground floor, for example, to detect abnormalities. Combining big data sources with these types of data might increase their informativity. Nevertheless, when using these types of alternative data sources, it is recommended to validate the information – at least for a subset of the data - by alternative data sources, such as surveys or administrative data.

3.5. Characteristics of Energy Poor

Energy poverty might have several correlates, both at the individual and contextual levels. Identifying the drivers behind energy poverty and characterizing the energy poor can be beneficial for designing policy interventions that try to target the energy poor on the one hand and tackle the mechanisms behind energy poverty on the other. Energy poverty is influenced by many factors, which exhibit variations between countries and even within geographically disaggregated regions. According
to the Energy Poverty Advisory Hub's report (2022), the driving forces behind energy poverty can be
categorized into contextual and individual factors. Additionally, the report identifies three principal
causes responsible for the occurrence of energy poverty: low income, energy inefficiency, and energy
prices.

To better understand what could be associated with energy poverty, we next describe the energy
poor, using the multidimensional energy poverty index; characterizing the energy poor can also be
helpful for the design of targeting strategies. Table 4 shows that the energy poor are more likely to
reside in households with at least one unemployed, with more than five members, and with at least
one pensioner when compared to households that are not energy poor. They are more likely to live in
rural areas, be elderly, and disabled. We confirm that these characteristics are correlated with energy
poverty incidence rates by estimating a Probit regression, using the probability of energy poverty based
on the energy poverty index as a binary outcome variable. Table 5 shows that these groups are still
more likely to be energy poor, even when compared with households with similar household
characteristics43. The fact that these characteristics relate to a higher probability of being energy poor
can help with targeting mechanisms, such as proxy mean testing, and generate insights on what might
be driving energy poverty in the first place (e.g., increased vulnerabilities, more generally speaking).

Table 4: Descriptive Statistics of Energy Poor and Non-Energy Poor

<table>
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<td>Energy poor</td>
<td>Non-energy poor</td>
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</tr>
<tr>
<td></td>
<td>Mean</td>
<td>sd</td>
<td>Mean</td>
<td>sd</td>
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<td>2.56</td>
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<td>0.50</td>
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<tr>
<td>HH with +1 unemployed</td>
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<td>0.41</td>
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<tr>
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<td>Female</td>
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<tr>
<td>Unemployed</td>
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<td>0.04</td>
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<td>23.43</td>
<td>42.61</td>
<td>22.04</td>
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<td>Elderly</td>
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<td>0.39</td>
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<td>0.15</td>
<td>0.35</td>
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<td>0.43</td>
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<td>0.24</td>
<td>0.43</td>
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<tr>
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<td>0.60</td>
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</table>

Notes: We define energy poverty using the multidimensional energy poverty index. “SD” is the standard
deviation.

Source: Own estimates based on EU-SILC (2020).

Unfortunately, we do not have sources of heating and cooking in the data to control for these characteristics.
<table>
<thead>
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<th>VARIABLES</th>
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<td></td>
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<td>Adult equ.</td>
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<td>HH with +1 child</td>
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<td>HH with +5 members</td>
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Observations 6,962,414

Notes: The table presents marginal effects from a Probit model that estimates the correlation between individual and household characteristics on energy poverty. Energy poverty relies on the definition of the energy poverty index (see Section 3.3). Source: Own estimates based on EU-SILC (2020).
4. Conclusion and Recommendations

In this paper, we review existing energy poverty indicators in the academic literature, white papers, and policy reviews and then explore the employability of these indicators in Bulgaria’s case. Energy poverty is a complex concept that lacks a common definition and is multidimensional by nature. It involves multisectoral and multilevel approaches. Based on these factors, measuring energy poverty is complex, and there are many different approaches to its measurement. In the work at hand, we review existing approaches and then explore their applicability to the concept of Bulgaria based on data availability and quality.

We show that Bulgaria’s energy poverty incidence rate fluctuates significantly by definition. The 10 percent measure deviates significantly from the other expenditure-based indicators, resulting in an approximately five times larger incidence rate. This could be related to the measurement issues and the criticism raised in the literature about this indicator. The rest of the monetary measures fluctuate between 9 and 13 percent. The incidence rates of consensual measures are slightly larger, varying between 11 and 47 percent.

Our evidence demonstrates that the monetary poor and energy poor only partly overlap. By construction, the monetary poor are also energy poor in the low-income-high-cost measure. If they report energy expenditure shares above the national median, this is not necessarily true for the rest of the measures. We find that, depending on the measure, only 1 to 12 percent of the population is affected by monetary and energy poverty. This has important implications for the targeting of policy interventions. As the monetary and energy poor only overlap partly, traditional social protection strategies might not target those who are energy poor, and additional policy instruments should be implemented when governments try to tackle energy poverty.

In addition, we show that different subsets of the population face different dimensions of energy poverty. This means that the government might want to include a different population set for interventions that target energy poverty in the short and long-run, for example. Those needing renovation programs and interventions that increase their energy efficiency might differ from those who cannot afford their energy bills.

Based on our literature review, we recommend moving away from single-indicator energy poverty metrics toward multiple-indicator approaches, which are consistent with previous studies. We show that the incidence rate of energy poverty fluctuates significantly depending on the underlying methodology. Based on this pattern of results, we recommend moving away from single-indicator energy poverty metrics towards multiple-indicator approaches. This recommendation is in line with recommendations made previously in the literature (see, for example, Herrero (2017) and Siksnelyte-Butkiene (2021)). It is also consistent with the latest EC recommendation developed by the Energy Poverty Advisory Hub, which emphasizes the importance of utilizing a mixed indicators approach that covers all contributing factors and accurately identifies vulnerable populations, given the complex nature of energy poverty. One example would be to follow previous pilots like the Belgium Energy Observatory or the French National Energy Poverty Observatory (ONPE), which both track more than one indicator. The operationalization of energy poverty measures should involve a cooperative approach between several ministries, academics, and local communities. In addition, big data sources

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44 Importantly, results differ from some of the results detailed in Rude and Robayo-Abril (2024) because we use income from the EU-SILC after a statistical matching procedure in this case, while we rely on income measures reported in the HBS in the work at hand.

can be useful, especially when considering disaggregated statistics, but should—at least for a subset of the data—be validated by traditional data sources.

To operationalize the measurement of energy poverty, Bulgaria could follow the model previously explored in Belgium. In Belgium, the King Baudouin Foundation has developed an Energy Poverty Barometer, considering the multidimensional nature of energy poverty (Meyer et al., 2018).\(^{46}\) The barometer considers several complementary measures of energy poverty and considers that different subsets of the population might suffer from different aspects of the overall concept of energy poverty (ibid). The Energy Poverty Barometer considers the following dimensions of energy poverty: measured energy poverty, hidden energy poverty, and perceived energy poverty measured, respectively, by the share of households reporting excessive energy bills compared to available income, restriction in energy consumption below basic needs, and self-reported difficulties to heat the housing adequately.

In addition, Bulgaria could learn from success stories and challenges identified in other countries, such as France, when operationalizing energy poverty. The EU Energy Poverty Observatory (EPOV)\(^ {47}\) (2019) published a case study outlining France’s successfully implemented energy poverty measures. This initiative relied on two complementarity measures: the energy stress indicator, based on household energy expenditure and income ratio, and the indicator on the ability to keep the home adequately warm. The main challenges identified in the case study were little awareness of energy poverty, lack of data, insufficient evaluations of existing energy poverty policies to identify what works and does not work, and lack of coordination between the involved stakeholders.

Moreover, the chosen indicator tracked to measure progress in the fight against energy poverty should reflect the aspect of energy poverty that the government aims to address. Suppose the government aims to implement long-term approaches to address energy poverty via renovation programs, for example. In that case, observational indicators about the square meters renovated or the energy efficiency of buildings and consensual metrics on the share of households experiencing leakages might be most appropriate. If governments are most interested in tackling the income component of energy poverty via social protection programs, for example, a measure incorporating total household income might be most appropriate. Similarly, if policymakers wish to address the dimension around low access to high-quality energy, measures that track connectivity to energy might be most suited.

Regarding expenditure-based approaches, we recommend relating energy expenditure to the measure used to define monetary poverty. This means that countries should use total household expenditure to scale energy expenditure in the case of relative measures when they also use consumption to define poverty. If their welfare measures rely on income-based approaches, they should relate energy expenditure to household income. Nevertheless, this approach should only be applied if income information from expenditure surveys is reliable. If income is unreliable, researchers and statisticians can explore alternative approaches to combine information on expenditure and

\(^{46}\) For more information, see the website: [https://kbs-frb.be/fr/barometre-de-la-precarite-energetique-2009-2017](https://kbs-frb.be/fr/barometre-de-la-precarite-energetique-2009-2017)

\(^{47}\) The European Energy Poverty Observatory (EPOV) initiative receives funding from the European Commission and is executed by a consortium of 13 diverse organizations, including universities, advocacy groups, think tanks, and representatives from the business sector. The University of Manchester leads this consortium. EPOV has several objectives, including enhancing information transparency and policy effectiveness by consolidating diverse data and knowledge sources existing across the EU. Additionally, it aims to offer an easily accessible resource that fosters public engagement and supports well-informed decision-making for local, national, and EU-level authorities. The Observatory strives for a comprehensive understanding of energy poverty in the European Union and intends to aid various stakeholders in their efforts.
income collected in different surveys, such as statistical matching. For the application in Bulgaria and the related performance evaluation, see Rude and Robayo-Abril (2024).

Moreover, Bulgaria would benefit from improving the data environment around measuring energy poverty based on three factors. First, greater granularity, both geographically speaking and concerning the frequency of data collection, could help with local implementation approaches and tracking of energy poverty over time. Next, harmonizing datasets across countries could facilitate the comparison of energy poverty rates across countries and identify those most in need at the European level. Third, close collaborations between academia, research institutions, analysts, and the government could create valuable knowledge and innovative approaches in this area, especially using big data sources.

The measurement of the definition of energy poverty and the development of all energy poverty policies should be based on meaningful and transparent processes of public involvement and inclusive engagement with various stakeholders. Establishing a common understanding of what energy poverty entails and how it is measured helps ensure that different stakeholders, including policymakers, researchers, and communities, are on the same page. This shared understanding forms the foundation for policies aiming to reduce energy poverty. Given the multidimensional nature of the issue, appropriate coordination and involvement of relevant stakeholders in energy poverty reduction efforts is critical, including national statistical offices, finance ministries, sectoral ministries, and other significant entities (at local and national levels). A broad consultation process can improve the acceptance of a methodological approach, including consensus on the minimum comfort levels.

Finally, energy poverty observatories are also invaluable tools for addressing and combatting energy poverty; in the EU, several countries have established country-specific energy poverty observatories. Well-designed energy poverty observatories work as a platform that unites practitioners, decision-makers, and researchers addressing energy poverty in the country and beyond. The growing importance of evidence-based energy poverty policy-making at the European Union (EU) level underscores the necessity for establishing a dedicated decision-support hub in Bulgaria. As an EU Member State with some of Europe's highest energy poverty rates, Bulgaria faces pronounced structural challenges at the intersection of energy, low incomes, and poor housing.

The Energy Poverty Observatory can help comprehensively tackle these issues. First, it provides a means to accurately quantify the current levels of energy poverty within a region or country. This quantification is vital for understanding the extent of the issue, identifying the affected population, and enabling targeted interventions. In the Bulgarian context, the observatory can help develop a rigorous and comprehensive set of indicators to operationalize the new legal energy poverty definition and create a central repository of these indicators. Second, the observatory can facilitate ongoing monitoring of energy poverty trends and developments. This longitudinal or temporal analysis helps assess the effectiveness of implemented policies and interventions, guiding adjustments or improvements where necessary. Third, it can be crucial to identify the multifaceted factors contributing to energy poverty and develop evidence-based policy recommendations. Lastly, it plays a crucial role in convening key stakeholders to understand energy poverty comprehensively across different sectors and levels. By pinpointing these factors, policymakers and stakeholders can tailor strategies to mitigate the root causes and alleviate the burden of energy poverty on vulnerable populations.

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48 This involves a broad spectrum of national and local decision-makers, encompassing the energy regulator, the Ministry of Labour and Social Policy, the Social Protection Agency, the Ministry of Health, Ministry of Regional Development and Public Works, the Ministry of Energy, the Sustainable Energy Development Agency, local authorities, the statistical office, and the Energy and Water Regulatory Commission (EWRC). Additionally, it includes practitioners from the energy, housing, and social sectors, advocacy groups, the media, other EU observatories, development support agencies, the private sector, and the research community.
communities. Overall, energy poverty observatories serve as indispensable tools in the fight against energy poverty, aiding in informed decision-making and the design of effective interventions.

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