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Article

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ENERGY POVERTY: MACROECONOMIC INSIGHT ON ROMANIA, BULGARIA AND THE VIȘEGRAD GROUP WITHIN THE EUROPEAN CONTEXT

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Abstract

Recent studies suggest a core-periphery pattern of energy poverty in the European Union. The energy vulnerability of Romania, Bulgaria, and the economies of the Visegrad Group as "peripheral" countries is frequently attributed to the legacy of the centrally planned economy and post-communist economic transformations towards a market economy. The aim of the paper is to investigate the potential occurrence of a core-periphery pattern and the relative situation of Romania, Bulgaria and the V4 countries in this pattern by employing a model that integrates three energy poverty thresholds, namely physical, technological, and economic. The research findings reveal some disparities among the selected countries following each of these thresholds and suggest the emergence of two clusters that are describable by a core-periphery pattern but, in our opinion, with some different meanings from those stated by classical economic development theory. The evidence provided by our study would prove its value and usefulness, on the one hand, by opening up new research directions and, on the other hand, by describing a state of affairs that calls for increasing attention from macroeconomic decision-makers, all the more so as the contextual factors that have shaped the socioeconomic environment in recent years (the Coronavirus pandemic, the military conflict in Ukraine) add even more value to research in this thematic registry, since not only energy security but also the achievement of sustainable development goals are seriously questioned.

Keywords: fuel poverty, vulnerability, disparities, thermal comfort, financial burden

JEL classification: Q01, Q43.

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Introduction

The current scientific area of fuel poverty is circumscribed by the older debate on *fuel* poverty, born in the 1970s and 1980s in the cold climate developed countries of Northern Europe. Since the energy crises of the 1970s, the concept of *fuel poverty* has increasingly emerged in social policy discourse to describe a condition in which individuals, families, and groups do not have sufficient resources to provide themselves with an ordinary or at least desirable level of heating and lighting in the societies they come from (Bradshaw and Hutton, 1983). Despite political skepticism about the possible existence of such a phenomenon, Boardman (1991) broadens the definition by adding a quantitative component and subsequently identifies a number of other components that are predominantly related to quantifiable technical and economic factors (Boardman, 2010). Energy poverty is often linked to the inability to access modern energy services (Bouzarovski and Buzar, 2011; Li et al., 2014; Nussbaumer et al., 2012; OECD/IEA, 2010; Ogwumike and Ozughalu, 2016; Pye et al., 2015), lack of access to electricity and widespread use of biomass for cooking (Sovacool, 2012) or the physical lack of certain types of energy, lack of income and high costs of energy use (Pachauri and Spreng, 2011), income levels, sociodemographic characteristics and housing typology (Bollino and Botti, 2017; Bouzarovski, 2014; Bouzarovski et al., 2012; Bouzarovski and Buzar, 2011; Healy and Clinch, 2002; Thomson et al., 2017), demographic circumstances (Lampietti and Meyer, 2002).

The European Commission estimates that around 11% of the EU population is unable to afford adequate heating comfort (European Commission, 2018; European Committee of the Regions, 2019). The scale of this problem is largely rooted in rising energy prices, low incomes, and energy inefficient housing; last but not least, energy-saving habits and lifestyle can exert significant influence (Dincă et al., 2022). The EU energy policy aims to increase efficiency and modernise the energy infrastructure to make Europe a sustainable economy (Avram et al., 2018; Constantin et al., 2019; Dragomir et al., 2022; Dumitru et al., 2019).

Regarding the Central and Eastern European countries, some research has identified the roots of the problem in the legacy of centrally planned economies (Bouzarovski et al., 2016; Bouzarovski and Tirado Herrero, 2017, 2016; Lampietti and Meyer, 2002; Pye et al., 2015). Despite the growing number of studies addressing the social implications of energy reforms in Central and Eastern European countries, the problem of energy poverty in this region is still insufficiently explored and clarified. As Buzar notes (Buzar, 2007a, p. 3) the conceptualisation of energy poverty in post-socialism suffers from the lack of an integrated theoretical understanding of the interdependencies among social, energy, and domestic reforms; transformation processes have created new geographies of inequality on a transnational scale that have deepened even after the EU's eastward enlargement. Romania, Bulgaria, and the countries of the Visegrad Group have undergone a painful process of transition to market economy mechanisms (Dinu, 2016), including liberalising energy markets, eliminating subsidies, and gradually bringing energy prices to full level (Herrero et al., 2012; Tirado Herrero and Ürge-Vorsatz, 2012). The scientific landscape covering these countries is quite scattered and in its early stages of development. Part of the studies are focused on measurement tools and capture the phenomenon using multidimensional indices at the level of a larger sample of countries, including selected countries (Maxim et al., 2016); other studies seek to highlight regional characteristics using such multidimensional indices (Maxim et al., 2017). Several researches focus on the socio-spatial determinants of energy

poverty (Bouzarovski, 2018, 2014; Bouzarovski and Tirado Herrero, 2017; Buzar, 2007b) and lead to the conclusion that the core-periphery pattern portrays more closely the spatial disparities in energy poverty within the EU.

In this context, the aim of this paper is to investigate the presence of a possible core-periphery pattern and the relative position of Romania, Bulgaria, and the V4 countries in this pattern by using a conceptual framework that integrates three energy poverty thresholds, namely physical, technological, and economic. Although scientific interest in energy poverty is increasingly evident, a large number of studies are predominantly constructed on static approaches (Phimister et al., 2015) and focus on measuring energy poverty at a point in time, using subjective measurement tools, and developing composite indicators that capture the magnitude of the phenomenon. The dynamics of the energy poverty phenomenon are still relatively unexplored through empirical research that also integrates the macroeconomic perspective. In Romania, Bulgaria, and the Visegrad Group economies, the transition to a market economy and, in general, the transformations that have taken place since 1990 have increased the complexity of the energy poverty issue. Moreover, the six selected countries account for about 86% of the total population of the former socialist countries of Central and Eastern Europe and 20% of the EU population. Therefore, a comparative study in the European context expands the area of knowledge both theoretically and empirically. Firstly, the literature on energy poverty in post-communist countries is in its infancy; the scientific approaches conducted so far have been built mainly on individual cases, forming a rather heterogeneous scientific landscape in terms of research topics; moreover, some studies have limited the scope of observation to specific regions/administrative units in these countries. Second, it provides an insight into the current state of knowledge on the topic of energy poverty. Third, it provides new empirical evidence by testing the "core-periphery" model argued by Bouzarovski & Tirado Herrero (2017) using the framework proposed by González-Eguino (2015) in the case of Romania, Bulgaria, and the V4 countries.

The paper is further structured as follows. The second section systematises the main contributions and theoretical developments on energy poverty. The third section outlines the methodological design and describes the data computed in this research. The next section is devoted to the discussion of the results of the study. Finally, several conclusions and possible future research directions are listed.

1. State of the art

The literature on the topic tends to focus on three mainstreams, namely the definition, main determinants and social and political recognition of fuel poverty; energy poverty as a descriptor of development: conceptual repertoire, estimation methods and observable impact; and the multidimensional nature of the phenomenon and assessment tools.

Regarding the first line of research, a large body of research initially investigated energy poverty in the UK and Ireland. For Ireland, there was even discussion of chronic energy poverty in which homeowners are trapped in a persistent trap, consistently unable to adequately heat their homes (Healy and Clinch, 2004). These studies were further complemented by qualitative approaches suggesting that energy poverty often had a complex impact on quality of life, with the solution affected mainly by information gaps and financial

constraints (Harrington et al., 2005). Basically, such studies have predominantly relied on approaches that integrate the low-income - energy/thermal inefficiency paradigm.

Since the economic crisis of the late 2000s, the issue of energy poverty in the UK has undergone a series of transformations in response to European and global developments both in fuel prices, whose rise could not be offset by measures to improve energy efficiency, and the growing political awareness of its existence (Boardman, 2012; Middlemiss and Gillard, 2015; Waddams Price et al., 2012). These transformations were also triggered by the debate on redefining energy poverty in line with observed realities, such a reconceptualisation being considered vital to determine the true nature and extent of the phenomenon, to design macroeconomic strategies/policies to alleviate it, and to monitor progress as existing definitions did not address those most affected by the phenomenon (Moore, 2012; Thomson et al., 2016). During this period, the need for conceptual harmonisation and the emergence of a pan-European definition was also discussed, so that, in the context of growing energy security concerns, energy poverty would be acknowledged as a policy issue by all EU Member States, although the European Commission considered such a definition inappropriate due to the different energy contexts in different countries (Thomson et al., 2016). In addition to studies focused on the UK and Ireland, a number of other quantitative and qualitative studies have investigated and documented the existence of this problem in other developed European countries, especially against a background of relatively low social and political awareness (Brunner et al., 2012; Dubois, 2012).

Among the components of the macroeconomic adjustment programmes implemented in Central and Eastern European countries after 1990 was the reform of the energy system, which involved the abolition of price controls, but without an adequate social protection mechanism for the energy vulnerable. In this context, the first investigations on the emergence of a particular type of energy poverty derived from low income, energy inefficiency, and contextual factors specific to countries in transition to a market economy were carried out. The studies initially focused on individual cases, but later on a possible European pattern of core-periphery energy poverty began to be discussed.

In one of the first studies of this nature, Buzar (2007b) has examined the institutional and demographic roots of energy poverty in the Czech Republic and Macedonia, two post-socialist countries with different trajectories/levels of development, and has found large disparities between them in levels of energy poverty, with Macedonia being affected to a much greater extent than the Czech Republic. On this basis, he has suggested the term 'hidden' geography of poverty, which also captures household energy deprivation. In the same vein, on the case of Hungary, Herrero & Ürge-Vorsatz (2012) propose a model for estimating energy poverty based on three expenditure thresholds and develop the concept by considering households that are adequately heated (in the centralised system specific to socialist countries) but with disproportionately high costs, usually at the expense of other categories of household expenditure. This type of energy poverty is the legacy of an inefficient and outdated residential system built at a time when energy prices were heavily subsidised. Studies that have been extended to the wider EU scale are in line with the view that energy poverty is a situation in which a household is unable to benefit from a level of energy services necessary to ensure material and social conditions. As Bouzarovski (2014) observes, the causes and consequences of energy poverty in the EU are largely analogous to those of fuel poverty. Bouzarovski & Petrova (2015) provide an integrated conceptual framework that outlines the main components and implications of energy services and vulnerability

approaches as they relate to energy deprivation worldwide. Therefore, it can be concluded that this situation is widespread in Europe, but its spatial and social distribution is heterogeneous. Geographical disparities in energy poverty across Europe are the subject of a more recent, broader study by Bouzarovski & Herrero (2017), which provides a baseline for exploring the relationship between the complex processes of social and technological transformation involved in the energy transition (as a feature of post-communist countries) and regional economic disparities. The results suggest the existence of a core-periphery pattern that features the clustering of energy poverty at the EU level, in line with the traditional core-periphery distinction argued in the 1970s and 1980s in the economic development literature. Central and Eastern European countries are the most affected; energy vulnerability in countries such as Estonia, Lithuania, Latvia, Poland, the Czech Republic, Slovakia, Hungary, Slovenia, Croatia, Romania and Bulgaria is rooted in contextual factors specific to the former centralised economic systems. Energy poverty is also observed in Western and Northern European countries, but with different intensities, the least affected being the Netherlands, Luxembourg, Denmark, Sweden, and Finland.

The relevant empirical contributions underpinning the second stream of research start from the observation of large disparities in energy consumption between developed and developing countries, which is considered a reasonable barometer of living standards with direct and indirect impact on other socioeconomic conditions related to human development. Given the developments that have shaped the socioeconomic and political context in recent decades, it is expected that the energy sector, and thus the economy and society as a whole, will undergo major transformations related to energy security, sustainability imperatives, and energy poverty.

González-Eguino (2015) considers a definition that integrates a number of interesting elements and nuances, namely he interprets energy poverty as the absence of a viable option in terms of access to adequate, affordable, reliable, high-quality, secure and clean energy services to support economic and human development. This interpretation is in the light of the meaning that the literature gives to development not as a strictly quantitative achievement, but as an improvement in access to options that enable the achievement of well-being in its broadest sense. In the same vein, Day et al. (2016) conceptualise energy consumption through the lens of capacity in a larger context of both developing and developed countries. This interpretation is the baseline for further studies, such as that of Sadath & Acharya (2017), which estimates the MEPI for India based on a household-level microdata set. The overall results show that India is largely affected by fuel poverty in tandem with other forms of economic and social deprivation.

Thomson et al. (2017b) investigate the interactions among fuel poverty, health, and well-being in 32 European countries. The results suggest a heterogeneous concentration of fuel poverty, poor health, and well-being, with Central and Eastern Europe being the most affected. This study, like the previous ones, leads to the conclusion that in developed economies, fuel poverty is mainly an affordability issue, while in developing economies the situation is more complex as they face both affordability and accessibility issues.

In the last decade, amid the increasing recognition of energy poverty as a complex condition affecting not only developing but also developed countries, a growing body of scientific work draws attention to the multidimensional nature of this phenomenon and the need to identify appropriate tools to measure its magnitude and intensity.

In 2012, following an extensive evidence review and stakeholder consultation, fuel poverty in the UK was again recognised as a serious national issue and the traditional official way of quantifying it was challenged. In this context, the Hills Report (Hills, 2012) proposes the use of an indicator that more accurately captures the extent and depth of the phenomenon by measuring the difference between the energy needs of vulnerable households and the threshold considered reasonable. Subsequently, a number of other studies critically assess the statistical and methodological tools for monitoring fuel poverty and investigate the multifaceted nature of the phenomenon through subjective and/or objective approaches (Legendre and Ricci, 2015; Papada and Kaliampakos, 2016; Thomson et al., 2017a). Drawing on the evidence reviewed, Herrero (2017) highlights the weaknesses of the single-indicator approach in assessing energy poverty, such as low-income-high-cost, and argues in favour of multiple-indicator approaches, which are better able to capture a more accurate picture of the phenomenon. In a similar vein, Bouzarovski & Herrero (2017) argue that the possibility of capturing fuel poverty solely through the lens of income-based indicators is less relevant in contexts where the population is frequently exposed to difficulties in securing an adequate level of energy services. A multidimensional perspective applicable to developed countries is proposed and tested by Okushima (2017) on the case of Japan after the 2011 earthquake, Japan being heavily dependent on external energy resources (Dincă and Carlea, 2016); basically, this multidimensional index integrates the cost, income and energy efficiency components. Along the same lines, other studies discuss the vulnerabilities of single indicator-based methods and propose/test multidimensional approaches as alternatives to traditional instrumentation. Thus, Meyer et al. (2018) design an energy poverty barometer in the Belgian national context; Gouveia et al. (2019) develop a composite index of higher accuracy at the spatial scale; Castaño-Rosa et al. (2019) argue for the need to mix different categories of indicators; Charlier & Legendre (2019) suggest aggregating poverty characteristics in an integrated manner that also features an energy poverty index. The recent systematic review of the literature and policy documents conducted by Siksnyte-Butkiene et al. (2021) identified 71 (composite) indicators used to assess energy poverty.

2. Research methodology

The aim of the research is to investigate the occurrence of a "core-periphery" pattern and the status of Romania, Bulgaria and the V4 countries in this pattern by using a conceptual framework that integrates three energy poverty thresholds, namely physical, technological and economic. As mentioned above, the literature discusses the emergence of disparities following a "core-periphery" profile of energy poverty in Europe (Bouzarovski, 2014; Bouzarovski and Herrero, 2017). We further explore the emergence of this pattern by adapting the three-dimensional conceptual framework (physical, technological, economic) suggested by González-Eguino (2015). Thus, the physical threshold estimates the minimum energy consumption required to meet basic needs. The technological threshold is linked to the idea that energy poverty is primarily a problem of access to modern energy services. The economic threshold essentially hinges on the approaches used to estimate relative poverty in developed countries in general, where there are vulnerabilities related to purchasing power, energy prices, and difficulties in maintaining adequate thermal comfort, especially in the winter season. Our interest in this conceptual framework is grounded in the interpretation of energy poverty that incorporates several nuances in line with the meaning that the literature gives to development, not as a strictly quantitative achievement, but as an improvement in

access to options that allow the achievement of well-being in its broadest sense. In this context, energy poverty assumes significant implications for sustainable economic and human development in terms of compromising access to the resources needed to meet basic needs, participate in society, and maintain adequate health.

This research is exploratory, longitudinal in its nature, and is conducted on secondary quantitative data collected from the Eurostat database. Table 1 presents and explains the data computed in this study for each of the three thresholds.

Table 1. Data description

<i>Indicator</i>	<i>Description</i>	<i>Unit of measurement</i>	<i>Time period</i>	<i>Source</i>
Physical threshold				
Final household energy consumption per capita (<i>FEC per capita</i>)	The indicator measures how much electricity and heat each citizen consumes on average at home, excluding the energy used for transport. As the indicator refers to the final energy consumption, only the energy used by the final consumers is taken into account. Consumption by the energy sector itself is excluded.	Kilogram oil equivalent (KGOE) per capita	2000-2020	Eurostat SDG_07_20
Technological threshold				
Household final energy consumption (<i>HFCs</i>)	Final household energy consumption	Thousands of tons of oil equivalent (TOE)	2009-2020	Eurostat TEN00125
Economic threshold				
Population having difficulty keeping their homes warm enough according to poverty level (<i>HW</i>)	Share of the population earning below 60% of the median equivalised income unable to maintain adequate thermal comfort	%	2003-2021	Eurostat SDG_07_60
Households with heavy financial burden due to housing costs (<i>HFC</i>)	Share of population earning below 60% of median equivalised income affected by high financial burden due to housing costs	%	2003-2020	Eurostat EU-SILC survey [ILC_MDED04]

In order to capture central trends and variability and to outline a pattern of distribution, we employed a descriptive analysis on each of the three thresholds and then combined the results into a model of the distribution of energy poverty at the EU level.

3. Results and discussion

This section presents and discusses a number of findings and trends that have emerged from the data processing.

In terms of the physical threshold, a number of estimates at the international level establish that a minimum acceptable standard of living implies a minimum energy consumption of 500 KGOE per capita per year; at the other end of the spectrum, a maximum acceptable standard

of living (but considered to be a path to *energy decadence*) is estimated to a maximum consumption between 1255 KGOE per capita per year and 1500 KGOE per capita per year (“How Much Energy Do We Need?,” 2018).

The following table depicts the central trends in selected countries regarding the physical energy poverty threshold, as measured by household final energy consumption per capita.

Table 2. Household final energy consumption per capita (FEC per capita)

	FEC per capita	Mean	SD	Min	Max
Countries					
Czech Republic		659.86	23.86	623 (2007)	710 (2010)
Hungary		619.00	36.86	549 (2000)	691 (2005)
EU 27 (from 2020)		584.29	26.81	529 (2014)	632 (2010)
Poland		522.00	33.10	450 (2000)	594 (2018)
Slovakia		436.95	66.22	360 (2014)	573 (2001)
Romania		379.67	21.80	329 (2001)	416 (2020)
Bulgaria		295.43	25.46	247 (2001)	344 (2020)

Source: Processed from Eurostat

We observe that, among the six selected countries, in Slovakia, Romania, and Bulgaria the central trend in per capita consumption, although slightly increasing, is below the level agreed as corresponding to a minimum acceptable standard of living, with a relatively uniform distribution over the period analysed. The lowest level of household consumption per capita was recorded in Bulgaria in 2001 and the highest in Slovakia also in 2001. The Czech Republic, Hungary, and Poland were consistently above the minimum threshold, with the Czech Republic peaking in 2010. However, overall EU energy consumption is above the energy efficiency target agreed on in line with internal strategies and the SDGs.

The technological threshold is depicted by the final household energy consumption, for which the central tendency is shown in Table 3.

Table 3. Total final household energy consumption and final solid fossil fuel consumption

	Total		Solid fossil fuel					
	Mean	SD	Min	Max	Mean	SD	Min	Max
Bulgaria	2252.34	88.08	2114.01 (2009)	2382.25 (2020)	156.46 6.95%	46.75	99.40 (2020)	238.37 (2011)
Czech Republic	7009.72	259.67	6554.17 (2014)	7440.71 (2010)	822.00 11.73%	111.23	634.44 (2020)	977.50 (2013)
EU – 27	254197.51	11580.15	234580.17 (2014)	278887.0 (2010)	8816.50	1292.11	6574.30 (2019)	11126.26 (2010)
Hungary	6125.08	351.41	5487.45 (2014)	6648.74 (2010)	119.10 1.94%	35.32	56.34 (2020)	171.98 (2011)
Poland	20508.32	1064.24	19032.33 (2015)	22557.49 (2018)	6474.53 31.57%	799.80	4978.79 (2019)	7886.42 (2010)
Romania	7768.92	258.50	7375.18 (2015)	8102.01 (2010)	37.98 0.49%	21.76	9.77 (2010)	80.12 (2015)
Slovakia	2193.43	251.88	1951.91 (2014)	2744.57 (2020)	35.99 1.64%	12.55	17.88 (2015)	53.78 (2020)

Source: Processed from Eurostat

For the EU as a whole, the central trend in household final energy consumption shows quite large differences among countries. Within the group of selected countries, there are also large discrepancies in trends in household energy consumption, with Poland showing the highest levels in total consumption, but also in consumption of solid fossil fuel, which can be explained by the fact that it is the most populous of the six countries and, moreover, one of the most coal-dependent countries in the world.

The economic threshold is generally addressed through expenditure-based methods because in developed countries energy vulnerability and energy poverty have become an issue of affordability rather than physical access.

Table 4 depicts the central tendency and variability for the indicators selected to assess the economic threshold for energy poverty.

Table 4. Vulnerable population/ households facing the economic energy poverty threshold (HW and HFB)

	HW		HFB					
	Mean	SD	Min	Max	Mean	SD	Min	Max
Bulgaria	67.45	12.62	42.6 (2021)	83.3 (2010)	65.39	7.82	53.7 (2020)	79.9 (2006)
Czech Republic	13.22	4.02	6.8 (2020)	20.2 (2006)	52.2	6.21	38.4 (2020)	59.6 (2014)
EU - 27	21.29	2.94	16.4 (2021)	25.2 (2012)	52.84	4	46.7 (2019)	57.7 (2014)
Poland	25.21	12.8	8.2 (2021)	51.2 (2005)	69.96	9.54	54.8 (2008)	80.4 (2013)
Romania	26.16	6.91	17.4 (2017)	46 (2007)	48.5	4.14	43.2 (2017)	56.3 (2011)
Slovakia	17.14	4.18	10.4 (2011)	28.6 (2019)	58.53	4.4	50 (2018)	65.8 (2007)
Hungary	23.54	7	14 (2019)	35.1 (2012)	57.06	12.49	39.8 (2005)	75.6 (2013)

Source: Processed from Eurostat

There are significant disparities across countries within the EU, the most affected in this respect tend to be those in the South. There are also quite large disparities among the selected countries, with the Czech Republic and Slovakia being the only ones below the EU average. Also, although there is an improving trend in each of these countries, Bulgaria continues to be the most affected, with a maximum of around 83% in 2010 and a minimum of 42% in 2021, and a relatively uniform variation. In Romania, Poland, and Bulgaria, the central trends in the share of the population experiencing difficulties in ensuring thermal comfort are similar, but it should be noted that Poland recorded a maximum of about 51% in 2005 and a minimum of 8.2% in 2021. Moreover, among the six countries, as well as in the EU as a whole, Poland shows the highest variability, i.e., an uneven distribution compared to the central trend, which indicates a notable improvement of its situation.

As in the case of access to thermal comfort, disparities are observed across the EU in terms of central trends and variability in the share of the vulnerable population facing energy poverty due to high housing costs. The most affected are the countries of Central and

Southern Europe, where the share of vulnerable population is above the EU average; at the opposite pole are the Nordic countries. In both cases, however, the variability differs, suggesting uneven developments over the period. There are also disparities between the six countries, but these are less marked than for access to thermal comfort. Poland and Bulgaria are the most affected, but the trends that describe these cases are different. Thus, in Bulgaria a clearer trend of improvement is observable, while in Poland the evolution continued to fluctuate, peaking at around 80% in 2013, after which it went on a downward trend. The situation has been aggravated by the pandemic context; in fact, with very few exceptions, all EU countries show an increase in the share of households with a high financial burden in 2020 compared to previous years.

It was previously discussed that in developed economies, energy poverty or energy vulnerability is becoming an issue of affordability rather than physical accessibility, despite the fact that in some European countries per capita consumption is below the threshold considered as necessary to meet basic needs. Following this finding, in the model that captures EU-wide disparities in energy poverty, displayed in Figure 1, we have considered only the technological threshold (reflected by the size of the spheres) and the economic threshold (the mean of the share of vulnerable households affected by difficulties in securing heating comfort and the mean of the share of vulnerable households facing a heavy financial burden due to housing costs).

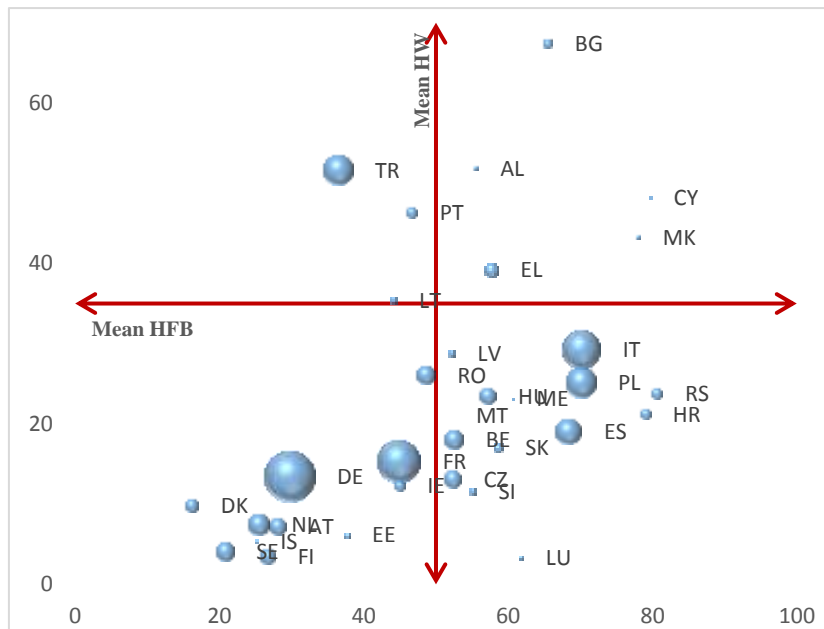


Figure 1. An integrated model of energy poverty disparities across the EU

This model suggests the emergence of two distinct clusters, in line with the results provided by Bouzarovski (2014), Bouzarovski & Herrero (2017) who explored geographical disparities in energy poverty in Europe following the "core-periphery" model. The first cluster consists of countries featuring lower levels of vulnerable populations facing difficulties in ensuring thermal comfort and lower levels of the share of vulnerable

households affected by a high financial burden due to high housing costs. This group of countries includes the Nordic countries, Germany, Austria, France, Estonia, which form the "core". The second cluster, or "periphery", brings together countries with lower levels of vulnerable populations facing difficulties in securing thermal comfort and higher levels of the share of vulnerable households affected by a heavy financial burden due to high housing costs. It includes other developed EU countries such as Italy, Belgium, Spain, Luxembourg, as well as the V4 countries. Romania is at the borderline between the two clusters, while Bulgaria is distinguished by high levels of both economic threshold indicators. It should also be noted that the technology threshold does not affect a country's relative positioning within a cluster.

Mapping countries into one of the two clusters provides a deeper understanding of the nature of energy poverty and, subsequently, can contribute useful information to support policy makers in identifying vulnerable groups facing energy poverty. As Bouzarovski & Herrero (2017) point out, in the 'core' group of countries energy poverty is concentrated in a limited segment of the population with affordability problems, while in the 'periphery' it is still a systemic condition affecting many categories of people, as this research suggests; moreover, in the periphery, in addition to the issue of affordability, there are problems related to the infrastructure needed to access adequate energy sources. However, the distinction between clusters should not be seen in absolute terms, since there are a number of common determinants in both the core and the periphery, such as rising energy prices, energy inefficient housing, disproportionate energy needs, etc.

Conclusions

In addition to systematically reviewing the main contributions in this area of knowledge, the aim of the paper was to investigate the emergence of a possible "core-periphery" pattern of disparities in energy poverty and to map Romania, Bulgaria and the V4 countries into this pattern by adapting a conceptual framework that integrates the physical, technological and economic dimensions of energy poverty. Subsequent to this aim, we conducted exploratory research that led, in the first stage, to the identification of some trends on each threshold of the framework and then the results were integrated into a model of energy poverty disparities at EU level. The model considered the technological threshold and the economic threshold; the physical threshold has lost its importance in the case of developed countries, where energy poverty is primarily a matter of affordability, and eventually of access to quality energy services in line with social needs and sustainable development imperatives. The results suggest a concentration of disparities in two clusters according to the core-periphery model by economic threshold, with the technological threshold not affecting the location of countries in these clusters. In the "core" are countries where energy poverty is concentrated among smaller segments of the population that are vulnerable to difficulties in securing thermal comfort and vulnerable households with a heavy financial burden due to high housing costs. At the "periphery" are countries with lower proportions of the population vulnerable to affordability problems and higher proportions of vulnerable households with a heavy financial burden due to high housing costs. It can therefore be concluded that both in the "core" and in the "periphery" (where the considered countries are located), energy poverty is mostly a problem related to economic circumstances, but significant disparities appear

predominantly in terms of affordability and less obviously in terms of difficulties in providing thermal comfort.

The exploratory nature of this research is also subject of certain limitations, mainly because it captures trends and describes the state of facts, creates and exploits a historical perspective, but does not reveal or explain possible influences or causal relationships. Another limitation stems from the selection of indicators. As mentioned above, more than 70 indicators have been identified in the literature and used in studies and research focusing on the energy poverty issue, and the use of one indicator or another may lead to different results and interpretations. In addition, the subjective nature of some indicators (such as those relating to thermal comfort) can also be expected to influence the accuracy of the results. Despite these limitations, the evidence provided by our study can demonstrate its value and usefulness, on the one hand, by opening up new research lines that could explore, among other things, patterns of determinants, causal relationships, and consequences of energy poverty across the same or larger samples of countries, and, on the other hand, by depicting a state of facts that demands greater consideration from macroeconomic policy makers. Contextual factors that have shaped the socio-economic environment in more recent years (Coronavirus pandemic, military conflict in Ukraine) add value to research in this thematic register, as not only energy security but also the achievement of sustainable development goals is under serious challenge.

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