Energy poverty in the EU – indicators as a base for policy action

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Abstract

In 2016, the European Commission presented the Clean Energy for all Europeans Package[1], comprising legislative proposals to facilitate the clean energy transition within the EU, such as the revised EPBD 2010/31/EU and EED 2012/27/EU. Besides putting energy efficiency first and achieving global leadership in renewable energy, a third goal of the package was to provide a "fair deal to consumers" with "no one left behind". While in some Member States the issue of energy poverty already was on the political agenda, enabling affordable access to basic energy services for all households and thus reducing energy poverty is now an explicit policy target of the revised EU Directives. In order to assess and monitor the extent of the issue across the EU and address it by suitable measures, the concept of energy poverty needs to be defined, operationalised and measured. The paper aims to investigate the role of energy poverty indicators for policy making. To do so, it provides an overview on existing measurement approaches. Furthermore, the paper presents the development and current state of energy poverty across the EU using a set of four complementary indicators used by the EU Energy Poverty Observatory. These consensual and expenditure-based indicators are calculated using data from the EU Survey on Income and Living Conditions and the Household Budget Survey. In addition, the paper highlights peculiarities of results on the different indicators, describes persisting issues with regard to their calculation and interpretation against the background of the underlying data base. Based on the results of this analysis, further necessities of data collection and research are pointed out.

Energy poverty: a major challenge of the energy transition

The first major publication describing energy poverty as a societal problem in a European country dates back almost 30 years (Boardman 1991). But only in the last decade, has the issue gained formal recognition on the European level as a matter of EU energy policy (cf. Bouzarovski 2018). The growing attention to the problem is driven by several developments in Europe on both the supply and demand side, which have made it more difficult for an increasing number of households to access and afford sufficient levels of energy services. While for one the loss of income and assets following the financial crisis in 2008 has impacted the ability of households to pay for energy in several countries (cf. Dagoumas/Kitsios 2014), other influences are related to the liberalisation of electricity and gas markets, climate policies and the transition of energy systems. Due to the associated deregulation of subsidised prices in some EU member states, the introduction of energy/CO_2-taxes as well as levies and charges for the deployment of renewable energy sources and grid expansion, energy has become costlier for households (cf. E-Control et al. 2018). Since costs of energy alternatives and the perceived fairness of their societal distribution have been found to shape public acceptance (Perlaviciute/Steg 2014), EU policy makers have taken initiative to address adverse impacts of the energy transition on vulnerable households.

1. Communication from the Commission to The European Parliament, The Council, The European Economic and Social Committee, The Committee of The Regions and The European Investment Bank Clean Energy For All Europeans COM/2016/0860 final

The increasing concern of policy makers about the social justice dimension of the energy transition and energy poverty in particular is reflected in the now adopted legislation contained in the Clean Energy Package (European Commission 2016). The package revises several major directives of the EU energy policy framework amending a number of provisions that require Member States to take action on the subject and to report on these actions as well as their outcomes:

- Article 29 of the revised Electricity Directive requires Member States to define a set of criteria for the purpose of measuring energy poverty, obliging Member States to monitor the number of households in energy poverty and report energy poverty levels to the Commission every two years as part of their Integrated National energy and Climate Progress Reports (Governance Regulation).
- Also the provisions of Article 7 in the revised Energy Efficiency Directive (EED) on energy poverty have been strengthened. Member States are now being requested to ensure that a share of energy efficiency measures under their national energy efficiency obligation schemes, alternative policy measures, or programmes or measures financed under an energy efficiency national fund, is implemented as a priority among vulnerable households including those affected by energy poverty.
- The revised Energy Performance of Buildings Directive (EPBD) now requires Member States to outline all relevant national actions that contribute to the alleviation of energy poverty within their national long-term renovation strategy.
- Lastly, the Governance Regulation now requires Member States to assess the extent of energy poverty within their jurisdiction and, if found significant, to include a national indicative target as well as suitable policies and measures into their integrated national energy and climate plans and to report on the progress of target achievement.

In order to comply with these provisions, Member States will thus have to assess the scope of the problem and then design policies and measures to address it. At this point however, most Member States neither have an agreed national definition nor a methodology to measure energy poverty and only few (UK, IE, CY, FR, SK) explicitly recognise the issue in legislation (Rademaekers et al. 2016; Thomson/Bouzarovski 2018). Those Member States that already address the issue via policy and/or programmes have chosen indicators to identify energy poor households and to monitor progress in the field. While it makes sense to define energy poverty and choose suitable metrics to measure it against the background of national political, cultural and climatic circumstances, differing definitions and energy poverty metrics render it difficult for EU policy makers to monitor progress in the field across Member States.

In order to establish a common data base and to monitor the state of energy poverty across the EU, in 2016 the European Commission has initiated the set up of the European Energy Poverty Observatory (EPOV). The Observatory is a web-based platform (www.energypoverty.eu), which continuously gathers and provides information on the current state of energy poverty research, pertinent policies and programmes as well as a range of energy poverty indicators based on pan-European statistics. As such, it provides for the first time harmonized information on the state and development of energy poverty across EU Member States over time. Apart from providing an overview on the prevalence of specific dimensions of energy poverty, it is yet unclear whether and how the displayed metrics will shape politics and policies on EU level and within the Member States.

The paper investigates the role of energy poverty indicators for policy making. To do so, it first discusses the general role of indicators for policy making, monitoring and evaluation and highlights the relevance of scale of energy poverty metrics. Subsequently, it presents different definitions of energy poverty currently used in the EU and approaches to measure it. In the following section, the EPOV approach to measure and monitor energy poverty across the EU on a national level and for sub-groups is portrayed. In doing so, the paper outlines the methodology of indicator calculation, the underlying data base as well as guidelines for interpretation. Lastly, selected findings on energy poverty in the EU are presented and policy implications discussed.

Indicators: basis for policy making, monitoring & evaluation

Indicators may serve as a means to assess the extent of a problem, define quantitative policy or programme targets and to evaluate whether these targets will likely be (ex-ante analysis) or have been (ex-post analysis) achieved. Indicators thus can play an important role in the policy making process, especially in policy fields in which evidence-based policy making is applied as a guiding principle. The concept of evidence-based policy making originally emerged in the field of US health policy in the 1960s and refers to a rationalist approach to policy making that is based on scientifically sound evidence (cf. Baron 2018). It thus promotes the notion that public policy should build on empirical insights about suitable approaches/policy instruments to address a specific issue, which have been gained through the use of rigorous evaluation methods such as e.g. randomized controlled trials (RCT). If no such evidence is readily available, it can be gathered via the implementation of policy experiments. In practice, this linear conception of policy making however rarely reflects the political process due to a range of reasons such as budgetary restrictions, ethical considerations, party politics and the need for quick policy responses. Nevertheless, policies or programmes are ideally based on an explicit policy intervention logic or programme theory, i.e. a description of the causal mechanism from the implementation of the planned actions to the desired policy outcome. As such, the policy intervention logic or programme theory and its inherent causal model provide a conceptual framework for monitoring, for evaluation, or for an integrated monitoring and evaluation framework. Within this policy intervention logic or programme theory, suitable indicators are selected to reflect the policy's or programme's success or failure and thus play a pivotal role for policy design and evaluation. The explanatory power of indicators in the ex-ante impact evaluation of policies or programmes or their ex-post evaluation depends on how well founded the described causal relationship between intervention and outcome is, how accurate indicators are being measured and whether all

relevant influencing factors besides the intervention have been considered/controlled for.

The role energy poverty indicators can play for policy making and evaluation largely depends on the level of observation and the scope of the underlying data (cf. Dubois/Meier 2016). Metrics such as e.g. the average share of energy expenditure in income measured on a macro-level at EU scale allow for the evaluation of energy-related hardship faced by households and the extent of specific manifestations of energy poverty in each country. However, due to their limited depth they can only provide guidance for general policy orientations. Furthermore, due to the differences between countries regarding a multitude of factors shaping different manifestations of energy poverty (Bartiaux/Gram-Hanssen 2005), direct comparison of countries on these macro level metrics is possible but offers limited insights with regard to the respective causes of energy poverty as well as suitable policy responses. Macro and micro-level data at national scale (e.g. national statistics on households, housing conditions, energy use, forms of household energy deprivation) may be used to identify profiles of energy poor households and can help to target national policies and measures, such as social tariffs or energy efficiency programmes. However, due to their broad scope and a consequently limited level of detail of underlying data, national analyses may fail to capture all constellations associated with energy poverty and thus may lead to vulnerable households remaining unaddressed by policy. Lastly, sector-specific and regional or local level data such as information on spatial distribution of non payment related disconnections, real consumption data of households or everyday practices can help to design well targeted measures for specific sectors, geographic regions or households, but may be limited with regard to their transferability.

To sum up, macro level observations of energy poverty at the EU and national levels may be used to quantify the phenomenon in order to identify its main characteristics. Local level analysis on the other hand may serve to identify interdependencies between different aspects of people's situations and thus provides useful information to interpret observations made at a larger scale. On EU-level, energy poverty metrics thus may serve as indicators that allow for the measuring and monitoring of energy poverty and provide policy makers with an understanding of the severity of the problem at Member State level, and for cross-comparison of trends across EU Member States.

Searching for a definition and indicators

Energy poverty describes a state in which a household is unable to access and/or afford sufficient levels of domestic energy services (such as heating, cooling, cooking, lighting…) for its social and material needs. It is a multi-dimensional phenomenon that is shaped by a multitude of factors related to national and individual circumstances (Simcock et al. 2016; Thomson et al. 2017) and can manifest itself in different ways ranging from low living comfort due to inadequate indoor temperature levels to physical and mental health issues as a consequence of mould formation or social isolation. Accordingly, there is a multitude of definitions that are used for the purpose of academic research and by other stakeholders from civil society (cf. Pye et al. 2015). However, only a small number of EU Member States has so far adopted an official energy poverty definition and even fewer have chosen supporting metrics to monitor it (for an overview see Rademaekers et al. 2016). While differences in some definitions may at first seem mainly of semantic nature, they include strong indications towards the operationalization/measurement of the underlying concept and thus build the basis for the application of different energy poverty indicators.

Matching the variety of definitions, in practice there is a multitude of metrics currently in use by researchers and statistical offices in Europe to measure energy poverty in different contexts (again see Rademaekers et al. 2016 for an overview), which are derived from the underlying definitions of the concept. The pertinent literature (Rademaekers et al. 2016; Thomson et al. 2017) identifies four different approaches to measure energy poverty:

1. *Expenditure-based metrics* define energy poverty based on information about the household's expenditure in energy and often compare it to the household's income;
2. *Consensual-based metrics* use self-reported assessments of indoor housing conditions, and the ability to access and afford basic energy services;
3. *Direct measurement* of the level of energy services (such as heating) achieved in the home compared to a set standard;
4. *Outcome-based metrics* focus on outcomes associated with energy poverty e.g. disconnections, arrears, cold-related mortality.

While each approach has its strengths and weaknesses, application of the latter two is hampered by a lack of consistent EU-wide and national-level statistics and limited data access. Furthermore, with regard to outcome-based metrics there is a causality problem where outcomes may be the result of many different factors besides energy poverty. Consequently, attempts to define and measure energy poverty (BPIE 2014; Thomson/Snell 2013; Tirado-Herrero/Bouzarovski 2014) are mostly based on the former two approaches, which are described in more detail in the following.

EXPENDITURE APPROACH

Expenditure-based metrics of energy poverty have the advantage of being objective measures based on data that is fairly comparable across time and locations but on the other hand do not reflect the cause of expenditure levels. Accordingly, while presenting the economic burden households face for the consumption of energy services, they lack information on whether e.g. low energy expenditure is the result of high building energy efficiency or budget constraints. Energy poverty indicators that are based on expenditure levels are defined as a share of income or in absolute terms. Households are thus considered energy poor if their relative (as a share of income) or absolute expenditure levels exceed or fall below a normative threshold respectively. In the latter case, low energy spending may indicate energy poverty if it is not the result of high domestic energy efficiency but reflects insufficient disposable income to cover actually required energy services. A third type of metrics identifies energy poverty if available household income after energy expenditure falls below a defined threshold.

Apart from choosing between the three types of expenditure based metrics, there are additional methodological decisions to be made that define the metrics and will strongly affect

indicator results. These relate to how income is defined, what the threshold is, whether actual or estimated required energy expenditure is used and whether its measurement is restricted to a specific income group. The discussion regarding the income definition revolves around the questions what benefits to include, whether to use income before or after housing costs and whether to use equivalised income to account for differing household size and composition (cf. Thomson 2013). The setting of the threshold needs to consider whether to use a fixed absolute threshold (such as 10 % of income) or a relative one (e.g. with reference to a median value) that reflects a country's characteristics (i.e. the distribution of energy expenditure and possibly income). Each approach has its shortcomings. While a fixed absolute threshold might be too sensitive to energy price increases, leading to an automatic increase of the number of energy poor households, a relative threshold might not reflect increasing burden at all.

The decision whether to use actual or required energy expenditure also has implications for the interpretation of indicator results. While actual energy expenditure does not reflect whether it covers a sufficient level of energy services, using required energy expenditure requires extensive information on the energy efficiency of the building stock, in which households reside. Lastly, the decision whether to restrict calculation to a specific income group (typically lower income deciles) depends on whether energy poverty is considered a sub-form of general poverty or something occurring also in higher income households.

CONSENSUAL APPROACH

Consensual data refers to the data collection via surveys conducted with a representative sample of households/individuals. Self-reported ("consensual") responses are then used for metric generation on a macro level. In general, a wide range of possible issues could be asked to interviewees to capture various dimensions of energy poverty. Common questions cover issues such as

- whether people can/cannot afford to heat/cool their home as they wish
- whether they have arrears on energy/utility bills
- building conditions (e.g. dampness, mould etc.)

In principle, income and expenditure data can also be collected through a consensual approach and above-mentioned expenditure-based indicators be generated from that.

However, the available data suffers from usual flaws of survey data. Whether the datasets are comparable between EU Member States hinges on a common understanding and comparable responses. Original questionnaires are translated to national languages, where already some distortions may arise. Then, questions need to be interpreted in a similar way (e.g. what actually is "adequately warm"), which depends on a joint set of values and beliefs that may be questionable across the EU, between Portugal and Bulgaria, Finland and Italy. And finally, respondents need to respond without biases (deserved answers).

As such, large-scale surveys are implemented across the EU since decades and executed by national statistical offices, it can be expected however, that the above issues are dealt with the necessary expertise. National surveys are gathered by Eurostat, and made available as harmonised datasets.

EPOV indicators: data base and calculation

INDICATOR OVERVIEW

In light of the described shortcomings of single metrics to fully capture energy poverty in its multifaceted nature, the European Energy Poverty Observatory's (EPOV) approach to measuring energy poverty is to use a suite of consensual and expenditure-based indicators, which should be viewed and used in combination. The selection of EPOV indicators has been based on a screening of pertinent literature on the measurement of energy poverty (cf. Hills 2012; Rademaekers et al. 2016; Thomson et al. 2017; Romero et al. 2018) and informed by the EPOV international advisory board, which comprises 100 energy poverty experts from 25 countries. In addition to theoretical considerations, the indicator selection process has also been guided by data availability on a European level resulting in the selection of four indicators. Each indicator captures a different aspect of the phenomenon.

EPOV provides four different primary indicators for energy poverty, of which two are based on self-reported experiences of limited access to energy services (based on EU-SILC data) and the other two are calculated using household income and/or energy expenditure data (based on HBS data).

Consensual-based indicators

The only pan-European data base for building consensual-based energy poverty metrics is the EU Survey on Income and Living Conditions (EU-SILC). EU-SILC is not based on one common questionnaire or centralised survey but on a framework. This framework defines a harmonised list of primary (to be collected on an annual basis) and secondary (to be collected every four years or less frequently) variables to be transmitted to Eurostat. Furthermore, it provides common guidelines, procedures, concept definitions (e.g. with regard to household and disposable income) and classifications aimed at maximising the comparability of the information produced.

The data is gathered by Eurostat, harmonised and made available to researchers as macro data outcomes (directly from the online data explorer), as anonymised micro data (available upon application) or as individualised data requests.

EPOV uses two items from EU-SILC as energy poverty metrics:

Ability to keep home adequately warm[2]
Item: Can your household afford to keep its home adequately warm?

Arrears on utility bills
Item: In the last twelve months, has the household been in arrears, i.e. has been unable to pay on time due to financial difficulties for utility bills (heating, electricity, gas, water, etc.) for the main dwelling?

An additional indicator is included as "secondary" energy poverty indicator and derived from a question that asks, whether

2. While inability to adequately *cool* (rather than heat) homes represents a more pressing issue for households in some countries (e.g. Greece, Italy), respective information has only infrequently been gathered within EU SILC, thus preventing a comparison of trends over time.

people live in a dwelling with a leaking roof, damp walls, floors or foundation, or rot in window frames of floor.

All consensual-based indicators are calculated as per-country shares of households responding yes/no.

Expenditure-based indicators

The expenditure-based EPOV indicators are calculated as the share of the population whose energy expenditure falls below (HEP) or whose share of energy expenditure in income exceeds (2M) a specified national threshold. Their aim is to capture relative underconsumption of basic energy services due to a lack of financial means to do otherwise or to identify when consumption of basic energy services puts an overproportionate financial burden on households with reference to their disposable income. The interpretation of outcomes is however not always straight forward (see below). In general, results on the chosen expenditure-based indicators have to be interpreted against the background of national circumstances.

> HEP M/2 Exp (Hidden energy poverty): Absolute (equivalised) energy expenditure below half the national median

The Hidden Energy Poverty indicator aims to capture underconsumption of energy services relative to the national median of energy expenditures. The indicator considers households whose energy expenditure is below half the national median value energy poor. Thus, country-specific results are shaped by the respective distribution of energy expenditures in the lower five deciles. Accordingly, in cases with a right-skewed distribution of values, the indicator may yield high levels of energy poverty within a country. While this in principle can reflect a real issue, there are also alternative explanations for low values of energy expenditure. First, in some countries, energy costs or a part of them are included in the rent and not captured separately. Second, comparatively lower energy expenditure of a household may also be the result of a higher energy efficiency level of the inhabited building. Hence, a part of the households considered energy poor under the HEP definition may in fact live in highly efficient buildings that technically require less energy (expenditure) in the first place. Also in some countries (e.g. Germany) parts of energy expenditure of low income households/unemployed persons is covered by the state. Accordingly, interpretation of HEP results requires additional information on national circumstances with regard to building sector characteristics/regulation and/or social policy.

> 2M: Share of (equivalised) energy expenditure (compared to equivalised disposable income) above twice the national median

The 2M indicator aims to capture the burden that energy bills put on households relative to their disposable income, using the national median as a reference point. Accordingly, whether a household is considered energy poor depends on the relation between its energy expenditure and disposable income in comparison to how this relation looks like on the macro level. Due to this, low-income households that underconsume relevant energy services such as heating may not be captured by this measure. On the other hand, high-income households are defined as energy poor according to this measure, if they have proportionally high energy expenditure. If energy poverty is defined as having limited access to energy services or – due to energy expenditure – being limited with regard to the consumption of other essential goods or services, then the latter may not fit the definition.

Similar to the HEP indicator, the macro results of the 2M indicator depend on the distributions of its two components income and energy expenditures. Those drive the distribution of the 2M indicator and its median/double median value and resulting share of population beyond the threshold. And equal to the HEP indicators, thresholds may change over time, for the 2M indicator dependent on changes in values and distributions of both underlying components.

DATA AVAILABILITY, DISAGGREGATION AND PRESENTATION

Data coverage across EU Member states for both data sources (EU-SILC and HBS) is good, all EU countries are covered, but yearly coverage varies. EU-SILC is an annual pan-European survey, where data is collected and transferred to Eurostat who harmonises and publishes the data. This process usually takes around one to two years. Currently, published SILC micro data covers the period 2004-2016. All EU member state countries provided data (i.e. prior to the entry to the EU, some countries have not provided data (e.g. HU, MT, RO).

HBS data are collected from various national data collections that also follow varying rules with regard to regularity and item specifications. Harmonisation of these data therefore remains a challenge and cannot in all cases be achieved by Eurostat. Moreover, Eurostat engages in the data collection and harmonisation only in 5-year intervals and the process takes time. Currently, the only micro data wave that is available is 2010 (and even this excludes NL). The last 2015 wave is still being processed and will likely be available within 2019. This means, that corresponding expenditure-based indicators for EPOV that are comparable across Member States can so far only be calculated for the year 2010.

For a better understanding of where energy poverty challenges are actually located within a country, the EPOV consortium decided (together with the European Commission and the expert advisory board) to display the above-mentioned four indicators, each of which captures different dimensions of energy poverty. In addition, apart from calculating and presenting indicator values at total national level, a further disaggregation or breakdown by other "second-level" variables can be helpful to analyse whether a particular indicator is especially high/low for certain parts of the population.

Pertinent literature (e.g. Pye et al. 2015; Bollino/Botti 2017; Bouzarovski/Tirado-Herrero 2017) and expert discussions with the advisory board yielded, that a breakdown by the following categories would yield important additional value to inform policymaking: income, tenure, degree of urbanisation and type of dwelling.

For EU-SILC-based consensual indicators, these disaggregating variables are available. For HBS-based expenditure indicators, disaggregation variables are only available for income and urbanisation density.

The "indicators & data" section on the EPOV platform is intended for browsing through these indicators and visualising results in a convenient way. To this end, indicators can be displayed as bar charts, as coloured EU map, and (currently only for SILC-based indicators) in their development over time as line charts. The platform additionally allows a disaggregation

Table 1. Overview on EPOV indicators, sources, disaggregations and time coverage.

	Consensual indicators	Expenditure indicators
Source	EU-SILC	HBS
EPOV indicators	Ability to keep home adequately warm Arrears on utility bills	Hidden energy poverty (HEP) High share of energy expenditure in income (2M)
Disaggregation by	Income deciles Degree of urbanisation (densely/intermediate/thinly) Tenure type (owner/market rent/reduced or free rent) Dwelling type (apartment, detached/semi-det. or terraced)	Income deciles Degree of urbanisation (densely/intermediate/thinly)
Years covered	2004-2016	2010

of the respective indicator by available second-level variables in all chart options.

Overview on EU indicator results

The underlying data for calculating the four EPOV indicators and their disaggregations contains millions of observations, only the results visualised in the EPOV dashboard include around 6,700 data-points – per indicator. Thus, summarising results is difficult, especially as the indicator outcomes are very heterogeneous between EU countries. Therefore, in this section for the consensual indicators we present a selection of country-level results representing different regions of the EU. In the next section, we then look into some of the disaggregations.

Figure 1 displays the development on the "inability to keep home adequately warm" indicator. For the sake of readability, trends are not displayed for all EU MS but instead for one country each from Northern (Denmark (DK)), Southern (Greece (EL)), Central (France (FR)) and Eastern (Bulgaria (BG)) Europe. The dark blue line represents the EU average, which has only slightly increased after the financial crisis hit in 2008 and decreased again.

Country-level figures for the selected countries show, that already without looking into further disaggregations, national realities vary substantially: The inability to keep the home adequately warm has decreased dramatically in Bulgaria (and also in other especially Eastern EU countries and Portugal) within the covered timeframe, from levels of almost 70 % to 30 percentage points less in 2016. In contrast, the especially difficult conditions in Greece led to an upsurge of the indicator there. France like other Central EU countries displays relatively stable 5–10 % of households being not able to keep their home adequately warm, while the low share in Denmark of less than 5% is representative for other Scandinavian countries[3].

For the "arrears on utility bills" indicator, the indicator has risen from 6.7 % of the households in 2007 to 10.5 % in 2016 (see Figure 2). The impact of the economic crisis again is clearly visible in the Greek figures. However, comparing the trends for all EU countries there is no immediate correlation between this and the previous indicator, some countries exhibit diverging patterns on those. For instance, in Bulgaria the share of households with arrears has not followed the downward trend of the previous indicator but seems to fluctuate between 25 and 30 % over time. Denmark and France display similar patterns on both indicators.

For the "high share of energy expenditure in income (2M)" indicator (see Figure 3), measuring the fraction of the population spending more than twice the median share on energy, there is no clear regional pattern visible at the national level: Most EU countries are around or somewhat above the EU average. Countries with lower shares of the concerned population include most but not all Eastern EU. Surprisingly, the lowest share of affected households can be found in Hungary.

For the "hidden energy poverty (HEP)" indicator (see Figure 4), measuring the fraction of the population spending less than half the national median in absolute values on energy, the picture is more diverse on a national level: some Eastern EU countries have the lowest shares of energy poor households (Hungary, Czech Republic), others display rather high shares (Bulgaria and Poland). Central EU countries are mostly around the EU average (except France) and two out of three Scandinavian countries display high shares of energy poor households. Particularly the latter finding seems surprising given the extensive welfare state arrangements. However, as pointed out in the indicator description above, country results are sensitive to the underlying distribution. In Sweden the distribution of household energy expenditure below the median value is strongly right-skewed, so that more households fall below the threshold (half the median value). While in principle this could indicate that a major share of Swedish households underconsume energy services, it is more likely that the result reflects a national idiosyncrasy that shape the distribution.

Discussion of sub-group findings

For an analysis what drives each of the identified four indicators, separate country-studies are necessary and a first analysis can be done by at least disaggregating the indicators by the proposed categories of income, tenure, degree of urbanisation and dwelling types for the most current data available (i.e. 2016). It is beyond the scope and aim of this study to fully explore these

3. The sharp drop from 2007 to 2008 is not the result of political action taken but of a changed wording in the underlying survey item (cf. Nierop 2014). Instead of asking for low indoor comfort levels, which also non-vulnerable households could experience due to drafty windows, the question from 2008 on focused more on the affordability aspect.

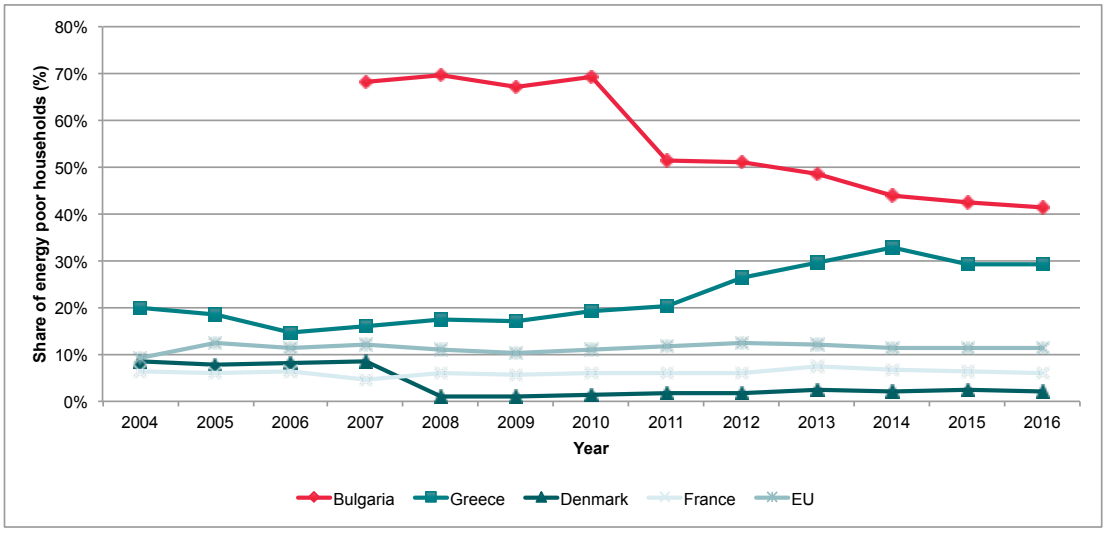

Figure 1. Development of "inability to keep home adequately warm" indicator in Bulgaria, Greece, France, Denmark and the EU from 2004 to 2016.

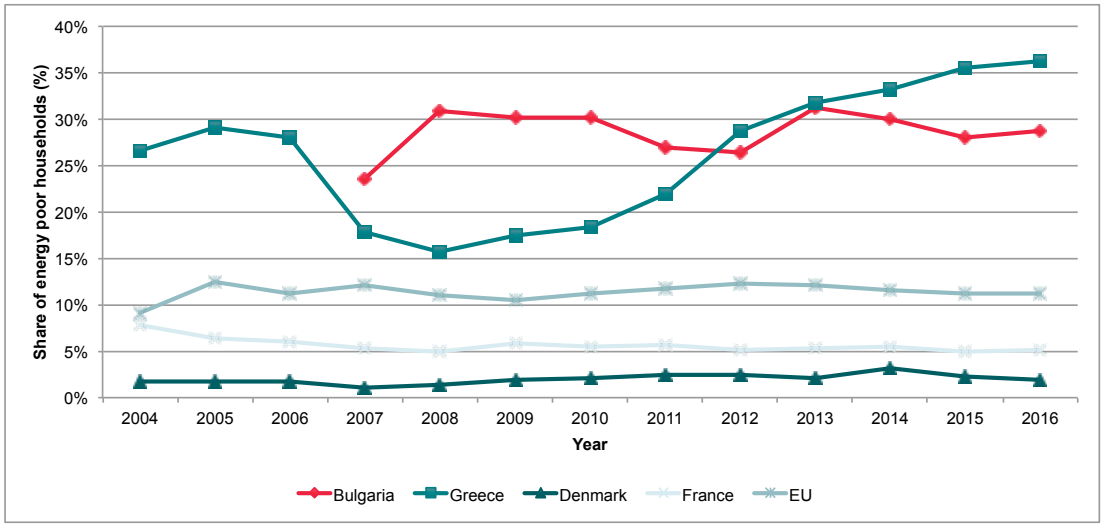

Figure 2. Development of "arrears on utility bills" indicator in Bulgaria, Greece, France, Denmark and the EU from 2004 to 2016.

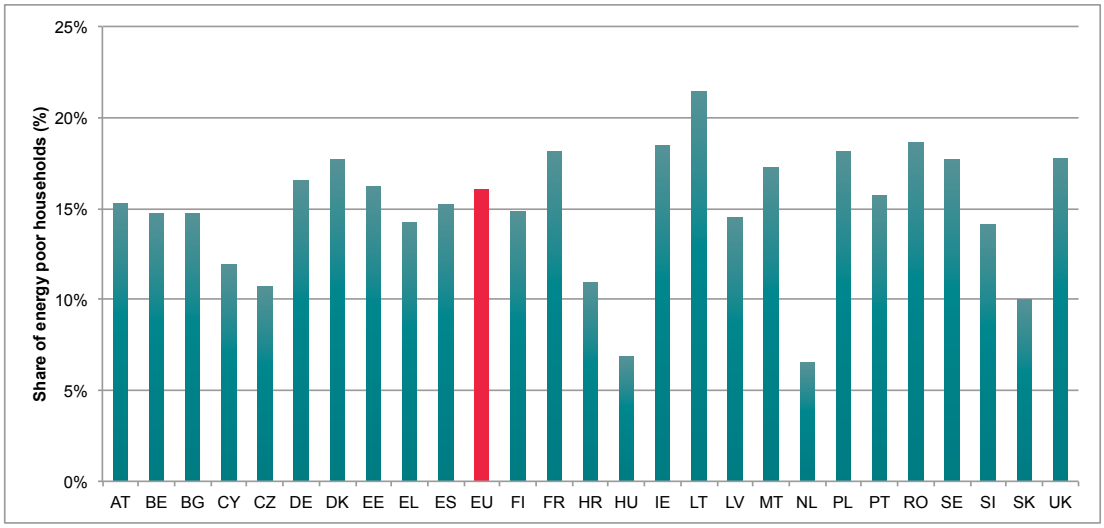

Figure 3. 2M indicator by EU Member states, 2010 (2012 for NL).

breakdowns by countries. In the following, we however present breakdowns of the inability to keep the home adequately warm indicator that provide first insights for policy regarding the distribution of energy poverty among sub-groups and can guide further research.

DISAGGREGATION BY INCOME DECILES

Not surprisingly, all indicators exhibit a relatively clear degression by income deciles, i.e. high shares of energy poor households in the lower income deciles and lower shares in the higher income deciles – which holds especially true for EU average figures. A surprising finding is that there are even households in the higher five deciles that suffer from energy poverty according to the different indicators. In Lithuania and Bulgaria, even in the tenth income decile still every fifth household has stated to be unable to keep the home adequately warm. This somewhat puzzling result points to necessary in-depth analysis in order to understand whether this represents a problem of data collection or is the outcome of specific national circumstances.

DISAGGREGATION BY DEGREE OF URBANISATION

There is no cross-EU pattern visible in this disaggregation. The share of households within the EPOV indicators is higher in some countries in urban than in rural regions, sometimes vice versa. This seems to be very country-specific and probably dependent on the socio-demographics of the urban/rural populations (see Figure 5 for an example).

DISAGGREGATION BY TENURE TYPE

EU-average findings hint at the two EU-SILC indicators being a major problem in households with reduced/free rent than for building owners or such renting at market rents. However, again, when analysing country data, the picture is very diverse (see Figure 6).

For the countries with the highest shares of households being unable to keep the home adequately warm, there are some that follow the EU-average pattern (PT, LV), and others where the problem seems to be especially high with market renters (LT, EL, CY, HR). And interestingly, there are countries where also

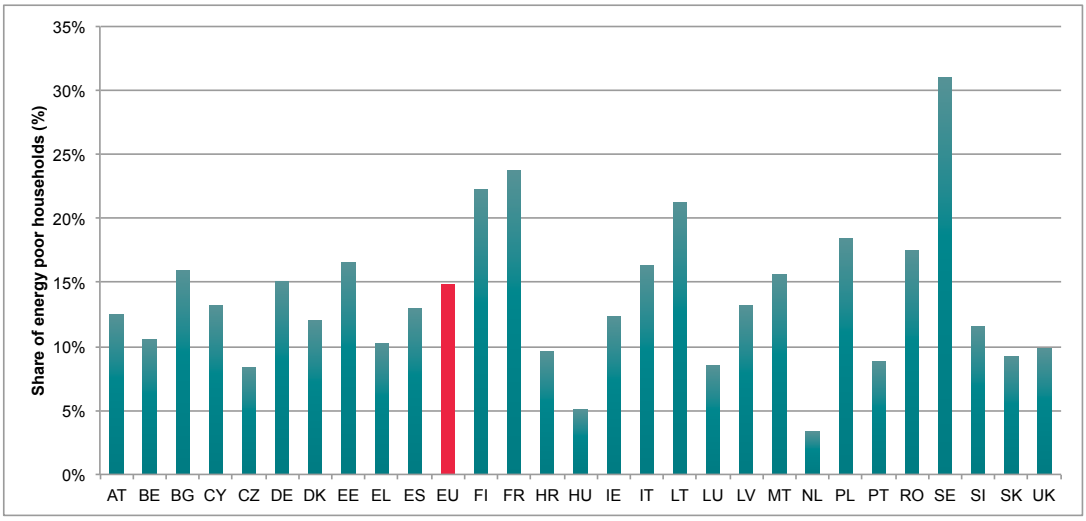

Figure 4. Hidden Energy Poverty indicator by EU Member states, 2010 (2012 for NL).

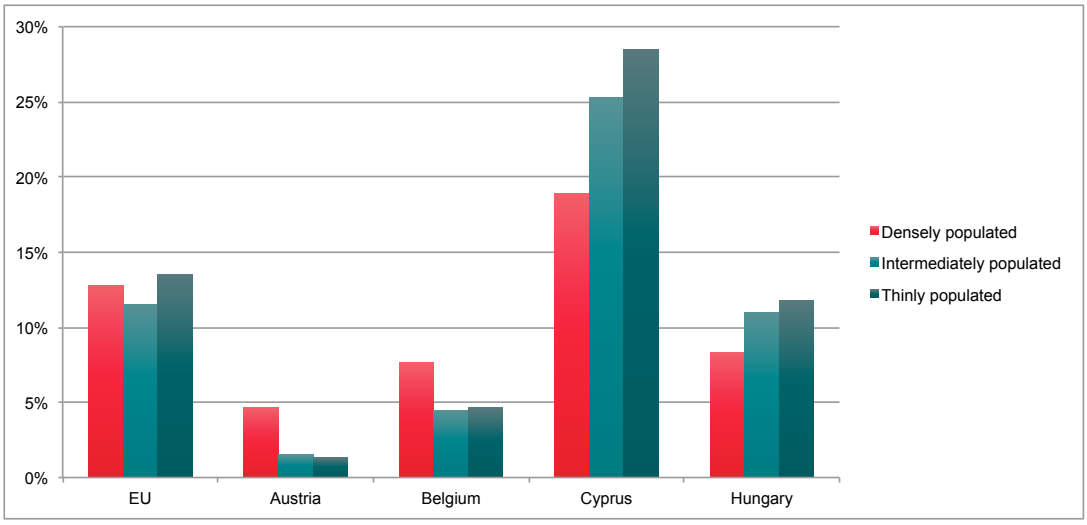

Figure 5. Inability to keep home adequately warm by degree of urbanization in 2016 for EU, AT, BE, CY and HU.

building owners are heavily concerned (BG, LT, EL, CY). This is somewhat less surprising in light of the high ownership rate in these countries, which range from 71 % (CY) to almost 90 % (LT) (cf. Eurostat 2019), and thus are an insufficient predictor of a household's economic status.

DISAGGREGATION BY DWELLING TYPE

As with the other disaggregations, the EU average shows a clear picture of households living in detached and apartment homes being more often affected than those living in semi-detached and terraced houses (cf. Figure 7). And again, on a country-level analysis, the picture is more complex: For the inability to keep the home adequately warm indicator, BG, EL, PT exhibit higher shares of energy poor households for detached houses and lower shares for apartments, while for others like CY this is inverse and for other countries like RO, LV, HU the peak is with semi-detached/terraced buildings. Accordingly, the dwelling type alone fails to predict the distribution of energy poverty in different national contexts.

Conclusions and implications for policy and research

As the preceding analysis has shown, the state of energy poverty within and across EU Member States may differ strongly depending on the indicator used. Each of the indicators reflects a different aspect of energy poverty thus providing valuable insights to general energy poverty trends within the EU which however may require additional in-depth analysis for interpretation. This is particularly the case for the expenditure-based indicators 2M and HEP, which themselves do not provide information on individual and structural factors influencing household energy expenditure (such as e.g. rents including heating costs, energy demand of buildings, social assistance programs asf.).

There currently are clear limitations of either single indicator on EU level due to their limited focus and lack of a harmonized dataset containing both consensual and expenditure data. A common and streamlined data base would allow to cross check whether energy poverty on one indicator is confirmed on another, thus strongly increasing validity of measurement and providing more meaningful orientation to policy-makers. Further-

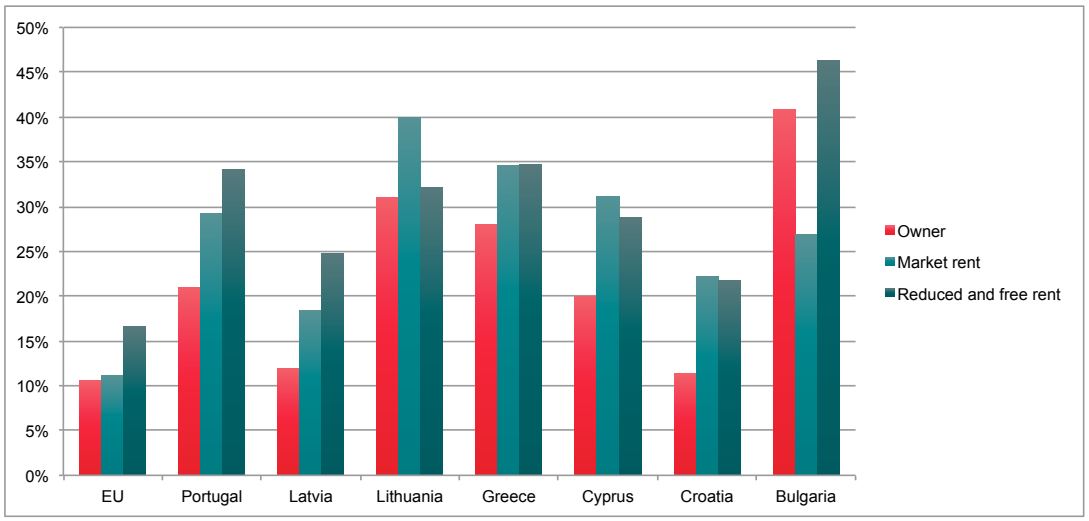

Figure 6. Inability to keep home adequately warm by tenure type in 2016 for EU, PT, LV, LT, EL, CY, HR and BG.

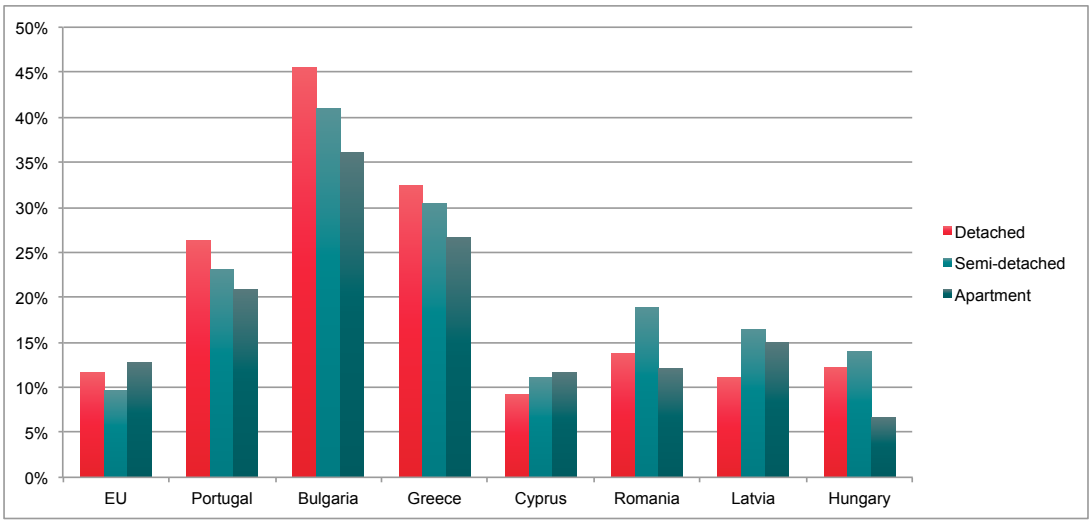

Figure 7. Inability to keep home adequately warm by dwelling type in 2016 for EU, PT, BG, EL, CY, RO, LV and HU.

more, besides improving the scope and validity of the presented EPOV indicators, an integrated and harmonized data base would also enable the development of more elaborate indicators on EU level such as a composite energy poverty index. Further indicator development and data collection is also necessary to better consider mobility related aspects of energy poverty, which currently are rarely examined in combination with dwelling related energy service needs.

The analysis of disaggregations for the inability to adequately heat the home indicator show, that there is strong heterogeneity of energy poverty patterns (at least as measured on this indicator) within the EU. As exemplified with the inability to keep the home adequately warm indicator, country-level indicators often diverge strongly from EU-average findings and in most cases, there is not one common pattern across countries with regard to the distribution of energy poverty among sub-groups. This lack of a clear pattern implies for policy, that there is probably not a "one-size-fits-all" successful European strategy of combatting energy poverty – the problem is very distinct in the various member states. The problem may be in some countries more with rural homeowners, in others with urban renters in apartment buildings.

National policymakers need thus to closely analyse the specific energy poverty issues within their country and develop targeted policies to address them. The EPOV indicators can aid this process via the provision of a first general orientation on the state of energy poverty with regard to the focused dimensions. However, eventually Member States will have to decide if not on a common then at least on a national definition that best reflects the problem within their domestic context and to define suitable indicators for monitoring its development and policy evaluation.

The finding of divergent patterns has direct implications for research: national studies and also comparative EU-wide studies are needed to analyse the different patterns of energy poverty that exist in EU countries and to provide a better understanding of national idiosyncrasies and to identify commonalities that can inform political action on EU level. This involves the identification of vulnerable parts of the population, which in the future also means moving beyond the four breakdown categories applied in this study and possibly extending e.g. to gender, age, household composition etc.

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