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Research Article

Measures of Heat Energy Poverty and Their Imperfections in Relation to The National Energy Security Strategy

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Abstract

The main motive for taking up the topic is the barrack of unambiguous determinants and measures of heat energy poverty, and thus the lack of an unambiguous definition of this phenomenon, which would be recognized by all experts on this subject, as well as by various public policies dealing with eliminating this phenomenon. In his research, the author focuses on three issues: attempts to define the concept of heat poverty in households on the basis of a review of international literature; discussing the phenomenon of heat poverty of households in Poland and presenting the research methodology in determining the indicators and measures of heat poverty of households; and pointing to some imperfections in shaping the energy security strategy of the state. The research problem discussed in the article is theoretical and empirical. In order to present the problem in more depth, the following methods were used: analytical and synthetic, inference, as well as quantitative and qualitative methods.

Keywords: security; thermal energy poverty; thermal poverty indicators; thermal poverty measures.

Introduction

Polish households are among those, which are characterized, among other European Union countries, by one of the highest ratio of expenditure on thermal energy. They amount to 11% and constitute the basic part, i.e. 2/3 of all energy expenditures. To heat a flat or to heat meals, households use various types of thermal energy carriers, depending on the type of heating installation in the flat. The largest share is held by expenditures on hard coal (21%), followed by natural gas (17%), municipal

gas (17%) and central heating (16%) (Świerszcz, 2017b). The Czech Republic (13%), Slovakia (14%) and Hungary (17%) have a slightly higher share of expenditures on thermal energy than Poland (Bouzarovski, 2018). However, it should be noted that a high share of these countries is characteristic for almost all Central and Eastern European countries. This shows that the thermal energy expenditure

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burden in this part of Europe is much higher than in other European countries.

The high share of thermal energy and the consequent high expenditures on it have long been a serious challenge for households, consisting of difficulties in maintaining the thermal comfort and ensuring healthy existential and living conditions for their inhabitants. It can be said that the care to maintain optimal heat in households is one of the basic activities for those inhabitants. Ensuring these standards is at the same time a fundamental element of social security systems, as well as the subject of strategies and policies for energy security developed both on a local and on a national level in all the developed countries. The United Nations HABITAT Agenda, which deals with the sustainable development of housing estates worldwide, in its "The Right to Adequate Housing" document, it highlights, inter alia, the need for households to have access to energy for cooking and heating; to be protected against cold, humidity and heat; and to be protected against other health and structural risks (The Right, 2009). Despite this fundamental need and necessity to have access to thermal energy and the possibility to provide optimal thermal standard to household residents, the issue of unambiguously setting the limit of deprivation of these needs is not fully defined at present. There are no clear deprivation's indicators and measures covering all households that experience it. One of the manifestations of this phenomenon, referred to as thermal energy poverty, has not been clearly defined until now, in a way that would be recognized by all experts specialized in this subject, as well as by various public policies whose task is to eliminate this phenomenon (deprivation).

The aim of the paper is therefore to present a proposal to use the indicators and measures of household thermal energy poverty, and an attempt to develop - based on them - the thermal poverty phenomenon definition, enabling the proper shaping of the national energy security policy.

The research problem addressed in the article is theoretical and empirical. For a deeper presentation of the problem, the following methods were used: analytical and synthetic methods, inference, and also quantitative and qualitative methods.

The concept of household heat energy poverty based on an international literature review

Thermal poverty, which is the element of energy poverty (fuel poverty, energy poverty), is currently a disturbing phenomenon in the social life, which is experienced in Poland, as well as in other low- and high-developed countries of the European Union and even in the world. Among the member-countries of the European Community, it is estimated that the problem of energy poverty affects between 50 and 125 million people, particularly in the countries of Central and Eastern Europe, as well as in the countries of Southern Europe. In Poland, however, this phenomenon is experienced by about 12% of the households in winter and 27% in summer, especially in large voivodships with an increased number of single-family houses, such as: Wielkopolskie, Mazowieckie, Podkarpackie, Małopolskie and Lubelskie; as well as in less developed voivodships, such as: Warmińsko-Mazurskie and Opolskie. This rate is higher than the European average of 9.8% in winter and 18.1% in summer (Owczarek and Miazga, 2015); (Howard, 2015); (Sánchez-Guevara Sánchez, Mavrogianni and Neila González, 2017).

The studies show that these figures can increase continuously as energy prices rise. The scale of the energy poverty experienced indicates that this phenomenon is not something new in the human (social) empiricism, but it has only been conceptualized and studied nowadays as an autonomous problem. Due to its scale and importance, this problem is particularly visible in the aspect of the thermal poverty phenomenon. At this point, it should be noted that this concept, in its wording, is not present and used both in the Polish law and in all-Poland public policies. It is also not directly articulated in

the subject literature, both domestic one and foreign one. However, the aspects and traits of this concept can be found in this literature. They can particularly be seen in the statements of the subject's experts examining the energy poverty phenomenon, the scope of which is much broader, because it also includes electricity.

Referring to the thoughts shown in a national literature, the definition by D. Owczarek and A. Miazga is worth noting, in which one can find aspects concerning thermal poverty. They can be seen when, as the authors say, households' inhabitants experience two difficulties in terms of energy needs. The first one is the problem to maintain a certain thermal standard, which allows to adequately satisfy the basic needs of a biological and social functioning of households' inhabitants. At this point, it should be emphasized that the thermal standard in Polish flats, determined by law, allowing inhabitants to experience the sense of comfort, is the temperature of 21oC, and in other occupied rooms is 18oC (Świerszcz, 2017a; Owczarek and Miazga, 2015). The second difficulty refer to the problems to purchase thermal energy for a reasonable price in a place of residence (Szpor, 2016; Scarpellini, Sanz Hernández, Llera-Sastresa, Aranda and López Rodríguez, 2017). A significant complement to the understanding of the thermal poverty phenomenon can be found in the definition of energy poverty developed in the Research Paper by A. Stępniak and A. Tomaszewska. Speaking of the various aspects of the problem discussed, the authors draw the attention to aspects such as: household members experiencing the problem of maintaining a comfortable thermal level (temperature), the lack of funds to pay bills for heating or to repair a non-functioning system or a heating device; the inability to buy and install a new system or device; and, finally, the inability to adequately modernise their heating systems. Another very important element defining the thermal poverty phenomenon in the discussed problem of energy poverty is that the habitants constantly experience the coolness and related humidity of the air and walls, as well as fungus of walls, which result in frequent diseases of the inhabitants beside mental discomfort. Thermal poverty also means a difficulty to heat up the utility water, which is needed by inhabitants in their everyday lives (Świerszcz, 2020; Świerszcz and Osial, 2019; Stępniak and Tomaszewska, 2013).

The issue of thermal poverty and the attempt to define it in the context of energy poverty can be found not only in the subject literature dealing with this issue in the scientific aspect, but also in government documents. The example is the "the Draft of the Energy Policy of Poland until 2050" proposed in 2014. In this document, the thermal poverty phenomenon considered in the context of energy poverty is understood as the situation, in which households are exposed to a reduction in energy consumption to the spheres and levels absolutely necessary for them to function on a daily basis, that is, to the existential-existential level. Projekt Polityki, 2014).

In the foreign subject literature, the authors from the Great Britain are the precursors of the scientific approach to the thermal poverty phenomenon discussed in the context of energy poverty. Among these authors, B. Boardman deserves special attention, who, undertaking a thorough examination of energy poverty, based on her experience and specificity of the phenomenon in her country, which is Great Britain, specifies the definition, from which elements concerning the thermal poverty phenomenon can be extracted. These elements refer to a situation in which, as the author notes, households - in order to achieve a sufficient level of heating, i.e. a temperature of 21oC in main rooms and 18oC in other rooms - are forced to spend more than 10% of their income. These expenditures relate both to costs incurred for heating and to the costs of water heating, cooking, lighting and the use of electrical equipment. In other words, these expenditures relate to all types of energy, including thermal energy, and vary depending on the types of flats (Bordman, 2012; Pye and Dobbins, 2015; Hilbert and

Werner, 2016). In this definition, the author draws the attention to two issues: hypothetical expenditures on energy and the threshold for household income, which is 10%. It should be stressed that this definition has, for a long time, been the basis for shaping public policies, not only in the UK but also in other countries experiencing the thermal poverty problem.

A complementary definition - functioning in parallel - is the Low Income High Costs (LIHC) definition, developed in the UK in mid-2013. This definition, specifying the energy poverty phenomenon, uses two criteria to determine the state of thermal poverty, which are: low financial incomes of household members (Low Income) and high energy expenditures (High Costs). Considering these criteria, this definition is referred to as Low Income High Costs (LIHC), i.e. high costs and low income (The UK Fuel Poverty Strategy, 2008). It should be stressed that the above-mentioned definition of energy poverty, which includes elements of thermal poverty, has been the only formally adopted and preferred definition of the phenomenon. Therefore, most of the research and statistics done so far, have been and are still being carried out on the basis of this definition.

The analysis of both domestic and foreign literature on energy poverty leads to an attempt to define the own concept of thermal poverty phenomenon of households. Therefore, thermal poverty can be defined as the state of experiencing difficulties, in a longer period of time, in the integral satisfaction of the inhabitants' basic needs of thermal energy - affecting the state and existential and living level (health, development, education) of households - both in terms of quality and price, which results in difficulties in adapting to the requirements and standards in terms of thermal energy and, as a consequence, results in social exclusion.

The phenomenon of thermal energy poverty of households in Poland

Thermal energy poverty in Poland is little known and therefore little researched, although it is experienced and felt in practice. Its manifestations can be seen in various aspects of the existence of Polish families and their households. They are most often expressed in the following forms: lack of access to central heating - 16% of households; late payment of utility bills, at least once a year - 14% of households; flats not heated up in winter - 11.5% of households; spending more than 10% of one's income on energy - 9.6% of households; lack of hot running water - 4.0% of households; and late payment of energy bills - 2.5% of households.

Preliminary studies show that to some extent, every fourth or fifth household has a difficulty to close its home budget, and the share of thermal energy expenditure is becoming a dominant position in the necessary expenditures. The cost of thermal energy used by household inhabitants is influenced by its price and consumption, as well as the technical condition of the buildings, their energy efficiency, thermo-modernization, awareness of the efficient use of energy and many other factors.

Based on the research conducted by the Central Office of Statistics (GUS, 2018) in 2016-2018, households (about 14 million) consumed, on average, about 2100-3000 kWh (kilowatt/hours) of thermal energy within the year. This energy is used mainly for room heating, water heating and food preparation. This is shown in Table 1.

Table 1: Household thermal energy consumption by type of use

The areas of use	2016	2017	2018
The heating of rooms	71.3%	70.2%	68.8%
The heating of water	15.0%	14.4%	14.8%
Preparation of meals	7.1%	8.2%	8.3%

Comparing the results of the amount of thermal energy consumed with the expenditures allocated to it in the total household budget - which, according to the definition, may be a criterion for determining the poverty of thermal energy - shows that in 2016-2018, the share of expenditures on thermal energy carriers themselves remained at the same level, i.e. 20.1%.

The price of electricity for households increased on average by more than 3% annually between 2016 and 2018. This price increase caused the share of expenditures to use a flat or a house and energy carriers to slightly increase within this period. According to Eurostat data, in 2016-2018, an average of 22% of the Polish population, i.e. about 8.6 million people, were not able to cope with the costs to heat up their flats in winter to a degree that would ensure thermal comfort. In the same period, less than 17% of the population, i.e. about 6.4 million people, had problems to pay their electricity bills on time. These arrears to energy companies were as follows: in 2016. - 3.9%; in 2017. - 4.3%; in 2018. - 4.7% of all the households (Pachauri & Jiang, 2008); (Sovacool, 2013). Therefore, as can be seen, the level of energy poverty among households is constantly increasing, which clearly indicates that the problem of energy poverty in Poland is of significant importance.

The results of the conducted analyses showed that the level of energy poverty in Poland in 2018 was 17.1% (6.44 million Poles). The vulnerable groups include, inter alia, multi-generational or multi-children families, farmers and villagers, pensioners and residents of single-family houses or flats ranging in size from 91 to 120 m2. Taking into account the technical condition of the buildings, studies show that the highest percentage of energy poverty was observed in buildings constructed between 1946 and 1960, and the lowest in buildings put into service after 2006 and new buildings, i.e. those built between 2000 and 2018. This fact clearly illustrates the existing link between the occurrence of this phenomenon and the low energy efficiency of buildings, e.g. the lack of appropriate insulation, or the leakage of windows and doors.

As shown by the socio-economic reality, the level of energy poverty depends to a large extent on, inter alia, the price of energy and the volume of its consumption. The latter, in turn, depends on factors such as: the degree of energy efficiency of the building, the use of expensive heating sources, inadequate management of temperature in a flat, the use of other energy-using devices and many others.

However, these two criteria (energy price and consumption) do not provide a clear indication of the existence of energy poverty. Not every household will suffer from inconvenience as it pays high costs for energy and consumes a lot of it. This fact indicates that also in this case, an appropriate criterion for determining energy poverty should be an income criterion - however, in relative terms (relative income) in relation to the income of households in the population. Such a criterion is relative economic poverty. Thus, if a household has a higher energy expenditure per population and at the same time has a lower income than the

average in the population, then there are grounds to believe that the household is experiencing or at high risk of energy poverty (Owczarek and Miazga, 2015; Bouzarovski and Petrova, 2015).

Research methodology in determining indicators and measures of thermal poverty of households

The existing definitions of thermal poverty are not sufficiently precise in both domestic and foreign literature. In their content, they do not clearly define the limit of deprivation of basic needs, the exceeding of which gives rise to the thermal poverty phenomenon. The lack of an unambiguous conceptualisation of this phenomenon means that the way it is understood is not clear both among experts and in the public policy on energy security, which sets the priority to reduce this deprivation.

The possibility to achieve this objective, therefore, raises the need to define appropriate indicators and indicate the thermal poverty measures, which will allow for a more precise definition of this phenomenon and show its scale both in the national and local aspect, depending on the needs.

Referring to the hitherto developed definitions of thermal poverty, two types of indicators of this phenomenon can be distinguished: the measure in absolute terms and the measure in relative terms. They are two separate types of measures that require adjustment (appropriate adaptation) to the appropriate conditions of households in a given country, in this case, in Poland.

The first type of thermal poverty measure is the type in absolute terms, talking about the 10% threshold of expenditures on thermal energy. This type of measure requires the identification of two issues. The first issue is to determine the indicator, which is a basket of goods (i.e. the determination of specific, basic energy needs) and its value (i.e. a reasonable price), which includes products and services necessary to maintain biological functions, i.e. life support (limited to the level of extreme poverty/minimal existence) (Deniszczuk et al., 2007) or, alternatively, the satisfaction of basic biological and social needs (defined as the social minimum threshold) by the inhabitants of households. The second issue is to determine the indicator of the threshold for the expenditure on heating relative to the household's income, which should be considered reasonable and necessary in the household budget. This is very necessary because it makes it possible to determine whether and to what extent a household can afford to maintain its flat's own type and nature. Different types and characteristics of the flats of the households should be taken into account, such as, for example, the biological type of the household; the type of the person in the household; the type of the child in the household; the types of socioeconomic groups; the type of the surface area of a flat; the year in which a building is constructed; the type of ownership of a flat, etc.

The amount (threshold) needed to fulfil these functions and needs is calculated for the household per capita by applying the equivalence scale established by the OECD each year. It should be noted that the data obtained on the amount (threshold) of the household surveyed (converted per capita) are objective in nature. This data is calculated on the basis of the actual purchasing power of the household in a given place and at a given time. The construction of this indicator is therefore simple, it assumes an objective value of the defined basket of goods consisting of thermal energy. The fulfillment by a household of this indicator (criterion) of extreme poverty (existence minimum) or social minimum depends exclusively on financial resources and current prices of goods (thermal energy), which are necessary for it to maintain biological functions (life) or possibly to satisfy basic social needs (Świerszcz, 2016a; Owczarek and Miazga, 2015).

Using this type of thermal poverty measure, it should be stated that in 2018, this phenomenon affected about 46% of

the Polish households (about 19 million people). Among them, the most vulnerable are people from single-person households (59%), people living on disability benefits (57%), people living on social benefits (49%), and also married couples with one child (23%). The problem of thermal poverty is most visible in the eastern and southern part of Poland, in the following voivodships: Podkarpackie (48%), Świętokrzyskie (47%), Lubelskie (45%), Małopolskie (40%) and Podlaskie (39%). The reason for this phenomenon in these areas of Poland is low household incomes. These are also predominantly rural areas, where thermal poverty affects more than 50% of households, while in cities of more than 500,000 inhabitants, it affects only 12%.

The second type of thermal poverty measure is a type in relative terms, which refers to the definition of thermal poverty defined as Low Income High Costs (LIHC), defining the conjunction of two independent criteria (indicators), which are: low household income (Low Income) and high energy costs (High Costs). This type of meter also requires two steps within each criterion.

Under the first criterion, which is "High Costs" (HC) - the first step is to determine two uncertainties, which are two indicators (criteria) of thermal poverty, namely: hypothetical (model) data on the household thermal energy expenditure per capita (person) in the household, and data on the financial income of this household. When talking about the model energy expenditure of a household, it is necessary to take into account its specific characteristics, such as e.g. the type of buildings, the period in which it was constructed, its character, the method of heating, the insulation of the building and many others, in order to satisfy the standard needs for heat. The standard expenditure on thermal energy is 60% of the mediana of the actual expenditures on thermal energy. The obtained model thermal energy expenditures constitute the sum of the model expenditures, which is spent by the household to purchase heat and hot water. The methodology to calculate the model expenditures is shown in Table 2.

Table 2: The mediana of the model expenditures and equivalization rate in proportion to the number of people in the household

Number of persons in the household	Mediana of heat expenditure (PLN)	Equivalization rate in Poland	Equivalization rate in UK
1	220,59	0,96	0,82
2	230,35	1,00	1,00
3	235,16	1,02	1,07
4	273,27	1,19	1,21
5 and more	435,91	1,89	1,32

The next task taken within this first step is to carry out the equivalization, taking into account the number of persons in a household. The aim of this action is to make it possible to compare household expenses regardless of the number of members. This equivalization consists in dividing the expenditure the household spends on thermal energy by the appropriate coefficient, which is shown in Table 2 above. The next task also taken within this first step is to divide the model expenditures by the resulting equivalization rate. This action makes it possible to take into account the impact of energy expenditure diversification, which is the effect of the size of a given household. The actions described in step one and the data derived from them are also necessary because they help to eliminate those

households that spend too little or too much money on heat.

The second step is to determine two indicators of thermal poverty, which are: the threshold of expenditure on thermal energy and the threshold of financial income per capita in the household under research, using the scale of equivalence, in relation to the mediana or average income, which is in the country (region), at a specific time (year, quarter, month). It is worth noting that for Poland - the Main Statistical Office (GUS, 2018) sets the threshold of 50% of the average household expenditure, while for Europe - Eurostat sets the threshold of 60% of the mediana of the household's financial income (Świerszcz and Grenda, 2018).

Moving to the second step, a number of tasks needs to be carried out. The first task is to determine the mediana of equivalized energy expenditures for the whole population. This mediana divides the collection of households into two equal parts. The first part consists of households whose expenditure on thermal energy is above the mediana, and thus meets one of the first criteria of the Low Income High Costs (LI-HC) definition, i.e. high energy costs (HC). To this end, a variable has to be created, which will divide the set into households that meet and do not meet this criterion. Therefore, if a household is characterised by higher equivalent model expenditures on thermal energy per number of inhabitants in a given household - in relation to the mediana in the population (which is the criterion of high thermal energy expenditures) and at the same time has a lower equivalent financial income than an average household in the population (i.e. it has less than 60% of the median income in the population) (which is the criterion of a low financial income - the relative poverty threshold adopted by Eurostat for the EU), then it can be said that the household experiences thermal poverty (Owczarek and Miazga, 2015). It can be assumed that the costs incurred by a household will be a serious burden on its home budget.

It should be noted that in this case, the thermal poverty indicator (criterion) is a relative one. It is based on a ranking (comparison) of the income situation (average expenses, items) of a given household in relation to other households (average expenses, items) in the country (region) in a given period of time. In other words, this comparison relates to the "basket of basic energy needs" of the household and the "reasonable price" incurred for this good, which is thermal energy, against the background of households in the country (region) at a given time.

Within the second criterion (indicator) which is "Low Income" (LI) - the first step is to calculate the Low Income criterion of a household by using the variable, which is disposable income. For this purpose, the value of disposable income shall be reduced by all expenditures, which include the costs of the accommodation - which gives rise to the income variable after deducting the expenditures for accommodation. This action makes it possible to determine the actual resources available to households after all the necessary expenditures have been made, which are always intended to be incurred. The deduction of costs related to the accommodation also eliminates from the analysis the impact of expenditures made on accommodation (which depend on the size of a flat, technical condition, location, etc.), on the resources of the household.

The second step in the "Low Income" criterion is to equivalize the household income on the basis of a previously received variable. It is the disposable income obtained after accommodation expenses are made due to the number of people in the household. The aim of this step is to be able to compare these incomes with each other regardless of the number of households. This equivalization is carried out on the basis of the OECD coefficient, which is shown in Table 3.

Table 3: The OECD equivalence ratios used in the calculation of disposable household income

Number of persons in the household	Equivalence ratio
The first adult in a household	0,58
The subsequent adults in a household	0,42
Children under 14 years of age	0,2

This conversion consists in dividing (quotient) the disposable income obtained, after accommodation expenses are made (IAHC), by the OECD rate.

The third step in the "Low Income" criterion - after the above calculations - is to determine the income poverty threshold. This action requires four tasks to be taken. The first task - within the determination of the income poverty threshold - is to determine the mediana of the equivalized disposable income after deducting the accommodation expenses. The second task is to calculate 60% of the value above the calculated mediana. The third task is to determine the income threshold of households by adding the equivalized energy expenditures in individual households to the value calculated in the second task - i.e. 60% of the mediana of equivalized disposable income after deducting accommodation expenses. This task makes it possible to obtain an individual income threshold for each household. Moreover, it also allows for a result to be obtained in which the income threshold is higher for households that have more expenditure compared to households that have less expenditure. The fourth task is to create a variable that qualifies households below or above the income threshold (Owczarek and Miazga, 2015).

Bearing in mind the above mentioned measure of thermal poverty, which is the relative Low Income High Costs (LIHC) measure, one can say that a household is poor in thermal energy when it simultaneously meets the two criteria described above: high energy costs and low financial income. In other words, a household has model equivalized energy expenditures above the median in Poland, and at the same time has an equivalized disposable income after deducting accommodation expenditures below the economic poverty threshold (determined by the sum of 60% of the median equivalized energy expenditures of this household). The situation can be summarised as follows:

Thermal poverty = Low Income criterion met + High Cost criterion met

The analysis of this measure clearly shows that its construction, in comparison to the first measure, is more sublime and assumes the necessity of a difference in the wealth of individual households. In other words, some households must always be less affluent than others in order to be able to determine the existence and level of thermal poverty of a household. It should also be noted that the adoption of the above mentioned type of measure in relative terms, in defining the concept of thermal poverty and determining its level and scope, makes it impossible to eliminate thermal poverty as understood in this way. Since, as it has already been pointed out, households with lower income than others are always considered poor in heat (Świerszcz, 2016b).

Using this type of thermal poverty measure, it should be stated that in 2018, this phenomenon affected about 19% of

the Polish households, i.e. 8 million Poles experienced thermal poverty.

In addition to the presented two types of thermal poverty measures that adapt to the UK definitions of energy poverty, other alternative versions of thermal poverty measures, based on other alternative definitions of heat poverty, may also be used. These alternative versions are the modifications of the original versions of the UK definitions. This study will focus on the methodology to determine variant versions of energy poverty measures (thermal poverty measures) based on the modification of the original definition of energy poverty "Low Income High Costs" (LIHC). The first part of the alternative version of the modification of the energy poverty (thermal poverty) measure of households concerns the modification of the "Low Income" (LI) criterion. The modification consists in setting other income thresholds under which households can be classified as energy poor households.

The first possibility is to set an income threshold of 50% of the average. In this case, the same steps are taken in developing the Low Income Criterion (LI) as in the original version of determining measures of the Low Income High Costs definition (LIHC) - changing only the income threshold. The "High Costs" (HC) criterion remains unchanged here. Therefore, in the alternative (modified) version, the following steps are taken when developing the "Low Income" (LI) criterion. The first step is to determine the average of the disposable income available for sale, after deducting the expenditure on accommodation, and then to calculate 50% of this value. The second step is to add, to the threshold thus set, the equivalized energy expenditures in individual households to determine the individual threshold for each household. As a third step, a two-tier variable should be created to classify households below or above the individual thresholds. The fourth (last) step is to qualify the household as energy poor in the aspect of heat - by applying the conjunction of the criteria "Low Income" (LI) - 50% threshold and "High Costs" (Owczarek and Miazga, 2015).

The second possibility to determine the income threshold concerns the determination of the income threshold on the basis of poverty determined by law. The poverty limit determined by law (understood as the limit of social intervention) is determined by the Ministry of Labour and Social Policy on the basis of household income, which is converted per capita in the household. Income below this threshold entitles the holder to financial benefits from social assistance institutions. In this case, the following steps are taken when developing the "Low Income" (LI) criterion. The first step is to set the poverty threshold, determined by law, based on the number of people in a given household. It should be noted that the social intervention threshold is modified every 3 years (Owczarek and Miazga, 2015).

The second step related to adding - to the poverty threshold determined by law - real, i.e. not equivalizated, energy expenditures that are incurred in individual households. This action will allow for the setting of an individual threshold for each household. The third step relates to the calculation of whether the real, i.e. non-equivalized disposable income derived from accommodation expenditure, is above the threshold determined. To this end, a two-tier variable should be created, which qualifies households below or above these individual thresholds. The fourth (last) step relates to the determination whether a given household is energy poor (heat poor) through the application of the conjunction of the "Low Income" criterion (understood as the threshold of poverty determined by law) and "High Costs" criterion.

The second part of the alternative version of the energy poverty (thermal poverty) indicator concerns the modification of the "High Costs" (HC) energy expenditure criterion. Instead of the equivalization of the model energy expenditures per person, based on the OECD equivalence rate, the determination of average energy expenditure per m^2 of a flat occupied by a household may be used based on the model

energy expenditures. In this case, (alternative) used expenditure for energy is more linked to the technical aspect of the household building and less to the number of inhabitants. The next tasks to be performed when creating the "High Costs" (HC) criterion are the same as in the original version of the LIHC definition. Thus, the mediana of the model energy expenditures per m^2 of an occupied flat is determined.

Results and Discussion

The adopted indicators and measures of thermal poverty defining this phenomenon and determining its scope in a given area, when confronted with subjective measures of households assessing the thermal comfort experienced by them, turns out to have a negligible degree of coverage. This is evidenced by the research conducted in 2018, where among the residents of households declaring that they live in buildings of low technical quality and damp walls, as much as 24% were qualified to the group poor in thermal energy, using the relative "Low Income High Costs" (LIHC) measure. However, as regards the inhabitants talking about experiencing the cold because of failing to heat up their flats during winter, 19% of them were classified as poor in heat energy. This small degree of overlap, between households that declare a lack of thermal discomfort and those that are low in thermal energy, can have a dual source. The first one may be the subjective character of the respondents' statements, the second one may be the relatively high income of households declaring the thermal discomfort of their flats. Research shows that people who talk about experiencing the cold or moisture in their homes may have relatively high expenses, but for some reasons they do not decide to warm or dry their homes. Therefore, the low degree of overlapping of thermal poverty with the measures adopted so far clearly shows the lack of an unambiguous conceptualisation of both the phenomenon of thermal poverty in households and the lack of the unequivocally adopted indicators and measures of this phenomenon (Świerszcz, 2017a; Bakirtas and Akpolat, 2018; Acharya and Marhold, 2019).

The existing measures of thermal poverty, i.e. absolute and relative measures, use the model expenditures of households on thermal energy as the basis. The absolute measure adopts a 10% threshold of expenditures on thermal energy in relation to household income, while the relative measure of the threshold of expenditures on thermal energy is subject to additional verification, which consists of three criteria: income criterion of a given household, equipment criterion (in relation to expenditures on thermal energy and income of individual households), and income criterion verified by fixed accommodation expenditures (e.g. rent, credit instalments, mortgage loans), which decrease the disposable income of a given household. Moreover, the empirical distribution used in this respect is consistent with the assumed correlates of thermal poverty, which consists of subjective measures of experiencing difficulties in maintaining the thermal comfort in a given household. It should also be noted that the applied criteria modifying the thermal poverty threshold indicates a moderate correlation coefficient between thermal poverty and economic poverty. It also shows that the phenomenon of thermal poverty is a phenomenon separate (specific) from economic poverty, i.e. it requires the use of other instruments and security policy to eliminate this phenomenon. This is not the case with absolute measurement, which points to the large link between thermal poverty and household economic poverty, and therefore proposes a different conceptualisation of the phenomenon and a different way of solving the problem. However, the accuracy of this measure is verified by reality, which shows that the financial assistance from the state to the people poor in energy does not solve the problem of thermal poverty in their households (Świerszcz, 2016a); (Pino-Mejías, Pérez-Fargallo, Rubio-Bellido and Pulido-Arcas, 2018).

The different methodologies used in both measures to determine the thermal energy poverty threshold, as can be seen, give different concepts of how to understand this phenomenon, as well as different results of the range of its scale. Using an absolute measure, it turns out that almost half of the Polish population is subject to this phenomenon. Similar results are also found in other European countries, such as: Estonia, Bulgaria, Romania, Latvia, the Czech Republic, Slovakia or Hungary. However, such a result does not seem to correspond to reality. Therefore, currently the most accurate and objective measure of thermal poverty, which allows to determine the definition of this phenomenon and its scope, seems to be the relative measure. This measure, however, is not final in its shape, and requires constant improvement. This is indicated by a number of important facts. The first fact is the continuous evolution of the phenomenon of thermal poverty, which may be caused by new factors over time. The second fact is the perception of the phenomenon of thermal poverty, mainly among households living in rural areas (34% in 2018), single-family houses heated locally - which results from a low precision of this measurement. Meanwhile, reality shows that the phenomenon of thermal poverty also occurs in urban areas, especially among households living in communal, social and small poor housing communities. This is evidenced by the fact that in 2018, about 14% of the households were not connected to the central heating system. It should also be taken into account that about 9% of the flats in the cities are municipal flats with a very low level of energy efficiency. The third fact is the failure to notice thermal poverty in small flats - which results from too low model expenditures assigned on thermal energy, which after the equivalization relating to a number of persons living in a given household, less frequently exceed the threshold of energy expenditures higher ones than the mediana (i.e. average) in the population in a given area. In other words, there is a less chance to meet the High Costs (HC) criterion. The fourth fact is the failure to notice thermal poverty also among wealthy households, which most often occupy larger flats requiring bigger expenditures on thermal energy. In this case, these households meet both criteria, both the High Costs (HC) criterion (high costs of thermal energy) and the Low Income (LI) criterion (high expenditures for thermal energy), because their income is reduced by rent and mortgage loan, which households are often burdened with (Świerszcz and Osial, 2019; Świerszcz and Grenda, 2019).

The presented analysis of the hitherto applied indicators and measures of the thermal poverty phenomenon in households continues to show their various shortcomings and imperfections. The conducted research also shows that the lack of existence of developed perfect measurements of this phenomenon has its consequences in the absence of an unambiguous conceptualisation of the thermal poverty phenomenon, as well as an unambiguous determination of the scale and scope of this phenomenon in Poland, other European countries and even in the world. Despite these imperfections or deficiencies, the theoretical analysis of domestic and foreign literature on the subject, as well as the analysis of numerous pragmatic research conducted among scientists on behalf of various governmental and non-governmental institutions, bring a lot of hope at the same time. The relatively advanced indicators developed at the present stage of research, which define the criteria of thermal poverty and the method of its measurement (the LIHC measure), make it possible to define this phenomenon relatively accurately and to outline its scale and scope to some extent. In addition, they open up a new space for analysis primarily in Poland and other European countries.

However, bearing in mind the need for a more efficient and effective fight to reduce or even eliminate thermal poverty among households, there is still a need to conduct intensive research to develop the most universal, unambiguous indicators and measures of thermal poverty, and thus to develop an unambiguous definition of thermal poverty. Responsibility for conducting research lies with both people

(entities) of the world of science and entities representing governmental and non-governmental administration offices, as well as various types of companies involved in the production, distribution and sale of thermal energy. These needs and related activities are very important and even urgent as they are the basis not only for the already mentioned proper way of describing and conceptualising thermal poverty, but also for the proper development of policies and strategies in the area of energy security, both locally and nationally, in both micro and macro-social terms. In other words, the point is to select the most effective and efficient instruments that would counteract this phenomenon, namely to direct social assistance towards the most needy households. How the household thermal poverty phenomenon will be understood and what thresholds of thermal poverty and related indicators and measures of thermal poverty will be determined and applied - will have an impact on which groups of households will be qualified as poor in thermal energy - whether they will be households with many children or households of pensioners and disabled pensioners; whether they will be rural households or households from urban areas, whether they will be small households or households living in large areas; etc. This choice, as can be seen, is a political decision. Aware of this, it is therefore necessary to continue to systematically pursue research using a variety of methodological instruments, both quantitative and qualitative, in order to reach those in need with effective help. The current level of knowledge about the household thermal energy poverty phenomenon may already constitute a certain foundation for shaping public policies (e.g. housing allowance, energy allowance), which are aimed at meeting this challenge. Nevertheless, their inadequacy resulting from the imperfections of the currently used indicators and measures of thermal poverty and the related definitions of this phenomenon - not only in Poland, but also in other European countries - is still the challenge topical for all people.

Conclusion

As it results from the presented analysis of the currently applied indicators and measures of the household thermal energy poverty phenomenon, many imperfections and related deficiencies can be observed in them. The lack of unambiguous measurements of this phenomenon leads to consequences such as the lack of a developed unambiguous understanding of the phenomenon of heat poverty, as well as an unambiguous determination of the scale and scope of this deprivation both in Poland, in other European countries, and even in the world. This fact is distressing, because it depends on how to properly develop policies and strategies in the field of energy security of households, both locally and nationally; in micro- and macro-social terms. This is about using the most appropriate instruments to counter this phenomenon, targeted at the most needy households. The way, in which the household thermal energy poverty phenomenon will be understood and which indicators and measures will be applied to it, will have an impact on which groups of households will be qualified as poor in thermal energy.

Despite the existing imperfections or shortcomings, the theoretical analysis of international literature on the subject, as well as the analysis of numerous pragmatic research conducted among scientists, also bring a lot of hope. The relatively advanced indicators and measures of thermal poverty developed at the present stage of research seem to be an inspiration and a new space for analysis, first of all in Poland, and also in other European countries, in search of new solutions, in the development of the most universal, unambiguous indicators and measures of thermal poverty, and thus in the development of an unambiguous definition of thermal poverty.Such indicators and measures allows for taking a more efficient and effective fight to reduce or even eliminate the phenomenon of thermal poverty of households. Responsibility for this fact lies with both people (entities) of the world of science and entities

representing governmental and non-governmental administration offices, as well as with various types of companies.

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