instytut badań strukturalnych

IBS WORKING PAPER 08/2016
NOVEMBER 2016

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Abstract

The purpose of the paper is to quantify the heterogeneity of causes and symptoms of energy poverty in order to provide guidance for policies aimed at fuel poverty alleviation. We quantify the diversity of the households in Poland in terms of energy efficiency and income using cluster analysis. We have identified twelve types of households. Fuel poverty in terms of either affordability measure (LIHC – Low Income High Costs) or subjective measure concentrates in six of them. Fuel poverty measured with the LIHC concerns mainly lower-income families with children, living in large houses in rural areas. The subjective measure (lack of thermal comfort indoors) points to energy deprivation in city households occupying dwellings in pre-war tenement houses and poor rural inhabitants living in old, run-down houses. We finally link the types of the fuel poor with their behavioural characteristics identified by the qualitative studies. Both the strategies adopted by the poor and insufficient central and local policies mitigating economic transition are highly relevant factors for shaping policies aimed at eradicating fuel poverty.

Keywords: fuel poverty, energy efficiency, cluster analysis, Household Budget Survey, Low Income High Costs

JEL: I32, Q40

We would like to thank Harriet Thomson, PhD (University of Manchester) and Piotr Lewandowski (IBS) for their many helpful suggestions. The publication was developed by a grant funded by the European Climate Foundation. All errors are the authors' sole responsibility. The usual disclaimers apply.

ISSN: 2451-4373

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1 Introduction

The key factors behind fuel poverty in the European countries are energy efficiency of buildings and income inequalities. Both of them depend upon many quantifiable variables such as the quality of the building, the size of the dwelling, the heating source, the efficiency of household appliances, the composition of the household and its income as well as the level of awareness of energy efficient behaviours. Fuel poverty evinces itself in the lack of thermal comfort, arrears in the payment of bills or high expenditures on energy, in particular when such expenses burden the budget to an extent making it impossible to satisfy other basic needs. All these dimensions create complex interdependencies that are rarely addressed by research in particular in Central and Eastern European countries. In case of this region the economic transition to market economy resulted in rapid economic growth but also in the accumulation of both social and energy efficiency problems due to insufficient government policies. Furthermore, the widely used measures of fuel poverty (LIHC - Low Income High Costs and the subjective measure) cover different symptoms of fuel poverty and very few studies focused on the overlap of measures and symptoms of fuel poverty. In this respect Poland is an interesting case due to high incidence of households reporting difficulties in keeping home adequately warm or the presence of leaks, damp or rot in their dwellings (Thomson and Snell, 2013).

In this article we analyse the diversity of Polish households that are at risk of fuel poverty. We quantify the identified symptoms and show the complexity of mechanisms leading to fuel poverty, as well as the varied remedial strategies undertaken by households. We use cluster analysis and apply it to the representative sample of Polish households from Household Budget Survey in order to deal with the complexity of interdependence of causes and symptoms of fuel poverty. We relate the fuel poverty to the sociological and anthropological descriptions of poverty in Poland and to the inadequacy of policy interventions. Therefore we deliver new evidence on the goals set for the Hills' report in terms of identifying the overlaps of general poverty and fuel poverty, as well as linking the measures of the fuel poverty with its causes (Hills, 2011; Moore, 2012). In addition, we show that the affordability and consensual measures cover different dimensions of fuel poverty and our results support the objectives to the LIHC measure stated by Moore (2012).

The paper is structured as follows. We start (Section 2) by summarising the results of research on fuel poverty symptoms described in literature. We examine which of them are reflected in existing fuel poverty measures. In the methodological part (Section 3), we indicate that the concept of energy efficiency is the key factor affecting fuel poverty risk. We also propose a broad definition of energy efficiency, taking into account, apart from technical parameters of buildings, the floor area per person at home and various ways of using energy. We then discuss the methods and data we use to draw up a map showing the diversity among Polish households in two dimensions: energy efficiency and income. In Section 4, we present the results of cluster analysis, which identified 12 types of households. We relate the identified types to the fuel poverty measures: the modified LIHC and the subjective measure based on a declared lack of thermal comfort in winter; we indicate the types where the most severe fuel poverty occurs. On the basis of qualitative studies of poverty in Poland, we describe the strategies and behaviours of the fuel poor, which impact the obtained quantitative results. Section 5 concludes with policy implications.

2 Literature overview

There is an ongoing discussion in literature concerning both fuel poverty definition and measurement methods. Heindl and Schuessler (2015) utilize the distinction of poverty measures on consensual (deprivation based, non-pecuniary) and affordability (income based, pecuniary). The first type of measures emphasises low energy efficiency and the resulting difficulties in satisfying energy needs. Measures from this group are based on symptoms of such difficulties as declared by households – lack of thermal comfort indoor, damp walls, leaking roofs and similar. On the other hand, the affordability measures focus only on income and energy-related expenditures, setting aside direct symptoms of fuel poverty. Both consensual and affordability measures of fuel poverty show common parts with income poverty in general, as well as some unique features that lead to acknowledge fuel poverty as a distinctive phenomenon.

Among the measures from the affordability group, two are the most popular. The first is the absolute measure of 10% threshold of energy-related expenditures relative to income (Boardman, 1991; Bradshaw and Hutton, 1983). It is based on the assumption that if the share of a given household's required energy costs in its disposable income exceeds 10%, then this financial burden is too heavy and the household must be considered as fuel poor. The 10% threshold was determined on the base of double median share of household's energy expenditures in UK. Keeping the threshold fixed enabled this measure to be an indicator of absolute fuel poverty. The second commonly used measure is the relative LIHC measure (Hills, 2011). It is currently used as the official fuel poverty measure in England (DECC, 2015). For a household to be classified as fuel poor according to the LIHC definition, it must simultaneously meet two criteria: low income and high required energy costs. The required energy costs of a households are based on the energy efficiency of the building and energy prices. The use of required expenditures instead of actual ones is justified mainly by observation that the fuel poor may under-heat their houses and, on the other hand, some people over-heat their houses much above the thermal comfort level (Hills, 2011; Liddell et al., 2011).

The fuel poverty measures described above show a few flaws. The 10% threshold is characterised by: (i) strong sensitivity to changes in energy prices, which means that the scope of poverty decreases without an increase in the energy efficiency of buildings (Moore, 2012); (ii) lack of the mechanism to exclude affluent households whose high energy-related expenditures is a result of their choice; (iii) lack of possibility to notice improvements in the situation of households, if such improvements have not led to exceeding the 10% threshold (Imbert et al., 2016; Hills, 2011).

The LIHC measure also shows several weaknesses. Firstly, the criterion of high required energy costs (HC) is met primarily by households with a large floor area. Households living in dwellings with a small floor area are passed over, even if they are highly energetically inefficient and have low income (Walker et al., 2014). Secondly, an exact estimation of the total expenditures necessary to satisfy the energy requirements of a household involves numerous technical difficulties. The methodology used in the United Kingdom - BREDEM 2012 (DECC, 2016), requires costly and time consuming process of obtaining detailed data on the energy conditions of households. Moreover, the complexity of the algorithm makes it difficult to replicate the measure in other countries (Liddell et al., 2011).This issue is highly relevant to the Polish case. The required heating expenditures for Poland have been calculated by the Polish National Energy Conservation Agency (Polish: *Krajowa Agencja Poszanowania Energii, KAPE*) on the basis of data from energy audits of buildings and matched with the buildings characteristics in the Households Budget Survey (Miazga and Owczarek, 2015b).The classes of buildings available at HBS cover only a few categories such as the age of the building, its type (multi-family house, single-family terraced house,

single-family detached house), type of heating, and therefore do not take into account other factors with a strong impact on energy-related expenditures. Apart from the level of details in each variable, the BREDEM 2012 algorithm takes into account behavioural adaptations. It includes putting part of the house out of use (e.g. upper floors in a single-family house) and not heating it without decreasing the temperature in other parts of the house and the possibility to control the temperature at different times of day in houses heated by local heat sources. Such data as well as detailed data on the level of thermal insulation are not available in the Polish HBS[1], which leads to an additional loss of estimation precision while ascribing households to classes distinguished by KAPE (Miazga and Owczarek, 2015b). Thirdly, the LIHC measure does not take into account the diversity of individual needs between households, e.g. higher temperature requirements in dwellings occupied by elderly people, the chronically ill or households with small children (Collins, 1986; Goromosov, 1968; Snell et al., 2015). Fourthly, Heindl and Schuessler (2015) list negative features of LIHC consisting of the possibility of a decrease in this measure despite an increase in the share of energy-related expenditures in all households and a decrease of income in all households. At the same time, due to the relative nature of LIHC, a substantial eradication of fuel poverty measured this way is a very unrealistic objective (Hills, 2012).

The subjective fuel poverty measure belongs to the consensual measures group. It is partly immune to the issues raised above. According to this approach households whose members declare having difficulties in heating their homes adequately are deemed fuel poor. This measure takes into account various energy requirements and allows to identify fuel poor who have been passed over by objective measures. These areas are divulged by taking into account opinions of persons who report the existence of the problem themselves (Hills, 2011). The basic flaw of a subjective measure is its moderate suitability for designing public policies – a subjective feeling cannot be criterion granting access to social policy instruments (Miazga and Owczarek, 2015a).

Depending on the measure used, the incidence of fuel poverty and composition of the fuel poor vary a lot. The analysis of fuel poverty in Poland conducted by Miazga and Owczarek (2015b) concluded that according to the LIHC measure and a 13%[2] share of energy-related expenditures fuel poverty concerns mainly inhabitants of detached houses, inhabitants of rural areas, households deriving their means of subsistence from unearned income sources, single parents with children and married couples with at least two children. Both poverty measures show significant cohesion with regard to types of buildings but differ in terms of socio-economic profile of the fuel poor. According to the LIHC measure the fuel poor include predominantly extended families (22% of the poor are in this group, versus a total rate of 17%), large families – with at least five children (26%) and households of pensioners (29%), farmers and self-employed (27%). However, the absolute threshold of 13% points more strongly to one-person households (fuel poverty rate of 58% versus 32% in total population), persons deriving their income from pensions (56%) or social benefits, such as unemployment and maintenance benefits (48%; Miazga and Owczarek, 2015a).

Various measures of fuel poverty overlap only to the limited extent. In France, only 35% of households classified as fuel poor were indicated by both measures (LIHC and 10%; Imbert et al., 2016). However, both the absolute and relative measure indicate concentration of fuel poverty in single-family houses (Legendre and Ricci, 2015). In

[1]The question concerning thermal insulation of buildings appears in PHBS module of 2012 on energy, however that study was conducted on a significantly smaller household sample, therefore usefulness of acquired information is lower.

[2]The authors modified the absolute measure and consider the poverty threshold to be a situation where the energy-related expenditures of a household exceeds 13% (not 10%) of income.

Poland, people living alone show highest risk of fuel poverty according to the absolute measure, whereas the LIHC measure points rather to the families with children (Miazga and Owczarek, 2015b).

The analysis of the various mechanisms leading to fuel poverty requires combining the quantitative with qualitative approach. An example of combination of different approaches is a survey conducted in Northern Ireland by Walker et al. (2014). In the first step, six groups of households were selected based on their vulnerability to fuel poverty depending on the budget strain caused by energy-related expenditures. In the second step, three households were selected from each group, and the situation of all 18 households was analysed in a more precise manner in order to create an image of each type. The study shows that the situation of fuel poor can be fully understood only after taking into account the variety of possible interactions between household characteristics and the domestic energy system (i.e. energy efficiency).

Purely qualitative research on poverty, based on interviews and field data collection, was conducted in Austria, Macedonia, the Czech Republic and the United Kingdom (Brunner, 2012; Buzar, 2007; Middlemiss and Gillard, 2015). Results of qualitative research ascribe different behavioural patterns, strategies and experiences to individual groups. However, the results of qualitative research can hardly be generalised. Therefore, analyses based on statistical data and "soft", qualitative research are complementary (Lister, 2007; Tarkowska, 2005). They jointly contribute to obtaining comprehensive knowledge of the phenomenon, useful in designing measures to combat fuel poverty.

Qualitative and quantitative descriptions of the diversified structure of the fuel poor point out the need for analysis of co-occurrence of causes and symptoms of fuel poverty in order to better understand the sources of this phenomenon and assess the relevance of applied measures and agreed definitions. In terms of the concept, the present paper is similar to the analysis of differentiation of fuel poor households in Northern Ireland (Walker et al., 2014), but it helps to obtain a broader perspective in three aspects. Firstly, due to the application of clustering of households the more accurate determination of the scale of fuel poverty of each type is possible. Secondly, the differences in affordability and consensual measures in the selected types of households help us better understand which households are indicated as fuel poor according to each type of measures. Thirdly, we deliver insight in the understanding fuel poverty through referring the statistical characteristics of the types of fuel poor with the behavioural description learned from the sociological and anthropological research on poverty.

3 Data and methods

3.1 Data

The analysis was based on a representative sample from the 2014 Polish Household Budget Survey (HBS).This survey is conducted every year by the Central Statistical Office of Poland (GUS). In 2014, the sample size was 36,626 households (100,133 people).The survey includes detailed information on income and expenditures of households, their social and demographic features as well as on characteristics of accommodation. It is run on the continuous manner and the information on income and expenditures refers to last month.

3.2 Energy efficiency

The per capita energy expenditures required to ensure thermal comfort in a place of living is a broad measure of energy efficiency. Such measure goes beyond thermal properties of buildings and accounts for the fact that too large floor area may be inefficient. It therefore helps to interpret differences in energy-related expenditures.

Expenditures based on energy efficiency measure consists of the intensive (expenditures per square meter) and extensive (number of square meters per person) part. Formally, the household's expenditures on thermal energy per capita (E/I) may be expressed as the function of intensive efficiency (expenditures per m^2) and extensive efficiency (m^2 per person):

$$\frac{E}{I} = \frac{E}{m^2}\frac{m^2}{I}$$

The intensive efficiency is a wider notion than thermal efficiency of buildings, since it also reflects different occupancy patterns for individual household groups. The application of the extensive efficiency helps in turn to account for the issue of the above-average floor area in under-occupied dwellings, which is one of the reasons for fuel poverty.

3.3 Innovation in computing LIHC measure in Poland

The procedure of estimating required energy expenditures that consists of merging the KAPE data on thermal efficiency of buildings with the HBS data on actual expenditures leads to significant discrepancies between required and actual spending. This is particularly evident when we compare detached houses with blocks of flats. According to the data from KAPE, expenditures on heating a square meter of a detached house should be 2-3 times higher than in the case of an apartment in a multi-family building. This is mainly due to a larger area of external walls, through which heat is lost. In fact, the actual expenditures per unit area in block of flats (PLN 4.10 per m^2) is higher than in the case of detached houses (PLN 2.60 per m^2 per month). This discrepancy could be partly attributed to higher daily temperature fluctuations in detached houses and the use of cheaper energy carriers of lower quality (e.g. garbage, saw dust, brushwood).

In order to account for this behavioural differences we calculate the required expenditures differently. We compute average actual expenditures per square meter in selected types of buildings, to the maximal level of detail available at HBS. This method accounts for behavioural differences between residents of various types of houses in terms of ensuring heating and actual energy carriers. Such approach indicates a much lower level of LIHC poverty – the share of fuel poor households drops from 15% to 9.6%, i.e. it reaches a level similar to the UK or France (Imbert et al., 2016; Legendre and Ricci, 2015).

3.4 Cluster analysis

In order to classify households by type, we conduct a cluster analysis in two dimensions: household income and energy efficiency of buildings. The variables covering the energy efficiency are the following: floor area, floor area per person, type of building (type of heating, type of building, year of construction), actual and required expenditures on heat, actual and required expenditures on heat per person, actual and required expenditures on electric power, expenditures on electric power per m^2, expenditures on electric power per person. As far as income is concerned, the variables are the following: total income, total consumption, income per person, equivalent income, consumption per person, equivalent consumption, type of main source of income in a household, overdue housing fees. The variables are described in detail in Appendix A1.

One of the applications of the cluster analysis is the exploratory data analysis, conducted in order to create distinctive types of objects. It classifies objects in such a way that the correlation within a class is the highest,

whereas the correlation between objects is the lowest. Clusters of households are created by means of Ward's hierarchical method (Ward, 1963).[3] Gower's coefficient (Gower, 1971) is used as the similarity measure because of the application of both continuous and discrete variables.[4] Due to computational reasons, it was impossible to apply hierarchical grouping to the entire sample (36,000 households) directly.[5] Therefore, at the first step the clustering algorithm was applied to a 44% random sub-sample. In the second step, the remaining households were assigned to identified clusters with discriminant analysis. Logistics discrimination was applied. In a sample of 16,115 households, 95% was correctly classified, while this value fluctuated from 87% (type 8) to 99.9% (type 10). Such results were considered satisfactory (see Appendices A2-A4).

The key criterion for the selection of the number of clusters was clarity of the results interpretation. A larger number of clusters leads to a greater uniformity among them, while a too large number obscures the analysis. The choice of 12 clusters was confirmed by Calinski's index (Calinski and Harabasz, 1974). The Duda-Hart index (Duda et al., 2001) suggested that four clusters would be an optimum choice. In general, the clusters are much more internally uniform in the case of discrete variables (type of building, type of household) than in the case of continuous variables (income, floor area, Appendix A5). Therefore, next to the average value of variables for each type we also present a standard deviation for all the variables and the average values of selected variables only for the fuel poor, by selected measure (Appendix A6-A7). Despite the differences among the individual types, for each type the characteristics of the fuel poor are similar to the characteristics of the general population in this type.

4 Fuel poverty – symptoms and measures

The hierarchical cluster analysis let us identify twelve household types (Table 1).[6] The description of the results is guided by the varied incidence of fuel poverty among households with a similar living standard in terms of floor area per person (extensive energy efficiency measure, Figure 1). When interpreting the results we take into account the fuel poverty measured by both the LIHC and the subjective measure (Figure 2). Our analysis starts with households occupying dwellings with the smallest floor area per person (types 7, 11, 12), then it moves to the households occupying houses and apartments of average standard (types 1, 6, 9, 10) and finally it focuses on factors leading to fuel poverty in households with large floor area (types 2, 3, 4, 5, 8). The quantitative data analysis results are interpreted in light of results from sociological and anthropological studies conducted on poverty in Poland within last 20 years. We attribute different behavioural patterns, strategies and experiences to the household types obtained from cluster analysis.

[3] It initially treats every object as a separate, single-object group and then combines the most similar objects. In Ward's method, at each step those two groups are combined, for which the combination will lead to the lowest increase in the sum of squared deviations.

[4] The problem from the point of view of Ward's method is the fact that Gower's coefficient is non-Euclidean. Despite the above and in spite of the reservations regarding the application of hierarchical grouping in the case of a large number of objects, this type of grouping was applied here.

[5] Stata 12 (SE) cannot run hierarchical clustering of more than around 16 000 objects.

[6] The most important statistics for each type are presented in Table 1; Appendix A6 includes their extended version; and Appendix A7 shows statistics related exclusively to the fuel poor according to LIHC in each type.

Table 1. The statistics for 12 identified types (clusters) of households

Type (cluster number)		1	2	3	4	5	6	7	8	9	10	11	12	total
Cluster size [% of households]		14.3	3.5	5.1	5.2	7.6	6.3	5.6	6.7	13.5	7.3	9.9	15.1	100
Floor area [m2]		109.5	131.0	100.6	109.9	92.3	99.8	48.3	81.5	46.7	50.5	51.0	53.5	75.6
Floor area per person [m2/os]		36.4	43.1	53.3	46.2	39.5	35.2	23.2	40.0	33.0	34.6	19.0	24.6	33.6
Average number of persons in a household		3.77	3.54	2.32	3.17	2.90	3.32	2.89	2.89	1.76	1.72	3.22	2.65	2.8
Household's disposable income [thous. PLN]		3.8	5.5	2.9	4.3	4.0	5.4	2.4	2.7	2.3	3.2	3.8	5.0	3.7
Type of building [%]	Block of flats	0.1	0.0	0.0	0.1	27.2	47.6	**95.1**	3.8	**99.9**	**100**	**100**	**100**	56.2
	Terraced house	0.1	0.0	1.1	8.0	61.2	8.3	4.9	3.3	0.1	0.0	0.0	0.0	6.2
	Detached house	**99.9**	**100**	**98.9**	**91.9**	11.5	44.1	0.0	92.9	0.0	0.0	0.0	0.0	37.6
Degree of urbanisation [%]	City with more than 500 thous. residents	1.1	2.6	1.7	4.8	17.4	20.0	12.7	2.2	19.5	**25.5**	12.4	33.5	14.7
	City with less than 500 thous. residents	24.2	39.7	34.8	35.9	51.5	49.7	68.5	22.6	**72.8**	69.9	**74.3**	62.4	52.5
	Rural areas	**74.7**	57.7	63.5	59.3	31.1	30.3	18.7	**75.1**	7.7	4.6	13.2	4.2	32.8
Socioeconomic group [%]	Farmers and self-employed	21.2	0.0	0.0	4.8	5.1	**100**	1.9	11.4	0.0	0.0	0.0	0.0	10.7
	Manual workers	50.1	0.0	0.0	29.6	27.7	0.0	37.2	27.2	3.0	0.0	**100**	0.5	25.1
	Non-manual workers	9.4	**100**	0.0	20.8	32.5	0.0	9.9	9.3	0.4	0.0	0.0	**99.4**	24.6
	Retirees	6.3	0.0	97.9	38.3	26.1	0.0	19.5	32.7	53.2	**98.0**	0.0	0.0	27.6
	Pensioners	9.2	0.0	0.3	5.1	5.2	0.0	15.9	13.3	23.6	0.2	0.0	0.0	7.0
	Living on social benefits	2.6	0.0	0.8	0.6	1.8	0.0	12.7	4.8	7.8	0.4	0.0	0.0	2.7
	Living on other non-earned sources	1.2	0.0	0.9	0.9	1.5	0.0	2.8	1.2	12.0	1.4	0.0	0.1	2.4

	Typ	1	2	3	4	5	6	7	8	9	10	11	12	total
Expenditurres on energy	Required expenditures on heat [PLN] (based on PHBS data)	280	300	255	281.1	250.7	285.5	140.5	222.4	202.8	219.0	219.5	224.0	236.8
	Required expenditures on heat [PLN] (based on KAPE data)	602	551	494	557	425	382	117.1	296.4	128.5	134.1	136.3	135.5	303.8
	Required expenditures on electricity [PLN] (based on PHBS data)	78.7	80.4	60.3	71.9	74.1	100.8	70.1	71.3	60.4	60.2	80.4	80.4	74.1
LIHC	Fuel poverty rate based on PHBS data [% of households]	**23.9**	7.6	**13.2**	9.4	8.0	**10.2**	3.2	**15.3**	7.5	1.7	7.5	2.8	9.6
	Fuel poverty rate based on KAPE data (heat) and PHBS data (electric power) [% of households]	**44.6**	12.0	**34.1**	**21.2**	**18.4**	12.5	3.7	**34.1**	2.6	0.4	1.3	0.7	14.9
	Percentage of households meeting LI criterion (based on PHBS data)	40.6	11.6	26.1	16.3	20.2	14.3	48.6	47.3	22.8	4.1	19.5	6.2	22.97
	Percentage of households meeting HC criterion (based on PHBS data)	62.3	72.3	56.6	66.3	47.8	75.2	8.5	37.7	41.7	49.9	40.5	50.2	50.0
Subjective fuel poverty rate (lack of thermal comfort in winter, % of households)		8.3	4.4	8.6	7.9	**15.0**	6.5	**38.8**	**22.8**	10.6	6.1	11.1	7.0	11.5
Relative income poverty [% of households]		**21.9**	6.4	**13.8**	1.3	10.3	6.1	**31.9**	**27.3**	7.9	1.7	10.4	2.0	11.4

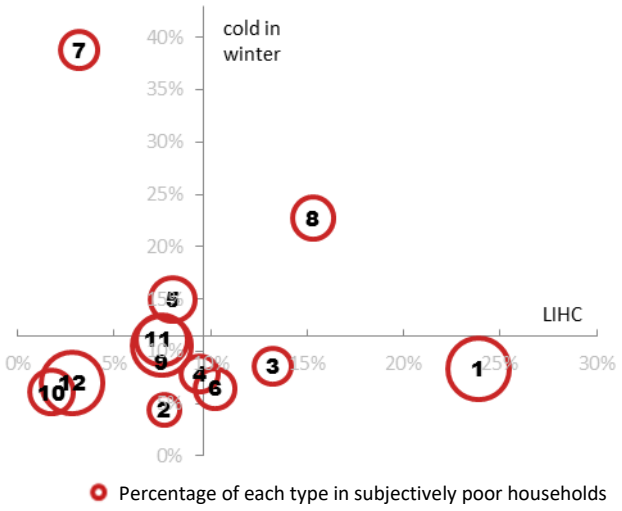
Source: Own calculation based on the 2014 Polish HBS data and KAPE data.

4.1 Overcrowded dwellings and fuel poverty

Types 7, 11, 12 are characterised by both a small floor area per person (20-25 m^2) and a small total floor area – approx. 50 m^2. In the case of all the three types, an above-average percentage of the households believe that their apartment is too small for their needs. The financial situation and social and economic status of the discussed types are different. Type 12 is dominated by wealthy inhabitants, predominantly living in big cities, whose incomes are derived from non-manual jobs. They usually occupy properties built after 1960. Their apartments meet basic sanitary standards and have central heating. Type 11 includes households of blue-collar workers, on average poorer than type 12, usually living in small towns or in rural areas. The properties they occupy are usually slightly older, but the percentage of pre-war buildings remains low. Type 7 includes the poorest households deriving income from manual work or social benefits. Half of them rent municipal properties and 80% live in old, pre-war tenement houses, without central heating. The sanitary and technical condition of many of occupied dwellings is poor – every fourth does not have a toilet flushed with running water, every third has problems with leaking roofs, damp walls or rotting windows.

Figure 1. Energy-related expenditures per m2 vs. floor area per person

Figure 2. LIHC poverty vs. subjective poverty



Note: The axes intersect at the average values for each variable.
Source: Own calculations based on the 2014 HBS data.

Out of all households facing fuel poverty according to the LIHC measure, only 14% live in dwellings with small floor area per person. In type 11, fuel poverty according to the LIHC measure occurs twice as often as in the two remaining types. It affects 7.5% of the households in this group despite the small floor area that reduces the probability of meeting the high cost (HC) criterion. Type 12 is hardly affected by fuel poverty. Small floor areas, relatively high income and good thermal quality eliminate the probability of meeting LIHC criteria as well as the subjectively perceived lack of thermal comfort. The scale of vulnerability to fuel poverty of households in type 7 requires a more thorough analysis. They show low energy expenditures both in the case of calculation per m^2 (Figure 1) and in absolute terms. This is due to the fact that on average costs of heating with coal are lower than costs of district heating networks. As a result of low required expenditures per m^2 combined with small floor area, these households do not meet the LIHC criterion. However, at the same time almost 40% of the households belonging to this group experience lack of thermal comfort in winter and they meet the criterion of subjective measure (Figure 2). This is due to the bad technical condition of pre-war tenement houses where these inhabitants live.

The situation of households classified as type 7 is closely related to the phenomenon of 'neighbourhoods of poverty', which have received considerable attention in the Polish sociological and anthropological research in recent years. Poverty concentrates in certain districts and neighbourhoods of the cities and its severity differs between cities (Tarkowska, 2005). Urban poverty is often the result of the economic transition processes of the 1990s. On the one hand, in the cities of Silesia region poverty concentrates in former industrial districts. On the other, in Lodz the poverty zones occurred as a result of secondary segregation of inhabitants in the 1990s. Initially, individuals who were in a difficult material situation were scattered around different city districts, but gradually they settled in more neglected, run-down areas where many social problems started to accumulate (Warzywoda-Kruszyńska, 2012). In the poverty zones many social problems and deficits overlap. Inhabitants are jobless and they do not have access to public services of decent quality – schools, health care as well as good housing conditions. Tight interdependence of income poverty and living in sub-standard conditions raise the severity of insufficiently heated apartments and difficulties in paying for energy expenditures.

Municipal housing are located mainly in neighbourhoods of poverty, however, due to intensive privatisation, municipal properties no longer dominate these districts. Neither private nor municipal ownership of the dwellings guarantees appropriate care for properties. While municipalities have very limited resources for investment, many private properties are owned by the poor who acquired them on preferential terms and have no financial capacities to carry out renovations (Kucharska-Stasiak et al., 2011). Municipalities are getting rid of the responsibility for the upkeep of properties, and as a result the social problems become more and more severe (Kucharska-Stasiak et al., 2011).

The qualitative studies deliver evidence that keeping thermal comfort is one of the fundamental concerns of the urban poor: *the bootleg miner families told me about private heating installations* ["bootleg miners" are the former miners who, after the mine closures in the 1990s, support themselves by extracting coal illegally out of the so-called "bootleg mines" – note by K.Ś.], *everybody kept talking about the need for heating. Periods of cold, when there was no money to buy heating fuel, were referred to as the worst moments, full of helplessness and suffering, "this is the most important now: we can cook dinner, we can eat more than just bread and it is warm in the house. This is most important. When it was cold we would seat at the gas cooker to keep warm (…)"* (Rakowski, 2009).

There are various ways to deal with low indoor temperature. Social workers visiting poverty zones in Lodz pointed out that in winter they would frequently encounter families wearing several layers of warm clothes (Potoczna, 2001). Furthermore, the poor quality of buildings and the lack of adequate installations lead some inhabitants to apply highly inefficient heating methods. Due to the lack of hot running water, women from Walbrzych would heat water in pots. This in turn generates high gas charges (Maciejewska and Marszałek, 2010). Using electric heaters in addition to ordinary heating system is another common and expensive practice (Potoczna, 2001; Warzywoda-Kruszyńska, 2012). Such measures lead to arrears in the payment of bills among the fuel poor.

Self-made modifications in the insulation or heating systems are another way to deal with low temperature. Lack of initiative of landlords (both - municipal and private) make the poor undertake repairs at their own expense. They replace rotten windows and doors, convert heating furnaces to improve their efficiency or even install makeshift central heating systems (Maciejewska and Marszałek, 2010; Rakowski, 2009). Rakowski (2009) points out that such modifications form the part of the overall life strategy of the poor families. Its aim is to meet basic needs by means of *internal circulation* – an efficient processing of possessed goods when they are scarce. Such processing is carried out in isolation from the outside world, it remains within the boundaries of the house, tenement, close circle of people with whom poor families struggle to survive.

The decision to live in a small area is frequently a way to ensure energy efficiency: *they consented to the lack of space, it was something that ensured autarky and a kind of psychology of efficient processing as well as efficiency of the heating installation. My landlords kept repeating that they could arrange for a bigger flat, but did not want to, because, as they said, 'it would be impossible to heat'* (Rakowski, 2009).

The situation of the households belonging to type 7 discloses material shortcomings of the LIHC measure. Apart from the fact that it is conductive to large floor areas, its weakness also lies in difficulties in estimating the real costs of heating in dwellings with very low thermal quality. The underestimation occurs regardless of the method applied in order to calculate the required energy expenditures. Estimation based on energy audits does not distinguish buildings characterised with an extremely bad thermal quality as a separate class. The averaged actual expenditures applied in this paper does not reflect costs necessary to heat such dwellings, as many inhabitants cannot afford to heat them sufficiently. Thus, high energy inefficiency in this household group remains elusive from the perspective of statistical data.

4.2 Medium size accommodations – varied energy costs

Type 1, 6, 9 and 10 households have an average level of floor area per household member. There are, however, significant differences between them, when it comes to socio-economic characteristics and the number of household members. Types 1 and 6 are dominated by large households (type 1–3.8 members, type 6 – 3.3 members; the population average – 2.8 members) occupying dwellings with a relatively large floor area. Type 1 includes mainly detached houses located in rural areas and in towns. Type 6 is varied both in terms of the size of the city of residence and the type of occupied dwelling. In the case of both types, buildings are equipped with central heating (district or domestic central heating). Type 1 includes households with incomes slightly below the average, earned mainly from agriculture and labour work, while households in type 6 are wealthier, with incomes derived from activities of liberal professions and self-employment. Types 9 and 10 are small households of retirees and pensioners living in multi-family residential buildings located in cities. Type 10 groups wealthier retirees whose income per capita is relatively high. Type 9 includes households whose incomes are slightly below the average, earned from pensions, invalidity pensions and benefits. The percentage of people living in the largest cities is low in type 9.

More than half of the fuel poor according to the LIHC measure live in dwellings with the average floor area per person. They are mainly type 1 households – 24% of households meet the LIHC criteria. They constitute as much as 36% of all fuel poor households (Figure 3). Types 6 and 9 are affected by fuel poverty to a smaller extent and type 10 remains virtually not affected by LIHC fuel poverty. Large floor area of buildings and a relatively low income per capita are main reasons for the concentration of fuel poverty (LIHC) in type 1. Ensuring an average standard of area per person is more costly for families with children than for single persons. Only a small percentage (8%) of households included in this type report the lack of thermal comfort in winter. It is also worth noting that out of the four types, households in type 1 spend significantly less to heat 1 m^2. It supports our point that behavioural adjustments in the case of heating detached houses are greater than in the case of blocks of flats (Figure 4, Section 3.3). This is due to a few mechanisms. Firstly, some living space of detached houses may be put out of use and left unheated (e.g. higher floors). Secondly, the temperature in detached houses is maintained at lower levels, especially during working hours and at night, as the management of domestic sources of heat is more flexible. Thirdly, in the case of using solid fuel stoves the actual heating costs are lower than the estimated costs. This is due to the fact that cheaper, low quality sources of heat are used (e.g. garbage, saw dust, brushwood).

Figure 3. Percentage of households meeting criteria of low income (LI) and high costs (HC)

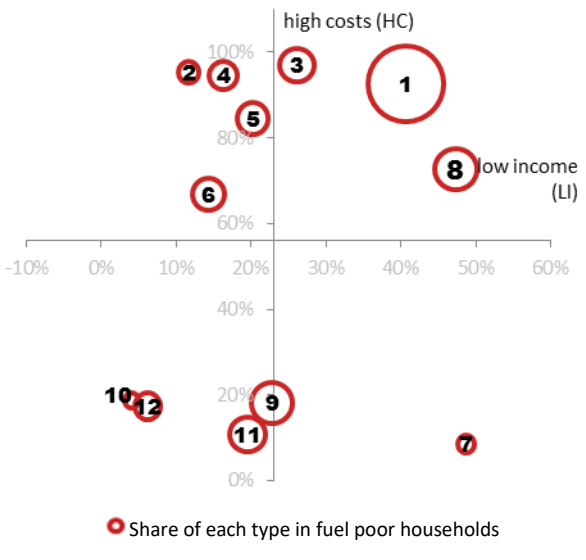
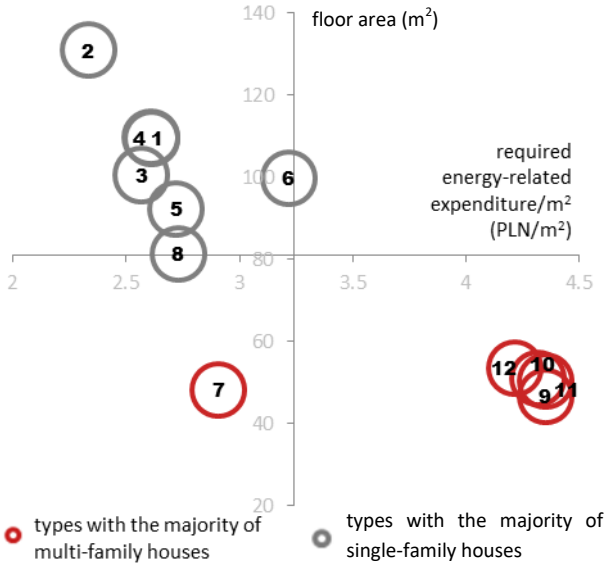


Figure 4. Building size and type vs. energy-related expenditures per m2



Note: The axes intersect at the average values for each variable.

Source: Own calculations based on the 2014 BAEL data.

4.3 Spacious dwellings – threat for the indigent and retirees

The last group – **types 2, 3, 4, 5, 8** - is dominated by households located in rural areas or smaller towns, living in detached houses with predominantly central heating. There are two exceptions: **type 5** includes terraced and semi-detached households with various heating sources - with gas heating being prevalent; while households in **type 8** are heated with solid fuel stoves and do not possess central heating.

In terms of household income, **type 2** and **type 8** are two interesting extremes. Type 2 includes the most prosperous households earning income from non-manual jobs. These are large households (of 3.5 persons) occupying very large floor areas (over 130 m^2 on average) in relatively new buildings. Their expenditures on heating one square meter is the lowest among all the identified types. The high energy efficiency is a result of behavioural adjustments and a good quality of heat insulation of occupied buildings. On the contrary, incomes in type 8 are significantly low. Over ¼ of households experience income poverty. From the perspective of rural areas, these households have a relatively small floor area, approximately 80m^2, with an average number of household members (2.8 persons). The significantly higher costs of heating one square meter in comparison to type 2 are explained by the age of occupied buildings. Most of them are very old dwellings built before the war or in 1946-1960, with low thermal efficiency.

In order to conduct further analysis, the features of the households assigned to **type 3**, i.e. households of lower-income retirees must also be taken into account. They are characterised by the above-average floor area per capita (over 50 m^2). Almost 9% of inhabitants of these households declare that their homes are too big compared to their needs (4% in the whole population).

Every third household that experiences fuel poverty according to the LIHC measure is a household with the above-average floor area per person. Out of five types included in this group, fuel poverty affects mainly **type 3** and **type 8**.

In the case of type 3, the extensive inefficiency is evident. Elderly inhabitants in these households occupy houses that are too big for their needs and do not match their financial capabilities. They face fuel poverty due to excessive energy-related expenditures (Figure 3). According to qualitative studies, the situation of lower-income retirees differs from that of younger generations. In some poor regions, retirees are the only individuals with permanent income. Thanks to stable, even low retirement pay it is easier for them to manage the household budget. Retirees have a wider access to credits: *although loans allow people to meet current needs, such as heating costs (coal), repairs (stoves) or family life (daughter's wedding), they create a situation which Danuta describes as "And so one goes on living, day by day". This "day by day" existence may be described as "from one loan to another" (…)The abovementioned participant describes the never ending circle of credit repayments: "I'm on my own. My husband died four years ago. It's hard to live just on one pension. It's just me, my pension amounts to 1000 PLN, but there are loans on top of that. I'm repaying four loans. Winter is coming, there is no money put aside, it's just impossible to save anything. Where would I get it from? And I will have to get a loan to buy coal for winter, there is no other way".* (Gawlicz and Starnawski, 2009).

Even if retirees experience fuel poverty, they usually avoid falling behind with payments of utility bills. Their permanent source of income is used to pay bills in the first place (Potoczna, 2001). However, payment of electricity bills may come at the expense of fulfilling other basic needs.

The main reasons of fuel poverty in type 8 are income poverty and low quality of occupied buildings and energy inefficiency at intensive margin. Out of twelve identified household types, only in the case of this group the subjective fuel poverty (23%) is accompanied by a high indicator of the fuel poor according to the LIHC measure (15%).Sociological research shows that energy deprivation in the rural areas concerns mainly owners of small farms located in regions with unfavourable conditions for agricultural production. Such farmers form the core of poverty in Poland (GUS, 2015; Tarkowska, 2000). Their problems accumulated since the beginning of the economic transition (1990) which resulted in structural changes in the farming sector. Small-scale farms turned out to be not enough competitive in the market economy. In some regions (e. g. *Świętokrzystkie* voivodship) the tough situation of farmers was magnified by closures of factories. These factories provided employment and income independent form farming activities.

According to the research carried out in *Świętokrzyskie* voivodship by Gawlicz and Starnawski (2009) and by Rakowski (2009), the main strategy adopted by individuals living in severe poverty is based on self-sufficiency in the situation of scarcity. This also applies to heating. The poor constructed self-made stoves, the so-called "sawdust stoves" and used wood collected from the forest as fuel. As Rakowski (2009) notes: *(…) In spring, towards the end of April, I saw pretty much immediate effects of work: piles or wagons of neatly cut twigs and branches; it was clear that they are still processing those poplars, it was said the they were "good for boards" (…), they were predominantly gathered as heating fuel.(…) I kept seeing people busy gathering heating fuel: they would say: "over here heating fuel for winter must be gathered throughout the whole year" (…)*

Sometimes, even in the case of less extreme poverty, fuel poverty occurs. Relying on own food production, combined with ad-hoc jobs that provide only tiny income, does not enable people to carry out complex retrofit. Random upgrades of thermal efficiency are made instead: partly insulations of the house or a replacement of old windows (Gawlicz and Starnawski, 2009).

Table 2. Causes of fuel poverty and strategies adopted by the fuel poor by houshold type

Fuel poverty - formation mechanisms	Urban poverty neighbourhoods **Type 7**	Poor villages **Type 8**	Retirees living in rural areas **Type 3**
Spatial concentration of poverty	X		
Secondary segregation of the population in the 90s	X		
Neglected municipal property	X		
"Poor owners" as a result of privatisation of housing stock	X		
Absence of the former administrator, dispersion of responsibility for the technical condition of buildings	X		
Collapse of local employers	X	X	
Reduction of household size without adjustment of floor area			X
Thermal inefficiency of buildings	X	X	
Strategies adopted in the face of fuel poverty:			
Using the "emergency", inefficient sources of energy	X		
Ad-hoc renovations	X	X	
Self-made modifications of installations, self-made stoves	X	X	
Wearing several layers of warm clothes	X		
Remaining in overcrowded flats	X		
Heating with forest wood		X	
Taking loans to buy heating fuels		X	X
Experiencing low temperatures indoors	X		
Arrears in the payment of bills	X		

Source: Own elaboration.

5 Conclusions

The cluster analysis of Polish households let us identify a variety of symptoms of fuel poverty. Fuel poverty occurs if at least two of the following factors overlap: low quality housing stock, low or very low income and large floor area. The coexistence of the first two factors is typical for households located in urban poverty neighbourhoods occupying small apartments of pre-war tenement houses and for poor inhabitants of rural areas living in old houses. Although highly successful, the economic transformation that started in Poland in1990 resulted in a few negative side effects. The spatial overlap of income poverty and deterioration of buildings created ground for most severe fuel poverty. The collapse of state-owned farming and industrial enterprises resulted in the rise of long-lasting unemployment and permanent reduction of income in specific regions. The insufficient efforts of central and local governments resulted in the deterioration of housing stock and its thermal efficiency in particular. Bouzarovski (2014) highlights complementary aspect of the economic transformation in Eastern and Central Europe. The state failed to take adequate steps in parallel to deregulation of energy prices in order to provide social support and improve energy efficiency of the housing stock.

The fuel poor take many measures to provide decent living conditions to themselves and their family (Table 2). However, some structural factors, which cannot be significantly influenced by them, limit the scope of their efforts. Only a systemic intervention can fundamentally change their situation (Lister, 2007). Even if inhabitants of neighbourhoods of poverty and rural areas find a job, they are rarely capable of rising their income enough to allow for in-depth retrofit of their houses in order to ensure thermal comfort and reduce spending on energy.

Therefore, as regards their housing conditions, they cannot expect a considerable improvement of their quality of life. As they cannot afford to move away from their place of residence either, they are stuck in a situation where they are forced to choose between experiencing cold and facing high energy expenditures which strain the household budget.

Another type of fuel poverty is faced by households occupying large houses. Their inhabitants rarely suffer from the lack of thermal comfort and they do not experience the extreme material deprivation. It predominantly affects big families with children living in detached houses located in rural areas, where a large floor area is combined with low income per capita. The sociological evidence of the mechanisms and strategies of this group of the fuel poor is limited in Poland. This type of the fuel poor is not perceived as interesting from the research perspective focused on the extreme poverty.

The cluster analysis also indicates that in households of retirees occupying large houses located in rural areas the extensive margin of energy inefficiency is present. Such houses are too big for their occupants' needs and financial capabilities. Most houses and apartments in Poland are privately-owned. The adjustment of living conditions to changes of income and household situation turns out to be problematic, especially for individuals whose income is low and due to the fact that most houses and apartments in Poland are privately-owned.

As a way to ensure thermal comfort cheaply the fuel poor use energy carriers that are not environmentally efficient. Switching to more environmentally friendly sources of energy (good quality coal instead of wood or garbage, gas instead of solid fuel stoves, district central heating, micro installations for heat and electricity) means higher energy expenditures or high investment outlays. This aspect shows contradictions between increasing eco-efficiency of heating and reducing fuel poverty, as described by Snell and Thomson (2013) and Ürge-Vorsatz and Herrero (2012). In order to mitigate this effect, public policies are needed for the investment and maintenance of eco-efficient heating systems and the increase of thermal efficiency of buildings.

The diversity of the fuel poor justifies the need for the multidimensional approach. The LIHC measure is not sufficient to identify the whole spectrum of households matching the definition of "experiencing difficulties in meeting basic energy needs at their place of residence". This measure manages to cover the households for whom high expenditures on energy constraint the spending on basic needs but fails to identify those suffering from lack of thermal comfort. The latter aspect is very often linked to low thermal energy efficiency of buildings, use of heating sources that emit harmful substances, falling behind on payments for energy bills. The identification of households affected by such problems is possible only by applying the subjective (consensual) measures. A broad approach to measurement of fuel poverty allows to better design the policies aimed at eradicating the problem.

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Appendices

A1. The variables used in cluster analysis

	Description	Type of variable
energy efficiency	floor area [m2]	continuous
	floor area per person [m2 per person]	continuous
	type of building	discrete - 3 categories (block of flats; terraced house, detached house)
	period of building's construction	discrete - 6 categories (before 1946; between 1946 and 1960; between 1961 and 1980; between 1981 and 1995; between 1996 - 2006; after 2006)
	type of heating	discrete - 4 categories (central heating; fuel stove; gas stove; electric stove)
expenditures on electricity	actual expenditures on electricity [PLN] - median in decile groups	continuous
	actual expenditures on electricity per m2 [PLN per m2] - median in decile groups	continuous
	actual expenditures on electricity per person [PLN per person] - median in decile groups	continuous
	required expenditures on electricity (60% of median in socio-economic groups)	continuous
expenditures on heat	actual expenditures on heat [PLN]	continuous
	actual expenditures on heat per m2 [PLN per m2]	continuous
	actual expenditures on heat per person [PLN per person]	continuous
	required expenditures on heat [PLN] (based on KAPE data)	continuous
	required expenditures on heat per person [PLN per person] (based on KAPE data)	continuous
income	household's disposable income [PLN] – median in decile groups	continuous
	household's disposable income per person [PLN per person] – median in decile groups	continuous
	household's equivalent disposable income [PLN] – median in decile groups	continuous
	main source of household's income	discrete - 12 categories (manual labour; non-manual labour; farm usage; self-employment other than at individually used farm; liberal profession; property; rent; retirement pay; pension; unemployment benefit; other social benefits; endowments, support maintenance and other incomes; other)
consumption	expenditures on consumer goods and services [PLN] - median in decile groups	continuous
	expenditures on consumer goods and services per person in household [PLN per person] - median in decile groups	continuous
	equivalent expenditures on consumer goods and services [PLN] - median in decile groups	continuous
	Subjective assessment of housing costs' burden and ability to pay it on time (utilities, rent, mortgage etc.)	discrete - 6 categories (good; rather good; average; neither good nor bad; rather bad; bad; not applicable; lack of such burden)

Source: Own elaboration based on the 2014 Polish HBS data.

A2. The percentage of correctly classified observations – discriminant analysis

		Cluster number after classification procedure											
		1	2	3	4	5	6	7	8	9	10	11	12
Original cluster number	1	**92.7%**	1.0%	0.4%	2.5%	1.1%	0.8%	0.0%	1.3%	0.0%	0.0%	0.0%	0.1%
	2	0.3%	**97.9%**	0.0%	1.4%	0.0%	0.0%	0.0%	0.5%	0.0%	0.0%	0.0%	0.0%
	3	1.6%	0.0%	**95.7%**	1.5%	1.1%	0.0%	0.0%	0.1%	0.0%	0.0%	0.0%	0.0%
	4	2.0%	1.7%	1.5%	**89.8%**	2.3%	1.1%	0.0%	1.6%	0.0%	0.0%	0.0%	0.0%
	5	0.4%	0.0%	0.7%	1.9%	**92.0%**	1.2%	1.8%	1.4%	0.4%	0.0%	0.0%	0.3%
	6	0.2%	0.0%	0.0%	0.6%	0.8%	**97.3%**	0.1%	0.7%	0.0%	0.0%	0.1%	0.0%
	7	0.0%	0.0%	0.0%	0.0%	2.0%	0.0%	**93.6%**	2.4%	1.9%	0.0%	0.0%	0.1%
	8	2.9%	0.3%	0.5%	0.7%	3.0%	0.6%	4.7%	**87.1%**	0.0%	0.0%	0.2%	0.0%
	9	0.1%	0.0%	0.1%	0.1%	0.8%	0.1%	0.5%	0.0%	**97.9%**	0.1%	0.2%	0.2%
	10	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.1%	**99.9%**	0.0%	0.0%
	11	0.0%	0.0%	0.0%	0.1%	0.2%	0.1%	0.1%	0.0%	0.3%	0.0%	**99.3%**	0.1%
	12	0.0%	0.0%	0.0%	0.0%	0.4%	0.1%	0.2%	0.0%	0.4%	0.0%	0.2%	**98.7%**

Source: Own calculations based on the 2014 Polish HBS data.

A3. Cluster size before and after classification procedure

	Cluster size [% of households]	
Cluster number	before classification (44% of sample)	after classification (100% of sample)
1	14.6%	14.3%
2	3.6%	3.6%
3	5.0%	5.2%
4	4.8%	5.2%
5	7.3%	7.6%
6	6.1%	6.2%
7	5.3%	5.6%
8	7.2%	6.7%
9	13.4%	13.5%
10	7.6%	7.3%
11	9.8%	9.9%
12	15.4%	15.0%

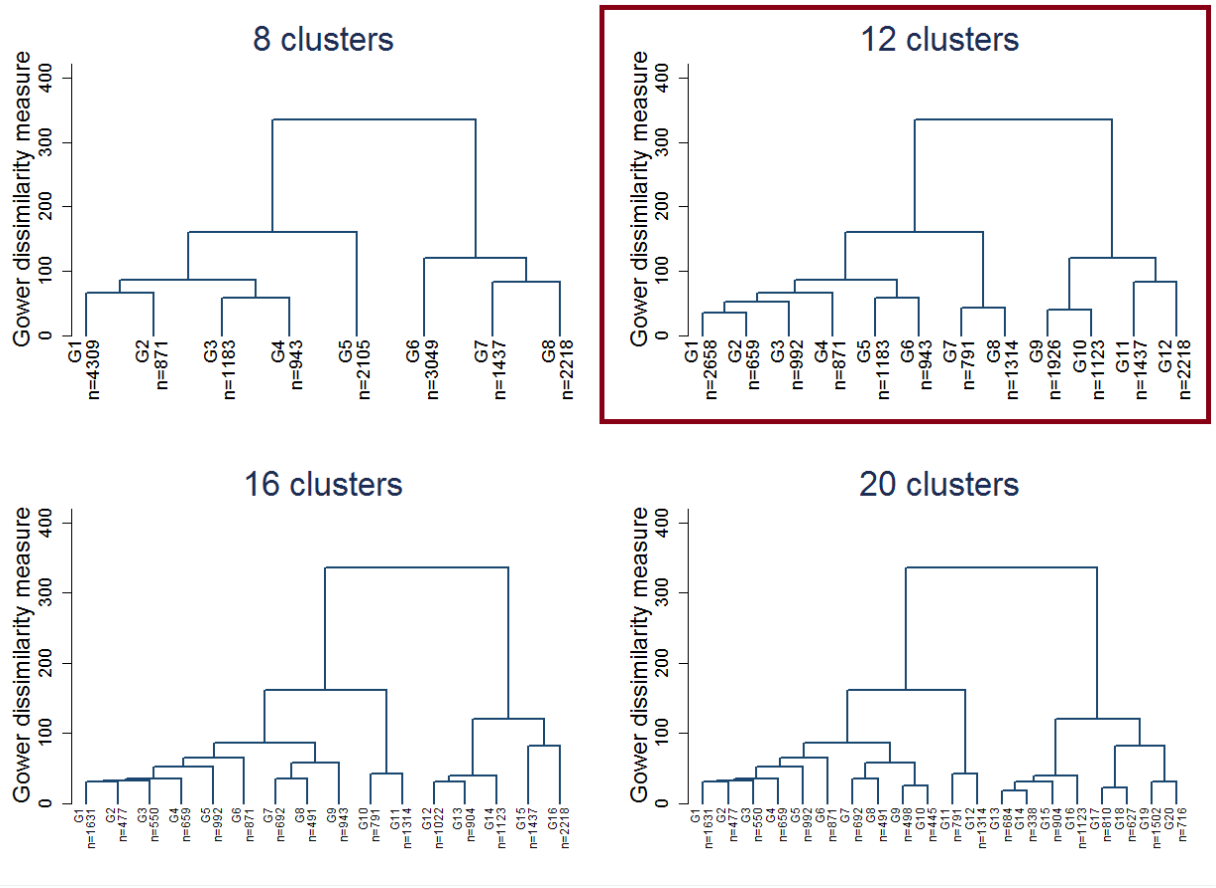
Source: Own calculations based on the 2014 Polish HBS data.

A4. Mean values for selected variables before and after classification procedure

	Cluster number	1	2	3	4	5	6	7	8	9	10	11	12	mean relative error
floor area [m2]	before classification (44% of sample)	111.1	131.9	101.4	110.2	94.0	95.7	48.6	79.9	47.0	50.1	51.0	53.6	
	after classification (100% of sample)	109.5	131.0	100.6	109.9	92.3	99.8	48.3	81.5	46.7	50.5	51.0	53.5	
	relative error	1.4%	0.7%	0.8%	0.3%	1.8%	4.3%	0.6%	2.0%	0.6%	0.7%	0.1%	0.2%	**1.1%**
floor area per person [m^2 per person]	before classification (44% of sample)	37.5	43.5	54.2	46.9	40.4	33.4	23.0	38.5	33.3	34.8	19.0	24.7	
	after classification (100% of sample)	36.4	43.1	53.3	46.2	39.5	35.2	23.2	40.0	33.0	34.6	19.0	24.6	
	relative error	3.0%	0.9%	1.6%	1.5%	2.4%	5.4%	1.0%	3.9%	1.1%	0.6%	0.3%	0.4%	**1.8%**
required expenditures on heat [PLN] (based on KAPE data)	before classification (44% of sample)	283.1	300.5	257.0	282.6	260.1	279.6	142.1	219.5	202.9	217.3	219.6	223.8	
	after classification (100% of sample)	280.2	300.5	255.3	281.1	250.7	285.5	140.5	222.4	202.8	219.0	219.5	224.0	
	relative error	1.0%	0.0%	0.7%	0.5%	3.6%	2.1%	1.1%	1.3%	0.0%	0.8%	0.0%	0.1%	**0.9%**
actual expenditures on electricity [PLN]	before classification (44% of sample)	150.9	183.2	129.0	157.2	162.2	171.1	116.4	121.2	81.3	87.0	114.6	106.4	
	after classification (100% of sample)	151.8	176.5	134.2	159.2	158.1	174.4	114.2	120.3	81.1	90.1	114.7	106.1	
	relative error	0.6%	3.6%	4.0%	1.3%	2.6%	1.9%	1.9%	0.8%	0.2%	3.5%	0.1%	0.3%	**1.7%**
household's disposable income [PLN]	before classification (44% of sample)	3816	5522	2940	4225	4112	5350	2374	2722	2265	3101	3822	5085	
	after classification (100% of sample)	3758	5468	2924	4302	4045	5430	2408	2700	2259	3158	3817	4982	
	relative error	1.5%	1.0%	0.6%	1.8%	1.6%	1.5%	1.4%	0.8%	0.3%	1.8%	0.1%	2.0%	**1.2%**

Source: Own calculations based on the 2014 Polish HBS data.

A5. Cluster trees for 8, 12, 16 and 20 clusters



Source: Own calculations based on the 2014 Polish HBS data.

A6. Detailed statistics of identified types of households

Table 1. Detailed statistics of identified types (clusters) of households – discrete variables

Type (cluster) number		1	2	3	4	5	6	7	8	9	10	11	12	total
Cluster size [% of households]		14.3	3.6	5.2	5.2	7.6	6.2	5.6	6.7	13.5	7.3	9.9	15.0	100.0
Cluster size [% of population]		19.2	4.5	4.3	5.9	7.9	7.3	5.8	6.8	8.4	4.5	11.4	14.1	100.0
Type of building [%]	Block of flats	0.1 (0.0)	0.0 (0.0)	0.0 (0.0)	0.1 (0.0)	27.2 (0.4)	47.6 (0.5)	**95.1** (0.2)	3.8 (0.2)	**99.9** (0.0)	**100** (0.0)	**100** (0.0)	**100** (0.0)	56.2 (0.5)
	Terraced house	0.1 (0.0)	0.0 (0.0)	1.1 (0.1)	8.0 (0.3)	61.2 (0.5)	8.3 (0.3)	4.9 (0.2)	3.3 (0.2)	0.1 (0.0)	0.0 (0.0)	0.0 (0.0)	0.0 (0.0)	6.2 (0.2)
	Detached house	**99.9** (0.0)	**100** (0.0)	**98.9** (0.1)	**91.9** (0.3)	11.5 (0.3)	44.1 (0.5)	0.0 (0.0)	92.9 (0.3)	0.0 (0.0)	0.0 (0.0)	0.0 (0.0)	0.0 (0.0)	37.6 (0.5)
Degree of urbanisation [%]	City with more than 500 thous. residents	1.1 (0.1)	2.6 (0.2)	1.7 (0.1)	4.8 (0.2)	17.4 (0.4)	20.0 (0.4)	12.7 (0.3)	2.2 (0.1)	19.5 (0.4)	**25.5** (0.4)	12.4 (0.3)	33.5 (0.5)	14.7 (0.4)
	City with less than 500 thous. residents	24.2 (0.4)	39.7 (0.5)	34.8 (0.5)	35.9 (0.5)	51.5 (0.5)	49.7 (0.5)	68.5 (0.5)	22.6 (0.4)	**72.8** (0.4)	69.9 (0.5)	**74.3** (0.4)	62.4 (0.5)	52.5 (0.5)
	Rural areas	**74.7** (0.4)	57.7 (0.5)	63.5 (0.5)	59.3 (0.5)	31.1 (0.5)	30.3 (0.5)	18.7 (0.4)	**75.1** (0.4)	7.7 (0.3)	4.6 (0.2)	13.2 (0.3)	4.2 (0.2)	32.8 (0.5)
Socioeconomic group	Farmers and self-employed	21.2 (0.4)	0.0 (0.0)	0.0 (0.0)	4.8 (0.2)	5.1 (0.2)	**100** (0.0)	1.9 (0.1)	11.4 (0.3)	0.0 (0.0)	0.0 (0.0)	0.0 (0.0)	0.0 (0.0)	10.7 (0.3)
	Manual workers	50.1 (0.5)	0.0 (0.0)	0.0 (0.0)	29.6 (0.5)	27.7 (0.4)	0.0 (0.0)	37.2 (0.5)	27.2 (0.4)	3.0 (0.2)	0.0 (0.0)	**100** (0.0)	0.5 (0.1)	25.1 (0.4)
	Non-manual workers	9.4 (0.3)	**100** (0.0)	0.0 (0.0)	20.8 (0.4)	32.5 (0.5)	0.0 (0.0)	9.9 (0.3)	9.3 (0.3)	0.4 (0.1)	0.0 (0.0)	0.0 (0.0)	**99.4** (0.1)	24.6 (0.4)
	Retirees	6.3 (0.2)	0.0 (0.0)	97.9 (0.1)	38.3 (0.5)	26.1 (0.4)	0.0 (0.0)	19.5 (0.4)	32.7 (0.5)	53.2 (0.5)	**98.0** (0.1)	0.0 (0.0)	0.0 (0.0)	27.6 (0.4)
	Pensioners	9.2 (0.3)	0.0 (0.0)	0.3 (0.1)	5.1 (0.2)	5.2 (0.2)	0.0 (0.0)	15.9 (0.4)	13.3 (0.3)	23.6 (0.4)	0.2 (0.0)	0.0 (0.0)	0.0 (0.0)	7.0 (0.3)
	Living on social benefits	2.6 (0.2)	0.0 (0.0)	0.8 (0.1)	0.6 (0.1)	1.8 (0.1)	0.0 (0.0)	12.7 (0.3)	4.8 (0.2)	7.8 (0.3)	0.4 (0.1)	0.0 (0.0)	0.0 (0.0)	2.7 (0.2)
	Living on other non-earned sources	1.2 (0.1)	0.0 (0.0)	0.9 (0.1)	0.9 (0.1)	1.5 (0.1)	0.0 (0.0)	2.8 (0.2)	1.2 (0.1)	12.0 (0.3)	1.4 (0.1)	0.0 (0.0)	0.1 (0.0)	2.4 (0.2)
Period of building's construction [%]	before 1946	13.4 (0.34)	9.5 (0.29)	21.1 (0.41)	13.8 (0.34)	**37.4** (0.48)	13.7 (0.34)	**78.9** (0.41)	**32.8** (0.47)	12.5 (0.33)	8.4 (0.28)	16.1 (0.37)	9.2 (0.29)	19.6 (0.4)
	between 1946 and 1960	**22.2** (0.42)	0.0 (0.0)	0.3 (0.05)	15.6 (0.36)	14.2 (0.35)	7.5 (0.26)	12.3 (0.33)	**26.7** (0.44)	10.5 (0.31)	11.1 (0.31)	11.5 (0.32)	8.6 (0.28)	12.7 (0.33)
	between 1961 and 1980	29.1 (0.45)	28.7 (0.45)	49.3 (0.5)	34.0 (0.47)	20.9 (0.41)	26.1 (0.44)	8.1 (0.27)	23.9 (0.43)	**55.2** (0.5)	**54.0** (0.5)	44.2 (0.5)	38.8 (0.49)	36.3 (0.48)

Type (cluster) number		1	2	3	4	5	6	7	8	9	10	11	12	total
Period of building's construction [%]	between 1981 and 1995	20.7 (0.41)	26.0 (0.44)	20.2 (0.4)	20.2 (0.4)	13.4 (0.34)	23.1 (0.42)	0.3 (0.06)	10.1 (0.3)	17.9 (0.38)	18.5 (0.39)	21.6 (0.41)	21.1 (0.41)	18.2 (0.39)
	between 1996 and 2006	10.3 (0.3)	**21.4** (0.41)	7.3 (0.26)	12.6 (0.33)	9.2 (0.29)	**19.3** (0.39)	0.2 (0.05)	4.9 (0.22)	1.8 (0.13)	6.3 (0.24)	4.1 (0.2)	13.1 (0.34)	8.6 (0.28)
	after 2006	4.3 (0.2)	**14.4** (0.35)	1.8 (0.13)	3.9 (0.19)	4.9 (0.21)	**10.3** (0.3)	0.2 (0.04)	1.6 (0.12)	2.1 (0.14)	1.8 (0.13)	2.5 (0.16)	9.1 (0.29)	4.6 (0.21)
Type of heating [%]	central heating	**99.8** (0.05)	**99.0** (0.1)	**99.3** (0.08)	**96.6** (0.18)	50.2 (0.5)	**94.6** (0.23)	4.3 (0.2)	3.1 (0.17)	**99.4** (0.08)	**100** (0.0)	**99.9** (0.04)	**99.8** (0.04)	83.6 (0.37)
	fuel stove	0.0 (0.0)	1.0 (0.1)	0.0 (0.0)	2.4 (0.15)	6.2 (0.24)	1.7 (0.13)	**91.8** (0.27)	**96.0** (0.2)	0.1 (0.03)	0.0 (0.0)	0.1 (0.03)	0.0 (0.01)	12.3 (0.33)
	gas stove	0.0 (0.02)	0.0 (0.0)	0.3 (0.06)	0.9 (0.09)	**34.1** (0.47)	2.9 (0.17)	0.9 (0.1)	0.2 (0.04)	0.5 (0.07)	0.0 (0.0)	0.0 (0.02)	0.1 (0.03)	3.0 (0.17)
	electric stove	0.2 (0.04)	0.0 (0.0)	0.4 (0.06)	0.1 (0.03)	**9.6** (0.29)	0.9 (0.09)	**3.0** (0.17)	0.6 (0.08)	0.0 (0.02)	0.0 (0.0)	0.0 (0.0)	0.1 (0.02)	1.1 (0.1)
Ownership of dwelling [%]	natural person	**99.6** (0.06)	**99.0** (0.1)	**99.9** (0.04)	**99.3** (0.08)	87.5 (0.33)	**95.2** (0.21)	43.5 (0.5)	**96.9** (0.17)	84.4 (0.36)	**92.6** (0.26)	80.6 (0.4)	**90.2** (0.3)	89.2 (0.31)
	housing cooperative	0.0 (0.01)	0.0 (0.0)	0.1 (0.02)	0.0 (0.02)	1.4 (0.12)	1.4 (0.12)	4.0 (0.2)	0.2 (0.04)	4.4 (0.21)	2.4 (0.15)	5.6 (0.23)	2.8 (0.16)	2.2 (0.15)
	municipality, State Treasury, employer	0.3 (0.05)	0.6 (0.08)	0.1 (0.03)	0.5 (0.07)	10.3 (0.3)	2.6 (0.16)	**48.8** (0.5)	2.4 (0.15)	10.0 (0.3)	4.5 (0.21)	11.2 (0.32)	4.7 (0.21)	7.4 (0.26)
	Social Building Society (TBS)	0.0 (0.0)	0.1 (0.03)	0.0 (0.0)	0.1 (0.02)	0.5 (0.07)	0.7 (0.08)	2.2 (0.15)	0.1 (0.03)	0.8 (0.09)	0.4 (0.06)	2.3 (0.15)	1.7 (0.13)	0.8 (0.09)
	other	0.1 (0.02)	0.3 (0.06)	0.0 (0.0)	0.1 (0.03)	0.3 (0.06)	0.1 (0.04)	1.2 (0.11)	0.3 (0.06)	0.3 (0.05)	0.0 (0.02)	0.3 (0.06)	0.4 (0.06)	0.3 (0.05)
	I don't know	0.0 (0.0)	0.0 (0.0)	0.0 (0.0)	0.0 (0.0)	0.0 (0.02)	0.0 (0.02)	0.2 (0.05)	0.0 (0.02)	0.2 (0.04)	0.1 (0.02)	0.0 (0.0)	0.2 (0.04)	0.1 (0.03)
Main source of household's income [%]	manual labour	50.1 (0.5)	0.0 (0.0)	0.0 (0.0)	29.6 (0.46)	27.7 (0.45)	0.0 (0.02)	37.2 (0.48)	27.2 (0.44)	3.0 (0.17)	0.0 (0.0)	**100** (0.0)	0.5 (0.07)	25.1 (0.43)
	non-manual labour	9.4 (0.29)	**100** (0.0)	0.0 (0.0)	20.8 (0.41)	32.5 (0.47)	0.0 (0.0)	9.9 (0.3)	9.3 (0.29)	0.4 (0.06)	0.0 (0.0)	0.0 (0.0)	**99.4** (0.07)	24.6 (0.43)
	farm usage	20.9 (0.41)	0.0 (0.0)	0.0 (0.02)	4.3 (0.2)	2.9 (0.17)	0.1 (0.02)	0.0 (0.0)	7.8 (0.27)	0.0 (0.02)	0.0 (0.0)	0.0 (0.0)	0.0 (0.01)	4.0 (0.2)
	self-employment other than at individually used farm, liberal profession	0.3 (0.05)	0.0 (0.0)	0.0 (0.0)	0.5 (0.07)	2.2 (0.15)	**99.9** (0.03)	1.9 (0.14)	3.7 (0.19)	0.0 (0.0)	0.0 (0.0)	0.0 (0.0)	0.0 (0.0)	6.8 (0.25)
	rent	0.2 (0.04)	0.0 (0.0)	0.1 (0.04)	0.2 (0.04)	0.3 (0.06)	0.0 (0.0)	0.0 (0.0)	0.1 (0.04)	0.1 (0.04)	0.2 (0.05)	0.0 (0.0)	0.0 (0.0)	0.1 (0.03)

Type (cluster) number		1	2	3	4	5	6	7	8	9	10	11	12	total
Main source of household's income [%]	retirement pay	6.3 (0.24)	0.0 (0.0)	**97.9** (0.14)	38.3 (0.49)	26.1 (0.44)	0.0 (0.0)	19.5 (0.4)	32.7 (0.47)	53.2 (0.5)	**98.0** (0.14)	0.0 (0.0)	0.0 (0.0)	27.6 (0.45)
	pension	9.2 (0.29)	0.0 (0.0)	0.3 (0.05)	5.1 (0.22)	5.2 (0.22)	0.0 (0.0)	**15.9** (0.37)	13.3 (0.34)	**23.6** (0.42)	0.2 (0.05)	0.0 (0.0)	0.0 (0.0)	7.0 (0.25)
	unemployment benefit	1.0 (0.1)	0.0 (0.0)	0.3 (0.06)	0.4 (0.06)	0.5 (0.07)	0.0 (0.0)	1.6 (0.13)	0.8 (0.09)	2.6 (0.16)	0.0 (0.0)	0.0 (0.0)	0.0 (0.0)	0.7 (0.08)
	other social benefits	1.5 (0.12)	0.0 (0.0)	0.5 (0.07)	0.3 (0.05)	1.3 (0.11)	0.0 (0.0)	**11.1** (0.31)	4.0 (0.2)	5.2 (0.22)	0.4 (0.06)	0.0 (0.0)	0.0 (0.0)	2.0 (0.14)
	endowments, support maintenance and other incomes	0.8 (0.09)	0.0 (0.0)	0.8 (0.09)	0.5 (0.07)	1.2 (0.11)	0.0 (0.0)	2.3 (0.15)	0.9 (0.09)	11.6 (0.32)	0.8 (0.09)	0.0 (0.0)	0.0 (0.02)	2.1 (0.14)
	other	0.3 (0.05)	0.0 (0.0)	0.0 (0.0)	0.2 (0.04)	0.0 (0.0)	0.0 (0.0)	0.5 (0.07)	0.2 (0.05)	0.3 (0.06)	0.4 (0.06)	0.0 (0.0)	0.0 (0.0)	0.2 (0.04)
Dwelling is equipped with gas[%]	yes, gas network	24.1 (0.43)	45.3 (0.5)	37.8 (0.48)	42.0 (0.49)	59.9 (0.49)	57.2 (0.49)	38.6 (0.49)	16.1 (0.37)	77.9 (0.41)	82.2 (0.38)	68.9 (0.46)	73.5 (0.44)	54.9 (0.5)
	yes, gas canister	71.5 (0.45)	47.1 (0.5)	56.9 (0.5)	53.3 (0.5)	35.1 (0.48)	28.4 (0.45)	49.0 (0.5)	70.8 (0.45)	16.4 (0.37)	11.2 (0.32)	24.1 (0.43)	9.1 (0.29)	36.3 (0.48)
	no	4.3 (0.2)	7.6 (0.26)	5.3 (0.22)	4.7 (0.21)	5.0 (0.22)	14.5 (0.35)	12.4 (0.33)	13.2 (0.34)	5.6 (0.23)	6.6 (0.25)	7.0 (0.25)	17.4 (0.38)	8.8 (0.28)
The dwelling is not equipped with a flushable toilet with running water [%]		1.2 (0.11)	0.1 (0.02)	0.9 (0.1)	0.6 (0.08)	3.4 (0.18)	0.1 (0.03)	**17.1** (0.38)	**25.2** (0.43)	0.6 (0.08)	0.1 (0.04)	0.4 (0.06)	0.1 (0.03)	3.3 (0.18)
The dwelling is not equipped with hot water [%]		0.8 (0.09)	0.3 (0.05)	1.5 (0.12)	1.1 (0.11)	4.2 (0.2)	0.4 (0.07)	**23.1** (0.42)	**25.5** (0.44)	1.0 (0.1)	0.2 (0.05)	0.6 (0.08)	0.4 (0.06)	3.9 (0.19)
The dwelling is too small - subjectively [%]		7.7 (0.27)	4.1 (0.2)	2.0 (0.14)	5.5 (0.23)	9.4 (0.29)	13.1 (0.34)	**25.3** (0.43)	12.6 (0.33)	8.6 (0.28)	5.4 (0.23)	**22.6** (0.42)	**18.7** (0.39)	12.0 (0.33)
The dwelling is too big - subjectively [%]		4.2 (0.2)	4.5 (0.21)	**8.6** (0.28)	**7.4** (0.26)	**6.5** (0.25)	4.3 (0.2)	3.1 (0.17)	4.8 (0.21)	4.1 (0.2)	3.9 (0.19)	1.2 (0.11)	1.7 (0.13)	4.1 (0.2)
Subjective fuel poverty rate (lack of thermal comfort in winter, % of households)		8.32 (0.4)	4.39 (0.2)	8.56 (0.3)	7.86 (0.1)	**14.95** (0.3)	6.47 (0.2)	**38.8** (0.5)	**22.75** (0.4)	10.57 (0.3)	6.08 (0.1)	11.13 (0.3)	7.01 (0.1)	11.45 (0.3)
LIHC	Fuel poverty rate based on PHBS data [% households]	**23.89** (0.4)	7.58 (0.3)	**13.23** (0.3)	9.42 (0.3)	8.03 (0.3)	**10.24** (0.3)	3.18 (0.2)	**15.31** (0.4)	7.46 (0.3)	1.73 (0.1)	7.48 (0.3)	2.81 (0.2)	9.60 (0.3)
	Fuel poverty rate based on KAPE data (heat) and PHBS data (electric power) [%]	**44.57** (0.5)	11.97 (0.3)	**34.07** (0.5)	**21.17** (0.4)	**18.43** (0.4)	12.49 (0.3)	3.74 (0.2)	**34.13** (0.5)	2.57 (0.2)	0.36 (0.1)	1.29 (0.1)	0.65 (0.1)	14.94 (0.4)
	Percentage of households meeting LI criterion (based on PHBS data)	40.63 (0.5)	11.63 (0.3)	26.07 (0.4)	16.28 (0.4)	20.19 (0.4)	14.29 (0.3)	48.63 (0.5)	47.31 (0.5)	22.84 (0.4)	4.07 (0.2)	19.53 (0.4)	6.19 (0.2)	22.97 (0.4)
	Percentage of households meeting HC criterion (based on PHBS data)	62.30 (0.5)	72.30 (0.4)	56.60 (0.5)	66.30 (0.5)	47.78 (0.5)	75.17 (0.4)	8.49 (0.3)	37.66 (0.5)	41.68 (0.5)	49.87 (0.5)	40.46 (0.5)	50.24 (0.5)	49.95 (0.5)

Type (cluster) number	1	2	3	4	5	6	7	8	9	10	11	12	total
Fuel poverty rate - 10% threshold based on PHBS data [% of households]	51.3	26.1	**61.3**	42.5	38.6	33.0	48.4	**63.3**	**68.4**	46.2	33.7	21.7	44.7
	(0.5)	(0.44)	(0.49)	(0.49)	(0.49)	(0.47)	(0.5)	(0.48)	(0.46)	(0.5)	(0.47)	(0.41)	(0.5)
Relative income poverty [% of households]	**21.85**	6.43	**13.78**	1.25	10.31	6.11	**31.94**	**27.31**	7.92	1.72	10.44	1.99	11.43
	(0.3)	(0.2)	(0.3)	(0.3)	(0.4)	(0.2)	(0.5)	(0.4)	(0.3)	(0.2)	(0.3)	(0.3)	(0.3)

Note: Standard deviations in parentheses. Standard deviations were calculated for each category of each discrete variable and are given in percentage points/100.

Source: Own calculations based on the 2014 Polish HBS data.

Table 2. Detailed statistics of identified types (clusters) of households – continuous variables

Type (cluster) number		1	2	3	4	5	6	7	8	9	10	11	12	total
Cluster size [% of households]		14.31	3.57	5.19	5.24	7.61	6.18	5.61	6.66	13.45	7.32	9.91	14.96	100
Floor area [m2]		109.5	**131.0**	100.6	109.9	92.3	99.8	**48.3**	81.5	**46.7**	50.5	51.0	53.5	75.69
		(46.4)	(49.6)	(43.5)	(46.3)	(51.4)	(57.1)	(18.7)	(39.3)	(15.2)	(14.8)	(14.8)	(17.7)	(44.8)
Floor area per person [m2 per person]		36.4	43.1	**53.3**	46.2	39.5	35.2	23.2	40.0	33.0	34.6	19.0	24.6	33.61
		(25.1)	(27.4)	(31.3)	(31.5)	(28.8)	(26.0)	(15.5)	(27.9)	(16.1)	(15.6)	(10.8)	(14.2)	(23.7)
Average number of persons in a household		3.77	3.54	2.32	3.17	2.90	3.32	2.89	2.89	1.76	1.72	3.22	2.65	2.81
		(1.8)	(1.3)	(1.3)	(1.9)	(1.5)	(1.4)	(1.8)	(1.9)	(1.1)	(0.9)	(1.3)	(1.2)	(1.6)
Households' expenditures on heat	Actual expenditures on heat [PLN]	80.5	96.2	70.8	1152	182.8	246.5	103.5	199.4	182.9	199.3	216.0	215.3	220.0
		(144.3)	(137.3)	(90.5)	(718.3)	(313.5)	(403.6)	(189.5)	(383.7)	(123.0)	(141.8)	(171.4)	(134.4)	(347.5)
	Actual expenditures on heat per person [PLN per person]	25.1	30.6	36.3	463.2	74.4	92.3	42.6	98.6	126.2	134.0	78.5	97.0	100.2
		(42.0)	(46.5)	(47.0)	(370.7)	(126.5)	(175.0)	(84.0)	(224.5)	(92.7)	(113.9)	(66.6)	(74.1)	(162.6)
	Actual expenditures on heat [PLN] – median in decile groups	79.8	100.1	72.2	851.2	176.3	227.1	108.6	184.3	185.6	197.7	217.3	219.6	203.0
		(122.9)	(155.0)	(92.9)	(185.9)	(255.5)	(261.8)	(192.9)	(302.7)	(127.0)	(113.0)	(162.6)	(143.5)	(240.1)
	Actual expenditures on heat per m2 [PLN per m2] – median in decile groups	0.8	0.8	0.8	8.6	2.0	2.9	2.0	2.2	4.1	4.0	4.4	4.2	3.1
		(1.2)	(1.2)	(1.1)	(2.7)	(2.7)	(2.9)	(2.8)	(3.4)	(2.3)	(2.0)	(2.7)	(2.2)	(3.0)

Type (cluster) number		1	2	3	4	5	6	7	8	9	10	11	12	total
Household's expenditures on heat	Actual expenditures on heat per person [PLN per person] – median in decile groups	25.2	31.1	36.4	255.5	66.2	78.4	39.8	64.7	128.5	133.9	78.4	97.9	85.9
		(39.2)	(48.0)	(46.9)	(53.1)	(86.6)	(85.3)	(62.0)	(95.4)	(84.7)	(77.6)	(61.9)	(68.7)	(88.2)
	Required expenditures on heat [PLN] (based on KAPE data)	602.0	551.9	493.7	557.0	425.2	381.7	117.1	296.4	128.5	134.1	136.3	135.5	303.8
		(250.1)	(213.7)	(202.1)	(234.8)	(246.1)	(279.9)	(49.2)	(149.4)	(41.4)	(42.6)	(43.7)	(47.4)	(253.8)
	Required expenditures on heat per m2 [PLN per m2] (based on KAPE data)	6.0	4.3	5.0	5.5	4.9	3.7	2.3	3.7	2.7	2.6	2.7	2.5	3.7
		(2.7)	(0.9)	(0.9)	(2.4)	(2.1)	(1.8)	(0.8)	(0.8)	(0.3)	(0.3)	(0.3)	(0.4)	(2.0)
	Required expenditures on heat per person [PLN per person] (based on KAPE data)	179.5	171.7	226.6	201.4	166.6	124.1	53.8	144.4	89.7	92.0	50.4	62.0	120.2
		(92.6)	(82.4)	(85.8)	(93.8)	(96.2)	(91.1)	(38.0)	(94.7)	(47.4)	(44.6)	(30.3)	(37.4)	(90.1)
	Required expenditures on heat [PLN] (based on PHBS data)	280.2	300.5	255.3	281.1	250.7	285.5	140.5	222.4	202.8	219.0	219.5	224.0	236.8
		(113.5)	(112.9)	(108.3)	(116.5)	(155.7)	(120.8)	(58.9)	(122.3)	(64.7)	(61.4)	(62.8)	(71.6)	(105.0)
	Required expenditures on heat per m2 [PLN per m2] (based on PHBS data)	2.6	2.3	2.6	2.6	2.7	3.2	2.9	2.7	4.3	4.4	4.3	4.2	3.4
		(0.4)	(0.4)	(0.3)	(0.4)	(0.8)	(1.0)	(0.4)	(0.6)	(0.3)	(0.2)	(0.3)	(0.4)	(0.9)
Households' expenditures on electric power	Actual expenditures on electricity [PLN]	151.8	176.5	134.2	159.2	158.1	174.4	114.2	120.3	81.1	90.1	114.7	106.1	125.3
		(141.5)	(159.8)	(127.3)	(136.9)	(145.7)	(212.6)	(103.3)	(120.2)	(81.1)	(79.0)	(93.6)	(95.7)	(126.7)
	Actual expenditures on electricity per person [PLN per person]	47.4	56.0	66.2	62.9	65.8	62.8	48.1	51.7	52.9	57.5	40.2	45.2	52.6
		(50.1)	(55.4)	(62.8)	(61.7)	(67.6)	(157.9)	(45.2)	(52.8)	(51.0)	(52.6)	(35.8)	(43.0)	(63.9)
	Actual expenditures on electricity [PLN] – median in decile groups	146.3	168.4	130.1	153.7	149.4	160.1	114.0	117.5	82.5	92.1	115.6	106.5	122.4
		(122.1)	(128.0)	(109.7)	(120.0)	(115.2)	(124.2)	(96.6)	(104.7)	(72.7)	(77.8)	(92.6)	(92.3)	(106.2)

Type (cluster) number		1	2	3	4	5	6	7	8	9	10	11	12	total
Households' expenditures on electric power	Actual expenditures on electricity per m2 [PLN per m2] – median in decile groups	1.5 (1.4)	1.5 (1.3)	1.5 (1.3)	1.6 (1.3)	1.9 (1.6)	1.9 (1.6)	2.3 (1.8)	1.6 (1.4)	1.7 (1.5)	1.8 (1.5)	2.3 (1.7)	2.0 (1.6)	1.8 (1.5)
	Actual expenditures on electricity per person [PLN per person] – median in decile groups	44.4 (38.5)	50.9 (40.2)	58.9 (44.5)	55.6 (42.9)	56.7 (42.0)	52.4 (41.5)	46.0 (37.5)	47.9 (40.5)	50.0 (41.0)	53.8 (41.1)	39.4 (32.3)	43.6 (37.5)	48.6 (39.9)
	Required expenditures on electricity [PLN] (based on HBS data)	78.7 (10.3)	80.4 (0.0)	60.3 (0.7)	71.9 (10.9)	74.1 (10.8)	100.8 (0.5)	70.1 (11.3)	71.3 (12.7)	60.4 (4.0)	60.2 (0.4)	80.4 (0.0)	80.4 (0.6)	74.1 (12.6)
	Required expenditures on electricity per m2 [PLN per m2] (based on HBS data)	0.9 (0.1)	0.9 (0.1)	0.8 (0.1)	0.9 (0.1)	1.1 (0.5)	1.1 (0.2)	1.4 (0.3)	0.9 (0.3)	1.1 (0.1)	1.1 (0.1)	1.3 (0.1)	1.3 (0.1)	1.1 (0.3)
Income	Household's disposable income [PLN] – median in decile groups	3723 (2204)	5275 (2235)	2951 (1688)	4203 (2222)	3932 (2259)	5086 (2413)	2477 (1468)	2747 (1837)	**2277** (1169)	3154 (1596)	3801 (1708)	4757 (2253)	3655 (2156)
	Household's disposable income per person [PLN per person] – median in decile groups	1102 (627,8)	1622 (728,6)	1374 (615,2)	1517 (702,0)	1485 (724,6)	1660 (805,9)	**992** (550,5)	1077 (567,2)	1459 (619,0)	1900 (637,1)	1317 (633,9)	1900 (778,1)	1459 (735,2)
	Household's equivalent disposable income [PLN] – median in decile groups	2469 (1313)	3740 (1554)	2726 (1221)	3234 (1435)	3199 (1511)	3790 (1714)	2078 (1017)	2228 (1129)	2743 (1109)	3645 (1294)	2941 (1248)	4159 (1596)	3090 (1506)
	Household's disposable income [PLN]	3758 (4166)	5468 (3018)	2924 (1696)	4302 (2683)	4045 (3266)	5431 (3705)	**2408** (1507)	2700 (2325)	**2259** (1171)	3158 (1572)	3817 (1897)	4982 (3764)	3727 (3063,9)

Type (cluster) number		1	2	3	4	5	6	7	8	9	10	11	12	total
Consumption	Expenditures on consumer goods and services [PLN] - median in decile groups	2807	3737	2213	3913	2956	3841	1967	2159	1874	2355	2907	3508	2809
		(1454)	(1662)	(1239)	(1696)	(1653)	(1746)	(1060)	(1292)	(926)	(1259)	(1342)	(1634)	(1570)
	Expenditures on consumer goods and services per person [PLN per person] - median in decile groups	832	1146	1038	1415	1125	1278	778	857	1189	1394	1003	1410	1126
		(435.3)	(533.5)	(503.5)	(558.7)	(562.4)	(606.5)	(422.0)	(468.9)	(515.1)	(519.7)	(489.2)	(584.0)	(563.9)
	Equivalent expenditures on consumer goods and services [PLN] - median in decile groups	1861	2629	2064	3044	2424	2903	1642	1767	2246	2681	2252	3107	2387
		(893.8)	(1144)	(1008)	(1152)	(1177)	(1285)	(811)	(909)	(952)	(1065)	(994)	(1211)	(1156)

Note: Standard deviations in parentheses.

Source: Own calculations based on the 2014 Polish HBS data.

A7. Detailed statistics for the fuel poor (LIHC measure) in identified types of households

Type (cluster) number		1	2	3	4	5	6	7	8	9	10	11	12	total*
Percentage of the fuel poor in each cluster (LIHC measure based on PHBS)		23.9	7.6	13.2	9.4	8.0	10.2	3.2	15.3	7.5	1.7	7.5	2.8	9.6
Floor area [m2]		130.7	146.4	123.6	128.3	128.3	126.8	84.3	108.5	62.0	61.6	67.2	64.4	111.0
Floor area per person [m2 per person]		43.1	41.3	64.7	48.0	49.5	36.2	33.3	56.0	41.2	43.4	22.2	26.8	43.4
Average number of people in a household		3.9	4.1	2.6	4.1	3.4	3.9	3.6	2.9	2.0	1.9	3.7	2.9	3.4
Type of building [%]	Block of flats	0.1	0.0	0.0	0.0	2.6	26.1	93.8	0.9	99.4	**100.0**	**100.0**	**100.0**	27.5
	Terraced house	0.0	0.0	1.1	5.7	**86.8**	16.2	6.2	2.7	0.6	0.0	0.0	0.0	7.4
	Detached house	**99.9**	**100.0**	**98.9**	94.3	10.6	57.7	0.0	**96.4**	0.0	0.0	0.0	0.0	65.0
Degree of urbanisation [%]	City with more than 500 thous. residents	0.3	2.2	0.9	1.9	3.6	9.1	2.3	0.3	8.1	**15.0**	6.1	19.8	3.6
	City with less than 500 thous. residents	18.2	23.3	15.4	22.2	41.2	39.5	64.5	16.7	**70.2**	73.7	**65.7**	74.6	34.2
	Rural areas	**81.5**	74.5	83.7	75.9	55.2	51.4	33.2	**83.0**	21.6	11.3	28.2	5.6	62.2
Socioeconomic group	Farmers and self-employed	31.0	0.0	0.0	8.4	19.2	**100.0**	4.9	15.7	0.3	0.0	0.0	0.5	21.1
	Manual workers	38.8	0.0	0.0	36.0	25.5	0.0	39.3	23.8	6.4	0.0	**100.0**	0.0	28.9
	Non-manual workers	6.4	**100.0**	0.0	10.4	19.2	0.0	8.8	6.3	0.0	0.0	0.0	**99.5**	12.0
	Retirees	5.9	0.0	97.8	30.9	22.9	0.0	7.3	31.2	40.6	**88.9**	0.0	0.0	21.0
	Pensioners	12.2	0.0	0.2	10.7	7.0	0.0	23.3	16.6	25.7	0.0	0.0	0.0	10.2

Type (cluster) number		1	2	3	4	5	6	7	8	9	10	11	12	total*
	Living on social benefits	3.8	0.0	0.9	1.8	4.6	0.0	10.7	3.7	16.6	0.0	0.0	0.0	4.1
	Living on other non-earned sources	1.8	0.0	1.1	1.9	1.6	0.0	5.8	2.8	10.3	11.1	0.0	0.0	2.6
Households' expenditures on heat	Actual expenditures on heat [PLN]	80.8	68.6	68.9	1123.0	189.2	160.9	151.2	141.5	194.6	155.8	200.8	211.6	180.9
	Actual expenditures on heat per person [PLN per person]	23.9	17.9	34.2	411.9	61.1	46.0	47.8	67.9	130.5	116.6	65.6	83.3	71.5
	Required expenditures on heat [PLN] (based on PHBS data)	339.0	342.3	319.7	346.0	379.1	348.0	277.6	320.7	266.8	261.3	289.7	272.0	322.8
	Required expenditures on heat [PLN] (based on KAPE data)	706.9	624.2	615.9	685.3	523.8	534.0	210.2	395.8	166.9	159.6	183.7	165.5	504.0
Households' expenditures on electricity	Actual expenditures on electricity [PLN]	141.7	166.1	125.8	156.0	156.6	180.6	112.8	117.0	85.1	77.0	111.9	113.5	132.0
	Actual expenditures on electricity per person [PLN per person]	43.1	45.2	61.0	50.1	52.1	49.9	31.6	49.9	49.4	44.0	33.4	44.2	46.3
	Required expenditures on electricity [PLN] (based on PHBS)	78.9	80.4	60.2	72.2	75.3	100.8	71.4	71.3	60.9	60.0	80.4	80.5	75.6
Subjective fuel poverty rate (lack of thermal comfort in winter, % of households)		9,0	10.2	9.8	9.1	8.0	11.6	**39.0**	**21.7**	11.9	6.9	**13.6**	5.8	11.6
Relative income poverty [% of households]		**32,6**	20.3	25.1	5.0	23.5	19.3	**44.4**	**35.6**	16.6	7.7	27.8	11.0	26.1

Note: All statistics, apart from the first row of the table, refer to fuel poor households indicated by LIHC definition (9.6% of all households).

Source: Own calculations based on the 2014 Polish HBS data.

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