IOP Conf. Series: Earth and Environmental Science **164** (2018) 012002 doi:10.1088/1755-1315/164/1/012002

SPATIAL DIFFERENTIATION OF ENERGY POVERTY IN EU COUNTRIES

M Zawada[1a], M Szajt[1], J Kowalik[1] and R Kucęba[2b]

[1] Technical University of Czestochowa, Faculty of Management, Department of Econometrics and Statistics, Al. Armii Krajowej 39b 42-200 Częstochowa, Poland
[2] Technical University of Czestochowa, Faculty of Management, Institute of Information Management Systems, Al. Armii Krajowej 19b 42-200 Częstochowa, Poland

[a]marcinzawada04@gmail.com; [b]robertkuceba@wp.pl

Abstract: The provision of heat and electricity in the household is one of the basic human needs. However, many households are experiencing energy poverty, so it is difficult to satisfy basic energy needs. These households have to choose between drastic energy savings, which results in experiencing lack of thermal comfort and energy expenditure at the expense of other basic needs, such as food or health. The main aim of this article is to analyse the state of energy poverty in the European Union countries by comparing the basic characteristics of its measurement such as: income, energy consumption, energy prices in the years 2006-2015. This allowed to indicate the existence of spatial variations between members of the European Union.

1. Introduction

Low incomes force people to limit their expenditures and more Modest existence. However, there are so called basic goods, resignation from which is difficult. It has been assumed that energy belongs to such goods. It is an essential element of our lives. It makes our lives easier, creates comfortable working and relaxation conditions. It is also indispensable to illuminate the households, prepare meals, prepare hot domestic water and also to heat our houses. The necessity to decrease the total energy consumption has been recognized to be a priority at the EU level, however, it needs to be stressed that energy is required in everyday lives of everybody, regardless of whether they are rich or poor. Therefore, it is this context in which the term of energy poverty should be analysed, which consists in, among others, lack of equal access of households to energy and problems that follow as a result of that situation [1].

A uniform definition of energy poverty does not exist. One of the first to propose such a definition was B. Boardman [2] in 1991, who stated that „energy poverty occurs if a household spends more that 10% of its income on all types of energy, in this energy required to heat the household at a satisfactory level". The 10-percent-treshold accompanied this definition of energy poverty, which is the most frequently applied index used to identify this phenomenon. In the course of years defining energy poverty has been undergoing permanent changes depending on the researcher of this phenomenon and the country of their origin. In 2011 the European Economic and Social Committee in its opinion suggested that the general definition of energy poverty should be each time adapted to the local situation of each of the EU's member states [3].

Spatial differentiation of particular dimensions of energy poverty is vital for constructing effective instruments of social policy. Efficiency of poverty counteracting instruments depends not only on proper identification of the group in need, but also on adjusting the type of support to the characteristics of the poor in the given region.

2. Characteristics of the European Union countries in the scope of energy consumption and economic development

Energy consumption and economic development remain in a close relationship [4]. Basic macroeconomic indexes that characterize particular countries usually comprise (per capita): GDP, energy consumption (in this electricity) and recently also CO2 emission. They are frequently supplemented by the value of Human Development Index (HDI) and average life expectancy of inhabitants. All these values for 28 countries of the European Union have been presented in Table 1.

In 2015 compared to 2006 the average life expectancy in each of the countries increased (most in Estonia), and the level of HDI likewise (most in Poland). In case of GDP its decrease was recorded only in two countries (Cyprus and Greece). The level of electricity consumption per capita in 10 countries increased (most in Estonia), in the remaining 18 counties it decreased, while the largest decrease was recorded in Luxembourg, Finland and Sweden. Electricity prices in comparative periods grew in all the countries except the Netherlands. The largest growth was recorded in Spain, the lowest one in Hungary and Slovakia. In 27 countries the emission of CO2 significantly decreased (most in Luxembourg and Denmark) The only country where the emission grew was Lithuania.

Table 1. Energy and development indicators in 2006, 2014 and 2015

Country	HDI		GDP per capita $ PPP		Life expectancy (years)		Electricity consumption per capita (kW h)		Energy consumption per capita (toe)		Electricity prices (EUR per kWh)		CO2 per capita (t)	
	2006	2015	2006	2015	2006	2015	2006	2014	2006	2014	2006	2015	2006	2014
Austria	0,860	0,893	41907	50078	79,9	81,8	8244	8361	4,1	3,8	0,134	0,201	8,7	6,9
Belgium	0,871	0,896	35406	46283	79,4	81,3	8684	7709	5,5	4,7	0,144	0,213	10,2	8,3
Bulgaria	0,755	0,794	14963	19199	72,6	74,5	4367	4709	2,7	2,5	0,066	0,094	6,4	5,9
Croatia	0,793	0,827	19205	23596	75,8	77,3	3635	3714	2,2	1,9	0,092	0,132	5,1	4,0
Cyprus	0,836	0,856	33295	32580	78,7	80,3	4238	3625	2,2	1,7	0,143	0,196	7,4	5,3
Czech Republic	0,851	0,878	27659	34711	76,5	79,5	6529	6259	4,5	3,9	0,099	0,139	11,9	9,2
Denmark	0,904	0,925	43083	49696	78,1	81,1	6825	5859	3,7	2,9	0,236	0,307	10,1	5,9
Estonia	0,829	0,865	21623	29365	72,7	77,1	5869	6732	3,8	4,6	0,073	0,130	12,0	14,8
Finland	0,873	0,895	38812	43053	79,2	81,4	17215	15249	7,1	6,2	0,108	0,155	12,6	8,7
France	0,873	0,897	36027	41466	80,8	82,7	7540	6938	4,2	3,7	0,119	0,168	5,9	4,6
Germany	0,898	0,926	39263	48730	79,1	81,1	7212	7035	4,2	3,8	0,183	0,295	9,9	8,9
Greece	0,855	0,866	28203	26783	79,4	81,6	5435	5063	2,7	2,1	0,070	0,177	8,8	6,2
Hungary	0,809	0,836	21467	26681	73,1	76,0	3882	3966	2,7	2,3	0,108	0,113	5,7	4,3
Ireland	0,902	0,923	43221	68883	79,2	81,5	6351	5722	3,4	2,8	0,149	0,243	10,1	7,4
Italy	0,862	0,887	35076	38161	81,3	83,5	5833	5002	3,2	2,4	0,211	0,245	8,1	5,3
Latvia	0,814	0,830	17593	26031	70,9	74,1	2967	3507	2,1	2,2	0,083	0,164	3,6	3,5
Lithuania	0,812	0,848	20130	29966	71,1	75,1	3353	3821	2,7	2,4	0,072	0,126	4,3	4,4
Luxemburg	0,877	0,898	85779	105882	79,3	82,2	16457	13915	9,2	6,9	0,160	0,177	24,0	17,4
Malta	0,808	0,858	27863	37899	79,4	81,9	4898	5007	2,1	1,8	0,095	0,126	6,4	5,5
Netherlands	0,899	0,924	44586	50898	79,7	81,7	7026	6713	4,9	4,3	0,209	0,199	11,0	9,9
Poland	0,808	0,855	21089	27811	75,1	78,2	3585	3972	2,5	2,5	0,119	0,144	8,4	7,5
Portugal	0,797	0,843	27361	30624	78,4	81,5	4827	4663	2,4	2,0	0,141	0,228	5,7	4,3
Romania	0,766	0,802	17181	23626	72,2	75,0	2446	2584	1,9	1,6	0,094	0,130	4,9	3,5
Slovenia	0,865	0,890	27793	32885	78,1	81,1	7124	6728	3,6	3,2	0,105	0,159	8,1	6,2
Slovakia	0,802	0,845	25011	30632	74,2	77,2	5153	5137	3,5	2,9	0,145	0,151	7,3	5,7
Spain	0,849	0,884	31984	36310	80,8	83,4	6105	5356	3,2	2,5	0,115	0,231	7,9	5,0
Sweden	0,895	0,913	41668	49175	80,7	82,6	15263	13480	5,5	5,0	0,144	0,185	5,5	4,5
United Kingdom	0,889	0,910	35741	42609	79,2	81,6	6201	5130	3,6	2,8	0,102	0,213	8,9	6,5

Source: World Bank and Eurostat

In most cases moderate linear dependencies occur among analyses values. A strong correlation can be observed in case of CO2 emission and energy consumption and life as well as life expectancy and HDI. Statistically insignificant proved to be the correlation between life expectancy and CO2 emission. Weak dependencies occur between CO2 and HDI and energy consumption and life expectancy (Table 2). Electricity price is negatively correlated with all the other variables. An exception is life expectancy. Unfortunately, these dependencies are weak or very weak and simultaneously statistically insignificant.

Table 2. Correlation coefficients among values characterizing development and energy consumption (2014)

	HDI	GDP	Life expec	Electricity	Energy	Prices	CO2
HDI	1	0,6650	0,7793	0,5390	0,5492	-0,0298	0,3812
GDP		1	0,5433	0,6473	0,6748	-0,1766	0,6352
Life expec			1	0,4787	0,3512	0,1222	0,2053
Electricity				1	0,9149	-0,0652	0,5362
Energy					1	-0,2444	0,7488
Prices						1	-0,2361
CO2							1

Source: own calculations on the basis of data by Eurostat and World Bank

To sum up, it can be concluded that energy consumption is necessary, but it alone is not sufficient for economic development. Moreover, from a certain level of development it is implemented political strategies that decide whether it is possible to improve or maintain the standards of welfare without an increase in energy consumption. Undoubtedly, the best way to understand the importance of energy is to analyse the effects of lack of access to it – for various reasons – that is the phenomenon of energy poverty.

3. **Energy poverty measurement**

Main measures that allow to assess the level of energy poverty most frequently applied in the research on this phenomenon include [5]:

- The Ten-Percent-Rule (TPR)
- Double Median or Mean indicator
- Low Income, High Cost (LIHC) indicator
- Minimal Income Standard (MIS) indicator

The first one of them has already been mentioned while defining the energy poverty phenomenon. This definition was accepted as a starting point to analyse energy poverty. In Great Britain, the country that as the first one took interest in this problem and possesses the greatest experience in measuring and limiting it, active works aimed at changing it for the one that better classifies the energy poor are ongoing. One of the most widely discussed definitions is the one coming from the breakthrough report of J. Hills [6]. The Ten-Percent-Rule (TPR) and Double Median indicators share a common history. However, I argue that they can and should be differentiated. Both indicators define energy poverty as excess spending on energy beyond a certain threshold, most prominently, a ten percent share or double median share of energy expenditure for all households relative to net income.

Low Income, High Cost LIHC is a relative measure. It is based on the concept of low incomes and high expenditures (model ones) on energy. In both dimensions the terms “high” and “low” are dependent on the distribution of incomes and expenditures of the population. Technically, they consist with reference to the level of median: households that achieve equivalent incomes lower than 60% of the median and expenditure on energy above the expense of the median household.

These minimum income standards (MIS) can be used with data from the Housing Survey to estimate the number of households in fuel poverty. In this context, households are deemed to be in fuel poverty if, after deducting their actual housing costs, they have insufficient residual net income to meet their total required fuel costs after all other minimum living costs (as defined by the MIS) have been met. Conversely, a household is in MIS based fuel poverty if Fuel costs (HS) > Net household income (HS) – housing costs (HS) – minimum living costs (MIS).

Figure 1 presents information concerning the percentage of population in particular EU countries who are in arrears with utility bills during 2015. The largest arrears occur in Greece (42%), Bulgaria (31,4%) and Croatia (28,7%), the lowest ones in Luxembourg (2,4%), the Netherlands (2,7%) and the Czech Republic (3%).

The relationship between arrears in utility bills payments and the average share of energy products in total consumption expenditures of households seems to be weak. However, it needs to be stressed that in case of some social and economic groups, whose share of energy products in total consumption expenditures is larger compared to the average national, the probability of arrears in utility bills is higher.

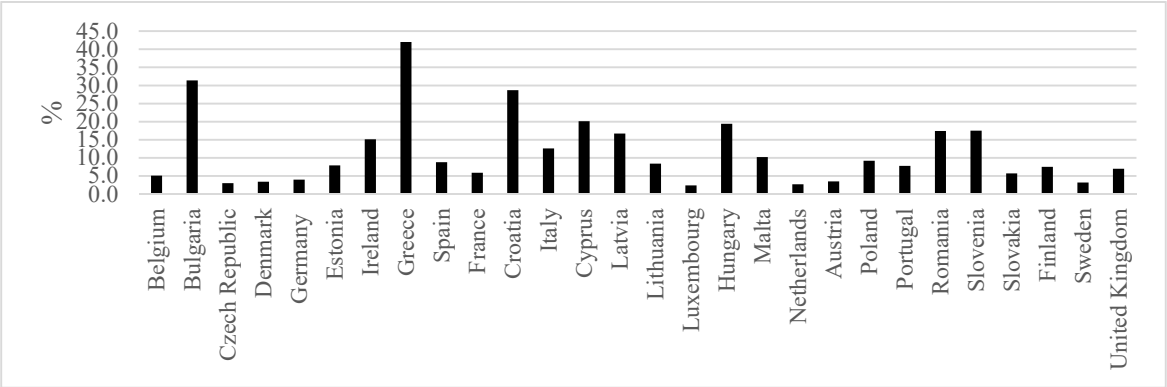

Figure 1. Percentage of population in arrears with utility bills in 2015
Source: own elaboration on the basis of data by Eurostat [ilc_mdes07]

Among the inhabitants whose incomes are below 60% of the median the largest percentage of those in arrears with utility bills can be observed in Greece, Bulgaria and Hungary. Among those whose incomes are above 60% of the median the largest arrears can be noticed in case of Greece, Bulgaria and Croatia (Figure 2).

Another picture (Figure 3) presents information concerning the percentage of expenditures incurred by households for electricity, gas and other fuels used to heat the accommodation and domestic hot water preparation. This information comes from the survey on consumption expenditures that was conducted by Eurostat in 5-year time intervals. The latest data from this survey comes from the year 2010. Another edition of this survey was conducted in 2015, but the data was not available yet at the time when the present paper was prepared. The largest expenditures are incurred by households in Slovakia, Hungary and the Czech Republic, the lowest ones in Malta, Cyprus and Spain. The largest growth of expenditures compared to the year 2005 concerns three countries: Latvia, Estonia and Great Britain, the largest decrease was recorded in Romania.

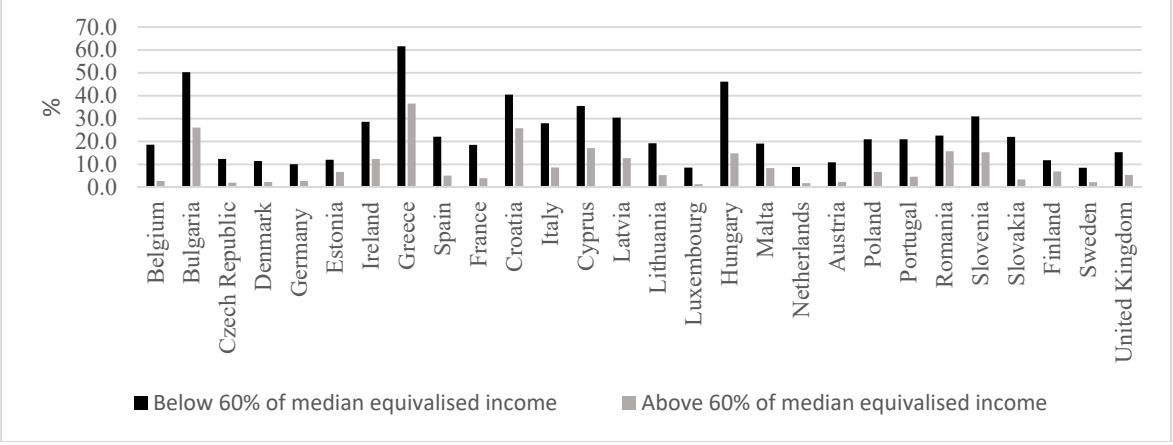

Figure 2. Percentage of population in arrears with utility bills: populations above and below 60% of median equivalised income in each Member State in 2015
Source: own elaboration on the basis of data by Eurostat [ilc_mdes07]

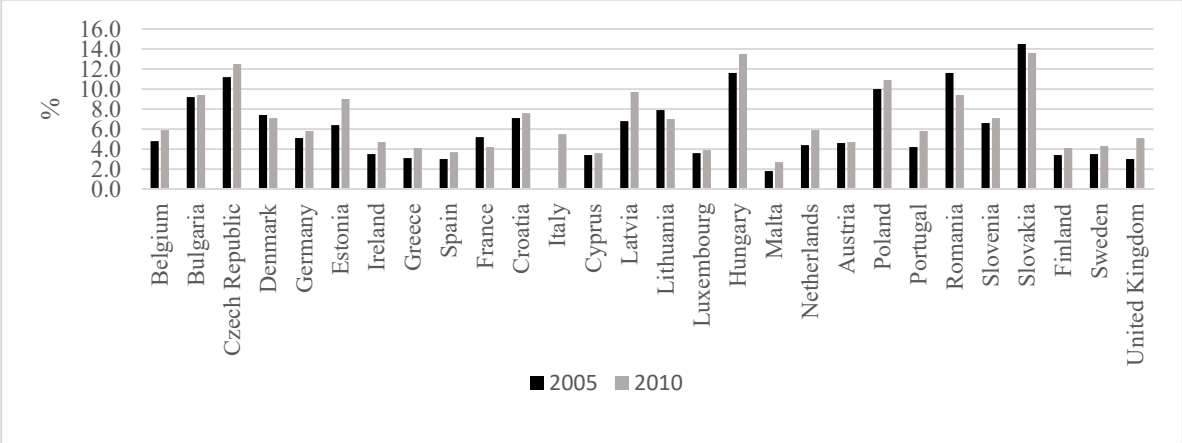

Figure 3. Percentage of expenditures incurred by households for electricity, gas and other fuels used to heat the accommodation and prepare hot domestic water
Source: own elaboration on the basis of data by Eurostat [hbs_str_t211].

4. Conclusions

In search for new measures that allow for better description of the problem of energy poverty the Authors suggest that the ones should be constructed that will consider [7]:

- Information on the choice and availability of energy carriers. It is important to note that this should not be limited to mains gas and electricity only – rather it should incorporate all potential sources, including, for example, self-collected firewood and peat. This would enable examination of 'energy degradation' issues.
- Information on householder flexibility to move to new energy services, to understand infrastructural and built environment contexts.
- Technical energy efficiency and housing quality data, to allow estimation of theoretical energy costs
- Information on the ways in which households may have rationed their provision of energy services in the home – for example by restricting heating, lighting and/or usage of appliances.

The EU has adopted numerous initiatives in order to evaluate the problem connected with energy poverty at the local, regional and national level and also to determine the most effective palliative actions. However, the most effective measures to prevent energy poverty in households or mitigate it are actions directed at the level of households.

5. References

[1] Szamrej-Baran I 2017 Ranking krajów UE ze względu na ubóstwo energetyczne. *Gospodarka w Praktyce i Teorii 43*, pp. 79-91
[2] Boardman B 1991 Fuel Poverty: From Cold Homes to Affordable Warmth, Belhaven Press London, pp. 2-224
[3] European Economic and Social Committee 2011 Opinion on Energy Poverty in the Context of Liberalisation and the Economic Crisis 2011/C 44/09, pp.53-56
[4] Zawada M Włodarczyk A Piłatowska M 2015 *CO2 Emissions, Energy Consumption and Economic growth in the EU Countries: Evidence from Threshold Cointegration Analysis*, 12th International Conference on the European Energy Market (EEM), Lisbon, Portugal, IEEE, pp.1-5
[5] Schuessler R 2014 Energy Poverty Indicators: Conceptual Issues-Part I: The Ten-Percent-Rule and Double Median/Mean Indicatorspp, Center for European Economic Research, pp.3-23

[6] Hills J 2012 *Getting the measure of fuel poverty. Final report of the fuel poverty review*, Raport CASE nr 72, London
[7] Thomson H Bouzarovski S Snell C 2017 Rethinking the measurement of energy poverty in Europe: A critical analysis of indicators and data, *Indoor and Built Environment*, 1420326X17699260