ENERGY POVERTY AND THE CHARACTERISTICS OF

ENERGY-POOR HOUSEHOLDS IN TURKEY

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ENERGY POVERTY AND THE CHARACTERISTICS OF ENERGY-POOR HOUSEHOLDS IN TURKEY

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DECLARATION OF ORIGINALITY

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ABSTRACT

Energy Poverty and the Characteristics of Energy-Poor Households in Turkey

Energy poverty is an important and distinct part of the multi-dimensional poverty concept and it is a growing concern in the international arena. There are many well-documented country-specific studies on the concept of energy poverty. The aim of this thesis is to constitute a comprehensive and detailed energy poverty analysis for Turkey, for the first time, focused on both "the estimation of the extent of energy poverty with each available indicator in the literature for Turkey" and "the characterization of energy-poor households using econometric analysis". The thesis is constructed in two parts: Part 1 includes the calculation of the rates of energy poverty in Turkey using the four expenditure-based and four consensual-based indicators and analyses related to this calculation. Part 2 includes different logit models to find the most influential demographic, socioeconomic, and dwelling characteristics of the energy-poor households in Turkey, and descriptive statistics to see the change of these characteristics over the years. Data analysis indicates that energy poverty rates for Turkey have decreased from 2003 to 2018 for all indicators. Regarding the most influential demographic, socioeconomic, and dwelling characteristics of the energy-poor households; having a household head who is unemployed or inactive, and with a low educational level; living in a detached house, and being a tenant seems to be the common key factors explaining the higher probability of a household being energy-poor.

ÖZET

Türkiye’de Enerji Yoksulluğu ve Enerji Fakiri Hanehalklarının Özellikleri

Enerji yoksulluğu, çok boyutlu yoksulluk kavramının önemli ve ayrı bir parçasıdır ve uluslararası alanda gündemi artan bir şekilde meşgul eden bir araştırma konusudur. Pek çok ülke için enerji yoksulluğu kavramı üzerine çok sayıda iyi belgelenmiş çalışmalar yapılmıştır. Bu çalışmanın amacı da, “literatürdeki mevcut her bir gösterge ile Türkiye’de enerji yoksulluğunun boyutunun tahmini" hem de "Türkiye’de enerji fakiri hanehalklarının ekonometrik analiz kullanılarak karakterizasyonu" için yıllar içinde kapsamlı ve ayrıntılı bir enerji yoksulluğu analizini ilk kez oluşturmaktır. Bu çalışma iki bölümden oluşmaktadır: Birinci bölüm, dört harcama temelli ve dört rızaya dayalı gösterge kullanılarak Türkiye’deki enerji yoksulluğu oranlarının hesaplanmasını ve bu hesaplamaya ilişkin farklı analizleri içermektedir. İkinci kısım ise, Türkiye’deki enerji fakiri hanehalklarının en etkili demografik, sosyoekonomik ve mesken özelliklerini bulmak için farklı logit modellerini ve bunların zaman içerisindeki değişimini görmek için tanımlayıcı istatistikleri içermektedir. Veri analizi, Türkiye için enerji yoksulluk oranlarının tüm göstergeler için 2003’ten 2018’e düştüğünü göstermektedir. Enerji fakiri hanehalklarının en etkili demografik, sosyoekonomik ve mesken özelliklerine gelince; işsiz veya çalışmayan/iş aramayan ve düşük eğitim seviyesine sahip bir hane reisine sahip olmak; müstakil bir evde yaşamak ve kiracı olmak bir hanenin enerji açısından fakir olma olasılığının daha yüksek olduğunu açıklayan ortak anahtar faktörlerdir.

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CHAPTER 1

INTRODUCTION

Energy poverty is an important and distinct part of the multi-dimensional poverty concept in terms of three aspects (Hills, 2011). Firstly, energy poverty alleviation also leads to a direct reduction in poverty itself as it constitutes a considerable part of it. The second aspect is about the physical-mental health and well-being of people. According to the 1987 review of the World Health Organization (WHO), an ideal indoor temperature interval should be between 18^0C and 24^0C. An environment whose temperature is below this level is said to cause serial health consequences like excess winter deaths. Lastly, the relationship of energy poverty with climate change issues such as the reduction in Greenhouse gas (GHG) emissions makes the topic of energy poverty distinct and notable.

In the literature, there are two interrelated terminologies regarding the problem of access to domestic energy consumption for residential households: fuel poverty and energy poverty. Fuel poverty occurs when insufficient funds to pay for the basic levels of energy are needed (Boardman, 2010). Energy poverty occurs when inadequate access to energy supplies (Bouzarovski, Petrova, & Tirado Herrero, 2014). While fuel poverty is about affordability, energy poverty is about accessibility. Although energy poverty and fuel poverty have similarities and differences, these two terms are used interchangeably in the literature (Foster, Tre, & Wodon, 2000; Buzar, 2007; Harrison & Popke, 2011; Bouzarovski, Petrova, & Sarlamanov, 2012; Castaño-Rosa, Solís-Guzmán, Rubio-Bellido, & Marrero, 2019). Moreover, the European Union Energy Poverty Observatory (EPOV) uses the term of energy poverty for both issues. Therefore, I also use the term of energy poverty throughout this paper for both issues.

As energy poverty is a multifaceted concept, it cannot be easily addressed by a single indicator (Moore, 2012; Middlemiss & Gillard, 2015; Bouzarovski & Petrova, 2015; Simcock, Walker, & Day, 2016). The literature identifies three main methods of measurement: the expenditure-based approach, the consensual-based approach, and the direct measurement approach (Rademaekers et al., 2016; Thomson, Bouzarovski, & Snell, 2017). In addition to addressing energy poverty by a set of indicators, several factors contribute to the concept of energy poverty. In the literature, the main factors contributing to energy poverty are low income, high energy prices, and poor housing quality or energy efficiency of housing. (Department for Business Enterprise and Regulatory Reform [BERR], 2001; The Organisation for Economic Co-operation and Development/International Energy Agency [OECD/IEA], 2011; Ürge-Vorsatz & Tirado Herrero, 2012). Ürge-Vorsatz and Tirado Herrero (2012) conclude that a long-term solution and the key factor for households to be out of energy poverty is indeed energy efficiency of housing. This solution also, they add, can lead to a reduction in GHG emissions and create other co-benefits such as net employment and reduction in energy dependency. Moreover, EPOV states that lower health spending by governments, lower air pollution and CO2 emissions, better comfort and well-being, improved household budgets, and increased economic activity are potential benefits of addressing energy poverty.[1]

Because energy poverty is a part of the multi-dimensional poverty concept and addressing energy poverty can deliver multiple benefits, energy poverty is a growing concern in international arena and the concept of energy poverty is well documented for many countries. Argentina, Brazil and Venezuela (World Energy Council [WEC], 2006), United Kingdom (Liddell, Morris, McKenzie, & Rae, 2012), Hungary (Tirado Herrero, Ürge-Vorsatz, & Petrichenko, 2013), France (Legendre & Ricci, 2015), China (Wang, Wang, Li, & Wei, 2015), Spain (Tirado Herrero & Jiménez Meneses, 2016), Japan (Okushima, 2016), Greece (Boemi, Avdimiotis, & Papadopoulos, 2017), and the Czech Republic (Karásek & Pojar, 2018) already have detailed energy

[1]Retrieved from: https://www.energypoverty.eu/about/what-energy-poverty

poverty reports. In all of the studies, the concept of energy poverty is deeply examined and the states of energy poverty in these countries in the concept are well reported. On the other hand, four energy poverty related studies have been conducted so far in Turkey. Although the concept of energy poverty is a multi-faceted concept, none of these studies fully assess the extent of energy poverty using all indicators in the literature. Besides, no significant analysis has been made for the characterization of energy-poor households in these studies. The aim of this thesis is to constitute a comprehensive and detailed energy poverty analysis over the years in Turkey, for the first time, for both "the estimation of the extent of energy poverty with both approaches in the literature" and "the characterization of energy-poor households using econometric analysis".

This thesis is constructed in two parts. In the first part, prior to the estimation of the energy poverty rates for Turkey, I first examine the structure of Turkish households' energy expenditures. I, then, estimate the extent of energy poverty in Turkey over the years between 2003 and 2018 using the four expenditure-based (i.e. the 10% indicator, the 2M indicator, the after-fuel-cost poverty (AFCP) indicator, and the hidden energy poverty (HEP) indicator) and four consensual-based indicators (i.e. the keep-warm indicator, the arrears indicator, the housing-faults indicator, and the Energy Poverty Index) and compare the state of energy poverty in Turkey with the European Union countries. Besides, I evaluate the main contributing factors of energy poverty in the literature for Turkey to explain the change in the extent of energy poverty rates of Turkey over this period.

In the second part, I conduct an econometric analysis for the most influential demographic, socioeconomic, and residential characteristics of the energy-poor households in Turkey. I estimate 3 different logit models for each of the expenditure-based indicators and 1 ordered logit model for the Energy Poverty Index from the consensual-based indicators for the characterization of energy-poor households. Then, I assess the descriptive statistics for the change in the composition of energy-poor households across these characteristics over the years.

The data sets used for this thesis are mainly the Turkish Statistical Institute's (TurkStat) 2003-2018 Household Budget Surveys (HBS), for expenditure-based indicators and analysis based on these indicators, and 2006-2018 Income and Living Conditions Surveys (SILC), for consensual-based indicators and analysis based on these indicators. They are all detailed and representative surveys at the country level that includes data on individuals' income, employment status, and demographic characteristics and information on dwelling conditions for a total of 161,844 households and a total of 224,026 households respectively.

The rest of this thesis is structured as follows: Chapter 2 presents a literature review on energy poverty and its measures. Chapter 3 describes the data sources and the methodology used in the calculation and analysis of energy poverty in Turkey. Chapter 4 presents the calculation of the rates of energy poverty in Turkey using the indicators in the literature and several analyses related to this calculation. Chapter 5 focuses on the regression analyses for the characteristics of energy-poor households and descriptive statistics for the change of these characteristics over the years. Chapter 6 provides a brief overview of the main findings and gives some possible future research ideas and paths.

CHAPTER 2

ENERGY POVERTY AND ITS MEASURES

Energy poverty is a multi-faceted concept as stated in the introduction. Although there is no consensus in the literature on one single definition of energy poverty, a consensus has almost been achieved in alternative ways of measuring energy poverty. There are three main methods of measurement: the expenditure approach, the consensual approach, and the direct measurement approach (Rademaekers et al., 2016; Thomson et al., 2017). The direct measurement approach tries to measure whether or not the sufficient level of energy services such as heating and lighting is achieved. While the approach is attractive in theory in terms of its directness, due to technical difficulties of measuring energy services, determining adequate standards, and ethical issues related to household monitoring, it has hardly been used in practice and regional scales. (Thomson et al., 2017).The expenditure approach gathers expenditure-based indicators that are energy-consumption related indicators and uses financial information to capture insufficient consumption or affordability of energy services. Finally, the consensual approach gathers consensual-based indicators that are based on self-assessments of households about their well-being and provide an effective way to understand the perceived energy poverty at the societal level (Rademaekers et al., 2016). There are 6 indicators under the expenditure-based indicators, and 4 indicators under the consensual-based indicators. A multi-faceted energy poverty concept then tries to capture different aspects of energy poverty through all these sets of indicators. In this chapter, firstly, I briefly look at what these indicators are and discuss what their pros and cons are when measuring energy poverty. Then, I review the studies in the energy poverty literature looking at the characteristics of energy-poor households using econometric analysis and studies in the energy poverty literature for Turkey.

2.1 Expenditure-based indicators

Expenditure-based indicators consist of the 10% indicator, the 2M indicator, the minimum income standard (MIS) indicator, the after-fuel-cost poverty (AFCP) indicator, the low-income high-cost (LIHC) indicator, and the hidden energy poverty (HEP) indicator.

Firstly, according to the 10% indicator (Boardman, 1991), households are energy-poor if the share of energy expenditure in income is more than 10 percent. Although this indicator is simple (i.e. easy to understand), objective (i.e. based on modeled energy needs, not actual energy spending) and takes into account the main drivers of fuel poverty (i.e. household income levels, fuel prices, and energy efficiency); it has the following criticisms: it has an outdated fixed threshold, 10% (i.e. twice median energy expenditure as a share of income or the 30% of households with the lowest incomes in 1988), is oversensitive to price changes, focuses on the extent of fuel poverty not the depth of energy poverty, and also has the potential to include high-income households (Hills, 2011).

Secondly, Boardman (2010) makes the threshold relative to both the energy expenditure and income of the median household. In this new measurement, which is called as the 2M indicator, households are energy-poor if the share of energy expenditure in income is more than twice the national median share. This approach which requires only a small adjustment to the 10% indicator, but it has different and significant outcomes. First of all, unlike the 10% indicator, the 2M indicator is based on actual energy spending, and the characteristics of each country are taken into account by associating the threshold definition with the distribution of income and energy spending of each country. Due to this relative nature of the 2M indicator, it is less sensitive to large shifts in energy prices. Apart from these, as Hills (2011) notes, other criticisms for the 10% indicator also apply to the 2M indicator.

Thirdly, Moore (2012) defines energy-poor households using a "Minimum Income Standard (MIS)". Accordingly, if the income of the household after housing costs and energy expenditures is below a "Minimum Income Standard (MIS)" determined according to certain characteristics of the household, households are energy-poor. According to Castaño-Rosa et al. (2019), the main disadvantage of this indicator is the determination of the correct definition of the MIS.

Fourthly, the after-fuel-cost poverty (AFCP) indicator is based on the MIS indicator and comes with a different threshold definition. Hills (2011) defines this indicator as follows: households are energy-poor if their income, after housing costs and energy expenditures, falls below 60% of the median household disposable income (according to the size and type of the household using the modified OECD scale). Even though this approach successfully captures those who would not normally be identified as income poor but whose over energy expenditures push them into poverty, it is more sensitive to household income than energy efficiency. The main criticism of this indicator is that this oversensitivity on income eliminates the distinction between being poor and fuel poor for those who are not on the margins. In this indicator, a household in the lowest income group is defined as "fuel poor" due to being "severely poor" in the conventional sense, rather than being defined specifically as "fuel poor" due to energy expenditure (Hills, 2011).

Fifthly, in the low-income high-cost (LIHC) indicator, again defined by Hills (2011), households are energy-poor if “they had required energy costs that were above the median level; and were they to spend that amount, they would be left with a residual income below the official poverty line.”(p. 137). Castaño-Rosa et al. (2019) state the main criticisms of the LIHC indicator as follows: As the indicator models the equivalent energy-consumption expenses, it is complex and unclear. The indicator eliminates the impact of household energy efficiency by setting the energy expenditure threshold to the median and uses required energy costs not actual energy spending.

The last indicator of expenditure-based indicators is the hidden energy poverty (HEP) indicator. Rademaekers et al. (2016) define a household as energy poor if “the absolute energy expenditure is below half the median absolute energy expenditure” (p. 50) by taking household composition and housing size into account. Castaño-Rosa et al. (2019) state that this indicator identifies the households who have to choose between either paying their utility bills or eating (i.e. the “heating or eating” effect) due to their low income and low energy and consumption expenditures.

2.2 Consensual-based indicators

Consensual-based indicators mainly consist of the keep-warm indicator, the arrears indicator, and the housing-faults indicator, and different weighted indicators generated from these indicators. Households that cannot afford to keep their homes adequately warm are identified as energy-poor by the keep warm indicator. The arrears indicator captures the households that have problems paying their utility bills in the last 12 months. Households with a leaking roof, damp walls or rot in window frames problems are identified by the housing-faults indicator. The advantages of these main consensual-based indicators are identified in the literature as follows: Collecting the data for consensual-based indicators can be less complex than for expenditure-based indicators (Thomson et al., 2017). Since all indicators are taken from the EU-SILC survey, they can be used for comparative research on a European scale (Healy & Clinch, 2004). These indicators can "capture the wider elements of fuel poverty, such as social exclusion and material deprivation" (Healy & Clinch, 2002, p.10). Moreover, these indicators provide the perceived reality of households regardless of their level of income (Castaño-Rosa et al.,2019). Conversely, the main criticism of the consensual-based indicators is that the consensual-based indicators are subjective (Thomson et al., 2017) and have a culturally dependent nature (Friel, 2007).

Besides the main consensual-based indicators (i.e. the keep-warm indicator, the arrears indicator, and the housing-faults indicator), there are many studies in the literature designing a weighted indicator using these main indicators and other questions from the EU-SILC survey. “Energy Poverty Index (EPI)” by Bouzarovski and Tirado Herrero (2017) based on the study of Thomson and Snell (2013); “Compound Energy Poverty Indicator (CEPI)” by Maxim et al. (2016); and “Multidimensional Energy Poverty Index (MEPI)” by Nussbaumer, Bazilian, and

Modi (2012); Okushima (2017) and Pelz, Pachauri, and Groh (2018) are some of these studies.

2.3 Literature on the characteristics of energy-poor households

Apart from indicators and alternative measurements, there are many studies in the energy poverty literature looking at the characteristics of energy poor household using econometric analysis. Legendre and Ricci (2015), Romero, Linares and López (2018), Belaïd (2018), and Costa-Campi, Jové-Llopis, and Trujillo-Baute (2019) make econometric analysis using expenditure-based indicators. On the other hand, Thomson and Snell (2013), Maxim et al. (2016), and Chaton and Lacroix (2018) use consensual-based indicators for their analyses.

Legendre and Ricci (2015) use the three measurement approaches (i.e. the 10% indicator, the AFCP indicator, and the LIHC indicator) to show the extent of fuel poverty and the composition of the fuel poor in France for the year 2006. They then characterize fuel vulnerable households by predicting logistic, complementary log-log, and mixed-effect logistic models. Their main findings are that retired people who live alone are significantly exposed to fuel vulnerability and, being a tenant or having a low level of education contribute more to this exposure. Besides, using an individual boiler and cooking with butane/propane also increases exposure to fuel vulnerability. Another significant fuel vulnerability factor is a low energy performance home.

Costa-Campi et al. (2019) estimate a discrete choice univariate probit model to find the characteristics of energy-poor Spanish households by using the LIHC indicator during the period 2011–2017. Their econometric results demonstrate that the most vulnerable energy-poor Spanish households are those where the main wage-earner is unemployed, where the household members have a lower educational level and those consisting of one person or also one parent caring for a child or children. Another finding is that the intrinsic properties of Spanish homes and climatic conditions affect the probability of being an energy-poor household. Besides, they state that a close relationship is evident between household income and the probability of being energy poor.

Thomson and Snell (2013) predict three separate logistic regression models for each consensual based indicator within the scope of 27 EU countries for the year 2007. They find that location, housing quality, and income are the keys defining features of fuel poverty. They also constitute a composite measure of fuel poverty assigning a weight to each indicator by showing the interaction between the three indicators chosen for analysis. Bouzarovski and Tirado Herrero (2017) create the energy poverty index based on this composite measure to examine spatial and temporal trends in the national-scale energy poverty among European Union countries. In the index, the keep-warm indicator receives a higher weight (i.e. 0.5) to reflect the greater importance and the arrears indicator and the housing-faults indicator receives 0.25 weight.

2.4 The case of Turkey

After looking at the general literature on energy poverty, it is worth reviewing the energy poverty literature for Turkey. Research conducted so far on energy poverty seems quite scarce. There are four studies worth mentioning in this context.

The first study related to the energy poverty concept in Turkey is a master thesis. Eke (2012) investigates the causes, measurement methods of energy poverty in general, and also analyzes implemented policies for energy poverty in Turkey. However, the author does not use any kind of data set or apply any methodology to measure the energy poverty rates or to examine household characteristics for Turkey.

In the second study, Emec, Altay, Aslanpay, and Ozdemir (2015) examine the concept of energy poverty in general and establish a multinominal logit model using HBS 2012 to find the fuel type preferences of households for Turkey. However, again any measurement or analysis of energy poverty has not been made for Turkey.

In another study, Kose (2019) investigates the links between energy poverty and health outcomes in Turkey by using SILC 2014. He uses the keep-warm indicator as the energy poverty indicator. He estimates a multi-level model and he founds that energy poverty is negatively associated with the health level of individuals for the Turkish case.

The most up-to-date and most relevant study to this thesis is "Energy Poverty in Turkey" study by Selçuk, Gölçek, and Köktaş in 2019. They investigate conceptually energy poverty and the data related to the current energy consumption in various countries including Turkey. They calculate the Energy poverty rates of Turkey for 2006 and 2017 and find that one-quarter of households in Turkey are energy poor. They then examine the characteristics of dwelling and habits of energy-poor households in Turkey by using the datasets of HBS 2003 and HBS 2017.

Their study mainly focuses on calculating energy poverty rates from the 10% indicator, the keep-warm indicator, and the arrears indicator and examine the characteristics of dwelling and habits of energy-poor households only from the 10% indicator using HBS only for the year 2003 and 2017, and SILC only for the year 2006 and 2016. Thus, they neither examine the change in energy poverty nor the characteristics of households between this period. Above all, they do not use any econometric model, or regression analysis as in the literature to examine energy-poor households characteristics, they only use descriptive statistics.

This thesis will contribute to this literature in 4 distinct ways: firstly, the extent of energy poverty in Turkey over the years is estimated using all available indicators in both the expenditure-based approach and the consensual-based approach. Secondly, the research methodology employed uses econometrics analysis in line with the recent literature focusing on the characterization of energy-poor households. Thirdly, the data employed also captures the recent year 2018 and gives a more current picture of energy poverty in Turkey. Lastly, the study results show the changes in energy poverty rates and the changes in the characteristics of energy-poor households in Turkey over the years by examining all years between 2003 and 2018.

CHAPTER 3

DATA SOURCES AND METHODOLOGY

In this section, I first describe the data sources used and then explain the methodology used in this thesis in detail.

3.1 Data

I use 2 sets of data set in this thesis: the 2003-2018 Household Budget Surveys[1] (HBS) for expenditure-based indicators and analysis based on these indicators, and the 2006-2018 Income and Living Conditions Surveys (SILC) for consensus-based indicators and analysis based on these indicators. The 2 data sets are gathered by the Turkish Statistical Institute (TurkStat) annually and both data sets are repeated cross-sectional surveys and representative at the country level. Income and Living Conditions Surveys are also representative across the 26 NUTS-2 regions.

The sample of HBS includes a total of 161,844 households between the year 2003 and 2018. HBS consists of three data sets: individual, household, and consumption expenditure of the household. The individual data set of HBS provides detailed information on individuals' employment status, income received during the last 12 months, and demographic characteristics such as age, educational attainment, and marital status. The household data set of HBS provides information on dwelling characteristics such as ownership status of the dwelling, dwelling type, heating system of the dwelling, and fuel type used in the dwelling. Lastly, the consumption expenditure of the household data set of HBS provides information on household consumption by COICOP [2] categories at current prices for a month.

[1] Although HBS also includes the year 2002, I did not include it in the dataset due to the inconsistency in the expenditure and income variables in the data.

[2] Classification of Individual Consumption by Purpose. In HBS, household consumption is recorded according to this classification of goods and services.

On the other hand, the sample of SILC includes a total of 224,026 households between the year 2005 and 2017.[3] SILC consists of three data sets: individual, individual-register, and household. Even though HBS mostly focuses on the household budget and consumption expenditure, and SILC mostly focuses on income, poverty, social exclusion, material deprivation, and living conditions, both data sets also include similar information. The individual and individual-register data sets of SILC provide detailed information on individuals' employment status, annual income, and demographic characteristics such as age, educational attainment, and marital status as in HBS. The household data set of SILC provides information on financial situation of the household, problems with dwelling and the environment, dwelling and housing conditions such as tenure status, dwelling type, heating system of the dwelling, and fuel type used in the dwelling.

3.2 Methodology

As previously mentioned in the introduction, the analysis in this thesis consists of two parts: The first part, in Chapter 4, includes the estimation of the rates of energy poverty in Turkey using the four expenditure-based and four consensual-based indicators and different analyses related to this calculation. The second part, Chapter 5, includes the regression analyses to find characteristics of energy-poor households and descriptive statistics to see the change of these characteristics over the years.

In the first part, in Chapter 4, before estimating energy poverty rates for Turkey, I first examine the structure of household expenditure in Turkey over the years 2003 and 2018 using the consumption expenditure of the household data set of HBS. In doing so, I aim to understand 3 points: first, how household energy expenditures change among other expenditures over time, second what the extent and composition of household energy expenditures are and how they change over time, and finally, how these changes in household energy expenditure differ for the average Turkish household and for the households in different quintiles.

[3] Since the data of the previous year are used in the SILC surveys, the 2006-2018 SILC data sets cover the years between 2005-2017.

Then, I calculate the energy poverty rates in Turkey in a multi-faceted fashion using the four expenditure-based indicators (i.e. the 10% indicator, the 2M indicator, the after-fuel-cost poverty (AFCP) indicator, and the hidden energy poverty (HEP) indicator) and four consensual-based indicators (i.e. the keep-warm indicator, the arrears indicator, the housing-faults indicator, and the Energy Poverty Index) described above.

The minimum income standard (MIS) indicator and the low -income high-cost (LIHC) indicator from expenditure-based indicators could not be used in this thesis. Because the MIS indicator uses "minimum income standard" data, and the LIHC indicator uses required energy cost data and these two data sets are not available for Turkey. The other four indicators use income and household energy expenditure data. However, HBS provides household expenditure data "monthly" and income data "annually". Many studies in the literature use annual based data while estimating energy poverty rates with different indicators (Hills, 2011; Tirado Herrero et al., 2013; Rademaekers et al., 2016; Costa-Campi et al., 2019). Hence, I turn monthly household expenditure data to annual data by multiplying it with 12. Naturally, monthly household expenditures can differ between different months and different locations, especially for energy expenditure. For example, Household Budget Survey can be collected for a household located in the south of Turkey in the summertime, but the energy expenditures for this household in the wintertime won't be the same, so monthly household energy expenditures data cannot be taken as average monthly expenditures. But, unfortunately, HBS does not include information on the survey month or the location of the household. Therefore, using a regression model to estimate the average annual household expenditure would not be appropriate for this study and instead monthly data is transformed to annual data. Besides, even if a household that is energy-poor but does not appear as energy-poor in the data; likewise a different household that is not energy-poor may appear to be energy poor in the data due to the survey month, there would not be any systematic error. Therefore, in total, it is assumed that each individual's situation will balance the other while calculating the energy poverty rates for Turkey.

After calculating household annual energy expenditure, I take the household size and composition into account to adjust household annual income and household annual energy expenditure in the three indicators (i.e. the 10% indicator, the 2M indicator, and the hidden energy poverty (HEP) indicator) by using the OECD equivalence scale (i.e. by assigning a value of 1 to the first household member, 0.5 to each additional adult member, and 0.3 to each child under 14 years old). Moreover, for the after-fuel-cost poverty (AFCP) indicator, adjusted household income is calculated after housing costs and annual energy expenditure deducted using the OECD equivalence scale. Housing costs include actual rents, water supply and materials for the maintenance and repair of the dwelling. After all of these required adjustments, I calculate the energy poverty rates in Turkey using the four expenditure-based indicators for the years between 2003 and 2018.

On the other hand, I calculate the three of consensual-based indicators (i.e. the keep-warm indicator, the arrears indicator, the housing-faults indicator) using the questions taken from SILC (i.e. "Ability to keep home adequately warm", "Leaking roof, damp walls or rot in window frames problems", "Arrears on utility bills in the last 12 months", respectively). If a household answers "yes" on one of these questions, then this household is energy-poor according to the indicator using that question. For the last indicator of consensual-based indicators, I calculate the Energy Poverty Index by Bouzarovski and Tirado Herrero (2017) as a weighted indicator for the years between 2005 and 2017 and then, since SILC is representative across the 12 NUTS-1 regions, I examine the change in energy poverty rates over time for the 12 NUTS-1 regions. Even though there are many other weighted indicators in the literature (Maxim et al.,2016; Nussbaumer et al., 2012; Okushima, 2017; Pelz et al. 2018) as underlined in the literature review section, due to data restrictions for the other weighted indicators in Turkey, I use the Energy Poverty Index for this thesis.

Next, after reviewing all energy poverty indicators in Turkey within self from the objective and subjective perspectives, I compare Turkey with other European Union countries for available indicators to better understand the situation in Turkey. Thus, I aim to understand the general energy poverty situation among the European countries and where Turkey is located in this picture. Finally, I examine the main contributing factors of energy poverty in the literature for Turkey. As previously mentioned in the introduction, in the literature, there are three main causes or factors contributing to energy poverty: low income, high energy prices, and poor housing quality or low energy efficiency of housing (BERR, 2001; OECD/IEA, 2011; Ürge-Vorsatz and Tirado Herrero, 2012). To be able to see the effects of these factors on energy poverty in Turkey, I use before-housing-cost income poverty which is calculated using HBS 2003-2018 for the first factor (i.e. low-income levels) as in the Fuel Poverty Report by Hills (2012). For the second factor (i.e. high energy prices), I use 2003 based consumer price indexes (CPI) by expenditure groups data TURKSTAT[4]. For the last factor (i.e.low energy efficiency of housing), I use the indicator of 'per dwelling temperature corrected energy intensity (GJ/dw)' from IEA's Energy Efficiency Indicators Database[5]. Then, as in the study of Tirado Herrero (2013), I estimate the Pearson's product-moment correlation coefficients to find the level of linear dependence between these three factors and the energy poverty rates calculated by the four indicators (i.e. the 2M indicator, the after-fuel-cost poverty (AFCP) indicator, and the hidden energy poverty (HEP) indicator and the Energy Poverty Index). I also run a two-tailed t-test to check the statistical significance of these correlation coefficients.

For the second part of the analysis, in Chapter 5, I construct 3 different logit models for each expenditure-based indicator, and 1 ordered logit model for the Energy Poverty Index from the consensual-based indicators. While expenditure-based indicators are binary variables, the Energy poverty Index takes the value of 0,

[4]Retrieved from: http://www.turkstat.gov.tr/PreIstatistikTablo.do?istab$_i d = 652$

[5]Retrieved from: https://iea.blob.core.windows.net/assets/d5e9c32a-00ff-46d2-8df0-2e009eec7144/Energyefficiencyindicators-short.xlsx

0.25,0.5, 0.75, and 1 and has an order between the values by its nature. I do not construct models for other indicators, because the 10% indicator is an outdated indicator and the Energy Poverty Index is a weighted indicator and has already information on the other three indicators (i.e. the keep-warm indicator, the arrears indicator, and the housing-faults indicator). The aim of this econometric analyses is to find the most influential demographic, socioeconomic, and dwelling characteristics of the energy-poor households in Turkey for each aspect of the energy poverty concept which captured by different indicators. I mainly use the studies of Legendre and Ricci (2015), Costa-Campi et al. (2019) and Thomson and Snell (2013) for the explanatory variables selection to use in the econometric analyses. Lastly, after finding the most influential demographic, socioeconomic, and dwelling characteristics of the energy-poor households in Turkey, I examine the descriptive statistics for these characteristics of energy-poor households to be able to see how they change over time.

CHAPTER 4

ENERGY POVERTY RATES IN TURKEY

This chapter is the first part of this thesis. In the first section of this chapter, I examine the structure of household energy expenditures. In the second section, I estimate the energy poverty rates for Turkey by using different indicators an, I compare these estimated energy poverty rates of Turkey with other European Union countries for available indicators. In the last section, I examine the main contributing factors of energy poverty in the literature for Turkey.

4.1 Turkey's energy expenditure

Prior to the estimation of the energy poverty rates for Turkey, in this section, I examine household energy expenditure in Turkey over the years by using HBS 2003-2018 from two main aspects: (i) the state of household energy expenditure among other subgroup expenditures for the average Turkish household and households in different income quintiles, and (ii) the composition of household energy expenditure for the average Turkish household and households in different income quintiles. I use consumption expenditure of the household data set of HBS which provides information on household consumption by COICOP categories at current prices for a month.

4.1.1 State of household energy expenditure

As a first step in the analysis of the state of household energy expenditure among other subgroup expenditures for the average Turkish household, I calculate the weighted mean of every household expenditure item for each year after multiplying by 12 to show the per capita annual expenditure pattern of the average Turkish household. For the average Turkish household, while 'housing, water, electricity and gas, and other fuels' (30.18% of the household's per capita annual expenditure), 'food and nonalcoholic beverages' (26.48% of the household's per capita annual expenditure) and 'transport' (10.48% of the household's per capita annual expenditure) are the most important COICOP categories, 'education'(1.29% of the household's per capita annual expenditure), 'health' (1.96% of a household's per capita annual expenditure) and 'recreation and culture' (2.03% of the household's per capita annual expenditure) are the least important in the period between 2003 and 2018. However, as Figure 1 shows, although the share of the least important COICOP categories in the household's per capita annual expenditure has not changed much over the years, the share of the most important COICOP categories has changed significantly over the period between 2003 and 2018. For 'housing, water, electricity and gas, and other fuels' (from 32.38% in 2003 to 28.86% in 2018) and 'food and nonalcoholic beverages' (from 32.80% in 2003 to 24.36% in 2018) categories, the share in the household's per capita annual expenditure over the years has decreased, while the share of 'transport' (from 6.43% in 2003 to 12.42% in 2018) has increased.

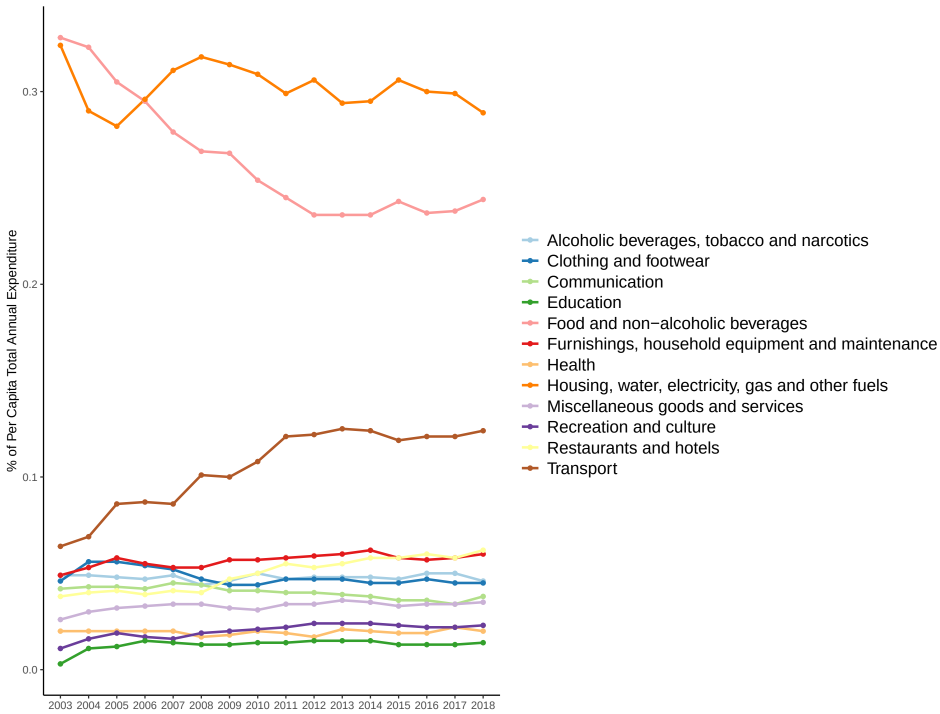

Figure 1. Expenditure pattern of the average Turkish household (%)

Then, after observing that the category of ’housing, water, electricity and gas, and other fuels’ is one of the most important COICOP categories, I divide this category into two sub-categories to compare the household energy with the other most important COICOP categories: (i)household energy (i.e. electricity, gas, and other fuels) and (ii)housing/water (i.e. rents, maintenance of the dwelling and water supply). Figure 2 shows that the decrease in the share of ’housing, water, electricity and gas, and other fuels’ category in the household’s per capita annual expenditure over the years mainly stems from the decrease in the sub-category of household energy. While the ‘housing/water’ sub-category has fluctuated around 23% between 2003 and 2018, the sub-category of household energy has decreased from 9.56% of the household’s per capita annual expenditure in 2003 to 6.11% of the household’s per capita annual expenditure in 2018.

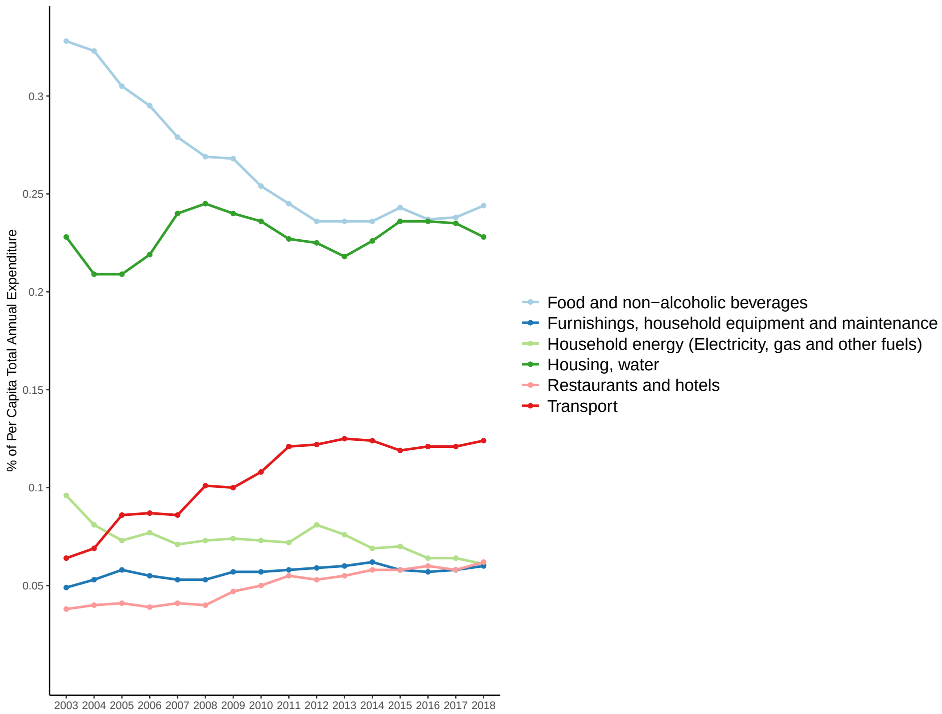

Figure 2. Expenditure pattern of the average Turkish household for the 5 most important COICOP categories (%)

In addition to the state of household energy expenditure of the average Turkish household among other sub-group expenditures, I also examine the state of household energy for households in different income quintiles. Figure 3 firstly indicates that the share of different COICOP categories in the household's per capita total annual expenditure differs significantly for households in different income quintiles. For the household in the lowest income quintile, 'food and non-alcoholic beverages' is the most important COICOP category and its share in the household's per capita total annual expenditure has decreased from 43.38% in 2003 to 32.62% in 2018. For the household in the highest income quintile, 'transport' and 'housing/water' are the most important COICOP categories. While the share of 'transport' in the household's per capita total annual expenditure has increased from 9.87% in 2003 to 23.57% in 2018, the share of 'housing/water' sub-category in the household's per capita total annual expenditure has decreased from 25% in 2003 to 18.80% in 2018. Secondly, Figure 3 shows that the decrease in the 'household energy' in Figure 2 comes mainly from the households in higher quintiles. While the share of 'household energy' in household's per capita total annual expenditure for the households in the lowest quintile has been constant around 8.5%, this share for the households in the highest quintile has decreased from 8.46% in 2003 to 3.05% in 2018.

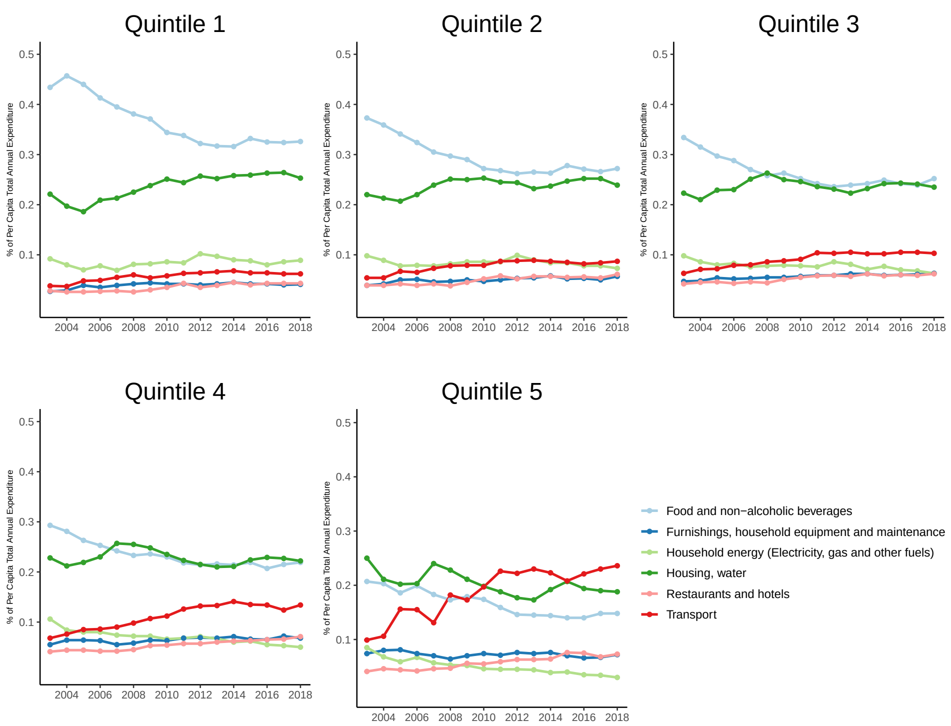

Figure 3. Expenditure pattern of the average Turkish household different quintiles for the 5 most important COICOP categories (%)

4.1.2 Composition of household energy expenditure

In addition to the analysis of the state of household energy expenditure among other subgroup expenditures for the average Turkish household and the households in the different quintiles, I examine the composition of household energy expenditure for the same households. Firstly, Figure 4 shows the share of each component of household energy in the household's per capita total annual energy expenditure for the average Turkish household. The figure indicates that electricity (3% of the household's per capita annual expenditure) is the type of energy that has the largest share of the average Turkish household's per capita total annual expenditure, and heat energy and liquid fuels (0.12% and 0.006% of the household's per capita annual expenditure, respectively) are the energy types that have the least shares in the period between 2003 and 2018. However, the shares of all household energy types in the household's annual expenditure have considerably changed during this period. For 'electricity' (from 3.68% in 2003 to 2.78% in 2018), 'solid fuels' (from 2.12% in 2003 to 1.24% in 2018), and 'liquified hydrocarbons (LPG)' (from 2.81% in 2003 to 0.66% in 2018), the share in the household's per capita annual expenditure over the years has decreased, while the share of 'natural gas and town gas' (from 0.58% in 2003 to 1.40% in 2018) has increased. Therefore, the figure shows that as the use of natural gas has increased, the use of solid fuels and LPG has decreased.

After examining the composition of household energy expenditure for the average Turkish household, I evaluate the composition of household energy expenditure for households in different income quintiles. Figure 5 indicates that even though 'electricity' has the biggest share in the household's per capita total annual expenditure for all income quintiles, the share of the other household energy types differs significantly for households in different income quintiles. For the household in the lowest income quintile, 'solid fuels' and 'liquified hydrocarbons (LPG) ' are the household energy types that have the largest shares of household's per capita total annual expenditure after electricity, and the share of 'natural gas and town gas' is very little. However, while the share of 'solid fuels' in the household's per capita total

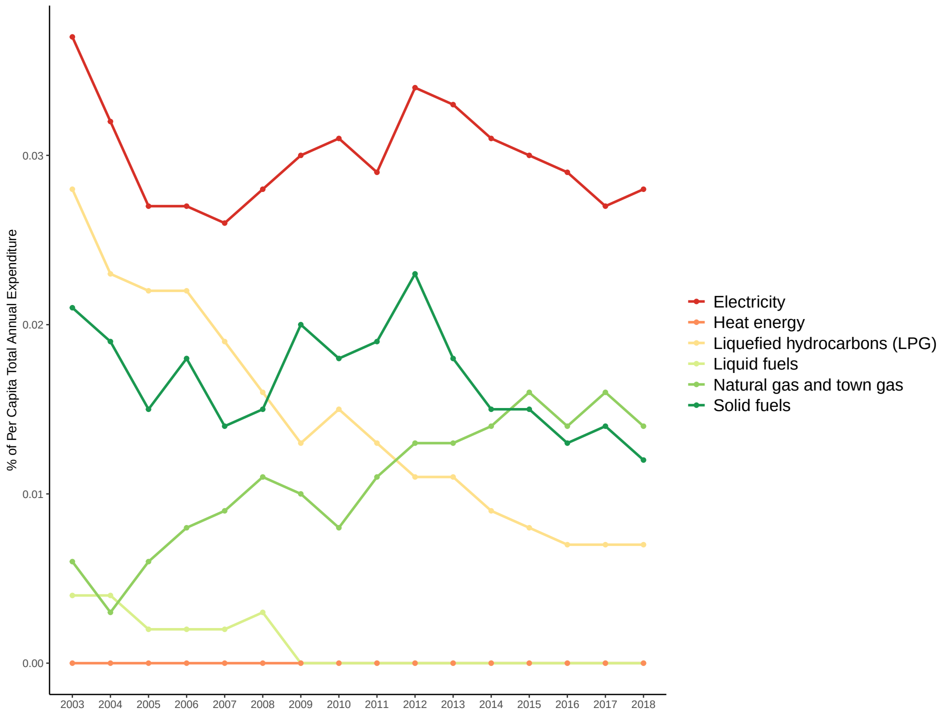

Figure 4. Expenditure pattern of the average Turkish household for the sub-categories of household energy (%)

annual expenditure has increased from 1.18% in 2003 to 2.42% in 2018, the share of ‘liquified hydrocarbons (LPG)’ in the household’s per capita total annual expenditure has decreased from 3.7% in 2003 to 1.33% in 2018. On the other hand, for the household in the highest income quintile, ’natural gas and town gas’ is the type of energy that has the largest share after electricity and its share has been constant around 1.4%. Moreover, Figure 5 shows that the decrease in ‘solid fuels’ in Figure 4 comes mainly from households in higher quintiles. While the share of ‘solid fuels’ in household’s per capita total annual expenditure for the households in the lower quintiles has increased, this share has rapidly decreased as the income quintile gets higher. Finally, Figure 5 also shows the increase in ’natural gas and town gas’ in Figure 4 stems from the households in the middle quintiles.

To sum up, it is possible to indicate that this section specified two key points. Firstly, ‘household energy’ expenditure is the fourth most important COICOP category for the average Turkish household. While it is the third most important COICOP category for the household in the lowest income quintile, it is the fifth most

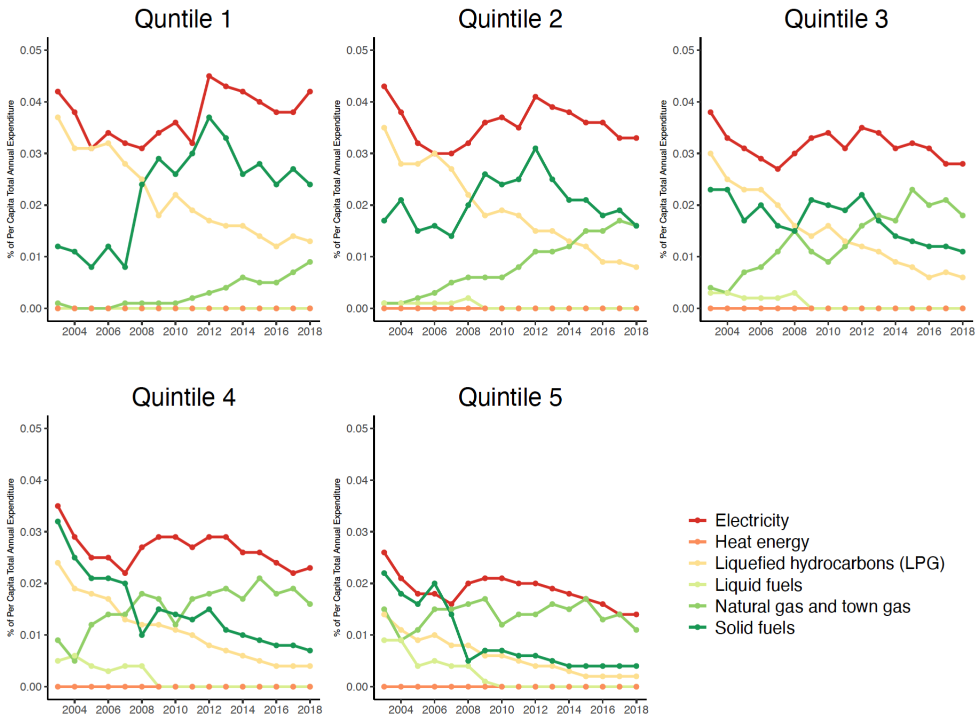

Figure 5. Expenditure pattern of the average Turkish household in different quintiles for the sub-categories of household energy (%)

important COICOP category for the household in the highest income quintile. Besides, the share of 'household energy' in the household's per capita annual expenditure has decreased from 9.56% in 2003 to 6.11% in 2018 for the average Turkish household. This share has been constant around 8.5% over the years for the household in the lowest income quintile, while the share of the households in the highest quintile has decreased from 8.46% in 2003 to 3.05% in 2018.

Secondly, about the composition of household energy expenditures, electricity is always the type of household energy that has the largest share of households' per capita annual expenditure for all households in different income quintiles over the period 2003 and 2018 (i.e. 3% of the household's per capita annual expenditure on average). Apart from electricity, the shares of the other household energy types in household's annual expenditure have considerably changed during this period and as the share of natural gas has increased, the share of solid fuels and LPG has decreased for the average Turkish household. However, although the change in natural gas and LPG is valid for all income quintiles, while the share of 'solid fuels' for the households in the lower quintiles has increased, this share has rapidly decreased as the income quintile gets higher.

4.2 Energy poverty rates in Turkey and comparison with the European Union

In this section, I estimate the energy poverty rates for Turkey by using "the 10% indicator", "the 2M indicator", " the after-fuel-cost poverty (AFCP) indicator", and "the hidden energy poverty (HEP) indicator" from expenditure-based indicators and "the keep-warm indicator", "the arrears indicator"," the housing-faults indicator", and "the Energy Poverty Index" from consensual-based indicators. Then, I compare the estimated energy poverty rates of Turkey with other European Union countries for available indicators.

4.2.1 Expenditure-based indicators

Table 1 and Figure 6 show the extent and the change of energy poverty in Turkey for different expenditure-based measures between the years 2003 and 2018. The values in the table indicate how much of the population is energy-poor. Since I use the household data set of the 2003-2018 HBS, I use population weight which is calculated as household weight (i.e. the variable named FAKTOR in the data set) multiplied by household size while estimating the energy poverty rates for the population in Turkey.[1] Table 1 shows several points. Firstly, the energy poverty rates in Turkey has decreased for all expenditure-based indicators from 2003 to 2018. While the decrease is at most in the 10% indicator (i.e. 14.49% point), it is at least in the 2M indicator (i.e. 1.08% point). Secondly, the estimated energy poverty rates differ among different indicators. While the highest energy poverty rates are

[1]Besides population-based energy poverty rates (i.e.% of the total population), energy poverty rates are also estimated at the household level (i.e. % of the total households) for the expenditure-based indicators in this thesis. Household-based energy poverty rates are 0.91% point and 0.9% point higher than the population-based energy poverty rates for the 10% indicator and the 2M indicator respectively. On the other hand, household-based energy poverty rates are 5.07% point and 4.15% point smaller than the population-based energy poverty rates for the AFCP indicator and the HEP indicator respectively. This shows that the energy-poor households according to the 10% indicator and the 2M indicator have fewer members than the average Turkish household, while the energy-poor households according to the AFCP indicator and the HEP indicator have more members than the average Turkish household.

calculated in the AFCP indicator (i.e. 29.43% on average over the period), the lowest rates are for the 2M indicator (i.e. 18.31% on average over the period).

Table 1. Energy Poverty Rates for Expenditure-Based Indicators in Turkey (%)

	10%	2M	AFCP	HEP
2003	27.38	19.42	27.13	27.54
2004	22.25	21.11	32.05	28.62
2005	20.25	19.80	31.56	30.08
2006	21.52	20.64	30.19	28.84
2007	16.75	18.67	30.67	27.82
2008	23.30	17.51	30.36	26.88
2009	24.50	18.61	30.41	26.01
2010	23.36	17.44	29.76	24.02
2011	21.33	17.17	29.32	26.21
2012	26.32	16.90	28.62	24.73
2013	22.67	16.92	28.24	23.61
2014	17.28	16.24	28.13	21.50
2015	18.73	18.05	29.51	25.32
2016	15.03	17.82	29.68	23.71
2017	14.78	18.34	27.87	23.95
2018	12.89	18.34	27.37	20.87

Besides, Figure 6 shows that there have been fluctuations in energy poverty rates in each indicator over the years. The reasons behind the overall decline in energy poverty for each indicator will be explored in Section 4.3, the last part of this chapter. However, the fact that these fluctuations occur in at most in the 10% indicator and are not in coherence with the fluctuations in other indicators, shows once again that this indicator is an outdated indicator. Therefore, this indicator is not used in the analyses for the rest of this thesis.

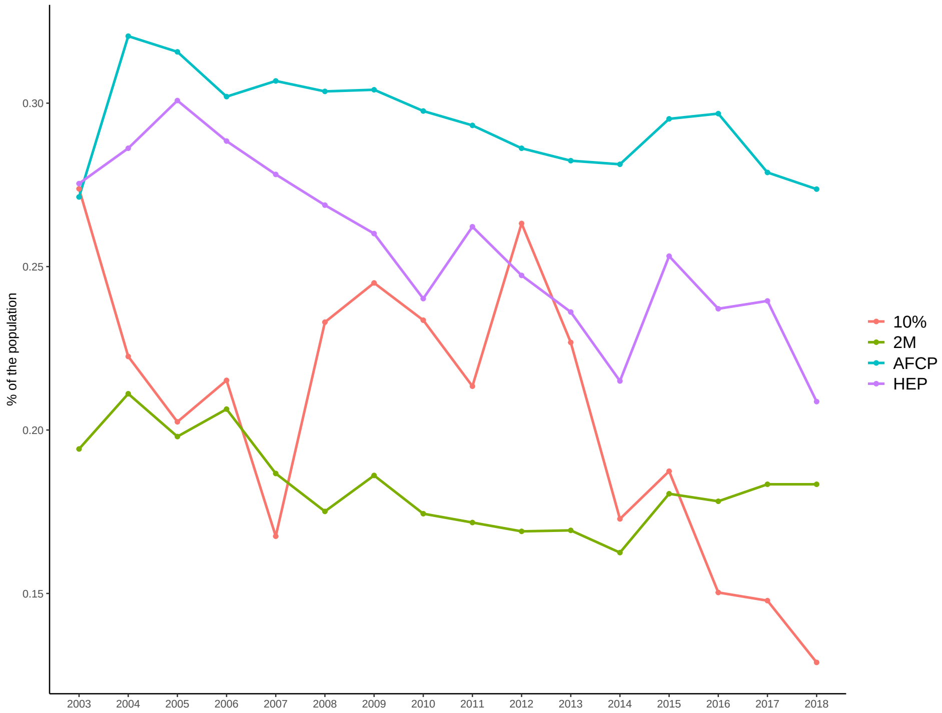

Figure 6. Energy poverty rates for expenditure-based indicators in Turkey (%)

Even though the energy poverty rates for Turkey have decreased for all indicators over the years 2003 and 2018, I look at the distribution of Turkish households according to variables used for to calculate energy poverty rates in each indicator to understand the depth of energy poverty (i.e. how far the energy-poor households are from the poverty line). Since the removal of six zeros from the currency occurred on 1 January 2005, I use the period between 2005 and 2018 in the distributions for a better comparison between the years. Firstly, the AFCP indicator uses households' annual OECD scaled disposable income after housing cost and energy expenditures deducted to calculate the energy poverty rates. Figure 7 shows the distribution of Turkish households according to this variable. Households located on the left of the dashed lines in the distribution are energy-poor households. The figure indicates that the energy-poor households have been increasingly moving far away from the poverty line over time. This indicates that although the energy poverty rate for Turkey has decreased according to the AFCP indicator over time, the depth of energy poverty has increased.

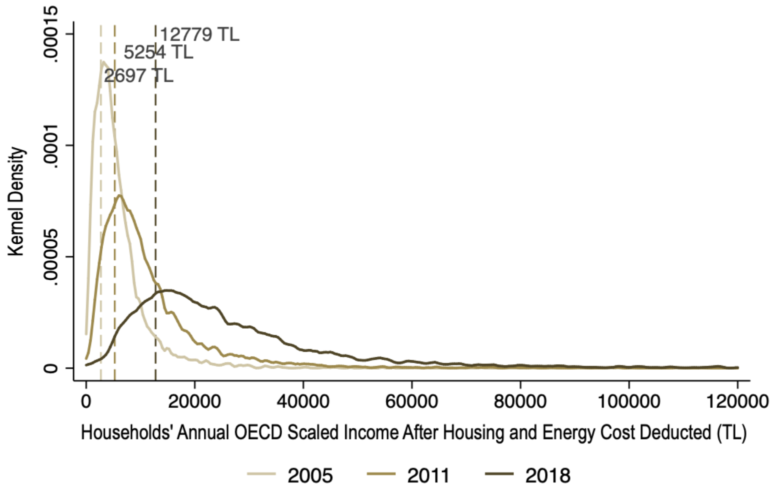

Figure 7. Distribution of Turkish households according to annual OECD scaled income
Note: The dashed lines show the poverty lines for the AFCP indicator. Although the upper limit is 833048 TL in the distribution, the upper limit is limited to 120000 TL for a better visualization.

Secondly, the HEP indicator uses households' OECD scaled energy expenditures to calculate the energy poverty rates. Figure 8 shows the distribution of Turkish households' OECD scaled energy expenditures. Again, households located on the left of the dashed lines in the distribution are energy-poor households. A similar situation in the AFCP indicator can also be observed for the HEP indicator. The energy-poor households according to the HEP indicator have been far away from the poverty line over time and the depth of energy poverty has increased, even though the energy poverty rate has decreased according to this indicator.

Lastly, Figure 9 shows the distribution of Turkish households' "energy expenditure/income" ratio that is the variable used for energy poverty calculation in the 2M indicator. Households located on the right of the dashed lines in the distribution are energy-poor households. The state of the depth of energy poverty for the APCP and the HEP indicators is not observed in the same way for the 2M indicators. In this indicator, although the energy-poor households have not steadily moved away from the poverty line over time, the Figure shows that these households

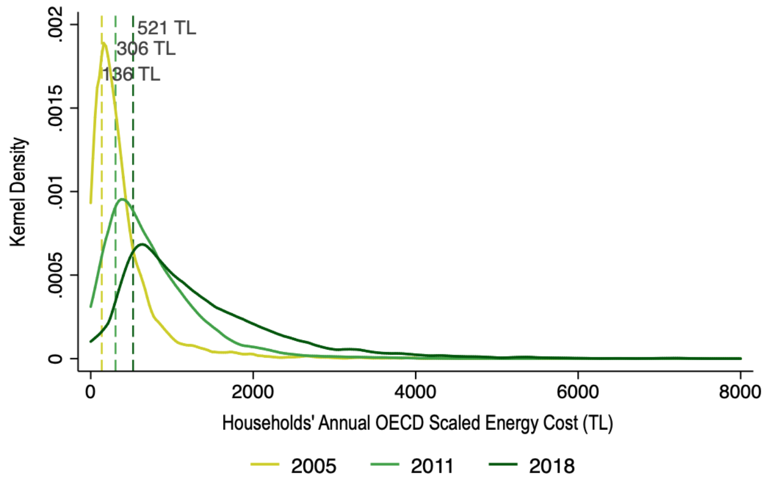

Figure 8. Distribution of Turkish households according to annual OECD scaled energy cost
Note: The dashed lines show the poverty lines for the HEP indicator. Although the upper limit is 14857 TL in the distribution, the upper limit is limited to 8000 TL for a better visualization.

are now farther away in 2018 than in 2005. Therefore, we can still say that the depth of energy poverty has increased slightly for the 2M indicator as well.

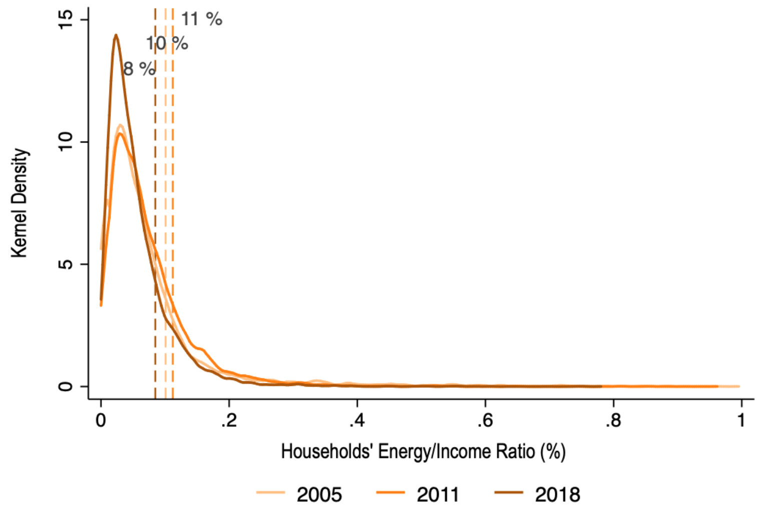

Figure 9. Distribution of Turkish households according to energy/income ratio
Note: The dashed lines show the poverty lines for the 2M indicator.

After the estimation of the extent and the depth of energy poverty in Turkey for different expenditure-based indicators, I compare the estimated energy poverty rates of Turkey with other European Union countries for available indicators. In the latest EU Energy Observatory Report published in June 2020, Bouzarovski and Thomson

(2020) show the share of energy-poor households among European Union countries according to the 2M indicator and the HEP indicator for the years 2010 and 2015. Table 2 has the information taken from this report and the 2018 EU Energy Observatory Report. Table 2 shows that the energy poverty rates calculated by both indicators have decreased in more than half of the countries. According to Bouzarovski and Thomson (2020), the reason of decrease for the 2M indicator is significant shifts in the pricing and consumption of energy in these countries, while the reason of decrease for the HEP indicator is the increase in households' energy expenditure and/or the change in median threshold. Bulgaria and Lithuania have the largest decreases in energy poverty rates for both indicators, while Finland has the largest increase. The energy poverty rates for the 2M indicator range between 6.9% and 28.7% among the EU countries. On the other hand, these rates for the HEP indicator range between 5.0% and 31.0%. Lastly, the overall EU average has decreased by 0.1% points for the 2M indicator and by 0.5% points for the HEP indicator from 2010 to 2015.

Since the 2018 and 2020 EU Energy Observatory Reports give information on the share of energy-poor households, in Table 3, I calculate the household-based energy poverty rates for Turkey using the 2M indicator and the HEP indicator for the comparison with the European Union countries in Table 2. Table 3 shows that the energy poverty rates have increased by 1.2% point for the 2M indicator (from 18.1% in 2010 to 19.3% in 2015) and by 0.6% point for the HEP indicator (from 19.9% in 2010 to 20.5% in 2015) in Turkey. On the picture of energy poverty among the EU countries, Turkey locates above-the-average. The energy poverty rates in Turkey for both indicators and both years are more than the EU average. When the extent and change of energy poverty rates are considered, it can be said that the situation of Turkey is similar to that of Estonia concerning expenditure based-indicators.

In addition to expenditure-based indicators, I estimate the energy poverty rates using the different consensual-based indicators and compare available ones with the EU countries.

Table 2. Share of Households (%) for ’2M Indicator’ and ’HEP Indicator’

	2M Indicator		HEP Indicator	
	2010	2015	2010	2015
EU average	16.3	16.2	15.1	14.6
Austria	15.3	16.0	12.5	15.0
Belgium	14.7	13.0	10.5	9.8
Bulgaria	14.7	11.5	15.9	9.4
Cyprus	11.9	12.0	13.2	13.2
Czech Republic	10.7	10.8	8.4	9.2
Germany	16.6	17.4	15.1	17.4
Denmark	17.7	-	12.0	-
Estonia	16.2	18.7	16.5	18.9
Greece	14.2	16.3	10.3	12.8
Spain	15.2	14.2	13.0	13.0
Finland	14.8	22.3	22.3	29.9
France	18.1	15.0	23.7	19.5
Croatia	10.9	12.0	9.6	7.5
Hungary	6.9	9.0	5.0	9.3
Ireland	18.4	17.6	12.3	14.8
Italy	-	-	16.3	13.6
Lithuania	21.4	13.9	21.2	14.4
Luxembourg	-	11.3	8.5	8.9
Latvia	14.5	12.7	13.2	10.7
Malta	17.3	20.1	15.6	16.7
Poland	18.1	16.3	18.5	19.5
Portugal	15.7	15.1	8.8	6.8
Romania	18.6	16.9	17.5	16.8
Sweden	17.7	28.7	31.0	24.3
Slovenia	14.1	13.9	11.5	8.9
Slovakia	10.0	9.3	9.2	7.9
United Kingdom	17.8	18.8	9.8	9.2

Source: Bouzarovski, S. & Thomson, H. (2018;2020)

Table 3. Share of Households (%) for '2M Indicator' and 'HEP Indicator' in Turkey

	2M Indicator		HEP Indicator	
	2010	2015	2010	2015
Turkey	18.1	19.3	19.9	20.5

4.2.2 Consensual-based indicators

Table 4 and Figure 7 show the extent and the change of energy poverty in Turkey for different consensual-based indicators between the years 2005 and 2017. As in the expenditure-based indicators, presented values show how much of the population is energy-poor. To get these values, I calculate energy poverty rates by using population weight which is household weight (i.e. the variable named HB040 in the data set) multiplied by household size, since the household data set of the 2005-2017 SILC is used estimating the energy poverty rates for Turkey.[2]Table 4 firstly indicates that the energy poverty rates in Turkey have decreased for all consensual-based indicators from 2005 to 2017. The keep-warm indicator has the largest decrease (i.e. 19.05% point), while the arrears indicator has the lowest decrease (i.e. 4.98% point). Besides the change, the estimated energy poverty rates differ among different indicators. The highest energy poverty rates are calculated using the housing-faults indicator (i.e. 38.55% on average over the period). On the other hand, the lowest rates are calculated using the keep-warm indicator (i.e. 28.48% on average over the period).

The points mentioned above for Table 4 can be seen in Figure 10. As in the expenditure-based indicators, Figure 7 shows also the fluctuations in energy poverty rates in each indicator over the years. Again, in the last section of this chapter (Section 4.3), the reasons behind the change in the energy poverty rates will be explored. However, it is worth noting that the question of "Ability to keep home

[2]Once again, energy poverty rates are also estimated at the household level (i.e. % of the total households) for the consensual-based indicators with the population-based energy poverty rates (i.e.% of the total population). Household-based energy poverty rates are 0.52% point, 1.45% point, 1.31% point, and 2.79% point smaller than the population-based energy poverty rates for the keep-warm indicator, the arrears indicator, the housing-faults indicator and the Energy Poverty Index respectively. This shows that the energy-poor households according to all consensual based indicators have more members than the average Turkish household.

Table 4. Energy Poverty Rates for Consensual-Based Indicators in Turkey (%)

	Keep-Warm	Arrears	Housing-Faults	the EPI
2005	36.77	26.67	42.63	35.71
2006	36.77	34.86	37.54	36.49
2007	39.00	29.39	37.16	36.14
2008	36.06	37.83	40.72	37.67
2009	35.52	41.13	42.23	38.60
2010	33.85	41.49	40.28	37.37
2011	35.60	39.83	39.35	37.60
2012	27.58	37.55	38.57	32.82
2013	14.29	33.64	36.19	24.61
2014	16.68	31.36	38.08	24.70
2015	22.97	27.16	37.24	27.57
2016	19.36	24.25	35.70	24.67
2017	17.72	21.69	35.47	23.15

adequately warm" in SILC for the keep-warm indicator has changed in the 2014 SILC (i.e. in the year 2013 in Figure 10) as “Can your household afford to keep its home adequately warm?”. This change may have affected how people perceive the question, and it can be a part of the reason behind the large decrease observed in the keep-warm indicator and the Energy Poverty Index from 2012 to 2013.

When the estimated energy poverty rates using consensual-based indicators are compared with the ones using the expenditure-based indicators, it can be seen that energy poverty rates for Turkey have decreased in both types of indicators over the years. However, the estimated energy poverty rates are higher in consensual-based indicators and there has been a greater decline in these rates over time than the expenditure-based indicators. For the rest of the thesis, I will use only the Energy Poverty Index for the analyses, since the EPI is a weighted indicator and has already information on the other three indicators.

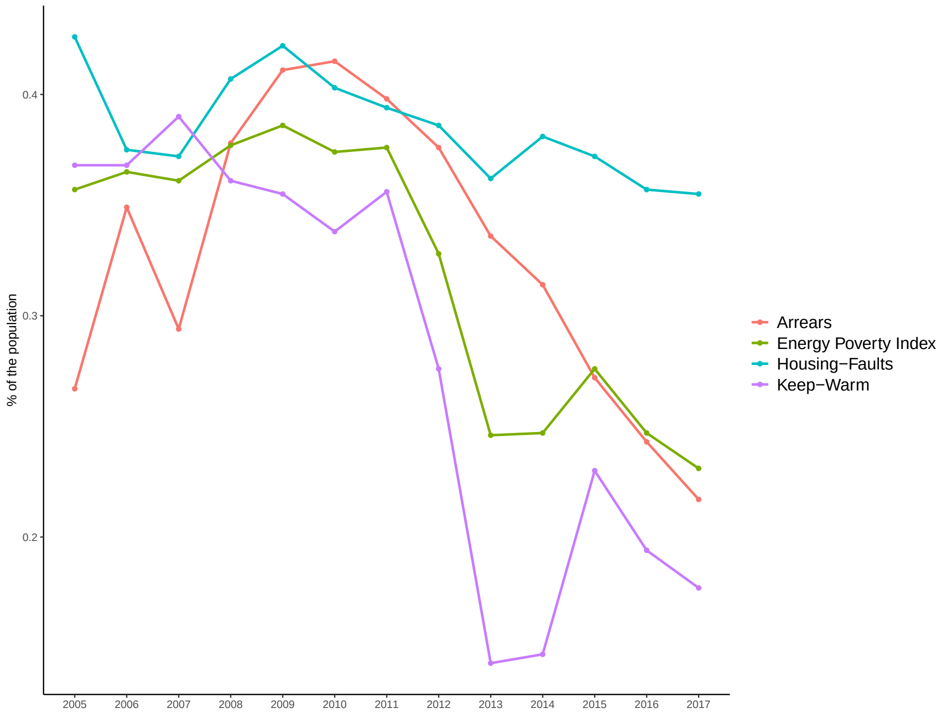

Figure 10. Energy poverty rates for consensual-based indicators in Turkey (%)

Since SILC has the information on the regions in which households are located and it is representative across the 12 NUTS-1 regions for all of the survey years, I estimate the Energy Poverty Index for 12 NUTS-1 regions to understand how the energy poverty rates differ among different regions over the years in Turkey. Figure 11 shows these changes for the 5 different years from 2005 to 2017 and indicates several points. Firstly, although there have been increases in some years, energy poverty rates have decreased for all regions from 2005 to 2017. While the decrease is at most in the West Anatolia region (i.e. 21.27% point), it is at least in the East Black Sea region (i.e. 5.36% point). Secondly, the Southeast Anatolia region has always had the highest energy poverty rate (i.e. 51.28% on average over the period). On the other hand, the West Anatolia region (i.e. 24.61% on average over the period) and the West Marmara region (i.e. 24.41% on average over the period) have had the lowest energy poverty rates over the years. From a different perspective, Table B4 (Appendix B) shows that the energy-poor households are mostly in Istanbul, Mediterranean, Aegean, and Southeastern Anatolia regions. However, the regional composition of these energy-poor households has not changed much over time. For example, while Istanbul has always been the region that energy-poor household lives the most, the Northeast Anatolia has been the region where energy-poor households reside the least.

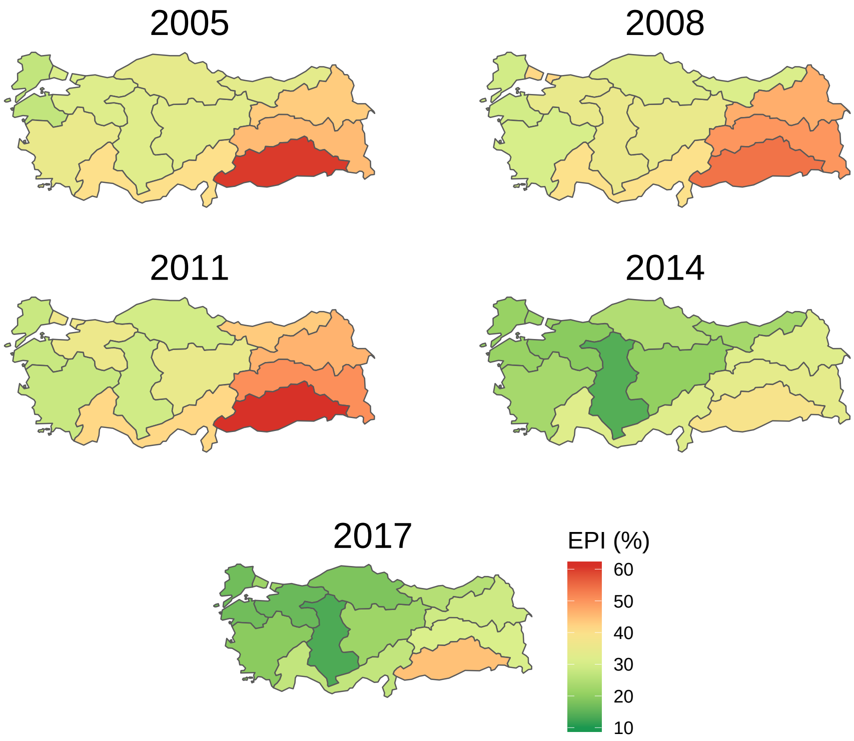

Figure 11. Energy poverty rates from the EPI for 12 NUTS-1 regions in Turkey (%)

Next, I compare the estimated energy poverty rates of Turkey with other European Union countries for available consensual-based indicators. The latest EU Energy Observatory Report published in June 2020 contains the information on energy poverty rates calculated by the keep-warm indicator and by the arrears indicator for the EU countries for the years between 2008 and 2018. Again, these rates show the share of energy-poor households. Table 5 and Table 7 have the information on energy poverty rates according to the keep-warm indicator and the arrears indicator respectively which are both taken from this report. Table 5 and Table 7 show that although there are increases in the rates over time for some countries, the energy poverty rates calculated by both indicators have decreased in more than half of the countries from 2008 to 2018. For the keep-warm indicator, Table 5 shows that Bulgaria (i.e. 32.6% point) has the largest decrease in energy poverty rates.

According to Bouzarovski and Thomson (2020), the reason for this is the sustained policies to improve the energy efficiency of dwellings in Bulgaria. On the other hand, Greece (i.e. 7.3% point) and Lithuania (i.e. 5.3% point) have the largest increases. The energy poverty rates for the keep-warm indicator has a fairly wide range between 0.6% and 66.33% among the EU countries over the years. However, the overall EU average is 10.1% in 2008 and 7.3% in 2018.

Table 5. Share of Households (%) for 'Inability to Keep Home Adequately Warm'

	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018
EU average	10.1	9.3	9.5	9.8	10.8	10.8	10.3	9.4	8.7	7.8	7.3
Belgium	6.4	5.1	5.6	7.1	6.6	5.8	5.4	5.2	4.8	5.8	5.2
Bulgaria	66.3	64.2	66.5	46.3	46.5	44.9	40.5	39.2	39.2	36.5	33.7
Czech Republic	6.0	5.2	5.2	6.4	6.7	6.2	6.1	5.0	3.8	3.1	2.7
Denmark	1.7	1.5	1.9	2.3	2.5	3.8	2.9	3.6	2.7	2.7	3.0
Germany	5.9	5.5	5.0	5.2	4.7	5.3	4.9	4.1	3.7	3.3	2.7
Estonia	1.1	1.7	3.1	3.0	4.2	2.9	1.7	2.0	2.7	2.9	2.3
Ireland	3.7	4.1	6.8	6.8	8.4	10.0	8.9	9.0	5.9	4.4	4.4
Greece	15.4	15.7	15.4	18.6	26.1	29.5	32.9	29.2	29.1	25.7	22.7
Spain	5.9	7.2	7.5	6.5	9.1	8.0	11.1	10.6	10.1	8.0	9.1
France	5.3	5.5	5.7	6.0	6.0	6.6	5.9	5.5	5.0	4.9	5.0
Croatia	-	-	8.3	9.8	10.2	9.9	9.7	9.9	9.3	7.4	7.7
Italy	11.4	10.8	11.6	17.8	21.3	18.8	18.0	17.0	16.1	15.2	14.1
Cyprus	29.2	21.7	27.3	26.6	30.7	30.5	27.5	28.3	24.3	22.9	21.9
Latvia	16.8	16.4	19.1	22.5	19.9	21.1	16.8	14.5	10.6	9.7	7.5
Lithuania	22.6	24.1	25.2	36.2	34.1	29.2	26.5	31.1	29.3	28.9	27.9
Luxembourg	0.9	0.3	0.5	0.9	0.6	1.6	0.6	0.9	1.7	1.9	2.1
Hungary	9.7	8.9	10.7	12.2	15.0	14.6	11.6	9.6	9.2	6.8	6.1
Malta	8.8	11.1	14.3	17.6	22.1	23.9	22.3	14.1	6.6	6.3	7.6
Netherlands	1.8	1.3	2.3	1.6	2.2	2.9	2.6	2.9	2.6	2.4	2.2
Austria	3.9	2.9	3.8	2.7	3.2	2.7	3.2	2.6	2.7	2.4	1.6
Poland	20.1	16.3	14.8	13.6	13.2	11.4	9.0	7.5	7.1	6.0	5.1
Portugal	34.9	28.5	30.1	26.8	27.0	27.9	28.3	23.8	22.5	20.4	19.4
Romania	24.4	22.1	20.1	15.6	15.0	14.7	12.9	13.1	13.8	11.3	9.6
Slovenia	5.6	4.6	4.7	5.4	6.1	4.9	5.6	5.6	4.8	3.9	3.3
Slovakia	6.0	3.6	4.4	4.3	5.5	5.4	6.1	5.8	5.1	4.3	4.8
Finland	1.9	1.3	1.4	1.8	1.5	1.2	1.5	1.7	1.7	2.0	1.7
Sweden	1.6	1.7	2.1	1.9	1.7	0.9	1.1	1.2	2.6	2.1	2.3
United Kingdom	6.0	5.8	6.1	6.5	8.1	10.6	9.4	7.8	6.1	5.9	5.4

Source: Bouzarovski, S. & Thomson, H., (2020)

In Table 6 and Table 8, I calculate the household-based energy poverty rates for Turkey using the keep-warm and the arrears indicator for the comparison with the European Union countries in Table 5 and Table 7. Once again, since the 2020 EU Energy Observatory Reports give information on the share of energy-poor households, I use household-based energy poverty rates for Turkey. Table 6 shows that the energy poverty rates have decreased by 21.2% point for the keep-warm indicator (from 38.1% in 2008 to 16.9% in 2018) in Turkey. According to this indicator, Turkey locates close to the upper limit on the picture of energy poverty among the EU countries. The energy poverty rates in Turkey for each year are much more than many of the EU countries, but it has the second-largest decrease in energy poverty rates after Bulgaria. Lastly, for the keep-warm indicator, Portugal is the most similar country to Turkey in terms of the extent and change of energy poverty rates.

Table 6. Share of Households (%) for ’Inability to Keep Home Adequately Warm’ in Turkey

	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018
Turkey	38.1	34.9	33.8	32.9	34.2	28.2	14.7	16.9	22.3	18.9	16.9

In addition to the keep-warm indicator, for the arrears indicator, Table 7 shows that Croatia (i.e. 10.5% point) and Italy (i.e. 9.4% point) have the largest decreases in energy poverty rates, while Greece (i.e. 19.7% point) and Cyprus (i.e. 4.7% point) have the largest increases. As in the keep-warm indicator, the energy poverty rates for the arrears indicator has also a wide range between 1.1% and 42.2% among the EU countries over the years. But the overall EU average is 7.9% in 2008 and 6.6% in 2018.

As stated above, Table 8 contains the information on the household-based energy poverty rates for the arrears indicator in Turkey. Table 8 shows that the energy poverty rates have decreased by 8.2% point for the arrears indicator (from 27.2% in 2008 to 19.0% in 2018) in Turkey. As in the keep-warm indicator, Turkey locates close to the upper limit on the picture of energy poverty among the EU countries and energy poverty rates for each year are much more than most of the EU countries. In fact, Turkey has the highest rate for this indicator at the beginning after Bulgaria. However, it has also the largest decrease in as in Croatia, Italy, and Romania. In terms of the extent and change of energy poverty rates, Turkey is again similar to Croatia and Romania.

All in all, the points of this section of Chapter 4 can be summed up as follows: Firstly, for the expenditure-based indicators, energy poverty rates for Turkey have

Table 7. Share of Households (%) for 'Arrears on Utility Bills'

	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018
EU average	7.9	8.9	9.1	9.0	9.9	10.2	9.9	9.1	8.1	7.0	6.6
Belgium	5.1	5.9	5.8	6.0	6.1	5.0	5.8	5.1	5.0	4.1	4.5
Bulgaria	33.4	32.2	31.6	28.6	28.4	34.0	32.9	31.4	31.7	31.1	30.1
Czech Republic	2.6	4.0	4.2	4.3	4.1	4.0	4.7	3.0	3.0	2.1	2.1
Denmark	2.2	2.6	3.2	3.4	3.5	3.6	4.6	3.4	2.5	3.5	5.1
Germany	3.9	3.6	3.5	3.9	3.4	3.6	4.2	4.0	3.0	2.8	3.0
Estonia	7.4	10.0	11.0	11.8	10.9	10.4	10.0	7.9	7.9	6.3	6.5
Ireland	8.3	11.2	12.6	14.8	17.4	17.9	18.2	15.1	11.9	9.9	8.6
Greece	15.9	18.9	18.8	23.3	31.8	35.2	37.3	42.0	42.2	38.5	35.6
Spain	4.6	6.3	7.5	5.7	7.5	8.3	9.2	8.8	7.8	7.4	7.2
France	6.1	7.5	7.1	7.1	6.7	6.2	6.3	5.9	6.1	6.1	6.4
Croatia	-	-	28.0	27.5	28.9	30.4	29.1	28.7	25.3	21.0	17.5
Italy	13.9	11.3	11.2	12.0	11.7	11.9	12.2	12.6	8.9	4.8	4.5
Cyprus	7.5	13.3	16.3	16.9	18.4	21.9	20.5	20.1	15.4	13.7	12.2
Latvia	11.8	17.8	22.5	23.4	22.4	20.7	19.6	16.7	13.2	11.9	11.6
Lithuania	6.2	8.4	10.9	11.8	12.6	13.2	10.4	8.4	9.7	7.9	9.2
Luxembourg	1.1	2.3	2.1	2.2	2.2	3.1	3.2	2.4	4.0	1.7	3.6
Hungary	14.2	20.7	22.1	22.7	24.4	25.0	22.3	19.4	16.2	13.9	11.1
Malta	7.3	7.9	6.8	8.6	10.1	11.6	14.6	10.2	9.5	5.6	6.9
Netherlands	2.2	2.1	2.1	2.4	2.3	2.4	3.0	2.7	2.0	2.1	1.5
Austria	3.5	4.0	4.4	4.0	3.8	4.6	3.5	3.5	4.2	3.6	2.4
Poland	10.0	12.5	13.9	12.9	14.1	14.0	14.4	9.2	9.5	8.5	6.3
Portugal	3.7	6.1	6.4	6.7	6.3	8.2	8.5	7.8	7.3	5.6	4.5
Romania	23.5	25.1	26.5	27.3	29.7	29.7	21.5	17.4	18.0	15.9	14.4
Slovenia	14.2	16.9	18.0	17.3	19.3	19.7	20.3	17.5	15.9	14.3	12.5
Slovakia	3.8	11.3	9.6	6.4	5.8	5.9	6.1	5.7	5.7	5.5	7.9
Finland	6.6	7.5	6.9	7.8	7.9	8.4	7.9	7.5	7.7	7.8	7.7
Sweden	6.2	5.4	5.2	4.6	4.3	4.7	3.6	3.2	2.6	2.2	2.2
United Kingdom	4.7	-	5.6	5.0	8.9	8.7	7.2	7.0	5.7	5.0	5.4

Source: Thomson, H., & Bouzarovski, S. (2020)

decreased from 2003 to 2018 for all indicators. However, the depth of energy poverty has increased over the period. Compared with the EU, Turkey ranks above the average in terms of energy poverty rates and is similar to Estonia. Secondly, for the consensual-based indicators, energy poverty rates have been higher and there has been a greater decline in these rates from 2005 to 2017 than the expenditure-based indicators. This decline has occurred in all regions of Turkey. While the Southeast Anatolia region has always had the highest energy poverty rate, the West Anatolia region and the West Marmara region have had the lowest energy poverty rates. In the comparison with the EU, Turkey is located near the upper limit in energy poverty among EU countries but it is one of the countries that have the largest decline rates and it is similar to Portugal, Croatia, and Romania.

Table 8. Share of Households (%) for 'Arrears on Utility Bills' in Turkey

	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018
Turkey	27.2	35.2	37.9	38.7	36.7	34.5	29.8	28.0	24.2	21.4	19.0

4.3 The main contributing factors of energy poverty in the literature for Turkey

In the literature, as previously stated in the introduction, the main factors contributing to energy poverty are stated as high energy prices, low income, and poor housing quality or low energy efficiency of housing (BERR, 2001; OECD/IEA, 2011; Ürge-Vorsatz and Tirado Herrero, 2012). In this section, I examine the effects of these factors on energy poverty in Turkey.

For the first factor (i.e. high energy prices), Figure 12 shows the change in the CPI and the prices of the different energy types used by households from 2003 to 2018. While the prices of gas and solid fuels have increased at a faster rate than the general Consumer Price Index (CPI) over this period, the increase in electricity prices has remained mostly below the CPI.

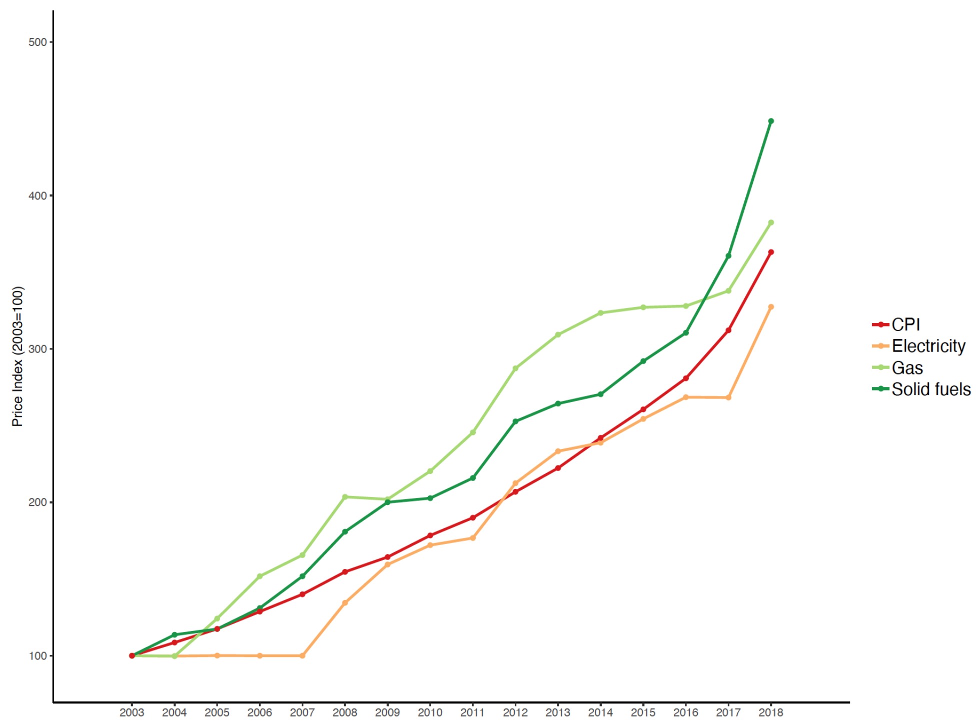

Figure 12. Price indices for electricity, gas and solid fuels in Turkey

Besides the change in energy prices, Figure 13 shows the before-housing-cost (BHC) income poverty levels and per dwelling temperature corrected energy intensity levels in Turkey. These variables are used for the other main contributing factors to energy poverty (i.e. low income and low energy efficiency). I calculate BHC income poverty using households' annual OECD scaled disposable income in the 2003-2018 HBS and the residential energy efficiency levels are directly taken from the IEA's Energy Efficiency Indicators Database.[3] Figure 13 indicates that the BHC income poverty rates in Turkey have decreased over the years (from 31.1% in 2004 to 24.9% in 2018). On the other hand, the residential energy efficiency levels have improved over the period (from 98 in 2004 to 81 in 2017). There are many energy efficiency policies that are currently in place in Turkey which have been carried out by the Ministry of Energy and Natural Resources with the General Directorate of Renewable Energy and the Energy Efficiency Coordination Board since 2007. These policies are Energy Efficiency Law (2007), TS 825 (2008), Energy Efficiency Regulation (2011), Energy Efficiency Strategy (2012), National Energy Efficiency Action Plan (2017), Buildings Energy Performance Regulation (2017), and the Green Buildings Regulation (2017). (Center, S.E.T., 2019) One of the reasons behind the improvement in the residential energy efficiency levels in Figure 13 can be these current policies.

After observing the change in the related variables for three main contributing factors to energy poverty in the literature, I estimate the Pearson's product-moment correlation coefficients to find the level of linear dependence between these three factors and the energy poverty rates calculated by the 2M indicator, the AFCP indicator, the HEP indicator, and the Energy Poverty Index. I also run a two-tailed t-test to check the statistical significance of these correlation coefficients. Table 9 shows the correlation coefficients and their significance levels. However, it should be noted that rather than establishing a cause-effect relationship, the values in Table 9 indicates an association between the three factors and different energy poverty rates.

[3]These levels are reported using the year 2000 as the base year in the IEA's Energy Efficiency Indicators Database. Since the values for the years 2003, 2004, 2006, 2007, 2008, 2009, and 2018 are missing, I cannot recalculate these residential energy efficiency levels to be compatible with the data for the change in prices using the year 2003 as the base year in Figure 9.

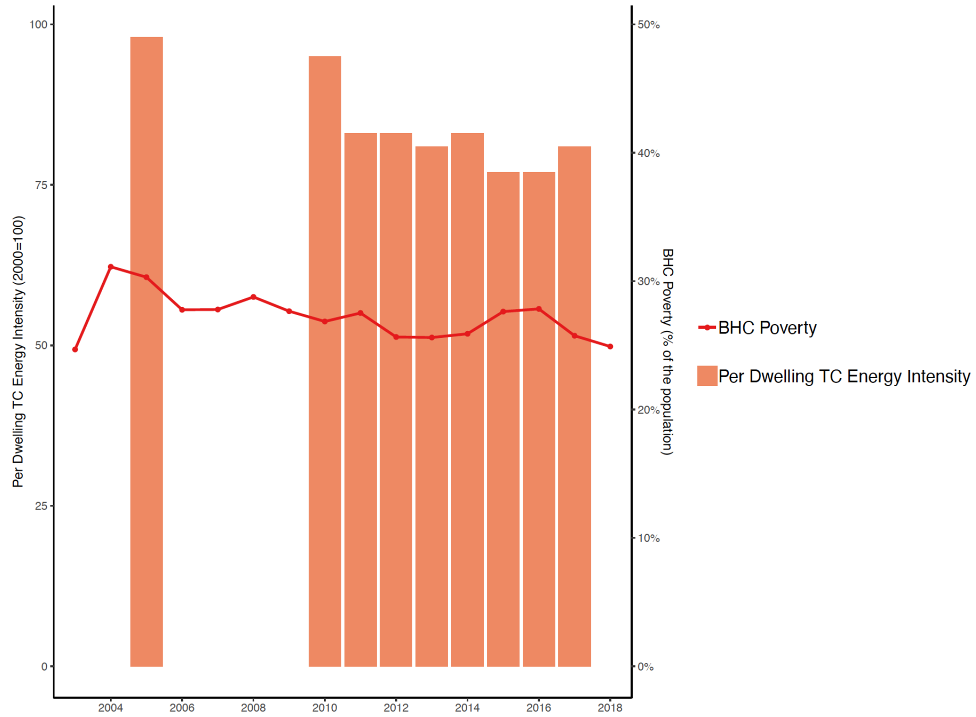

Figure 13. BHC poverty rates and energy efficiency indicator for Turkey

Tirado Herrero (2013) assumes a 0.5 threshold value of correlation coefficients for a relatively strong correlation. Using the same assumption, Table 9 gives important information on the change of energy poverty rates from different indicators which can be seen in Figure 6 and Figure 10.

Firstly, all energy poverty rates calculated by different indicators have a positive, statistically significant, and strong correlation with the before-housing-cost income poverty. While the correlation is at most for the AFCP indicator, the 2M indicator's correlation is the lowest. Secondly, although the correlation between energy efficiency and all energy poverty rates calculated by different indicators is positive, it is only statically significant for the AFCP indicator and the Energy Poverty Index. Since the residential energy efficiency levels for Turkey is missing for the 7 out of 18 years in the dataset, this correlation may have turned out to be insignificant. If the data set had included information for each year, this correlation could be statistically significant and stronger for energy poverty rates calculated by different indicators. Lastly, all energy poverty rates calculated by different indicators have a negative, statistically significant, and strong correlation with the prices of all energy types. The correlation is highest for the electricity prices for all energy poverty rates except the one calculated by the 2M indicator.

Table 9. Correlation Coefficients (Pearson's) Between Energy Poverty Rates and the BHC Income Poverty, Energy Prices and Residential Energy Performance Indicator

	The BHC Income Poverty	Energy Efficiency	Electricity Prices	Gas Prices	Solid Fuel Prices
The 2M Indicator	0.53**	0.43	-0.59**	-0.69***	-0.52**
The AFCP Indicator	0.96***	0.63*	-0.62**	-0.59**	-0.59**
The HEP Indicator	0.68***	0.55	-0.90***	-0.89***	-0.87***
The Energy Poverty Index	0.54*	0.69**	-0.85***	-0.84***	-0.83***

Note:*** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$

Last but not least, the reasons behind the overall decline of energy poverty rates from different indicators seen in Figure 6 and Figure 10 can be explained in three aspects: Firstly, since the before-housing-cost income poverty has decreased over the years (Figure 13) and has a positive and statistically significant correlation with all energy poverty rates calculated by different indicators (Table 9), this decrease can one of the reasons behind the overall decline in all energy poverty rates. Secondly, the residential energy efficiency levels have improved over the period (Figure 13) and again has a positive and potentially statistically significant correlation with all energy poverty rates calculated by different indicators (Table 9), this improvement can be the second reason for the overall decline in all energy poverty rates. Finally, since electricity has the biggest share in the household's per capita total annual expenditure for all income quintiles (Figure 5) and the increase in electricity prices has remained mostly below the CPI (Figure 12) and also electricity prices have a higher correlation with different energy poverty rates than the other energy types' prices (Table 9), the last reason behind the overall decline can be the decrease in reel prices of electricity.

CHAPTER 5

ENERGY-POOR HOUSEHOLDS IN TURKEY

This chapter is the second part of this thesis and mainly focuses on the energy-poor households' characteristics in Turkey. In the first section of this chapter, I use regression analyses to find characteristics of energy-poor households according to different indicators and in the second section, I look at the descriptive statistics to see the change of these characteristics over the years.

5.1 Regression analysis for the characteristics of energy-poor households

Expenditure-based indicators are dichotomous variables, and the Energy poverty Index from the consensual-based indicators is an ordered and 5-valued variable. In this section, in order to find the most influential demographic, socioeconomic, and dwelling characteristics of the energy-poor households in Turkey I construct 3 different logit models for each expenditure-based indicator (i.e. the 2M indicator, the AFCP indicator, and the HEP indicator), and 1 ordered logit model for Energy Poverty Index.

5.1.1 Expenditure-based indicators

Three different logistic regression models are constructed to examine the probability of being energy-poor for a household according to the 2M indicator, the AFCP indicator, or the HEP indicator. I estimate the following model:

$$Pr\left(Y_{it} = \text{ Energy-Poor } \mid X_{it}'\right) = \Phi\left(\alpha + H_{it}'\Gamma_1 + D_{it}'\Gamma_2 + \delta_t + u_{it}\right) \qquad (5.1)$$

where Y_{it} denotes the situation of energy poverty for household i at time t, and it takes the value 1 when a household is energy-poor according to the indicator used in the model and 0 otherwise. X_{it} contains all explanatory variables for household i at time t in the model and Pr stands for probability. Φ is cumulative logistic distribution function and H_{it} includes variables related to the household head characteristics for household i at time t. Besides, D_{it} includes variables related to the dwelling characteristics for household i at time t. δ_t stands for the year dummies and u_{it} is the error term.

The variables related to the household head in the vector of H are 11 age groups (i.e. 15–19, 20–24, 25–29, 30–34, 35–39, 40–44, 45–49, 50–54, 55–59, 60–64 and more than 64), four education groups for the highest education level attained (i.e. less than basic education, basic education, high school, and college/university education and more), four employment status groups (i.e. employed, unemployed, retired and inactive), gender and marital status. On the other hand, the variables related to the dwelling in the vector of D are household size, four ownership groups (i.e. owner, tenant, lodging, and not owner but also not paying rent), four dwelling type groups (i.e. detached house, semi-detached or terraced house, apartment and other dwelling types), seven construction date of the building groups (i.e. before 1946, between 1946-1960, between 1961-1970, between 1971-1980, between 1981-1990, between 1991-2000, and after 2000) and four heating system groups (i.e. stove, central heating, individual floor heating/combi, and other heating systems), six main fuel type groups (i.e. firewood, coal, natural gas, electricity, dried dung, and other fuel types) and living area per person. All explanatory variables in the model are selected based on the existing energy poverty literature. Mainly, I use the studies of Legendre et al. (2015) and Costa-Campi et al. (2019) and the study of Thomson et al. (2013).

Table 10 shows the results of logistic regressions for each indicator providing information on odds ratios and margins. Since the coefficient estimates in logistic models cannot be interpreted directly, I report odds ratios and margins (i.e. the marginal effect at the mean). Odds ratios are obtained by exponentiating the coefficients. In this way, the effect of each variable on the odds of being in the situation of energy poverty for a household can be determined compared to households having the baseline category of that variable. Besides odd ratios, the marginal effects at the mean are obtained by the derivative of equation (5.1) with respect to each variable when all the other explanatory variables are at their mean. Marginal effects show the change in the predicted probability, for binary explanatory variables, as they change from 0 to 1, and measure the instantaneous rate of change for continuous variables.

Table 10 contains two groups of explanatory variables as it is seen in the equation (5.1): 5 variables related to the household head characteristics and 7 variables related to the dwelling characteristics. Firstly, I examine the variables for household head characteristics.

The age of the household head is statistically significant for the AFCP indicator and the HEP indicator, while none of the age groups is statistically significant for the 2M indicator. Odds ratios and margins for this variable show that as the age of household head increases until 60, the predicted probability of a household being energy-poor decreases for both indicators. However, if the age of the head of the household is over 60, this probability starts to increase.

The variable of gender shows different results for each indicator. While being a female of the household head is not statistically significant for the AFCP indicator, it has a significant positive effect on the probability of a household being energy-poor for the 2M indicator whereas it has a significant negative effect on the probability for the HEP indicator. The low number of female household heads (i.e. 12.7% of the households) may be the reason behind this inconsistency.

For marital status, Table 10 indicates that even though that household head is married has a statistically significant effect on the probability of being energy-poor for households for all indicators, it increases the predicted probability for the 2M indicator and the AFCP indicator, while it decreases for the HEP indicator. Since it may be easier for a person to cut energy expenditures while living alone than when living with someone because of altruism, the effect of being married on the probability of in the situation of energy poverty for the household could be reductive

Table 10. Energy Poverty Regression from HBS 2003-2018

	The 2M Indicator		The AFCP Indicator		The HEP Indicator	
	Odds Ratios	Margins	Odds Ratios	Margins	Odds Ratios	Margins
Household Head Characteristics						
Age Group						
between 20 and 24	1.138	0.020	0.582***	-0.078***	0.646	-0.068
between 25 and 29	1.166	0.024	0.454***	-0.114***	0.475***	-0.115***
between 30 and 34	1.151	0.022	0.373***	-0.142***	0.394***	-0.144***
between 35 and 39	1.187	0.026	0.362***	-0.147***	0.355***	-0.160***
between 40 and 44	1.139	0.020	0.324***	-0.162***	0.330***	-0.172***
between 45 and 49	1.023	0.004	0.248***	-0.201***	0.304***	-0.184***
between 50 and 54	0.961	-0.006	0.198***	-0.234***	0.283***	-0.195***
between 55 and 59	0.966	-0.005	0.198***	-0.233***	0.268***	-0.204***
between 60 and 64	1.079	0.012	0.213***	-0.223***	0.262***	-0.207***
more than 64	1.292	0.039	0.299***	-0.174***	0.304***	-0.184***
Gender						
Female	1.118***	0.017***	0.976	-0.003	0.862***	-0.023***
Marital Status						
Married	1.234***	0.032***	1.100***	0.014***	0.799***	-0.035***
Education Level						
Basic Education	0.888***	-0.018***	0.630***	-0.066***	0.763***	-0.042***
High School	0.771***	-0.040***	0.427***	-0.123***	0.641***	-0.069***
Collge/University Education and More	0.388***	-0.145***	0.135***	-0.288***	0.531***	-0.098***
Employment Status						
Unemployed	1.609***	0.073***	3.397***	0.176***	1.564***	0.069***
Retired	1.430***	0.055***	0.909*	-0.014*	0.725***	-0.050***
Inactive	1.465***	0.059***	3.093***	0.163***	1.546***	0.068***
Dwelling Characteristics						
Household Size	0.935***	-0.010***	1.227***	0.029***	1.211***	0.030***
Ownership						
Tenant	1.523***	0.064***	5.529***	0.246***	1.153***	0.022***
Lodging	0.815***	-0.031***	0.654***	-0.061***	1.287***	0.039***
Not Owner but also not Paying Rent	1.098**	0.014**	1.248***	0.032***	1.152***	0.022***
Dwelling Type						
Semi-Detached or Terraced House	0.922***	-0.012***	0.830***	-0.027***	0.900***	-0.016***
Apartment	0.682***	-0.059***	0.399***	-0.132***	0.600***	-0.079***
Other Dwelling Types	0.881	-0.019	0.740***	-0.043***	0.800***	-0.035***
Construction Date of the Building						
between 1946 and 1960	0.982	-0.003	0.922	-0.012	0.976	-0.004
between 1961 and 1970	0.993	-0.001	0.796***	-0.033***	0.806***	-0.033***
between 1971 and 1980	0.961	-0.006	0.719***	-0.047***	0.812***	-0.032***
between 1981 and 1990	0.945	-0.009	0.690***	-0.054***	0.818***	-0.031***
between 1991 and 2000	0.963	-0.006	0.690***	-0.053***	0.803***	-0.034***
after 2000	0.906*	-0.015*	0.809**	-0.031**	0.935	-0.010
Heating System						
Central Heating	1.477***	0.060***	0.550***	-0.086***	0.558***	-0.090***
Individual Floor Heating/Combi	1.403***	0.052***	0.613***	-0.070***	0.752***	-0.044***
Other Heating Systems	0.977	-0.004	0.679***	-0.056***	0.842 *	-0.027 *
Main Fuel Type						
Coal	1.014	0.002	0.974	-0.004	1.002	0.000
Natural Gas	0.514***	-0.102***	0.580***	-0.078***	1.444***	0.057***
Electricity	0.414***	-0.135***	0.612***	-0.071***	1.598***	0.073***
Dried Dung	0.707**	-0.053**	2.590***	0.137***	3.333***	0.186***
Other Fuel Types	0.684***	-0.058***	0.922	-0.012	1.219	0.031
Living Area per Person	1.002***	0.000***	0.989***	-0.002***	0.996***	-0.001***
Observations	161844		161844		161844	
Pseudo R^2	0.048		0.256		0.097	
Log Pseudo Likelihood	-78077.774		-69201.699		-76554.695	

Note: *** p < 0.01, ** p < 0.05, * p< 0.1. Year fixed effects are controlled. Omitted categories are less than 20, male, single (never married,widowed,divorced), less than basic education and employed for household head characteristics and owner, detached house, before 1946, stove, fire wood for dwelling characteristics. Standard errors are clustered at the year level.

for the HEP indicator. (i.e. the predicted probability of being energy-poor is 3.5% point greater for the household whose head is single than for one whose head is married.)

The variable of the education level of the head of the household has the same statistically significant effect for each indicator. The predicted probability of household's being energy-poor decreases, as the completed education level of household head increases. This improvement occurs at most for the AFCP indicator.

For the employment status of the household head, while having an employed household head rather than having a retired household head has different effects for different indicators, having an employed household head for a household decreases the probability of being in the situation of energy poverty for all indicators compared to having an unemployed or inactive household head. As in the education level, this improvement occurs at most for the AFCP indicator. Since the AFCP indicator has a closer association with income variable than the other indicators, and education level and employment status are the good indicators for income, the higher improvements in education level and employment status may occur for the AFCP indicator.

Besides the variables for household head characteristics, secondly, I examine the effects of the variables for dwelling characteristics on the predicted probability of a household being energy-poor.

Table 10 firstly indicates that as household size increases, the probability of being an energy-poor household increases for the AFCP indicator and the HEP indicator, while it decreases for the 2M indicator.

For the ownership situation of the dwelling, being a tenant in the dwelling increases the predicted probability of a household being energy-poor compared to owning the dwelling for each indicator. But the magnitude of the effects of each indicator differs significantly. While being a tenant increases the probability by 24.6% point in the AFCP indicator, it increases only 2.2% point for the HEP indicator. Besides, if the dwelling is a lodging, the probability of being in the situation of energy poverty for a household decreases in the AFCP indicator and the 2M indicator, while the living in the lodging increases this probability in the HEP indicator. Since the pricing of energy expenditures in the lodging is lower, the nominal amount of energy expenditure of the people living here may be much less than those living in other places. Therefore, living in the lodging may make appear it as if it increases the probability of a household being energy-poor according to the HEP indicator.

In addition to ownership state, the variable of dwelling type has the same statistically significant effect for each indicator. Living in an apartment decreases the probability of being in the situation of energy poverty for households for all indicators compared to living in a detached, semi-detached, or terraced house.

As for the construction date of the building, the variable is statistically significant for the AFCP indicator and the HEP indicator, while none of the construction date groups, except after 2000, is statistically significant for the 2M indicator. While the probability of a household being energy-poor decreases as the construction date of a building comes to the present date after 1960, this probability increases for the buildings constructed after 2000.

For the heating system and the main fuel type of the dwelling, Table 11 indicates that even though using central heating or individual floor heating/combi has a statistically significant effect on the predicted probability of being energy-poor for households for all indicators, it increases the predicted probability for the 2M indicator, while it decreases for the HEP indicator and the AFCP indicator. On the other hand, using natural gas or electricity as the main fuel type in the dwelling decreases the probability of a household being energy-poor in the 2M indicator and in the AFCP indicator, it increases this probability for the HEP indicator. This may be because the price of wood is cheaper. Because in the HEP indicator, the energy-poor households have very low energy expenditure and while this low amount is enough to buy enough wood, it may not get enough units for natural gas or electricity.

Lastly, living area per person has a statistically significant effect on the probability of a household being energy-poor for each indicator. However, it is magnitude is negligibly low in each indicator.

All in all, even though the effect of some variables related to the household head and dwelling on the predicted probability of being in the situation of energy poverty for a household differs for different indicators, there are also common variables that have the same effect on this probability. Therefore, the following can be said for the state of energy poverty from the expenditure-based perspective: for the variables related to the household head; being unemployed or inactive, and having a low education level are the key factors for all indicators in explaining the higher probability of a household being energy-poor. On the other hand, for the variables related to the dwelling; living in a detached house, and being a tenant are the other key factors explaining why this probability is higher for all of the indicators.

5.1.2 Consensual-based indicators

An ordered logistic regression model is constructed to examine the probability of having different energy poverty levels for a household according to the Energy Poverty Index. I estimate the following model:

$$Pr(Y_{ijt} = m \mid X'_{ijt}) = \begin{cases} \Phi\left(\tau_1 - X'_{ijt}\boldsymbol{\beta}\right) & m = 1, \\ \Phi\left(\tau_m - X'_{ijt}\boldsymbol{\beta}\right) - \Phi\left(\tau_{m-1} - X'_{ijt}\boldsymbol{\beta}\right) & 1 < m \leq 4, \\ 1 - \Phi\left(\tau_4 - X'_{ijt}\boldsymbol{\beta}\right) & m = 5, \end{cases} \quad (5.2)$$

where Y_{ijt} denotes energy poverty level for household i in region j[1] at time t, and it takes one of the values in the Energy poverty Index (i.e. 0, 0.25,0.5, 0.75, or 1). m is one of the five categories in the EPI. Pr stands for probability. Φ is cumulative logistic distribution function and τ_m is the cut-off point between energy poverty levels. β is a vector of coefficients and it does not vary across equations. X_{ijt} contains all explanatory variables for household i in region j at time t in the model. X_{ijt} includes almost the same explanatory variables used in the logistic regression models for expenditure-based indicators in the previous to make a better comparison between the

[1]I use the 2005-2017 Income and Living Conditions Surveys for the ordered logistic regression and the surveys have the information on the regions in which households are located.

characteristics of energy-poor households by expenditure-based and by consensual-based indicators. All variables related to the household head characteristics (i.e. the vector of H) and all variables related to the dwelling head characteristics (i.e. the vector of D), except the variable of 'construction date of building'[2], in the logistic regression models are included in X_{ijt}. Differently from the logistic regression models, X_{ijt} also includes the dummy for the insulation state of dwelling and the NUTS-1[3] region dummies.

Since the magnitudes of the coefficient estimates cannot be interpreted, Table 11 shows the results of ordered logistic regression providing information on odds ratios. Odds ratios are obtained by exponentiating the coefficients. These ratios give information on the effect of each variable on the odds of being in the highest energy poverty level for a household versus being in a combined energy poverty level calculated by the lower categories (or the odds of being in the combined energy poverty level by the higher categories versus being in the lowest energy poverty level) compared to households having the baseline category of that variable. For margins, there are 5 sets of marginal effects, since the dependent variable, the Energy Poverty Index, has 5 categories. I do not report marginal effects for the ordered logistic regression, since it would be too detailed to interpret each set separately.

Table 11 contains 5 variables related to the household head characteristics and 7 variables related to the dwelling characteristics. Firstly, I examine the variables for household head characteristics. The age of the household head is statistically significant for several age groups. Odds ratios for this variable show that as the age of household head increases until 40, the predicted probability of a household being in a higher level of energy poverty increases. However, if the age of the head of the household is over 40, this probability starts to decrease. According to this variable, households having a middle-aged household head are the households in which the probability of being in a situation of a higher energy poverty level is highest.

[2]This variable is not included in SILC.

[3]After the 2014 SILC, the information on NUTS-2 level regions is included in the surveys. Since all years between 2005-2017 are used in the regression, I control for the NUTS-1 level region dummies.

Table 11. Energy Poverty Regression from SILC 2005-2017

	The Energy Poverty Index
	Odds Ratios
Household Head Characteristics	
Age Group	
between 20 and 24	1.298***
between 25 and 29	1.413***
between 30 and 34	1.564***
between 35 and 39	1.584***
between 40 and 44	1.437***
between 45 and 49	1.303***
between 50 and 54	1.174 *
between 55 and 59	1.106
between 60 and 64	0.990
more than 64	0.901
Gender	
Female	1.024
Marital Status	
Married	0.775***
Education Level	
Basic Education	0.808***
High School	0.609***
Collge/University Education and More	0.344***
Employment Status	
Unemployed	2.304***
Retired	0.963**
Inactive	1.596***
Dwelling Characteristics	
Household Size	0.901***
Ownership	
Tenant	1.560***
Lodging	1.001
Not Owner but also not Paying Rent	1.364***
Dwelling Type	
Semi-Detached or Terraced House	0.991
Apartment	0.780***
Other Dwelling Types	1.150
Insulation	
Dwellings without heating problems due to insulation	0.237***
Heating System	
Central Heating	0.473***
Individual Floor Heating/Combi	0.624***
Other Heating Systems	0.680***
Main Fuel Type	
Coal	0.989
Natural Gas	0.852***
Fuel-Oil	0.879
Diesel Oil-Gasoil	1.423**
Electricity	1.089
Dried Dung	1.594***
Other Fuel Types	1.208***
Living Area per Person	0.987***
Cut 1	-2.446
Cut 2	-1.066
Cut 3	-0.068
Cut 4	1.153
Observations	224026
Pseudo R^2	0.153
Log Pseudo Likelihood	-273655.637

Note: *** p < 0.01, ** p < 0.05, * p< 0.1. Year fixed effects, NUTS1 fixed effects and their interactions are controlled. Omitted categories are less than 20, male, single (never married,widowed,divorced), less than basic education and employed for household head characteristics and owner, detached house, dwellings with heating problems due to insulation , stove, fire wood for dwelling characteristics. Standard errors are clustered at the NUTS-1 region and year level.

For marital status, Table 11 indicates that household head is married has a statistically significant and negative effect on the predicted probability of being in higher levels of energy poverty for households. In other words, households having a married household head have a lower probability of being in the higher levels of energy poverty.

Education level is another statistically significant variable in the model. It can be seen from Table 11 that as the completed education level of household head increases, the predicted probability of household's being in a higher energy poverty level decreases.

For the last variable related to the household head characteristics, employment status, Table 11 shows that having an employed household head for a household decreases the probability of being in the situation in a higher-level energy poverty compared to having an unemployed or inactive household head. On the other hand, this probability increases if the household has a retired household head.

After the variables for household head characteristics, secondly, I examine the variables for dwelling characteristics' effects on the predicted probability of a household being in a higher level of energy poverty. Table 11 indicates that:

As household size increases, the probability of being in a situation of a higher energy poverty level decreases for households.

For the ownership situation of the dwelling, being a tenant in the dwelling or the state of not owning the dwelling but also not paying rent increases the predicted probability of a household being energy-poor compared to owning the dwelling.

About the dwelling type, it can only be said from Table 11 that living in an apartment decreases the predicted probability of a household being in a higher level of energy poverty compared to living in a detached house. Because the other categories for dwelling type are not statistically significant.

As for the insulation variable, dwellings without heating problems due to insulation have notably a much lower predicted probability for being in a higher level of energy poverty compared to the dwellings with heating problems due to insulation.

Concerning another variable for dwelling characteristics, the heating system used in the dwelling, Table 11 shows that the probability of being in a higher energy poverty level is lowest for the households using central heating as the heating system, while this probability is highest for the households using stove as the heating system.

For the main fuel type used in the dwelling, the probability of being in a higher energy poverty level is the statistically lowest for the households using natural gas as the main fuel type in the dwelling compared to households using firewood. On the other hand, this probability is the statistically highest for the households using dried dung or diesel oil-gasoil as the main fuel types in the dwelling.

Lastly, living area per person has a statistically significant, negative, and small effect on the probability of household's being in a higher energy poverty level and as living area per person increases, this probability decreases.

In conclusion, it can be said for the state of energy poverty which is calculated using the Energy Poverty Index from consensual based indicators as follows: Being middle-aged or single, having a low level of education, or being unemployed or inactive are the key factors of the household head when explaining why the probability of a household being in a higher level of energy poverty is higher. On the other hand, living in a detached house, being a tenant, living a dwelling with heating problems due to insulation, or using dried dung as the main fuel type and stove as the heating system in the dwelling are the other key factors explaining why this probability is higher. As it stated in the previous part, 4 of these factors (i.e. having a low level of education, and being unemployed or inactive for the household head, living in a detached house and being a tenant in the dwelling) are also the key factors that are used in explaining the higher probability of a household being energy-poor in the expenditure-based approach.

5.2 Change in the characteristics of energy-poor households over time

The tables in Appendix A and Appendix B show all descriptive statistics for the change in the composition of energy-poor households across different demographic, socio-economic, and residential characteristics that are used in the regression models. However, in this section, I only examine the change in the variables found statistically significant in the previous section for each indicator.

5.2.1 Expenditure-based indicators

Tables A1,A2, and A3 (Appendix A) show the descriptive statistics for the change in the composition of the household head characteristic of energy-poor households for the 2M indicator, the AFCP indicator and the HEP indicator respectively. Besides, Tables B1,B2, and B3 (Appendix B) show the descriptive statistics for the change in the composition of the dwelling characteristic of energy-poor households. Since the variables related to the household head and the dwelling that found statistically significant in the previous section for each indicator quite differ and it would be very long and detailed to examine the change in all these variables, and I also want to make a common evaluation about the expenditure-based approach; I only examine the change in the variables that have the same significant effect for each indicator on the predicted probability of being in the situation of energy poverty for a household. These variables are education level and employment status from household head characteristics and ownership status, dwelling type from dwelling characteristics.

Firstly, I examine the change in the variables related to the household head characteristics. For the variable of education level, Tables A1,A2, and A3 (Appendix A) show that the composition of energy-poor households according to the education level of household heads has quite changed in time for all indicators. The proportion of energy-poor households having a household head who has a less than basic education level has decreased over time for all indicators. This decrease occurs most for the HEP indicator (from 75.62% in 2003 to 52.38% in 2018), while it occurs at the lowest level for the 2M indicator (from 69.92% in 2003 to 63.17% in 2018). Since the logistic regression in the previous section shows that the predicted probability of household's being energy-poor decreases, as the completed education level of household head increases; this change in the composition of energy-poor households according to education level means that energy-poor households are still less-educated than non-energy-poor households over the period. Indeed, this situation can be seen in the descriptive statistics of non-energy-poor households as well.

Secondly, about the variable of employment status, Tables A1,A2, and A3 (Appendix A) show that the composition of energy-poor households according to the employment status of household heads has changed in the same way for all indicators over time. The proportion of energy-poor households having a retired household head has decreased over time, while the proportion of energy-poor households having an inactive household head has increased for all indicators. The reason behind why the 2M indicator gives a different result for the effect of having a retired household head for households on the probability of being an energy-poor household can be seen here. While the proportion of energy-poor households having a retired household head (from 28.94% in 2003 to 18.14% in 2018) is higher than the proportion of non-energy-poor households (from 25.32% in 2003 to 16.86% in 2018) for the 2M indicator over the period, while the other way around occurs for the AFCP and HEP indicator. Tables A1,A2, and A3 (Appendix A) also indicate that the main occupation group in energy-poor households is being a worker in the sectors of service and sales, agricultural, forestry and fishery or craft and related trades.

After examining the change in the variables related to the household head characteristics, I also examine the change in the variables related to the dwelling characteristics. For the variable of ownership status, the logistic regression model in the previous section indicates that being a tenant in the dwelling increases the probability of being an energy-poor household. Tables B1,B2, and B3 (Appendix B) show that the proportion of being a tenant has increased over the period in energy-poor households for all indicators. (from 23.90% in 2003 to 28.95% in 2018 for the 2M indicator; from 33.97% in 2008 to 45.85% in 2018 for the AFCP indicator; from 21.00% in 2008 to 30.54% in 2018 for the HEP indicator). Moreover, the composition of energy-poor households according to the ownership status has changed in the same way for all indicators over the period. While the proportion of energy-poor households living in an apartment has increased over time, the proportion of energy-poor households living in a detached house has decreased for all indicators. The magnitude of this change is the highest for the HEP indicator (32.87% point increase in the proportion of energy-poor households living in apartments), whereas it is lowest for the 2M indicator (6.89% point increase in the proportion of energy-poor households living in apartments). Since the logistic regression in the previous section shows that that living in an apartment decreases the predicted probability of a household being energy-poor compared to living in a detached house, it can be said that for all indicators the proportion of non-energy-poor households living in apartments has increased much more than for the proportion of energy-poor households.

In sum, the following can be said about the changing profile of energy-poor households over time for the variables found statistically significant in the previous section for the expenditure-based approach. Firstly, the education level of household heads in energy-poor households has increased. Secondly, while the proportion of energy-poor households with an employed household head hasn't changed, this proportion has decreased for those with a retired household head and increased for those with an inactive household head. Lastly, the proportion of being a tenant in the dwelling has increased for energy-poor households, and these energy-poor households have started to live in apartments rather than detached houses.

5.2.2 Consensual-based indicators

Table A4 (Appendix A) and Table B4 (Appendix B) show the descriptive statistics for the change in the composition of the household head characteristic and dwelling characteristics of energy-poor households respectively. Firstly, I examine the change in the variables related to the household head characteristics. In the previous section, the variables of age, marital status, education level, and employment status from household head characteristics have significant effects on the probability of a household being in a higher level of energy poverty.

For the variable of age, the ordered logistic regression indicates that having a middle-aged household increases at most the probability of being a household in a higher energy poverty level compared to having a household head in the other age groups. Table A4 (Appendix A) shows that the average age of the household head has increased among the energy-poor households over the period according to descriptive statistics for the EPI. In 2005, households with a household head under the age of 45 constituted the majority of the energy-poor households (54.8%), while in 2017 the households with a household head over the age of 45 were the majority (60.57%). Secondly, having an unmarried household head is another factor increasing this probability according to the model and it can be seen in Table A4 (Appendix A) that over time more energy-poor households have had an unmarried household head. For the variables of education level and employment status from household head characteristics, Table A4 (Appendix A) shows that while the composition of energy-poor households according to the education level of household heads hasn't much changed over time, this composition has changed for the employment status of household heads. Table A4 (Appendix A) shows that the proportion of energy-poor households having a retired household head (from 11.43% in 2005 to 21.27% in 2017) has increased over time, while the rate had decreased for having an employed household head (from 65.78% in 2005 to 56.91% in 2017). Since the ordered logistic regression in the previous section shows that households having a retired household head have a lower probability of being in a higher level of energy poverty compared to the households having an employed household head, it means that the extent and the increase in the proportion of non-energy-poor households having a retired household head (from 18.47% in 2005 to 23.17% in 2017) are more than the proportion for energy-poor households. As in the expenditure-based approach, Table A4 (Appendix A) also shows the main occupation group in energy-poor households according to the EPI is being a worker in several sectors such as service and sales, agricultural, forestry, and fishery or craft and related trades.

Besides the change in the household head characteristics in energy-poor households, I also look at the change for the dwelling characteristics of energy-poor households. The ordered logistic regression in the previous section shows that the variables of ownership status, dwelling type, having insulation, used heating system and main fuel type in the dwelling have significant effects on the probability of a household being in a higher level of energy poverty. For the ownership status, the ordered logistic regression model in the previous section indicates that being a tenant in the dwelling increases the probability of being in a higher level of energy poverty for households. Table B4 (Appendix B) shows that the proportion of being a tenant has increased over the period in energy-poor households (from 11.43% in 2005 to 21.27% in 2017). Secondly, although that living in an apartment decreases the predicted probability of a household being in a higher level of energy poverty compared to living in a detached house is shown by the ordered logistic regression in the previous section, Table B4 (Appendix B) shows that while the proportion of energy-poor households living in apartments has increased (from 38.20% in 2005 to 51.79% in 2017), the proportion of households living in detached houses has decreased over the period (from 56.55% in 2005 to 41.09% in 2017). The reason for this is that the proportion of non-energy-poor households living in apartments has increased (from 57.03% in 2005 to 73.34% in 2017) much more than for the proportion of energy-poor households. For the variable of having insulation, the composition of energy-poor households has not changed over time for the state of having insulation. Lastly, Table B4 (Appendix B)shows that while the use of natural gas as the main fuel type and individual floor heating/combi as the heating system has increased over time in energy-poor households, the use of stove and coal has decreased. But again these changes have occurred lower than for the non-energy-poor households, since using natural gas as the main fuel type and individual floor heating/combi as the heating system in the dwelling decreases the predicted probability of a household being in a higher energy poverty level as it is shown in the ordered logistic model in the previous section.

In conclusion, the changing profile of energy-poor households over time for the variables found statistically significant in the previous section for the consensual-based approach can be summed up as follows. Firstly, the average age of the household head in energy-poor households has increased and the probability of having a married household head for energy-poor households has decreased. Secondly, the proportion of energy-poor households with an employed household head has decreased, while the proportion has increased for those with a retired household head. Thirdly, the proportion of being a tenant in the dwelling and living in apartments rather than detached houses has increased for energy-poor households. Lastly, the use of natural gas as the main fuel type and individual floor heating/combi as the heating system has increased over time in energy-poor households, while the use of stove and coal has decreased.

CHAPTER 6

CONCLUSIONS

This thesis was constructed in two parts. The first part included (i) the examination of the structure of Turkish households' energy expenditures, (ii) the estimation of the energy poverty rates in Turkey under both expenditure-based approach and consensual approach over the period 2003-2018 and the comparison of these rates with the EU, and lastly (iii) the evaluation of the main contributing factors of energy poverty in the literature for Turkey. As for the second part, it included (i) the econometric analyses for the most influential demographic, socioeconomic, and residential characteristics of the energy-poor households in Turkey and (ii) the descriptive statistics for the change in the composition of energy-poor households across these characteristics over the years.

My findings indicate that for the structure of household energy expenditures, while household energy expenditure is the fourth most important consumption category in the household's per capita annual expenditure for the average Turkish household, its share has decreased from 9.56% in 2003 to 6.11% in 2018. Concerning the composition of household energy expenditures, electricity has been always the type of household energy that has the largest share of households' per capita annual expenditure over the period 2003-2018. In this period, while the share of natural gas has increased, the share of solid fuels and LPG has decreased for the average Turkish household.

Energy poverty rates for Turkey have decreased on average from 25.37% in 2003 to 19.87% in 2018 for the expenditure-based indicators. On the other hand, for the consensual-based indicators, although energy poverty rates have been higher than the expenditure-based indicators for the period between 2007-2017, there has been a greater decline in these rates (on average from 35.36% in 2003 to 24.96% in 2018). In comparison with the EU, while Turkey ranks above the average in the EU for the expenditure-based approach, and is similar to Estonia; for the consensual-based approach, it is located near the upper limit in energy poverty among EU countries but has one of the largest decline rates and, it is similar to Portugal, Croatia, and Romania.

When the main contributing factors to energy poverty (i.e. high energy prices, low income, and low energy efficiency of housing) in the literature are evaluated for Turkey, this thesis shows that the decrease in the before-housing-cost income poverty, the improvement in the residential energy efficiency and the decrease in reel prices of electricity seems to be the reasons behind the overall decline of energy poverty rates over the period for both the expenditure and consensual-based indicators.

Regarding the most influential demographic, socioeconomic, and dwelling characteristics of the energy-poor households; having a household head who is unemployed or inactive, and with a low educational level; living in a detached house, and being a tenant are the key factors in explaining the higher probability of a household being energy-poor for the expenditure-based approach. About the change in the composition of energy-poor households across these characteristics over the years, while the proportion of energy-poor households with a retired household has decreased, the proportion has increased for those with an inactive household head. The education level of household heads in these households has increased over time as well. Besides, the proportion of being a tenant in the dwelling has increased for energy-poor households, and these households have started to live in apartments rather than detached houses.

When it comes to consensual based approach, having a household head who is middle-aged, single, unemployed or inactive, and with a low educational level; living in a detached house, being a tenant, living a dwelling with heating problems due to insulation, or using dried dung as the main fuel type and stove as the heating system in the dwelling arise as the key factors when explaining why the probability of a household being in a higher level of energy poverty is higher. The change in the composition of energy-poor households across these characteristics over the years in

Turkey is as follows: the average age of the household head in energy-poor households has increased and the probability of having a married household head for energy-poor households has decreased. While the composition of energy-poor households according to the education level of household heads hasn't much changed over time, the proportion of energy-poor households with an employed household head has decreased, and the proportion has increased for those with a retired household head. Furthermore, the proportion of being a tenant in the dwelling and living in apartments rather than detached houses has increased for energy-poor households. The use of natural gas as the main fuel type and individual floor heating/combi as the heating system has increased over time in these households, the use of stove and coal has decreased.

Notwithstanding these conclusions, this thesis has still limitations and some issues that haven't been analyzed yet. The MIS indicator, the LIHC indicator, and the other weighted indicators in the consensual-based approach couldn't be used in this thesis due to the lack of data in Turkey. Since each indicator captures a different side of the concept of energy poverty, a study with the inclusion of these indicators could yield different results. On the other hand, I only use cross-sectional data in this study. Income and Living conditions Surveys also includes the longitudinal data set and hence a panel data analysis would be worth conducting for future research to track the energy poverty state of households according to the consensual-based approach using the same data set to find the factors for the non-energy-poor households that would lead them to become-energy poor households over time or the factors for the energy-poor households that would lead them to get out of this situation.

APPENDIX A

DESCRIPTIVE STATISTICS FOR HOUSEHOLD HEADS

Table A1. Household Head Characteristics of Energy-Poor Households under the 2M Indicator (%)

	2003	2006	2009	2012	2015	2018
Age Group						
less than 25	2.47	1.32	1.25	1.52	1.48	0.74
between 25 and 34	24.01	18.46	18.62	15.94	15.28	12.22
between 35 and 44	8.75	25.55	24.54	23.83	22.96	24.26
between 45 and 54	19.67	23.33	19.23	19.39	19.10	18.50
between 55 and 64	21.94	15.43	15.56	16.22	16.45	18.59
more than 64	23.16	15.91	20.80	23.10	24.73	25.68
Gender						
Male	88.77	87.74	83.39	84.11	79.85	77.73
Female	11.23	12.26	16.61	15.89	20.15	22.27
Marital Status						
Married	86.29	89.21	83.99	81.27	75.38	72.41
Single	13.71	10.79	16.01	18.73	24.62	27.59
Education Level						
Less than Basic Education	69.92	70.31	70.68	68.78	64.06	63.17
Basic Education	10.18	11.91	10.67	11.21	12.56	13.42
High School	13.93	13.76	13.44	14.66	15.30	15.82
College/University Education and More	5.97	4.02	5.21	5.35	8.08	7.60
Employment Status						
Employed	55.43	64.52	61.53	62.18	57.31	56.39
Managers	4.04	7.72	5.72	2.59	2.54	2.15
Professionals	2.57	1.77	1.66	1.84	2.46	2.38
Technicians and Associate Professionals	1.80	1.65	3.46	2.30	2.47	2.04
Clerical Support Workers	1.63	2.25	2.02	1.86	2.66	2.35
Service and Sales Workers	5.84	5.72	6.62	10.55	11.40	10.45
Skilled Agricultural, Forestry and Fishery Workers	17.60	14.29	17.47	17.66	10.12	11.43
Craft and Related Trades Workers	10.12	12.45	8.17	10.87	11.41	10.04
Plant and Machine Operators and Assemblers	4.65	8.82	7.19	7.03	6.78	8.11
Elementary Occupations	7.18	9.84	9.21	7.32	7.47	7.44
Unemployed	2.79	2.08	4.70	3.84	4.00	4.91
Retired	28.94	20.76	16.31	17.83	17.84	18.14
Inactive	12.84	12.64	17.47	16.16	20.86	20.56
Number of Households	11346	8556	10046	9987	11491	11828

Table A2. Household Head Characteristics of Energy-Poor Households under the AFCP Indicator (%)

	2003	2006	2009	2012	2015	2018
Age Group						
less than 25	4.61	1.39	2.25	2.15	2.16	1.76
between 25 and 34	32.03	21.96	22.24	21.12	18.32	16.63
between 35 and 44	11.74	30.54	30.70	28.18	29.01	31.65
between 45 and 54	17.55	20.22	17.54	19.63	20.21	21.06
between 55 and 64	17.27	13.64	11.07	12.76	12.75	12.92
more than 64	16.79	12.25	16.20	16.17	17.55	15.98
Gender						
Male	91.92	87.50	83.13	85.94	82.31	81.42
Female	8.08	12.50	16.87	14.06	17.69	18.58
Marital Status						
Married	90.13	89.46	84.36	85.20	79.86	78.44
Single	9.87	10.54	15.64	14.80	20.14	21.56
Education Level						
Less than Basic Education	79.13	82.44	80.89	75.81	72.80	64.39
Basic Education	8.82	8.60	9.78	10.61	13.50	17.32
High School	11.09	7.80	8.30	11.80	10.28	14.15
College/University Education and More	0.96	1.16	1.03	1.78	3.41	4.14
Employment Status						
Employed	67.04	70.72	66.22	69.05	60.99	62.41
Managers	2.82	3.50	3.77	2.13	1.11	1.65
Professionals	0.47	0.56	0.37	0.93	0.98	1.07
Technicians and Associate Professionals	1.05	1.23	1.66	1.24	1.01	1.61
Clerical Support Workers	0.87	1.19	1.19	1.09	1.76	1.64
Service and Sales Workers	7.19	7.80	6.60	10.18	11.68	12.14
Skilled Agricultural, Forestry and Fishery Workers	23.18	21.38	21.10	19.80	11.89	9.07
Craft and Related Trades Workers	13.98	12.89	10.23	13.33	12.44	13.57
Plant and Machine Operators and Assemblers	5.02	7.33	8.45	7.71	7.81	8.80
Elementary Occupations	12.45	14.85	12.86	12.61	12.32	12.85
Unemployed	4.46	4.05	7.47	5.25	7.10	7.28
Retired	15.10	9.41	5.76	7.98	7.88	9.21
Inactive	13.40	15.80	20.54	17.72	24.03	21.10
Number of Households	11346	8556	10046	9987	11491	11828

Table A3. Household Head Characteristics of Energy-Poor Households under the HEP Indicator (%)

	2003	2006	2009	2012	2015	2018
Age Group						
less than 25	3.97	1.48	2.43	2.44	1.87	2.52
between 25 and 34	27.19	20.13	20.71	20.51	18.55	18.37
between 35 and 44	11.59	29.92	27.12	26.67	27.51	26.91
between 45 and 54	22.10	23.75	21.03	22.62	23.37	24.26
between 55 and 64	18.36	12.63	12.70	14.40	13.88	13.49
more than 64	16.80	12.09	16.02	13.36	14.82	14.45
Gender						
Male	92.91	89.37	84.81	86.94	85.35	84.32
Female	7.09	10.63	15.19	13.06	14.65	15.68
Marital Status						
Married	88.32	89.92	83.63	85.56	81.14	77.86
Single	11.68	10.08	16.37	14.44	18.86	22.14
Education Level						
Less than Basic Education	75.64	76.87	75.63	66.04	62.39	52.38
Basic Education	8.00	9.32	9.03	11.69	13.06	16.83
High School	12.07	10.22	11.26	15.03	14.38	16.07
College/University Education and More	4.29	3.59	4.09	7.24	10.16	14.71
Employment Status						
Employed	69.65	73.28	68.34	71.76	68.15	69.27
Managers	5.53	6.15	6.60	4.40	3.44	3.71
Professionals	2.70	2.03	1.04	2.61	3.96	5.09
Technicians and Associate Professionals	2.06	2.45	2.34	2.83	2.59	4.81
Clerical Support Workers	1.79	2.02	1.78	2.37	2.77	3.55
Service and Sales Workers	6.58	7.67	5.44	10.84	11.88	11.89
Skilled Agricultural, Forestry and Fishery Workers	24.36	19.32	21.86	17.17	11.19	8.01
Craft and Related Trades Workers	11.95	13.17	9.49	11.39	12.25	12.29
Plant and Machine Operators and Assemblers	5.64	9.45	8.17	8.18	9.19	8.70
Elementary Occupations	9.05	11.02	11.61	11.62	10.89	11.22
Unemployed	3.09	2.95	6.79	3.76	5.33	4.93
Retired	16.58	11.53	7.43	10.04	9.19	10.52
Inactive	10.68	12.22	17.43	14.44	17.33	15.27
Number of Households	11346	8556	10046	9987	11491	11828

Table A4. Household Head Characteristics of Energy-Poor Households under the Energy Poverty Index (%)

	2005	2008	2011	2014	2017
Age Group					
less than 25	1.99	2.21	1.96	1.91	1.73
between 25 and 34	24.42	20.03	17.90	15.17	13.68
between 35 and 44	28.42	27.40	26.28	24.79	26.01
between 45 and 54	21.02	22.52	23.35	21.10	23.17
between 55 and 64	12.64	14.28	15.56	16.00	16.93
more than 64	11.52	13.57	14.95	21.03	18.47
Gender					
Male	87.29	83.88	83.05	76.52	77.69
Female	12.71	16.12	16.95	23.48	22.31
Marital Status					
Married	85.53	83.68	80.61	72.67	75.61
Single	14.47	16.32	19.39	27.33	24.39
Education Level					
Less than Basic Education	73.45	71.08	69.88	72.96	70.09
Basic Education	9.82	10.48	10.95	10.98	12.88
High School	11.93	13.62	13.79	11.40	11.70
College/University Education and More	4.80	4.82	5.39	4.67	5.32
Employment Status					
Employed	65.78	61.10	64.31	54.67	56.91
Managers	6.24	5.81	2.13	1.88	1.54
Professionals	2.05	1.89	1.92	1.72	1.77
Technicians and Associate Professionals	2.52	2.70	2.31	2.03	1.90
Clerical Support Workers	1.65	2.40	2.13	1.35	1.57
Service and Sales Workers	6.86	7.06	11.07	10.79	10.44
Skilled Agricultural, Forestry and Fishery Workers	11.78	11.49	12.75	9.38	8.83
Craft and Related Trades Workers	13.88	11.51	11.83	10.60	11.95
Plant and Machine Operators and Assemblers	9.50	8.62	9.44	7.17	8.45
Elementary Occupations	11.31	11.22	10.95	10.90	10.87
Unemployed	5.98	6.97	4.54	5.33	7.45
Retired	11.43	15.25	13.15	17.16	21.27
Inactive	16.82	16.68	18.00	22.84	14.36
Number of Households	10920	11870	17562	22763	24068

APPENDIX B

DESCRIPTIVE STATISTICS FOR DWELLINGS

Table B1. Dwelling Characteristics of Energy-Poor Households under the 2M Indicator (%)

	2003	2006	2009	2012	2015	2018
Household Type						
Couple without Children	31.17	14.71	17.07	20.50	19.73	18.41
Couple with Children	39.49	57.09	50.36	46.78	45.18	41.90
One Adult Household (w/ or w/o children)	12.11	7.45	11.20	17.52	21.06	26.46
Extensive Household	16.21	20.23	18.33	13.98	12.71	11.82
Persons Live Together	1.03	0.52	3.04	1.22	1.33	1.40
Ownership						
Owner	70.61	68.66	59.23	58.60	54.39	54.84
Tenant	23.90	23.08	24.85	25.03	29.27	28.95
Lodging	0.84	0.64	1.46	1.09	1.08	0.64
Not Owner but also not Paying Rent	4.65	7.62	14.46	15.28	15.26	15.57
Dwelling Type						
Detached House	44.49	46.87	45.29	50.85	46.33	37.53
Semi-Detached or Terraced house	8.90	8.52	11.53	10.22	5.02	11.89
Apartment	43.69	43.51	42.74	38.81	48.65	50.58
Other Dwelling Types	2.92	1.10	0.44	0.12	0.00	0.00
Construction Date of Building						
before 1960	11.11	9.11	11.70	9.98	7.31	6.66
between 1960 and 1980	37.93	30.26	25.27	24.99	23.14	24.60
between 1980 and 2000	49.38	56.16	49.79	46.83	46.41	42.68
after 2000	1.59	4.48	13.25	18.19	23.14	26.06
Heating System						
Stove	84.17	80.28	74.85	71.36	57.06	55.95
Central Heating	9.31	7.97	9.27	7.08	7.83	9.52
Individual Floor Heating/Combi	6.27	11.37	14.92	19.50	31.33	31.53
Other Heating Systems	0.25	0.39	0.96	2.06	3.78	2.99
Main Fuel Type						
Fire Wood	74.09	61.89	56.23	57.19	42.20	16.65
Coal	9.20	17.83	19.53	18.85	16.92	44.43
Natural Gas	9.76	14.81	18.96	19.96	34.04	32.49
Electricity	1.46	1.42	2.40	3.26	4.44	4.09
Dried Dung	0.49	2.42	1.44	0.31	1.01	1.32
Other Fuel Types	5.00	1.63	1.42	0.42	1.28	0.58
Number of Households	11346	8556	10046	9987	11491	11828

Table B2. Dwelling Characteristics of Energy-Poor Households under the AFCP Indicator (%)

	2003	2006	2009	2012	2015	2018
Household Type						
Couple without Children	19.25	7.84	9.56	10.57	10.44	9.51
Couple with Children	50.69	61.98	54.70	54.85	54.15	52.36
One Adult Household (w/ or w/o children)	8.63	6.82	10.62	13.20	16.31	20.22
Extensive Household	20.47	22.82	22.65	20.32	17.76	16.32
Persons Live Together	0.96	0.54	2.47	1.06	1.34	1.59
Ownership						
Owner	60.74	59.78	50.07	46.88	44.33	40.61
Tenant	33.97	32.73	37.67	38.11	41.88	45.85
Lodging	0.29	0.16	0.37	0.71	0.42	0.51
Not Owner but also not Paying Rent	5.00	7.33	11.89	14.30	13.37	13.03
Dwelling Type						
Detached House	56.11	61.91	56.70	51.96	58.01	37.41
Semi-Detached or Terraced house	11.83	10.01	12.41	13.28	6.46	11.94
Apartment	28.26	26.78	30.54	34.57	35.54	50.65
Other Dwelling Types	3.80	1.31	0.34	0.19	0.00	0.00
Construction Date of Building						
before 1960	12.72	12.48	13.70	10.28	8.81	5.98
between 1960 and 1980	38.99	31.41	26.89	26.14	24.59	22.84
between 1980 and 2000	46.54	50.13	47.22	46.09	43.10	43.82
after 2000	1.74	5.98	12.18	17.49	23.50	27.36
Heating System						
Stove	96.14	95.15	90.80	84.99	76.39	64.70
Central Heating	2.42	1.92	3.09	3.57	2.65	4.86
Individual Floor Heating/Combi	1.29	2.45	5.00	10.23	16.10	26.91
Other Heating Systems	0.16	0.47	1.11	1.21	4.87	3.52
Main Fuel Type						
Fire Wood	87.23	70.05	64.05	62.66	50.39	17.82
Coal	5.23	14.53	19.60	16.18	18.19	41.13
Natural Gas	2.13	3.50	7.09	12.54	18.35	30.25
Electricity	1.07	1.43	3.08	4.50	6.75	5.17
Dried Dung	1.89	8.39	4.89	3.51	5.09	3.41
Other Fuel Types	2.44	2.10	1.30	0.60	1.10	1.42
Number of Households	11346	8556	10046	9987	11491	11828

Table B3. Dwelling Characteristics of Energy-Poor Households under the HEP Indicator (%)

	2003	2006	2009	2012	2015	2018
Household Type						
Couple without Children	21.00	9.88	11.35	10.13	11.83	10.52
Couple with Children	46.20	60.01	52.12	54.79	52.82	50.40
One Adult Household (w/ or w/o children)	8.72	6.51	10.16	12.94	13.89	20.33
Extensive Household	22.84	22.96	23.40	20.92	20.10	16.05
Persons Live Together	1.24	0.65	2.98	1.23	1.36	2.70
Ownership						
Owner	73.58	69.95	60.82	54.86	55.30	52.97
Tenant	21.00	19.59	22.20	25.68	28.54	30.54
Lodging	0.62	1.26	1.63	1.87	1.06	1.75
Not Owner but also not Paying Rent	4.81	9.20	15.35	17.59	15.09	14.74
Dwelling Type						
Detached House	55.23	56.78	53.95	41.70	47.82	26.90
Semi-Detached or Terraced house	10.73	10.13	10.24	10.97	4.47	9.53
Apartment	30.70	31.82	35.61	47.15	47.72	63.57
Other Dwelling Types	3.34	1.27	0.20	0.19	0.00	0.00
Construction Date of Building						
before 1960	11.97	10.40	10.35	8.60	5.93	4.37
between 1960 and 1980	36.58	29.65	26.40	21.92	20.98	16.68
between 1980 and 2000	49.55	53.10	49.83	45.69	43.11	42.70
after 2000	1.90	6.85	13.42	23.79	29.98	36.24
Heating System						
Stove	92.78	89.25	81.11	65.29	59.77	43.36
Central Heating	3.70	2.98	3.76	6.62	4.59	5.36
Individual Floor Heating/Combi	3.44	6.49	12.74	25.21	27.89	46.71
Other Heating Systems	0.07	1.27	2.40	2.88	7.76	4.58
Main Fuel Type						
Fire Wood	82.32	65.91	53.95	42.41	35.53	12.81
Coal	6.25	14.95	16.45	13.16	13.69	22.86
Natural Gas	5.43	7.35	16.00	30.80	33.30	51.73
Electricity	1.71	2.60	5.91	7.41	9.99	7.16
Dried Dung	1.62	6.81	6.09	5.31	5.95	3.71
Other Fuel Types	2.68	2.38	1.60	0.90	1.42	1.17
Number of Households	11346	8556	10046	9987	11491	11828

Table B4. Dwelling Characteristics of Energy-Poor Households under the Energy Poverty Index (%)

	2005	2008	2011	2014	2017
Region					
Istanbul	16.90	20.24	18.18	15.33	16.88
West Marmara	3.88	3.98	4.18	4.57	3.87
Aegean	14.90	12.44	11.60	15.50	15.12
East Marmara	8.54	9.02	9.33	7.43	5.91
West Anatolia	8.58	8.77	8.12	6.21	6.45
Mediterranean	13.95	14.13	15.03	17.90	15.70
Central Anatolia	4.92	4.74	4.74	4.12	5.37
West Black Sea	5.78	5.43	4.76	6.07	5.37
East Black Sea	3.47	3.02	4.27	3.17	3.48
Northeast Anatolia	2.83	2.88	2.61	2.80	3.13
Central East Anatolia	4.62	4.67	5.10	4.84	4.49
Southeast Anatolia	11.65	10.68	12.10	12.07	14.24
Household Type					
Single Person	4.83	6.64	8.13	18.36	15.05
2 adults, No Dependent Children	11.91	15.37	14.29	16.56	11.20
Single Person with Dependent Children	2.85	2.46	2.58	2.74	7.94
Two Adults with At Least One Dependent Child	46.63	41.80	41.62	36.19	49.68
Other Household Types	33.78	33.72	33.39	26.15	16.13
Ownership					
Owner	55.28	55.06	55.48	52.98	48.81
Tenant	27.43	25.68	23.86	26.53	30.67
Lodging	0.64	0.61	0.72	0.70	0.68
Not Owner but also not Paying Rent	16.65	18.66	19.95	19.80	19.83
Dwelling Type					
Detached House	56.55	51.29	51.73	53.30	41.09
Semi-Detached or Terraced House	5.16	4.52	5.25	4.84	7.02
Apartment	38.20	43.96	42.88	41.09	51.79
Other Dwelling Types	0.09	0.23	0.15	0.77	0.11
Insulation					
Having Heating Problems because of Insulation	62.24	61.39	64.97	63.38	62.84
Not Having Heating Problems because of Insulation	37.77	38.61	35.04	36.62	37.16
Heating System					
Stove	86.08	76.89	74.31	74.81	66.00
Central Heating	3.90	4.21	3.42	3.33	3.57
Individual Floor Heating/Combi	9.06	16.55	19.58	19.30	27.26
Other Heating Systems	0.97	2.36	2.70	2.57	3.17
Main Fuel Type					
Fire Wood	22.08	19.44	22.98	23.81	22.39
Coal	51.97	46.13	42.59	42.38	35.79
Natural Gas	13.10	22.60	23.93	22.92	30.72
Fuel Oil	0.50	0.25	0.11	0.08	0.03
Diesel Oil-Gasoil	0.43	0.33	0.04	0.05	0.01
Electricity	3.81	5.45	5.74	6.29	6.16
Dried Dung	5.98	4.63	3.99	3.95	4.41
Other Fuel Types	2.15	1.17	0.63	0.46	0.25
Number of Households	10920	11870	17562	22763	24068

REFERENCES

Belaïd, F. (2018). Exposure and risk to fuel poverty in France: Examining the extent of the fuel precariousness and its salient determinants. *Energy Policy, 114*, 189-200.

Boardman, B. (1991). *From cold homes to affordable warmth*. London, United Kingdom: Belhaven Press.

Boardman, B. (2010). *Fixing fuel poverty: Challenges and solutions*. London, United Kingdom: Earthscan.

Boemi, S. N., Avdimiotis, S., & Papadopoulos, A. M. (2017). Domestic energy deprivation in Greece: A field study. *Energy and Buildings, 144*, 167-174.

Bouzarovski, S., Petrova, S., & Sarlamanov, R. (2012). Energy poverty policies in the EU: A critical perspective. *Energy policy, 49*, 76-82.

Bouzarovski, S., Petrova, S., & Tirado Herrero, S. (2014). *From fuel poverty to energy vulnerability: The importance of services, needs and practices*. (Science Policy Research Unit Working Paper, 25, 1-28.)

Bouzarovski, S., & Petrova, S. (2015). A global perspective on domestic energy deprivation: Overcoming the energy poverty–fuel poverty binary. *Energy Research Social Science, 10*, 31-40.

Bouzarovski, S., & Tirado Herrero, S. (2017). The energy divide: Integrating energy transitions, regional inequalities and poverty trends in the European Union. *European Urban and Regional Studies, 24*(1), 69-86.

Bouzarovski, S., Thomson, H., Cornelis, M., Varo, A., & Guyet, R. (2020). Towards an inclusive energy transition in the European Union: Confronting energy poverty amidst a global crisis. Luxembourg, Luxembourg: EU Energy Poverty Observatory.

Buzar, S. (2007). The 'hidden' geographies of energy poverty in post-socialism: Between institutions and households. *Geoforum, 38*(2), 224-240.

Castaño-Rosa, R., Solís-Guzmán, J., Rubio-Bellido, C., & Marrero, M. (2019). Towards a multiple-indicator approach to energy poverty in the European Union: A review. *Energy and Buildings, 193*, 36-48.

Center, S. E. T. (2019). *Enhancing Turkey's policy framework for energy efficiency of buildings, and recommendations for the way forward based on international experiences.* (SHURA Energy Transition Center and the Buildings Performance Institute Europe (BPIE) Working Paper.)

Chaton, C., Lacroix, E. (2018). Does France have a fuel poverty trap?. *Energy Policy, 113*, 258-268.

Costa-Campi, M. T., Jové-Llopis, E., & Trujillo-Baute, E. (2019). Energy poverty in Spain: An income approach analysis. *Energy Sources, Part B: Economics, Planning, and Policy, 14*(7-9), 327-340.

Eke, E. U. (2012) Enerji yoksulluğunun giderilmesine yönelik sosyal politikalar (Unpublished MA thesis). Hacettepe University, Ankara, Turkey.

Emec, H., Altay, A., Aslanpay, E., & Ozdemir, M. O. (2015). Energy poverty and energy choice profile in Turkey. *Finans Politik Ekonomik Yorumlar, 52*(608), 9-21.

Foster, V., Tre, J. P., & Wodon, Q. (2000). Energy prices, energy efficiency, and fuel poverty. Washington, DC: World Bank.

Friel, S. (2007). Housing, fuel poverty and health: A pan-European analysis. *Health Sociology Review, 16*, 195–197.

Harrison, C., & Popke, J. (2011). "Because you got to have heat": The networked assemblage of energy poverty in eastern North Carolina. *Annals of the Association of American Geographers, 101*(4), 949-961.

Healy, J. D., & Clinch, J. P. (2002). *Fuel poverty in Europe: A cross country analysis using a new composite measurement*. (Environmental Studies Research Series Working Paper 02/06).

Healy, J. D., & Clinch, J. P. (2004). Quantifying the severity of fuel poverty, its relationship with poor housing and reasons for non-investment in energy-saving measures in Ireland. *Energy Policy, 32*(2), 207-220.

Heffner, G., & Campbell, N. (2011). *Evaluating the co-benefits of low-income energy-efficiency programmes*. Workshop Report, OECD/IEA, Paris.

Hills, J. (2011). *Fuel poverty: The problem and its measurement. Interim report of the Fuel Poverty Review* (No. casereport69). Centre for Analysis of Social Exclusion, London School of Economics and Political Science.

Hills, J. (2012). *Getting the measure of fuel poverty: Final report of the Fuel Poverty Review.* Centre for Analysis of Social Exclusion, London School of Economics and Political Science.

Karásek, J., & Pojar, J. (2018). Programme to reduce energy poverty in the Czech Republic. *Energy Policy, 115*, 131-137.

Kose, T. (2019). Energy poverty and health: The Turkish case. *Energy Sources, Part B: Economics, Planning, and Policy, 14*(5), 201-213.

Legendre, B., & Ricci, O. (2015). Measuring fuel poverty in France: Which households are the most fuel vulnerable? *Energy Economics, 49*, 620-628.

Liddell, C., Morris, C., McKenzie, S. J. P., & Rae, G. (2012). Measuring and monitoring fuel poverty in the UK: National and regional perspectives. *Energy policy, 49*, 27-32.

Maxim, A., Mihai, C., Apostoaie, C. M., Popescu, C., Istrate, C., & Bostan, I. (2016). Implications and measurement of energy poverty across the European Union. *Sustainability, 8*(5), 483.

Middlemiss, L., & Gillard, R. (2015). Fuel poverty from the bottom-up: Characterising household energy vulnerability through the lived experience of the fuel poor. *Energy Research Social Science, 6*, 146-154.

Moore, R. (2012). Definitions of fuel poverty: Implications for policy. *Energy Policy, 49*, 19-26.

Nussbaumer, P., Bazilian, M., & Modi, V. (2012). Measuring energy poverty: Focusing on what matters. *Renewable and Sustainable Energy Reviews, 16*(1), 231-243.

Okushima, S. (2016). Measuring energy poverty in Japan, 2004–2013. *Energy Policy, 98*, 557-564.

Okushima, S. (2017). Gauging energy poverty: A multidimensional approach. *Energy, 137*, 1159-1166.

Pelz, S., Pachauri, S., & Groh, S. (2018). A critical review of modern approaches for multidimensional energy poverty measurement. *Wiley Interdisciplinary Reviews: Energy and Environment, 7*(6), e304.

Rademaekers, K., Yearwood, J., Ferreira, A., Pye, S., Hamilton, I., Agnolucci, P., Grover, D., Karásek, J., & Anisimova, N. (2016). *Selecting indicators to measure energy poverty*. Rotterdam, The Netherlands:Trinomics.

Romero, J. C., Linares, P., & López, X. (2018). The policy implications of energy poverty indicators. *Energy Policy, 115*, 98-108.

Selçuk, I. Ş., Gölçek, A. G., & Köktaş, A. M. (2019). Energy poverty in Turkey. *Sosyoekonomi, 27*, 283-299.

Simcock, N., Walker, G., & Day, R. (2016). Fuel poverty in the UK: beyond heating. *People, Place and Policy, 10*(1), 25-41.

Thomson, H., & Snell, C. (2013). Quantifying the prevalence of fuel poverty across the European Union. *Energy Policy, 52*, 563-572.

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, 26*(7), 879-901.

Thomson, H., & Bouzarovski, S. (2018). Addressing energy poverty in the European Union: State of play and action. Manchester, United Kingdom: EU Energy Poverty Observatory.

Tirado Herrero, S. (2013). Fuel poverty alleviation as a co-benefit of climate investments: Evidence from Hungary Budapest. Central European University, Budapest, Hungary.

Tirado Herrero, S., Ürge-Vorsatz, D., & Petrichenko, K. (2013). *Fuel poverty alleviation as a co-benefit of climate investments: Evidence from Hungary*. Paper presented at European Council for an Energy Efficient Economy Summer Study (ECEEE) Summer Study Proceedings, Hyères, France. Retrieved from http://proceedings.eceee.org/visabstrakt.php?event=3doc=5B-485-1

Tirado Herrero, S., & Jiménez Meneses, L. (2016). Energy poverty, crisis and austerity in Spain. *People, Place and Policy, 10*(1), 42-56.

UK Fuel Poverty Strategy. (2001). London, United Kingdom: Department for Business Enterprise and Regulatory Reform (BERR).

Ürge-Vorsatz, D., & Tirado Herrero, S. (2012). Building synergies between climate change mitigation and energy poverty alleviation. *Energy Policy, 49*, 83-90.

Wang, K., Wang, Y. X., Li, K., Wei, Y. M. (2015). Energy poverty in China: An index based comprehensive evaluation. *Renewable and Sustainable Energy Reviews, 47*, 308-323.

WEC. (2006). *Alleviating urban energy poverty in Latin America*. London: World Energy Council.