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Energy Poverty and Its Effect on Economic Growth in Türkiye

Türkiye'de Enerji Yoksulluğu ve Ekonomik Büyüme Üzerindeki Etkisi

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Abstract

The energy poverty of households presents one of the significant threats to sustainable development worldwide. Governments, international organizations like the United Nations, and various non-governmental organizations have enacted policy measures to mitigate energy poverty and its negative impacts on society. This concern is exacerbated by the finite nature of fossil fuel resources globally and persistent instabilities such as the Russia-Ukraine conflict, the Iran-Israel conflict, and the COVID-19 pandemic, which contribute to price fluctuations and energy supply insecurity. Consequently, the issue of energy poverty may become increasingly intricate and prominent in the near future. Due to its importance, the issue of energy poverty has been widely investigated in the literature. A new dimension in the literature is based on the relationship between energy poverty, which is defined as the inability to access a sufficient volume of clean energy, and economic growth. Energy poverty can affect the economy through lower productivity and lower labor force participation. In this regard, the majority of studies in the literature have focused on African countries with low electricity access rates, typically using energy access rates as a proxy for energy poverty. In those studies, "energy poverty" and "energy deprivation" are often used interchangeably. However, this approach is not appropriate, as energy poverty and energy deprivation due to low energy access rates imply different conditions. While energy access rate can serve as a measure of energy poverty, relying solely on this indicator may not always accurately reflect the extent of energy poverty. This is because households with full infrastructure and access to clean and continuous energy sources may not always be able to fully utilize these sources, owing to cost constraints, income deficiencies, or other factors. A striking example of this situation can be seen in Türkiye, where 20.3% of households face difficulties in adequately heating their homes, representing one of the highest rates in Europe. Additionally, the average per capita household energy consumption in Europe was 1.7 MWh in 2021, whereas in Türkiye, it was only 0.56 MWh on average, which is one-third of the EU average. This happens despite Türkiye having relatively low energy prices, various support programs in place, and nearly 100% electricity access and very high natural gas access rates. Hence, unlike other studies that use energy access rate, this study utilizes per capita household electricity consumption as an indicator of energy poverty, which could provide a more precise evaluation, especially for Türkiye. This introduces a novel viewpoint in the research on energy poverty and economic growth. For this reason this study examines data from 2007 to 2021 comprising 15 years of annual data with DOLS and FMOLS panel econometric techniques across 26 regions of Türkiye, to uncover the association between energy poverty and economic growth. Additionally, factors such as the consumer price index, population, and industrial electricity demand per capita for production are used as control variable. According to both of the estimation techniques an increase in household electricity consumption may also lead to an increase in per capita GDP in Türkiye.

Keywords: Energy Poverty, Household Energy Consumption, GDP, FMOLS, DOLS

Türkiye’de Enerji Yoksulluğu ve Ekonomik Büyüme Üzerindeki Etkisi

Öz

Hanehalklarının enerji yoksulluğu, son yıllarda önemi gittikçe artan ve gündemde önemli bir yer tutan sürdürülebilir kalkınma çabaları aleyhine dünya çapında önemli tehditlerden birini teşkil etmektedir. Hükümetlerle birlikte, Birleşmiş Milletler gibi uluslararası örgütler ve çeşitli sivil toplum kuruluşları ise, enerji yoksulluğunu gündeme taşımakta ve bu durumun olumsuz etkilerini hafifletmeye yönelik politika önlemleri geliştirmektedirler. Bu endişenin, küresel fosil yakıt kaynaklarının sınırlı doğası ve Rusya-Ukrayna ve İran-İsrail çatışması ile COVID-19 pandemisi gibi süregelen istikrarsızlıklar nedeniyle oluşan fiyat şokları ve enerji arz güvenliği sorunları nedeniyle yakın gelecekte giderek daha karmaşık ve belirgin hale gelebileceği söylenebilir. Bu önemi dolayısıyla, enerji yoksulluğu konusunun önemi gittikçe artmakta ve akademik literatürde de geniş çapta araştırılmaktadır. İlişkili olarak, literatürdeki yeni bir bakış açısı enerji yoksulluğu ile ekonomik büyüme arasındaki ilişki üzerine odaklanmaktadır. Enerji yoksulluğu, hanehalklarının temiz enerji kaynaklarına yeterli miktarda erişememesi veya bu kaynaklardan yeterli miktarda faydalanamaması olarak tanımlanabilir. Temelde bu durum ise iki farklı etki aracılığıyla bir ülkenin ekonomik büyüme oranlarını olumsuz etkileyebilir. Bu etkilerden birincisi hanehalklarının sağlıklı şekilde yeterince enerjiden faydalanamaması dolayısıyla azalan işgücü verimliliğiyle ilişkiliyken diğeri ise düşen işgücüne katılım oranları ile alakalıdır. Bu bağlamda, literatürdeki çoğu çalışma, enerji alt yapısının çok yetersiz olduğu ve enerjiye erişim oranlarının düşük olduğu Afrika ülkelerine odaklanmıştır ve genellikle enerji erişim oranlarını enerji yoksulluğunun bir ölçütü olarak kullanmaktadırlar. Bu çalışmalarda, "enerji yoksulluğu" ve "enerji yoksunluğu" sıklıkla birbirinin yerine kullanılmaktadır. Ancak, bu yaklaşım pek doğru değildir zira enerji yoksulluğu ve enerji alt yapısının olmamasından kaynaklanan enerji yoksunluğu farklı kavramları ifade etmektedir. Her ne kadar enerji erişim oranı, enerji yoksulluğunun bir ölçüsü olarak kullanılabilirse de, sadece

bu gösterge enerji yoksulluğunun gerçek boyutunu her zaman tam olarak yansıtmayabilir. Bunun nedeni, %100 enerji altyapısına sahip ve temiz enerji kaynaklarına erişimi olan hanehalkları dahi, yüksek maliyet, yoksulluk veya diğer faktörler nedeniyle bu kaynaklardan her zaman tam manasıyla istifade edemeyebilirler. Bu durumun en çarpıcı örneklerinden biri Türkiye'de görülebilir; zira Türkiye’de hanehalklarının %20,3'ü evlerini yeterince ısıtamamaktadırlar ve bu oran Avrupa'daki en yüksek oranlardan biridir. Ek olarak, Avrupa'da 2021'de kişi başına düşen ortalama hanehalkı elektrik tüketimi 1,7 MWh iken, Türkiye'de bu miktar sadece 0,56 MWh olup, AB ortalamasının üçte biri kadardır. Bu durum, Türkiye'deki nispeten düşük enerji fiyatlarına, devletin sağlamış olduğu çeşitli enerji destek programlarına ve neredeyse %100 elektrik erişimine ve çok yüksek doğal gaz erişim oranlarına sahip olmasına rağmen gerçekleşmektedir. Bu nedenle, enerji erişim oranını kullanan diğer çalışmaların aksine, bu çalışmada özellikle Türkiye için daha doğru bir değerlendirme sağlayabilecek şekilde, kişi başına düşen hanehalkı elektrik tüketimi enerji yoksulluğunun bir göstergesi olarak kullanılmaktadır. Bu yaklaşım, enerji yoksulluğu ve ekonomik büyüme arasındaki ilişkiyi ele alan literatüre orjinal bir katkı sağlamakta ve yeni bir bakış açısı getirmektedir. Bu doğrultuda, çalışmada Türkiye’de enerji yoksulluğu ile ekonomik büyüme arasındaki ilişkiyi anlamak üzere Türkiye'nin 26 bölgesi için 2007'den 2021'e kadar olan 15 yıllık veri seti DOLS ve FMOLS panel ekonometrik teknikleri yardımıyla ele alınmıştır. Ayrıca, tüketici fiyat endeksi, nüfus ve üretimde kullanılan kişi başına endüstriyel elektrik talebi gibi faktörler kontrol değişkeni olarak kullanılmıştır. Her iki tahmin tekniğine göre de, hanehalklarının elektrik tüketimindeki artışın Türkiye'de kişi başına GSMH'da bir artışa neden olabileceği sonucuna varılmıştır.

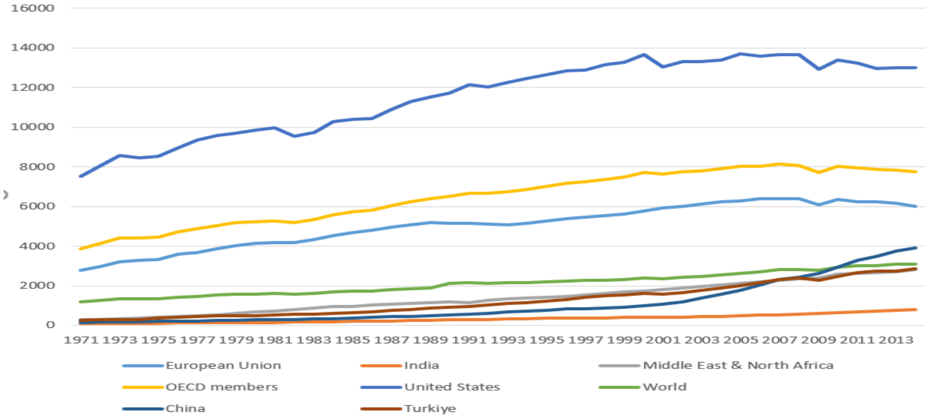
Anahtar Kelimeler: Enerji Yoksulluğu, Hanehalkı Enerji Tüketimi, GSYH, FMOLS, DOLS

Giriş

Energy, as a vital input in all production processes, holds significant importance in influencing various macroeconomic variables. Particularly with the recent emphasis on sustainable development, the role of energy becomes even more pronounced. However, factors such as the COVID-19 pandemic, conflicts between nations such as Russia and Ukraine, and more recently, tensions between Israel and Iran and their respective allies, contribute to heightened instability in the energy market. This instability manifests in fluctuating energy prices and potential disruptions in energy supply chains, impacting global economies.

Furthermore, climate change, primarily driven by the use of energy, especially fossil fuels, poses a significant environmental challenge. The significant surge in global population in the last century has resulted in a rapid surge in production and consequently, an escalated demand for energy. This surge is evident in the notable growth in energy demand, particularly in recent decades as illustrated in Figure 1. However, the emission of greenhouse gases resulting from energy combustion exacerbates environmental concerns, contributing to rising temperatures and ultimately, climate change. This constitutes a serious threat to ongoing sustainable development initiatives.

Figure 1. Per Capita Electricity Consumption, KWh



Source: World Bank (WDI)

Another critical issue associated with escalating energy demand is energy supply security. Ensuring a continuous and sustainable supply of energy sources, without interruptions, at affordable costs is essential for supporting productive activities worldwide, a cornerstone of sustainable development efforts.

Therefore, ongoing research seeks to establish a balance between energy usage and its notable side effects, including climate change, and to ensure energy supply security, thus promoting sustainable growth. However, this issue is primarily examined from the production perspective, overlooking its importance in consumption for meeting the household needs of people worldwide, which are continuously growing. Consequently, another critical concern related to energy is energy poverty, prevalent in underdeveloped and developing nations, and even in certain regions of developed countries.

However, while climate change and energy supply security have received considerable attention in research, less focus has been placed on the issue of energy poverty, despite its profound impact on the lives of millions worldwide (González-Eguino, 2015). Particularly with the rapid advancement of artificial intelligence and related technologies, which may elevate the significance of energy for households in their daily activities, it is anticipated that discussions on energy poverty will gain momentum in the future.

A relatively new topic emerging in the literature concerns the association between energy poverty in households and its impact on the economic growth of countries. While there are few studies on this topic currently, it is anticipated to gain more attention in the future. Energy poverty affects millions of people globally, impacting essential needs such as heating, cooling, cooking, lighting, transportation, telecommunications, and more. Households that lack access to sufficient quantities of high-quality, clean energy for these needs are unable to contribute efficiently to GDP.

This is significant because difficulties in achieving effective, sufficient, safe, and clean energy may not only impact the health of households but also affect the productivity of workers, subsequently influencing the growth rate of countries. For instance, various studies (Mannan & Al-Ghamdi, 2021; González-Martín et al., 2021) indicate that indoor air pollution resulting from the use of solid fuels generally for cooking leads to a range of health problems. Similarly, the inefficient use of energy or the use of polluting traditional solid fuels for heating purposes may also be associated with adverse health conditions (Chen et al., 2018; Kennard et al., 2020).

Another way in which high levels of energy poverty can impact the growth rates of countries is by consuming time that could otherwise be used for productive activities. For example, in underdeveloped and developing regions, many individuals, particularly women and children, spend a substantial amount of time each day collecting wood for various purposes such as heating and cooking. Additionally, animal dung is often used as a solid fuel in impoverished areas, but its preparation is a laborious and time-consuming process. This involves collecting and drying the dung through several stages before it can be used effectively for heating and cooking.

Old-fashioned heating stoves also contribute to time-consuming tasks, requiring significant effort to heat and clean after each use, as well as disposal of ashes. Additionally, in remote regions where obtaining or affording access to electrical power is impractical or economically unfeasible, some women are unable to benefit from modern household appliances such as washing machines, dishwashers, electric or gas cookers, and ovens. This leads to women spending most of their time on household chores in challenging and unhealthy conditions. These examples can be expanded in various ways, potentially hindering women, especially those in rural areas, from entering the workforce and contributing to the economic growth of nations. As a result, there is a growing number of studies investigating the relationship between energy poverty and economic growth in the literature.

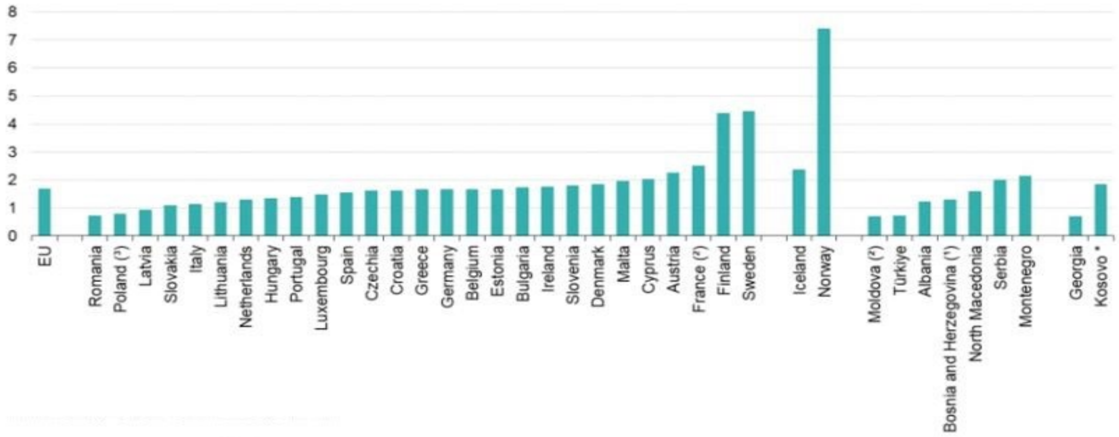
On the other hand, in theoretical discussions, energy poverty is categorized into three distinct classifications. The first category, often referred to as The Ten Percent Rule, quantifies energy poverty based on the proportion of household income allocated to energy expenditures and if this percentage exceeds 10%, the household is deemed to be experiencing energy poverty (Ullah et al., 2021). The second approach, termed the quantitative or technical approach, establishes a minimum physical energy requirement for a healthy life, with households consuming energy below this threshold considered to be in a state of energy poverty (Demir and Kuveloğlu, 2023). The third methodology encompasses a comprehensive assessment of various technological and socioeconomic factors, aiming to construct indexes for measuring energy poverty (Ullah et al., 2021).

Each of these three approaches has its own advantages and disadvantages. However, the definition and application of the term "energy poverty" in applied literature remains contentious and problematic. In academic discourse, as well as in official regulations and corporate research, various terms related to energy poverty, such as energy deprivation, fuel poverty, vulnerability, and affordability, are used with different meanings (Emre et al., 2021). Nonetheless, in applied literature, "energy poverty" and "energy deprivation" are often used interchangeably inappropriately, and the rate of energy access is frequently utilized as a proxy for energy poverty.

While the household energy access rate can serve as a measure of energy poverty, relying solely on this indicator may not always accurately reflect the extent of energy poverty. This is because households with full infrastructure and access to clean and continuous energy sources may not always be able to fully utilize these sources, owing to cost constraints, income deficiencies, or other factors. Similar challenges are also observed in the application of the Ten Percent Rule. Even if a household has full access to energy sources, they may still face energy poverty if they cannot consume sufficient energy to adequately heat their dwelling or resort to using solid fuels for cooking in order to save money, despite the associated indoor air pollution risks.

A compelling illustration of this scenario can be observed in Türkiye, a country heavily reliant on imported fossil energy sources. In Türkiye, the per capita household energy consumption is notably lower compared to European nations, which also rely on imported energy sources. As evidenced by Eurostat data, the average per capita electricity consumption in European households was 1.7 MWh in 2021. For certain countries like Sweden and Finland, this figure exceeded 4 MWh per capita, while in Türkiye, it stood at only 0.56 MWh, approximately one-third of the European average (Eurostat1). Additionally, it's worth noting that even in Europe, an estimated 50 million individuals are reported to experience energy poverty (Emre et al., 2021). Consequently, when considering the disparity between Turkish household energy consumption and the European average, alongside the nearly 100% electricity access rate in Turkish households, it suggests that energy access rates may not accurately reflect the true extent of energy poverty in Türkiye.

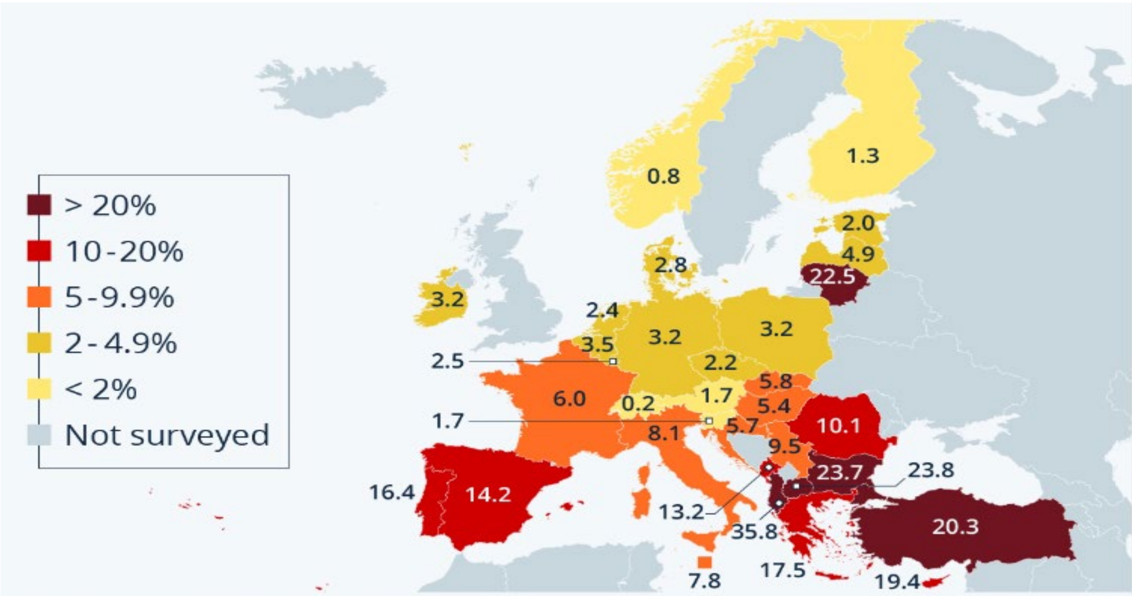
Figure 2. Per Capita Household Electricity Consumption in Europe (2021, MWh)



Source: Eurostat1

Furthermore, a similar situation can be analyzed through the lens of the Ten Percent Rule. In Türkiye, the proportion of electricity consumption relative to household disposable income varies across geographical regions, ranging from 2.37% to 4.6% (Eke and Ayranci, 2018). Additionally, as depicted in Figure 3 below, 20.3% of households struggle to adequately heat their homes, signifying one of the peak rates in the area. This circumstance, coupled with the observation that Turkish households only consume one-third of the electricity compared to European households, suggests that despite having access to electricity, households may not benefit from it adequately due to various factors.

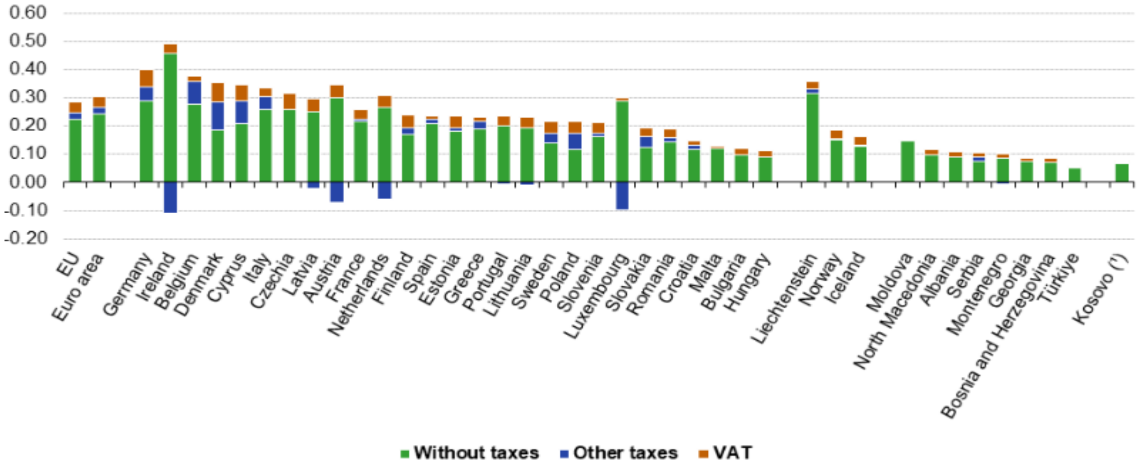
Figure 3. Households unable to adequately heat their homes in 2021(%)



Source: Eurostat, as cited in Statistita

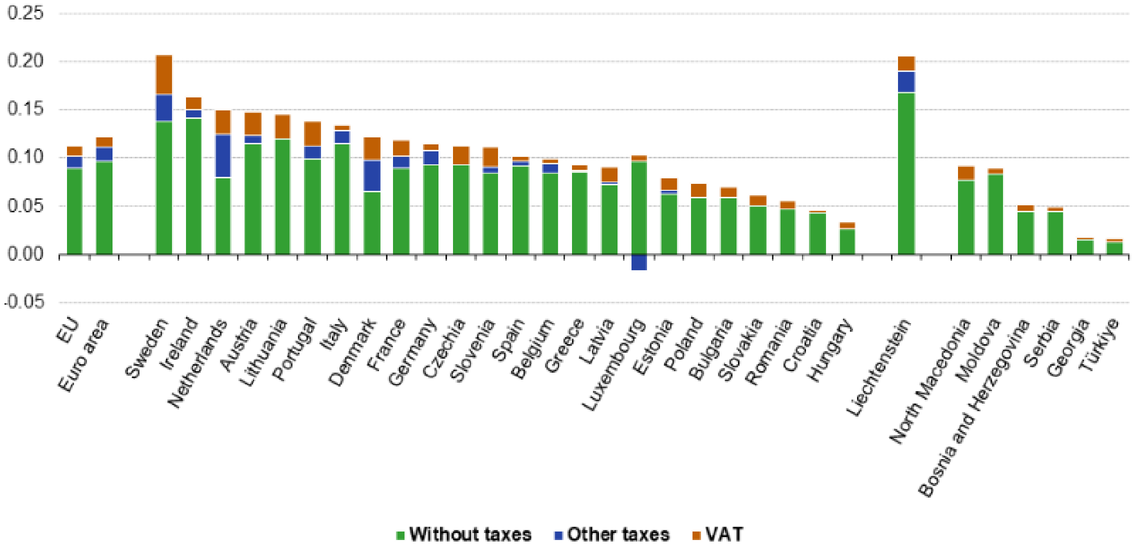
Hence, it can be argued that a high rate of energy access does not necessarily imply low energy poverty, as these are distinct concepts. Despite Türkiye's seemingly favorable performance in terms of energy poverty based on indicators such as the ten percent rule and energy access rates, the country warrants closer scrutiny regarding its energy poverty situation. Having only one-third of the per capita household energy consumption compared to neighboring European countries, Türkiye's energy poverty issue should be carefully examined. Another noteworthy aspect that makes Türkiye an interesting case for analysis concerning its high energy poverty rates is that these rates persist despite relatively low energy prices observed in recent years. Turkish households have benefited from some of the lowest electricity and natural gas prices in Europe, particularly during challenging periods such as the COVID-19 pandemic and the Russia-Ukraine conflict, as illustrated in Figures 4 and 5 below.

Figure 4. Electricity Prices for Household Consumers, 2023 (€ per kWh)



Source: (Eurostat2)

Figure 5. Natural Gas Prices for Household Consumers, 2023 (€ per kWh)



Source: (Eurostat3)

As previously discussed, the inability to access adequate and clean energy sources can adversely impact a country's growth rates through two channels: reduced productivity and low labor force participation. Türkiye is an interesting case in this regard. The country demonstrates notably low female labor force participation rates, ranking among the lowest globally with a rate of 35% in 2023, in contrast to rates of 52%, 53%, and 49% in the EU, OECD, and globally, respectively (World Bank).

However, the majority of studies in the literature focused on African countries with low electricity access rates, typically using energy access rates as a proxy for energy poverty. In contrast, this study employs per capita household electricity consumption as a measure of energy poverty, which may offer a more accurate assessment, particularly for Türkiye. This represents a novel perspective in the literature on energy poverty and economic growth. Consequently, this study addresses the issue of energy poverty and its relationship with economic growth for the first time in the context of Türkiye. It also stands as one of the pioneering investigations into a developing country characterized by nearly 100% electricity access and significant dependence on imported energy, within a fast-growing economy. The findings of this study have the potential to introduce new insights to the existing literature, providing a variety of original contributions and perspectives.

The study examines data from 2007 to 2021 across 26 regions of Türkiye, comprising 15 years of annual data. It employs DOLS and FMOLS panel econometric techniques to analyze the relationship between energy poverty and economic growth. In addition to per capita household electricity consumption and GDP, factors such as the consumer price index, population, and industrial electricity demand per capita for production are considered. Following this introduction, the first section analyzes the relevant literature. The second part encompasses the Data, Preliminary Tests, Estimations and Discussion. Lastly, the third section presents conclusions and policy implications.

1. Literature Review

In recent decades, the issue of energy poverty has received increased attention in the literature, explored from various perspectives. Studies have examined the determinants of energy poverty, its diverse health implications on society, and the impact of renewable and sustainable energy on alleviating energy poverty, among other perspectives. However, a new dimension has emerged in the literature, focusing on the relationship between energy poverty and economic growth. This stems from the understanding that when people lack sufficient access to energy for essential needs such as cooking, heating, and other purposes, their ability to work effectively and contribute to GDP growth is compromised.

However, the number of studies on this topic is quite limited, and they often use energy access rates as a proxy variable for energy poverty. Additionally, these studies commonly focus on lower-income countries in Africa, Asia, and Latin America. Some of them examine the causal relationship between economic growth and energy poverty. For instance, Ghodsi and Huang (2015) conducted causality tests using both time domain Granger causality and frequency domain causality tests on Sub-Saharan Africa, utilizing data from 1973 to 2012. The results of their analysis indicated a bi-directional causal relationship between the variables, with varying levels of significance across different methods and variables. Furthermore, the authors noted that the causality from energy poverty to economic growth is more pronounced than the reverse direction.

Another study, conducted by Garba and Bellingham (2021), focused on investigating the causal relationship between the use of solid or traditional energy sources (such as dung, coal, and crops) and economic growth, specifically GDP per capita, across 46 Sub-Saharan African countries for the period of 2000 and 2015. In this study, the authors used the use of solid fuels for cooking and/or heating as a measure of energy poverty. Moreover, they also employed FMOLS and DOLS techniques. Their analysis indicates that rising consumption of solid fuels causes GDP to decrease. Another analysis, run by Doğanalp et al. (2021), for BRICS countries. Their results implies causality from energy consumption to growth and energy consumption has a positive impact on growth.

In contrast to Garba and Bellingham (2021) and Doğanalp et al. (2021), who used clean energy for cooking as a proxy, the literature mostly uses access rates to clean energy sources as a proxy for energy poverty. One of those studies, conducted by Ansari et al. (2023), utilized access rates to electricity as a proxy for energy poverty in Sub-Saharan African countries and found a bi-directional causality between GDP growth and energy poverty. On the other hand, their FMOLS and random effects model estimates revealed an insignificant relationship between energy poverty and growth.Another study conducted on 14 Sub-Saharan African countries, and the findings of this study, as reported by Singh and Inglesi-Lotz (2021), indicate that access to electricity positively contributes to GDP growth. In their analyses, Manga (2020) for several African countries concluded mixed causation estimations for different countries.

While most of the studies employ panel data approaches, some of the works employed a time series perspective. For instance, John and Deinde (2021), using the ARDL model with electricity access as a proxy for energy poverty in the case of Nigeria, concluded that energy poverty may have a negative or inverse association with economic growth. Another study on Nigeria by Olusegun et al. (2023), by employing the OLS method, concluded that increasing energy access can be useful for GDP growth in Nigeria. Besides African countries, there are a few studies for other country cases too. For example, Cárdenas and Yúñez (2023) investigated the issue for nine Latin American countries using panel techniques. They found that, increasing access to electricity, which is a proxy for energy poverty, may cause GDP growth.

Finally, Ullah et al. (2021) took up the issue in the case of Pakistan. Unlike previous studies, this study created an index of different variables to represent energy poverty. These variables included clean energy, energy services, energy affordability, and energy governance. The findings suggest significant short-run and long-run relationships between these variables, indicating that reducing energy poverty is expected to promote economic growth in Pakistan.

2. Data, Preliminary Tests, Estimations and Discussion

2.1. Data

In this study, the investigation into the impact of energy poverty on economic growth is undertaken. A proxy variable for the primary independent variable, energy poverty, is selected as household per capita electricity consumption. Alongside, GDP per capita at current prices (2009 $) is chosen as the dependent variable. Control variables commonly found in the literature, namely the consumer price index and population, are incorporated. Furthermore, to discern between energy demand for consumption and production, industrial electricity demand per capita for production is selected as a novel variable. The data utilized in this study ranges from 2007 to 2021, encompassing 15 years of annual data. All variables are transformed into their natural logarithmic forms except the inflation variable which is already in percentage form. A concise overview of all variables employed in this study is provided in Table 1 below.

Table 1. Variables and Sources

Variable	Notation	Definition	Data Source
GDP per capita	gdpusd	Per Capita GDP at current prices (2009$)	TurkStat(RSD)
Energy Poverty	enhous	Household electricity consumption, per capita (KWh/Year)	TurkStat(RSD)
Inflation	cpi	Consumer Price Index Change, Annual (2003 %)	TurkStat(RSD)
Industrial Energy con.	enin	Industrial electricity consumption per capita (KWh/Year)	TurkStat(RSD)
Population	pop	Total Population, sourced from Address Based Population Registration System	TurkStat(RSD)

The data utilized in this study is obtained from the Turkish Statistical Institute (TurkStat) Regional Statistics Database (RSD). Within TurkStat RSD, geographical regions are classified into three levels: Level 1, Level 2, and Level 3. While Level 1 contains 12 regions, in the Level 2 categorization, these regions are further subdivided into 26 regions. At the Level 3 categorization, each city in Türkiye is treated as a separate entity, resulting in a total of 81 regions. For this study, Level 2 categorization is selected to strike a balance between better data availability over time and regional dimensions. Descriptive statistics and correlation analysis are presented in Table 2 below.

Table 2. Descriptive Statistic and Correlation Analysis

Variable	Obs	Mean	Std. Dev.	Min	Max
gdpusd	390	8711.53	3488	3373	20883
enhous	390	564.81	171.09	202	1059
cpi	390	12.08	8.05	3.43	42.64
enin	390	1344.88	1173.29	30	5373
pop	390	2989546	2503732	732790	1.58e+07
		Correlation Analysis			
	gdpusd	**pop**	**cpi**	**enin**	**enhous**
gdpusd	1.0000				
enhous	0.6840	1.0000			
cpi	-0.1490	0.2448	1.0000		
enin	0.5639	0.6141	0.0977	1.0000	
pop	0.4911	0.4032	0.0276	0.1250	1.0000

2.2. Preliminary Tests

The theoretical model employed in this study to elucidate the relationship between energy poverty and economic growth is delineated in Equation 1 below. The significance of this topic and the variables involved can be discerned in Figure 6 below. Notably, in most of the 26 regions, a close relationship between GDP per capita and household electricity consumption is evident.

Figure 6. GDP and Household Electricity Consumption for 26 Regions of Türkiye

Source: TurkStat (RSD) and author's own calculations

In Equation (1) below, "i" represents the 26 Turkish regions classified according to TurkStat Level 2 categorization, and "t" denotes the annual time period spanning from 2007 to 2021. "GDP" stands for per capita GDP at current prices (2009). *"Enhous"* serves as a proxy variable for energy poverty, representing annual household electricity consumption in kilowatt-hours (KWh) per capita. *"cpi"* represents inflation, expressed as the, percentage change in the consumer price index, while *"enin"* denotes annual industrial electricity consumption per capita in KWh. Lastly, *"pop"* signifies the total population. Variables are utilized in their logarithm forms except the inflation variable, which is already in percentage form.

$$\boldsymbol{Ln}\mathbf{GDP}_{\boldsymbol{it}} = \vartheta_0 + \vartheta_1 Ln\text{enhous}_{it} + \vartheta_2 \text{cpi}_{it} + \vartheta_3 Ln\text{enin}_{it} + \&\vartheta_4 Lnpop_{it} + \mu_{it} \tag{1}$$

Considering the investigation of regions within a country like Türkiye, it is likely that a shock to one region may affect others, indicating potential cross-sectional dependency in the database. Additionally, ensuring the homogeneity of the data is crucial for selecting appropriate statistical tests. The results, as shown in Table 3, indicate that the null hypothesis of no cross-sectional dependency ($Cov(u_{it}, u_{jt}) = 0$ for all t and $i \neq j$) is rejected at the 1% significance level for all three different cross-sectional dependency tests, as per the Breusch and Pagan (1980) LM test, Pesaran (2004) CD tests, and the Pesaran, Ullah, and Yamagata (2008) bias-adjusted LM test. This suggests the presence of cross-sectional dependency. Furthermore, according to the delta test of Pesaran and Yamagata (2008), the null hypothesis of homogeneity of slope coefficients is rejected at the 1% significance level.

Table 3. Cross-Sectional Dependence Test and Homogeneity Test

CD	**LM Test**		**LM Adj.**		**LM CD**
Statistics	2053		101.7		43.54
p-value	0.00*		0.00*		0.00*
Homogeneity	**Δ**	**p-value**	**Δ_{adj}**	**p-value**	
	2.75	0.00*	3.54	0.00*	

Note: *denotes significance level at 1%

After establishing the likelihood of cross-sectional dependency and heterogeneity in the dataset, the next step is to employ suitable unit root analyses to assess the stationarity of the data. In this study, three different unit root tests, specifically chosen to account for cross-sectional dependency and heterogeneity, are utilized to verify the stationary condition of the data. This step is crucial prior to conducting coefficient analysis to mitigate the risk of encountering spurious relationship issues.

Table 4. Unit Root Tests

		Level I (0)							
	CIPS	**Fisher ADF (p-values)**				**Fisher P.Perron (p-values)**			
		P	Z	L*	Pm	P	Z	L*	Pm
Gdpusd	-1.85	0.00*	0.02**	0.00*	0.00*	0.04**	0.08***	0.08***	0.03**
enhous	-2.66*	0.47	0.52	0.50	0.50	0.01**	0.03**	0.02**	0.01**
cpi	-3.53*	0.00*	0.00*	0.00*	0.00*	0.00*	0.00*	0.00*	0.00*
enin	-2.44*	0.00*	0.00*	0.00*	0.00*	0.00*	0.00*	0.00*	0.00*
pop	-1.94	0.91	0.99	0.99	0.90	0.32	0.75	0.77	0.34
		At Difference I (1)							
Gdpusd	-3.10*	0.00*	0.00*	0.00*	0.00*	0.00*	0.00*	0.00*	0.00*
enhous	-4.78*	0.00*	0.00*	0.00*	0.00*	0.00*	0.00*	0.00*	0.00*
cpi	-5.18*	0.00*	0.00*	0.00*	0.00*	0.00*	0.00*	0.00*	0.00*
enin	-3.70*	0.00*	0.00*	0.00*	0.00*	0.00*	0.00*	0.00*	0.00*
pop	-3.60*	0.00*	0.00*	0.00*	0.00*	0.00*	0.00*	0.00*	0.00*

Note 1: CIPS Critical Values: -2.07 (10%), -2.17 (5%) , -2.34 (1%). **Note 2:** *, **, *** implies significance level at 1%, 5% and 10% respectively, under H0 (non-stationary): bi = 0 for all i. P: Inverse chi-squared, Z: Inverse normal, L*: Inverse Logit t, Pm: Modified Inverse chi-squared

For this purpose, the Cross-sectionally Augmented Im-Pesaran-Shin (CIPS) unit root test proposed by Pesaran (2007) is employed, which is suitable for datasets exhibiting cross-sectional dependency. Additionally, the Fisher Augmented Dickey-Fuller (ADF) unit root test recommended by Maddala and Wu (1999), as well as the Fisher Phillips Perron(FPP) test developed by Choi (2001), are applied. These tests are chosen for their suitability in handling datasets with heterogeneity. Moreover, the CIPS test is an appropriate tool for addressing cross-sectional dependence. For other unit root and cointegration tests, the data is demeaned to account for cross-sectional dependence, as recommended by Levin et al. (2002). The results of the unit root tests, both at the level and for the first difference, are presented in Table 4. According to the results of the three tests, the majority of variables are stationary at the level with varying levels of significance, except for the population variable, which is not stationary. However, all variables are stationary at the first difference with a significance level of 1%.

After confirming that the majority of variables are stationary at the level and all are integrated at their first difference, a cointegration analysis is conducted to further ascertain if there is a statistically significant relationship among variables in the long run. Initially, the Westerlund (2005) panel cointegration test is applied, followed by the Pedroni (1999) and Kao (1999) panel cointegration tests for robustness check. As shown in Table 5, the null hypothesis of no cointegration is rejected for all tests. This indicates that all variables are cointegrated, allowing for the subsequent phase of coefficient analysis in the next section.

Table 5. Panel Cointegration Tests

		Statistics	**p-value**
Westerlund(2005)	Variance Ratio	2.85	0.00*
Pedroni(1999)	Modified Phillips Perron t	4.58	0.00*
Pedroni(1999)	Phillips Perron t	-2.10	0.01**
Pedroni(1999)	Augmented Dickey Fuller t	-4.38	0.00*
Kao(1999)	Modified Dickey-Fuller t	-3.27	0.00*
Kao(1999)	Dickey-Fuller t	-2.63	0.00*
Kao(1999)	Augmented Dickey-Fuller t	-2.23	0.01**
Kao(1999)	Unadjusted modified Dickey-Fuller t	-4.46	0.00*
Kao(1999)	Unadjusted Dickey-Fuller t	-3.16	0.00*

Note: * and ** implies significance level at 1% and 5% respectively.

2.3. Estimations and Discussion

The Fully Modified Least Squares (FMOLS) technique, developed by Phillips and Hansen (1990), is the primary methodology employed for coefficient estimation in this study. It is chosen because, according to Hamit-Haggar (2012), FMOLS is considered the most suitable estimation technique for panel datasets exhibiting heterogeneous cointegration (Khan et al., 2019). Furthermore, FMOLS is known to perform well with small sample sizes and is capable of addressing issues such as serial correlation and endogeneity (Hamit-Haggar, 2012). The FMOLS estimator is expressed in Equation (2) below, where $\hat{\boldsymbol{\lambda}}_{12}^{+} = \hat{\boldsymbol{\lambda}}_{12} - \hat{\boldsymbol{\omega}}_{12}\hat{\boldsymbol{\Omega}}_{22}^{-1}\hat{\boldsymbol{\Lambda}}_{22}$ represents bias correction terms (Wang and Wu, 2012).

$$\hat{\boldsymbol{\theta}} = \begin{bmatrix} \hat{\boldsymbol{\beta}} \\ \hat{\boldsymbol{\gamma}}_1 \end{bmatrix} = \left[\sum_{t=1}^{T} \mathbf{z}_t \mathbf{z}_t'\right] \left[\sum_{t=1}^{T} \mathbf{z}_t y_t^{+} - T \begin{pmatrix} \hat{\boldsymbol{\lambda}}_{12}^{+\prime} \\ 0 \end{pmatrix}\right] \quad (2)$$

Furthermore, to strengthen the reliability of the findings, a supplementary approach called the panel dynamic ordinary least squares (DOLS) methodology is utilized. The DOLS estimator incorporates the lead and lag of Δ_{xt} to account for the long-term correlation between u_{1t} and u_{2t}, as demonstrated in Equation (3). Importantly, it is highlighted that the DOLS estimators in the equation share the same asymptotic distribution as FMOLS (Wang and Wu, 2012).

$$y_t = \mathbf{x}_t'\boldsymbol{\beta} + \mathbf{d}_{1t}'\boldsymbol{\gamma}_1 + \sum_{j=-q}^{r} \Delta\mathbf{x}_{t+j}'\boldsymbol{\delta} + v_{1t} \quad (3)$$

Both FMOLS and DOLS outperform the classic OLS estimations. While both of them are parametric approaches, FMOLS additionally addresses serially correlated errors and endogeneity (Jebli et al., 2016; Doğanalp et al., 2021). Furthermore, the use of FMOLS necessitates that all variables must be of the same order of integration (Yahyaoui and Bouchoucha, 2021). However, a common and significant aspect of both methods is their ability to mitigate small sample biases and endogeneity (Othman and Masih,2015; Doğanalp et al., 2021). The estimation results of both methods are presented in Table 6.

Table 6. FMOLS and DOLS Estimations

			FMOLS			
Gdpusd	**Coefficient**	**Std. Error**	**z**	**P>|z|**	**[95% Conf. Interval]**	
enhous	0.6544	0.1597	4.10	0.00*	0.3413	0.9676
cpi	-0.0174	0.0046	-3.73	0.00*	-0.2661	-0.0082
enin	0.1057	0.0459	2.30	0.02**	0.0156	0.1957
pop	0.2244	0.0694	3.23	0.00*	0.8831	0.3604
Constant	1.0778	0.9990	1.08	0.28	-0.8801	3.0359
			DOLS			
enhous	0.7214	0.1830	3.94	0.00*	0.3627	1.0801
cpi	-0.0354	0.0103	-3.43	0.00*	-0.0556	-0.0151
enin	0.0841	0.0514	1.64	0.10***	-0.0166	0.1849
pop	0.1499	0.0763	1.96	0.04**	0.0003	0.2995
Constant	2.1096	1.1097	1.90	0.05*	-0.0654	4.2847

Note: *, **, *** implies significance level at 1%, 5% and 10% respectively, under H0 (non-stationary): bi = 0 for all i

Upon reviewing the estimation results for the FMOLS technique, it is evident that all explanatory variables exhibit statistically significant relationships with GDP growth at a significance level of 1%. However, the most notable variable is *"enhouse"* indicating that a 1% increase in household electricity consumption per capita may result in a 0.65% increase in GDP per capita. Similar results are observed in the DOLS estimation as well. According to the DOLS estimations, a 1% increase in household electricity consumption per capita may lead to a 0.72% increase in GDP per capita.

These results are expected because reducing energy poverty can improve the welfare and health conditions of households by providing better heating, cooking facilities, indoor air quality, and other related health benefits, which in turn may enhance household productivity. Since this study is the first to use per capita household electricity consumption as a proxy variable for energy poverty, direct comparison with existing literature is not feasible. However, findings from similar literature that use energy access rate or similar variables as proxies(Amin et al., 2020; Ullah et al., 2021; Doğanalp et al., 2021; Singh and Inglesi-Lotz, 2021; Cárdenas and Yúñez, 2023) also suggest that increasing energy access is associated with higher GDP growth rates. Therefore, the results of this study are consistent with and complement the findings in the existing literature.

Similarly, industrial energy consumption per capita exhibits a positive and significant relationship with economic growth in both FMOLS and DOLS estimations, with significance levels of 1% and 10% respectively. This is attributed to the fact that energy is a crucial input for production across all sectors in any country worldwide. According to the findings from FMOLS and DOLS, a 1% increase in industrial energy consumption leads to a 0.1057% and 0.0841% growth in GDP respectively. It is noteworthy that, to the best of our knowledge, industrial energy consumption has not been extensively studied in the context of energy poverty and growth literature. However, similar findings are observed in other literature focusing on energy consumption and growth (Soytas and Sari, 2003; Narayan and Smyth, 2008; Odhiambo, 2010; Bhattacharya et al., 2016).

Population is also found to significantly affect GDP growth, a relationship extensively studied in the literature. According to the estimation results of both FMOLS and DOLS techniques, a 1% increase in the total population leads to a 0.2244% and 0.1499% increase in GDP, with significance levels of 1% and 5% respectively. Conversely, inflation, measured by the percentage change in the consumer price index, is found to negatively impact GDP growth.

In some developed countries, inflation is generally observed to increase alongside economic growth. However, the effect of inflation on growth varies across countries, and some of studies support the hypothesis of a negative relationship between inflation and growth (Akinsola and Odhiambo, 2017). Thus, the results obtained from both methods used in this study align with existing literature, particularly in light of the fact that recessions in Türkiye are typically associated with high inflation.

Conclusion and Policy Implications

Energy is arguably the most indispensable factor for economies globally. Its significance stems from its essential role in the production process of all economic activities, particularly evident since the industrial revolution. However, another crucial aspect of energy is its role in sustaining households for the consumption of essential needs such as cooking and heating. Especially given the finite nature of fossil fuel resources worldwide, the issue of energy poverty may become more complex in the near future.

Furthermore, the situation may be particularly challenging for Türkiye in general, and Turkish households specifically. Türkiye, with a high dependency on energy imports, is highly susceptible to fluctuations in energy prices and issues related to energy supply security. This vulnerability is exacerbated by ongoing political tensions in its vicinity, such as the Russia-Ukraine conflict, the Iran-Israel conflict, and other issues in the Middle East. Additionally, the COVID-19 pandemic has made Turkish households more vulnerable to energy poverty, as global energy price fluctuations and supply security concerns directly impact Türkiye and its households.

Due to its significance, this study investigates the impact of energy poverty on per capita economic growth across 26 geographic regions in Türkiye, using annual data spanning from 2007 to 2021. The findings from the FMOLS and DOLS econometric techniques reveal important insights for Türkiye. Both estimation techniques suggest that an increase in household electricity consumption may also lead to an increase in per capita GDP.

As explained earlier, the positive contribution of household electricity consumption to GDP can occur through two distinct channels. Firstly, it may enhance productivity by ensuring sufficient and healthy energy consumption, such as improved heating and smoke-free cooking facilities. Secondly, it may increase low labor force participation by enabling households, particularly women, to utilize energy sources more effectively, thereby reducing the time-consuming burden of household chores and providing opportunities for household members to participate in the labor force and contribute to the economy.

In the contemporary era, energy is considered as essential as food and shelter. Consequently, people's capability to fulfill their energy requirements can be regarded as a fundamental development indicator. Furthermore, one of the goals of global sustainable development initiatives is to alleviate energy poverty worldwide. Therefore, governments, international organizations like the United Nations, and various non-governmental organizations worldwide have introduced policy measures aimed at reducing energy poverty and its adverse effects on society.

Türkiye, being a net importer of energy with a high dependency on foreign sources, has implemented several policy measures to alleviate the impact of energy poverty on society. One such initiative is the Electricity Consumption Support Program administered by the

Ministry of Family and Social Services (MFSS). This program targets individuals who already receive social and financial assistance through various government support programs, such as the elderly, disabled individuals, or those experiencing financial hardship, providing direct support without additional bureaucratic procedures (MFSS).

Under this program, households consisting of 1-2, 3, 4, or 5 or more individuals receive 75 kWh, 100 kWh, 125 kWh, or 150 kWh of free electricity per month respectively (MFSS). Additionally, individuals with chronic illnesses requiring medical devices receive 150 kWh of free electricity per month for each affected person (MFSS). Furthermore, individuals with chronic illnesses utilizing certain medical devices are eligible for support such as Uninterruptible Power Supply (power generator support) and assistance with accumulated electricity debts (MFSS).

Furthermore, in 2022, a gradual pricing system was implemented in the electricity sector to assist lower-income households. As explained by the Energy Market Regulatory Board (EMRB), electricity usage up to 240 kWh per month is charged at 1.26 TL/kWh with subsidy, whereas electricity usage exceeding 240 kWh is charged at 1.89 TL/kWh (EMRB). Additionally, the value-added tax (VAT) on electricity was reduced from 18% to 8% (EMRB), but then in 10th July 2023 VAT increased again to 20% (EPIAS). Moreover, companies providing electricity, natural gas, or other forms of heating support to their employees up to 1000 TL are eligible for tax exemptions (PwC).

Regarding natural gas, there are several support initiatives in place. One such program, initiated last year, offers 25m3 of free natural gas to all households in Türkiye, without any conditions (EMRA). This allocation aims to cover cooking and hot water needs for one year, aiming to alleviate the burden of increased energy bills resulting from the pandemic and other political tensions.

The second support, also coordinated by the Ministry of Family and Social Services (MFSS), provides electricity bill assistance ranging between 188-438 TL monthly to households with a per capita income lower than one-third of the minimum wage (MFSS). Apart from these government support programs, some municipalities administer social assistance initiatives where energy bills of individuals in need are compiled by the municipalities and covered by volunteers.

These policy measures and other similar initiatives not mentioned here serve as effective examples of support systems combating energy poverty. However, these policies are still insufficient, as evident from Figure 3, which indicates that over 20% of Turkish households struggle to adequately heat their homes. Targeting energy support towards the segments of society with the lowest income levels could improve living conditions significantly and potentially contribute to higher growth rates in the medium to long term.

Planning and organizing a significant collective support scheme is crucial for those efforts. The initial and foremost step of this scheme should involve understanding the reasons and dynamics behind energy poverty in Türkiye. It is imperative to uncover why, despite having some of the lowest electricity and natural gas prices, and despite various support schemes, a significant portion of households in Türkiye still experience energy poverty. This inquiry could serve as a valuable topic for further research to potential readers and researchers.

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