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Energy Poverty and Women in Turkey: Household-level Insights and Policy Implications

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Abstract

This study examines the impact of women's income, employment, education, health and household characteristics on energy poverty in Turkey. The research utilizes logit and probit regression methods to analyse household data comprehensively, providing a detailed understanding of the factors influencing energy poverty. According to the results, women with any income – particularly those with above-average income – significantly reduce household energy poverty. While the impact of women's employment type on energy poverty is mixed, paid employment strongly reduces it. Higher levels of women's education decrease the likelihood of energy poverty. Women's health insurance does not significantly affect energy poverty; however, households with disabled women are more likely to experience it. The gender of the household head does not affect energy poverty. The study emphasizes that empowering women through greater access to education, job opportunities and financial resources is essential not only for individual well-being but also as a crucial strategy for effectively reducing energy poverty at the household level.

Keywords: Energy, gender, logistic regression, marginal effect, education

JEL Classification: Q48, I32, J16, D13

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1. Introduction

Energy is essential for daily life activities such as cooking, heating, lighting, food production and storage, education and health services. Unlike other production factors, it cannot be substituted. Research shows that energy directly influences poverty, food security, gender inequality, environmental quality and national security (Wang *et al*., 2017; Xu *et al*., 2019). Due to this multifaceted impact, energy policies have a complex structure. Therefore, it is critically important for countries/regions to determine a sustainable energy strategy and ensure access to modern energy for Sustainable Development Goals (SDGs) (Lambrou and Piana, 2006). Despite the global electricity access rate rising from 83% to 91% between 2010 and 2020, 733 million people still lacked electricity in 2020. Additionally, 2.4 billion people were unable to cook using clean energy sources (IEA, 2022). Without global action, over 2.1 billion people will likely continue relying on biomass, kerosene or charcoal for cooking by 2030. Energy poverty has thus become a growing global concern, closely tied to the United Nations' SDGs.

Energy poverty does not have a single, universal conceptual definition. The literature provides different definitions that consider different aspects of energy poverty. Boardman (2013) defined energy poverty as the inability to adequately meet the energy needs of households. According to another definition, energy poverty is defined as inadequate access to affordable and reliable energy services. Inadequate access to energy also triggers problems such as the inability to perform vital basic activities or the inability to take into account alternative solutions to perform these activities (Day *et al*., 2016). IEA (2002) defined energy poverty as a lack of electricity, clean fuels and energy facilities in a country or region and a high dependence of households on traditional fuels. Definitions also differ between developed and developing countries. In developed countries, energy poverty relates to the burden of high energy costs and low household incomes rather than access. In contrast, in developing countries, it primarily stems from limited access to modern energy (Q. Wang *et al*., 2021).

The literature examines energy poverty and its multifaceted dynamics extensively. Studies have highlighted its connections with various factors, including economic crises, inequality, social policies, health, education, ethnic diversity and gender (Awaworyi Churchill and Smyth, 2020; Banerjee *et al*., 2021; Halkos and Gkampoura, 2021). Additionally, evidence shows that the negative social, economic, environmental and health impacts of energy poverty disproportionately affect women and children (Aristondo and Onaindia, 2018).

Men and women experience energy use differently due to gender roles shaping their responsibilities and daily activities. While factors such as socioeconomic status and urban-rural location influence women's time use, women are primarily responsible for unpaid domestic work in many developing countries. Managing energy for household tasks, including cooking and heating, often falls to women (Rewald, 2017). Women's decision-making roles in the home are often limited, making them unlikely to have a say in spending levels and options, including clean and renewable energy. The types of fuel used, the amount of energy purchased, the devices and technology selected, as well as the domestic infrastructure related to ventilation, lighting priorities and purchased energy-based equipment are generally chosen by the male head of the household. Gender roles affect women's daily lives in very rapid and practical ways (Asian Development Bank, 2012). Despite limited authority, women are often the primary energy managers in households. Women can play a critical role in economic development processes if they are empowered, especially in developing countries. Women are key agents of change and as primary energy managers in households, they can play powerful roles in expanding access to sustainable modern energy, adopting energy efficiency technologies and improving consumer behaviour. It is necessary to take gender dimensions into account and actively promote women's leadership at every stage of the energy planning and policy-making process. The empowerment of women, economically, provides a wide range of benefits for the development process. Direct economic contributions can be made by providing opportunities such as encouraging women's employment in registered sectors, supporting them in establishing small-scale businesses and improving their livelihoods through skill development and education (Nelson and Kuriakose, 2017). Therefore, women's social roles, economic status, education, health and household responsibilities significantly influence energy poverty.

The SDGs aim to tackle key challenges of the 21st century, including eradicating poverty and hunger, eliminating gender-based inequalities and combating climate change. SDG 5 seeks to end discrimination and economically empower women and girls, while SDG 7 aims for universal access to affordable, reliable and modern energy by 2030 (Castor *et al.*, 2020). Women's empowerment and sustainable energy are central to achieving these goals. Modern energy drives development – from lighting that helps children study to streetlamps that enhance women's safety at night. As primary energy managers, women play a crucial role in promoting sustainable energy. Studies show that women save more energy than men, with behaviour changes reducing energy use by up to 22% (UN Women, 2016).

Women's socioeconomic characteristics play a crucial role in addressing energy poverty and women-focused research offers valuable insights for policy development. This study examines how women's income, employment, education, health and household characteristics influence energy poverty. Employing logit and probit regressions, the study provides three key contributions. Firstly, it fills a gap in the literature by focusing on women's role in energy poverty, an area with limited research. Secondly, it introduces a multidimensional energy poverty metric, encompassing aspects such as cooking, appliances, lighting, indoor air quality and communication, tailored to a country's development status. Finally, it highlights the growing importance of women's empowerment in achieving SDGs (Hermawati *et al*., 2023; Kazembe, 2020), offering policy guidance for sustainable development strategies.

2. Literature Review

The existing literature on women's energy poverty is quite extensive and presents multidimensional aspects. Women's energy poverty is influenced by a range of variables such as income, education, health, employment and household characteristics (household size, household head, *etc*.). For example, the literature on energy poverty and women primarily explores gender inequality in access to energy, energy use and household decision-making (Choudhuri and Desai, 2020). Some studies have examined women's employment in the energy sector and the role of women in energy transformation (Gray *et al*., 2019; Rojas, 2020). Additionally, there are studies on the effects of energy poverty on women's health (Oliveras *et al*., 2021; Pan *et al*., 2021), feminization (Listo, 2018) and the relationship between household headship and energy poverty (Son and Yoon, 2020). Although these studies highlight how energy poverty affects women, they do not provide empirical evidence that women's empowerment and socioeconomic characteristics can mitigate energy poverty. In developing countries, household responsibilities and power dynamics significantly affect the adoption of modern energy services. Empowered, healthier and better-educated women can enhance the success of programmes promoting access to modern energy and drive the transition to improved energy services (Pachauri and Rao, 2013).

2.1 Impact of income on energy poverty

The energy ladder hypothesis suggests that as household income increases, both the quantity and quality of energy consumed improve (Hosier and Dowd, 1987). With higher incomes, households tend to replace traditional fuels with cleaner, modern energy sources. Low-income households often live in poorly insulated homes and rely on outdated, inefficient equipment (Clancy *et al*., 2017), making them more prone to energy poverty. Income is therefore a key factor in alleviating energy poverty. Studies also show that higher household income is linked to less time spent on energy-intensive tasks such as cooking, shopping and cleaning (De Lauretis *et al*., 2017). Since these tasks are traditionally performed by women, achieving gender equality and empowering women economically can play a crucial role in improving household energy use and income dynamics.

Many studies highlight the impact of income on energy poverty. These studies (Pangaribowo and Iskandar, 2022; Xia *et al*., 2022) have provided remarkable empirical evidence that income is a crucial determinant of energy poverty. Pangaribowo and Iskandar (2022) explored the factors influencing cooking fuel choices in Indonesia, emphasizing the importance of the household head's income and education level for using clean cooking fuels. Similarly, Xia *et al*. (2022) examined the determinants of energy poverty in rural China and the characteristics of energy poverty in time and space. Their findings reveal that disposable income is the most important determinant of energy poverty in rural areas. Some studies have also analysed energy poverty by considering regional income differences based on rural-urban segregation. For instance, Castaño-Rosa and Okushima (2021) studied energy poverty in Japan at a regional level in the context of vulnerabilities, accessibility, affordability and new technologies. According to the results, income is closely related to energy poverty, especially within the scope of affordability and energy poverty is higher in regions with low income in the country. Bezerra *et al*. (2022) analysed energy poverty in Brazil by region, income group and rural-urban households, finding that income in non-energy-poor households is at least twice as high as in energy-poor ones.

Women's and men's incomes differ at the household and social levels, not only in less developed or developing countries, but even in developed ones. Since the average income of women in EU countries is lower than that of men, women are at a higher risk of energy poverty. In 2017, men in the EU were paid on average 16% more than women. Similarly, in the EU in 2018, women above the age of 65 received an average pension that is 30% lower than men's (Birgi *et al*., 2021).

2.2 Employment and energy poverty

Employment is a key driver of energy poverty and has a significant impact on women's energy poverty in particular. Women are generally responsible for cooking, caring for children, the elderly and the disabled, carrying out unpaid agricultural activities and collecting traditional energy resources, especially in rural areas (Nguyen and Su, 2021; Robinson, 2019). Such activities restrict women's employment in paid and permanent employment. Women's employment is expected to have a positive impact on household energy poverty, as women's employment outside of domestic work and in non-agricultural sectors will facilitate a clean and modern energy transition (Lin and Zhao, 2021).

There is also evidence that the employment of women reduces energy poverty. Koomson and Churchill (2022) concluded that employment insecurity increases the likelihood of energy poverty in South Africa. Dogan *et al*. (2022) investigated the linkage between race and energy poverty in the USA at the household level. According to the results, employment level, among other factors, reduces the likelihood of energy poverty. Also, women's working conditions, income level and employment type affect women's decision-making level within the household (Pachauri and Rao, 2013). Employment type can affect the level of income obtained as a result of employment and thus energy poverty (Koomson and Churchill, 2022).

2.3 Effects of women's health on energy poverty

Another indicator affecting energy poverty is health. Women's health status can directly affect household energy poverty. Health-related problems can cause additional burdens on the household due to healthcare expenses such as visits to emergency rooms or hospitalizations. Having health insurance for women in the household can reduce energy poverty (K. H. Wang *et al*., 2021). In addition, healthier and more educated individuals can contribute to human capital accumulation and work in qualified jobs (Hatak and Zhou, 2021). This also affects their income positively. Chen *et al*. (2022) argued that in the USA, the energy burden is more intense in regions where older, poor, disabled and uninsured individuals live. Tu *et al*. (2022) found that disabled or chronically ill social housing tenants in the south-west of England are more vulnerable to fuel poverty.

Women's disability can significantly affect energy poverty. Disabled individuals may spend more time at home due to limited mobility (Büchs *et al*., 2018), increasing household energy consumption and exposing them to high energy costs. Since income is a major driver of the energy and carbon footprint (Wiedmann *et al*., 2020), energy use in disabled households is typically below average. Their energy consumption is further constrained by challenges accessing employment, education and social opportunities due to low income and special needs (Snell *et al*., 2015). Thomson *et al*. (2017) revealed a strong connection between poor health and energy poverty in 32 European countries. Ivanova and Middlemiss (2021) found that disabled households in the EU consumed 10% less energy due to lack of income compared to other households. Robinson (2019) and Tu *et al*. (2022) have pointed out that disability and long-term illness make individuals more vulnerable to energy poverty in the UK. Fry *et al*. (2022) examined the factors affecting the energy poverty of retired individuals with different statuses in Australia. The results reveal that disability has an increasing effect on energy poverty. Sokołowski *et al*. (2020) stated that in Poland, people living in old buildings, living in rural areas, retired individuals and those receiving disability benefits are more likely to be in energy poverty.

2.4 Education and energy poverty

The literature draws attention to the relationship between education and energy poverty (Amin *et al*., 2020). Crentsil *et al*. (2019) revealed that educational attainment is important in the likelihood of household multidimensional energy poverty in Ghana. Education directly affects the decision-making process in terms of household consumption. College-educated women have careers, activities and incomes that significantly reduce their dependence on a partner (Permana *et al*., 2015). Educated female decision-makers prefer cleaner fuels over traditional fuels (Sharma and Dash, 2022). Heltberg (2004) showed that as the education level increases, the use of modern fuel grows, while the use of solid fuel decreases. Also, for women to continue their education, the use of modern equipment for home education, distance education methods and on-site education is necessary. The ability to use this equipment is closely related to sufficient and cost-effective energy (Apergis *et al*., 2022). On the other hand, household energy poverty may increase due to individuals continuing education postponing their opportunities to earn income and consuming more energy. However, this effect is short-term, and the energy poverty of educated individuals is expected to decrease in the long term.

There exists empirical evidence that rising household education levels reduce energy poverty. For instance, Acharya and Sadath (2019) showed that energy poverty decreased as education and income levels at the household level increased in India. Phoumin and Kimura (2019) pointed out that in Cambodia, having a university graduate as the head of a household reduces the likelihood of energy poverty as the income-earning potential increases.

2.5 Household characteristics and energy poverty

Literature also highlights the relationship between household characteristics and energy poverty. According to the results obtained by Abbas *et al*. (2020) from data consisting of 674,834 households in a South Asian country, household size, household wealth, education, occupation and gender of the household head are negative socioeconomic determinants of household multidimensional energy poverty. Besides, place of residence, homeownership status, family size and age of the breadwinner have a significant positive impact on multidimensional energy poverty. Hasanujzaman and Omar (2022) showed that household characteristics such as the household head having completed primary and secondary education, household income, household literacy rate, married household head, age, living space area and living in an urban area diminish the probability of multidimensional energy poverty in the household.

3. Materials and Methods

The study uses the 2019 Household Budget and Consumption Survey data provided by the Turkish Statistical Institute. The survey includes household and individual information for 11,521 households. After pre-processing the dataset, the sample consists of 10,429 households. Within the scope of the research, an energy poverty index is first created at the household level. Then, the data are evaluated and some initial information is presented. Finally, the effects of women's socioeconomic characteristics on energy poverty are estimated with binary logit and probit models. Finally, we check the robustness of our main findings.

3.1 Energy poverty index

The concept of energy poverty can be discussed from micro and macro perspectives. From a microeconomic perspective, energy poverty includes the household's basic needs such as cooking, indoor air pollution, access to hot water, lighting, home appliance ownership, education and entertainment, communication and space heating/cooling (Nussbaumer *et al.*, 2012; Sovacool, 2012). From a macro perspective, energy poverty is an indicator that affects many variables such as climate, energy policy, energy prices, poverty and GDP (Primc *et al.*, 2019). Since energy poverty is a multidimensional concept, many methods are used to measure it, including at the household and country levels. The literature divides energy poverty measurements into three classes: unidimensional/single indicators, dashboard indicators and multidimensional or composite indicators. Unidimensional indicators can be divided into (i) engineering-oriented subclasses that target energy consumption and access to energy, or (ii) economy-oriented subclasses that adopt approaches such as energy budget share, borderline-income poor energy consumption and income-invariant energy demand. Dashboard indicators calculate energy poverty focusing on energy sustainability indicators, millennium development goal indicators and energy indicators for sustainable development. Binary (multidimensional energy poverty index and its approaches – MEPI, total energy access minimum standards – TEA, *etc.*), multifaceted (energy supply index – ESI, multi-tier framework for measuring energy access – MTF, household energy poverty index – HEPI, energy access index – EAI, *etc.*) and target-based (energy development index – EDI, clean energy development index – CEDI, comprehensive energy poverty index – CEPI, *etc.*) approaches are used in multidimensional or composite indicator calculations (Sy and Mokaddem, 2022). While one group of researchers focuses on a single dimension in calculating energy poverty (Barnes *et al.*, 2011; Ye and Koch, 2021), the other group of researchers follows multidimensional calculation (Cao *et al.*, 2022; Hosan *et al.*, 2023).

This study uses two indices to measure energy poverty at the household level: the 10% energy expenditure limit and the MEPI. Energy expenditures for a household are calculated by adding up the monthly costs for electricity, natural gas, town gas, liquefied hydrocarbons, liquid fuels, coal, other solid fuels and heating energy. The ratio of energy expenditures to total household expenditures is then calculated. If this ratio exceeds 10%, the household is classified as being in energy poverty. Households in energy poverty are coded as 0, while those not in energy poverty are coded as 1.

During the MEPI calculation process, relevant indicators may affect the index with different weights. One of the effective/robust methods in determining weight is the entropy method (Li *et al*., 2021; Zhang and Feng, 2020). The entropy method is an objective weighting technique frequently employed in multi-criteria decision-making (MCDM) frameworks. It evaluates the degree of disorder or uncertainty of each criterion to quantify its informational contribution to the decision-making process. Criteria exhibiting greater variability across alternatives are considered to contain more information and are therefore assigned higher weights. As a data-driven approach, the entropy method eliminates subjectivity by relying exclusively on the intrinsic properties of the decision matrix. Eight dimensions and sixteen sub-indicators are applied to evaluate the weights of energy poverty. The paper assumes that X_{ij} refers to the value of the j-th indicator of the i-th household. The first step aims to calculate the proportion of the value of X_{ij} as follows:

$$p_{ij} = \frac{X_{ij}}{\sum_{i=1}^{n} X_{ij}} \tag{1}$$

The second step to calculate the entropy value of the j-th indicator is as follows:

$$e_j = -k \sum_{i=1}^{n} p_{ij} \ln(p_{ij}) \tag{2}$$

where k is a constant (where $k = 1 / \ln n < 0$; $e_{ij} \geq 0$) at the maximum entropy. The degree of diversification d_j of the information provided by a decision criterion j is defined as:

$$d_j = 1 - e_j \tag{3}$$

The objective indicators of the weight set are calculated as follows:

$$w_j = \frac{d_j}{\sum_{j=1}^{n} d_j} \tag{4}$$

In the MEPI calculation process, sub-dimensions such as access to hot water, type of fuel used for hot water and type of fuel used for space heating/cooling were also added, considering the woman's unpaid workload in the household and her health. Table 1 shows the sub-dimensions, proxy indicators, poverty line and weights used in the MEPI calculation. According to calculations, the first three indicators with the highest weight in energy poverty of a household are the lack of a computer (0.148), the presence or absence of natural gas in the heating system of the house (0.142) and the type of fuel most used in heating the house (0.135). Dimensions such as space heating/cooling (0.406), communication (0.257) and home appliance ownership (0.104) are also indicators with significant weights in the calculation of the MEPI.

Table 1: Subdimensions and weights

Dimension	Indicator	Household poverty line	Weight
Cooking	Modern cooking fuels	If the house uses cooking fuel other than electricity, natural gas, kerosene or biogas, it lacks the relevant dimension.	0.016
Indoor air pollution	Separate room for cooking	If there is no kitchen in the house, it lacks the relevant dimension.	0.002
Hot water	Access to hot water	If the house does not have access to hot water, it lacks the relevant dimension.	0.022
	Type of fuel used to obtain hot water	If the house uses fuel for hot water other than electricity, natural gas, kerosene and biogas, it lacks the relevant dimension.	0.018
Lighting	Access to electricity	If the house has no electricity consumption as of the survey month, it lacks the relevant dimension.	0.016
Household appliances	Household appliance ownership	If there is no refrigerator, it lacks the relevant dimension.	0.002
		If there is no washing machine, it lacks the relevant dimension.	0.007
		If there is no dishwasher, it lacks the relevant dimension.	0.095
Education and entertainment	Ownership of assets	If there is no TV, it lacks the relevant dimension.	0.065
Communication	Ownership of assets	If there is no landline phone, it lacks the relevant dimension.	0.093
		If there is no mobile phone, it lacks the relevant dimension.	0.008
		If there is no internet connection, it lacks the relevant dimension.	0.008
		If there is no computer, it lacks the relevant dimension.	0.148
Space heating/ cooling	Ownership of assets	If the house does not have a heating system (natural gas), it lacks the relevant dimension.	0.142
		If the household uses fuels such as coal and coal derivatives, wood, sawdust, shell, pomace and dung, it lacks the relevant dimension.	0.135
		If there is no air conditioning, it lacks the relevant dimension.	0.129

Source: Authors' own elaboration

Finally, the MEPI is calculated with the following formula:

$$EP_i = \sum_{j=1}^{m} w_{ij} p_{ij} \tag{5}$$

3.2 Method

Logit or probit models are widely used to determine the dynamics affecting energy poverty at the household level (Awan *et al.*, 2022). These models are employed to examine the effects of independent variables on the categorical dependent variable. The impact of the independent variables in the models is conveyed through odds ratios. Logit and probit models, which are generalized linear models, are a suitable strategy to model which of two alternative situations occurs. Energy poverty is a binary variable and therefore the following model is used to estimate the regression parameters.

$$Y_i = \alpha + \beta_j X_{ji} + \mu_i \tag{6}$$

Y_i is the dependent variable measuring the energy poverty status of the household and is coded as follows. X_{ji} represents all explanatory variables as variables related to household characteristics and energy use. β and μ refer to the parameter and error term, respectively.

$$Y_i = \begin{Bmatrix} 0 \text{ Households are in energy poverty} \\ 1 \text{ Households are not in energy poverty} \end{Bmatrix} \tag{7}$$

The logit model is applied as follows. P_i in Equation (8) is the probability of the household not being in energy poverty.

$$\text{logit}\,(P_i) = \ln\left(\frac{P_i}{1-P_i}\right) = \alpha + \beta_j X_{ji} \tag{8}$$

The probit model can be shown as follows.

$$\varphi^{-1}(Y_i) = \sum_{J=0}^{J=n} \beta_j X_{ji} \tag{9}$$

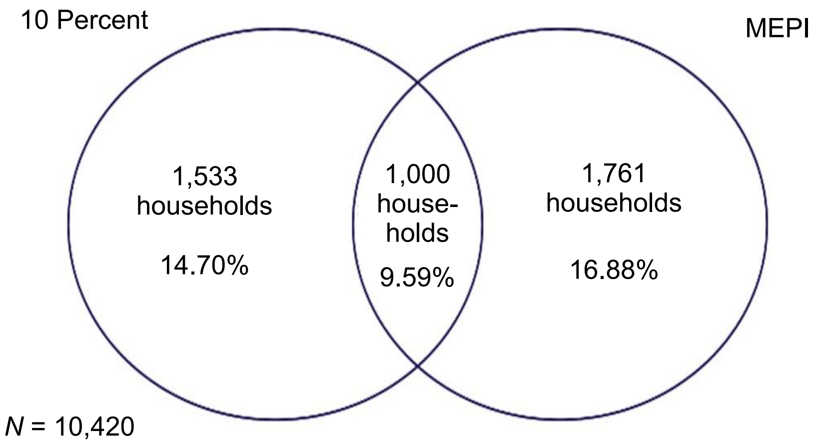
The probit model estimates the probability of an event occurring. While examining the tendency of women to be in energy poverty in the study, marginal effects can also be estimated for each independent variable regarding socioeconomic status. When other variables are held constant, the probability of a unit change in each independent variable shows the marginal effect. Equation (10) refers to the calculation of the marginal effect.

$$\frac{\partial P(Y_i = 1|X_i)}{\partial X_i} = \frac{\partial E(Y_i|X_i)}{\partial X_i} = \varphi(X'\beta)\beta \tag{10}$$

3.3 Preliminary findings

In Turkey, 26.5% of households were in energy poverty according to the MEPI and 24.3% were in energy poverty according to the 10% approach. The rates determined for the two calculations are close to each other. Figure 1 depicts the distribution of energy poverty across households. According to the distribution, 1,000 households are in energy poverty according to both metrics; 1,533 households are in energy poverty based on the 10% limit metric; and 1,761 households are in energy poverty according to the MEPI metric. Although the energy poverty rates are similar, when the distribution is examined, it can be stated that the calculation method used will cause changes in the evaluation of energy poverty.

Figure 1: Household energy poverty according to 10% and MEPI approaches



Source: Authors' own elaboration

Before the empirical analysis, the socioeconomic status and employment characteristics of women are evaluated. Table 2 shows the socioeconomic characteristics of women. The majority of women are between the ages of 36–50 (34%) and 51–65 (28%). A significant portion of the women (84.4%) is married. Remarkably, approximately half of the women (50%) do not have any income. It is seen that 25% of the women are heads of households and many households consist of more than one person.

Table 2: Women's age, marital status, income, household headship status and household characteristics

Indicator	Category	Total	%
Age	≤35	2,262	21
	36–50	3,632	34
	51–65	2,979	28
	≥65	1,556	14
Marital status	Single	197	2
	Married	8,803	84
	Divorced	352	3
	Widowed	1,077	10
Income	No income	5,180	50
	Below average	1,819	17
	Above average	3,430	33
Household head	Female	2,561	25
	Male	7,868	75
Household type	Single person household	706	7
	Extended-family households	1,304	13
	Multi-person no family-households	135	1
	Couple without a resident child	2,230	21
	Couple with at least one resident child	5,363	51
	Lone parents with at least one resident child	691	7

Source: TUIK (Turkish Statistical Institute), 2019

Table 3 reveals the employment status of women. According to the data, 69.8% of the women do not work; 66.8% of the women are not looking for a job, that is, they do not participate in the workforce. A significant portion of the women (54.3%) give the reason for not looking for a job as being busy with housework. A very small portion of the women

(0.4%) are employers. While 4.1% are self-employed, 7.8% are unpaid family workers. Additionally, 16.4% are wage earners.

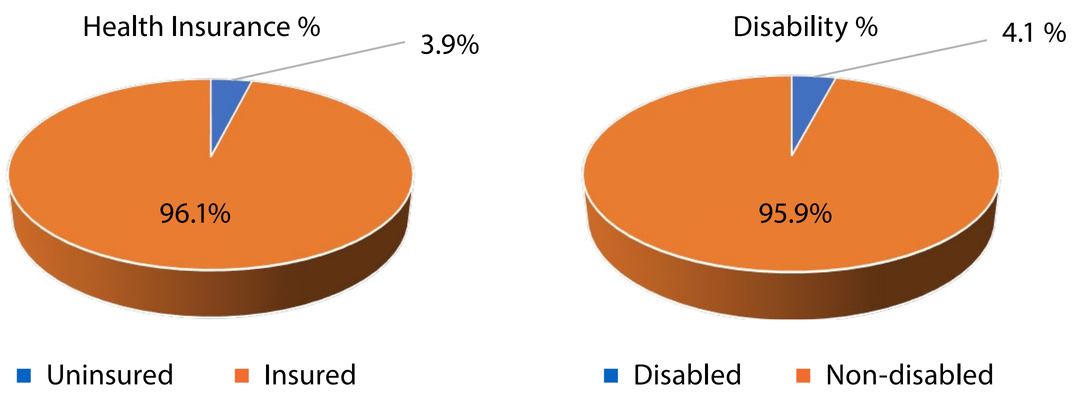
Table 3: Employment status

Indicator	Category	Total	%
Working status	Employee	3,146	30.2
	Non-employee	7,283	69.8
Job search situation	Not specified	3,192	30.6
	Yes	275	2.6
	No	6,962	66.8
Reason for not looking for a Job	Busy with housework	5,662	54.3
	Not specified/other	3,721	35.68
	Retired	672	6.4
	Elderly (≥65)	374	3.6
Job situation	Unemployed	7,237	69.4
	Employer	46	0.4
	Self-employed	425	4.1
	Unpaid family worker	812	7.8
	Wage earner	1,711	16.4
	Seasonal workers or daily work	198	1.9

Source: TUIK (Turkish Statistical Institute), 2019

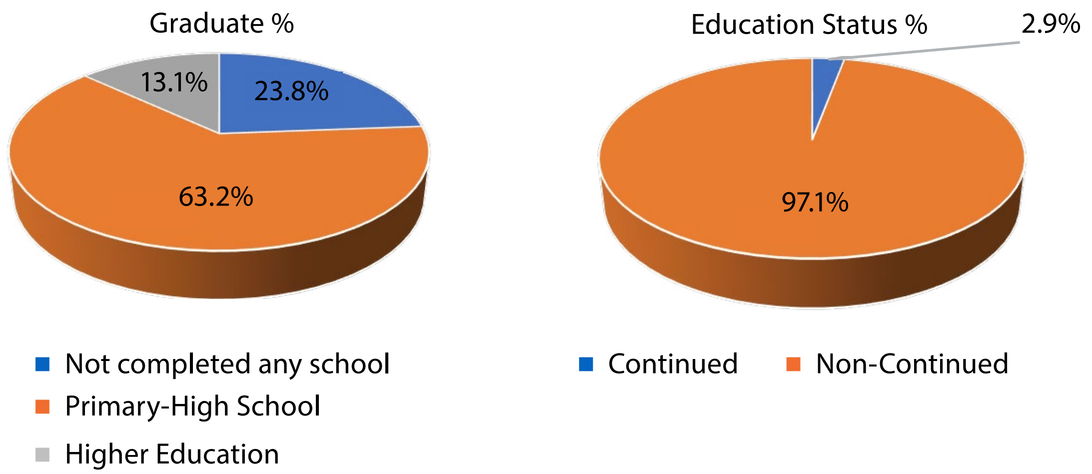
Figures 2 and 3 show the women's status regarding health insurance, disability and education level. Approximately 4% of the women do not have health insurance. Similarly, 4% of the women are disabled. Approximately one-quarter of the women (23.80%) have not graduated from any school, while only 13% have graduated from higher education institutions. A significant portion of the women do not continue education.

Figure 2: Health insurance and disability status of women



Source: TUIK

Figure 3: Education status of women



Source: TUIK

Approximately half of the women do not have an income, a quarter of them have not graduated from any level of education, approximately 70% do not work and approximately 50% of those who do not work are not looking for a job due to housework. On the other hand, according to the energy poverty metrics calculated using two different approaches, approximately one in four households is in energy poverty. In this context, it can be implied that empowering women, who are the primary energy managers in the household, is a critical element of the solution to combating energy poverty.

4. Results and Discussion

Table 4 reports logistic regression estimation results for the effects of women's income, education, health and household characteristics on energy poverty calculated based on the 10% approach and the MEPI. Estimates are interpreted below.

Table 4: Logistic regression results

Covariates	**Model (1)**	**Model (2)**
	10%	**MEPI**
Income level (base category: no income)		
Below average	0.022* (0.012)	−0.064*** (0.012)
Above average	0.066*** (0.013)	0.090*** (0.012)
Employment status (base category: unemployed)		
Employer	0.053 (0.066)	0.049 (0.074)
Self-employed	−0.018 (0.022)	−0.082*** (0.021)
Unpaid family worker	−0.056*** (0.016)	−0.224*** (0.015)
Wage earner	0.033** (0.015)	0.028* (0.015)
Seasonal workers or daily work	0.051* (0.028)	−0.079*** (0.028)
Education (base category: never finished school)		
Primary – high school	0.064*** (0.010)	0.285*** (0.011)
Upper secondary – postgraduate	0.207*** (0.013)	0.472*** (0.011)
Education maintenance (base category: do not continue education)	−0.059** (0.026)	−0.202*** (0.024)
Health		
Health insurance (base category: no health insurance)	0.003 (0.020)	0.030 (0.018)
Disability (base category: disabled)	0.063*** (0.021)	0.061*** (0.018)
Household characteristics		
Household head (base category: women)	−0.017 (0.014)	−0.009 (0.013)

Table 4: Continuation

Household size (base category: single person household)		
Extended-family households	0.188*** (0.026)	0.185*** (0.024)
Multi-person no-family households	0.091* (0.047)	0.133*** (0.045)
Couple without resident children	0.124*** (0.028)	0.123*** (0.025)
Couple with at least one resident child	0.222*** (0.026)	0.259*** (0.024)
Lone parents with at least one resident child	0.107*** (0.025)	0.207*** (0.023)
Observations	10,429	10,429
Pseudo R^2	0.054	0.225

Notes: The standard error is in parentheses; (energy-poor = 0, not energy-poor = 1); ***, **, * denote statistical significance at 1%, 5%, and 10% levels, respectively.

Source: Authors' own calculations

In Model (1), which considers the 10% energy poverty measurement, there is a higher probability of not having energy poverty in households where women earn below or above-average income compared to women who earn no income. Additionally, it can be said that as the woman's income rises, the probability of the household not being in energy poverty increases. For Model (1), it can be concluded that energy poverty is less likely to occur in households where women have any income than those who have no income. This result is also compatible with previous findings (Bezerra *et al.*, 2022; Pangaribowo and Iskandar, 2022; Xia *et al.*, 2022). In Model (2), which takes the MEPI into account, the likelihood of energy poverty is lower in households where women earn above-average income compared to women who earn no income. On the other hand, in households where women earn below-average income, the household is more likely to be in energy poverty than those with no income. This result can be attributed to several interrelated factors such as higher household income despite women's low earnings and accumulated wealth and credit access. In other words, the wealth level is higher in households where the woman has no income than in households where the woman earns below-average income. Household wealth may lead to an increased propensity to pay for a better quality energy source (Awan *et al.*, 2022). Households where women live with below-average income are at a disadvantage compared to other income groups, especially in terms of owning a dishwasher, lack of natural gas, the type of fuel used in space heating/cooling being sourced from traditional fuels and television ownership. Bao and Li (2020) pointed out that housing prosperity in the UK is closely linked to energy consumption and energy poverty.

According to the findings in terms of employment type, compared to women who are not employed, having a paid job reduces household energy poverty in both models. Having a paid job for women is a factor that reduces energy poverty. On the other hand, in both models, women working as unpaid family workers increases the possibility of energy poverty. In Model (2), if the woman is self-employed, the probability of the household being in energy poverty increases. In Model (1), there is no such significant linkage. While women's employment as seasonal workers or daily workers affects household energy poverty positively in Model (1), it affects household energy poverty negatively according to Model (2). In other words, in Model (1), compared to women who are not employed, the fact that the woman is employed as a seasonal or daily worker raises the probability of the household not being in energy poverty. On the other hand, this probability decreases according to Model (2). The impact of women's employment type on household energy poverty yields mixed results depending on the energy poverty measurement approach. However, the findings indicate that women's employment type has a significant impact on household energy poverty. In addition, to reduce energy poverty at the household level, it is critically important for women to work in paid jobs where the opportunity for continuity and security is higher, rather than the types of jobs that are unpaid family workers, which are generally found in the agricultural sector. The results are consistent with previous findings that women's participation in the workforce and working in paid jobs will facilitate the transition to clean energy and sustainable energy technologies and reduce energy poverty (Awan *et al.*, 2022; Lin and Zhao, 2021).

According to the results in terms of education, in both models, compared to those who have no education, the fact that the woman is educated at the primary or high school, upper secondary and postgraduate level raises the probability of the household not being in energy poverty. When evaluated in terms of the coefficients, education at the upper secondary – postgraduate level has a stronger effect (0.207 in Model 1 and 0.472 in Model 2) than education at the primary–high school level (0.064 in Model 1 and 0.285 in Model 2). In other words, as the woman's education level increases, the probability of the household not being in energy poverty increases. On the other hand, in both models, the probability of the household being in energy poverty is higher if the woman continues her education, compared to those who do not attend any education. This situation can be explained by the need for modern equipment for home education, distance education methods and on-site education to continue education, and the additional energy consumption required for the use of this equipment negatively affects household energy poverty. The foundations behind this result can be explained by the fact that educated women have careers, activities and income (Permana *et al*., 2015). Empowered women are therefore vital in tackling energy poverty. A good education for women leads to higher incomes, independence or significantly reduced dependence on a spouse (Gray *et al*., 2019). It is also important for sustainability that educated female decision-makers tend to prefer cleaner fuels over traditional fuels (Sharma and Dash, 2022).

When women's health security status is evaluated, it can be said that women who have health insurance do not have any advantage over household energy poverty compared to those who do not have health insurance in both models. This result is not compatible with the results of the literature that women's health insurance positively affects the energy poverty of the household. On the other hand, 96.1% of the women had health insurance in 2019. In Turkey, the public influence is dominant in the health sector and many citizens have public health insurance. Citizens who are not covered by health insurance continue to benefit from free health treatment within the framework of the Green Card application since 1992 (Dundar *et al*., 2010). For this reason, it can be expected that women's health insurance reduces the possibility of energy poverty in other countries where there is no state insurance in the health system and the private sector is dominant. On the other hand, in both models, the probability of energy poverty in households where disabled women live is higher than in households where non-disabled women live. Disabled individuals spend more time at home and consume more energy due to travel restrictions (Büchs *et al*., 2018). Disabled individuals also have more limited income-earning opportunities and therefore may have a lower income. Having a disabled woman in the household may be a factor that increases the possibility of energy poverty. The findings are consistent with the view that disabled individuals face more energy poverty (Snell *et al*., 2015).

Finally, findings regarding household characteristics are explained as follows. In both models, it is concluded that whether the head of the household is male or female does not have any effect on energy poverty. This research does not support arguments that energy poverty is more likely to occur in female-headed households (Crentsil *et al*., 2019; Gafa and Egbendewe, 2021). Additionally, in terms of household size, the probability of the household not being in energy poverty is higher in all other household types compared to single-person households. The findings do not support the argument that as household size increases, the probability of a household becoming energy-poor increases (Poblete-Cazenave and Pachauri, 2021).

The robustness of the estimates is tested with a probit model. Table 5 presents the probit model results. The impact of women's income, employment status, education, health and household characteristics on energy poverty is similar to that in the logistic regression results.

Table 5: Probit regression results

Covariates	Model (1)	Model (2)
	10%	MEPI
Income level (base category: no income)		
Below average	0.022^{*} (0.012)	-0.064^{***} (0.012)
Above average	0.067^{***} (0.013)	0.089^{***} (0.012)
Employment status (base category: unemployed)		
Employer	0.057 (0.064)	0.049 (0.069)
Self-employed	−0.017 (0.022)	-0.084^{***} (0.021)
Unpaid family worker	-0.057^{***} (0.016)	-0.229^{***} (0.015)
Wage earner	0.030^{**} (0.015)	0.022 (0.015)
Seasonal workers or daily work	0.049^{*} (0.028)	-0.082^{***} (0.028)
Education (base category: never finished school)		
Primary – high school	0.065^{***} (0.010)	0.290^{***} (0.011)
Upper secondary – postgraduate	0.204^{***} (0.014)	0.471^{***} (0.011)
Education maintenance (base category: do not continue education)	-0.056^{**} (0.025)	-0.177^{***} (0.024)
Health		
Health insurance (base category: no health insurance)	0.002 (0.020)	0.030 (0.018)
Disability (base category: disabled)	0.066^{***} (0.021)	0.063^{***} (0.019)
Household characteristics		
Household head (base category: women)	−0.017 (0.014)	−0.007 (0.013)

Table 5: Continuation

Household size (base category: single person household)		
Extended-family households	0.182*** (0.026)	0.180*** (0.024)
Multi-person no-family households	0.093** (0.046)	0.129*** (0.044)
Couple without resident children	0.119*** (0.027)	0.118*** (0.024)
Couple with at least one resident child	0.216*** (0.026)	0.254*** (0.023)
Lone parents with at least one resident child	0.104*** (0.025)	0.204*** (0.023)
Observations	10,429	10,429
Pseudo R^2	0.054	0.224

Notes: The standard error is in parentheses. (energy-poor = 0, not energy-poor = 1). ***, **, * denote statistical significance at 1%, 5%, and 10% levels, respectively.

Source: Authors' own calculations

The analysis results presented in Tables 4 and 5 offer valuable insights into the impact of women's socio-economic factors on household-level energy poverty. However, the results for both the 10% and the MEPI do not provide any insight into the depth of poverty, especially for energy-poor households. The depth of poverty indicates how far, on average, households or individuals fall below the poverty line (SESRIC, 2015). To give a concrete example, if the income poverty line is \$3 per day, the problems faced by a person earning \$2.8 per day and a person earning \$0.5 per day may be different due to poverty or the measures needed to escape poverty.

From this perspective, and given the multifaceted nature of energy poverty, households identified as energy-poor according to the MEPI calculation used in the study can be further disaggregated and reassessed. Based on the MEPI calculation, 2,761 households were identified as energy-poor. The average MEPI score of these households was calculated, and those with scores below the average (1,340 households, coded as 0) were classified as experiencing severe (deep) energy poverty. Households with scores above the average (1,421 households, coded as 1) were categorized as energy-poor. Focusing on these energy-poor households, the study examined the impact of socio-economic factors of female-headed households using logit and probit models. The findings from the analysis are presented in Table 5.

Table 6: Robustness check: Logistic and probit regression results, coefficients of marginal effects

Covariates	Logit	Probit
Income level (base category: no income)		
Below average	−0.050** (0.024)	−0.051** (0.024)
Above average	0.141*** (0.052)	0.138*** (0.052)
Employment status (base category: unemployed)		
Employer	0.206 (0.231)	0.172 (0.223)
Self-employed	0.012 (0.045)	0.012 (0.045)
Unpaid family worker	−0.015 (0.025)	−0.015 (0.045)
Wage earner	0.084* (0.048)	0.085* (0.048)
Seasonal workers or daily work	0.106* (0.058)	0.108* (0.059)
Education (base category: never finished school)		
Primary – high school	0.134*** (0.019)	0.134*** (0.019)
Upper secondary – postgraduate	0.138 (0.148)	0.140 (0.148)
Education maintenance (base category: do not continue education)	0.031 (0.217)	0.032 (0.217)
Health		
Health insurance (base category: no health insurance)	−0.039 (0.044)	−0.036 (0.043)
Disability (base category: disabled)	0.072* (0.037)	0.070* (0.036)
Household characteristics		
Household head (base category: women)	0.026 (0.033)	0.027 (0.033)

Table 6: Continuation

Household size (base category: single person household)		
Extended-family households	0.188*** (0.045)	0.185*** (0.045)
Multi-person no-family households	0.007 (0.094)	0.010 (0.091)
Couple without resident children	0.121*** (0.046)	0.118*** (0.046)
Couple with at least one resident child	0.209*** (0.045)	0.207*** (0.045)
Lone parents with at least one resident child	0.188*** (0.051)	0.185*** (0.051)
Observations	2,761	2,761
Pseudo R^2	0.044	0.044

Notes: The standard error is in parentheses. (energy-poor = 0, not energy-poor = 1). ***, **, * denote statistical significance at 1%, 5%, and 10% levels, respectively.

Source: Authors' own calculations

The findings derived from the analysis presented in Table 6, when compared to the main results in Table 4, yield the following insights:

i) Both below- and above-average income levels exhibit significant and consistent effects on energy poverty, aligning with the findings in Table 4.

ii) While wage earners show a significant and consistent effect on energy poverty, seasonal and daily workers demonstrate a significant negative effect in Table 4 (increasing the likelihood of energy poverty), whereas in Table 6, they exhibit a significant positive effect (reducing the likelihood of severe energy poverty).

iii) Households where the woman has completed primary to high school education are less likely to experience severe energy poverty.

iv) Similar to Table 4, households where the woman is not disabled have a reduced likelihood of experiencing severe energy poverty.

v) The household characteristics variable shows consistent findings across both analyses, suggesting its stable influence on energy poverty outcomes.

5. Conclusion

This paper examined the impact of women's income, employment, education, health, disability and household characteristics on energy poverty. The research captured energy poverty at the household level with two different metrics. The first is the 10% energy expenditure limit metric, which is widely used in the literature and is considered a general indicator of energy poverty. The second one measures the concept of energy poverty using the MEPI, which is a more comprehensive metric that also considers sub-dimensions such as cooking, household appliances, hot water, lighting, indoor air pollution, education and entertainment, communication and cooling. While logistic regression is used in the estimation process, the probit model is followed for the robustness check. Research findings are detailed in the results and discussion section. The empirical results of this paper focused on women provide some critical policy implications for tackling energy poverty.

Firstly, women having any income reduces the household's likelihood of energy poverty. The wealth level of the household may also be a possible determinant. However, it is seen that especially women providing an above-average income reduces energy poverty in both models. Assuming that household wealth does not change in the short term, according to Turkey's 2019 household data, the ratio of women earning no income and earnings below average income to the total female population corresponds to 67%. Therefore, it is strongly recommended to develop social policies that will increase women's incomes.

Secondly, the research confirms that women's employment type has a significant impact on energy poverty. It is strongly demonstrated that compared to those who are unemployed, women having paid employment reduces the possibility of energy poverty in households. On the other hand, the findings confirm that unpaid family labour, which can also be called hidden unemployment or low marginal productivity work, increases the possibility of energy poverty. The fact that the rate of paid women among the total female population is 16.4% is also an important constraint in terms of SDGs. Since hidden unemployment is predominantly in the agricultural sector, women's transition from housework or the agricultural sector to the industrial and service sectors as paid workers can also yield meaningful results in the fight against energy poverty. Another problem is that especially women do not participate in the workforce. According to the OECD, while the labour force participation rate of women in Turkey was 34.2% in 1990, this rate was 33.6% in 2017. In OECD countries, this rate is 64% on average. Over the last few decades, despite significant gains in education and falling fertility rates, the total labour force participation rate of women in Turkey has tended to decline towards the 21st century. The situation gets worse as this downward trend is accompanied by migration from rural areas to urban areas. The reason for this situation is the decline in the role of agriculture, where women have a significant share in the workforce, in national output and employment, and the lack of employment opportunities for low-educated women in other sectors (Tunalı *et al.*, 2021).

Thirdly, the most convincing results of the research are on the probability that women's education level reduces energy poverty in households. Compared to the uneducated, women's primary/high school, secondary and postgraduate education increases the probability of the household not being in energy poverty. Thus, increasing the education level increases the probability of the household not being in energy poverty. One of the most important problems in women's education is gender inequality. In Turkey, among younger groups, boys' expected years of education still outperform girls'. On the other hand, the problem of gender inequality in education also triggers the problem of wage inequality, which is greater, especially in the private sector (Tekgüç *et al.*, 2017). In order to improve women's educational performance and develop more qualified female individuals, gender inequality must be addressed separately in education and wage policies.

Finally, women's health insurance has no significant effect on the probability of the household being in energy poverty. The reason behind this result may be related to the role of the state in the health system. In Turkey, the state provides health insurance, financing and ease of access to its citizens to achieve universal health coverage, and the system helps eliminate inequalities (Atun *et al.*, 2013). This result may not generalize to other developing countries where health insurance cannot be covered by the state. On the other hand, this paper shows that households with disabled women are more likely to experience energy poverty. Disabled women are at the top among the disadvantaged groups in society. Research underlines that the most basic problems of disabled people are income difficulties, difficulty in self-care, psychological distress, inability to receive adequate service from institutions, lack of continuity in participating in education and social exclusion (Genc, 2016). The biggest role in overcoming this problem falls on the state and its social policies. Although disabled citizens are taken into consideration in education, health, employment and wage policies, current policies are not sufficient to solve the problems. Existing policies for disabled people need to be constantly updated and improved.

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