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Price and Income Elasticities of Hungarian Household Energy Demand: Implications for Energy Policy in the Context of the Energy Crisis

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Abstract: The energy crisis that began in the second half of 2021, exacerbated by the Russian–Ukrainian war, created unexpected difficulty for European Union Member States in terms of shaping their energy policies. Hungary was one of the most vulnerable countries, whose economic development was fraught with severe risk due to the strong dependence on Russian energy sources and regulated energy prices for households, significantly slowing down the transition to green energy. The sharp change in energy prices due to the introduction of a price cap in 2013–2014 and the partial adjustment in 2022 draws attention to the situation of Hungarian energy demand. This study describes the absolute short-term price elasticities of Hungarian household natural gas and electricity demand and gas and electricity cross-price and income elasticities of the former for income deciles between 2010 and 2021 using the midpoint percentage method. The results show that electricity demand is more elastic than gas demand, implying that Hungarian household consumers are more responsive to changes in electricity prices than those of gas. In addition, low-income Hungarian households are more sensitive to changes in both of the latter than high-income households, while no consistent pattern is identified in the relationship between income and energy demand. Accordingly, the study recommends the implementation of a multi-tariff pricing strategy based on the energy burden of the income deciles. This should particularly target the first two deciles, which are the most vulnerable and sensitive to energy price changes.

Keywords: energy crisis, price elasticity of demand, household energy consumption, utility cost reduction, Hungary

1. Introduction

The 2021–2022 European energy crisis was triggered by various circumstances. It began with the economic boom after COVID-19, which increased energy demand. The ongoing conflict between Russia and Ukraine exacerbated the problem. In response, natural gas and coal prices in Europe have recently increased dramatically. As coal and natural gas are used for electricity generation, electricity prices have also increased [1]. As a result, the European Commission addressed the problem of rising energy prices in 2022[1]. Despite the sharp decline in Russian energy exports, Europe has secured alternative suppliers and reduced its consumption to make up for the deficit [2]. Member States have implemented several measures to alleviate price pressure on residents and businesses at the national level. In Hungary, the government declared an energy emergency and adopted a seven-point action plan in July 2022. The plan calls for keeping gas and electricity prices low for households, increasing domestic gas and lignite extraction, restarting the Mátra lignite-fired power plant units (950 MW), extending the life of the Paks nuclear power plant (2000 MW), storing sufficient natural gas to secure Hungary's natural gas supply for the following winter (to the level of transmission and storage capacity), and imposing export restrictions on energy carriers.

The affordability of residential gas and electricity prices in Hungary has been the focus of interest since 2013. As measured by the Purchasing Parity Standard, Hungarian gas and electricity tariffs for households were the highest in the EU in 2010 [3]. In 2013, the enormous share of utility expenditure in household budgets and the difficult economic situation of Hungarian households prompted the Hungarian government to launch a comprehensive and large-scale initiative to reduce utility costs [3]. Due to this so-called utility cost reduction program, household gas and electricity prices declined by around 25% in local currency between 2013 and 2015 and remained constant until 2022[2]. This price reduction was not differentiated according to the income level of households. Due to the 2021–2022 energy crisis, the

[1]Atlatszo. (2023). *This is how the Hungarian government is dealing with the energy crisis*. https://english.atlatszo.hu/2023/03/03/this-is-how-is-the-hungarian-government-is-dealing-with-the-energy-crisis/

[2]Hungarian Central Statistical Office. (2023). *Average consumer price of certain products and services*. Retrieved from: https://www.ksh.hu/stadat_files/ara/hu/ara0044.html

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Hungarian government significantly increased residential gas and electricity tariffs in 2022 for energy use above a specified average level [2]. This increase disproportionately affects low-income Hungarian households because of their generally low level of energy efficiency, leading to energy insecurity for families sensitive to even small increases in electricity and gas prices.

Gas plays an important role in Hungary's energy mix. In 2021, gas accounted for 51.8% of final household energy consumption [4]. Consequently, the price of natural gas is critical and affects people's everyday lives. Since 2013, regulated (and low) gas prices (along with a price cap on district heating and electricity) have been one of Hungary's primary tools for mitigating energy poverty. The combination of high energy prices, a low level of disposable income, and the poor energy performance of buildings are the leading causes of energy poverty in Hungary [5]. The share of households unable to keep their homes adequately warm was 5.8% in Hungary in 2021 (see Figure 1 [6]). The European Energy Poverty Index [6] paints a negative picture of the situation in Hungary, ranking the country 28th in the EU in 2019 (at that time, the EU had 28 Member States) with an extremely low score.

The aim of this study is to assess the adjustments caused by the utility cost reduction program and the short-term response of Hungarian households in terms of energy consumption (particularly gas and electricity consumption) to changes in gas and electricity prices and income. For this purpose, the price and income elasticity of household energy consumption is calculated for each income decile. We assume regulated energy prices have discouraged energy efficiency improvements and energy-saving measures since 2013. The following hypotheses are tested:

H1: Hungarian households can flexibly adjust their energy consumption in line with price changes.
H2: Low-income Hungarian households are more sensitive to electricity and gas price changes than high-income households.
H3: Low-income Hungarian households are more sensitive to income changes than high-income households.

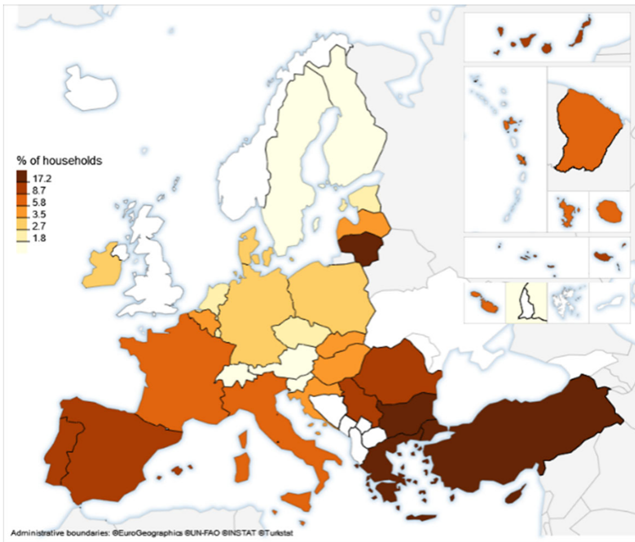
Section 2 provides an overview of the literature on the price and income elasticity of demand and presents the methods most commonly used to assess this. Besides the general description, we include some international findings about the price and income elasticity of energy demand and other results on price elasticity in economic sectors in Hungary. Section 3 explains the methodology (the so-called midpoint percentage method) and the data sets used to measure the impact of price on consumption. Section 4 presents the main findings and results. Section 5 concludes and suggests adjusting the utility cost reduction program to address the energy poverty caused by the current energy crisis.

2. Literature Review

Conventionally, growing or declining prices similarly affect the demand and supply of goods. An increase in the price of a good increases opportunity cost because less money is available to spend on other goods and services [7]. To measure the impact of price changes on demand, economists use the concept of price sensitivity or the price elasticity of demand. This refers to how the price of a product affects consumers' purchasing decisions, which also affects demand.

In the energy sector, the price elasticity of energy demand has become an increasingly important factor in measuring the socioeconomic and environmental impacts of energy policies or

Figure 1
Inability to keep home adequately warm in countries of the European Union (%, 2021)



other events that affect the price of energy products. Since the 1970s, scientific studies have used different models, data, and methods to produce short- and long-term price elasticity estimates for various countries [8]. These studies [9–16] measure the latter for various energy products such as electricity, natural gas, gasoline, and car fuels. In most cases, it is concluded that the short-run elasticity of demand is inelastic. However, in the long run, it is somewhat elastic, implying that sufficient time must elapse before the energy demand response to price changes may be adequately observed.

However, the methodology used to measure elasticity may yield different results. Drollas [13] applied time series and cross-sectional models to a sample of 37 highly developed and extremely low-income countries to measure the short- and long-term price elasticity of gasoline demand. The authors found that gasoline demand is inelastic in the short run (within 1 or 2 years). In the long run, time series models suggest that price elasticity is not statistically different from unity, although cross-sectional models suggest that elasticity may be greater than unity. The method that is applied affects the elasticity of energy demand, as does the time frame (including the number of years after 1973), the composition of price changes, the sectoral breakdown, and taxes and regulations [15]. Regarding the sectoral breakdown, the short- and long-term elasticities of energy demand can vary considerably across sectors. For example, several studies have found that natural gas consumption in the industrial sector is more responsive to income than to demand in the residential and commercial sectors [9].

A moderate decrease in energy consumption, especially natural gas consumption, indicates high price elasticity of demand, which can be beneficial in some circumstances. According to George [15], the latter indicates the long-term capacity of the economy to withstand the impact of rising energy prices. Although price shocks have significant inflationary and recessionary consequences in the short run, they do not impede economic growth in the long run. In contrast, weak price elasticity indicates a weak response to rising energy prices and adverse effects on output and inflation in the long run.

The Hungarian literature on the price and income elasticity of demand since the millennium focuses on food, energy products, and the import of goods and services, providing good insight into Hungarian consumer price sensitivity. Results indicate that external shocks change the consumption of goods and consumer behavior. Kiss and Kocsis [17] found that significant macroeconomic influences such as wars, changes in political and economic systems, and financial crises affected net electricity consumption in Hungary between 1925 and 2011. The price of electricity for households increased significantly in Hungary between 1995 and 2010. Despite this, household electricity consumption also slightly increased, indicating the inelastic long-term price elasticity of electricity demand. This result also holds for the income elasticity of electricity demand, confirming that electricity is an everyday commodity in Hungary. Energy commodities and other products and services have also been the focus of elasticity studies. Michalkó et al. [18] analyzed the impact of the 2007 economic crisis on Hungarian shopping tourism, focusing on changes between 2006 and 2010 in the purchases of day trippers from neighboring countries. The results showed that the economic crisis made customers more price sensitive: those who had the opportunity to save money shopped more in Hungary. Visitors from Eurozone Member States took advantage of the favorable EUR/HUF exchange rate, while citizens from countries outside the Eurozone tended to reduce their spending in Hungarian retail stores.

Regarding issues other than energy products, Novak [19] examined the short-term dynamics of price and income elasticities of imports in Hungary using data from 1996 to 2018. Results indicate that the income elasticity of import demand was significant and mostly positive, while the price effect was not. Further, Hungary's accession to the EU did not greatly impact import demand patterns with other EU members. Accession was expected to lead to greater alignment of Hungarian prices with EU levels. The impact of national and EU policies on Hungarian producers and consumers is relevant because the latter were confronted with a new situation. For this reason, Szigeti and Podruzsik [20] analyzed the impact of welfare changes on Hungarian food consumers. Calculation of the price, cross-price, and income elasticities of demand for food products for individuals from different income deciles indicated that all income groups were affected by price changes. Price elasticities were different for low-income and middle-income groups. Larger elasticities suggest that low-income consumers are more sensitive to price changes than high-income consumers. Additionally, almost all Hungarian goods were found to be inferior and negatively income inelastic. This was attributed to a shift in consumer behavior toward more consumption of fast food.

Among the more recent studies, those focusing on residential energy use and regulated energy prices are highlighted below. It is important to emphasize that regulations and government intervention can affect consumer demand response to price changes and have socioeconomic effects. Weiner and Szép [3] examined the impact of Hungary's utility cost reduction program (launched in 2013) on household energy consumption. They found that by 2018 an additional 13.2 PJ of consumption was attributable to the program, which was unevenly distributed across income deciles. Low energy prices were more favorable for members of higher-income deciles than low-income deciles who typically use lower-quality market fuels and live in inefficient housing. The authors advocated ending the program and providing assistance only to those who needed it.

The program heavily burdened the Hungarian state budget [21]. In response to the current energy crisis that started in the second half of 2021, the Hungarian government changed the scheme[3] to provide all consumers with officially priced gas and electricity up to the national average level of household consumption. At above this level, the market price applies. Moreover, to further curb energy consumption, the government ordered a reduction in the consumption of electricity and natural gas in public buildings by 25%, including limiting heating to a maximum of 18° Celsius [22]. Because of the gas and electricity price growth for households and nonhouseholds, in 2022, consumption decreased by 15.0% [23] and 1.8% [24], respectively.

In summary, the relationship between energy demand and price changes is a multifaceted issue that researchers have thoroughly studied. Policymakers should consider numerous variables that can affect short- and long-term elasticities when developing energy policies aimed at maintaining long-term economic development and stability. The case of Hungary's utility cost reduction program illustrates the uneven distribution of benefits and the need for targeted support. Recent changes in the regulation of energy prices and utility subsidies in Hungary show the tradeoffs that must be made in balancing consumer needs with government budgetary constraints. Finally, research on import demand and food consumption in Hungary illustrates the importance of considering income deciles and consumer behavior when designing policies that affect consumers' lives.

3. Methodology and Data

The midpoint percentage method is applied to calculate the price elasticity of demand. The sample period is from 2010 to 2021, which is justified by the fact that data from before 2010 are unavailable in several cases. Table 1 lists the utilized indicators, their units, and their sources.

We applied climate adjustment only to household energy consumption and household gas consumption but not to household electricity consumption. In our view, the former is significantly affected by weather (and climate) because, as mentioned above, most space heating in Hungary is gas-fired. However, electricity heating is not standard in Hungary, thus weather negligibly influences electricity consumption. In 2021, about 60% of Hungarian household energy consumption for heating purposes was covered by natural gas and only 2.1% by electricity [4]. For climate adjustment, the following formula was applied:

$$CE = E \times \frac{HDD_m}{HDD} \tag{1}$$

where CE is the climate-corrected energy or gas consumption, E is the energy or gas consumption, HDD is the heating degree days, and HDD_m is the mean value of heating degree days over the years 2010–2021.

The price elasticity of demand is the measure most commonly used to assess the consumer response to price changes. The elasticity of demand is the extent to which demand responds to a change in an economic component, and price is the most common economic component used to measure this [31]. Demand for a product is said to be elastic if a small change in price causes a substantial change in demand. When a significant change in price causes only a small change in demand, demand is said to be inelastic. There are two other main types of demand elasticity: cross-elasticity and

[3]Government Decree 259/2022 (VII. 21.) on setting certain universal service tariffs.

Table 1
Data parameters

Variable	Unit	Source
Climate-corrected household energy consumption per capita	Koe	Eurostat [25]; Eurostat [26]; Eurostat [27]
Climate-corrected household gas consumption per capita	Koe	Eurostat [25]; Eurostat [26]; Eurostat [27]
Household electricity consumption per capita	Koe	Eurostat [25]; Eurostat [27]
Gas prices for household consumers	EUR	Eurostat [28]
Electricity prices for household consumers	EUR	Eurostat [29]
Heating degree days	Celsius (°C)	Eurostat [26]
Annual per capita household energy expenditure by COICOP, income deciles	HUF	Hungarian Central Statistical Office [30]
Annual per capita net income by income decile	HUF	Hungarian Central Statistical Office [30]
Population	Inhabitants	Eurostat [27]

Table 2
Overview of types of demand elasticity and representation of their values

Type	Value representation	
Price elasticity of demand	Elastic • The good can be substituted • The good is a luxury good • A large proportion of income is spent on the good • Over the long run	Inelastic • The good cannot be substituted • The good is a necessity • A small proportion of income is spent on the good • Over the short run
Income elasticity of demand	Positive The good is normal; as income increases, the quantity demanded at a given price increases	Negative The good is inferior; as income increases, the quantity demanded at a given price decreases
Cross elasticity of demand	Positive The two goods are substitutes	Negative The two goods are complementary

income elasticity of demand. The cross elasticity of demand refers to how fluctuations in the price of one product affect the quantity demand for another. This relationship varies depending on whether the two products are substitutes, complementary, or unrelated. Income elasticity of demand refers to how income fluctuations affect quantity demand.

Four main factors affect the price elasticity of demand: (1) the availability of alternatives, (2) whether the good is a luxury good or a necessity, (3) the proportion of income spent on the good, and (4) the length of time since the last price change[4]. If the good can be substituted, the price elasticity of demand is said to be elastic. If it is not substitutable, demand will be inelastic. Moreover, the price elasticity of demand is low when the good is a necessity and high when it is a luxury. Regarding income, the price elasticity of demand is low when people spend only a small proportion of their income on the good and vice versa. The sign is important in this case. A good is "normal" if the income elasticity of demand is positive, meaning that an increase in income is accompanied by an increase in the quantity demanded at a given price. If it is negative, it is an inferior good for which the quantity demanded at a given price decreases as income increases. Finally, the quantity demanded by the market is generally slow to respond to price changes in the short run but becomes more responsive. As a result, demand is usually inelastic in the short run but elastic eventually. Table 2 provides a summary of these different cases.

Numerous statistical techniques have been developed for modeling elasticities, including time series and regression models such as multiple regression [32, 33], Autoregressive Integrated Moving Average (ARIMA) models [34, 35], Vector Autoregressive (VAR)/Vector Error-Correction (VEC) models [36–38], and Autoregressive Distributed Lag (ADL)/Error-Correction Model (ECM) models [39, 40]. However, insufficient observations make it challenging to estimate long-term elasticities and obtain accurate and reliable results using time series models. Additionally, it is impractical to use multiple regression models because the respective variables are nonstationary even after differencing and logarithmic transformation. As a result, this study determines the short-run price and income elasticities of demand using the simple midpoint percentage method. This involves dividing the percentage change in the quantity demanded of a good by the percentage change in its price or income. Unlike the basic percentage change method, this method involves dividing the difference between two values by their average value. It has the advantage of calculating the same elasticity between two price points regardless of whether the price increases or decreases. The results can be classified as follows: perfectly elastic (∞), elastic (>1), unitary (1), inelastic (<1), and perfectly inelastic (0). The greater the elasticity, the stronger the influence of the price or income on the quantity demanded. The following equation is used to measure the price elasticity of demand for gas, electricity, and total energy:

$$PED = \frac{(Q_t - Q_{t-1})}{\left(\frac{Q_t+Q_{t-1}}{2}\right)} \Big/ \frac{(P_t - P_{t-1})}{\left(\frac{P_t+P_{t-1}}{2}\right)} \quad (2)$$

where PED is the price elasticity of demand, Q is the gas, electricity, or final energy consumption, P is the gas price, electricity price, or income, and t is the current year.

[4]Corporate Finance Institute. (2023). *Elasticity – Overview, examples and factors, calculation*. Retrieved from: https://corporatefinanceinstitute.com/resources/economics/elasticity/

4. Results

Figures 2 [4] and 3 [4] show the Hungarian household energy mix and energy consumption according to household activity in 2021, respectively. According to Figure 2, natural gas is the primary source of household energy, accounting for 51.8% of the total, followed by renewable energy (21.1%), electricity (17.4%), and district heating (7.8%). The use of petroleum products, coal, and coal products is not widespread; their combined share is around 1.8%. The relatively large share of renewables looks impressive at first sight; however, it is worth noting that this includes traditional solid biomass fuel (firewood), which is the fuel of people experiencing poverty. Regarding energy consumption by household activity, Figure 3 shows that Hungarian households consumed the largest share of energy (namely 72.8%) for heating, 11.9% for hot water, 10.2% for lighting and electrical appliances, 4.8% for cooking, and finally 0.3% for cooling.

In what follows, we focus on the relationship between residential gas and electricity consumption and price changes. Figure 4 shows the negative relationship between gas consumption and gas prices. The decreasing trend in gas prices from 2011 to 2015 was mainly due to the utility cost reduction program (which started in 2013), after which prices fluctuated slightly (remained constant in local currency) until 2021. Despite the decrease in price, gas consumption also declined between 2010 and 2013 before increasing again until 2021. This drop in gas consumption was due to the coping strategies of households (2010–2013). The high gas prices were a huge burden for households, forcing them to save energy. Many families also switched from using gas to cheaper but more polluting firewood. This shift was particularly marked between 2010 and 2013.

After 2013, one of the biggest benefits of the utility cost reduction program was that the share of energy costs in household income declined steadily from 7.1% in 2010 to 6.1% in 2013 and to 3.4% in 2021[5]. This may also be due to factors such as energy efficiency improvements. This finding is consistent with the claims in the literature that sufficient time must elapse before the energy demand response to price changes may be fully understood.

A similar inverse relationship between prices and consumption is observable for electricity (see Figure 5). The figure shows that the price decreased from 1.98 (EUR/Koe) in 2010 to 1.31 (EUR/Koe) in 2015 and then fluctuated slightly (remained constant in local currency) until 2021 due to the utility cost reduction program. Similarly to gas consumption, per capita electricity consumption declined from 2011 to 2014 before gradually increasing until 2021. This implies that Hungarian families consumed more electricity while paying the same price during the time of the utility cost reduction program.

Table 3 presents information on the price elasticities of Hungarian households' natural gas and electricity demand between 2010 and 2021. Since the focus is on the elasticity value and not on the direction of the relationship, the values are calculated in absolute terms. It can be seen that the elasticity of gas and electricity fluctuated over time. In general, gas demand was more inelastic than electricity demand, as seen in the lower elasticity values for gas. Electricity and gas consumption remained relatively inelastic from 2010 to 2015. Nevertheless, elasticity increased significantly for both gas and electricity from 2015 to 2019, showing that demand became more sensitive to price fluctuations. This is due to the impact of the utility cost reduction program. Lower prices led to overconsumption, creating a safety margin for households. However, this allowed enough space for families to adjust their consumption following price changes.

In 2019–2020, gas and electricity demand became inelastic, with elasticity values falling to 0.17 and 0.67, respectively. This

Figure 2
Energy mix of Hungarian households in 2021

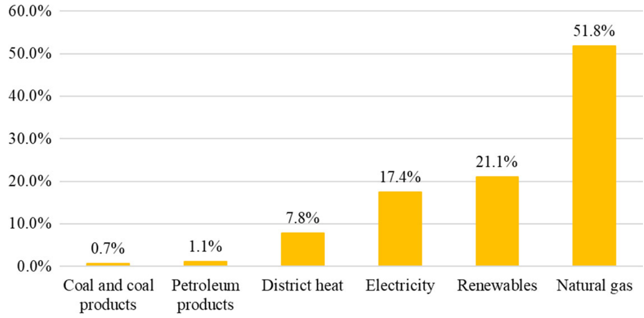


Figure 3
Household energy consumption in Hungary according to household activity (2021)

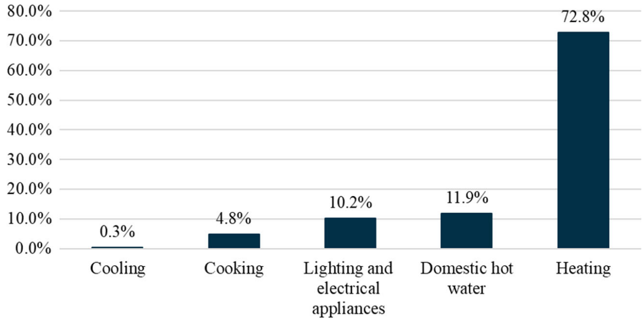
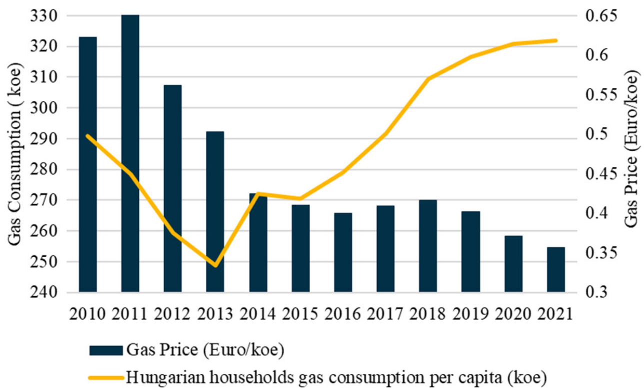


Figure 4
Climate-corrected household natural gas consumption per capita (Koe) and price (EUR/Koe) for medium-sized (annual consumption between 20 and 200 GJ) Hungarian household consumers (2010–2021)



[5]Hungarian Central Statistical Office. (2023). *Proportion of household energy costs in relation to available income*. Retrieved from: https://ksh.hu/s/kiadvanyok/fenntartha to-fejlodes-indikatorai-2022/1-4-sdg-7#1-abra

Figure 5
Household electricity consumption per capita (Koe) and price (EUR/Koe) for medium-sized (annual consumption between 2500 and 5000 kWh) Hungarian household consumers (2010–2021)

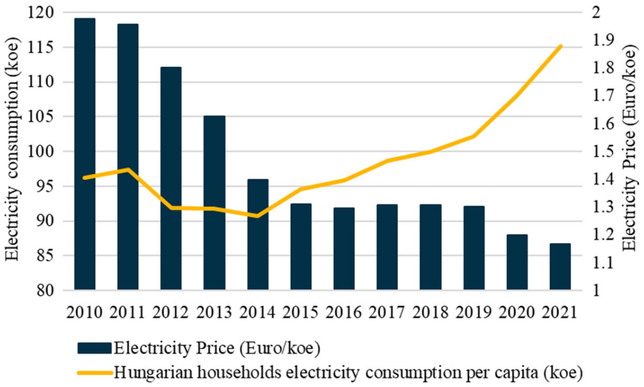


Table 3
Absolute price elasticities of Hungarian household natural gas and electricity demand (2010–2021)

	Natural gas		Electricity	
Period	Absolute PED	Status	Absolute PED	Status
2010–2011	0.97	Inelastic	1.12	Elastic
2011–2012	0.48	Inelastic	0.70	Inelastic
2012–2013	0.37	Inelastic	0.01	Inelastic
2013–2014	0.53	Inelastic	0.08	Inelastic
2014–2015	0.17	Inelastic	0.64	Inelastic
2015–2016	1.22	Elastic	1.13	Elastic
2016–2017	2.02	Elastic	3.05	Elastic
2017–2018	3.28	Elastic	7.11	Elastic
2018–2019	0.65	Inelastic	8.28	Elastic
2019–2020	0.17	Inelastic	0.67	Inelastic
2020–2021	0.08	Inelastic	2.31	Elastic

Table 4
Absolute natural gas and electricity cross-price elasticities of Hungarian household energy demand (2010–2021)

	Natural gas		Electricity	
Period	Absolute PED	Status	Absolute PED	Status
2010–2011	0.82	Inelastic	3.37	Elastic
2011–2012	0.05	Inelastic	0.10	Inelastic
2012–2013	0.05	Inelastic	0.05	Inelastic
2013–2014	0.27	Inelastic	0.30	Inelastic
2014–2015	1.31	Elastic	0.70	Inelastic
2015–2016	0.31	Inelastic	0.67	Inelastic
2016–2017	0.55	Inelastic	1.25	Elastic
2017–2018	1.60	Elastic	16.10	Elastic
2018–2019	0.34	Inelastic	4.51	Elastic
2019–2020	0.18	Inelastic	0.18	Inelastic
2020–2021	0.53	Inelastic	0.76	Inelastic

means that a 1% change in the price of gas or electricity resulted in a 0.17% change in gas demand and a 0.67% change in electricity demand. In 2020–2021, gas consumption remained inelastic with an elasticity of 0.08, while electricity demand became more elastic at 2.31. In general, electricity demand was more price elastic than gas demand. Furthermore, since the values are measured over 1 year, they represent short-term elasticities, which is why they are inelastic in most periods. However, it is clear that the utility cost reduction program massively increased the responsiveness of consumers to price changes, indicating growing elasticity in the short term.

To measure the impact of gas and electricity prices on total household energy consumption, cross-price elasticities of energy demand for gas and electricity were calculated from 2010–2011 to 2020–2021 (see Table 4, where the values are measured in absolute terms). Although the direction of the relationship is important in the case of cross-price elasticity, an increase in the price of gas and electricity usually reduces energy consumption.

Figure 6
Absolute values for electricity cross-price elasticity of energy demand according to per capita energy expenditure by income decile (2010–2020)

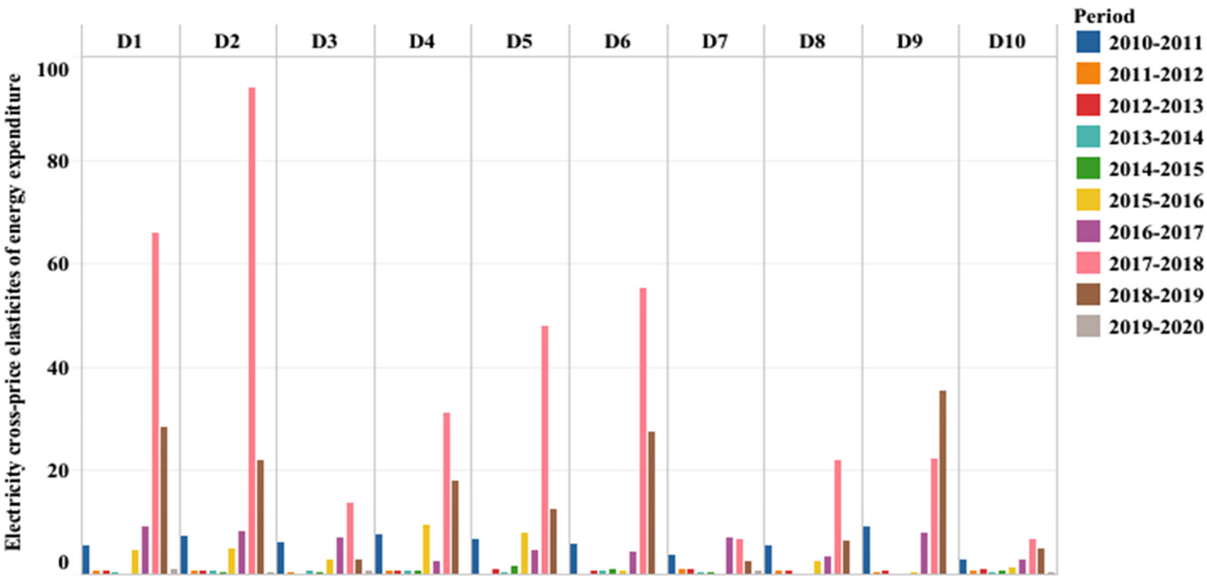


Figure 7
Absolute values for gas cross-price elasticity of energy demand according to per capita energy expenditure by income decile (2010–2020)

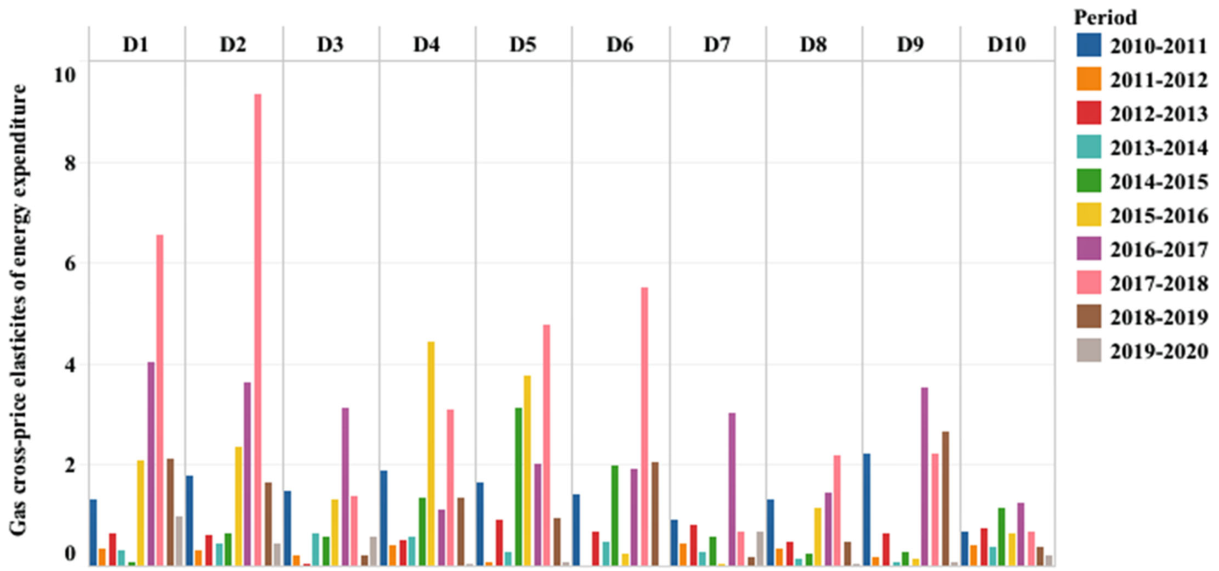
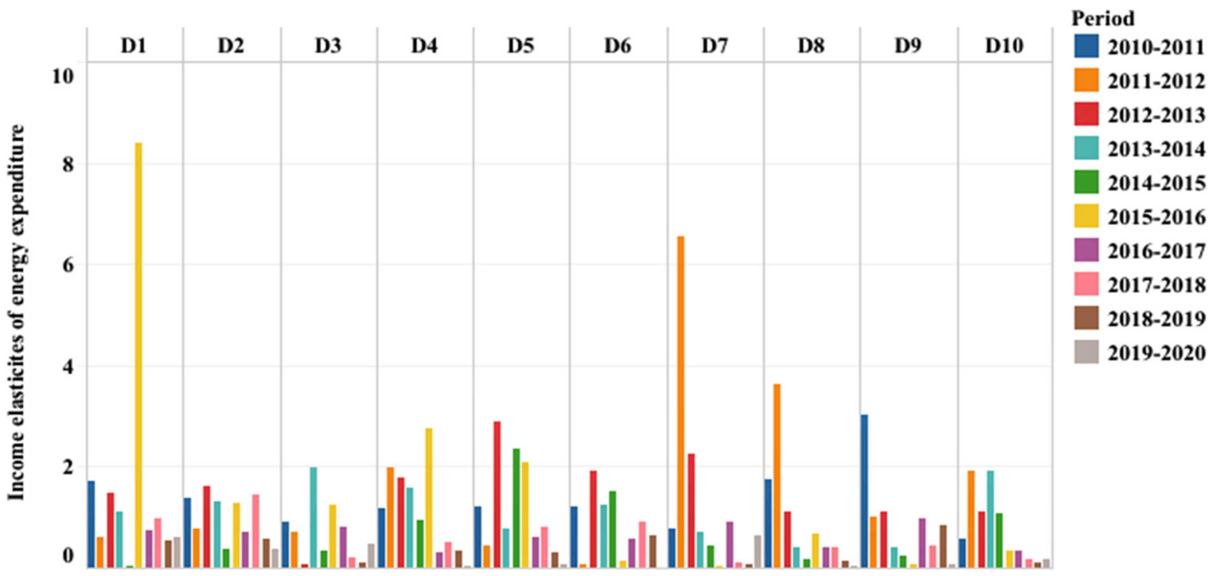


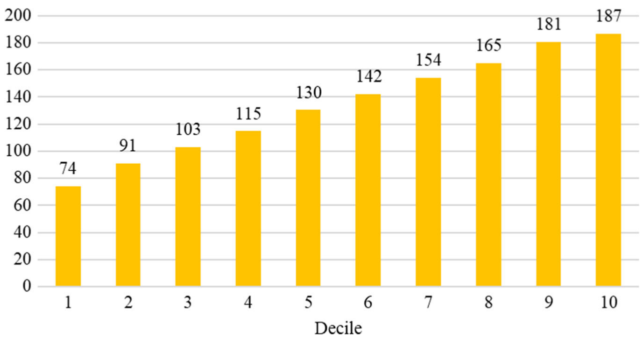
Figure 8
Absolute values of net income elasticity of energy demand according to per capita energy expenditure per income decile (2010–2020)



From the standpoint of price and consumption, gas prices and energy consumption have generally been inelastic, with elasticity values of less than one for most periods. On the other hand, the situation with electricity prices and energy consumption varied greatly. The latter was elastic in 2010–2011 and more significantly elastic in 2017–2018, showing that electricity price changes significantly impacted energy consumption. The values became elastic from 2016 to 2019, confirming the impact of the utility cost reduction program in these years. This indicates that Hungarian household consumers were more responsive to electricity price changes than to gas price changes. However, in the other periods, demand for energy was inelastic, suggesting that electricity price changes had little impact on energy consumption, even in the short term.

For a more granular analysis and to test the second and third hypotheses, Figures 6, 7, and 8 show the absolute values of electricity price, gas price, and income elasticities of energy demand as measured by energy expenditure for each income decile from 2010 to 2020. The electricity cross-price elasticity of energy demand was very high for all deciles, especially between 2017 and 2019, reaching 93.75 for the second decile in 2017–2018. Figure 6 also shows that the values for each decile vary similarly for all deciles combined (Table 3); they were elastic in

Figure 9
Average annual per capita energy expenditure for Hungarian household income deciles (2010–2020) (thousand HUF)

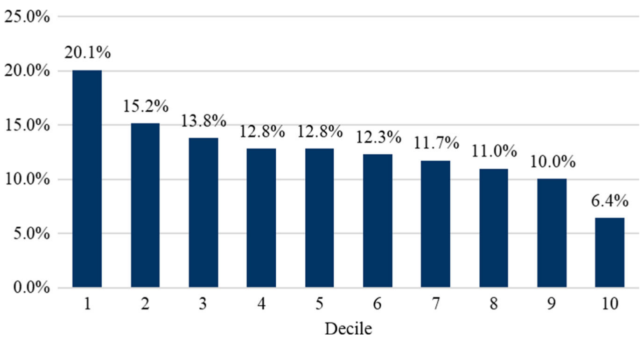


2010–2011 and 2015–2019. The figure shows that the elasticities are highest for the first and second deciles and lowest for the tenth decile, meaning that the first two deciles are the most sensitive to price changes, and the tenth decile is the least sensitive. In addition, the fifth and sixth deciles had relatively high elasticity in 2017–2019 compared with the third decile. Households in these deciles and most other deciles increased their energy expenditure rapidly in 2018 and decreased it in 2019. Nonetheless, the figure shows that low-income deciles have high elasticities. In contrast, high-income deciles have low values, confirming that low-income households are more sensitive to electricity price changes than high-income households.

A similar conclusion for the gas cross-price elasticity of energy demand can be grasped from Figure 7, with relatively low elasticity values. The first two deciles are associated with the highest values, and the tenth decile the lowest. Overall, this indicates that low-income Hungarian households are more sensitive to electricity and gas price changes than high-income households. In terms of income, Figure 8 shows that the values in most cases and deciles are inelastic as they are measured in the short run. The highest value was 8.37 for the first decile in 2015–2016. However, the values vary randomly among the different income deciles with no identifiable pattern. As a result, we conclude that energy expenditure behavior is not determined by household income in Hungary.

Figures 9 and 10 display the average annual per capita energy expenditure and average annual per capita energy expenditure as a proportion of net income for Hungarian household income deciles in

Figure 10
Average per capita energy expenditure as a proportion of net income for Hungarian household income deciles on an annual basis (2010–2020) (%)



2010–2020. Energy expenditure increases gradually among the deciles, from 74,000 HUF for the first decile to 187,000 HUF for the tenth decile. Further, energy expenditure as a proportion of net income decreases gradually among the deciles, from 20.1% for the first decile to 6.4% for the tenth decile, reflecting the uneven distribution of energy expenditure among Hungarian household income deciles. This suggests the need for a new energy pricing tool to reduce this inequality and protect low-income deciles from energy poverty. The application of a multi-tariff pricing strategy that is based on the energy burden is recommended. The first two income deciles are the most vulnerable and sensitive to energy price changes and should be protected from the large energy burden by being permitted to buy electricity and gas at a very low price.

5. Conclusion and Policy Implications

The European energy crisis that began in 2021–2022 was due to a combination of factors that led to a sharp rise in energy prices. Like many other countries, Hungary faced several challenges. The increase in residential gas and electricity tariffs could have disproportionately affected low-income households. Consumer protection became the main objective of energy policy. Under the circumstances, the utility cost reduction program had to be adjusted. While it was formerly undifferentiated in relation to household income, in 2022, regulated prices were partially phased out (households whose gas and electricity consumption is above the national average must now pay market prices). The price elasticity of energy demand has always been an underrepresented research area in Hungary, and it is important to fill this research gap, producing better valuation analyses and more accurate scenarios for household energy consumption. The period 2010–2021 represents a unique opportunity to measure the price elasticity of energy demand. The introduction of a price cap, a period of long-term stability of household energy prices with an adjustment at the end, and the sudden price increase have significantly influenced consumer behavior. The aim of this study was to examine the short-term impact of gas and electricity price changes and income on the energy demand of Hungarian households according to income deciles in relation to the Hungarian utility cost reduction program.

The results show that electricity demand is generally more elastic than gas demand, which means that changes in gas prices have less impact on demand, implying that gas is a more necessary commodity than electricity in Hungary. However, the elasticity of both gas and electricity demand increased significantly from 2015 to 2019 due to the regulated energy prices. The government intervention increased consumers' responsiveness to price changes, resulting in elastic short-run values. The energy crisis significantly impacted consumer behavior as well. In 2020–2021, gas consumption remained inelastic with an elasticity of 0.08, while electricity demand became more elastic at 2.31. This suggests that Hungarian household consumers were more responsive to changes in electricity prices than gas prices. Therefore, our first hypothesis is partly rejected. We conclude that Hungarian households have limited flexibility to adjust their energy consumption in line with price changes.

Further, the study finds that electricity prices significantly impact the energy demand of households in all income deciles, with high cross-price elasticities observed across all deciles. The first and second deciles are the most sensitive to price changes, while the tenth is the least sensitive. Similarly, gas prices affect the energy demand of all income deciles, although the elasticities are relatively smaller. This suggests that low-income Hungarian households are more responsive to electricity and gas price changes than high-income households. Accordingly, our second hypothesis is accepted.

Regarding income, no pattern is identifiable in the relationship between income deciles and energy expenditure behavior, suggesting that income does not significantly influence Hungarian household energy demand. Our third hypothesis is rejected.

The findings also reveal a gradual increase in energy expenditure with income decile, ranging from 74,000 HUF for the first decile to 187,000 HUF for the tenth. Conversely, energy expenditure as a proportion of net income decreases steadily, starting from 20.1% for the first decile and decreasing to 6.4% for the tenth. These figures highlight the unequal distribution of energy expenditure across income deciles and suggest the need for a new energy pricing approach to protect low-income deciles from energy poverty. The recommendation is to implement a multi-tariff pricing strategy based on the energy burden, particularly focusing on the first two income deciles, which are the most vulnerable and sensitive to changes in energy prices. Energy policy targets should maintain the energy burden at below 10% for all income deciles in Hungary. It is also recommended that this target be achieved through changes in electricity prices followed by changes in gas prices because electricity prices have a proportionately greater impact on Hungarian households' energy demand.

Ethical Statement

This study does not contain any studies with human or animal subjects performed by any of the authors.

Conflicts of Interest

The authors declare that they have no conflicts of interest to this work.

Data Availability Statement

Data available on request from the corresponding author upon reasonable request.

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