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ENERGY VULNERABILITY AS A RISK FACTOR FOR QUALITY OF LIFE: CASE OF MOLDOVA

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Formulation of the problem: The European energy crisis not only led to an increase in energy prices but also to a recession in the Moldovan economy. After the end of the energy crisis, stagnation was registered in Moldova. The recession and subsequent stagnation led to an increase in the number of people living below the poverty line, as well as to the rise in energy poverty. Thus, in these circumstances, the study of energy vulnerability and its impact on the quality of life has become especially relevant. Therefore, the main research problem in this article is to analyze energy vulnerability as a risk factor for the decline in the quality of life in Moldova. *The aim of the research* is to assess the relationship between energy vulnerability and quality of life in Moldova. The main objectives of this study are to analyze the theoretical aspects of the concept of energy vulnerability, identify and analyze the determinants of energy vulnerability, and conduct an empirical assessment of the impact of energy vulnerability on households in Moldova. *The object of the study* is energy vulnerability and its impact on the quality of life. The article examines the theoretical aspects of the concept of energy vulnerability, as well as the determinants of energy vulnerability. *Research methods:* abstract logical method, comparative analysis method, statistical and economic methods. *The central hypothesis:* Moldova's energy vulnerability at the macro level is transformed into a decline in the quality of life and into deprivation of households at the micro level. *The statement of basic materials:* The conducted empirical analysis showed that Moldova is vulnerable to external energy shocks, as it mainly imports energy resources. Domestic primary energy production covered 22.2% of total energy consumption, while domestic electricity production covered 11.3% of total electricity consumption in 2023. The primary sources of electricity are the CHP (Combined Heat and Power) plants in Chisinau and Balti, as well as the growing green energy. But, unfortunately, the share of renewable energy is still small. Moldova is pursuing a strategy of energy resource diversification to strengthen energy security. To this end, the synchronization of Moldovan power grids with the European ENTSO-E (European Network of Transmission System Operators for Electricity) network and the construction of the Iasi-Ungheni-Chisinau gas pipeline were carried out. However, the implementation of these projects has not yet yielded tangible results. The main reason is the increase in the price of energy resources, which has negatively affected the competitiveness of goods, as their prices have also risen due to the rise in energy costs. As a result, there is a decline in production and an increase in the number of unemployed, which negatively affects the quality of life. At the same time, the increase in tariffs for energy resources has led to a rise in the share of energy expenditure above 10% of total consumer spending, which indicates both energy poverty and a decrease in the quality of life of the population. *The originality and practical significance of the study:* This study contributes to the scientific literature by presenting the results of an empirical analysis using the example of a country with a high dependence on energy imports. In this paper, the authors examine how the impact of external shocks on energy vulnerability is manifested in the quality of life of the population. *Conclusions and prospects for further research:* The results of the study revealed that energy vulnerability is a persistent issue in Moldova. It is leading to energy poverty and limiting the basic opportunities of the population to access quality food, to purchase clothes and shoes, since, within the available budget, households are forced to reduce other expenditure items to cover the costs of heating, hot water, and electricity. The transition to lower-quality nutrition leads to health problems. Thus, energy vulnerability will lead to a decrease in the quality of life and is an obstacle to a decent life.

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Keywords:
energy vulnerability, energy poverty, energy resilience, socioeconomic inequality, quality of life, resilient policy.

ЕНЕРГЕТИЧНА ВРАЗЛИВІСТЬ ЯК ФАКТОР РИЗИКУ ЯКОСТІ ЖИТТЯ: ПРИКЛАД МОЛДОВИ

Постановка проблеми: Європейська енергетична криза призвела не лише до зростання цін на енергоносії, а й до рецесії в економіці Молдови. Після завершення енергетичної кризи в Молдові було зареєстровано стагнацію. Рецесія та подальша стагнація призвели до збільшення кількості людей, які живуть за межею бідності, а також до зростання енергетичної бідності. Таким чином, за цих обставин вивчення енергетичної вразливості та її впливу на якість життя стало особливо актуальним. Тому основною дослідницькою проблемою в цій статті є аналіз енергетичної вразливості як фактора ризику зниження якості життя в Молдові. *Метою дослідження* є оцінка взаємозв'язку між енергетичною вразливістю та якістю життя в Молдові. Основними завданнями цього дослідження є аналіз теоретичних аспектів концепції енергетичної вразливості, визначення та аналіз детермінант енергетичної вразливості, а також проведення емпіричної оцінки впливу енергетичної вразливості на домогосподарства в Молдові. *Об'єктом дослідження* є енергетична вразливість та її вплив на якість життя. У статті розглядаються теоретичні аспекти концепції енергетичної вразливості, а також детермінанти енергетичної вразливості. *Методи дослідження:* абстрактно-логічний метод, метод порівняльного аналізу, статистичний та економічний методи. *Центральна гіпотеза:* Енергетична вразливість Молдови на макрорівні трансформується у зниження якості життя та у злидні домогосподарств на мікрорівні. *Виклад основних матеріалів:* Проведений емпіричний аналіз показав, що Молдова вразлива до зовнішніх енергетичних шоків, оскільки вона переважно імпортує енергетичні ресурси. Внутрішнє виробництво первинної енергії покривало 22,2% від загального споживання енергії, тоді як внутрішнє виробництво електроенергії покривало 11,3% від загального споживання електроенергії у 2023 році. Основними джерелами електроенергії є ТЕЦ (теплоелектроцентраль) у Кишиневі та Бєльцях, а також зростаючий сектор зеленої енергетики. Але, на жаль, частка відновлюваної енергетики поки що невелика. Молдова проводить стратегію диверсифікації енергетичних ресурсів для зміцнення енергетичної безпеки. З цією метою було здійснено синхронізацію молдавських енергосистем з європейською мережею ENTSO-E (Європейська мережа операторів систем передачі електроенергії) та будівництво газопроводу Ясси-Унгени-Кишинів. Однак реалізація цих проектів поки що не дала відчутних результатів. Основною причиною є зростання цін на енергоресурси, що негативно вплинуло на конкурентоспроможність товарів, оскільки ціни на них також зросли через зростання вартості енергоносіїв. Як наслідок, спостерігається спад виробництва та збільшення кількості безробітних, що негативно впливає на якість життя. Водночас, підвищення тарифів на енергоресурси призвело до зростання частки витрат на енергоносії понад 10% від загальних споживчих витрат, що свідчить як про енергетичну бідність, так і про зниження якості життя населення. *Оригінальність та практична значущість дослідження:* Це дослідження робить внесок у наукову літературу, представляючи результати емпіричного аналізу на прикладі країни з високою залежністю від імпорту енергоносіїв. У цій статті автори досліджують, як вплив зовнішніх шоків на енергетичну вразливість проявляється на якості життя населення. *Висновки та перспективи подальших досліджень:* Результати дослідження показали, що енергетична вразливість є постійною проблемою в Молдові. Вона призводить до енергетичної бідності та обмежує основні можливості населення щодо доступу до якісних продуктів харчування, придбання одягу та взуття, оскільки в межах наявного бюджету домогосподарства змушені скорочувати інші статті витрат для покриття витрат на опалення, гарячу воду та електроенергію. Перехід до харчування нижчої якості призводить до проблем зі здоров'ям. Таким чином, енергетична вразливість призведе до зниження якості життя та буде перешкодою для гідного життя.

Ключові слова:
енергетична вразливість, енергетична бідність, енергетична стійкість, соціально-економічна нерівність, якість життя, стійка політика.

Formulation of the problem. The energy crisis in the second half of 2021 led to a recession in Moldova in 2022. At the end of the energy crisis, stagnation of the national economy was registered in 2024. Since energy prices, even after the energy crisis, are much higher than before the crisis, it becomes relevant to study the energy vulnerability of the population of Moldova and its impact on the quality of life. Access to affordable energy resources is one of the basic needs of the population. The lack of such access and the high price of energy resources have two

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effects. Firstly, they lead to the creation of energy vulnerability in households. Secondly, they lead to an increase in the cost of production of goods and services and, finally, to the rise in prices for goods and services for the end consumer. As a result, the level of well-being and quality of life of the population decreases, and an increasing number of citizens live below the poverty line.

Moldova is one of the poorest European countries, with a GDP per capita (PPP) of $18,700 in 2024, which is 3.3 times lower than the EU average and 14.8% lower than in Bosnia and Herzegovina [1]. The republic also recorded the lowest level in another indicator – the energy self-sufficiency ratio. Over the past five years (2019-2023), domestic primary energy production has covered only about 19-24% of total energy consumption [2], which is two times lower than the EU average. Moldova is an energy-importing country, so both producers and households depend on fossil fuel imports. All of this evidence proves the relevance of studying the relationship between energy vulnerability and quality of life.

The main research problem in this article is to analyze energy vulnerability as a risk factor for the decline in the quality of life in Moldova. In recent years, the economic situation in Moldova has been deteriorating. Accordingly, well-being also declines. The reason was some shocks (energy and geopolitical crises, the economic recession caused by the COVID-19 pandemic, and climate cataclysms). All of these economic shocks affected macroeconomic indicators [3] and led to stagflation. For an increasing number of households, energy expenditure exceeds 10% of total consumer spending, indicating an increase in energy poverty in Moldova. Thus, internal and external shocks that provoke increased energy vulnerability led to a deterioration in the quality of life.

Analysis of recent research and publications. There are various approaches to studying energy vulnerability in the world's scientific literature. The approach used by Swiss scientists is based on capabilities. They consider energy vulnerability as one of the forms of capability deprivation [4], which affects both energy-poor households and those that are at risk and may become energy-poor in the near future. According to empirical studies, the most significant factor that influences energy vulnerability is income. The higher the income, the lower the probability of energy vulnerability. A. Hearn et al. consider that the significance of the following factors is very low: gender, residence in an urban or rural area, and household size.

Neil Simcock et al. explored the concept of "double energy vulnerability." They examined the sociodemographic and spatial factors that may influence both types of poverty. The results of the study showed that low-income people, people with disabilities, people with chronic diseases, older people, and households with children are subject to double energy vulnerability. The more children, the more vulnerable these households are. Spatially, the following contextual variations were found: suburban areas are more susceptible to transport poverty, and the inner-urban regions are more vulnerable to energy poverty [5]. Households with the highest level of double energy vulnerability were those that face multiple unfavorable sociodemographic and spatial factors.

Various researchers have developed the Energy Vulnerability Index (EVI), and the factors taken into account in its calculation differ from one author to another. Cameron Ward et al. have developed a spatial-temporal energy vulnerability index. They argue that there are indicators of the housing and socio-economic status of households that have the most significant influence on the composite EVI index [6]. Irish and Spanish scientists used a multidimensional approach and factor analysis in developing the EVI. According to their results, the main factors that prolong the period of households' stay in energy poverty are unemployment, disability, and reduction of social benefits [7].

Scientists studying energy vulnerability have mainly focused on its assessment. However, a unique EVI has not been developed. Another gap in scientific works is the study of energy vulnerability as a risk factor for quality of life. The main goal of this study is to fill this gap.

The aim of the research is to assess the relationship between energy vulnerability and quality of life in Moldova. The main objectives of the study are: analysis of the theoretical aspects of the concept of energy vulnerability and its differences from energy poverty and energy resilience; identification and analysis of factors determining energy vulnerability based on the study of the energy and socio-economic situation in Moldova; conducting an empirical assessment of the impact of energy vulnerability on households in Moldova.

Presentation of the primary material. Energy Vulnerability (EV) is the risk of falling

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into energy poverty. It is measured using the Energy Vulnerability Index. There are some algorithms for calculating this index. The Global Energy Vulnerability Index comprises six pillars, ranging from "Energy accessibility" to "Alternatives to fossils", with shares varying from 5% to 35%. The classic vulnerability index consists of three pillars: Exposure, Sensitivity, and Adaptive Capacity. These two calculation methods differ not only in the number of pillars but also in the calculation algorithm. If the pillars are summed up in the first case, taking into account the share of each, then in the second case, the "Adaptive Capacity" pillar is subtracted from the sum of the first two pillars.

In contrast to vulnerability, Energy Poverty (EP) is a situation in which households cannot provide themselves with the necessary amount of energy resources for a decent life, for heating, lighting, and cooking. A household is considered energy poor if the share of energy expenditure is more than 10% of total expenses or income. Suppose energy vulnerability is the predisposition for households to become energy poor as a result of an energy crisis or other shocks in the energy sector. In that case, energy resilience is the ability of households to cope with these kinds of shocks and prevent energy poverty.

Moldova's energy sector depends on energy imports. The share of imports in gross consumption varies from 67.7% to 80.5% in 2019-2023, while primary production covers a small share of consumption (Figure 1).

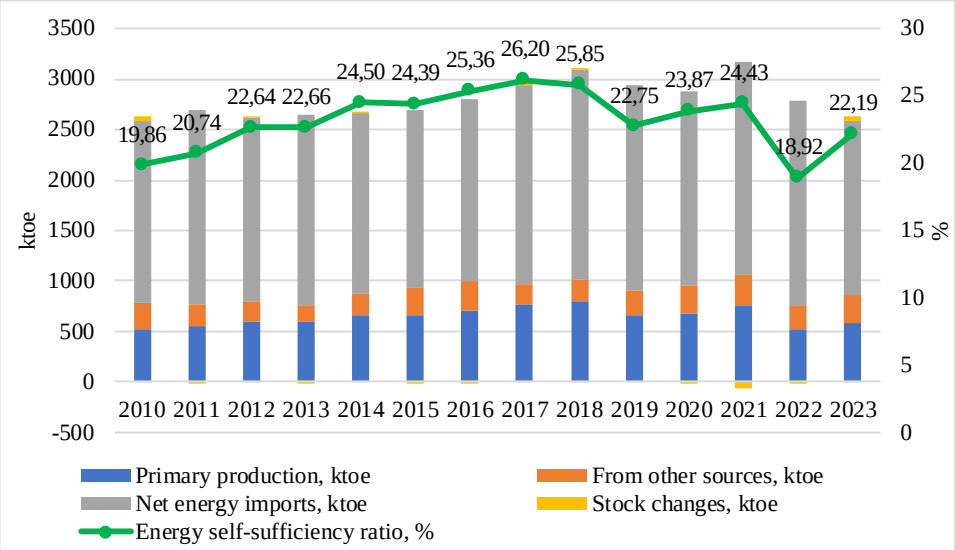

Figure 1 – Energy balance of Moldova and energy self-sufficiency ratio, 2010-2023
Source: computation by the author

During the period 2010-2017, the energy self-sufficiency ratio recorded an upward trend. Paradoxically, the lowest level was reached during the energy crisis (18.92%). The lowest level of primary production was in 2010 and 2022. Although green energy is developing and the volume of electricity produced from renewable energy sources is growing, its share is still insignificant. It cannot contribute to increasing the energy independence of Moldova. Primary production is mainly represented by solid biomass (firewood, agricultural waste), which is used primarily in rural areas for heating.

To identify sources of vulnerability, let us analyze the structure of gross consumption. As can be seen from Figure 2, almost 65% of Moldova's gross consumption is provided by oil products (42.9%) and natural gas (22%). These two types of energy resources are mainly imported. Moldova has gradually reduced the volume of gas, and the share of gas in gross consumption has decreased over the analyzed period from 36.5% in 2010 to 22.0% in 2023.

Structural vulnerability of the energy sector affects the socio-economic development of the country, and energy vulnerability of households affects the quality of life. If a country or households are energy vulnerable, it means that they have limited resources to mitigate external shocks. According to the data in Table 1, Moldova has registered growth in GDP per capita PPP, but it is still much lower than in Romania and the EU.

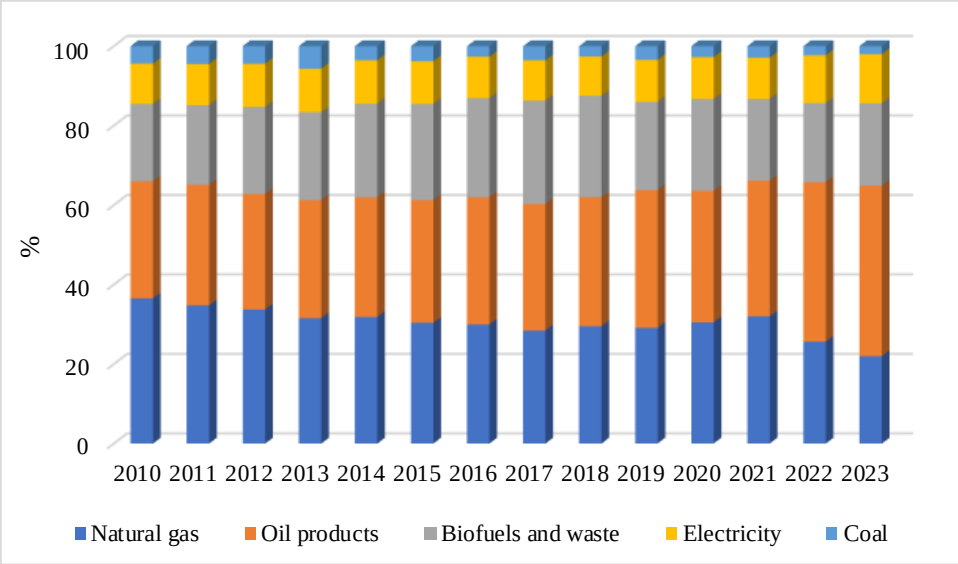

Figure 2 – Structure of gross energy consumption, 2010-2023
Source: computation by the author

Table 1 – Socio-economic indicators of Moldova in the regional context

	2019	2020	2021	2022	2023
Moldova					
GDP per capita, PPP (current $)	13413	13527	15682	16453	17747
Average income per capita, Euro	1757	1882	2013	2565	3003
Human Development Index (HDI)	0.775	0.77	0.773	0.784	0.785
Absolute poverty rate, %	25.2	26.8	24.5	31.1	31.6
Gini coefficient, %	33.9	34.7	35.6	35.3	36.2
European Union					
GDP per capita, PPP (current $)	48594	47575	51978	57526	59009
Mean equivalized net income, Euro	19567	20757	20913	21602	23067
Persons by risk of poverty, %	10.4	10.6	10.7	10.7	10.4
Gini coefficient, %	30.2	30.0	30.2	29.6	29.6
Romania					
GDP per capita, PPP (current $)	33638	34386	37730	42215	45770
Mean equivalized net income, Euro	4419	4846	5449	6130	7108
Human Development Index (HDI)	0.838	0.832	0.829	0.84	0.845
Persons by risk of poverty, %	10.5	9.2	10.1	9.0	10.4
Gini coefficient, %	34.8	33.8	34.3	32.0	31.0

Source: computation by the author

Although GDP per capita PPP, average income per capita, and the Human Development Index (HDI) have increased in Moldova, the absolute poverty rate and Gini coefficient have risen too. This can be attributed to the fact that the population has become poorer, and inequality in income distribution has increased, which will inevitably lead to a decrease in the quality of life. It indicates that many households do not have a financial buffer.

Although Moldova's HDI increased to 0.785 in 2023, it still lags behind Romania's HDI (0.845), highlighting gaps not only in income but also in access to education and life expectancy. In 2019, Moldova's Gini coefficient was one percentage point lower than Romania's. However, by 2023, the situation had changed, and Moldova's Gini coefficient was significantly higher than Romania's (by 5.2 percentage points) and the EU's (by 6.6 percentage points). A high Gini coefficient means that the burden of energy shocks is unevenly distributed, and the poorest groups of the population suffer the most.

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Under the influence of the energy crisis, tariffs for gas, central heating, hot water, and electricity have increased sharply in 2022-2023. A comparative analysis of the dynamics of the natural gas network tariff index, the central heating tariff index, and the dynamics of the average gross salary index showed that the growth of tariffs is higher than the growth of gross wages (Figure 3), which indicates a dramatic decline in the purchasing power of households to pay bills for heating, hot water, and electricity.

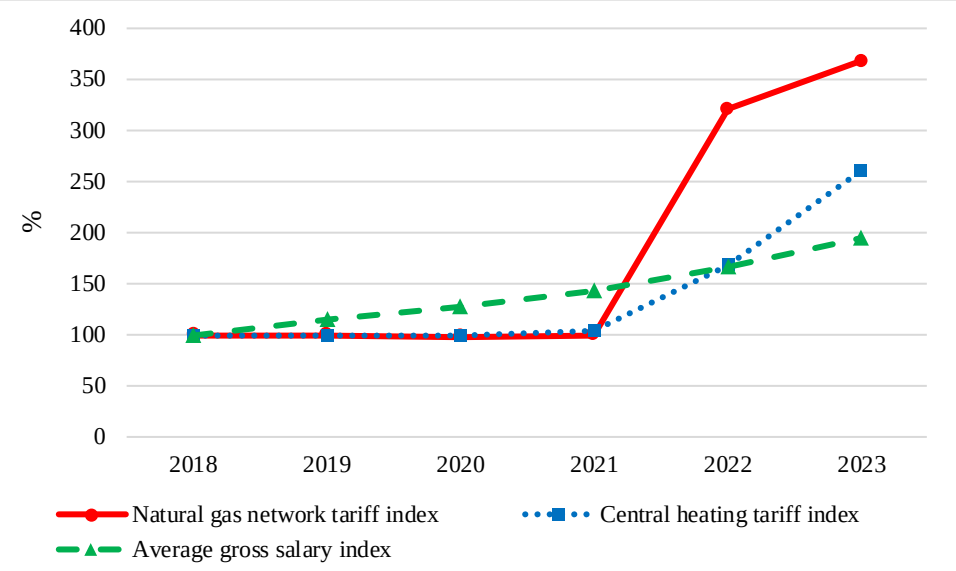

Figure 3 – Natural gas network tariff index and Central heating tariff index in comparison with Average gross salary index, 2018-2023 (index, 2018=100)
Source: computation by the author

Thus, when the growth rate of energy prices is higher than the growth rate of household incomes, it leads to an increase in energy poverty, reducing the well-being [8] and quality of life of the population. Another proof of this statement is the growing share of energy expenditure in the structure of the average monthly consumption spending per capita. The share of expenditure on "Housing, water, electricity and gas" increased from 16.2% in 2019 to 17.6% in 2023. This growth did not pass without a trace for other expenditure items. There was a crowding-out effect when mandatory payments for energy forced the population to reduce their consumption of other goods and services. According to the data in Table 2, the individual reduced his spending on clothing and footwear, as well as on food, by switching to cheaper and lower-quality products. Thus, people's lifestyle changed, which is direct evidence of a decrease in the quality of life.

Table 2 – Structure of the average monthly consumption expenditures per capita

	2019	2020	2021	2022	2023
Food, beverages and tobacco	42.4	45.5	43.9	42.8	41.4
Housing, water, electricity and gas	16.2	16.1	15.2	16.3	17.6
Transport and communication	10.6	10.2	11	11.4	11.3
Clothing and footwear	9.7	8.8	9.1	8.4	7.8
Dwelling equipment	5.1	5.6	5.7	5.8	5.3
Education, recreation and culture	3.9	3.2	3.1	3.5	4.2
Restaurants and hotels	2.6	2.0	2.2	2.2	3.2
Miscellaneous goods and services	4.3	4.1	4.2	4.5	4.8

Source: computation by the author

It should be noted that the government has taken measures to mitigate the consequences of the energy crisis. To diversify energy resources, the Moldovan power grids were synchronized with the European ENTSO-E (European Network of Transmission System Operators for Electricity) network. In addition, the government supported the construction of the Iasi-Ungheni-Chisinau gas pipeline. Due to the excessively high growth of energy prices and the continued

implementation of the Third Energy Package, the implementation of these projects has not yielded tangible results. More effective strategies are needed that are aimed not at mitigating the consequences, but at their cause.

The growth of energy prices has a negative impact on both the development of trade and the economy, and on the well-being of the population. Firstly, the cost of energy resources is included in the price of goods and services, which reduces their competitiveness. Secondly, it leads to a decline in production and an increase in the number of unemployed, which negatively affects the level of income of the population and, accordingly, the quality of life. Thirdly, the share of energy expenditure in the total volume of consumer spending increases (above 10%), which indicates both energy poverty and a decrease in the quality of life of the population.

Conclusions and prospects for further research. The causal relationship between energy vulnerability and the quality of life of the population was identified in this study. Moldova's dependence on energy imports was aggravated by external shocks and eventually transformed, due to price shocks, into energy poverty for a larger number of households. The growing burden of increased energy costs prompted households to reconsider their expenditure items and reduce the share of expenses on clothing, footwear, and quality food products, which will inevitably affect health and quality of life.

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