THE ROLE OF DIGITALIZATION IN ENERGY VULNERABILITY ASSESSMENT IN MOLDOVA

Tatiana GUTIUM,
PhD in Economics, Associate Professor,
National Institute for Economic Research,
Academy of Economic Studies of Moldova,
Email: gutium.tatiana@ase.md

Abstract: Moldova's economy and population have been subjected to a series of economic, social, and political shocks. Energy shocks had the most severe economic consequences on the population. So, assessing the energy vulnerability of the population becomes a relevant research topic. The paper examines the energy vulnerability and energy poverty of Moldova's population and aims to identify the most vulnerable groups. This study uses a data-driven approach and open datasets to analyze public policies to support the population. The results of this study allowed us to identify the most vulnerable groups of the population from Moldova. This study demonstrated the need to implement digital analytical tools for monitoring the effectiveness of social and energy policies.

Keywords: *energy vulnerability, digital economy, data-driven analysis, living standards, household welfare.*

Introduction

In today's world, no area is untouched by digitalization. The influence of data in management decision-making has increased across all sectors of the national economy (Gojaeva et al., 2024, April), including in the implementation of socially oriented policies to support the population. Moldova imports all types of energy resources. The share of green energy is insignificant (Balan, 2024). Under these circumstances, especially amid the energy crisis and high inflation, the population in Moldova became more energy-vulnerable, and most households are in energy poverty (Gutium, 2019, October). Energy vulnerability directly affects both the population's standard of living and the stability of economic development.

The government annually updates the algorithm used to calculate households' vulnerability categories to help them pay their electricity, heating, and natural gas bills. The amount of state assistance depends on the household's vulnerability category. To improve the process of assessing citizens' vulnerability, reduce errors, and eliminate abuse and corruption, the government is using digital technologies.

If the state had not provided assistance to energy-vulnerable populations, the share of energy poverty households could have reached 83.5% in the first heating season after the onset of the energy crisis (2021–2022) (United Nations Development Programme, 2025). Previous studies have shown that, despite state assistance, one in three Moldovan citizens has fallen below the absolute poverty line in 2024 (Balan & Gutium, 2025). This was driven by high inflation and declining real incomes, which ultimately led to lower household well-being and increased household energy poverty (Gutium, 2021). The aim of this study is to identify the most energetically vulnerable groups. This paper analyzes the methodology used in Moldova to clas-

sify households' vulnerability in 2022–2025.

Conceptual foundations and categories of energy vulnerability of households in the digital age

Energy vulnerability can be calculated for individuals, households, and countries. A. Gatto and F. Busato argue that "energy vulnerability reflects a country's exposure to adverse energy shocks, such as supply disruptions and price volatility." Key factors denoting a country's energy vulnerability include dependence on a single energy source, heavy reliance on imports, or a large share of energy-intensive industries in the national economy. To assess this vulnerability category, the Global Energy Vulnerability Index (GEVI) is used, which comprises the following variables: energy intensity of Gross Domestic Product (GDP), energy import dependency, energy-related emissions relative to Total Primary Energy Supply (TPES), electricity supply vulnerability, and non-diversity of transport fuels (Gatto & Busato, 2020).

D. Guarascio, J. Reljic, and F. Zezza have systematized the opinions of scientists on this topic published in 2010-2023, and proposed an algorithm for calculating the Energy Vulnerability and Resilience Index, which consists of 25 indicators grouped into the following five dimensions: energy availability, energy affordability, technological efficiency, energy intensity, and environmental sustainability (Guarascio et al., 2024).

Household energy poverty is defined as a situation in which a household's energy expenditure exceeds 10% of its total consumption. Household energy vulnerability is defined as either a lack of physical access to energy sources or a lack of financial access, i.e., the inability to afford and secure sufficient energy, including for heating.

Energy vulnerability indices consist of pillars, and each pillar comprises indicators with their own weights. These weights can be derived using statistical methods, depending on the importance of the components. The number of energy vulnerability categories may vary not only by country but also by year of application. In Moldova, during the 2022-2023 heating season, there were four vulnerability categories (plus the "non-vulnerable" group). The category is determined according to the household's ratio (Table 1). The household's ratio is calculated as the ratio between expenditure on consumed energy resources and disposable income.

Table 1

Classification of the category of vulnerability (heating season 2022-2023)

Category of vulnerability	Household's ratio
Very high vulnerability (category 4)	Ratio ≥ 0.90
High vulnerability (category 3)	$0.35 \leq$ Ratio < 0.90
Medium vulnerability (category 2)	$0.20 \leq$ Ratio < 0.35
Low vulnerability (category 1)	Ratio < 0.20
No vulnerability (category 0)	Those who don't wish to receive compensation

Source: Systematized information (United Nations Development Programme, 2024).

The Moldovan government has used digital technologies to determine household vulnerability categories. The Energy Vulnerability Information System (EVIS) was launched on October 12, 2022, and is accessible to citizens through the portal compensatii.gov.md.

For the next heating season 2023-2024, the number of energy vulnerability categories has increased to seven (Table 2). This change was made to provide greater compensation to the most vulnerable households. Other innovations in the EVIS system include the introduction of energy compensation in the form of a cash payment and a new module, "Eco-Voucher." This module allows for monitoring the implementation of subsidized projects for effective energy consumption and the application of renewable energy sources.

Table 2

Classification of the category of vulnerability (heating season 2023-2024)

Category of vulnerability	Household's ratio
Extreme vulnerability	TMHI < 60% of MCB
Very high vulnerability	60% of MCB ≤ TMHI < 100% of MCB
High vulnerability	Ratio ≥ 0.40
Medium vulnerability	0.20 ≤ Ratio < 0.40
Low vulnerability	0.10 ≤ Ratio < 0.20
Primary vulnerability	0.05 ≤ Ratio < 0.10
No vulnerability	Ratio < 0.05

Note: TMHI – Total Monthly Household Income;
MCB – Minimum Consumption Basket.
Source: Systematized information (Ministry of Labor and Social Protection, 2023).

Analysis of the effectiveness of the Energy Vulnerability Reduction Fund: the impact of compensation on different population groups

The Energy Vulnerability Reduction Fund (EVRF) was established by the Moldovan government and officially became operational on September 1, 2022. Its central purpose is to reduce energy poverty (Table 3).

Table 3

Energy poverty rate by population groups, according regarding scenarios without/with compensation, %

Population group	Scenarios without compensation	Scenarios with compensation
Heating season 2022-2023		
Residents of small towns	99.6	93.7
Residents of large cities	94.3	79.8
Rural residents	98.7	91.5
Heating season 2023-2024		
Residents of small towns	98.5	92.0
Residents of large cities	91.9	69.9
Rural residents	98.7	90.7
Heating season 2024-2025		
Residents of small towns	98.1	88.6
Residents of large cities	92.5	65.4
Rural residents	100.0	91.6

Source: Systematized data (United Nations Development Programme, 2025).

The data in Table 3 show that in large cities (Chisinau, Balti), access to compensation for households with centralized heating reduced the level of energy poverty from 92.5% to 65.4% in the 2024-2025 heating season. However, in rural areas, where households often use solid fuels (wood, coal), the energy poverty rate remains extremely high (over 90% even after receiving compensation). This demonstrates the need for measures to improve building energy efficiency.

An analysis of the impact of compensation on energy poverty and the well-being of the population showed that during the 2022–2023 heating season, the activities of the Energy Vulnerability Reduction Fund led to a considerable drop in energy poverty among Category 1 households with low vulnerability (from 98.4% to 70.8%) (Table 4). The smallest reduction in

energy poverty was recorded among households with high vulnerability (from 99.5% to 94.8%).

Table 4

Energy poverty rate of vulnerability categories by population, according regarding scenarios without/with compensation (heating season 2022-2023), %

Vulnerability categories of the population	Scenarios without compensation	Scenarios with compensation
Very high vulnerability (category 4)	99.9	93.4
High vulnerability (category 3)	99.5	94.8
Medium vulnerability (category 2)	99.0*	85.9
Low vulnerability (category 1)	98.4	70.8
No vulnerability (category 0)	43.4	43.4

Note: * Figure revised by the author.
Source: Systematized data (United Nations Development Programme, 2025).

Despite the increase in the number of household vulnerability categories, a significant decrease in energy poverty was again recorded for households in Category 1 (Primary Vulnerability) during the 2023–2024 heating season (from 92.3% to 55.3%), while the slightest decrease was recorded for households with a high vulnerability level (from 98.9% to 94.7%) (Table 5). However, energy poverty among households with an extreme level of energy vulnerability decreased by 17.2 percentage points. Thus, the new methodology is more socially equitable.

Table 5

Energy poverty rate of vulnerability categories by population, according regarding scenarios without/with compensation (heating season 2023-2024), %

Vulnerability categories of the population	Scenarios without compensation	Scenarios with compensation
Extreme vulnerability	100.0	82.8
Very high vulnerability	99.7	88.5
High vulnerability	98.9	94.7
Medium vulnerability	97.7	82.6
Low vulnerability	93.8	76.7
Primary vulnerability	92.3	55.3
No vulnerability	24.5	24.5

Source: Systematized data (United Nations Development Programme, 2025).

Energy poverty dynamics following the implementation of the Energy Vulnerability Reduction Fund

In 2024, compared to 2020, energy poverty increased in urban areas for all population groups, except the richest (income quintile 5) (Figure 1). Thus, the energy crisis severely affected the well-being of the population, and the implementation of the Energy Vulnerability Reduction Fund only mitigated its impact.

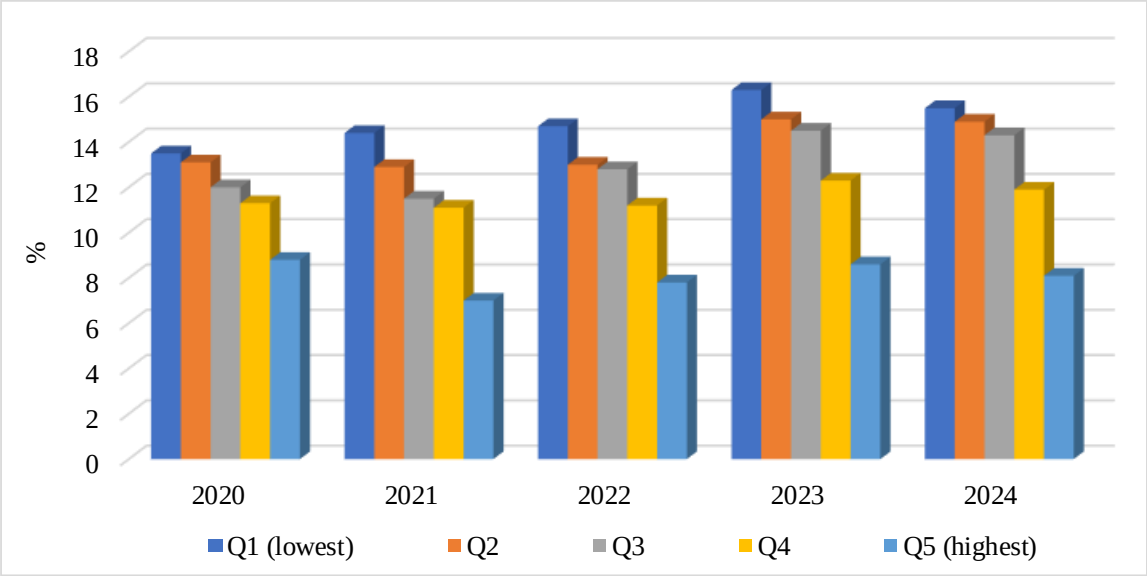

Figure 1. Share of energy expenditure in total consumption expenditure by income quintile in urban areas

Source: Author's estimation using statistical data (NBSRM, n.d.).

In rural areas, energy poverty among households from all five income quintiles increased during the analyzed period (Figure 2).

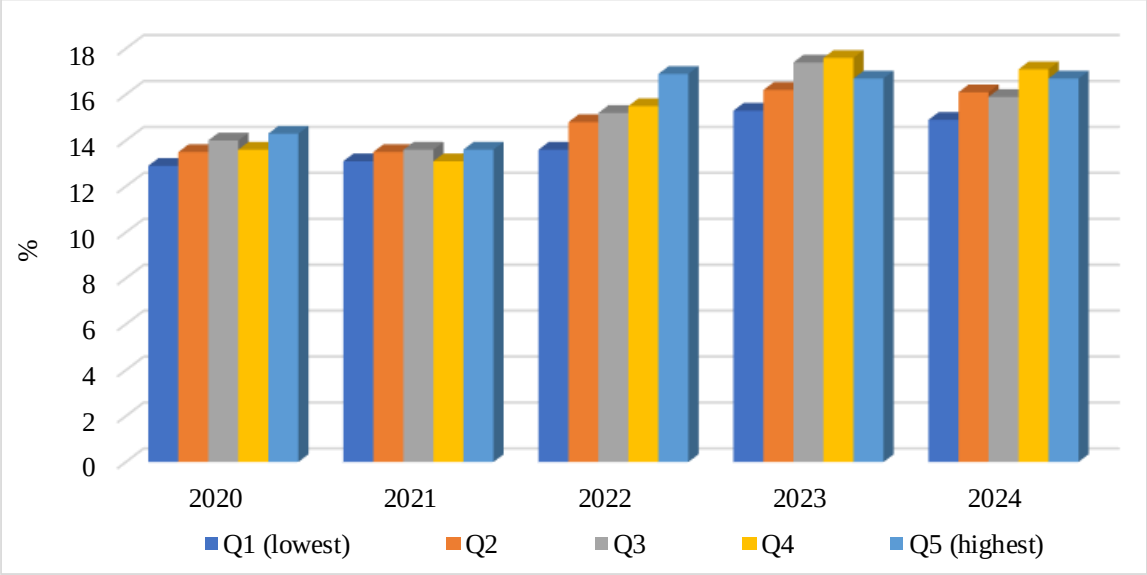

Figure 2. Share of energy expenditure in total consumption expenditure by income quintile in rural areas

Source: Author's estimation using statistical data (NBSRM, n.d.).

Improvements of the EVIS system in 2023 resulted in a slight reduction in energy poverty among urban households headed by individuals with primary or less education (Figure 3). Although this indicator increased slightly for households headed by individuals with higher education, these households remain the only ones not in energy poverty.

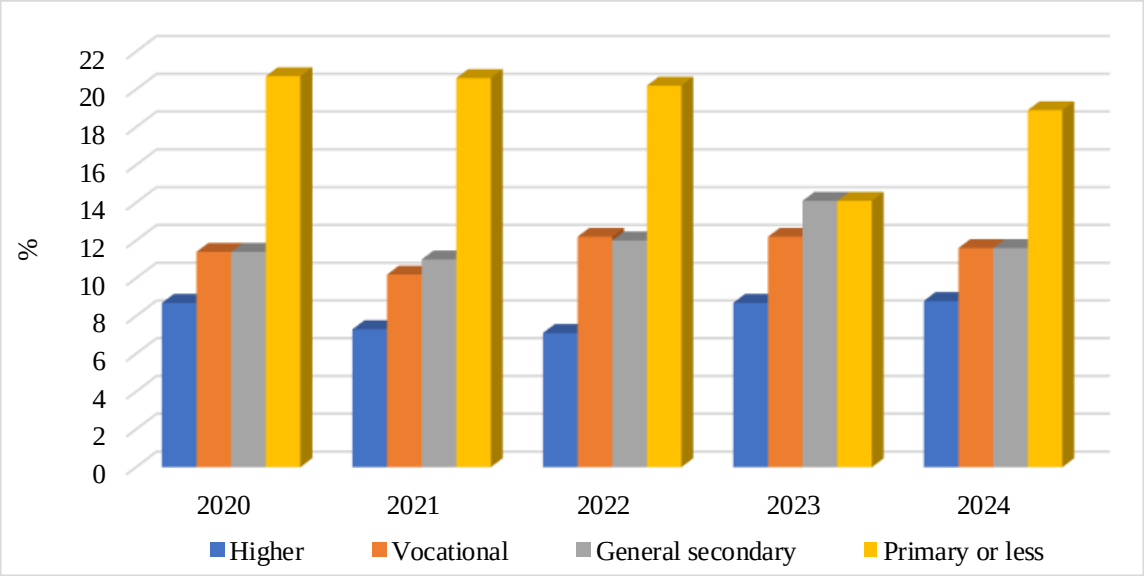

Figure 3. Share of energy expenditure in total consumption expenditure by the education level of the household head in urban areas

Source: Author's estimation using statistical data (NBSRM, n.d.).

An analysis of household energy poverty by the education level of the household head in rural areas showed that poverty increased across all household categories in 2024 compared to 2020 (Figure 4).

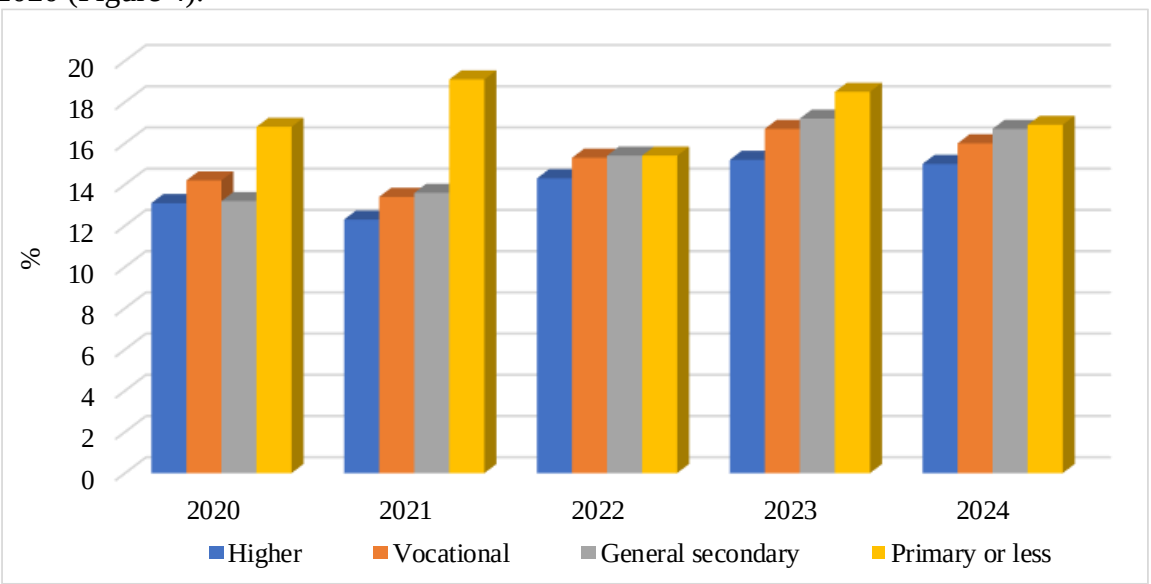

Figure 4. Share of energy expenditure in total consumption expenditure by the education level of the household head in rural areas

Source: Author's estimation using statistical data (NBSRM, n.d.).

A comparative study of household energy poverty by the age of the household head revealed that households headed by individuals aged 65 and over had the highest share of energy expenditure in total consumption expenditure (Figure 5). Thus, pensioners are the most energy poverty.

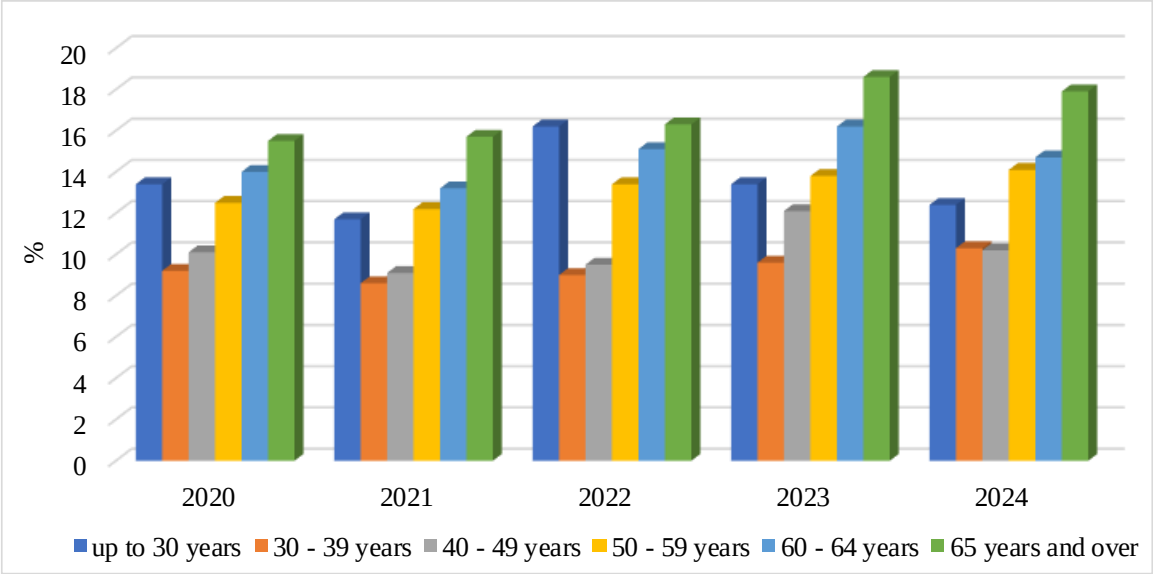

Figure 5. Share of energy expenditure in total consumption expenditure by the aged of the household head

Source: Author's estimation using statistical data (NBSRM, n.d.).

Conclusions

The implementation of the Energy Vulnerability Information System and the Energy Vulnerability Reduction Fund helped reduce the impact of the energy crisis and high inflation on household energy vulnerability in Moldova. However, these measures failed to greatly decrease the number of households in energy poverty, particularly in rural areas. The most energy-poverty groups are rural households, households from the following income quintiles: Q1, Q2, and Q3, households headed by individuals with primary or less education, and households headed by individuals aged 65 and over.

Acknowledgments

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