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ENERGY SECURITY AND ECONOMIC RESILIENCE OF RA IN THE CONTEXT OF CURRENT GEOPOLITICAL DEVELOPMENTS

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Abstract: This article analyzes the current manifestations of Armenia's energy security and economic resilience in the context of recent geopolitical changes. It assesses the current state of Armenia's energy security and economic resilience based on key indicators used in international policy and well-supported in the academic literature. The analysis shows that the adopted indicators - such as energy intensity, external energy dependence, and measures of supplier concentration - have methodological limitations and do not fully reflect the country's structural and geopolitical specificities. The main goal of this study is to examine the limitations and gaps of commonly used energy security indicators in the context of Armenia's green transition policies and current geopolitical developments. By analyzing various indicators of energy security and economic resilience and contextualizing them for the Armenian economy, a multi-component qualitative assessment has been investigated, showing that these indicators alone do not provide a comprehensive picture and do not fully reflect the country's structural and geopolitical characteristics. Energy policy can be more effective and targeted when informed by clear and integrated assessments of these factors. Such an approach is essential to support Armenia's long-term energy security and economic resilience.

Key words: Energy security; Economic resilience; Geopolitical risks; Energy intensity, Primary energy supply; Energy market.

Introduction

Modern energy systems are shaped by geopolitical uncontrollable risks, global energy transitions, and structural vulnerabilities, which most acutely affect small and import-dependent states. Armenia's energy profile is particularly risky: energy security and economic resilience are jointly determined by limited domestic resources, high import dependence, geopolitical shocks, and dependence on infrastructure pathways. As defined in the Energy Security Concept of the Republic of Armenia (2007), energy security is understood as a set of measures ensuring reliable, high-quality, and affordable energy supply under normal, emergency, and wartime conditions. Despite the increasing use of quantitative indicators such as energy intensity, diversification indices, external dependency ratios, and supplier concentration metrics, these tools often fail to capture the multidimensional risks that characterize Armenia's position in the regional energy profile. In this context, Armenia's strategic energy priority is to ensure that energy is affordable,

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reliable, and clean—a triad that is easy to achieve individually but extremely difficult to balance simultaneously in practice. Recent geopolitical shifts, including disruptions to traditional trade routes, instability in the broader post-Soviet energy space, and the acceleration of the global transition to low-carbon systems, have further exacerbated the need for an integrated assessment of Armenia's energy vulnerabilities. At the same time, existing policy analyses rely heavily on standardized international indicators, which, while methodologically sound, only partially capture the real picture on the ground.

Following Lefevre (2010), the distinction between reliability (a physical criterion) and affordability (an economic criterion) is crucial for understanding Armenia's constraints, as the interaction of these two pillars is particularly visible in small, import-dependent energy systems. In this context, the current study addresses three interrelated questions:

- ✓ To what extent do traditional energy security indicators reflect Armenia's real structural and geopolitical vulnerabilities?
- ✓ How are energy security constraints reflected in broader outcomes of economic resilience for a small, landlocked, and import-dependent state?
- ✓ What analytical framework can best capture the multifaceted risks facing Armenia's energy system in a rapidly changing regional environment?

To answer these questions, the article combines approaches from the energy security literature, economic vulnerability analysis, and regional geopolitical studies, allowing for a more holistic assessment that goes beyond the limitations of indicator-based assessments. As a result, the study places Armenia's energy security challenges in a broader strategic context, emphasizing the need to understand not only quantitative criteria but also the structural, institutional, and geopolitical development dynamics that shape long-term resilience.

Research methodology and information bases

In this study, a qualitative and analytical approach is employed to examine Armenia's energy security and resilience. The methodology focuses on conceptual analysis of the trade-offs between energy affordability, reliability, and sustainability, considering geopolitical and structural shocks. The analysis focuses on identifying limitations and gaps in widely used energy security indicators in the context of green transition policies and current geopolitical developments. Combining a wide range of academic literature and scientific research on energy security, as well as insights gained from economic vulnerability studies and regional geopolitical assessments, it presents which aspects of Armenia's energy system are not sufficiently reflected by standard quantitative criteria. The information base includes both quantitative and qualitative sources, including: (i) International organizations: World Bank, IEA, EBRD; (ii) National sources: Statistical Committee of the Republic of Armenia, Public Services Regulatory Commission, Ministry of Territorial Administration and Infrastructure; (iii) Academic and professional literature on energy security and economic resilience. This approach allows for a systematic identification of the gaps and methodological limitations of conventional indicators, forming the basis for a more comprehensive understanding of Armenia's real energy security and economic resilience profile.

1. Foundations of Energy Security: Armenia

Armenia's current strategic priority is to ensure that its energy system is affordable, reliable, and clean. While separate mechanisms can and are being developed to address each of these pillars separately, implementing all three simultaneously is a complex challenge in all economies, and is particularly sensitive and problematic in a small, open, and geopolitically vulnerable country like Armenia. Reliability refers to the physical availability of energy that ensures the smooth and consistent operation of supply systems. Availability takes into account economic factors, making energy affordable for both businesses and households.

Reliability: electricity is not reliable if the mechanisms for delivering it to the consumer are not functioning smoothly. Reliable electricity is not always available to householders.

Availability: availability is an economic concept. Energy can be available, but so expensive that the business refuses or limits its use. From the perspective of the end consumer, it does not matter whether the energy is unavailable or not affordable, since in both cases it is not used by the latter.

In Armenia, the two aforementioned issues are often interrelated, especially in rural or border communities, where electricity supply may be interrupted due to wear and tear on distribution networks (a reliability issue), and in some remote areas, it may not be available due to low-income levels (an accessibility issue). Of course, reliability can be improved by adding new transmission lines, reserve capacity, or new fossil/hydro power plants, but these are additional costs, which, if not implemented under direct state control, can make energy more expensive and, therefore, further reduce affordability.

Clean energy: clean energy emphasizes environmental sustainability and the long-term economic resilience of the system. Together, these three pillars form the foundation of Armenia's energy security, guiding both policy and investment decisions in the context of regional and global challenges. The World Bank highlights that without prioritizing climate action, Armenia's energy security and economic resilience could face significant long-term risks, emphasizing the need for investments in sustainable energy infrastructure and adaptive policies (World Bank, 2024).

These three pillars of energy security - affordability, reliability, and clean energy - characterize Armenia's energy profile, the system of internationally acceptable indicators of which and their limitations will be discussed below. According to the government of the Republic of Armenia (2021), the Strategic Program for the Development of the Energy Sector up to 2040, Armenia seeks to develop "a free, competitive, non-discriminatory, inclusive, and diversified energy system with a high level of energy independence" (Government of RA, 2021).

2. Economic Resilience: Concept

Economic resilience is the ability of an economy to absorb, recover from, and adapt to external shocks, such as geopolitical tensions or market volatility (Tsiotas, 2022; Mirjalili, 2025). In small, open and import-dependent economies like Armenia, resilience is deeply intertwined with energy security. Energy supply disruptions disproportionately and tangibly damage economic performance, affecting economic stability and social well-being. The scientific literature distinguishes three main types of economic resilience, including absorptive capacity (the ability to withstand shocks),

adaptive capacity (to adapt to systemic changes), and transformative capacity (the ability to structurally transform the economy) (OECD, 2020; Mirjalili, 2025; World Bank, 2023, 2024). There are many indices assessing economic resilience, but perhaps the most comprehensive is the FM Global Resilience Index, which combines economic, infrastructure, and risk management metrics to form a comprehensive picture of the comparative resilience of countries. Specifically, the index, which presents a score for 130 countries/territories, is based on 8 global "resilience factors" with both macro and physical risks, including energy intensity, political risk, climate risk, infrastructure risk, etc., which are the most important indicators of energy security. As a result, the index provides a comprehensive picture of a country's overall "resilience" that you can use as a sub-section of a comprehensive assessment of economic resilience and energy security. *The FM Global Resilience Index* assesses a country's overall resilience through three main pillars: Economic, Risk Quality, and Supply Chain. From the perspective of this research, the current scores in these pillars provide an important picture of how a country's economy and energy system respond to shocks and geopolitical risks. The FM Global Resilience Index (2025) is constructed from 18 factors (6 physical, 12 macro), standardized using z-scores and summed into a score of 0-100. All factors included in the index are directly or indirectly related to the energy system. Some of these factors (notably energy intensity, logistics, water stress, greenhouse gas emissions, and physical risk metrics such as climate impact and seismic risk) directly reflect different aspects of a country's energy system, but they do so at a level of aggregation that misses important structural details specific to Armenia (FM Global, 2025).

Table 1

Groups of Resilience Factors (FM Global Resilience Index)

Group	Factor	Energy Sector Linkage	Linkage
Physical (6)	Climate change impact	Energy production & consumption affected by climate events	Indirect
	Climate risk exposure	Extreme weather events can disrupt energy infrastructure	Direct
	Climate risk quality	Quality of adaptation measures for energy systems	Direct
	Cybersecurity	Protection of energy grids and critical infrastructure	Direct
	Fire risk quality	Wildfires affecting energy infrastructure	Direct
	Seismic risk exposure	Earthquakes damaging energy facilities	Direct
Macro (12)	Corruption control	Governance affects energy sector investments and reliability	Indirect
	Education	Skilled workforce for energy sector and efficiency improvements	Indirect
	Energy intensity	Direct measure of energy efficiency	Direct
	GHG emissions	Reflects energy mix and fossil fuel dependence	Direct
	Health expenditure	Energy access impacts public health (heating, cooling, hospitals)	Indirect

	Inflation	Energy price shocks contribute to inflation	Indirect
	Internet usage	Digitalization supports smart grids and energy management	Indirect
	Logistics	Energy supply chains depend on transport infrastructure	Direct
	Political risk	Geopolitical instability affects energy imports and security	Direct
	Productivity	Energy disruptions reduce economic output	Indirect
	Urbanization	Higher urban energy demand and infrastructure needs	Indirect
	Water stress	Hydropower generation and cooling of thermal plants	Direct

Source: *Compiled by the author based on the study's analysis.*

According to the data, over the past four years, significant shifts have been observed in several countries, including Armenia, which has declined by nine positions (Composite Rank (Score) - 85 (51)). According to the FM Global Resilience Index (2025), Armenia's energy intensity score is 65.4, placing the country 95th globally. This reflects structural challenges in energy efficiency and the need for policies enhancing energy use and economic resilience (FM Global, 2025). For understanding the mechanisms of influence of these pillars of economic resilience, the next section examines the main indicators, which used to assess energy security, highlighting both their observations and limitations.

3. Indicators of energy security: limitations of indicators

Energy security has traditionally been defined in terms of ensuring uninterrupted supply, accessibility, and infrastructure reliability (Yergin, 2006). However, recent developments have changed the criteria for security. Not only security of supply, but also diversification, sustainability, governance, and geopolitical resilience are considered important (Cherp & Jewell, 2014; Sovacool, 2013).

The system of energy security indicators commonly used in policymaking has serious limitations (Bohringer and Bortolamedi, 2015). These indicators focus primarily on supply-side factors, neglecting the demand side (Jansen and Siebregts, 2010; Gracceva and Zeniewski, 2014). Most importantly, these indicators are only indirect quantitative assessments and do not qualitatively and fully assess the vulnerability of the energy system to potential shocks (Cherp and Jewell, 2011).

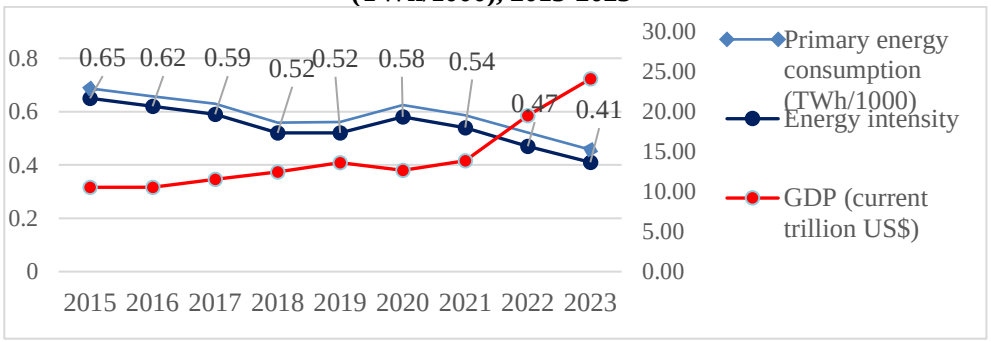
Four widely used indicators of energy security are the following (Bohringer and Bortolamedi, 2015):

1. ***Primary energy intensity*** - indicator is calculated as the ratio of a country's total primary energy consumption to its gross domestic product (GDP). Since primary energy use is a physical measure, this indicator only indicates reliability and does not reflect availability. So, the indicator has many limitations and in the context of Armenia, these limitations become especially visible:

1.1. It does not differentiate between more reliable and less reliable energy supplies. The indicator only assesses the reliable use of energy. But it does not distinguish whether energy is reliably available (available for use) or not: when the country consumes a lot of energy due to the development of energy-intensive sectors of the economy, but most of the energy used is imported, and energy access is vulnerable.

Figure 1

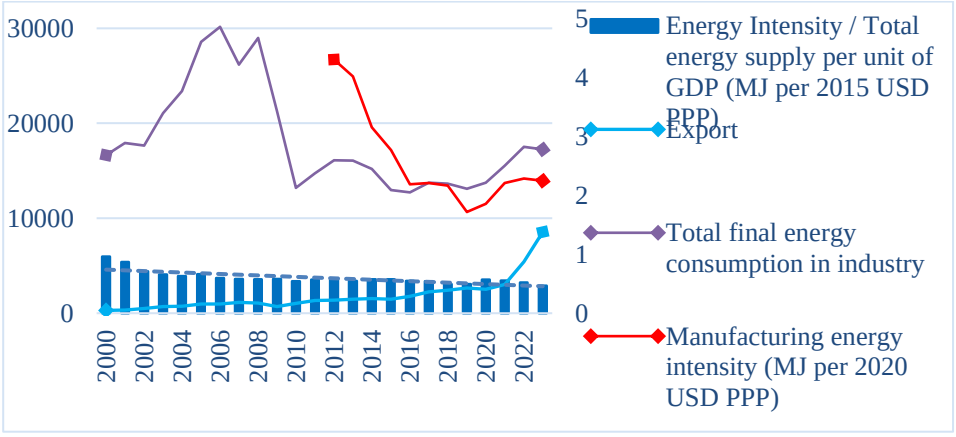
(i) Energy Intensity; (ii) Primary energy consumption; (iii) GDP (cur. trln USD) (TWh/1000), 2015-2023[1]



Source: *(ArmStat, SDG data, 2025;* Ritchie, Rosado, and Roser 2023*).*

Figure 2

(i) Trends in Armenia's energy indicators; (ii) Total energy intensity (MJ per 2015 USD PPP); (iii) Manufacturing energy intensity (MJ per 2020 USD PPP); (iv) Total final energy consumption in industry; (v) Export of goods, Armenia, 2000-2023[2;3]



Source:*https://www.iea.org/countries/armenia/efficiency-demand;*
https://armstat.am/en/?nid=12&id=10003;
ArmStat SDG data; https://sdg.armstat.am/7-3-1/. Seen 05.12.2025

[1] The Figure was compiled by the author based on ArmStat reports (SDG data; https://sdg.armstat.am/7-3-1/); Hannah Ritchie, Pablo Rosado, and Max Roser. 2023. "Energy." *Our World in Data*. Seen 05.12.2025. https://ourworldindata.org/energy.

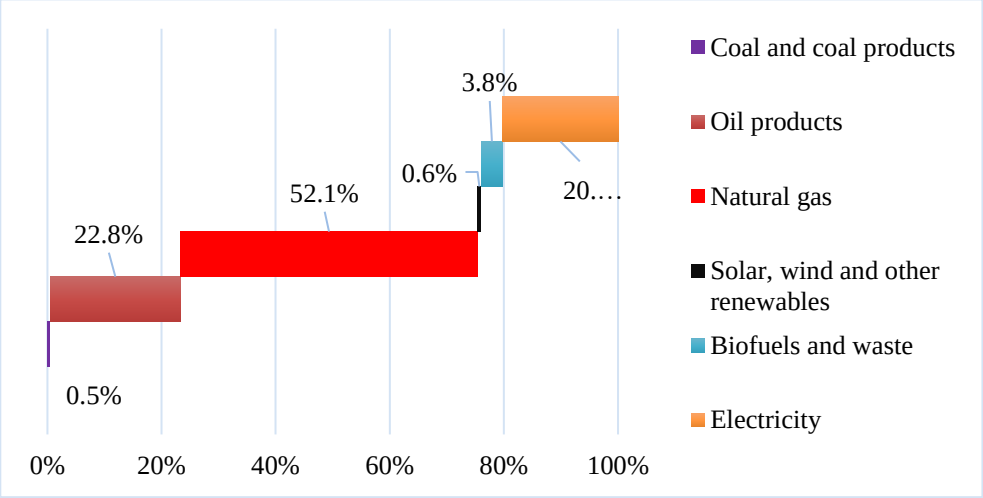
[2] Note: Although the GDP base years differ (2015 USD PPP for total energy supply per unit of GDP and 2020 USD PPP for manufacturing energy intensity), Figure 2 illustrates the comparative trends of overall and industrial energy intensity in Armenia, highlighting the role of the manufacturing sector in shaping the country's energy profile.

[3] All figures in this paper were created by the author using "IEA statistics".

Case of Armenia: Although Armenia uses significant amounts of primary energy relative to the size of its economy, and particularly in urban heating, transport and energy-intensive manufacturing, a significant portion of this energy is imported. In 2023, Armenia used about 2,889 MJ of energy per 1 USD (PPP) of GDP, showing a 51% decrease since 2000 (IEA, 2024). As a result, the indicator classifies Armenia as a country with high and stable energy use, implying a certain level of "reliability", even though the main supply is structurally vulnerable (we will address the issue of diversification in our further discussions). Since the indicator only reflects the volume of energy used, and not the terms on which it is supplied, it does not reflect the risks associated with Armenia's geographical and geopolitical location. In the case of dependence on a single import route and a dominant external supplier, energy may be widely used, but not necessarily reliably available. Thus, while improvements and high levels of the indicator may indicate high energy consumption (which could be mistakenly interpreted as sustainability), it does not reveal issues such as the fact that Armenia's energy access is subject to transit vulnerabilities, infrastructure constraints, and external political risks. This discrepancy highlights why using the primary energy use indicator alone is not sufficient to characterize the true energy security situation in Armenia.

Figure 3

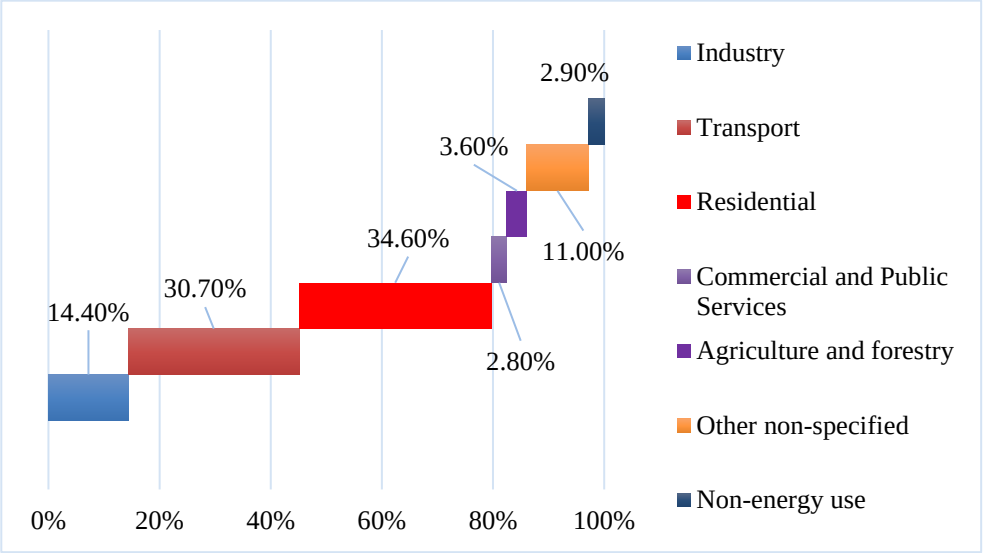
Total final consumption structure, Armenia, 2023



Source: *https://www.iea.org/countries/armenia/efficiency-demand. Seen 05.12.2025*

Figure 4

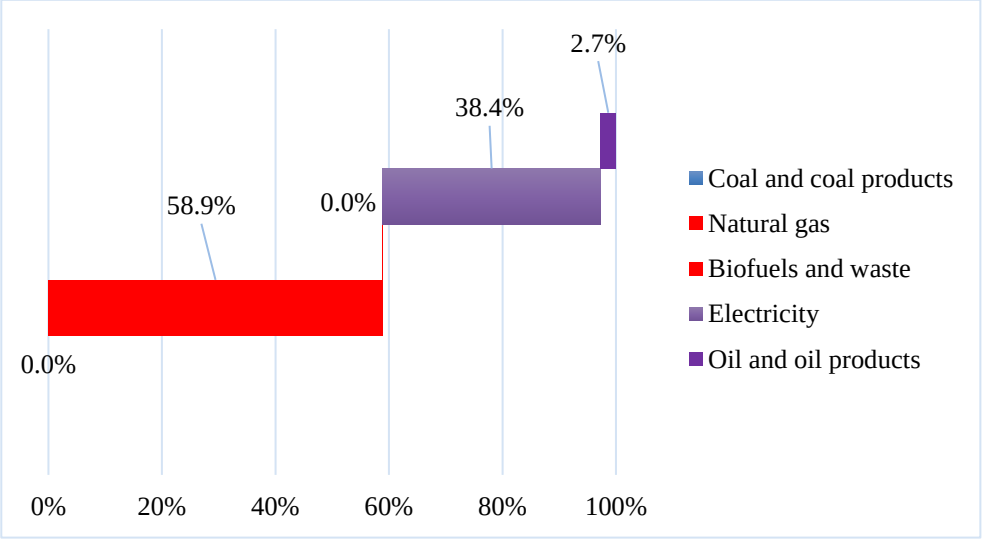
Total final energy consumption structure by sectors, Armenia, 2023.



Source: *https://www.iea.org/countries/armenia/efficiency-demand. Seen 05.12.2025*

Figure 5

Industry total final consumption by source, Armenia, 2023



Source: *https://www.iea.org/countries/armenia/efficiency-demand. Seen 05.12.2025*

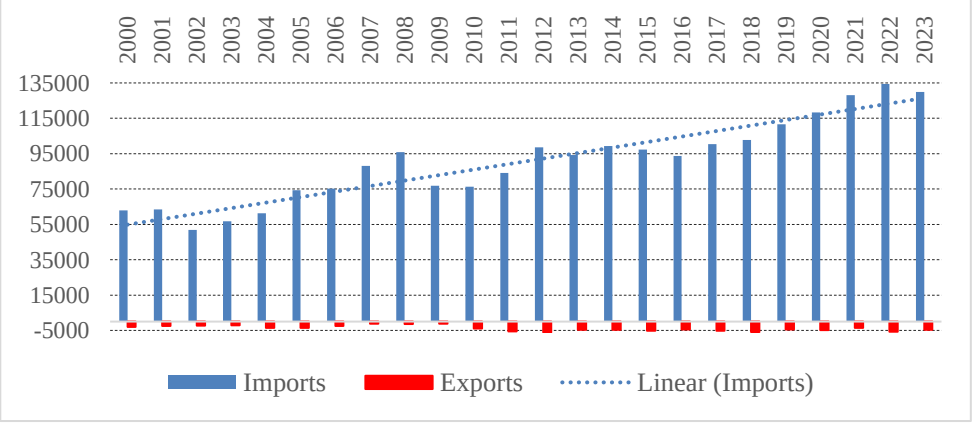
1.2. International energy trade is ignored. For example, exporting energy-intensive goods may appear to improve energy security, even if the imported goods come from countries with higher energy intensity. This means that if a country exports energy-

intensive products, it may appear to be more energy secure because it is "exporting" energy in exchange for GDP, but in reality, this energy is imported.

Case of Armenia: Armenia imports the majority of its primary energy, but some of this imported energy is later incorporated into exported goods and services. In such cases, the standard indicator may suggest that Armenia is creating economic value from domestic energy use, while in reality the energy underlying these exports is largely of foreign origin. In Armenia, heavy industry, mining, and some sectors of light industry consume significant amounts of imported fuel or electricity. When Armenia exports these products, the indicator may interpret this as an improvement in energy security, as the country's GDP grows, seemingly at the expense of the efficient use of its own energy resources. In reality, however, most of the energy used is imported, and exporting these products does not mean that energy security has been strengthened. However, the primary energy used in production is not produced domestically; it is imported, often from a single supplier or via a transit route. Of course, the indicator has improved significantly in recent years: between 2012 and 2023, an improvement of about 48% was recorded, but not because the country is purposefully implementing a targeted policy to increase energy efficiency in the sector, and the recorded reduction /see Figure 2/ was recorded only with the latest production technologies (IEA, 2022). This means that Armenia is essentially re-exporting the value of imported energy, without demonstrating independence or resilience in its own energy system. Moreover, since the indicator does not reflect the energy contained in imported intermediate goods, it ignores the fact that Armenia's export competitiveness in certain sectors may depend on external energy conditions. Any disruption in energy imports, whether due to geopolitical tensions, supply disruptions, or price volatility, would immediately lead to a reduction in export capacity, revealing a fragility that the indicator does not capture. Thus, ignoring international energy trade in the case of Armenia leads to a distorted perception: the country may appear to benefit from energy-based economic activity, but this activity is built on external energy dependence, not on domestic energy security.

Figure 6

Trade in energy, Armenia, 2000-2023



Source: *https://www.iea.org/countries/armenia/energy-mix. Seen 05.12.2025*

1.3. GDP is one of the first indicators of economic performance and is highly sensitive to external shocks. The use of GDP as a denominator in energy efficiency indicators necessitates additional interpretation of the estimates, which are particularly relevant in the case of Armenia. In small open economies. The Armenian economy is highly affected by developments occurring outside its borders, such as fluctuations in world prices, changes in trade corridors, and changes in regional geopolitical conditions. As a result, GDP has increased or decreased sharply even when domestic energy consumption has remained relatively stable. Conversely, GDP has decreased in response to geopolitical tensions, war situations, and global economic shocks, even when the energy needed to maintain essential services has remained unchanged. As a result of these independent developments, Armenia's energy intensity may appear to have improved or deteriorated purely due to macroeconomic fluctuations, rather than changes in energy efficiency or security.

Case of Armenia: Armenia's GDP is highly sensitive to external factors, including global prices (oil, gas, metals), regional logistical constraints, import/export structure, as well as war or geopolitical changes. We have contradictory developments; for example, in 2020, due to the war and COVID, the country's energy consumption almost did not decrease in the face of a sharp decline in GDP. But in 2022–23 the sharp growth in GDP was due especially to emigration flows from Russia, the expansion of the IT sector, and the export of services—not energy-related changes, but in 2023 a decline in electricity consumption was recorded, which distorts the real change in the indicator, especially if it coincides with high GDP growth.

1.4. Exchange rate - Artificial exchange rate fluctuations, which are largely underived and unrelated to structural economic indicators, change the value of the energy efficiency indicator. It is clear that a stronger dram artificially increases GDP (in US dollars), which "makes Armenia more energy efficient." A weaker dram has the opposite effect, although actual energy consumption trends may not change. Thus, international comparisons of Armenia's energy efficiency can be misleading when they are based on GDP at market exchange rates.

Case of Armenia: In Armenia, fluctuations in the national currency, the Armenian dram (AMD), significantly distort energy efficiency indicators when GDP is expressed in US dollars. Exchange rates of small economies are extremely sensitive to external factors. This was the case both during the war months of 2020 and in 2022, when the dram temporarily depreciated against the dollar due to macroeconomic factors occurring against the backdrop of the Russia-Ukraine conflict. As a result, the energy efficiency indicator calculated in US dollars decreased, creating the illusion that Armenia has become more energy efficient, while the structure of energy consumption and import dependence have not changed significantly.

1.5. Informal economic activity - Another important issue not fully captured by this indicator is that although ArmStat estimates non-observed (informal) economic activity following the UN SNA methodology, GDP still does not fully reflect informal economic activity, which remains significant in Armenia despite government efforts to reduce it (ArmStat, Non-observed economy methodology). ***Case of Armenia:*** some sectors, notably agriculture, construction, and small-scale manufacturing, include informal components that consume energy but are not fully reflected in GDP. Informal economic activity in Armenia, estimated at 22% of official GDP (in 2022). This means that

Armenia's actual energy intensity is underestimated, as the numerator (energy consumption) is fully visible, while the denominator (real economic output) is partially missing.

Thus, GDP constraints in Armenia significantly distort the true picture of the primary energy intensity indicator. International energy trade, artificial exchange rate fluctuations, GDP sensitivity to external shocks, and the presence of informal economic activity affect the accuracy of this indicator. As a result, changes in Armenia's energy intensity indicator are often driven by macroeconomic factors rather than by real improvements in energy efficiency or security.

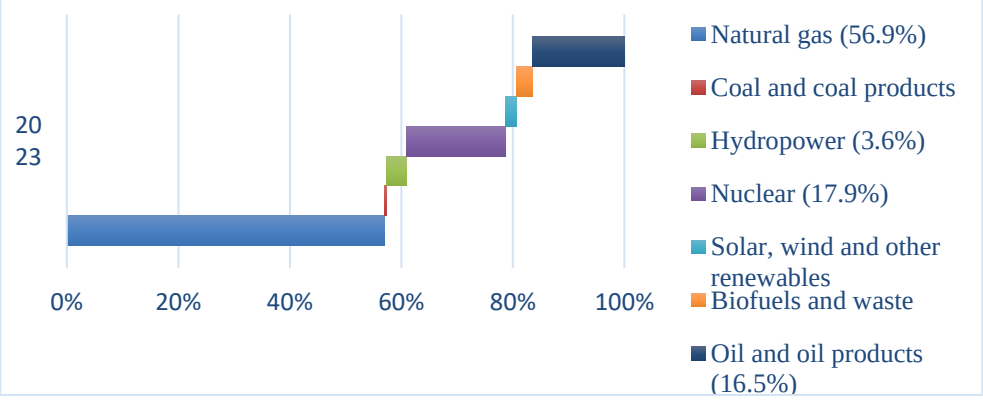
2. ***Dependence on foreign primary energy supply,*** defined as the ratio between the sum of net imports (or zero for net exporters) (for all fuels) and total primary energy use (Le Coq and Paltseva, 2009). The external energy dependence indicator is also not free from limitations in its use. In particular, it does not distinguish between more and less reliable suppliers.

2.1. All foreign suppliers are considered equally risky, while all domestic suppliers are considered non-risky.

Case of Armenia: In Armenia, only 23 % of primary energy demand was met with domestic production. Between 2000 and 2023, the share of natural gas in the total energy supply increased reaching 56.9%, while the share of supply from nuclear energy decreased reaching 17.9% in 2023 (IEA, 2024). The indicator considers all imports to be equally risky. In reality, Russian gas imports are regulated by long-term contracts and are relatively reliable. Oil imports from Iran are more sensitive to geopolitical risks and sanctions. The indicator does not reflect these differences in reliability. Thus, although this is considered "external dependence", the reliability of this supply depends on long-term contracts, transit stability, and regional geopolitics, which the indicator does not capture.

Figure 7

Total energy supply, Armenia, 2023



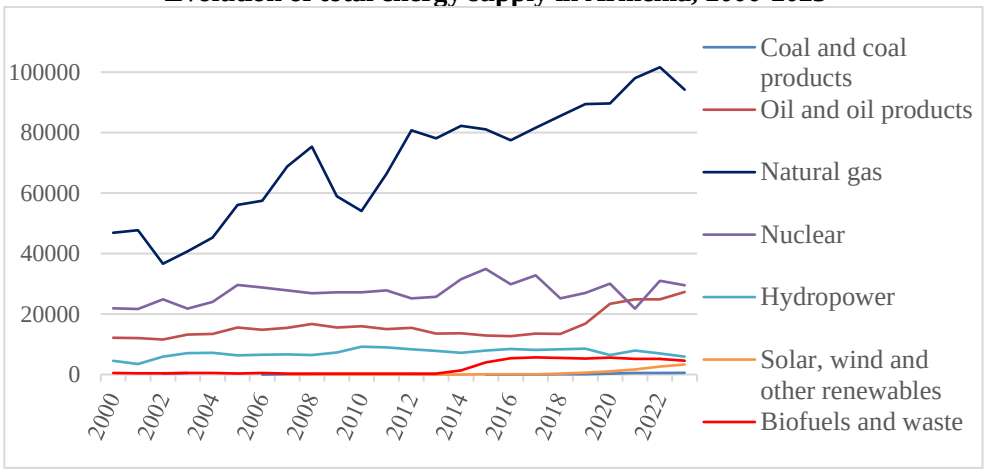
Source: *https://www.iea.org/countries/armenia/energy-mix. Seen 05.12.2025*

2.2. There is also no distinction between fuel types. Different fuels serve different purposes in the economy (electricity generation, heating, transport), and disruptions in one may be more important than in another.

Case of Armenia: The vast majority of energy used in Armenia is gas consumption. The country's economy is heavily dependent on imported natural gas for heating residential buildings and domestic services. In contrast, imports of liquid fuels (diesel/petrol) are less important from the perspective of immediate energy security. The indicator thus does not allow for the assessment of these differences.

Figure 8

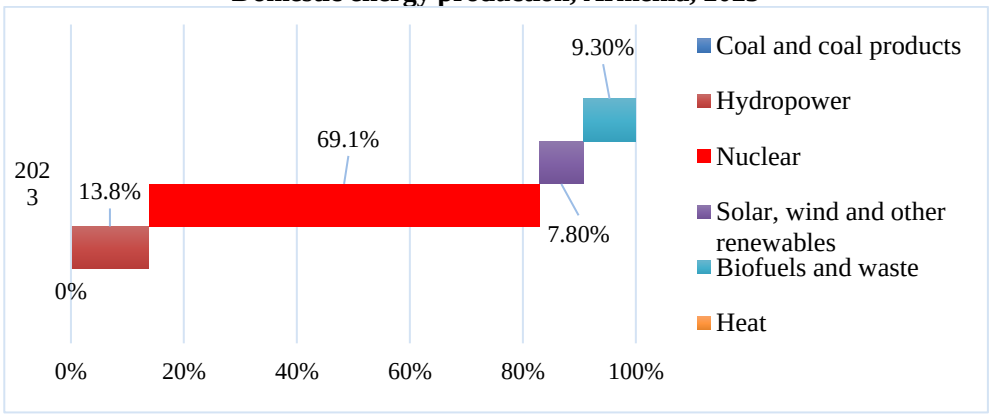
Evolution of total energy supply in Armenia, 2000-2023



Source: *https://www.iea.org/countries/armenia/energy-mix. Seen 05.12.2025*

Figure 9

Domestic energy production, Armenia, 2023



Source: *https://www.iea.org/countries/armenia/energy-mix. Seen 05.12.2025*

2.3. ***Domestic diversification*** and strategic reserve issues are also ignored. Even if a country imports most of its energy, it may have diversified sources or strategic storage that reduce external risks.

Case of Armenia: In Armenia's case, the nuclear power plant and the increasing volume of renewable energy have partially mitigated the risks of external dependence, but this is also beyond the scope of the indicator. Armenia's Metsamor Nuclear Power

Plant generates approximately 35% of the country's electricity. Armenia also has significant hydroelectric capacity (18-20% of electricity in 2023-2024), and solar and wind power are also expanding year by year. The RA State Strategy aims to increase the share of solar energy generation in the total to at least 15% or 1.8 billion kWh by 2030. These developments provide a buffer against external shocks, reducing dependence on imported fuel.

3. An indicator of primary energy supply concentration, also known as the Herfindahl-Hirschman index, is the sum of the squares of fuel market shares (Bhattacharyya, 2011).

3.1. The indicator does not reflect the true reliability of energy supply, nor does it take into account the strategic importance of different fuels.

Case of Armenia: In Armenia, both in the case of natural gas, gasoline and oil products, we have a problem of supplier concentration and fuel concentration. This situation means that the HHI of energy supply is very high, since the market is physically concentrated on a few fuels and a few suppliers. However, the problem here depends not only on the type of fuel, but also on the reliability of supply. In Armenia, the concentration of energy supply is high, mainly from a few external sources, which indicates high concentration according to the HHI calculation. However, the real danger is also due to the fact that these fuels are not easily interchangeable, and the reliability of supply is not always reflected in the concentration indicator.

4. An indicator of concentration of foreign primary energy supply, known as ***the Herfindahl-Hirschmann index***, for net energy imports, where concentration is measured either based on the number of foreign suppliers or on the number of foreign suppliers and fuels (Frondel and Schmidt, 2014).

4.1. Once again, the indicator does not reflect the reliability of imports. It is also important whether another third country is involved in the purchase process, which solves the transit logistics problem. A country can buy oil from multiple suppliers, but if it is imported through the same third-party country, this will not protect the importer from a possible shock.

Case of Armenia: In the case of Armenia, the concentration of foreign energy supply is high not only due to reliance on a few suppliers, but also because imports pass through a limited number of transit countries (via Georgia). Armenia has a very high HHI because the vast majority of its imported energy comes from a single source (Russia), and even the energy it produces itself (e.g., nuclear) depends on imported fuel. Even if multiple suppliers exist, dependence on the same transit routes creates significant risk, which is not captured by conventional concentration indices.

In the academic literature on energy security, one can find more than 80 different definitions and numerous indicators, none of which fully characterize the situation in the country (Ang et al., 2015). Energy is not reliable if the energy supply source is temporarily or permanently (i) unavailable or (ii) unavailable and cannot be replaced in a short time. Energy reliability is difficult to measure precisely, as it is a probability assessment process. In turn, energy availability is predictable to the extent of incomes and energy prices. Is the price acceptable to the end user?

The fact that the unreliability of electricity negatively affects both companies (Elliott et al., 2021; Chen et al., 2022), households (Meles, 2020; Bajo-Buenestado, 2021; Aweke and Navrud, 2022), as well as the entire economy (Carranza and Meeks, 2021)

has been presented in numerous studies. Moreover, the negative impact generates new impacts in a chain. Unreliable electricity leads to the interruption of production and daily life, which in turn increases other costs, leading to an increase in the price of goods, in turn giving a new negative impulse to the economy. Thus, an unreliable energy supply has a negative impact on the economy in the short term and on economic development in the long term. High energy access, in turn, has a largely positive impact on economic, social and environmental outcomes for all levels of development, both in the short and long term (Ayana and Degaga, 2022; Bo et al., 2022).

All of the above mechanisms, the purpose of which is to improve the level of energy security, in particular increasing reliability, require large-scale and carefully calculated investments.

Energy access, which is the next important pillar of energy security, is closely linked to social problems, uneven territorial development, and income inequality in Armenia. A state support program can temporarily improve energy access, especially in poor and border communities.

4. Green Economy Transition Challenges and Energy Security Risks

The issue of energy security has long ceased to be a two-dimensional one. It is a three-dimensional one, requiring the provision of reliable, affordable and "clean" energy. Reliability and affordability together constitute energy security in the short term. The pursuit of cleaner energy affects long-term reliability and affordability. In Armenia, the energy sector is the primary source of greenhouse gas (GHG) emissions, accounting for 70% of total emissions (EBRD, 2024). Of course, replacing fossil fuels with renewable energy will provide a more "reliable energy supply" in the long term. Here, reliability takes a different form. In addition to affecting the reliability of energy supply, green transition policies affect energy affordability. Estimates show that green energy is more expensive. And if a large-scale transition to green energy production occurs, energy, which is considered a primary consumption resource, could experience a price shock that could reduce the resilience of the economy in the short term. The burden of high energy prices will be felt particularly by businesses in the lower deciles. (Vandyck et al., 2021; Garaffa et al., 2021; Chepeliev et al., 2021). Climate policies directly affect energy access. In 2023, about 22.4% of Armenia's CO_2 emissions will be from electricity generation, 34.6% from transport, 9% from industry, and 24.3% from household consumption (IEA, 2023). This structure shows that building a green economy for the country is extremely challenging, as economic and energy policies must simultaneously strengthen energy security, reduce external energy dependence, and increase economic resilience (IEA, 2024).

Conclusion

This study aimed to reassess Armenia's energy security and economic resilience in light of recent geopolitical, structural, and systemic developments. Energy security is almost impossible to measure precisely, due to the limitations of the main indicators that we have addressed in our discussions. It is also difficult because it consists of two contradictory vectors: energy reliability and energy affordability. Green energy is a global public good, and its production can strengthen Armenia's energy independence and increase economic resilience. The results show that while internationally accepted

indicators such as energy intensity, external dependence, and supply concentration metrics offer useful starting points for comparative assessment, they capture only a fraction of the multifaceted vulnerabilities that shape Armenia's real energy profile. In line with the concerns raised in the introduction, the analysis shows that these indicators systematically ignore important qualitative metrics such as asymmetric interdependence with dominant suppliers, transit and infrastructure constraints, exchange rate distortions, informal economic activity, and global geopolitical pressures. As a result, the traditional analytical toolkit, when applied mechanically, provides an incomplete and sometimes misleading picture of the country's energy security (Keohane & Nye, 2011).

Armenia's economic resilience is deeply linked to its energy vulnerabilities. Energy supply disruptions, whether physical, geopolitical, or price-related, exacerbate macroeconomic instability in a small, import-dependent, and landlocked country. The FM Global Resilience Index and related literature further demonstrate that energy-related risks are reflected in economic, infrastructural, and supply chain sectors, shaping a country's absorptive, adaptive, and transformative capacities.

But analyses show that the FM Global Resilience Index 2025 estimates for Armenia do not (a) separate the share of imported primary fuels used in electricity and heating, (b) reflect the concentration of transit routes (in the case of Armenia, the only transit corridor through Georgia), or (c) reflect asymmetric relationships with suppliers and contractual stability (e.g., long-term Russian gas contracts compared to more volatile regional supplies). This rather complex energy profile from an assessment perspective creates a situation where: (i) the FM "Energy Intensity" factor may overestimate the country's economic resilience, especially if GDP growth masks the dependence on energy imports. and (ii) the FM system's logistical and physical risk factors hardly reflect the impact of transit transport and hazards, as the vulnerability of transit transport depends on the small number of corridor barriers, rather than the average logistic performance used in the indices between countries. In summary, Armenia's composite PF score can be viewed as a comparative tool, rather than a definitive measure of energy security or economic resilience. Therefore, the PF score serves as another assessment in characterizing a country's energy security profile, but it necessarily needs to be complemented by Armenia-specific energy balance criteria (ArmStat / RA MTAD / IEA) and a qualitative assessment of the country's structural features and risks. Thus, resilience cannot be meaningfully assessed without placing a comprehensive assessment of energy security at its core.

Addressing the third guiding question of the study, the analysis highlights the need for an integrated, multi-component framework to understand Armenia's energy system. A purely quantitative approach is not sufficient. A comprehensive assessment should include structural constraints, institutional arrangements, geopolitical dynamics, and physical and economic dimensions of reliability, affordability, and clean energy. Only such an approach can fully reflect the risks Armenia faces in a rapidly evolving regional and global environment.

Ultimately, the findings highlight that Armenia's long-term energy security requires a strategic synthesis of diversification, infrastructure modernization, improved domestic production (including low-carbon options), improved regulatory capacity, and targeted social and regional policies that ensure equitable access and affordability. Strengthening economic resilience, in turn, depends on the country's ability to manage asymmetric

dependencies, reduce exposure to external shocks, and implement energy and economic reforms that are consistent with global shifts toward cleaner and more resilient energy systems. By moving beyond superficial indicators and adopting a holistic analytical approach, this study provides a deeper and more accurate understanding of Armenia's vulnerabilities and opportunities. Such an approach is important not only for diagnosing current challenges but also for developing long-term, evidence-based policies that can improve both energy security and economic resilience in an increasingly uncertain geopolitical landscape.

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