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**Article**

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# Comparative Assessment of Energy Security Level: The Case of the South Caucasus Countries

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**ABSTRACT**

The paper compares the energy security of three South Caucasus countries - Azerbaijan, Georgia, and Armenia. These countries differ from each other due to the use of different energy sources. The investigation used 28 indicators classified into six groups based on World Bank data to assess energy security. Indicators for each group were assessed as "stimulating" or "not stimulating" energy security. According to the results, Georgian's energy security is less risky because of it uses renewable energy sources. Ensuring long-term energy security in Azerbaijan requires greater use of renewable energy sources. Armenia's energy security is at higher risk due to its higher dependence on imports and poor use of renewable resources.

**Keywords:** Energy Security, Renewable Energy, Energy Consumption, Energy Import, Natural Resources
**JEL Classifications:** Q430, F520

## 1. INTRODUCTION

There is no need to prove how important energy is for modern civilization and also for the economy. On the other hand, the national security of each country is based on energy security. In particular, the military conflicts that took place in the Middle East in recent decades, and between Russia and Ukraine since February 2022, have greatly strengthened energy's geo-economic and geo-political importance. The rapid decrease of hydrocarbon reserves and the increase in energy demand make it increasingly difficult for every country to ensure energy security. Although the development of technology has reduced the demand for energy to a certain extent as it increases efficiency, the tendency to increase the state of well-being on a global scale raises the demand again.

In the economic literature, there are many studies dedicated to the development of the level of energy security and its components in the example of different countries.

Although the concept of "energy security" may seem clear and unambiguous at first glance, it varies from country to country and from study to study in the academic economic literature. Academic studies are mostly conducted on its various aspects, components and various dimensions. The most widely used definition of energy security is definition proposed by Yergin (2006). He notes that energy security for developed countries is ensuring the supply of the necessary amount of energy at an appropriate price. European Commission (2000) gives an essentially similar definition to "energy security." According to this definition, the continuous physical availability of energy products in the market for all consumers at a feasible price is considered as energy security. Cherp and Jewell (2010) noting that there is no unambiguously accepted definition of energy security. They note that the research in this field should be bound by the meaning given to it. Therefore, when they say "energy security" for their research, they mean that not any abstract "energy" is protected, but a concrete system, especially a vital system. The boundaries of the system that is important to protect must be specified.

It should be noted that there are researchers who tend not to express the concept of "energy security" in a broader sense. For example, Sovacool and Mukherjee (2011) they believe that the concept of "energy security" should be understood from the point of view of its aspects, components, size, cost and so on. Five dimensions of "energy security" are distinguished in the study: First, availability of energy, that is, it is assumed that the country has sufficient energy reserves. It also means being energy independent. Secondly, the possibility of obtaining energy (Affordability). This means the supply of energy at low prices, the possibility of obtaining energy on the basis of a fair price, as well as having predictable prices. The third is a measure of technical development and efficiency. It is the ability to adapt and respond to power outages. The fourth is the dimension of environmental and social sustainability. This measure includes minimizing deforestation and land degradation, sufficient water in quantity and adequate quality, minimizing environmental and indoor pollution, reducing climate-related carbon emissions, and adapting to climate change. The fifth is the dimension of regulation and governance. This dimension involves establishing a stable, transparent and broadly representative energy policy, the existence of a competitive market, the promotion of fuel and energy technology trade, and the expansion of social and community-based knowledge on energy issues and education.

Enerji security problems were studied by Alemzero et al. (2020) on the example of African countries. According to them, countries with less energy resources try to ensure their energy security by connecting with countries with more resources. The study compared the level of energy security in 28 African countries in the period 2000-2018. A composite index of 13 indicators has been prepared in this investigation. Based on the results of the research, it is suggested that investment should be allocated to the development of renewable energy sources and energy infrastructure in order to ensure energy security. Efforts should be increased in the direction of reduction of electricity loss and sustainable development of the environment.

Yang et al. (2022) argue that energy security is crucial for China's sustainable development. In the study, is proposed an index system for energy security assessment based on the DPSİR model. This index consists of 5 dimentions: Energy security driving-forces, energy security pressures, energy security state, energy security impacts and energy security responses. Certain weights are also given for each index. The obtained results show that economic growth, urbanization and other factors have a serious impact on energy security. The study claims that China's energy security level is weak, but the country has already above the minimum level that is necessary for its security.

Shepard et al. (2020) assessed the role of indirect energy trade, along with direct energy, in ensuring energy security. Researchers claim that 23% of cross-country energy trade is related to indirect energy trade. 90% of international trade is related to indirect energy imports.

In the study conducted by Cergibozan (2022), the need to increase the use of renewable energy is justified for energy security. The study assessed the impact of renewable energy sources on energy security risk in 23 OECD countries over the period 1985-2016. Based on the results obtained by applying the Augmented Mean Group (AMG) method, the result is that renewable energy sources, especially wind and hydropower sources, reduce the risk of energy security.

In the study, conducted by Shah et al. (2019) the distinguishing feature is that it links the problem of energy security with environmental protection. In the study, a new index-Energy Security and Environmental Sustainability Index, which includes the aspect of environmental sustainability in South Asian countries, was proposed for the assessment of energy security. The study covers indicators from 2006 to 2017. Based on the results of the study, Bhutan has a higher level of energy security and environmental sustainability than other South Asian countries. India, Sri Lanka and Pakistan are in the next position. According to the study, Maldives has the weakest energy security and environmental sustainability in the region. Based on the results of the study, the authors suggest that in order to ensure energy security and environmental sustainability in the region, there is a need to expand cross-country energy trade and increase investment in the use of renewable energy sources in the long run.

Esfahani et al. (2021) also conducted a comparative analysis of articles published in 53 different journals included in 7 prestigious scientific bases in the period between 2002 and 2019 for the formation of appropriate knowledge about energy security. Among them, 240 articles are devoted to energy security problems. In addition to the concept of "energy security," the concepts of "renewable energy security" and "energy supply security" are distinguished from each other. The study shows that in recent decades, energy security problems have attracted the attention of researchers as a subject of scientific research.

In the research carried out by Brodny and Tutak (2023), it is considered important to solve the issue of climate-neutral energy security in the countries that joined the European Union in 2004. The study shows that the level of sustainable development in these countries in the period between 2008 and 2018 differs from other European Union countries. 14 indicators were used in this study. The study shows that among these countries, the Czech Republic has the highest sustainable energy security. Poland's sustainable energy security is weaker than other European Union countries.

A study conducted by Novikau (2019) analyzed the threat posed by energy prices to national security. The author argues that the instability in the price of gas imported from Russia and the increase in prices pose a threat to the energy security of Belarus and Eastern European countries. Since hydrocarbon reserves of these countries are small, it is proposed to expand the use of renewable energy sources for the continuous provision of their energy security. The author concludes that the use of renewable energy sources alongside nuclear energy may be more reliable for energy security in the long run.

Šprajc et al. (2019) used the Energy Trilemma Index developed by the World Energy Council. 125 countries were included in the study. The research shows that North African and European Union countries have high indicators on this index. Although the researchers consider it possible to use the Energy Trilemma Index in a certain approximation, they consider it important to improve it for energy security assessment.

In the research conducted by Mara et al. (2022) various approaches to the definition of "energy security" are compared and it is pointed out that this concept is still ambiguous. They argue that energy security should be viewed in the context of global security and scientifically based indicators should be used to calculate it. The authors argue that most research on energy security does not analyze this issue in relation to national security. On the contrary, energy security is studied more in connection with economic security. But "energy security" and "economic security" do not correlate with each other in the example of most countries.

Ainou et al. (2023) analyzed Morocco's energy security problems. The 4-A methodology was used in the study. This methodology allows the assessment of energy security based on four main parameters: the availability of energy resources, the applicability of technology, the acceptability by the environment and society, and the affordability of energy resources. The results of the study show that Morocco's energy security indicators were at an optimal level in the period between 2000 and 2004. However, prices and import volumes have increased in the following periods. The authors suggest that to ensure Morocco's energy security, it is necessary to expand the use of renewable energy sources, develop efficient technology through green financing and green investment projects.

Amin et al. (2022) assessed the level of energy security in Bangladesh using the 4A methodology. Based on the obtained results, from 2014 to 2016, the level of energy security in Bangladesh had a decreasing trend. Since 2017, an improvement in energy security has been observed.

The Gray Relational Analysis (GRA) method was used in the study conducted by Tutak and Brodny (2022). The study included 17 indicators covering energy security, economic, environmental and social aspects. According to the results, Austria's energy security is higher than other European countries. The energy security level of Poland and Bulgaria is lower than other European countries.

For the assessment of energy security Sotnyk et al. (2021) suggested to include indicators such as decoupling index of the renewable energy financial burden on the state budget, the energy efficiency decoupling index, the households' energy poverty indicator, the index of capacity development for balancing electricity generation volumes, and the energy fluctuations indicator.

Fouladvand et al. (2022) looked at energy security at the micro level and proposed the development of energy communities to ensure energy security from the household level. The authors claim that energy communities are important in absorbing as much as 60% of carbon emissions. The authors also argue that raising energy prices instead of carbon taxes is more effective in ensuring energy security.

Azerbaijan's energy security issues have also been studied by various researchers. For example, in the research conducted by Azakov (2018), it is argued that hydrocarbon energy sources will be superior to renewable energy sources in the short and medium term, and will play a special role in ensuring energy security. Therefore, it is noted that Azerbaijan's oil and gas production is of great importance in the energy security of European countries. The South Caucasian gas pipeline and construction of Trans-Anatolian (TANAP) and Trans-Adriatic (TAP) pipelines from Azerbaijan to Europe will play an important role in the energy security of Turkey and some European countries. In this study, energy security is mainly limited by the availability of hydrocarbon energy sources. Most of the studies devoted to Azerbaijan's energy security problems, including those conducted by Ganz (2022) and Korkut and Preljevic (2017) note that hydrocarbon energy plays a key role in energy security.

Georgia's energy security problems studied by Pignatti (2023), Zachmann (2014), Alieva and Shapovalova (2015) and others. In these studies, it is noted that Georgia has high economic and political relations with Azerbaijan in ensuring energy security. In order to transport Azerbaijani oil and gas from the territory of Georgia to the world market and ensure the energy security of Georgia, it is important to establish energy trade between these two countries on a mutually beneficial basis. Studies show that the efficient establishment of the use of renewable energy sources in Georgia also makes a great contribution to ensuring energy security.

In the last 35 years, the Armenian-Azerbaijani conflict in the region has created serious obstacles to the economic development of both countries. For this very reason, Armenia's exclusion from regional energy projects was also reflected in its energy security level. The lack of hydrocarbon resources and distance from the energy market in this country creates energy problems in the country's economy. The long-term conflict with neighboring countries, especially Azerbaijan, completely stopped energy trade between these countries. Armenia's energy security problem studied *by* Kosowska et al. (2018). The study claims that more than 90% of Armenia's energy supply is provided through imports. The use of renewable energy sources in the country is also not at a high level. Nevertheless, it is proposed to develop renewable energy sources for the country's energy supply.

## 2. METHODOLOGY

A comparative analysis of the studies devoted to energy security suggests that each study uses a matrix of different indicators as indicators of energy security. In our study, we will use the methodology followed Stavytskyy et al. (2021). Six groups of indicators were used in their methodology. Each indicator group also consists of several sub-indicators.

The indicators characterizing the consumption of natural resources are concentrated in the first group. Here (a) consumption volume of hydrocarbon fuel (share in total consumption-%)- $I_{11t}$; (b) the share of renewable energy consumption in the total consumption volume (%)-$I_{12t}$; (c) electricity consumption volume (per capita, Kwt.h)- $I_{13t}$; (d) total energy consumption (in oil equivalent-kg)- $I_{14t}$; (e) energy consumption per $1,000 of GDP volume (in oil equivalent-kg)- $I_{15t}$; (f) energy import (share in total energy consumption-%)- $I_{16t}$; (g) fuel import (share in total goods import-%)- $I_{17t}$. Among these indicators, the first one, i.e., in point (a), and the last two, i.e., in points (f) and (g), are indicators that reduce energy security, that is why, they can be considered as non stimulant.

The second group of indicators is included in the resource depletion group. In this group, 4 indicators are collected and each of them acts as a non stimulant for energy security. These are (a) regulated saving-energy depletion (share in UMG-%)- $I_{21t}$. The energy depletion indicator is the ratio of energy reserves to the duration of its use. The higher this ratio, the worse it is for energy security; (b) regulated savings-exhaustion of mineral resources (share in UMG-%)- $I_{22t}$. This indicator refers to mineral resources other than energy, and if it is high like the previous indicator, it has a negative impact on energy security; (c) regulated savings-exhaustion of forest resources (share in UMG-%)- $I_{23t}$. This indicator characterizes the extent to which deforestation exceeds natural growth; (d) regulated savings-depletion of natural resources (share-%)- $I_{24t}$. This indicator characterizes the sum of indicators of forest depletion, mineral resource depletion and energy depletion.

The third group of indicators is the resource efficiency group. This group includes four indicators: (a) Energy intensity level of primary energy (Mj/GDP PPP)- $I_{31t}$. This indicator shows how much energy is used to produce one unit of GDP. Too much of this indicator reduces energy security, that is, this indicator is a non stimulant; (b) GDP volume produced by consumption of one unit of energy (GDP PPP/[kg oil equivalent])- $I_{32t}$. This indicator indicates the efficiency of energy consumption. Producing more GDP with one unit of energy consumption increases energy security, that is, this indicator is a stimulant; (c) energy loss during the transportation and distribution of electric energy (share in total energy volume-%)- $I_{33t}$. A high level of this indicator means that the country is technologically weak. That is, it is a non stimulant; (d) fuel export (share in total goods export-%)- $I_{34t}$. A large number of this indicator indicates energy abundance in the country and is a stimulant.

The fourth group of indicators is the "attraction of new energy sources" group, and five indicators are combined in this group: (a) Renewable energy consumption (share in total energy consumption-%)- $I_{41t}$. If the volume of consumption in the country is high, it can be said that the technological development in this country is high, that is, this indicator is a stimulant; (b) volume of alternative and nuclear energy consumption (share in total energy consumption-%)- $I_{42t}$. This indicator cannot be considered a stimulant. Because the use of nuclear energy, in addition to characterizing technological development, also means the creation of a serious threat to the environment; (c) share of renewable energy obtained from waste combustion in total energy consumption (%)-$I_{43t}$. This indicator is a stimulant; (d) excluding hydroelectric power stations, share of electricity from renewable energy sources in total electricity production from renewable energy sources (%)-$I_{44t}$. This indicator is a stimulant; (e) share of electricity obtained from from renewable energy sources in total electricity (%)-$I_{45t}$. This indicator is also a stimulant.

The fifth group of indicators is a group of indicators representing waste generated during the extraction industry. There are five indicators in this group: (a) the share of solid waste emissions in GHG (%)-$I_{51t}$. This indicator is a non stimulant. Because any waste poses an additional threat to human life; (b) Volume of carbon emissions per unit of GDP volume (kg)- $I_{52t}$. This indicator is also a non stimulant; (c) volume of carbon emissions per capita (metric tons per capita)- $I_{53t}$. Too much of this indicator reduces energy security and is a non stimulant; (d) Adjusted net savings, including perceived waste emission share in GHG (%)- $I_{54t}$. This indicator is calculated by subtracting energy depletion, mineral depletion, forest depletion, carbon emission damage, and greenhouse gas damage from the sum of education expenditures with net national income. When this indicator is high, the country's energy security is also considered high, that is, it is a stimulant; (e) the share of carbon emission damage in GMM (%)-$I_{55t}$. Too much of this indicator poses a threat to energy security and is a non stimulant.

The sixth group of indicators is the access to resources group. There are three indicators in this group: (a) the share of the population supplied with electricity in the total population (%)-$I_{61t}$. This indicator is a stimulant; (b) Share of the population supplied with electricity in rural regions in the number of people living in such regions (%)-$I_{62t}$. This indicator is also a stimulant; (c) share of the population supplied with electricity in the cities in the total urban population (%)-$I_{63t}$. This indicator is also a stimulant.

Thus, Stavytskyy et al. (2021) collected 28 indicators for energy security in 6 groups, distinguishing them as stimulatory and non-stimulatory. Based on the algorithm of the research, it is intended to obtain data on these indicators, to calculate their average values and the energy security index. The study proposes the following formula for calculating energy security:

$$I_{ts} = f * \prod_{j=1}^{u} \frac{g_{jts}}{g_{jtw}} \tag{1}$$

Here, the j index indicates the number of the above-mentioned group, t-time, and s-which country was studied. $g_{jts}$ - is the indicator in group j belonging to country s at time t. $g_{jtw}$ -is the average of the values of the indicators in group j of the countries included in the study at time t. f(·) is a function for normalizing values. Usually, this function is considered as a function with a degree equal to the number of elements. We will use identity (2) rather than identity (1) in our study

$$ES_{it} = \frac{\sum_{j}^{u}\left[\left(\sum_{m}^{n} NI_{ijmt}\right)/n\right]}{u} \tag{2}$$

Here $ES_{it}$ - the level of energy security of the i-th country at time t, $NI_{ijmt}$ - the normalized value of the m-th indicator in the j-th group belonging to the i-th country at the time t, n- the number of indicators in the j-th group, u-the number of groups. According to the methodology we will use, u = 6. It should be noted that here $NI_{ijmt}$ - is the normalized value of indicators between [−1;+1]. Such normalization will be conducted based on the formula

$$NI_{ijmt} = \frac{I_{ijmt}(cari) - I_{ijmt}(min)}{I_{ijmt}(max) - I_{ijmt}(min)} \tag{3}$$

Each group has indicators for which it is easy to determine max and min. For example, min=0, max=100 can be taken for all indicators expressed as a percentage. However, determining such minimum and maximum values for some indicators is quite difficult and controversial. For example, in order to determine the minimum and maximum for the amount of electricity consumption, it is necessary to take the comparative price with other countries. Here, the value should be taken in such a way that the obtained results can be used to determine the dynamics.

We believe that the advantage of identity (2) over identity (1) is the possibility of calculating energy security for a country taken separately. On the other hand, during the calculations with identity (2) always [−1; 1] and does not depend on prices in other countries, allows to establish its dynamics. However, the missing aspect of this identity is related to the fact that in cases where it is not possible to obtain data on any indicator, the comparison of the obtained result with the obtained results for other countries may be distorted. Energy security index ($ES_{it}$) calculated on the basis of identity (2) varies between "−1" (means no energy security), and "1" (means full energy security). Of course, the existence of both extremes is difficult in reality.

## 3. RESULTS AND DISCUSSION

The countries of the South Caucasus differ sharply from each other in terms of their natural resources. Thus, Azerbaijan has rich hydrocarbon resources, but water resources are few. Due to the climatic conditions of Azerbaijan, the possibilities of using solar and wind energy in this country are wide (Gulaliyev et al., 2020a). Georgia has few hydrocarbon resources, but rich forest resources and water resources. Small and medium-sized hydropower plants, solar and wind energy are widely available in this country. Armenia also has very few hydrocarbon reserves. However, the presence of a nuclear power plant in Armenia meets a certain part of the demand for electricity in the country.

At first glance, the abundance of hydrocarbon resources gives reason to claim that the country's energy security is ensured at a high level. But in modern times, energy security should not be measured only by wealth of hydrocarbon resources. The gradual depletion of these resources does not guarantee energy security for the long run. Globalization and the formation of the world economic system have expanded international relations, and activity of the transnational companies, as well as of the international financial institutions, that are striving to ensure the availability of hydrocarbon resources for all. As a result of the liberalization of international trade relations, the priority is not to have hydrocarbon reserves, but to have the financial capacity and a liberal foreign trade regime to acquire it. Therefore, we will try to evaluate to what extent South Caucasus countries' energy security is ensured on the basis of the above-mentioned indicators.

The data used in the study were obtained from the statistical database of the World Bank. it should also be noted that the data on some indicators in the study covers the years 1990-2014. The lack of data from recent years does not prevent comparative assessments of energy security in the countries of the South Caucasus. Because the main indicators related to energy security are not indicators prone to serious changes in the short term.

It should be noted, in the World Bank's data on energy imports, if there is no import and the country exports energy, the indicators are given with a "-" sign. During the calculations, we accept the minimum limit for this indicator, that is, the limit of no imports, "0." Therefore, we accept the indicators of Azerbaijan after 1994 as "0."

The comparison of the countries of the South Caucasus on the first group, that is, on the indicators characterizing the consumption of natural resources, suggests that the level of use of renewable energy sources in Azerbaijan is very low compared to Georgia. Even in Armenia, this indicator is higher than in Azerbaijan. The presence of oil and gas reserves in Azerbaijan favors the use of these types of energy sources in consumption. Indicators on the use of electricity per capita do not differ significantly from each other. Table 1 shows the dynamics of the first group of indicators, i.e. indicators characterizing the consumption of natural resources in the South Caucasian countries. Since Azerbaijan has rich hydrocarbon resources, the first of these indicators, i.e. the consumption volume of hydrocarbon fuel (share in total consumption-%) is even close to the maximum. However, the second indicator, i.e. the share (%) of renewable energy consumption in the total consumption volume, is quite small and even close to the minimum. Electricity consumption per capita in Azerbaijan is not that high.

However, the per capita consumption of electricity in Azerbaijan was higher than both Georgia and Armenia in some years. Various factors influence the large consumption of electricity in Azerbaijan, including the fact that the prices are lower than the competitive market price. Studies show that if the state monopoly on electricity in Azerbaijan is transferred to a competitive market, prices may increase significantly (Gulaliyev et al., 2020b). As well as the amount of consumption will decrease to some extent. Total energy consumption per capita in oil equivalent in Azerbaijan is higher than both countries. According to World Bank data for 2014, Georgia and Armenia import a significant part of their consumption (69% and 71%, respectively). Azerbaijan's energy import is very small in total energy consumption. Table 1 shows the normalized values (according to the identity [3]) of natural resources consumption indicators for these countries. Based on these indicators, the "consumption of natural resources" sub-index (4) will be calculated as follows:

$$NI_{jt} = \sum_{m}^{7} NI_{jmt}) / 7 \quad (4)$$

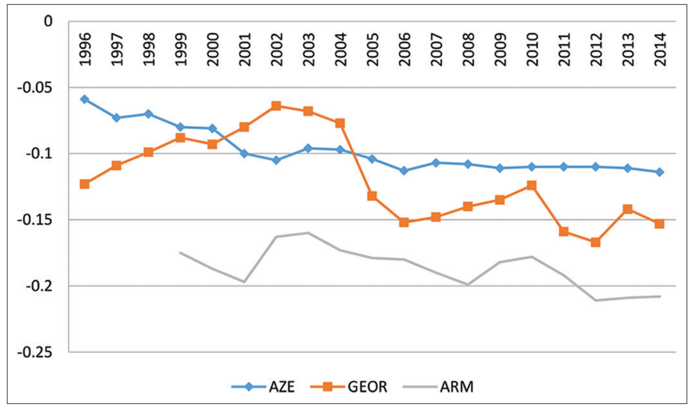
According to the group of indicators, i.e. "The consumption of natural resources" components of energy security of Azerbaijan, Georgia and Armenia have been decreasing in the last 25 years (Graph 1). This is due to the fact that the volume of energy consumption has increased in all three countries. The volume of demand for energy was provided by internal energy reserves in Azerbaijan, and by imports in Georgia and Armenia. Both options have a negative impact on the level of energy security. In order to ensure sustainable energy security, it is important to reduce consumption or meet the demand for energy through

**Table 1: The first group of indicators (normalized): Indicators characterizing the consumption of natural resources in the South Caucasus countries**

| | Consumption volume of hydrocarbon fuel (share in total consumption)- $NI_{11t}$ | | | Share of renewable energy consumption in total consumption volume- $NI_{12t}$ | | | Electricity consumption volume (per capita Kwt.h)- $NI_{13t}$ | | | Total energy consumption (in oil equivalent-kg)- $NI_{14t}$ | | | Energy consumption per $1,000 of GDP (in oil equivalent-kg)- $NI_{15t}$ | | | Energy import (share in total energy consumption)- $NI_{16t}$ | | | fuel import (share in total goods import)- $NI_{17t}$ | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | AZE | Geor | Ar | AZE | Geor | Arm | AZE | Geor | Arm | AZE | Geor | Arm | AZE | Geor | Arm | AZE | Geor | Arm | AZE | Geor | Arm |
| 1996 | 0.98 | 0.605 | - | 0.017 | 0.428 | - | 0.031 | 0.019 | - | 0.061 | 0.033 | - | 0.507 | 0.223 | - | 0.000 | 0.570 | - | 0.045 | 0.388 | - |
| 1997 | 0.98 | 0.599 | - | 0.020 | 0.444 | - | 0.030 | 0.022 | - | 0.058 | 0.030 | - | 0.462 | 0.177 | - | 0.000 | 0.562 | - | 0.100 | 0.274 | - |
| 1998 | 0.98 | 0.591 | - | 0.025 | 0.475 | - | 0.032 | 0.025 | - | 0.059 | 0.029 | - | 0.436 | 0.159 | - | 0.000 | 0.547 | - | 0.058 | 0.245 | - |
| 1999 | 0.98 | 0.557 | 0.65 | 0.021 | 0.497 | 0.084 | 0.034 | 0.026 | 0.022 | 0.055 | 0.027 | 0.024 | 0.377 | 0.141 | 0.156 | 0.000 | 0.523 | 0.641 | 0.063 | 0.230 | 0.216 |
| 2000 | 0.98 | 0.590 | 0.70 | 0.021 | 0.473 | 0.072 | 0.034 | 0.026 | 0.022 | 0.056 | 0.028 | 0.026 | 0.351 | 0.143 | 0.162 | 0.000 | 0.538 | 0.681 | 0.049 | 0.196 | 0.208 |
| 2001 | 0.98 | 0.551 | 0.71 | 0.018 | 0.532 | 0.054 | 0.035 | 0.026 | 0.021 | 0.056 | 0.026 | 0.026 | 0.324 | 0.122 | 0.147 | 0.000 | 0.508 | 0.696 | 0.151 | 0.208 | 0.223 |
| 2002 | 0.97 | 0.496 | 0.62 | 0.024 | 0.568 | 0.089 | 0.033 | 0.028 | 0.021 | 0.057 | 0.026 | 0.025 | 0.299 | 0.115 | 0.122 | 0.000 | 0.478 | 0.602 | 0.176 | 0.208 | 0.175 |
| 2003 | 0.97 | 0.521 | 0.66 | 0.029 | 0.553 | 0.098 | 0.037 | 0.029 | 0.022 | 0.059 | 0.027 | 0.026 | 0.285 | 0.110 | 0.113 | 0.000 | 0.492 | 0.645 | 0.113 | 0.180 | 0.075 |
| 2004 | 0.97 | 0.538 | 0.67 | 0.031 | 0.545 | 0.087 | 0.038 | 0.030 | 0.024 | 0.062 | 0.028 | 0.028 | 0.274 | 0.107 | 0.108 | 0.000 | 0.537 | 0.638 | 0.114 | 0.172 | 0.153 |
| 2005 | 0.97 | 0.644 | 0.68 | 0.034 | 0.415 | 0.065 | 0.040 | 0.032 | 0.025 | 0.064 | 0.029 | 0.034 | 0.225 | 0.100 | 0.114 | 0.000 | 0.655 | 0.654 | 0.119 | 0.199 | 0.155 |
| 2006 | 0.98 | 0.704 | 0.67 | 0.029 | 0.372 | 0.077 | 0.043 | 0.029 | 0.027 | 0.062 | 0.031 | 0.035 | 0.165 | 0.097 | 0.102 | 0.000 | 0.694 | 0.665 | 0.116 | 0.194 | 0.160 |
| 2007 | 0.98 | 0.707 | 0.71 | 0.038 | 0.362 | 0.070 | 0.035 | 0.030 | 0.030 | 0.056 | 0.035 | 0.039 | 0.121 | 0.095 | 0.100 | 0 | 0.679 | 0.708 | 0.025 | 0.176 | 0.158 |
| 2008 | 0.98 | 0.668 | 0.73 | 0.031 | 0.363 | 0.064 | 0.034 | 0.031 | 0.028 | 0.061 | 0.031 | 0.041 | 0.120 | 0.083 | 0.099 | 0 | 0.642 | 0.732 | 0.016 | 0.180 | 0.157 |
| 2009 | 0.98 | 0.670 | 0v68 | 0.033 | 0.367 | 0.078 | 0.027 | 0.031 | 0.028 | 0.053 | 0.032 | 0.036 | 0.098 | 0.089 | 0.100 | 0 | 0.617 | 0.681 | 0.011 | 0.181 | 0.156 |
| 2010 | 0.97 | 0.647 | 0.67 | 0.045 | 0.392 | 0.094 | 0.027 | 0.034 | 0.029 | 0.051 | 0.033 | 0.035 | 0.091 | 0.085 | 0.093 | 0 | 0.580 | 0.647 | 0.011 | 0.183 | 0.177 |
| 2011 | 0.98 | 0.728 | 0.72 | 0.036 | 0.315 | 0.080 | 0.028 | 0.038 | 0.030 | 0.055 | 0.038 | 0.038 | 0.098 | 0.090 | 0.097 | 0 | 0.684 | 0.674 | 0.009 | 0.178 | 0.203 |
| 2012 | 0.98 | 0.745 | 0.77 | 0.028 | 0.287 | 0.066 | 0.034 | 0.039 | 0.032 | 0.059 | 0.040 | 0.041 | 0.105 | 0.088 | 0.099 | 0 | 0.703 | 0.727 | 0.009 | 0.174 | 0.212 |
| 2013 | 0.98 | 0.689 | 0.75 | 0.025 | 0.332 | 0.068 | 0.035 | 0.042 | 0.032 | 0.059 | 0.042 | 0.040 | 0.101 | 0.089 | 0.094 | 0 | 0.634 | 0.721 | 0.013 | 0.173 | 0.221 |
| 2014 | 0.98 | 0.722 | 0.75 | 0.021 | 0.313 | 0.071 | 0.037 | 0.045 | 0.033 | 0.060 | 0.047 | 0.000 | 0.101 | 0.096 | 0.092 | 0 | 0.688 | 0.714 | 0.032 | 0.167 | 0.196 |

Note: Calculated by the authors

**Graph 1:** Dynamics of the composite index of indicators characterizing the consumption of natural resources




renewable sources. However, for comparison, it should be noted that Azerbaijan is in a better position on this indicator.

The composite index calculated on the second group of indicators characterizes resource depletion. Table 2 shows the last 25-year dynamics of the sub-indices. All indicators included in this group are indicators that weaken energy security. Any extractive industry, including oil and gas, depletes a country's reserves. The advantage of using renewable energy is that it does not run out. That is why the use of renewable energy sources is important in ensuring sustainable energy security. Hydrocarbon reserves are depleting. The resource potential of solar energy is high in the countries of the South Caucasus. Effective use of resource potential is important. According to the second group of indicators, Azerbaijan is in a disadvantageous position compared to other South Caucasus countries. However, the solar energy potential of Azerbaijan is high (Gulaliyev et al., 2020) and the measures taken to use it will bear fruit in the near future.

The composite index for the second group will be calculated by the equation (5):

$$NI_{jt} = \sum_{m}^{4} NI_{jmt}) / 4 \quad (5)$$

The dynamics of the composite index shows that (Graph 2) the energy security of Azerbaijan is below the average index (i.e. "0" index). The trend of depletion of the country's mineral resources, forest resources, and natural resources poses a serious threat to the country's energy security.

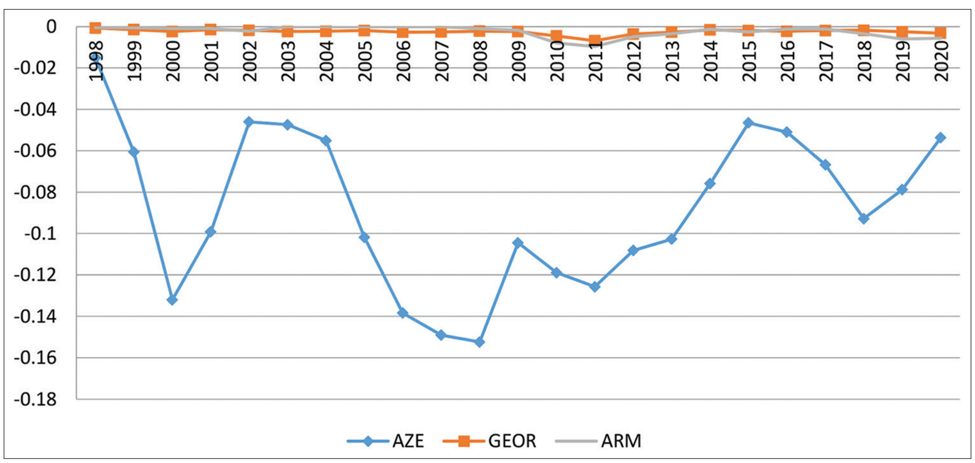
The dynamics of economic development of different countries show that the more energy required to create one unit of added value, the more competitive it is in that country. Also, the higher the GDP generated by one unit of energy, the higher the productivity in that country. High losses during energy transportation or distribution also pose a risk to energy security in the country. These indicators are related to how efficiently energy sources are used. The composite index calculated on the basis of these indicators consists of four sub-indices and is calculated using the equation (5). For the calculation of these sub-indices, the maximum and minimum indicators were adopted for the normalization of the indicators. The maximum value "30" can be

**Table 2: The second group of indicators: indicators characterizing the depletion of resources in the South Caucasus countries**

| | Adjusted savings: Energy depletion (share in GNI)- $NI_{21t}$ | | | Adjusted savings-depletion of mineral resources (share in GNI)- $NI_{22t}$ | | | Adjusted savings -depletion of forest resources (share of the forest reserve)- $NI_{23t}$ | | | Adjusted savings -depletion of natural resources (share in GNI)- $NI_{24t}$ | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | AZE | Geor | Arm | AZE | Geor | Arm | AZE | Geor | Arm | AZE | Geor | Arm |
| 1998 | 0.030 | 0.000 | 0.000 | 0.000 | 0.000 | 0.0005 | 0 | 0.000 | 0.000 | 0.030 | 0.001 | 0.001 |
| 1999 | 0.121 | 0.001 | 0.000 | 0.000 | 0.001 | 0.0009 | 0 | 0.001 | 0.000 | 0.121 | 0.003 | 0.001 |
| 2000 | 0.264 | 0.002 | 0.000 | 0.000 | 0.001 | 0.0016 | 0 | 0.001 | 0.000 | 0.264 | 0.004 | 0.002 |
| 2001 | 0.198 | 0.001 | 0.000 | 0.000 | 0.001 | 0.0017 | 0 | 0.000 | 0.000 | 0.198 | 0.002 | 0.002 |
| 2002 | 0.092 | 0.001 | 0.000 | 0.000 | 0.002 | 0.0044 | 0 | 0.000 | 0.000 | 0.092 | 0.003 | 0.005 |
| 2003 | 0.095 | 0.002 | 0.000 | 0.000 | 0.001 | 0.0000 | 0 | 0.001 | 0.000 | 0.095 | 0.004 | 0.000 |
| 2004 | 0.110 | 0.001 | 0.000 | 0.000 | 0.002 | 0.0000 | 0 | 0.001 | 0.000 | 0.110 | 0.004 | 0.000 |
| 2005 | 0.204 | 0.001 | 0.000 | 0.000 | 0.001 | 0.0000 | 0 | 0.001 | 0.000 | 0.204 | 0.003 | 0.000 |
| 2006 | 0.277 | 0.001 | 0.000 | 0.000 | 0.003 | 0.0000 | 0 | 0.001 | 0.000 | 0.277 | 0.005 | 0.000 |
| 2007 | 0.298 | 0.000 | 0.000 | 0.000 | 0.003 | 0.0000 | 0 | 0.001 | 0.000 | 0.298 | 0.005 | 0.000 |
| 2008 | 0.305 | 0.000 | 0.000 | 0.000 | 0.002 | 0.0000 | 0 | 0.001 | 0.002 | 0.305 | 0.004 | 0.002 |
| 2009 | 0.209 | 0.000 | 0.000 | 0.000 | 0.003 | 0.0002 | 0 | 0.001 | 0.003 | 0.209 | 0.004 | 0.004 |
| 2010 | 0.237 | 0.000 | 0.000 | 0.001 | 0.007 | 0.0130 | 0 | 0.001 | 0.002 | 0.238 | 0.009 | 0.016 |
| 2011 | 0.251 | 0.000 | 0.000 | 0.001 | 0.011 | 0.0148 | 0 | 0.001 | 0.005 | 0.251 | 0.013 | 0.020 |
| 2012 | 0.216 | 0.000 | 0.000 | 0.001 | 0.006 | 0.0064 | 0 | 0.000 | 0.004 | 0.216 | 0.007 | 0.010 |
| 2013 | 0.205 | 0.000 | 0.000 | 0.000 | 0.004 | 0.0048 | 0 | 0.000 | 0.002 | 0.206 | 0.005 | 0.007 |
| 2014 | 0.151 | 0.000 | 0.000 | 0.000 | 0.002 | 0.0004 | 0 | 0.000 | 0.002 | 0.152 | 0.003 | 0v003 |
| 2015 | 0.093 | 0.000 | 0.000 | 0.001 | 0.002 | 0.0026 | 0 | 0.000 | 0.003 | 0.093 | 0.003 | 0.005 |
| 2016 | 0.101 | 0.000 | 0.000 | 0.001 | 0.003 | 0.0000 | 0 | 0.000 | 0.002 | 0.102 | 0.004 | 0.002 |
| 2017 | 0.131 | 0.000 | 0.000 | 0.002 | 0.002 | 0.0000 | 0 | 0.000 | 0.003 | 0.134 | 0.003 | 0.003 |
| 2018 | 0.184 | 0.000 | 0.000 | 0.001 | 0.002 | 0.0041 | 0 | 0.000 | 0.003 | 0.186 | 0.003 | 0.007 |
| 2019 | 0.156 | 0.000 | 0.000 | 0.001 | 0.004 | 0.0094 | 0 | 0.000 | 0.003 | 0.158 | 0.005 | 0.012 |
| 2020 | 0.105 | 0.000 | 0.000 | 0.002 | 0.005 | 0.0088 | 0 | 0.000 | 0.003 | 0.107 | 0.006 | 0.012 |

Note: Calculated by the authors

**Graph 2:** Dynamics of the resource depletion group composite index for South Caucasus countries




taken for the energy intensity level of primary energy (Mj/GDP 2017 PPP). We will take “40” as the maximum value for GDP volume (GDP PPP/[kg oil equivalent]) produced by consumption of one unit of energy. We will take “90” as the maximum value for energy loss (share of total energy volume-%) during the transportation and distribution of electricity. Unfortunately, in some countries, such as Togo, in 2012, losses during the transmission and distribution of electricity even exceeded 80%. Although it is impossible to completely avoid losses during the transmission and distribution of energy, we will theoretically accept “0” as the minimum loss percentage.

The dynamics of the third group of indicators, i.e. indicators characterizing the efficiency of resources, are given in Table 3. The indicators of Azerbaijan on the sub-indices included in this composite index are higher than the average.

The composite index for the third group will be calculated by the equation (5). Despite this, the possibilities of more efficient use of resources are still high. In recent years, the development of the sub-indices included in this group has been felt and the dynamics are positive (Graph 3). According to the sub-indices given in Table 3, as well as the composite index (Graph 3) expressing resource efficiency, the indicators of Azerbaijan are much higher than those of Georgia and Armenia.

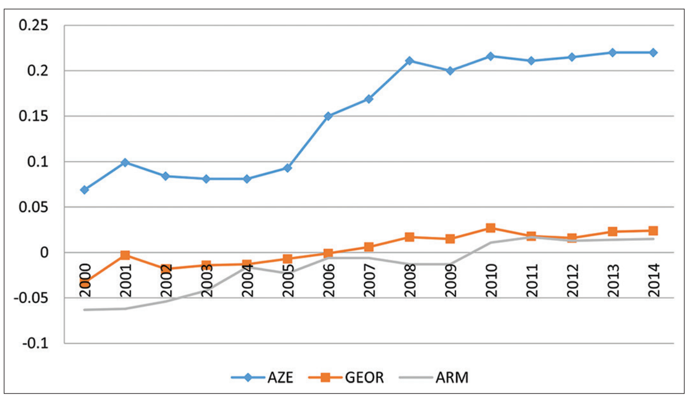
The fourth group of indicators, i.e indicators characterizing the attraction of new energy sources in the South Caucasus countries

**Table 3: The third group of indicators: indicators characterizing the efficiency of resources in the South Caucasus countries**

| | Energy intensity level of primary energy (Mj/GDP 2017 PPP) - non-stimulant - $NI_{31t}$ | | | The volume of GDP produced by the consumption of one unit of energy (GDP PPP/(kg oil equivalent)) – stimulant- $NI_{32t}$ | | | Energy loss during the transportation and distribution of electric energy (share in total energy volume-%) - non-stimulant- $NI_{33t}$ | | | Fuel export (share in total goods export-%)- stimulant- $NI_{34t}$ | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | AZE | Geor | Arm | AZE | Geor | Arm | AZE | Geor | Arm | AZE | Geor | Arm |
| 2000 | 0.482 | 0.200 | 0.226 | 0.071 | 0.175 | 0.154 | 0.165 | 0.187 | 0.282 | 0.851 | 0.081 | 0.101 |
| 2001 | 0.444 | 0.171 | 0.206 | 0.077 | 0.204 | 0.170 | 0.150 | 0.135 | 0.290 | 0.913 | 0.091 | 0.079 |
| 2002 | 0.410 | 0.160 | 0.170 | 0.084 | 0.218 | 0.205 | 0.228 | 0.185 | 0.285 | 0.889 | 0.055 | 0.032 |
| 2003 | 0.391 | 0.153 | 0.157 | 0.088 | 0.228 | 0.222 | 0.232 | 0.180 | 0.250 | 0.860 | 0.051 | 0.020 |
| 2004 | 0.377 | 0.149 | 0.151 | 0.091 | 0.234 | 0.232 | 0.212 | 0.173 | 0.176 | 0.822 | 0.035 | 0.031 |
| 2005 | 0.309 | 0.139 | 0.159 | 0.111 | 0.251 | 0.220 | 0.196 | 0.173 | 0.176 | 0.768 | 0.032 | 0.022 |
| 2006 | 0.227 | 0.135 | 0.143 | 0.152 | 0.258 | 0.245 | 0.171 | 0.158 | 0.146 | 0.846 | 0.031 | 0.020 |
| 2007 | 0.171 | 0.133 | 0.140 | 0.207 | 0.263 | 0.249 | 0.175 | 0.143 | 0.146 | 0.814 | 0.037 | 0.012 |
| 2008 | 0.172 | 0.116 | 0.138 | 0.208 | 0.300 | 0.253 | 0.162 | 0.144 | 0.172 | 0.971 | 0.030 | 0.003 |
| 2009 | 0.140 | 0.125 | 0.139 | 0.254 | 0.280 | 0.250 | 0.241 | 0.140 | 0.165 | 0.929 | 0.044 | 0.001 |
| 2010 | 0.127 | 0.118 | 0.130 | 0.275 | 0.295 | 0.269 | 0.227 | 0.121 | 0.125 | 0.945 | 0.050 | 0.030 |
| 2011 | 0.140 | 0.125 | 0.135 | 0.254 | 0.279 | 0.258 | 0.218 | 0.124 | 0.135 | 0.947 | 0.041 | 0.079 |
| 2012 | 0.149 | 0.123 | 0.138 | 0.238 | 0.284 | 0.252 | 0.163 | 0.125 | 0.136 | 0.934 | 0.030 | 0.074 |
| 2013 | 0.143 | 0.133 | 0.131 | 0.249 | 0.280 | 0.267 | 0.156 | 0.089 | 0.137 | 0.930 | 0.033 | 0.057 |
| 2014 | 0.143 | 0.136 | 0.137 | 0.247 | 0.260 | 0.271 | 0.151 | 0.064 | 0.133 | 0.928 | 0.038 | 0.059 |

Note: Calculated by the authors

**Graph 3:** Dynamics of the resource efficiency group composite index




include four subindices. For all for all sub-indices we will take "100" as maximum and "0" as minimum. Of course, there is currently no country with a renewable energy sector at these leveles. However, this is a wish, and the use of renewable energy sources will increase with technological development. According to the Table 4 the indicators of Azerbaijan on the sub-indices included in this group are much weaker than the indicators of both Georgia and Armenia. As we mentioned above, Azerbaijan is rich in hydrocarbon resources, and electricity generated from these types of energy is cheaper. Due to the state monopoly of the electricity sector, electricity is cheaper than in a competitive market. Electricity generated from renewable energy sources, especially solar and wind energy, is also much more expensive than the monopoly price. Therefore, there is still no incentive to use renewable and alternative energy sources in Azerbaijan. Georgia is in a more favorable position on the indicators included in this group.

Alternative and nuclear energy consumption volume (share in total energy consumption-%) indicator was considered as a non-stimulator in our study. Because the use of nuclear energy currently provides an important part of the demand for energy, it is not desirable to expand its use in the future. Because the environmental effects of nuclear energy are more serious and difficult to eliminate. Taking this into account, "100" was taken as the maximum limit for this indicator. The maximum limit "100" can be taken for the share of renewable energy (%) obtained from waste combustion in the total energy consumption. We will take "0" as the minimum threshold.

The fourth group of indicators, the composite index of indicators characterizing the attraction of new energy sources, is positive, but not very high. The state programs implemented in the last 10 years in Azerbaijan in the field of expanding the use of renewable energy sources indicate that there are opportunities for the development of this field.

The composite index for the fourth group will be calculated by the equation (6):

$$NI_{jt} = \sum_{m}^{5} NI_{jmt}) / 5 \quad (6)$$

The dynamics of the composite index for indicators characterizing the attraction of new energy sources is given in Graph 4. It can be seen from the graph that the high level of use of hydrocarbon energy in Azerbaijan has not yet created a serious need for the use of renewable energy sources. The share of energy obtained from renewable sources in the country's energy balance is about 3%. Since an essential part of the country's energy balance is in hydrocarbon reserves, the level of diversification is low (Bayramov, 2021).

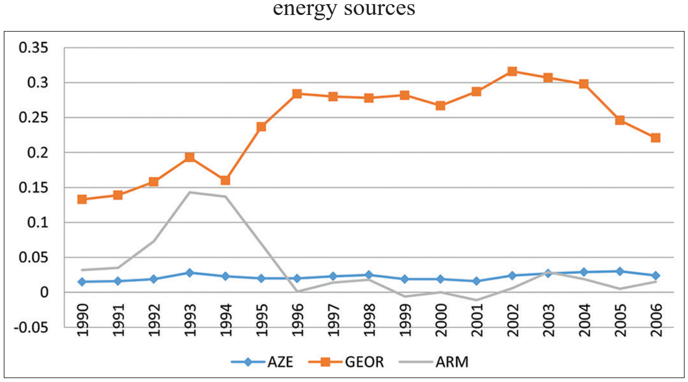
It can be seen from the 4th Graph that Armenia's energy security is weak in comparison to both Georgia and Azerbaijan on the sub-indicators included in this group. The use of nuclear

**Table 4: The fourth group of indicators: indicators characterizing the attraction of new energy sources in the South Caucasus countries**

| | Renewable energy consumption (share in total energy consumption) – stimulant- $NI_{41t}$ | | | Alternative and nuclear energy consumption volume (share in total energy consumption)- non-stimulant- $NI_{42t}$ | | | Share of renewable energy obtained from waste combustion in total energy consumption)- stimulator- $NI_{43t}$ | | | Share of electricity from renewable energy sources, excluding hydropower plants, in total electricity production from renewable sources- stimulator- $NI_{44t}$ | | | Share of electricity derived from renewable energy in total electricity -stimulator- $NI_{45t}$ | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | AZE | GEOR | ARM | AZE | GEOR | ARM | AZE | GEOR | ARM | AZE | GEOR | ARM | AZE | GEOR | ARM |
| 1990 | 0.007 | 0.128 | 0.021 | 0.004 | 0.052 | 0.015 | 0.001 | 0.037 | 0.002 | 0.000 | 0.000 | 0.000 | 0.072 | 0.552 | 0.150 |
| 1991 | 0.008 | 0.141 | 0.023 | 0.005 | 0.060 | 0.015 | 0.001 | 0.043 | 0.002 | 0.000 | 0.000 | 0.000 | 0.075 | 0.571 | 0.162 |
| 1992 | 0.012 | 0.185 | 0.067 | 0.006 | 0.056 | 0.044 | 0.001 | 0.078 | 0.004 | 0.000 | 0.000 | 0.000 | 0.088 | 0.583 | 0.338 |
| 1993 | 0.020 | 0.260 | 0.129 | 0.009 | 0.065 | 0.102 | 0.001 | 0.136 | 0.007 | 0.000 | 0.000 | 0.000 | 0.127 | 0.631 | 0.682 |
| 1994 | 0.015 | 0.227 | 0.178 | 0.008 | 0.105 | 0.125 | 0.001 | 0.062 | 0.010 | 0.000 | 0.000 | 0.000 | 0.104 | 0.614 | 0.621 |
| 1995 | 0.014 | 0.464 | 0.093 | 0.007 | 0.097 | 0.103 | 0.001 | 0.181 | 0.008 | 0.000 | 0.000 | 0.000 | 0.091 | 0.638 | 0.345 |
| 1996 | 0.017 | 0.428 | 0.125 | 0.008 | 0.097 | 0.382 | 0.002 | 0.255 | 0.008 | 0.000 | 0.000 | 0.000 | 0.090 | 0.835 | 0.253 |
| 1997 | 0.020 | 0.444 | 0.101 | 0.009 | 0.126 | 0.270 | 0.002 | 0.238 | 0.007 | 0.000 | 0.000 | 0.000 | 0.102 | 0.844 | 0.231 |
| 1998 | 0.025 | 0.475 | 0.094 | 0.011 | 0.148 | 0.259 | 0.002 | 0.231 | 0.007 | 0.000 | 0.000 | 0.000 | 0.108 | 0.831 | 0.248 |
| 1999 | 0.021 | 0.497 | 0.084 | 0.009 | 0.165 | 0.331 | 0.002 | 0.242 | 0.007 | 0.000 | 0.000 | 0.000 | 0.083 | 0.838 | 0.210 |
| 2000 | 0.021 | 0.473 | 0.072 | 0.009 | 0.151 | 0.292 | 0.002 | 0.225 | 0.006 | 0.000 | 0.000 | 0.000 | 0.082 | 0.789 | 0.212 |
| 2001 | 0.018 | 0.532 | 0.054 | 0.008 | 0.145 | 0.283 | 0.001 | 0.251 | 0.004 | 0.000 | 0.000 | 0.000 | 0.069 | 0.799 | 0.168 |
| 2002 | 0.024 | 0.568 | 0.089 | 0.012 | 0.174 | 0.364 | 0.001 | 0.254 | 0.005 | 0.000 | 0.000 | 0.000 | 0.108 | 0.932 | 0.300 |
| 2003 | 0.029 | 0.553 | 0.098 | 0.014 | 0.169 | 0.320 | 0.002 | 0.238 | 0.006 | 0.000 | 0.000 | 0.000 | 0.116 | 0.911 | 0.360 |
| 2004 | 0.031 | 0.545 | 0.087 | 0.014 | 0.163 | 0.328 | 0.001 | 0.232 | 0.006 | 0.000 | 0.000 | 0.000 | 0.127 | 0.874 | 0.331 |
| 2005 | 0.034 | 0.415 | 0.065 | 0.015 | 0.164 | 0.322 | 0.002 | 0.123 | 0.003 | 0.000 | 0.000 | 0.000 | 0.132 | 0.858 | 0.281 |
| 2006 | 0.029 | 0.372 | 0.077 | 0.013 | 0.122 | 0.316 | 0.002 | 0.123 | 0.005 | 0.000 | 0.000 | 0.000 | 0.103 | 0.729 | 0.307 |
| 2007 | 0.038 | 0.362 | 0.070 | 0.012 | 0.128 | 0.278 | 0.007 | 0.118 | 0.003 | 0.000 | 0.000 | 0.001 | 0.108 | 0.818 | 0.315 |
| 2008 | 0.031 | 0.363 | 0.064 | 0.010 | 0.149 | 0.257 | 0.006 | 0.126 | 0.003 | 0.000 | 0.000 | 0.000 | 0.103 | 0.847 | 0.312 |
| 2009 | 0.033 | 0.367 | 0.078 | 0.011 | 0.155 | 0.302 | 0.006 | 0.123 | 0.003 | 0.000 | 0.000 | 0.001 | 0.122 | 0.866 | 0.357 |
| 2010 | 0.045 | 0.392 | 0.094 | 0.017 | 0.200 | 0.325 | 0.008 | 0.115 | 0.003 | 0.000 | 0.000 | 0.001 | 0.184 | 0.925 | 0.395 |
| 2011 | 0.036 | 0.315 | 0.080 | 0.012 | 0.155 | 0.299 | 0.008 | 0.089 | 0.003 | 0.000 | 0.000 | 0.000 | 0.132 | 0.774 | 0.335 |
| 2012 | 0.028 | 0.287 | 0.066 | 0.008 | 0.144 | 0.246 | 0.007 | 0.083 | 0.003 | 0.000 | 0.000 | 0.000 | 0.079 | 0.745 | 0.289 |
| 2013 | 0.025 | 0.332 | 0.068 | 0.007 | 0.168 | 0.257 | 0.007 | 0.123 | 0.003 | 0.003 | 0.000 | 0.001 | 0.067 | 0.822 | 0.282 |
| 2014 | 0.021 | 0.313 | 0.071 | 0.006 | 0.157 | 0.257 | 0.006 | 0.106 | 0.011 | 0.004 | 0.000 | 0.001 | 0.056 | 0.804 | 0.258 |

Note: Calculated by the authors

**Graph 4:** Dynamics of the composite index of the attraction of new energy sources




energy in this country has a negative impact on energy security. Only one of the sub-indicators included in the fifth group, i.e. "Adjusted net savings, including solid waste emissions share in GHG-stimulator," was evaluated as a stimulator. The other four sub-indicators were rated as non-stimulatory. The indicator, i.e. "Adjusted savings: share of solid waste emissions in GHG (%) is non-stimulant and has "10" value for its maximum, as well as "0" for the minimum. The indicator "Volume of carbon emissions per unit of GDP volume (kg)" is non-stimulant and has maximum value as "5," as well as the minimum value as "0." The indicator "volume of carbon emissions per capita (metric tons per capita)" is non-stimulant and we will take the maximum value for this indicator as "60" and the minimum value as "0." The indicator "Adjusted net saving, including solid waste emission, plays the role of a share (%) in GHG" is stimulator, and we will take "60" for the maximum value of this indicator, and "-60" for the minimum value. The indicator "share of carbon emission damage in GMM (%)" is non-stimulant and we will take "60" for the maximum of this indicator and "0" for the minimum.

The dynamics of normalized values for the fifth group of indicators, i.e. indicators characterizing the waste generated during the extraction industry, are given in Table 5. According to this indicator, the dynamics of Azerbaijan in the last 10 years is positive. In the last 20 years, the composite indicator has grown rapidly. In the last 20 years, changes in these indicators in Georgia and Armenia were less than in Azerbaijan.

The composite index for the fifth group will be calculated by the equation (6). The indicators of all three South Caucasus countries on the fifth group of indicators are very close after 2016. However, in the period from 2008 to 2015, Azerbaijan's performance on these indicators was better than both Georgia and Armenia. Until

2006, Azerbaijan's position on these indicators was much weaker. However, after 2014, there was a slight decrease (Graph 5). Despite the rapid improvement of the obtained results, the indicators of Azerbaijan are still far behind the developed countries.

The results for the sixth group of indicators, i.e. indicators characterizing access to resources, are given in Table 6. Each of these indicators was considered as a stimulator. Each indicator is directly related to the well-being of the population. The maximum value for these indicators is "100" and the minimum value is "0."

The obtained results prove that Azerbaijan has a high position on these indicators. Households in villages and cities of Azerbaijan, Georgia and Armenia are fully supplied with electricity. The dynamics of this composite indicator are given in Graph 6.

According to the equation (2) we can calculate the composite index $ESI_t$ based on the results obtained in Tables 1-6. The obtained result shows that Azerbaijan's energy security was slightly higher than average in the period between 2001 and 2014 (Graph 7). However, it is necessary to take necessary steps to increase this indicator and take necessary measures to reduce non-stimulating indicators.

The obtained results show that a positive trend towards improvement of energy security is observed in all three South Caucasus countries. but the growth rate of this trend is weak. Due to the large share of renewable energy sources in Georgia's

**Table 5: The fifth group of indicators: indicators characterizing the waste generated during the extraction industry in the South Caucasus countries**

| | Adjusted savings: Share of solid waste emissions in GHG -non-stimulant- $NI_{51t}$ | | | Volume of carbon emissions per unit of GDP volume (kg)-non-stimulant- $NI_{52t}$ | | | Volume of carbon emissions per capita (metric tons per capita)-non-stimulant- $NI_{53t}$ | | | Adjusted net savings, including solid waste emissions share in GHG-stimulator- $NI_{51t}$ | | | Share of carbon emission damage in GNI-non-stimulant- $NI_{55t}$ | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | AZE | GEOR | ARM | AZE | GEOR | ARM | AZE | GEOR | ARM | AZE | GEOR | ARM | AZE | GEOR | ARM |
| 1998 | 0.085 | 0.106 | 0.063 | 0.196 | 0.052 | 0.061 | 0.056 | 0.020 | 0.019 | 0.285 | 0.526 | 0.372 | 0.253 | 0.038 | 0.051 |
| 1999 | 0.066 | 0.104 | 0.062 | 0.180 | 0.046 | 0.053 | 0.055 | 0.018 | 0.017 | 0.299 | 0.544 | 0.387 | 0.242 | 0.046 | 0.049 |
| 2000 | 0.059 | 0.114 | 0.058 | 0.172 | 0.048 | 0.057 | 0.057 | 0.019 | 0.019 | 0.252 | 0.467 | 0.349 | 0.242 | 0.048 | 0.057 |
| 2001 | 0.052 | 0.109 | 0.055 | 0.149 | 0.033 | 0.053 | 0.054 | 0.015 | 0.020 | 0.345 | 0.540 | 0.404 | 0.226 | 0.035 | 0.054 |
| 2002 | 0.047 | 0.098 | 0.049 | 0.135 | 0.027 | 0.040 | 0.053 | 0.012 | 0.017 | 0.427 | 0.546 | 0.443 | 0.212 | 0.029 | 0.043 |
| 2003 | 0.044 | 0.077 | 0.045 | 0.134 | 0.026 | 0.040 | 0.058 | 0.013 | 0.019 | 0.490 | 0.520 | 0.503 | 0.173 | 0.028 | 0.043 |
| 2004 | 0.042 | 0.064 | 0.043 | 0.121 | 0.026 | 0.039 | 0.057 | 0.014 | 0.021 | 0.508 | 0.567 | 0.540 | 0.153 | 0.024 | 0.037 |
| 2005 | 0.037 | 0.052 | 0.041 | 0.101 | 0.030 | 0.040 | 0.060 | 0.018 | 0.025 | 0.575 | 0.554 | 0.584 | 0.121 | 0.025 | 0.034 |
| 2006 | 0.030 | 0.043 | 0.040 | 0.076 | 0.030 | 0.036 | 0.060 | 0.020 | 0.025 | 0.603 | 0.492 | 0.628 | 0.076 | 0.024 | 0.028 |
| 2007 | 0.023 | 0.038 | 0.038 | 0.055 | 0.032 | 0.037 | 0.054 | 0.024 | 0.030 | 0.635 | 0.486 | 0.632 | 0.042 | 0.024 | 0.023 |
| 2008 | 0.021 | 0.040 | 0.039 | 0.055 | 0.027 | 0.037 | 0.058 | 0.021 | 0.033 | 0.664 | 0.424 | 0.634 | 0.030 | 0.017 | 0.021 |
| 2009 | 0.020 | 0.046 | 0.050 | 0.042 | 0.032 | 0.035 | 0.048 | 0.025 | 0.026 | 0.648 | 0.395 | 0.520 | 0.028 | 0.024 | 0.023 |
| 2010 | 0.022 | 0.046 | 0.052 | 0.038 | 0.029 | 0.032 | 0.045 | 0.023 | 0.025 | 0.661 | 0.471 | 0.500 | 0.023 | 0.021 | 0.021 |
| 2011 | 0.021 | 0.047 | 0.050 | 0.043 | 0.033 | 0.035 | 0.050 | 0.029 | 0.029 | 0.676 | 0.467 | 0.485 | 0.023 | 0.022 | 0.023 |
| 2012 | 0.021 | 0.046 | 0.046 | 0.046 | 0.034 | 0.038 | 0.054 | 0.032 | 0.033 | 0.673 | 0.505 | 0.511 | 0.024 | 0.023 | 0.027 |
| 2013 | 0.019 | 0.046 | 0.042 | 0.045 | 0.036 | 0.036 | 0.055 | 0.035 | 0.032 | 0.671 | 0.513 | 0.516 | 0.024 | 0.025 | 0.025 |
| 2014 | 0.018 | 0.044 | 0.040 | 0.045 | 0.037 | 0.034 | 0.056 | 0.038 | 0.031 | 0.681 | 0.513 | 0.504 | 0.025 | 0.027 | 0.025 |
| 2015 | 0.018 | 0.044 | 0.040 | 0.044 | 0.039 | 0.032 | 0.055 | 0.041 | 0.030 | 0.612 | 0.491 | 0.538 | 0.036 | 0.037 | 0.028 |
| 2016 | 0.020 | 0.050 | 0.040 | 0.046 | 0.040 | 0.031 | 0.055 | 0.043 | 0.029 | 0.553 | 0.513 | 0.533 | 0.055 | 0.040 | 0.028 |
| 2017 | 0.019 | 0.048 | 0.035 | 0.046 | 0.038 | 0.030 | 0.054 | 0.043 | 0.030 | 0.580 | 0.532 | 0.528 | 0.051 | 0.039 | 0.028 |
| 2018 | 0.019 | 0.044 | 0.034 | 0.046 | 0.036 | 0.030 | 0.055 | 0.043 | 0.032 | 0.567 | 0.554 | 0.515 | 0.047 | 0.037 | 0.029 |
| 2019 | 0.019 | 0.045 | 0.032 | 0.049 | 0.036 | 0.031 | 0.059 | 0.045 | 0.035 | 0.560 | 0.535 | 0.468 | 0.049 | 0.041 | 0.029 |

Note: Calculated by the authors

**Graph 5:** The dynamics of the composite index of the group of indicators representing the waste generated during the extraction industry

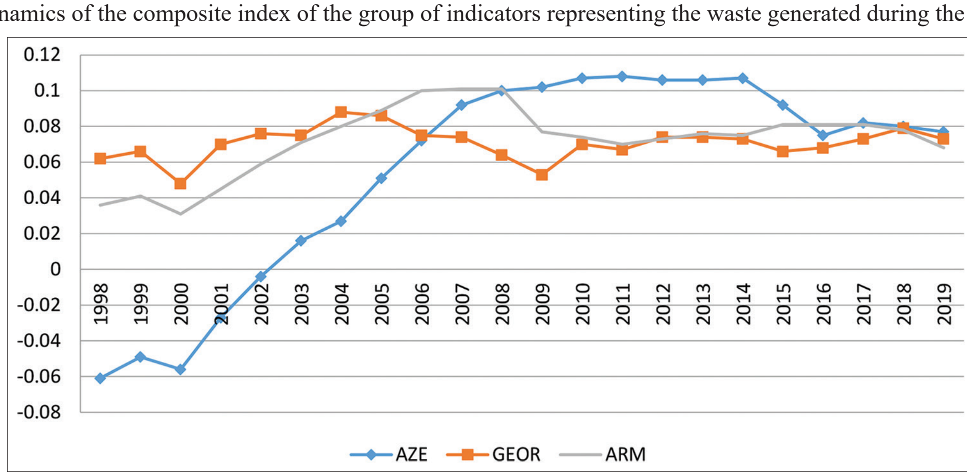
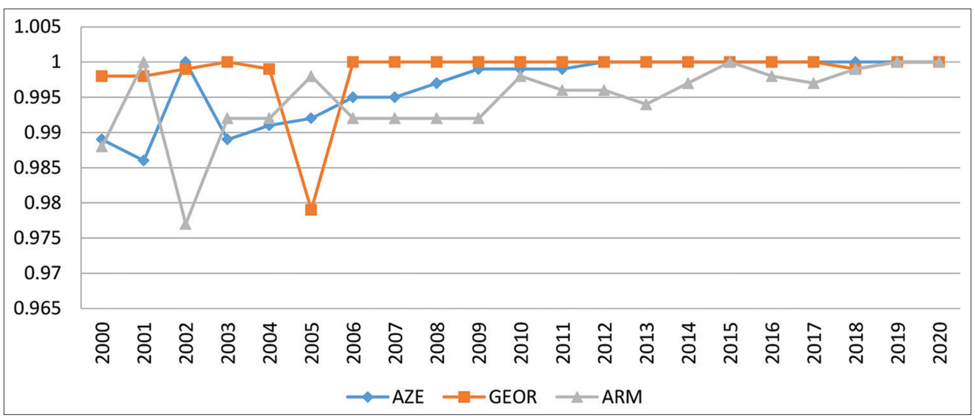


**Table 6: The sixth group of indicators: Indicators characterizing access to resources in the South Caucasus countries**

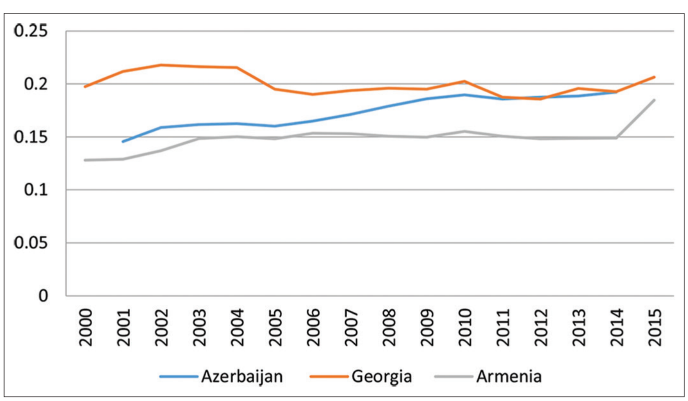
| | Share of the population supplied with electricity in the total population- $NI_{61t}$ | | | The share of the population supplied with electricity in rural regions in the number of people living in such regions- $NI_{62t}$ | | | Share of the population supplied with electricity in cities in the total urban population- $NI_{63t}$ | | |
|---|---|---|---|---|---|---|---|---|---|
| | AZE | GEOR | ARM | AZE | GEOR | ARM | AZE | GEOR | ARM |
| 2000 | 0.989 | 0.998 | 0.989 | 0.981 | 0.997 | 0.985 | 0.997 | 0.999 | 0.991 |
| 2001 | 0.986 | 0.998 | 1.000 | 0.976 | 0.997 | 1.000 | 0.996 | 0.999 | 1.000 |
| 2002 | 1.000 | 0.999 | 0.980 | 1.000 | 0.998 | 0.957 | 1.000 | 1.000 | 0.993 |
| 2003 | 0.989 | 1.000 | 0.992 | 0.983 | 1.000 | 0.991 | 0.996 | 1.000 | 0.993 |
| 2004 | 0.991 | 0.999 | 0.992 | 0.985 | 0.999 | 0.991 | 0.996 | 0.999 | 0.992 |
| 2005 | 0.992 | 0.979 | 0.998 | 0.988 | 0.975 | 0.996 | 0.996 | 0.983 | 0.999 |
| 2006 | 0.995 | 1.000 | 0.992 | 0.992 | 1.000 | 0.990 | 0.998 | 1.000 | 0.993 |
| 2007 | 0.995 | 1.000 | 0.992 | 0.993 | 1.000 | 0.989 | 0.997 | 1.000 | 0.993 |
| 2008 | 0.997 | 1.000 | 0.992 | 0.995 | 1.000 | 0.989 | 0.998 | 1.000 | 0.994 |
| 2009 | 0.999 | 1.000 | 0.992 | 0.998 | 1.000 | 0.988 | 0.999 | 1.000 | 0.995 |
| 2010 | 0.999 | 1.000 | 0.998 | 0.999 | 1.000 | 1.000 | 1.000 | 1.000 | 0.997 |
| 2011 | 0.999 | 1.000 | 0.996 | 0.999 | 1.000 | 0.996 | 0.999 | 1.000 | 0.996 |
| 2012 | 1.000 | 1.000 | 0.996 | 1.000 | 1.000 | 0.994 | 1.000 | 1.000 | 0.998 |
| 2013 | 1.000 | 1.000 | 0.994 | 1.000 | 1.000 | 0.994 | 1.000 | 1.000 | 0.994 |
| 2014 | 1.000 | 1.000 | 0.997 | 1.000 | 1.000 | 0.998 | 1.000 | 1.000 | 0.997 |
| 2015 | 1.000 | 1.000 | 1.000 | 1.000 | 1.000 | 1.000 | 1.000 | 1.000 | 1.000 |
| 2016 | 1.000 | 1.000 | 0.998 | 1.000 | 1.000 | 0.998 | 1.000 | 1.000 | 0.998 |
| 2017 | 1.000 | 1.000 | 0.997 | 1.000 | 1.000 | 0.995 | 1.000 | 1.000 | 0.998 |
| 2018 | 1.000 | 0.999 | 0.999 | 1.000 | 1.000 | 0.999 | 1.000 | 0.998 | 0.999 |
| 2019 | 1.000 | 1.000 | 1.000 | 1.000 | 1.000 | 1.000 | 1.000 | 1.000 | 1.000 |
| 2020 | 1 | 1.000 | 1.000 | 1.000 | 1.000 | 1.000 | 1 | 1.000 | 1.000 |

Note: Calculated by the authors

**Graph 6:** Dynamics of the composite index of the resource access group




**Graph 7:** Dynamics of energy security composite index of the South Caucasus countries




energy balance, its energy security is less risky than in Azerbaijan and Armenia. However, as a result of the expansion of the use of renewable energy sources in Azerbaijan in recent years, the level of energy security in Azerbaijan is increasing. The large volume of energy imports and the use of nuclear energy in Armenia pose additional risks to its energy security. It should be noted that energy security in all three countries is much lower than the desired "1" level. The main reasons are (1) the low level of use of renewable energy sources and (2) the low efficiency of the energy used.

## 4. CONCLUSION

South Caucasus countries differ from each other due to the use of different energy sources. Azerbaijan is rich in hydrocarbon energy. Georgia has few sources of hydrocarbon energy, but Azerbaijan's export oil and gas pipelines pass through this country and it imports the necessary amount of energy from Azerbaijan. Renewable energy sources are also widely used in Georgia. Armenia does not have hydrocarbon energy sources and the possibilities of using renewable energy sources are also limited. However, an important part of the energy supply of this country is provided by the nuclear power plant and imports.

According to the results, since Georgia uses more renewable energy sources, its energy security is less risky. Ensuring long-term energy security in Azerbaijan requires greater use of renewable energy sources. Armenia's energy security is at higher risk due to its higher dependence on imports and poor use of renewable resources. Thus, the current situation of energy security of South Caucasus countries can still be considered risky. In order to reduce the risk, there is a need to increase the use of renewable energy sources and increase the efficiency of energy use.

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