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ANALYSIS OF TERRITORY ENERGY SECURITY IN THE CONTEXT OF SUSTAINABLE DEVELOPMENT (CASE OF GEORGIA)

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Abstract

The topicality of energy security (*EnS*) issues is confirmed by the unstable energy situation in the macroeconomic space. Countries with low energy potential risk losing autonomy. The development of methods for conducting EnS analysis will become an effective tool for reducing such negative threats. The goal of this research is to build a toolkit for the analysis of *EnS* for territories. To do this, it is proposed to consider the Energy Trilemma Index (*ETI*), to work out a methodology for assessing the level of EnS and to build a regression model of dependence of the obtained values on the selected economic parameters. The scientific novelty of the proposed toolkit lies in development of a methodology that allows the comparison of the EnS level of different territories and the identification of “influence-factors”. The developed tools were tested on the case of Georgia, for which *EnS* issues are a national priority. As a result of the test, the trend of reduction in Georgia’s level of EnS (from 0.772 in 2008 to 0.705 in 2018) was revealed, and Georgia’s dependence on the state of import-exports was substantiated. The findings show the viability of the model and the possibility of adapting it to other territories. The importance of the problem of maintaining *EnS* is growing today due to the need to ensure the sustainable development of territories at different levels. In this context, the expansion of scientific and applied knowledge in this area is aligning with the interests of regional economies and the world community.

Keywords: energy security, energy economics, innovative energy, sustainable development, energy sustainability, regional economy.

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АНАЛИЗ ЭНЕРГЕТИЧЕСКОЙ БЕЗОПАСНОСТИ ТЕРРИТОРИИ В КОНТЕКСТЕ УСТОЙЧИВОГО РАЗВИТИИ (НА ПРИМЕРЕ ГРУЗИИ)

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Аннотация

Актуальность вопросов энергетической безопасности подтверждается нестабильной энергетической обстановкой в макроэкономическом пространстве. Страны со слабым энергетическим потенциалом рискуют потерять свою самостоятельность. Развитие способов проведения анализа энергетической безопасности станет действенным инструментом для сокращения таких негативных угроз. Цель исследования заключается в построении инструментария для проведения анализа энергетической безопасности территорий. Для этого предлагается рассмотреть Индекс энергетической трилеммы, проработать методику оценки уровня энергетической безопасности и построить регрессионную модель зависимости полученных значений от отобранных экономических параметров. Научная новизна предложенного инструментария заключается в разработке методики, позволяющей сопоставить уровень энергетической безопасности различных территорий и выявить «факторы-влияния». Выработанный инструментарий был апробирован на примере Грузии, для которой вопросы энергетической безопасности являются приоритетными на национальном уровне. В результате апробации выявлен тренд на снижение уровня энергетической безопасности страны (с 0.772 в 2008 году до 0.705 в 2018 году) и обоснована его зависимость от состояния импорта-экспорта. Полученные данные свидетельствуют о жизнеспособности данной модели и возможности ее адаптации к другим странам и территориальным структурам. С авторской позиции отмечено, что высокая значимость проблемы поддержания энергетической безопасности приобретается на сегодняшний день в связи с необходимостью обеспечения устойчивого развития регионов и территорий на разных уровнях. В таком контексте расширение научных и прикладных знаний данного направления соответствует интересам региональной экономики и мирового сообщества.

Ключевые слова: энергетическая безопасность, экономика энергетики, инновационная энергетика, устойчивое развитие, устойчивость энергетики, региональная экономика.

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1. Introduction

The complex apparatus of *EnS* does not allow the formation of a unified system of energy process management. The macroeconomic space is constantly becoming more complex, having a direct or indirect impact on the energy situation of countries, regions, territories. For example, there is serious energy instability in many areas of the planet because of ever-increasing energy consumption. Many countries lack sufficient energy capacity, which leads to the risk of loss of independence in the event of excessive dependence on energy resources and their irrational use. The energy crisis of 2008 proved the emergence of global problems due to the insolvency of energy systems (Li and Liu, 2013), (Öztürk et al., 2013).

The current scientific thought on *EnS* is incomplete and highly fragmented, and its further formation expands the apparatus of search for energy efficiency strategies with certain alternatives and compromises. In particular, a number of studies (Böhringer and Bortolamedi, 2015; Cherp and Jewell, 2014), note the need to develop a multi-purpose energy policy. The strategy for *EnS* support facilitates detailed exploration of vulnerabilities for a combination of potential risks and sustainability parameters. Energy systems should be considered a vital element of the regional economy, hence the need to expand the existing apparatus to identify synergies between *EnS* and sustainability. As Axon and Darton (2021) have demonstrated, the methodological analysis of risks in energy systems remains barely studied; however, the further development of knowledge would be practically impossible without deepening the theoretical and methodological basis.

Thus, it becomes much more urgent to explore the possibilities of rational implementation of *EnS* measures, which will result in the resolution of methodological difficulties. Despite the existence of approaches to energy resource research in international practice, there exist limitations in the theoretical and practical consideration of the *EnS* category (Jakstas, 2020). This article proposes to develop a toolkit for *EnS* analysis based on the need to decrease current negative threats influencing the energy sector.

The scientific novelty of the study lies in the development of a toolkit that facilitates not only the determination of the level of *EnS* of various territories (country, region, etc.) but also the identification of "influence-factors" by which it is proposed to understand the determining factors contributing to the change at this level. The study importance is confirmed by the fact that based on the proposed methodology, it becomes possible to form *EnS* management mechanisms by changing the influence of certain factors.

The purpose of the study is to build a toolkit for analysing the *EnS* of territories. Achieving this goal requires addressing the following objectives: consideration of methods for estimating *EnS* based on the *ETI* analysis; working out a methodology for assessing *EnS* at the territorial level; building a re-gression model of the dependence of the obtained values on the selected economic parameters. In the context of the study, the national level is considered, and the indicators are adapted to analyse the country. The practical testing of the analytical toolkit was carried out using Georgia as an example.

2. Literature review

2.1. Common energy security issues

Energy security issues have been under consideration for a long time, so there is a sufficient body of research exploring the conditions for building energy potential and reducing the negative impact of systemic constraints. It is necessary to mention the research on the economic aspects of energy functioning and opportunities for diversification of the energy balance, in particular the studies of Bahgat (2008), Biggar and Hesamzadeh (2014) and Pillay et al. (2015). Öztürk et al. (2013) provide a comparative analysis of the energy independence of countries based on statistical analysis. All researchers note that the problem of energy independence and *EnS* will only gain importance in the scientific and practical sense every year in association with the inevitable increase in energy consumption.

The innovative component of sustainable development plays a massive role in the construction of rational energy policies. Continuous work in the area of innovation development allows us to build the innovative potential of enterprises and industries, as discussed by Mamrayeva et al. (2018). This practice is also common in the energy sector, without innovative renewal of production assets, it is impossible to ensure the *EnS* of fuel and energy enterprises and industries. The importance of integrated innovation development reflects the possibility of creating additional value for the energy complex because of their innovative transformation. Innovative value, discussed by Zaytsev et al. (2020a, 2020c), should become an incentive to transform energy enterprises, and the focus of innovation in *EnS* can be an effective tool of public energy policy.

It should be noted that *EnS* gains key importance for regional development as the creation of favourable interactions between corporate structures in the energy sector and local governments ensures the improvement not only of energy but also of economic security of territory (Kichigin et al., 2018). The energy policy of the territories should be aimed at the rational import of primary energy sources and maintaining the stability of the energy balance (Vosta and Musiyenko, 2015). The imperfection of regional economic policy does not ensure the maximum level of *EnS* of a territory. These imperfections should include the ratio of economic, environmental, energy, social and other interests. Maintaining sustainable development causes a reduction in the negative impact on the environment, which can lead to a decrease in the *EnS* level and industrial production, which is analysed by Tvaronavičienė et al. (2015). This practice negatively influences the territories functioning and necessitates the search for new energy policy instruments.

The transformation of the ecological and economic space of territorial formations determines the development and transformation of various segments of the national economy, including the energy sector, which should take into account the mechanisms for regulating innovation on the basis of green economy principles (Shabunina et al., 2017). Now, energy resources are a key source of economic development, and their lack can lead to a decline in economic growth, up to the complete stagnation or degradation of economic relations. At the same time, energy must be environmentally friendly and aimed at maintaining the sustainability of the territories. This practice necessitates implementation of eco-innovations in the energy sector and ways to provide environmentally sustainable energy resources, the essence of which is reflected in the work of Blum and Legey (2012). To support this approach, it is necessary to attract investments in complex projects and implement new methods of strategic management of economic complexes; for example, it is possible to introduce lean manufacturing tools into the energy sector (Zaytsev et al., 2020b).

After analysing the scientific literature, it becomes clear that *EnS* faces a number of economic problems that prevent the development of policies aimed at purposefully reducing costs, as noted by Labandeira and Manzano (2012). However, the importance of *EnS* remains undeniable as this indicator characterises the degree of significant vulnerability of the economy in the global energy market. The crisis state of energy systems in various regions prevents long-term forecasts and high-quality results for maintaining the energy balance of territories. The development and adaptation of methodological approaches to the analysed problem will facilitate solutions to some pressing issues and improvements to the existing *EnS* policy.

2.2. Energy security methodological issues

EnS is one of the key elements of national security, which increases the importance of forming a methodological apparatus for its practical analysis. Thus, many approaches and techniques for practical calculations have been implemented in the scientific community. At the same time, many methods require the use of a significant amount of information, which makes them difficult to implement. Thus, the researcher is primarily interested in finding ways to assess energy security with a minimum number of indicators. For example, the research analyses and expands the requested assessment of *EnS* based on widely available information as proposed by Vasikov et al. (2010).

An overview of methods for assessing *EnS* for the comparison of different territories, for example, was presented by Berezhnaya and Yegorchenko (2012) and Mazur (2014). Modern approaches to assessing the *EnS* of a territory allow researchers to calculate general and specific indicators of energy resource use efficiency. The obtained results can be used to determine the reserves for boosting energy potential and forming economically sound ways for making management decisions aimed at preventing and neutralising energy threats. Meanwhile, for specific countries and regions, different methods and approaches can be applied, considering specific conditions of functioning for these territories. Specific practical methods for evaluating and analysing *EnS* have been studied. Augutis et al. (2012) proposed a dynamic model for assessing the level of *EnS* for Lithuanian conditions; Kisel et al. (2016) described approaches and reflected the *EnS* matrix based on Estonian data; Sovacool (2013) examined *EnS* indices in Japan, Laos and Myanmar; Smagulova et al. (2018) and Amirov et al. (2018) considered Kazakhstan's *EnS*; and Myzin et al. (2012) described a developed software complex for calculating the state of *EnS* in the Russia.

If sufficient information is available, it is possible to use expert methods, such as those discussed by the Karapetyan (2009). The extended method of expert assessments allows the determination of the *EnS* level for certain types of energy resources. In the scientific literature, in most cases, an indicative method is used, which implies the use of many indicators that can be combined into blocks, such as electricity supply, heat supply, fuel supply, structural-mode blocks and reproduction of energy reserves. The data obtained after structuring allow us not only to determine the value of indicators but also to highlight their threshold values to prevent the onset of crisis situations (Biggar and Hesamzadeh, 2014; Dyer and Trombetta, 2013; Reddy and Ulgiati, 2015).

Despite the effectiveness of statistical methods, such calculations are extensive and time consuming and require greater accessibility of the information base. However, less precise methods are permissible for highlighting key factors and obtaining comparative results for different territories. In this study, of interest was the economic and mathematical modelling used to highlight key parameters. Specifically, Dmitriev et al. (2021) and Lebedev et al. (2014) considered the possibility of constructing optimisation models in the electricity industry based on correlation-regression analysis. So, it is fair to say that the use of mathematical modelling makes it possible to identify the key factors that influence the change in each parameter of the regression model.

3. Materials and Methods

At the first stage, it is proposed to analyse the concept of the ETI. According to this concept, a balance must be maintained between the three pillars of the trilemma. There is no single indicator of *EnS* in international practice, and the use of a global index based on statistics allows the construction of

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a model of *EnS* based on balanced indicators. ETI, ensuring balance through the integration of energy systems, allows the assessment of a country's ability to facilitate sustainable energy. The first assessment of the *ETI* was carried out in 2010. This index allows to track the country's progress in the energy sector and look for weaknesses in its energy policy to eliminate them as soon as possible.[1]

In the 2020 ranking, 108 countries were selected to construct a balance assessment (AAA – highest score and DDD – lowest). The first letter represents *EnS*, the second letter represents energy equity and the last letter represents the environmental sustainability of energy systems. Trilemma scores are weighted indicators (0 to 100 points, with lower scores indicating more effective energy policy) for each measure (so-called national results) (Fu et al., 2021; Tovar-Facio et al., 2021). The key indicators (lower indicators indicate a higher Trilemma Index):

1. Energy security: the country's ability to reliably meet current and future energy demand and to withstand and recover swiftly from systemic shocks with minimal supply disruptions.

2. Energy equity: the country's ability to provide universal access to reliable, affordable and abundant energy for domestic and commercial use.

3. Environmental sustainability: the transition of the country's energy system to mitigating and preventing potential environmental damage and the effects of climate change.

It can be concluded that this interactive index is an effective way to assess the sustainability of national energy policy. It should be used as a tool to construct energy policy analysis and forecast its transformation in order to improve quality returns (Song et al., 2017). In the research, this index is used to reveal economic indicators, controlling which can ensure the growth of *EnS*.

It should be noted that the status of *ETI* is determined based on factors that include the following indicators: the concentration of primary energy reserves in the territory, dependence on energy imports, the price of energy for industry actors, the intensity of carbon dioxide emissions, the state of the environment and the impact on it and the concentration of electricity generation. At the same time, the use of this method in the context of *EnS* assessment is not universal as the lack of relevant data and the confidentiality of information make it impossible to make calculations for many countries, as well as for the period up to 2010.

In order to achieve high-quality *EnS* at the national level, monitoring and timely assessment of *EnS* should be ensured on the basis of the definition of a given set of parametric indices (Reddy and Ulgiati, 2015). Indices should reflect the development of mechanisms for ensuring the *EnS* of a territory, making it possible to identify problem areas in the functioning of an energy system. In this manner, at the research stage, it is proposed to assess the level of *EnS* of a territory, which can be further used to identify the main factors and threats that impede its provision. The toolkit was based on a simplified assessment of the level of *EnS* based on widely available information (Vasikov et al., 2010), in which the following indicators were selected to calculate the *EnS* index: the human development index, the solvency index and the efficiency index. The final formula for assessing *EnS* is calculated according to Formula 1.

$$I_{es} = \tfrac{1}{2} \times (I_{hr} + I_{s}) \times I_{ef}, \tag{1}$$

I_{es} – energy security index;
I_{hr} – human development index;
I_{s} – solvency index;
I_{ef} – efficiency index.

[1] WES, World Energy Trilemma Index, 2020. https://trilemma.worldenergy.org/.

At the same time, methods and step-by-step toolkits were proposed to calculate each index. However, the proposed methodologies are subject to revision to improve the quality of the calculation values. It is possible to use weight coefficients of the integral index (Karapetyan, 2009) to increase the effective part of the resulting score. The weight coefficients are in the range between 0 and 1. The classic version of the integral index calculation is shown in Formula 2.

$$LI_{es} = \sum (k_i \times N_i), \tag{2}$$

LI_{es} – energy security index;
k_i – weight at the stage i ($\sum i=1$);
N_i – value of an indicator at the stage i.

The presence of secondary and irrelevant data based on expert assessments in this formula distorts the results, making it impossible to base practical recommendations solely on this approach. In the toolkit, it is proposed to set weights only to index values, which will help form an apparatus of identification of factors and risks that determine the functioning of the energy sector. In this manner, the assessment of *EnS* in the toolkit for the analysis of the *EnS* of a territorial association is calculated in three stages:

1. Self-sufficiency index calculation (Formulas 3 and 4). This index differs by calculations from the previously mentioned solvency index. Data on the consumption and production of primary energy are used to calculate it. Formula 3 is extended and is used in the case of combinatory models for a certain period exceeding 20 years. Formula 4 is standardised and suitable for a quick assessment that is part of the integrated *EnS* index.

$$I_{\Delta ss} = ((P_{pe\,j} / C_{pe\,j}) - (P_{pe\,min} / C_{pe\,max})) / ((P_{pe\,max} / C_{pe\,min}) - (P_{pe\,min} / C_{pe\,max})), \tag{3}$$

$I_{\Delta ss}$ – combinatory index of a territory's energy self-sufficiency.;
$P_{pe\,j}$ – value of primary energy production at stage j;
$P_{pe\,min}$ – minimum value of primary energy production;
$P_{pe\,max}$ – maximum value of primary energy production;
$C_{pe\,j}$ – value of primary energy consumption at stage j;
$C_{pe\,min}$ – minimum value of primary energy consumption;
$C_{pe\,max}$ – maximum value of primary energy consumption.

$$I_{\Delta(st)ss} = P_{pe\,j} / C_{pe\,j}, \tag{4}$$

$I_{\Delta(st)ss}$ – standardised index of a territory's energy self-sufficiency;
$P_{pe\,j}$ – value of primary energy production at stage j;
$C_{pe\,j}$ – value of primary energy consumption at stage j.

2. Efficiency index calculation (Formulas 5 and 6). It uses data on net consumption and electricity generation. Formula 5 is extended and is used in the case of combinatory models for a certain period exceeding 20 years. Formula 6 is standardised and suitable for a quick assessment that is part of the integral *EnS* index.

$$I_{\Delta ef} = ((G_{ne\,j} / D_{ne\,j}) - (G_{ne\,min} / D_{ne\,max})) / ((G_{ne\,max} / D_{ne\,min}) - (G_{ne\,min} / D_{ne\,max})), \tag{5}$$

$I_{\Delta ef}$ – combinatory index of energy efficiency of the territory;
$G_{ne\,j}$ – net power generation at stage j;

$G_{ne\ min}$ – minimum value of net electricity generation;
$G_{ne\ max}$ – maximum value of net electricity generation;
$D_{ne\ j}$ – net electricity consumption at stage j;
$D_{ne\ min}$ – minimum value of net electricity consumption;
$D_{ne\ max}$ – maximum value of net electricity consumption.

$$I_{\Delta(st)ef} = G_{ne\ j} / D_{ne\ j}, \tag{6}$$

$I_{\Delta(st)ef}$ – standardised index of a territory's energy efficiency;
$G_{ne\ j}$ – net power generation at stage j;
$D_{ne\ j}$ – net electricity consumption at stage j.

3. Energy security index calculation (Formula 7). This index differs in calculations from the previously mentioned *EnS* formula. It is based on an integral assessment and the introduction of weight coefficients. These coefficients are based on expert assessments and fair distribution of indices.

$$I_{\Delta(st)es} = 0.2 \times I_{hr} + 0{,}4 \times I_{\Delta(st)ss} + 0.4 \times I_{\Delta(st)ef}, \tag{7}$$

The third step proposes to use the *EnS* assessment to identify the threats that have a direct impact on the energy supply of a territory due to external and internal factors. To do this, it is proposed to use the apparatus of economic and mathematical analysis and, more specifically, a regression model based on the least squares method (Dmitriev et al., 2021; Lebedev et al., 2014). Over 20 parameters were selected for the analysis, of which it is recommended to keep only the most significant, considering the presence of multicollinearity and the conformity of parameters to the specified values of the model. Formula 8 presents the model of the least square's method of the optimisation problem, allowing the selection of indicators that have the strongest or most insignificant impact on the dynamics of the model indicators. For the resulting indicator, it is possible to choose the *ETI* or Energy Security Index. Formula 8 demonstrates the classic approach to calculating the regression model.

$$Y_{es} = a_i \times X_i + const, \tag{8}$$

Based on the data, it is possible to obtain the mathematical values of dependent and independent variables, reflecting the quantitative indicators of the factors analysed. After selecting statistically significant results with minimal standard deviations, it is possible to identify parameters that can be used to manage the *EnS* of the territory. If the energy base is divided into separate components, it is possible to identify ways to diversify the sources of energy imports and create a system of optimal energy supplies to maintain energy independence. However, the proposed toolkit is one of many in economic science, and now there is no generally accepted method of assessing *EnS* due to the inability to accurately evaluate the various territries based on an identical apparatus.

4. Results

4.1. Georgia's energy situation: Trilemma Index and key economic parameters

Adaptation of the *EnS* analysis toolkit to Georgia facilitates discourse about the situation of the country in the energy space. To begin with, the *ETI* (Table 1) was analysed. Georgia is ranked 53rd, and its *EnS* leaves much to be desired. It should be noted that the energy sector is dominated

Table 1. Place of Georgia and other post-Soviet countries in the ETI

Index rank	Country name	Balance grade	Trilemma score	Energy security rank	Energy equity rank	Enviromental sustainability rank
16	Lithuania	BAA	77.6	43	18	16
22	Latvia	ABB	76.4	5	54	31
26	Estonia	BAB	75.3	38	23	52
29	Russia	AAC	73.8	16	12	73
36	Azerbaijan	ABB	72.1	17	44	54
42	Kazakhstan	ABD	70.3	15	38	83
43	Albania	DBA	69.9	83	53	4
50	Ukraine	ACB	68.9	12	74	49
53	Georgia	CBB	67.6	66	70	34
54	Armenia	CBB	67.4	66	65	34
83	Tajikistan	DCC	57.1	86	82	69
84	Moldova	CCD	56.9	81	81	88

by hydropower, which can fluctuate depending on weather and climatic conditions. Additionally, a dependence on fossil fuels remains. However, the country's small population (3.7 million people) has high access to electricity, and prices remain at an affordable level. In many ways, the ranking is improved by reducing CO2 emissions and maintaining sustainable energy. Now, there is an increase in the consumption of energy resources, primarily in the industrial sector, which leads to an increase in the country's energy dependence and may negatively affect *EnS*.

Forecasts for 2020 showed that among the countries in the post-Soviet space there are no states with secure energy sectors, and Georgia is at risk. In the following 10 years, the onset of an energy shortage is possible due to the expansion of energy consumption. Such forecasts necessitate the search for ways to improve *EnS*, the development of which should begin with the construction of high-quality analytical models.

It is possible to use *EnS* assessment methods based on rating comparisons, indicative parameters, expert modelling; however, their use will not provide objective information, as there are insufficient data for comprehensive analysisй. Table 2 and Figure 1 show data on the ETI, which displays gaps and insufficient information. The lack of statistics for the area does not allow the formation of models of *EnS* analysis through this indicator.

It is worth noting that the rapid growth of energy consumption with insufficient power generation is not conducive to talking about ensuring *EnS*. Alternative energy, which the state relies on, does not provide for all the needs of the country, and hydropower capacity hardly covers domestic needs.[2] It is necessary to establish measures to revise the energy policy, considering the methodological approaches to the transformation of regional relations in the way of sustainable development since the formation of economic parameters within *EnS* is impossible to imagine without taking into account socio-environmental factorsв.[3]

Table 2. Change in the *ETI* (Georgia)

	2014	2015	2016	2018	2019	2020
Trilemma score	55	51	51	69	63.1	67.6
Change	–	–7.27%	–	35.29%	–8.55%	7.13%

[2] WES, World Energy Trilemma Index, 2020. https://trilemma.worldenergy.org/

[3] ESCO, Energy Balance, 2021. https://esco.ge/en/energobalansi

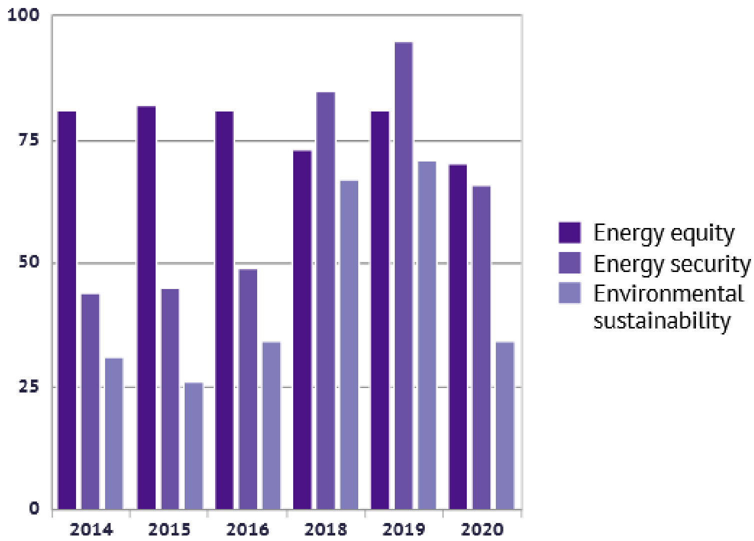

Figure 1. *ETI* components (Georgia)

4.2. Assessment of Georgia's energy security

To assess the *EnS* of the territory, a system and practice of mathematical calculations should be formed, allowing further identification of threats and assessments of the state of the country's energy potential. In the context of Georgia, there is a problem with statistical data on many indicators, but the available list of indicators is presented in Table 3:

X1 – Electricity imports (billion kilowatt-hours – blh).
X2 – Electricity exports (blh).
X3 – Net production of traditional thermal electricity (blh).
X4 – Net power generation (blh).
X5 – Net hydropower generation (blh).
X6 – GDP (billions of USD).
X7 – Human Development Index (points).
X8 – Primary energy consumption (quadrillion BTU).
X9 – Primary energy production (quadrillion BTU).

Table 3. Key indicators for *EnS* assessment (Georgia)

Year	X1	X2	X3	X4	X5	X6	X7	X8	X9
2008	0.56	0.68	1.21	8.3	7.09	12.795	0.74	0.18	0.07
2009	0.26	0.74	1.08	8.42	7.34	10.767	0.75	0.18	0.08
2010	0.23	1.49	0.71	9.98	9.27	12.244	0.75	0.19	0.09
2011	0.48	0.93	2.17	9.98	7.81	15.107	0.76	0.18	0.08
2012	0.62	0.53	2.32	9.47	7.15	16.488	0.77	0.19	0.07
2013	0.48	0.45	1.68	9.87	8.19	17.190	0.78	0.21	0.09
2014	0.85	0.6	1.91	10.17	8.25	17.627	0.78	0.22	0.09
2015	0.7	0.66	2.24	10.61	8.37	14.954	0.79	0.23	0.09
2016	1.33	1.41	2.1	11.35	9.24	15.142	0.79	0.25	0.09
2017	1.75	0.94	2.1	11.31	9.12	16.243	0.8	0.24	0.09
2018	1.52	0.6	1.99	11.92	9.85	17.600	0.81	0.25	0.09
2019	1.76	0.38	2.68	11.61	8.84	17.477	0.81	–	–

The dynamics of the indicators are available since 2008, and some of the data are limited to 2018, which allows an assessment for 10 years. *EnS* assessment calculations based on Formulas 4, 6 and 7 are presented in Table 4. Graphic dynamics are shown in Figure 2. The figure shows that there is a clear downward trend in *EnS* (linear trend: $y = -0.0117x + 24.308$). The range of the study is from 2008-2018, which makes it possible to build a regression model to identify the threats and opportunities for the growth of energy potential.

Table 4. *EnS* assessment (Georgia)

Year	IΔ(st)ss	IΔ(st)ef	Ihr	IΔ(st)es
2008	0.389	1.171	0.7400	0.77182
2009	0.444	1.229	0.7500	0.81946
2010	0.474	1.310	0.7500	0.86336
2011	0.444	1.191	0.7600	0.80615
2012	0.368	1.118	0.7700	0.74859
2013	0.429	1.085	0.7800	0.76127
2014	0.409	1.037	0.7800	0.73432
2015	0.391	1.068	0.7900	0.74191
2016	0.360	1.083	0.7900	0.73521
2017	0.375	1.009	0.8000	0.71357
2018	0.389	1.171	0.8100	0.70466

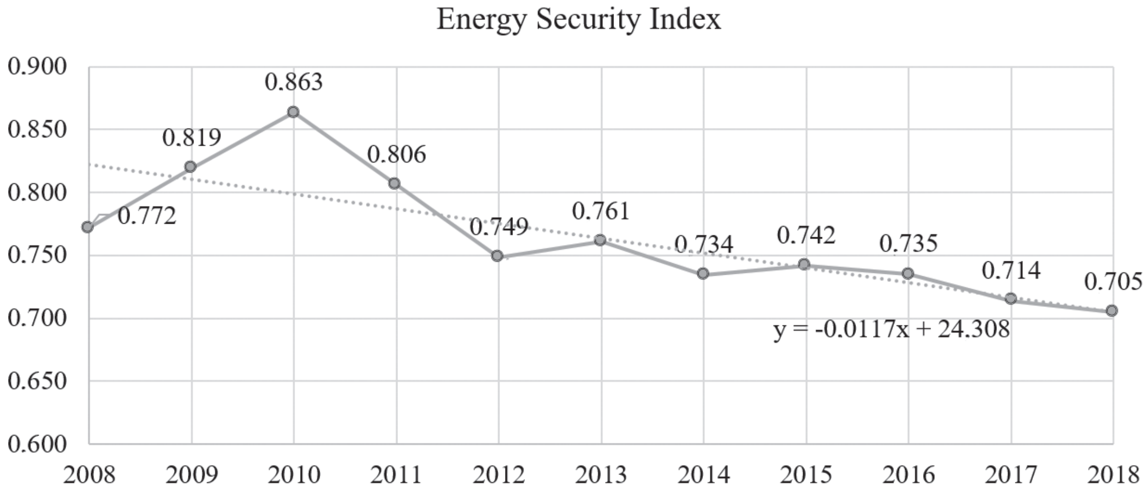

Figure 2. *EnS* assessment (Georgia)

4.3. Regression model of dependency of selected indicators

Since data on the *ETI* are not available for the model due to the lack of statistical data on the country being analysed, the dependence of the assessment of Georgia's *EnS* (Y_{es}) on a few indicators was built. After the selection, X1, X2, X3, X4 and X5 remained the most significant indicators. The rest of the indicators are not statistically significant within this model.

cators are not statistically significant within this model.

As a result of the regression model, the following data were obtained:

1. R-square: 0.993201; Adjusted R-square: 0.986402.
2. Coefficient: const = 0.83202; X1= – 0.125637; X2 = 0.0810529; X3 = – 0.912016; X4 = 0.912256; X5 = 0.918351.

3. P-value: const < 0.00001***; X1 = 0.00006***; X2 = 0.00011***; X3 = 0.00099***; X4 = 0.00109***; X5 = 0.00109***.

$$Y_{es} = 0.83202 - 0.125637 \times X1 + 0.0810529 \times X2 - 0.912016 \times X3 + 0.912256 \times X4 - 0.91835 \times X5$$

Thus, it is possible to draw the following conclusions:

– Increasing electricity imports (X1) leads to a reduction in *EnS*.

– Increasing electricity exports (X2) results in a slight increase in *EnS*.

– Increasing the net generation of traditional thermal electricity (X3) leads to a significant reduction in *EnS*.

– Increasing net power generation (X4) leads to a significant increase in *EnS*.

– Increasing net hydropower generation (X5) leads to a significant reduction in *EnS*.

It can be concluded that now it is in Georgia's interest to maintain a low import of energy resources, as well as to facilitate net power generation. At the same time, hydroelectric and thermal power capacity are insufficient to maintain *EnS* growth. However, these indicators are not enough to build a comprehensive study, and access to statistics is needed.

It is proposed to consider a regression model with indicators of energy imports and exports. For example, the following data were obtained:

1. R-square: 0.903946; Adjusted R-square: 0.879932.
2. Coefficient: const = 0.772889; X1 = – 0.0801297; X2 = 0.066675.
3. P-value: const < 0.00001***; X1 = 0.00005***; X2 = 0.00245***.
4. Variance inflation factor method: X1 = 1.003; X2 = 1.003 (no multicollinearity).

$$Y_{es} = 0.772889 - 0.0801297 \times X1 + 0.066675 \times X2$$

There is also an increase in *EnS* with increased electricity exports and a reduction in *EnS* while importing electricity. It should be noted that in this case, a complete lack of multicollinearity between the factors is observed.

In general, it should be noted that the obtained data show the viability of the author's toolkit and the possibility of adapting it to other territory.

5. Discussion

The use of the toolkit allows the assessment of the *EnS* level based on the methodical monitoring. It is possible to expand the proposed tools based on the development of indicative analysis, but this direction requires a more in-depth discussion of the scientific community on energy issues (Dyer and Trombetta, 2013). The position of the state on *EnS* should be more integrated, since without the implementation of a functional apparatus of regulation it is impossible to ensure the execution of the targeted plans to achieve security of energy supply. Identifying trends in *EnS* changes allows for the development of mechanisms of influence, primarily financial, on the energy sector (Blum and Legey, 2012; Labandeira and Manzano, 2012).

The quantitative measurement of the *EnS* territory is not calculated in international practice; however, from the author's point of view, this issue will be revised in the near future as ratings, indices and *EnS* indicators are closely related to sustainable development (Jakstas, 2020; Tvaronavičienė et al., 2015). In theoretical and methodological terms, previous studies are based on obtaining results without specific quantitative estimates, which prevents the acquisition of objective information for predicting

EnS based on economic and mathematical methods. The indices of organisations and research companies are of particular interest in the research environment; however, their calculation requires the use of specific information, which is not always available to researchers. Additionally, available studies do not allow the determination of the universal assessment of *EnS*, instead only giving an idea of the analysed phenomenon (Cherp and Jewell, 2014).

Since empirical research requires more data and access to private information, the use of the proposed toolkit based on publicly available information leads to a fair conclusion about its advantages. The analysis also showed the possibility of forming a methodological toolkit in the context of maintaining *EnS* in connection with the need to ensure the sustainable development of territories at different levels (Reddy and Ulgiati, 2015). The development of sets of indicators, indices and structures to assess the *EnS* of countries becomes a key parameter in determining the sustainability of the territory under the influence of geopolitical uncertainty (Axon and Darton, 2021). Therefore, the expansion of scientific and applied knowledge in this area is in the interests of the global community. The result of the development of the instrumental apparatus will be the formation of algorithms for determining problem areas, and the regression analysis will provide a few opportunities to identify the impact of factors on the *EnS*.

As a result of the testing of the toolkit using Georgia as an example, the data on the dynamics of the assessment of the country's *EnS* were obtained, which allowed the building of a regression model of dependencies. Despite the lack of statistical data on the analysed region, the trend between electricity imports and exports was revealed. To strengthen Georgia's position in the global energy market, measures should be taken, such as balancing energy imports and exports, primarily by focussing efforts on reducing imports and meeting domestic needs through net electricity generation. At the same time, the impact of traditional thermal electricity, the growth of which has a negative impact on *EnS*, should be reduced. Of course, these indicators may not reflect a complete functional picture, but the results show the effectiveness of the instrumental approach and the possibilities for its further development. Unfortunately, the results obtained during testing of the proposed methodology are difficult to compare with the results of other studies as there are no objective scientific studies on the region in the context of *EnS*. However, when compared with the ETI, there is a clear correlation with the energy equity indicator;[4] a complete comparison of the proposed methodology and the *ETI* is not required. They are complementary and allow for the assessment of different aspects of energy development in the territory.

6. Conclusions

The article considered: the theoretical aspects of the *EnS* concept, which allowed us to expand the contribution to the study of the problem of sustainable development; methodological approaches and methods of evaluating *EnS* are analysed; the issues of the ETI, which is poorly developed in the scientific literature and is practically unused in the context of the formation of instrumental approaches of optimisation and rationalisation, have been considered.

The author's method of assessing the level of *EnS* at the territorial level has been also constructed, allowing the determination of the *EnS* index and a regression model of the dependence of *EnS* on various factors has been built.

The proposed approach was tested using Georgia as an example. An assessment of the country's *EnS* was calculated, and the downward trend in the level of *EnS* was revealed (from 0.772

[4] WES, World Energy Trilemma Index, 2020. trilemma.worldenergy.org

in 2008 to 0.705 in 2018). An example of a regression model was provided, in which a strong correlation between Georgia's *EnS* and import-export indicators was revealed.

Limitations of the study include the following:

– statistical imbalance: the difficulty of finding statistics by region and the lack of long-term observations of a few indicators.

– structural incompleteness: selected indices are not final, and they are planned to be expanded and complicated.

– innovative insufficiency: the innovative context and state of the territory's energy funds are not sufficiently accounted for in assessing *EnS*.

However, these restrictions are not serious, and they open the way to resolve the problems in further research. The overall result was the construction of a toolkit for the analysis of the *EnS* of a territory. In the future, it is planned to build expanded models of dependency by country and region, highlighting the key parameters for creating energy efficiency for different territories.

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