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RENEWABLE ENERGY SOURCES

On the Issue of Choosing Indicators of Energy Security of the Republic of Uzbekistan in the Context of Scaling Renewable Energy

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Abstract—The accelerated transformation of the world's energy system, associated with events observed over the past 10 years, such as the global energy crisis that began in 2021, the COVID-19 pandemic, and others, have influenced a noticeable change in the face of global energy, dictating the introduction of renewable energy sources at a rapid pace for a "post-crisis" recovery of the global economy. As in other countries of the world, the fourth energy transition in Uzbekistan is also accompanied in accordance with the Sustainable Development Goals. The state plans to install renewable energy sources with a capacity of 4300 MW in 2023, which ultimately contributes to the diversification of energy resources and will make it possible to assess the country's energy security level, taking into account the share of newly introduced renewable energy capacities. However, if we take into account the peculiarity of the "instability" of renewable energy sources, the energy security of the state may remain under threat. The purpose of this work is to identify the most significant indicators of energy security in assessing its level for Uzbekistan, taking into account the geostrategic, political, technical, and technological features of the country's energy system based on a detailed and critical review of existing global methodologies regarding the comparison of primary data from two or more samples. It has been revealed that the weight of the indicator "Ratio of primary energy production (extraction) from renewable energy sources to gross fuel and energy consumption" has a significantly comparable role with the indicators of the blocks "Block of diversification of suppliers and types of energy resources," "Block of reliability of electricity supply," and "Block of reproduction of the main fund of production (MFP)" due to the political course of Uzbekistan in recent years. Based on the selected indicators, a methodology for assessing the level of energy security of the Republic of Uzbekistan is proposed, which allows one to obtain a transparent picture of energy security in economic sectors. As a result of which it is possible to identify strengths and weaknesses in various areas and timely prevent expected negative results through energy scenarios with a stable and reliable indicator of electricity supply, contributing to an increase in the level of energy security of the country.

Keywords: fuel and energy complex, energy security, energy independence, Sustainable Development Goals, green economy, renewable energy sources, diversification of energy resources, methodology for assessing the level of energy security taking into account the share of renewable energy sources, energy security indicators

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INTRODUCTION

According to experts, "the transition to a new system of environmentally friendly energy supply using a large number of renewable sources in combination with energy storage and large power plants, including nuclear, still necessary to ensure a stable electricity supply, requires a completely different approach..." [1]. At the same time, experts argue that green hydrogen can be considered as a universal source of energy and in the future for a complete transition from traditional to renewable energy sources (RESs) and the displacement of hydrocarbons as energy sources [2], which affects the distribution system of energy resources, thereby dictating a revision of the power system management mechanisms as a whole.

Within the current geopolitical circumstances, energy security (ES), as an element of ensuring energy independence, is more important than ever. This factor is of key importance in the economies of countries, providing access to reliable energy sources, including both traditional and renewable ones [3].

The concept of "energy security" is interpreted quite differently and covers broader aspects of economic and political discussions related to energy supply [4]. The most common definition is the following: energy security – ensuring uninterrupted access to energy resources for current and subsequent generations at affordable prices. Despite some differences in wording, other interpretations include three basic concepts: "energy interests," "energy threats," and "energy protection."

For example, as noted in the Doctrine of Energy Security of the Russian Federation, "... ensuring energy security is carried out in peacetime, in emergency situations, during mobilization, and in wartime" [5].

According to expert data, the energy sector can be divided into several interdependent clusters and nodes that together constitute the foundation of the state system. If any segment is missing, then the state is forced to adapt to other regional and transnational players, making several geopolitical concessions [6].

In the Doctrine of Energy Security of the Russian Federation [7], since global energy security is the ultimate global public good, to achieve it it is necessary to take into account the following priority factors related to both foreign economic and foreign policy, as well as internal challenges:

— Slowdown in the growth of global demand for energy resources and changes in its structure.

— Increasing the share of renewable energy sources in the global fuel and energy balance.

— A sharp aggravation of the military-political situation (interstate relations).

— Making incorrect long-term investment decisions in conditions of high uncertainty in global energy markets.

— Discrepancy between the capabilities of the fuel and energy complex and the needs of socio-economic development.

— High level of depreciation of fixed production assets of organizations of the fuel and energy complex, low efficiency of use, and insufficient rates of renewal of these assets.

— Adverse and dangerous natural phenomena, environmental changes leading to disruption of normal functioning and destruction of infrastructure and facilities of the fuel and energy complex.

— The need to import hydrocarbon fuels.

— The growing need for ongoing investment along the entire energy chain.

— Excessive politicization of the energy sector.

The relevance of the energy security policy problem is based on the general social significance of energy, which consists of four main aspects of its use by the socio-economic system [6]:

(1) Functioning, i.e., ensuring basic human needs and energy supply for economic activities.

(2) Maintaining the existing level of infrastructure of modern society.

(3) Use of energy to ensure growth of population, capital, and consumption.

(4) Ensuring the dynamics of changes in economic infrastructure, technical progress, and growth in labor productivity.

Systematic monitoring of the country's energy security level allows one to make informed decisions in the field of security. For this purpose, it is necessary to improve the methodology for assessing ES, which in turn helps to increase the effectiveness of measures to prevent threats.

RATIONALE FOR THE CHOICE OF COUNTRIES FOR REVIEW OF METHODS FOR ASSESSING THE LEVEL OF ENERGY SECURITY

The article discusses methods for assessing the level of economic security in the United States, Russia, Belarus, Armenia, Kazakhstan, and Kyrgyzstan.

Considering the leading position of the United States as the second largest producer and consumer of energy in the world, as well as a leader in natural gas production [9], coal reserves, oil production and consumption, and production and export of petroleum products [9], it is necessary to analyze the methodology used in this country and a mechanism for assessing the level of energy security.

Russia ranks second in the world after the United States in terms of total primary energy reserves, according to estimated data [10]. Despite the recent decline in energy exports [11]. Against the backdrop of military-political actions, issues of territorial planning in the field of energy, the functioning of the information system of the fuel and energy complex, as well as issues of security of fuel and energy facilities still remain relevant. It is also worth taking into account Uzbekistan's dependence on Russian gas, in 2023, a transit supply of gas through Kazakhstan via the Central Asia Center (CAC) pipeline was confirmed to cover the energy consumption deficit in the country during the winter period [12]. The above facts prove the need to consider the methodology for assessing the level of energy security in the Russian Federation.

The Republic of Belarus is the only country in whose energy efficiency assessment methodology there is an indicator that takes into account the share of renewable energy sources in the overall energy balance of the state, which is of no small importance against the backdrop of recent global reforms in the energy sector and long-term strategic documents for achieving carbon neutrality and low-carbon development [13].

As experts note, "The Republic of Armenia, despite the complete absence of fossil energy reserves, is one of the most energy-rich CIS countries, moreover, a state with a growing potential for electricity exports, thanks to a competent attitude to the resource capabilities formed back in the Soviet period and policies aimed at the use of modern efficient and energy-saving technologies," in connection with which it is advisable to consider its methodology for assessing energy efficiency [14].

The energy infrastructures of the Republic of Kazakhstan and the Kyrgyz Republic are closely connected with the infrastructure of the Republic of Uzbekistan, since they are members of the United Energy System of Central Asia, which requires consideration of energy policies in these countries. Also, consideration of the methodology of energy security in Kazakhstan is interesting because, in connection with the sovereignty of regions in the country in recent years, issues of energy security and economic feasibility are not linked [15].

REVIEW OF EXISTING METHODOLOGIES FOR ASSESSING THE LEVEL OF ENERGY SECURITY IN THE UNITED STATES AND SOME CIS COUNTRIES

Methodology for Assessing the Level of Energy Security in the United States

The Global Energy Institute's (GEI) 2020 United States Energy Security Risk Index includes the most recent historical and forecast data to assess the current and future state of United States energy security risks [16]. The index consists of 37 various energy security risk indicators in nine categories: world fuels; fuel import; energy costs; price and market volatility; energy consumption intensity; electricity sector; transport sector; environment; basic science; and energy research and development.

The index covers the historical period from 1970 to 2019 and the forecast period until 2040. The GEI includes four sub-indices that identify the main areas of risk to United States energy security: geopolitical, economic, reliability, and environmental. Each of the 37 indicators is mapped to one or more of these four sub-indices. These sub-indices are weighted (30% for geopolitical and economic indicators, 20% for reliability and environmental protection) and combined to obtain an overall index score [17, 18].

The index is designed to define and use the concept of risk: a lower index score indicates a lower risk of energy security, and a higher score indicates a higher risk. When evaluating results, it is important to understand that the index necessarily moves on an open scale.

To give a relative sense of the potential danger, the index score for 1980, a particularly bad year for the United States (and global) security risks, was set at 100. Thus, index scores approaching or exceeding 100 imply a very high degree of risk.

Methodology Used to Develop the United States Energy Security Risk Index

The GEI's ultimate goal in developing the United States Energy Security Risk Index was to use existing data and projections to develop indicators that collectively describe geopolitical, economic, reliability, and environmental risks that measure the risk to the overall United States Energy Security in a single index. Reducing such a multifaceted concept as United States economic security to a single number was a serious problem. The index was compiled on the basis of just over three dozen individual indicators measuring energy security in various aspects. The index uses historical and forecast data covering the period from 1970, before energy efficiency first became a major concern of the American public, through 2040, using "business as usual" forecasts from the Energy Information Administration (EIA).

Selection and Justification of Indicators

Before selecting indicators, the first task was to establish some criteria that would ensure that the data used had several important characteristics. Therefore, the data for each indicator had to be:

"Reasonable"	Data must meet common sense expectations
"Trustworthy"	The data source must be well recognized and authoritative
"Available"	The data had to be easily accessible and publicly available
"Transparent"	Data output and manipulations with them must be understandable
"Full"	The data record should extend back a reasonable period of time, preferably back to 1970
"Promising"	Historical data must be clearly consistent with forecast data extending to 2040, if available
"Updated"	Historical data had to be revised every year, adding a new historical year and preparing new forecasts

Total US energy security risk	Geopolitical 30%	Global fuels metrics	1. Security of world oil reserves	2. Security of world oil production	3. Security of world natural gas reserves	4. Security of world natural gas production	5. Security of world coal reserves	6. Security of world coal production
		Fuel import metrics	7. Security of US petroleum imports	8. Security of US natural gas imports	9. Oil and natural gas import expenditures	10. Oil and natural gas import expenditures per GDP		
	Economic 30%	Energy expenditure metrics	11. Energy expenditures per GDP	12. Energy expenditures per household	13. Retail electricity prices	14. Crude oil prices		
		Price and market volatility metrics	15. Crude oil price volatility	16. Energy expenditure volatility	17. World oil refinery utilization	18. Petroleum stock levels		
		Energy use intensity metrics	19. Energy consumption per capita	20. Energy intensity	21. Petroleum intensity	22. Household energy efficiency	23. Commercial energy efficiency	24. Industrial energy efficiency
	Reliability 20%	Electric power sector metrics	25. Electricity capacity diversity	26. Electricity capacity margins	27. Electricity transmission line mileage			
		Transportation sector metrics	28. Motor vehicle average MPG	29. Transportation VMT per $ GDP	30. Transportation non-petroleum fuels			
	Environmental 20%	Environmental metrics	31. Energy-related CO_2 emissions	32. Energy-related CO_2 emissions per capita	33. Energy-related CO_2 emissions intensity	34. Electricity non-CO_2 generation share		
		Research and development metrics	35. Industrial energy R&D expenditures	36. Federal energy and science R&D expenditures	37. Science and engineering degrees			

Fig. 1. A comprehensive structure for constructing an index of US energy security risks [16].

The selected indicators were clustered around nine broad types of indicators that represent and balance some of the key and often competing aspects of energy security.

Using these categories as guides, 37 individual indicators were selected and developed, covering a wide range of energy supply, energy end-uses, operations, and environmental emissions. Three to six indicators were selected for each indicator category (Fig. 1).

Due to the fact that "the United States plans to commission 35 GW of solar and wind power plants in 2023," due to investment incentives in accordance with the Inflation Reduction Act [19], it is advisable to take into account the above indicator in the United State energy security risk assessment system.

Methodology for Assessing the Level of Energy Security in the Russian Federation

In 2019, the Russian Federation adopted the "Energy Security Doctrine of the Russian Federation," which states that indicators of the state and threats to energy security must be developed, justified, and approved for all levels: individual, object-by-object, territorial, systemic, and federal (national) energy security [20].

According to experts, increasing international efforts to implement climate policy and accelerate the transition to a green economy stands out as a particular challenge: Russia "considers it unacceptable to consider these issues from a biased point of view, infringing on the interests of energy producing states and deliberately ignoring such aspects of sustainable development as ensuring universal access to energy and the development of clean hydrocarbon energy technologies" [21].

The Doctrine of Energy Security of Russia provides six concepts that characterize different levels of energy security: global; national; systemic (survivability); regional; object (corporate); local (individual).

Currently, in the Russian Federation there are several approaches to assessing energy security: various methodologies have been developed by scientists; one of them was proposed by specialists from the Institute of Economics, Ural Branch, Russian Academy of Sciences, the peculiarity of which is the use of the indicative analysis method [19]. Table 1 contains a list of indicators and their threshold values used within this methodology.

It should be noted that in the methodology of the Institute of Economics, Ural Branch, Russian Academy of Sciences, energy efficiency indicators are tied

Table 1. Indicators that determine the level of energy security of the Russian Federation [21]

No.	Indicator
	1. Block of production and resource provision of the fuel and energy supply system of the region
1.1	The ratio of the total available power of power plants in the region to the maximum electrical load of consumers on its territory
1.2	The ratio of the sum of the available power of power plants and the capacity of intersystem connections of a region with neighboring ones to the maximum electrical load of consumers on its territory
1.3	Possibility of meeting the needs for boiler and furnace fuel from local resources of the region, %
	2. Block of reliability of fuel and energy supply to the region
2.1	Share of the dominant resource in the total consumption of combined heat and power (CHP) in the region, %
2.2	Share of the largest power plant in the installed electrical capacity of the region, %
2.3	Level of potential supply of demand for fuel in the conditions of a sharp cold snap (+10% of CHP consumption) in the region, %
	3. Reproduction block for industrial production in the energy sector
3.1	Degree of wear and tear of the regional energy sector, %
3.2	The ratio of the average annual commissioning of installed capacity and reconstruction of power plants in the region over the previous 5-year period to the installed capacity of the region, %
	4. Ecological block
4.1	Emissions of harmful substances into the atmosphere from electric power industry enterprises per unit area, units.
	5. Financial and economic block
5.1	Ratio of overdue accounts payable (at the end of the year) of energy enterprises to their annual production volume, %
5.2	Ratio of overdue accounts payable (at the end of the year) of fuel industry enterprises to their annual production volume, %
	6. Energy saving and energy efficiency block
6.1	Energy intensity of gross regional product, %

to boiler and furnace fuel. In addition, this methodology separates financial, economic, and environmental indicators into a separate block. The same group of scientists developed energy security indicators for the Chelyabinsk oblast [21], presented in Table 2.

According to Table 2, the methodology for assessing the level of energy security in the Chelyabinsk oblast does not include certain blocks of indicators. The main feature of this methodology is its emphasis on the electric power system: out of 21 indicators, 11 cover the electricity sector, 4 cover the heat power sector, and 6 cover the energy sector as a whole. Due to the fact that Russia plans to increase the share of renewable energy sources in the country's energy balance by 10 times, from the current 1 to 10% in 2040 [22], it is worth noting that both methodologies must include an indicator of the share of renewable energy sources in the country's overall energy balance.

Methodology for Assessing the Energy Security Level of the Republic of Belarus

The existing methodology for assessing the level of energy security in the Republic of Belarus was approved in the "Concept of Energy Security of the Republic of Belarus by Resolution of the Council of Ministers of the Republic of Belarus No. 1084 of December 23, 2015." [13]. The methodology contains 4 blocks, including a total of 11 indicators (Table 3). According to the Concept, "Energy security is a state of protection of citizens, society, the state, and the economy from threats of shortages in meeting their energy needs with economically available energy resources of acceptable quality, and from threats of disruption of uninterrupted energy supply."

The Republic of Belarus has adopted the third edition of the Energy Security Concept, which indicates the continuous improvement of the methodology for its assessment. The concept, in addition to the meth-

Table 2. Indicators that determine the level of energy security in the Chelyabinsk oblast of the Russian Federation [21]

No.	Indicator
1	Weighted average provision of the region with its own fuel and energy resources, %
2	Self-sufficiency of the region in electricity, %
3	Electricity production index compared to the previous year, %
4	Electricity production per capita, kWh/person
5	Electricity consumption per capita, kWh/person
6	Index of change in per capita electricity consumption compared to the previous year, %
7	Thermal energy production index compared to the base period, %
8	Heat energy production per capita, Gcal/person.
9	Heat energy consumption per capita, Gcal/person.
10	Index of change in per capita heat energy consumption compared to the base period, %
11	Share of the largest energy source in the UES, %
12	Relative value of power reserve capacity of power systems, %
13	Annual growth rate of energy capacity, %
14	Annual growth rate of energy consumption, %
15	Ratio of increase in power and increase in electricity consumption (values of point 13—values of point 14), %
16	Self-sufficiency of the region in coal fuel, %
17	Coal production index compared to the previous year, %
18	Share of the dominant type of fuel (gas) in the structure of fuel and energy resources consumption, %
19	Share of the dominant fuel type (gas) in total CHP consumption, %
20	Share of dominant fuel (gas) at power plants, %
21	Share of coal-fired stations in electricity production, %

odology for calculating indicators, includes forecasting the values of the main indicators until 2035, assessing threats, and principles for ensuring energy security. As noted in Table 1, the main focus of the Concept is on the block "Reliability of supplies, redundancy, processing, and distribution of fuel and energy resources."

As stated above, the methodology for assessing the level of energy efficiency of the Republic of Belarus takes into account the share of renewable energy sources in the country's energy balance, and also on the basis of this methodology, the authors made an attempt to assess the level of energy efficiency of the Republic of Uzbekistan, as a result of which it was revealed that, subject to the adoption of threshold values for the integral assessment of sustainable energy development state for the Republic of Belarus, the state of the economic security of the Republic of Uzbekistan is at a high level (0.610) [23].

Methodology for Assessing the Level of Energy Security of the Republic of Armenia

By Decision of the Government of the Republic of Armenia No. 50 dated December 22, 2011, "Concept for ensuring energy security of the Republic of Armenia" [24]. In this document, energy supply is defined as a set of political, economic, legal, organizational, methodological, and other measures that ensures high-quality and reliable energy supply at economically reasonable prices to meet the needs of the state on a daily basis, as well as in emergency situations and during war [25]. Since in this definition, energy security is considered as a set of measures, we can conclude that the basic document provides, first of all, for the regulation of management processes in the energy system: political, economic, social, legal, etc.

This document focuses on identifying and analyzing both external and internal threats to the country's energy security. However, there is a lack of detailed methodology for assessing this safety [24].

Scientists such as A.A. study the issues of ES of the Republic of Armenia. Markarov, V.S. Davtyan [25] and K. Karapetyan [26]. Their research is devoted to areas of strengthening the energy security of the Republic of Armenia but is not based on a quantitative assessment of the current state of the energy security. Since Armenia intends to choose the path of low-carbon development to diversify the energy system in

Table 3. Indicators that determine the level of energy security of the Republic of Belarus and their calculation methods [13]

Indicator	Calculation method
1. Block of indicators "Energy independence"	
Indicator 1. "The ratio of the volume of production (extraction) of primary energy to the gross consumption of fuel and energy resources"	The ratio of the volume of production (extraction) of primary energy in the Republic of Belarus (including electricity generated at nuclear power plants) in thousand t.e. to the volume of gross consumption of fuel and energy resources in the Republic of Belarus in thousand t.e., multiplied by 100
Indicator 2. "The ratio of the volume of production (extraction) of primary energy from renewable energy sources to the gross consumption of fuel and energy resources"	The ratio of the volume of production (extraction) of primary energy from renewable energy sources (hydro, solar and wind energy, biofuel, biogas, firewood, and other biomass) in thousand t.e. to the volume of gross consumption of fuel and energy resources in the Republic of Belarus in thousand tons of equivalent fuel, multiplied by 100
2. Block of indicators "Diversification of suppliers and types of energy resources"	
Indicator 3. "Share of the dominant supplier of energy resources in total imports of fuel and energy resources", %	The ratio of the amount of energy resources supplied from the main supplier of energy resources (meaning the supplying country) in thousand t.e. to the total amount of energy resources imported by the country per year, in thousand t.e., multiplied by 100
Indicator 4. "Share of the dominant type of fuel in gross consumption of fuel and energy resources"	The ratio of the volume of consumption of the dominant fuel in thousand t.e. to gross energy consumption in thousand t.e., multiplied by 100
3. Block of indicators "Reliability of supplies, redundancy, processing and distribution of fuel and energy resources"	
Indicator 5. "The ratio of the total installed capacity of power plants to the maximum actual load in the power system (reservation)"	The ratio of the total installed capacity of all power plants at the beginning of the year in MW to the maximum actual load in the energy system for the year under review in MW, multiplied by 100
Indicator 6. "The share of accumulated depreciation in the initial cost of fixed assets of fuel and energy companies"	The ratio of the amount of accumulated depreciation of fixed assets of fuel and energy companies in millions of rubles to the original (revalued) cost of fixed assets of fuel and energy companies in millions of rubles, multiplied by 100
Indicator 7. "The ratio of the volume of investments in fixed capital invested in the development of the fuel and energy complex to the initial cost of fixed assets of fuel and energy companies"	The ratio of the volume of investments in fixed capital invested in the development of the fuel and energy complex, in million rubles, to the initial (revalued) cost of fixed assets of fuel and energy sector organizations in million rubles, multiplied by 100
Indicator 8. "Share of the dominant energy resource (gas) in the production of thermal and electrical energy"	Ratio of consumption of the dominant energy resource (natural gas) for the production of thermal and electrical energy in thousand t.e. to the total volume of fuel consumption for the production of thermal and electrical energy in thousand t.e., multiplied by 100
Indicator 9. "The ratio of the average daily number of power supply disruptions in populated areas per year to the total number of populated areas"	The ratio of the total number of power supply disruptions to populated areas per year to the number of populated areas, multiplied by 100
4.Block of indicators "Energy efficiency of final consumption of fuel and energy resources and economic sustainability of the fuel and energy complex"	
Indicator 10. "Energy intensity of GDP (in 2005 prices)"	The ratio of the volume of gross consumption of fuel and energy resources in the Republic of Belarus in 2005 prices to the gross domestic product in 2005 prices, multiplied by 100
Indicator 11. "Ratio of the cost of imports of energy goods to GDP"	The ratio of the volume of imports of oil, natural gas, and electricity in billions of rubles to the gross domestic product at current prices in billions of rubles, multiplied by 100

order to ensure energy efficiency in the country (according to the country's development strategy, by 2025 it is planned to achieve the following indicators: 50% of electricity generation from nuclear power plants (NPPs), 20% from solar power plants (SPPs), and 15% from thermal power plants (TPPs)) [27], in the methodology for assessing the level of energy efficiency of the Republic of Armenia it is also recommended to include an indicator of the share of RESs in the overall energy balance of the state.

Methodology for Assessing the Level of Energy Security of the Republic of Kazakhstan

According to UN experts, "The goal of achieving carbon neutrality by 2050 in the countries of Central Asia must be considered while ensuring energy efficiency and creating environmentally friendly jobs" [28].

In the Republic of Kazakhstan there is also no methodology approved at the state level for assessing the level of energy security of the country. However, in the "Kazakhstan-2050" Strategy, out of ten global challenges of the 21st century, energy security ranks fifth.

R.M. Mustafina conducted a study of the state of energy security in the regions of the Republic of Kazakhstan in 2006, using the indicative analysis method. The study covered the following indicators:

— Change in energy consumption per capita.

— Change in energy consumption per capita in the domestic sector.

— Share of own sources in the total volume of energy production.

— Change in the share of regional enerfy production relative to the country's total production.

— Change in the share of regional energy consumption relative to the total consumption in the country.

— Share of the largest power plant in the region's energy system.

According to the authors [31], threats to energy security at the present stage of the country's development are threats to the processes of economic transformation, since instability in the provision of energy security can have a negative impact on the ongoing fundamental transformations of the country's economy, thereby slowing them down, or significantly increasing the costs of solving the assigned tasks. One of the crises and quite significant phenomena that threatens the energy supply is the energy wastefulness of the republic's economy.

A. Elibaeva also dealt with issues of the energy security of Kazakhstan in the aspect of sustainable development [32]. This scientist interprets the concept of energy security as follows: energy security, considered in the economic security system as one of its main elements, implies the optimal use of limited resources and the use of environmentally friendly nature, energy, and material-saving technologies, including the extraction and processing of raw materials, the creation of an environmentally acceptable products, minimization, recycling, and destruction of waste.

The following key indicators of energy independence are noted in [32]:

— Sufficiency and availability of primary energy to meet the needs of the country's economy.

— Productivity of equipment for converting primary energy into other types of energy for each of them.

— Productivity of transport infrastructure for the transportation of each type of energy (primary and/or converted).

— Environmental acceptability of the processes of extraction, transformation, and consumption of various types and forms of energy.

Methodology for Assessing the Level of Energy Security of the Kyrgyz Republic

The "Concept of Energy Development of the Kyrgyz Republic for the Period up to 2030" presents an analysis of the situation in the field of energy security based on the main indicators: achievements and problems [33]. The methodology for assessing the level of energy security is discussed in more detail in the works of V.M. Kasymova [34]. The concept of energy development of the Kyrgyz Republic defines energy supply as the minimum necessary condition for the functioning and strategic development of the fuel and energy complex, as well as the entire socio-economic policy of the state.

According to the Concept, energy security is influenced by external and internal factors. External factors include: natural (depletion of natural resources), climatic (global warming, natural disasters); geopolitical (dependence on imports of fuel and energy resources, discriminatory actions of individual states, etc.), and macroeconomic (unstable global fuel price environment, lack of investment, etc.). Internal factors include the irrational structure of the fuel and energy balance, financial destabilization due to the crisis of non-payments, pricing and tariff policies taking into account socially vulnerable segments of the population, a lack of investment and depreciation of fixed assets, a high level of energy intensity of the economy and a decrease in its competitiveness, a sharp reduction in the volume of geological exploration, and the lack of reserves, such as industrial reserves, low level of environmental protection activities and environmental

Table 4. Key indicators of economic security of the Kyrgyz Republic [34]

No.	Indicator
	1. Fuel supply unit
1	Satisfying the need for fuel and energy resources with our own energy resources
2	Provision of our own fuel for the production of electricity and heat
3	Provision of our own fuel for housing and communal services and the population
	2. Power generation unit
4	Ratio of electricity production to consumption
5	Ratio of capacity commissioning growth rates to load growth rates in the power system
6	Ensuring reliable coverage of the base load in the power system (share of installed capacity of large power plants)
7	Depreciation of fixed assets of power plants
	3. Electricity transmission, distribution, and import unit
8	Wear level of equipment and networks by energy companies
9	Provision of transformer power per 1 km^2
10	Level of reserve for intersystem connections
11	Share of electricity imports
	4. Ecological block
12	CO_2 emissions to TER
13	CO_2 emissions to GDP
14	CO_2 emissions per capita
	5. Block of electricity and heat consumers
15	Share of housing and communal services in the structure of electricity consumption
16	Population share in heat energy consumption
17	Share of average per capita income of the population spent on paying for energy resources
	6. Economic indicators
18	Level of accounts receivable from consumers and accounts payable from energy companies
19	Increase in tariffs for electricity, heat, and natural gas
20	Energy intensity of GDP
21	Electricity intensity of GDP
	7. Energy Investment Block
22	Share of capacity of commissioned facilities in total installed capacity
23	Volume of annual investments in energy
	8. Sociological block
24	Level of growth in the number of employees in the energy sector
25	The amount of wages in the energy sector in relation to the average in the economy

safety, failure to comply with the terms of international agreements to minimize the impact of the fuel and energy complex on the environment, etc. Key indicators of energy security of the Kyrgyz Republic are presented in Table 4.

As can be seen from Table 4, the methodology for assessing the level of energy security of the Kyrgyz Republic pays significant attention to the electricity sector. What distinguishes this methodology is the inclusion of a sociological block and a block focused on consumers of electricity and heat.

The Republic of Kazakhstan and the Kyrgyz Republic are part of the United Energy System of Central Asia and have not only a common energy space, but also a common space of water resources, which dictates the need to consider indicators related to the availability of both energy and water resources.

Table 5. Comparison of indicators for assessing the level of energy security in the United States and in some CIS countries

No.	Indicator	Belarus	Russia (2)	Kazakhstan	Armenia	Kyrgyzstan	Uzbekistan	USA
1. Block of resource availability of the fuel and energy supply system								
1	The ratio of the volume of production (extraction) of primary energy to the gross consumption of fuel and energy resources	+	+	+	+	+	+	
2	Opportunities to meet the needs for boiler and furnace fuel from the region's own sources		+		+			
3	The level of potential supply of demand for fuel in the conditions of a sharp cold snap (+10% of CPH consumption) in the region							
4	Provision of own fuel for housing and communal services and the population					+		
5	Self-sufficiency of the region in electricity		+			+	+	
6	Shares of own sources in the electricity balance		+	+		+	+	
7	Use of oil refineries in the world							+
8	Self-sufficiency of the region in oil reserves							+
2. Fuel and energy supply infrastructure reliability block								
9	Adequacy of equipment performance for converting primary energy into other types of energy for each of them			+			+	
10	Adequacy of transport infrastructure performance for each type of energy (primary and/or converted)			+			+	
3. Block of diversification of suppliers and types of energy resources								
11	Share of the dominant energy supplier in total imports of fuel and energy resources	+			+		+	
12	Share of the dominant type of fuel in gross consumption of fuel and energy resources	+	+				+	
13	Share of the dominant resource in the total consumption of CPT in the region		+					
14	Share of the dominant energy resource (gas) in the production of thermal and electrical energy	+	+				+	+
15	Exposure of the economy to unreliable and concentrated oil and natural gas supplies and import costs							+
16	World reserves and production of oil, natural gas and coal							+
4. Electricity supply reliability block								
17	The ratio of the total installed capacity of power plants to the maximum actual load in the power system (reservation)	+	+				+	
18	Ratio between power increase and electricity consumption increase		+			+	+	
19	Share of the largest power plant in the installed electrical capacity of the region		+	+		+		
20	The ratio of the average annual commissioning of installed capacity and reconstruction of power plants in the region for the previous five-year period to the installed capacity of the region		+		+	+		
21	Ratio of electricity production to consumption					+	+	+
22	Level of reserve for intersystem connections					+		
23	Provision of transformer power per 1 km^2					+	+	

Table 5. (Contd.)

No.	Indicator	Belarus	Russia (2)	Kazakhstan	Armenia	Kyrgyzstan	Uzbekistan	USA
24	The ratio of the average daily number of power supply disruptions in populated areas per year to the total number of populated areas	+					+	
25	Diversification of electricity production capacities							+
26	Power line mileage							+
	5. MFP reproduction block							
27	The share of accumulated depreciation in the initial cost of fixed assets of fuel and energy companies	+			+	+	+	
28	The ratio of the volume of investments in fixed capital invested in the development of the fuel and energy complex to the initial cost of fixed assets of fuel and energy companies	+			+	+	+	
	6. Macroeconomic block							
29	Energy intensity of GDP	+				+	+	+
30	Electricity intensity of GDP					+		
31	Ratio of import value of energy goods to GDP	+			+			
32	Household energy efficiency							+
33	Commercial Energy Efficiency							+
34	Industrial energy efficiency							+
35	Expenditures on oil and natural gas imports per GDP							
	7. Ecological block							
36	Emissions of harmful substances into the atmosphere from electric power industry enterprises per unit area, units.							+
37	CO_2 emissions to TER					+		
38	CO_2 emissions to GDP					+		+
39	CO_2 emissions per capita					+		+
40	The ratio of the volume of production (extraction) of primary energy from renewable energy sources to the gross consumption of fuel and energy resources	+						
41	Environmental acceptability of production, transformation, and consumption of energy of various types and forms			+				
42	Share of electricity not associated with CO_2 production							+
	8. Financial and economic block							
43	Ratio of overdue accounts payable (at the end of the year) of energy enterprises to their annual production volume					+		
44	The ratio of overdue accounts payable (at the end of the year) of fuel industry enterprises to their annual production volume					+		
45	Crude Oil Price Volatility							+
46	Energy cost volatility							+
47	Energy costs per household							+
48	Retail electricity prices							+
49	Transport VMT per GDP in dollars							+
50	Non-petroleum fuel transportation costs							+

Table 5. (Contd.)

No.	Indicator	Belarus	Russia (2)	Kazakhstan	Armenia	Kyrgyzstan	Uzbekistan	USA
	9. Block of electricity and heat consumers							
51	Changes in per capita energy consumption in municipal services			+		+		
52	Population share in heat energy consumption					+		
53	Share of average per capita income of the population spent on paying for energy resources					+		
54	Increase in tariffs for electricity, heat and natural gas					+		
55	Electricity consumption per capita		+					+
56	Index of change in per capita electricity consumption compared to the previous year		+	+				
57	Heat energy consumption per capita		+					
58	Index of change in per capita heat energy consumption compared to the base period		+					
59	Annual growth rate of energy consumption		+					
	10. Social block							
60	Level of growth in the number of employees in the energy sector					+		
61	The amount of wages in the energy sector in relation to the average in the economy					+		
	11. Other indicators							
62	Coal production index compared to the previous year		+					
63	Electricity production index compared to the previous year		+					
64	Electricity production per capita		+					
65	Thermal energy production index compared to the base period		+					
66	Heat energy production per capita		+					
67	R&D expenses in the field of industrial energy							+
68	Federal spending on R&D in energy and science							+
69	Coverage of the sphere by scientific and engineering personnel							+
70	Average miles per gallon for a motor vehicle							+

Table 5 presents a comparison of indicators for assessing the level of energy security for the countries considered in the blocks identified by the authors based on the study of methods. In the case of the Republic of Armenia, due to the lack of indicators, the potential connection of external and internal threats with indicators presented in other methodologies was considered. In the Republic of Kazakhstan, due to the small number of indicators in the presented methods, they were considered as a single method.

It is worth noting that the largest number of coincidences in indicators in some CIS countries falls on the blocks of resource availability of the fuel and energy supply system, as well as on the block of reliability of electricity supply.

Development of a Draft Methodology for Assessing the Level of Energy Security of the Republic of Uzbekistan

According to expert data, "Uzbekistan is one of the few countries in the world that fully provides itself with energy efficiency from its own resources" [35]. The country has formed an institutional infrastructure in the field of energy policy, established goals, and ways to painlessly achieve carbon neutrality in accordance with global regulatory documents (UNFCCC, Paris Climate Agreement).

Uzbekistan is the most populous among all the Central Asian countries reviewed above and is one of the world's largest producers of natural gas, annually producing about 60 billion m^3. Since the early 2000s,

Uzbekistan has exported 10–15 billion m^3 natural gas annually and, in addition to domestic oil production, additionally imports crude oil for its refineries [36]. It is worth noting that the residential sector is the largest consumer with a share of almost 40%, while the industrial, transport, and services sectors account for approximately 20% each. This fact explains the relatively high final consumption of electrical energy of 54000 million kW h. The country also strives to achieve carbon neutrality by 2050 and increase the share of renewable energy sources in the country's overall energy balance to 40% by 2030, in connection with which it is planned to install 5 GW of solar power plants, 3 GW of wind power plants by 2025 [37–39].

Uzbekistan is a member of significant international communities and programs in the field of energy, such as Economic and Social Commission for Asia and the Pacific (ESCAP), Electric Power Council of the Commonwealth of Independent States, SCO, CAWEP, USAID, WB, etc., which are aimed at creating conditions to improve energy security at the regional level and in beneficiary countries. Also, the main task of the above organizations and programs in general is to strengthen stability and economic security in a wide area, develop economic and energy partnerships, and manage the process of globalization in the field of sustainable development [40].

In the EAEU, Uzbekistan is still an observer and an active trading partner of the organization's member countries. In this context, it should be noted that the status and level of the state's energy security are strongly influenced by international relations with close neighbors, which determine the prospects for the development of the region's energy infrastructure. Thus, the Turkmenistan–Uzbekistan–Kazakhstan-China gas pipeline (2010) has become a serious factor in energy security in Central Asia (CA), which aims to "...increase the energy self-sufficiency and security of the Central Asian countries" [41].

Subsidies provided by the government of Uzbekistan to the gas sector are holding back the development of renewable energy sources. Low domestic gas prices do not allow for high incomes and limit the possibilities of reinvestment in the development of renewable energy sources. Gas subsidies make renewable energy sources unattractive for private investors due to the high cost of renewable energy sources, as well as low gas prices.

According to the strategy "Uzbekistan–2030" [42] "... the basis for the transition to a green economy in the country will be an increase in the use of renewable energy. At the same time, it is expected that the capacity of power plants based on renewable energy sources will be increased to 40%," which dictates the need to consider it as a separate indicator of the state's energy efficiency.

Despite the fact that systematic studies to assess the level of energy efficiency using an indicative approach for the Republic of Uzbekistan have not been carried out, the influence of individual elements or components of the fuel and energy complex on the level of energy efficiency of the country has been studied both within the framework of various international programs and projects (CAWEP—Central Asia Water-Energy Programm, OSCE Program "Increasing energy security in Central Asia", USAID "Power the future" program, etc.), and scientists such as R.A. Zahidov. [43, 44], G.Zh. Allaeva [45], D.G. Umarov [46], etc.

In this context, it is worth noting [47], dedicated to finding ways to jointly develop the energy systems of Central Asia, taking into account the introduction of renewable energy sources, and solutions that promote the efficient use of water resources and the creation of peak power to compensate for the influence of renewable energy sources in order to effectively regulate power plants, while maintaining reliable communications with the UES of Kazakhstan and Russia. As the authors note, this will not only increase the reliability of the Central Asian connected power system, but will also remove, perhaps, the main problem in the form of a weak transit connection between the north and south of Kazakhstan, which is the main obstacle to the large-scale introduction of renewable energy sources in the energy system of Uzbekistan and in other energy systems of the energy interconnection.

Taking into account the above, as well as based on Table 5, the project "Methodology for assessing the energy security of the Republic of Uzbekistan" was proposed based on the following principles (Table 6):

(1) When forming a set of indicators for assessing the level of energy security, priority was given to those that had the greatest number of matches in all the considered methods and demonstrated maximum representativeness in each block.

(2) Priority was given to significant problems or advantages of the state relative to its geostrategic location.

(3) Special attention was paid to the indicators: the environmental block, the block of consumers of electricity and heat, the social block, and indicators that were most important for the Republic of Uzbekistan were included.

The methodology for calculating the main indicators for assessing the level of energy security of the Republic of Uzbekistan is given in Table 7.

Table 6. Proposed "Methodology for assessing the energy security of the Republic of Uzbekistan"

No.	Indicator
	1. Block of resource availability of the fuel and energy supply system
1	The ratio of the volume of production (extraction) of primary energy to the gross consumption of fuel and energy resources
2	The ratio of the volume of primary energy production from renewable energy sources to the gross consumption of fuel and energy resources
3	Share of our own sources in the electricity balance
4	Ratio of the average annual volume of water used for technological needs by power plants to the existing water supply
5	Energy consumption in buildings and structures
	2. Block of diversification of suppliers and types of energy resources
6	Share of the dominant energy supplier in total imports of fuel and energy resources
7	Share of the dominant type of fuel in gross consumption of fuel and energy resources
8	Share of the dominant energy resource (gas) in the production of thermal and electrical energy
	3. Electricity supply reliability block
9	Share of the largest power plant in the installed electrical capacity of the region
10	The ratio of the average annual commissioning of installed capacity and the reconstruction of power plants in the region
11	The ratio of the total installed capacity of power plants to the maximum actual load in the power system (reservation)
12	The ratio of the average daily number of power supply disruptions in populated areas per year to the total number of populated areas
13	Ratio between power increase and electricity consumption increase
	4. MFP reproduction block
14	The share of accumulated depreciation in the initial cost of fixed assets of fuel and energy companies
15	The ratio of the volume of investments in fixed capital invested in the development of the fuel and energy complex to the initial cost of fixed assets of fuel and energy companies
16	Index of losses during fuel extraction and transportation
17	The level of technological losses of electrical energy during its transportation and distribution
18	Level of automation and digitalization of electric power facilities
	5. Block of energy efficiency of final consumption of fuel and energy resources and economic sustainability of the fuel and energy complex
19	Energy intensity of GDP in prices
20	Ratio of import value of energy goods to GDP
21	Ratio of overdue accounts payable (at the end of the year) of energy enterprises to their annual production volume
22	Energy consumption in relation to economic results and energy efficiency
	6. Ecological block
23	Emissions of harmful substances into the atmosphere from electric power enterprises per unit area of territory
24	CO emissions$_2$ to TER
25	CO emissions$_2$ per capita
	7. Social block
26	Share of average per capita income of the population spent on paying for energy resources
27	Ratio of wages in the energy sector and the average in the economy
28	Level of growth in the number of employees in the energy sector
29	The effectiveness of R&D in the field of traditional and non-traditional energy (nuclear, hydrogen, renewable, low-carbon, etc.)"

Table 7. Proposed energy security indicators of the Republic of Uzbekistan and their calculation methods

	Indicator	Calculation method
	1. Block of indicators "Energy independence"	
1	Indicator "Ratio of production volume (extraction) of primary energy to gross consumption of fuel and energy resources", %	The ratio of the volume of production (extraction) of primary energy in the Republic of Uzbekistan (including electricity generated at nuclear power plants) in thousand t.e. to the volume of gross consumption of fuel and energy resources in the Republic of Uzbekistan in thousand tons of equivalent fuel, multiplied by 100% $I_1 = \frac{W_{PEV}}{W_{GCFER}} \times 100\%$
2	Indicator "Ratio of the volume of primary energy production from renewable energy sources to gross consumption of fuel and energy resources"	The ratio of the volume of primary energy production from renewable energy sources (hydro, solar and wind energy, biofuel, biogas, firewood, and other biomass) in thousand t.e. to the volume of gross consumption of fuel and energy resources in the Republic of Uzbekistan in thousand t.e., multiplied by 100% $I_2 = \frac{W_{PEV\,RES}}{W_{GCFER}} \times 100\%$
3	Indicator "Share of own sources in the electricity balance"	The ratio of the volume of production (extraction) of primary energy from own sources, in thousand t.e., to the volume of imported fuel, in thousand t.e., multiplied by 100% $I_3 = \frac{W_{PEV}}{W_{IF}} \times 100\%$
4	Indicator "Ratio of the average annual volume of water used for technological needs by power plants to the existing water supply"	Ratio of the average annual volume of water used for technological needs by power plants (thermal power plants, combined heat and power plants) in million m^3 to the existing water supply, million m^3, multiplied by 100% $I_4 = \frac{W_{AAVW\,PP}}{W_{FWR}} \times 100\%$
5	Indicator 4 "Energy consumption in buildings and structures"	The ratio of the volume of energy consumption in buildings and structures, in thousand tons of fuel equivalent, to the volume of gross consumption of fuel and energy resources in the Republic of Uzbekistan in thousand tons of fuel equivalent, multiplied by 100% $I_5 = \frac{W_{BS}}{W_{GC\,FER}} \times 100\%$
	2. Block of indicators "Diversification of suppliers and types of energy resources"	
6	Indicator "Share of the dominant supplier of energy resources in total imports of fuel and energy resources"	The ratio of the amount of energy resources supplied from the main supplier of energy resources (meaning the supplying country) in thousand t.e. to the total amount of energy resources imported by the country per year, in thousand t.e., multiplied by 100% $I_6 = \frac{W_{ER\,MS}}{W_{GCFER}} \times 100\%$
7	Indicator "Share of the dominant type of fuel in gross consumption of fuel and energy resources"	The ratio of the volume of consumption of the dominant fuel in thousand t.e. to gross energy consumption in thousand t.e., multiplied by 100% $I_7 = \frac{W_{DF}}{W_{GCFER}} \times 100\%$

Table 7. (Contd.)

	Indicator	Calculation method
8	Indicator "Share of the dominant energy resource (gas) in the production of heat and electricity"	Ratio of consumption of the dominant energy resource (natural gas) for the production of thermal and electrical energy in thousand t.e. to the total volume of fuel consumption for the production of thermal and electrical energy in thousand t.e., multiplied by 100% $I_8 = \frac{W_{\text{DER for TEE}}}{W_{\text{GC FER for TEE}}} \times 100\%$
	3. Block of indicators "Reliability of supplies, redundancy, processing, and distribution of fuel and energy resources"	
9	Indicator "Share of the largest power plant in the installed electrical capacity of the region"	Ratio of generated energy, in thousand t.e., to gross energy consumption in thousand t.e., multiplied by 100% $I_9 = \frac{E_{\text{GEC}}}{W_{\text{GC FER}}} \times 100\%$
10	Indicator "Ratio of the average annual commissioning of installed capacity and reconstruction of power plants in the region over the previous 5-year period to the installed capacity of the region"	The ratio of the average annual commissioning of installed capacity and reconstruction of power plants in the region for the previous 5-year period, in MW, to the installed capacity of the region, in MW, multiplied by 100% $I_{10} = \frac{P_{\text{IC for 5 year}}}{P_{\text{TIG}}} \times 100\%$
11	Indicator "Ratio of the total installed capacity of power plants to the maximum actual load in the power system (redundancy)"	The ratio of the total installed capacity of all power plants at the beginning of the year in MW to the maximum actual load in the energy system for the year under review in MW, multiplied by 100% $I_{11} = \frac{P_{\text{TIC}}}{P_{\text{MEL}}} \times 100\%$
12	Indicator "Ratio of the average daily number of power supply disruptions in settlements per year to the total number of settlements"	The ratio of the total number of power supply disruptions to populated areas per year to the number of populated areas, multiplied by 100% $I_{12} = \frac{N_{\text{TD}}}{N_{\text{PA}}} \times 100\%$
13	Indicator "Ratio of increase in power and increase in electricity consumption"	The ratio of the production of newly installed capacities, in thousand t.e., to the gross consumption of energy resources in thousand tons t.e., multiplied by 100% $I_{13} = \frac{N_{\text{NIC}}}{N_{\text{GC FER}}} \times 100\%$
	4. Indicator block Reproduction of MFP	
14	Indicator "Share of accumulated depreciation in the initial cost of fixed assets of fuel and energy companies"	The ratio of the amount of accumulated depreciation of fixed assets of fuel and energy companies in millions of soums to the original (revalued) cost of fixed assets of fuel and energy companies in millions of soums, multiplied by 100% $I_{14} = \frac{A_{\text{ADFA}}}{A_{\text{OCFA}}} \times 100\%$
15	Indicator "The ratio of the volume of investments in fixed capital invested in the development of the fuel and energy complex to the initial cost of fixed assets of fuel and energy companies"	The ratio of the volume of investments in fixed capital invested in the development of the fuel and energy complex, in million soums, to the initial (revalued) cost of fixed assets of fuel and energy sector organizations in million soums, multiplied by 100% $I_{15} = \frac{W_{\text{IV to FEC}}}{W_{\text{ICFA}}} \times 100\%$

Table 7. (Contd.)

	Indicator	Calculation method
16	Indicator "Index of losses during fuel extraction and transportation"	Ratio of final fuel volume, thousand t.e. to the initial extracted volume of fuel in thousand t.e., multiplied by 100% $I_{16} = \frac{W_{FEV}}{W_{IEFV}} \times 100\%$
17	Indicator "Level of technological losses of electrical energy during its transportation and distribution"	The ratio of power loss in the network at average loads for the design interval, in MW, to the total load of the network for the design interval, in MW, multiplied by 100% $I_{17} = \frac{W_{PL}}{W_{TL}} \times 100\%$
18	Indicator "Level of automation and digitalization of electric power facilities"	Ratio of the number of automated (implemented ASKUE system) electric power facilities, in units, to the total number of electric power facilities in the region, in units, multiplied by 100% $I_{18} = \frac{N_{DEPF}}{N_{TEF}} \times 100\%$
	5. Block of indicators "Energy efficiency of final consumption of fuel and energy resources and economic sustainability of the fuel and energy complex"	
19	Indicator "GDP energy intensity (in 2005 prices)"	The ratio of the volume of gross consumption of fuel and energy resources in the Republic of Uzbekistan in 2005 prices to the gross domestic product in 2005 prices, multiplied by 100% $I_{19} = \frac{W_{GCFER}}{W_{GDP}} \times 100\%$
20	Indicator "Ratio of the cost of imports of energy goods to GDP"	The ratio of the volume of imports of oil, natural gas, and electricity in billions of soums to the gross domestic product at current prices in billions of soums, multiplied by 100 $I_{20} = \frac{W_{I\ of\ EP}}{W_{GDP}} \times 100\%$
21	Indicator "Ratio of overdue accounts payable (at the end of the year) of energy enterprises to their annual production volume"	The ratio of overdue accounts payable (at the end of the year) of energy enterprises, in billion soums, to their annual production volume, in billion soums, multiplied by 100 $I_{21} = \frac{W_{OAP\ of\ EE}}{W_{APV\ of\ EE}} \times 100\%$
22	Indicator "Energy consumption in relation to economic results and energy efficiency"	The ratio of the amount of energy consumption by enterprises for the current year, in thousand t.e., to the amount of energy consumption in 2020 in thousand t.e., multiplied by 100 $I_{22} = \frac{W_{EC\ in\ E}}{W_{TEC\ in\ current\ yaer}} \times 100\%$
	6. Block of Indicators "Environmental efficiency of the fuel and energy complex"	
23	Indicator "Emissions of harmful substances into the atmosphere from electric power enterprises per unit area of territory"	The ratio of emissions of harmful substances into the atmosphere from electric power enterprises, in g/s, to the total area of the enterprise's territory, in ha, multiplied by 100% $I_{23} = \frac{W_{HSE\ by\ E}}{W_{TA\ of\ E}} \times 100\%$

Table 7. (Contd.)

	Indicator	Calculation method
24	Indicator "CO_2 emissions to TER"	CO_2 emission ratio in m, to the volume of gross consumption of fuel and energy resources in the Republic of Uzbekistan in thousand t.e., multiplied by 100% $I_{24} = \frac{W_{CO_2}}{W_{GC\,FER}} \times 100\%$
25	Indicator "CO_2 emissions per capita"	CO_2 emission ratio registered in the inventory list, in m/g, to the number of population, people, multiplied by 100% $I_{25} = \frac{W_{CO_2}}{W_{NP}} \times 100\%$
	7. Social indicators block	
26	Indicator "Share of average per capita income of the population spent on paying for energy resources"	The ratio of the average per capita income of the population, in billion soums, to the amount of energy payment per person, in billion soums, multiplied by 100% $I_{26} = \frac{W_{AI\ per\ capita}}{W_{AP\ per\ capita}} \times 100\%$
27	Indicator "Wages in the energy sector in relation to the average in the economy"	Ratio of average wages in the energy sector, in billions of soums, to the average wages in the economy, in billions of soums, multiplied by 100% $I_{27} = \frac{W_{AW\ in\ ES}}{W_{AW}} \times 100\%$
28	Indicator "Growth level of the number of specialists working in the energy sector"	Ratio of the number of people working in the energy sector for the current year, people, to the number of people working in the energy sector for 2022, people, multiplied by 100% $I_{28} = \frac{N_{in\ ES\ CY}}{N_{in\ ES\ for\ last\ year}} \times 100\%$
29	Indicator "R&D performance in the field of traditional and non-traditional energy (nuclear, hydrogen, renewable, low-carbon, etc.)"	Ratio of the number of security documents received for development, pcs., to the number of R&D performed for the current year, pcs., multiplied by 100% $I_{29} = \frac{N_{SD}}{N_{R\&D}} \times 100\%$

CONCLUSIONS

Thus, based on a critical and detailed analysis of existing methodologies for assessing the level of energy security in various countries of the world, such as the United States, the Russian Federation, and some CIS countries, a project "Methodology for assessing the level of energy security of the Republic of Uzbekistan" has been developed and proposed, taking into account the significant results of completed scientific and practical research and related regulations, as well as current policies in the energy sector of the Republic of Uzbekistan.

The proposed Methodology includes seven blocks of indicators with 29 indicators:

—Block of indicators "Energy independence."

— Block of indicators "Diversification of suppliers and types of energy resources."

— Block of indicators "Reliability of supplies, redundancy, processing, and distribution of fuel and energy resources."

— Block of indicators "Reproduction of the general population."

— Block of indicators "Energy efficiency of final consumption of fuel and energy resources and economic sustainability of the fuel and energy complex."

— Block of indicators "Environmental efficiency of the fuel and energy complex."

— Block of social indicators.

The proposed methodology displays indicators that are of high importance for the economy of the Republic of Uzbekistan, such as "The ratio of the average annual volume of water used for technological needs by power plants to the existing water supply," "Energy consumption in the construction sector," "Level of automation and digitalization of electric power facilities," "The level of attraction of workers to the energy sector," "The level of growth in the number of specialists working in the energy sector," "The effectiveness of R&D in the field of traditional and non-traditional energy (nuclear, hydrogen, renewable, low-carbon, etc.)," etc.

It should be noted that the indicators "The ratio of the average annual volume of water used for technological needs by power plants to the existing water supply" and "The effectiveness of R&D in the field of traditional and non-traditional energy (nuclear, hydrogen, renewable, low-carbon, etc.)" are used for the first time, and the indicator " The ratio of the volume of primary energy production from renewable energy sources to the gross consumption of fuel and energy resources is taken into account only in the methodology for assessing the level of energy efficiency of the Republic of Belarus.

It is known that the problems of water supply to the energy sector, which act as a global threat to the overall energy security of the Republic of Uzbekistan, deserve careful study in connection with the UN "Water-Energy-Food-Ecosystem" (NEXUS) task. It is obvious that the irrational use of water and energy resources leads to disasters and negative environmental consequences.

The proposed methodology is important for strengthening certain areas of energy development in the long term, and will also make it possible to indicate the share of renewable energy sources in the country's overall energy balance in order to provide the population with stable, clean, and affordable energy, which is consistent with fulfilling obligations under the Paris Agreement on climate change and achieving the SDG-7 goals.

Increasing renewable energy capacity in Uzbekistan also provides for the regulation of energy prices in order to preserve traditional resources, and also contributes to the implementation of the political program, power plants based on renewable energy sources in the future will provide the opportunity to both export "clean" energy and become the dominant supplier of carbon-free energy in the Central Asian region.

Let us note that when implementing the proposed methodology for assessing energy efficiency, it is possible to obtain a transparent picture of the level of energy security in economic sectors, as a result of which we can identify strengths and weaknesses in various areas and prevent the expected negative results in a timely manner. Also, using this methodology, it is possible to predict energy scenarios with a stable and reliable indicator of electricity supply, which will lead to an increase in the country's energy efficiency.

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CONFLICT OF INTEREST

The authors of this work declare that they have no conflicts of interest.

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