

# Comparative analysis of the trend in the stability and efficiency of the performance of energy sector of Azerbaijan

Valeh Nasibov<sup>1,\*</sup>, Rana Alizade<sup>1</sup>

<sup>1</sup>Azerbaijani Research and Design–Prospecting Institute of Energetics, 94, Zardabi, Baku, Azerbaijan

**Abstract.** Methodological and practical aspects of determining the trends in the stability and efficiency of the energy sector of Azerbaijan for 2013-2018, based on the methodology presented by the World Energy Council (WEC) and the World Economic Forum (WEF) are analyzed in the paper. The basis of the methodology for assessing the stability and efficiency of the energy sector is the developed method of use of energy tetrahedron, where the vertices are economic growth and development, energy security and energy accessibility and environmental sustainability, where a set of indicators with their weight coefficients is used to evaluate each of the subsystems. The number of indicators and, naturally, the weight coefficients are adjusted with time for the most complete taking into account of all the features of the energy sector. Trends in the values of stability and efficiency of the Azerbaijan's energy sector for the period under consideration are determined taking into account all available indicators; potentials for improvement for each of the subsystems are identified.

## 1 Introduction

Indicators for assessing the effective and sustainable development of the energy sector in a country-exporter of hydrocarbon raw materials are proposed in the paper. A method for assessing the state of energy subsystems is proposed based on the use of regular tetrahedron, where the areas of the faces show the state of individual energy subsystems, and the volume shows the effective and sustainable development of the energy sector.

Currently, all the world is plunged into a deep social and economic crisis associated with the rapid spread of a new coronavirus COVID-19, which is destroying communities and livelihoods.

Short-term economic recovery solutions must comply with the medium- and long-term priorities set out in the United Nations 2030 Agenda and the Paris Agreement, where the energy transition is considered as a key instrument for ensuring a safe environment while achieving healthy, prosperous, equitable and sustainable future.

In order to assess the current state and determine the prospects for the development of the energy economy in many countries of the world, the concepts, strategies and programs for the development of the energy sector are being developed and adopted, as well as fundamental works are being carried out by such international organizations as the World Economic Forum (WEF), the World Energy Council (WEC) and the International Energy Agency – IEA in the field of energy efficiency, energy stability, energy security [1-7]. According to the procedure of the World Economic Forum and the World Energy Council, we have developed energy triangles of

stability and efficiency of the energy sector in the Azerbaijan Republic based on relevant indicators. It should be noted that the results obtained according to the presented methods have recommendatory nature, they can be used for a comparative analysis of the functioning of the energy sector and determination of improvement potentials in different countries of the world, but these results do not always reflect the real situation in the energy sector for a particular country. The main parameter in the study of the above areas of energy sector performance is the level of fuel supply of the country.

According to the degree of provision of fuel and energy resources, the countries of the world in accordance with the classification of the World Bank are divided into the following groups:

- industrial countries - net importers of energy resources;
- the largest countries-exporters of hydrocarbon raw materials;
- the largest emerging markets with rapidly growing demand for energy resources;
- mean-income net energy importers;
- low-income net energy importers.

In terms of the main parameters of the functioning of the fuel and energy complex, determined according to the procedure of the World Bank, Azerbaijan belongs to the group of the largest countries - exporters of hydrocarbon raw materials.

Studies for the stability and efficiency of the energy sector are based on the so-called energy triangles, the vertices of which are: for stability Energy Security, Environmental Sustainability, Energy Availability, and for efficiency: Economic growth and development,

\* Corresponding author: rena\_alizade@mail.ru

Energy availability and safety, Environmental sustainability. As is obvious, both energy security and environmental sustainability are included in the subsystems of stability and efficiency of energy sector performance, although the composition of indicators and their weight coefficients in the first and in the second case are different.

For Azerbaijan, as a country-exporter of hydrocarbon raw materials, the presented procedure for assessing the stability of energy development is not completely adequate, since the vertex of the "energy availability" of the energy triangle is not an essential component - the physical availability of energy today and in the near future is almost 100%, and the price of energy, including electric power, is one of the lowest. At the same time, there is no "economic growth and development" in the subsystems for assessing the energy sector stability, although for Azerbaijan the energy is the main source of currency earnings. The only indicator of economic development - energy intensity is included in the indicators of environmental sustainability.

## 2 Method for determining the sustainable and effective performance of energy

Based on the above-mentioned, we have developed a method for studying the stability and efficiency of energy sector for exporting countries based on the energy tetrahedron, the vertex of which is the effectiveness of state policy, and the base is the energy security, environmental sustainability, economic growth and development.

The indicators of subsystems of sustainable and effective development of the energy sector in Azerbaijan (energy security, environmental sustainability, economic growth and development, efficiency of state administration) are presented in Table 1.

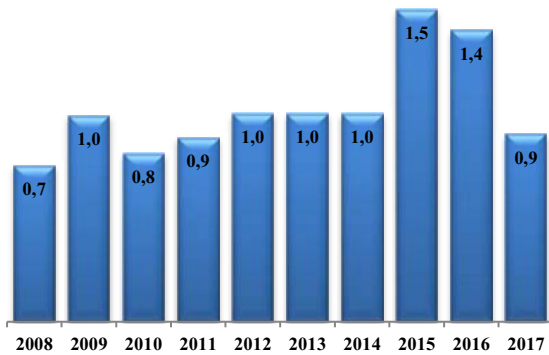
**Table 1.** Energy Trilemma Index structure and weighting

Total	Types of indicators	Measuring	Indicators	
Functioning of country 100%	1. Energy performance 75%	Energy security 25%	1.1.1 The share of the dominant type of fuel in the gross consumption of FER (Fuel and energy resources), %	1/6
			1.1.2 Installed capacity reserve of power plants,%	
			1.1.3 Depreciation of fixed assets of enterprises of FEC (Fuel and energy complex), %	
			1.1.4 Average number of hours of disconnection of consumers per year, hours	
			1.1.5 The ratio of the volume of investments in the development of the FEC to the initial cost of	

2. State policy efficiency 25%	Economic growth and development 25%	FPA (fixed production assets) of FEC, %	1/4
		1.1.6 The ratio of the growth rate of energy consumption to GDP growth over the past 10 years	
		1.2.1 Energy intensity of the economy (GDP per unit of energy use (PPP in USD per kg))	
		1.2.2 Export of energy resources as a percentage of GDP, %	
		1.2.3 Share of electric power in total energy consumption, %	
		1.2.4 Electric power consumption per capita per year, kWh/man	
	Environmental sustainability 25%	1.3.1 The ratio of the volume of energy consumption from renewable energy sources to the gross consumption of FER	1/6
		1.3.2 CO <sub>2</sub> intensity, kg/US\$	
		1.3.3 Air and water pollution impact	
		1.3.4 Gram CO <sub>2</sub> / kWh from electricity generation	
		1.3.5 Percentage of population using solid fuels for cooking	
		1.3.6 Average fuel consumption for passenger cars (l/100 km)	
Political stability 8.3%	Political stability 8.3%	2.1.1 Political stability	1/3
		2.1.2 Management quality	
		2.1.3 Government efficiency	
	Social stability 8.3%	2.2.1 Corruption control	1/4
		2.2.2 Law supremacy	
		2.2.3 Education quality	
		2.2.4 Health quality	
	Economic strength 8.3%	2.3.1 Cost of living expenses	1/3
		2.3.2 Macroeconomic stability	
2.3.3 Availability of loans for the private sector			

Energy stability is assessed using, on the one hand, the efficiency of the energy sector performance, and on the other hand, the peculiarities of the state's functioning. The energy sector performance should provide the economy with economically sound energy of adequate quality, without disturbing the ecological balance. To assess the peculiarities of the functioning of the state (Contextual performance dimensions), the following synthetic factors are used: Macroeconomic Environment, Governance,

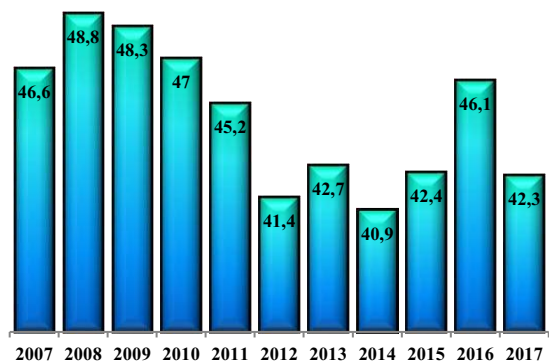
Stability for Investment and Innovation [8-10]. The trends of changes in some indicators for assessing the state of energy subsystems in Azerbaijan over the past few years are presented in Figures 1-4. The ratio of the increase in energy consumption to the country's GDP is shown in Figure 1. As is obvious from the figure, over the past 10 years, since 2008 this parameter has a slight increase, which is associated with the devaluation of the manat.



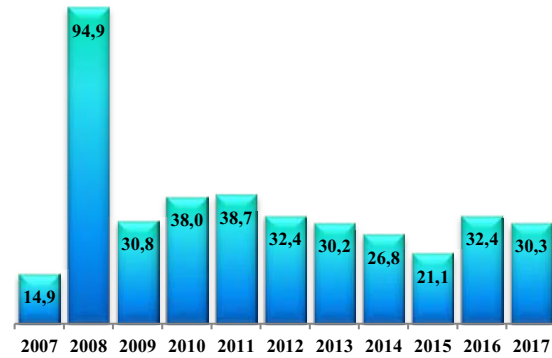
**Fig. 1.** The ratio of increase of energy consumption to the country's GDP.

The indicators “Share of the dominant type of fuel in the gross consumption of FER”, “Export of energy resources as a percentage of GDP” are shown in Figures 2-3 respectively.

The most important indicator of the stability and efficiency of energy development is the Energy intensity of the economy [10].

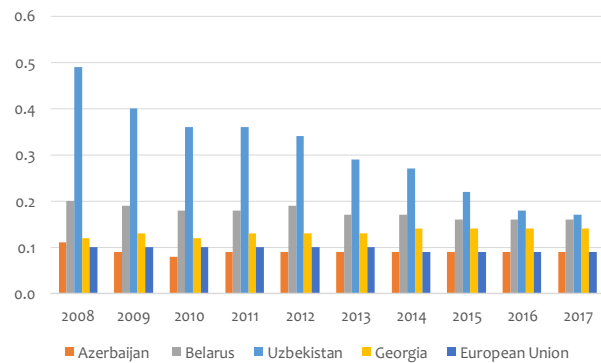


**Fig. 2.** The share of the dominant type of fuel in the gross FER consumption.



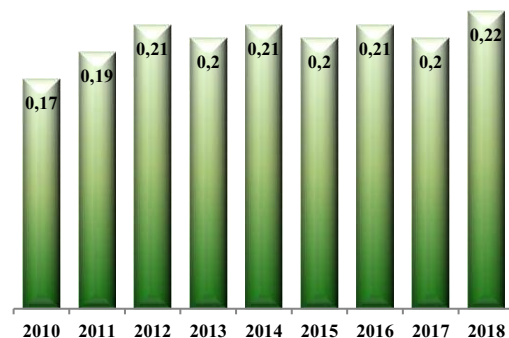
**Fig. 3.** Export of energy resources as a percentage of GDP, %.

This multifunctional and linking indicator can equally characterize "energy security" and "economic growth and development" and "environmental sustainability". As is obvious from the graph in Figure 4, the energy intensity of the Azerbaijan economy is at the level of the European Union countries [8].

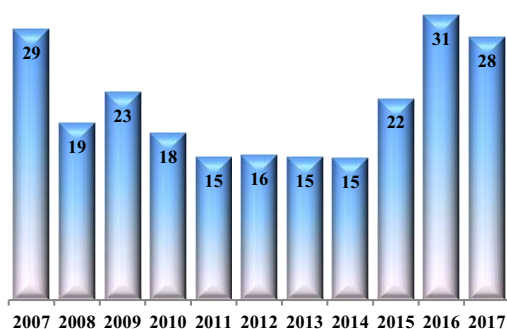


**Fig. 4.** Energy intensity of Azerbaijan's economy.

The trend of change in the value of the indicator from the subsystem “Environmental sustainability” is shown in the Figures 5-6.



**Fig. 5.** CO2 emission intensity kg / US \$.



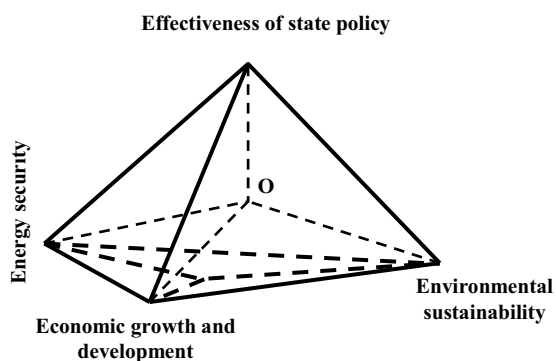
**Fig. 6.** Emissions of pollutants into the atmosphere, gr/US\$.

Despite the fact that 2 indicators of environmental sustainability “CO<sub>2</sub> intensity” and “Emissions of pollutants into the atmosphere” are in good condition, as is obvious from Figures 5 and 6, according to two other indicators – “The ratio of the volume of energy consumption from renewable energy sources to the gross consumption of fuel and energy resources” and “Average fuel consumption for passenger cars (l/100 km)” has significant potential for improvement. According to the proposed indicators, the numerical values of each of the subsystems of sustainable and effective development of the energy sector of Azerbaijan are calculated based on the correspondence of the numerical values to the letter designations, as shown in Table 2, where the letters correspond to the following states of the subsystems: A - "excellent", B - "normal", C - "not bad", D - "bad" and E - "very bad".

**Table 2.** Numerical values of letters

A	B	C	D	E
22,5–25	18,5–22,5	14–18,5	8,5–14	0–8,5

If, using a hundred-point system, the range of values of each subsystem is taken from 0 to 25, then the state of ideal stability of the power system will be determined by a regular tetrahedron with a radius of the circumscribed ball around it of 15, as shown in Figure 7.



**Fig. 7.** Energy stability and efficiency study diagram

In the proposed method, the area of the lateral faces of the tetrahedron is the effectiveness of state policy in pairs in the areas of "energy security" and "economic growth and development", "environmental sustainability" and

"energy security", "economic growth and development" and "environmental sustainability", the values of which correspond to letter designations as shown in Table 3.

**Table 3.** Effectiveness of state policy in the energy sector

A	B	C	D	E
560–720	370–560	210–370	75–210	0–75

The volume of the tetrahedron will show the current state of stability and efficiency of the country's energy sector, the values of which will correspond to the letter designations, as shown in Table 4.

**Table 4.** Ranges of values of subsystems for assessing the effectiveness of state policy in the energy sector

A	B	C	D	E
5800–8000	3250–5800	1400–3250	300–1400	0–300

In this case, in order to correspond to the state of "excellent", all subsystems must be at least 22.5. According to the proposed indicators, the numerical values of individual subsystems of energy sector for 2018 are determined: Effectiveness of state policy - 19, Energy security - 20, Economic growth and development - 18 and Environmental sustainability - 18, which shows that the current values of the subsystems of stability and efficiency of the energy sector in Azerbaijan for 2018 are at level B - normal. At these values, the efficiency of state energy policy and the state of stability and efficiency of energy sector in Azerbaijan are presented in Table 5.

**Table 5.** The state of stability and efficiency of energy sector in Azerbaijan for 2018

	Energy Security and Economic Growth and Development	Energy security and Environmental sustainability	Economic growth and development and Environmental sustainability
Effectiveness of state policy in the energy sector	417 – B	417 – B	388 – B-C

Stability and efficiency of energy sector	3366 – B-C
---	------------

As is obvious from the Table 5, in general, the stability and efficiency of the energy sector (the volume of the tetrahedron) of Azerbaijan is also at the "normal" level. The stability and efficiency of Azerbaijan's energy sector for 2013 are presented in Table 6.

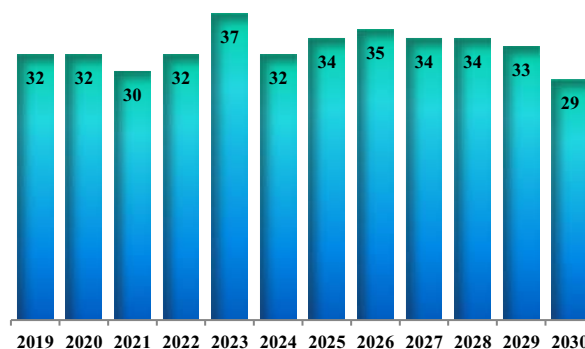
**Table 6.** The state of stability and efficiency of Azerbaijan's energy sector in 2013

	Energy Security and Economic Growth and Development	Energy security and Environmental sustainability	Economic growth and development and Environmental sustainability
Effectiveness of state policy in the energy sector	477 – B	414 – B	400 – B-C
Stability and efficiency of energy sector	3570 – B-C		

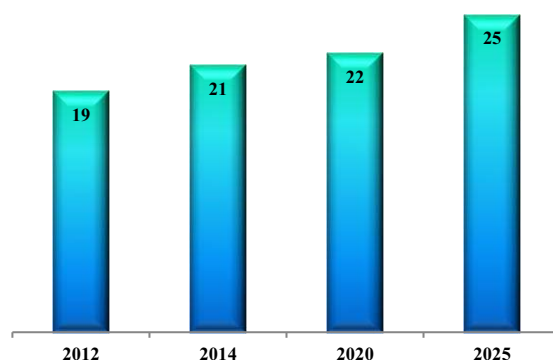
Comparing Tables 5 and 6, it can be stated that compared to 2013, the state of stability and efficiency of energy sector in Azerbaijan in 2018 has slightly worsened, although it is still in the "normal" area. This happened by reason of deterioration of economic indicators due to decrease of currency earnings. The values of energy subsystems in 2013 were as follows: Effectiveness of state policy - 20, Energy security - 21, Economic growth and development - 18, and Environmental sustainability - 16.

When studying the stability and efficiency of the energy sector performance, along with assessing the current state, it is equally important to determine the

composition of indicators and their values for long term. With the development of the economy and living standards, the requirements for the stability of the energy sector performance become more stringent, while both the composition of the indicators and their threshold values may change. The perspective values of the indicators characterizing the state of the energy sector for long term are shown in Figures 8-9.



**Fig. 8.** Power reserve level for long-term, %



**Fig. 9.** Depreciation of the main generating equipment, %

As is obvious from the Figures 8-9 and for long-term, the state of the energy sector in Azerbaijan will be maintained at a fairly high level, if the country's independence on the main types of energy resources remains in the future.

## Conclusions

1. The indicators proposed by international organizations for assessing the efficiency and stability of the energy sector performance do not always allow for assessing adequately the state of the energy sector in a given country.
2. Indicators and method for assessing the stability and efficiency of energy sector performance based on the use of triangular tetrahedron with corresponding vertices are proposed for a country-exporter of hydrocarbon raw materials.
3. Compared to 2013, in 2018 the state of the energy sector in Azerbaijan has slightly worsened, although it is still in the "normal" area.

4. It is shown that the prospective state of the energy sector in Azerbaijan as a whole can correspond to the "normal" level, if in the future the country's independence on the main types of energy resources is preserved.

## References

1. World Energy Trilemma, 2013, <https://www.worldenergy.org/assets/images/imported/2013/09/2013-Energy-Sustainability-Index-VOL-2.pdf> (2013)
2. 2014 Energy Trilemma Index, <https://www.worldenergy.org/assets/images/imported/2014/11/20141105-Index-report.pdf> (2014)
3. 2015 Energy Trilemma Index, <https://www.worldenergy.org/assets/downloads/20151030-Index-report-PDF.pdf> (2015)
4. World Energy Trilemma Index 2016, [https://www.worldenergy.org/assets/downloads/Full-report\\_Energy-Trilemma-Index-2016.pdf](https://www.worldenergy.org/assets/downloads/Full-report_Energy-Trilemma-Index-2016.pdf) (2016)
5. World Energy Trilemma Index 2017, <https://www.worldenergy.org/assets/downloads/Energy-Trilemma-Index-2017-Report.pdf> (2017)
6. World Energy Trilemma Index 2018 <https://www.worldenergy.org/assets/downloads/World-Energy-Trilemma-Index-2018.pdf> (2018)
7. World Energy Trilemma Index 2019 [https://www.worldenergy.org/assets/downloads/WETrilemma\\_2019\\_Full\\_Report\\_v4\\_pages.pdf](https://www.worldenergy.org/assets/downloads/WETrilemma_2019_Full_Report_v4_pages.pdf) (2019)
8. Yusifbeyli N.A., Nasibov V.Kh., *Electroenergetics, electrotechnics, electromechanics + control*, V.4, 3 (2013)
9. Nasibov V.Kh., Alizade R.R., *18th IFAC Conference on Technology, Culture and International Stability, TECIS* (13-15th September, Baku, Azerbaijan), Volume 51, Issue 30 (2018)
10. Yusifbayli N.A., Nasibov V.Kh., *Methodological problems in reliability study of large energy systems*, Issue 65, Reliability of liberalized energy systems (2014)