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Methodological aspects of assessing the sustainable development of energy companies

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Abstract. There was given an analysis of existing methods for assessing the level of sustainable development of energy companies, respectively. There has been highlighted the components of sustainable development which are interconnected and are separate objects of management. Methodological aspects of energy company sustainable development assessment are proposed, which are based on an integrated approach, which allow to present sustainable energy company development as a multicomponent phenomenon in the form of a set of sustainable development factors and indicators that shape them.

1. Introduction

Today, most countries around the world are moving from an outdated model of energy sector operation to a new model that equalizes opportunities for sustainable development and minimizes the dominance of one type of energy production or sources and / or fuel supply routes. This model of functioning of the energy sector creates conditions for improving energy efficiency and energy use from alternative sources and implementing measures to prevent and adapt to climate change, which are one of the priorities of global energy development.

Ukraine is one of Europe's largest producers of hydrocarbons and is a reliable transit country for natural gas and oil, ensuring a safe and secure supply of energy to its own consumers and consumers in related markets, which must be extracted and delivered with a high level of environmental and social responsibility.

An important condition for the functioning of the country's energy complex is to ensure the sustainable development of energy companies, which ensures the stability of the country at the macro level. It is very important for energy companies to choose the right direction of development, but at the same time it is necessary to realize that addressing the vector of sustainable development is quite a complex process and will require hard work and consolidated efforts of managers at all levels, and the result will be gradual the usual pattern of development that does not take into account socio-environmental interests.

World energy production continued growing in 2019 (+ 1.5%), but it was shown at a rather slower pace than expected in previous years (+ 2% / year). Due to a significant increase in crude oil and coal production, the main countries in which the growth of energy production in the world in 2019 were the

United States and China. It should be noted that due to the reduction of crude oil production in the Middle East there was a slight decrease in production of this raw material by 0.7%. Due to the growth of gas production in the United States, Russia and Australia, the rate of gas production in the world has been increased by 4%.

Over the last 10 years, there has been an increase in coal production by 3%, but with an increase in coal production in China by 4%. This figure was offset by a decline in India, the US and the EU and amounted to 0%. Electricity production in the world increased by 1% compared to 2018.

Due to the commissioning of new liquefied natural gas production facilities, energy production has increased in Russia and Australia, in Brazil - due to the growth of oil production, in South Africa - due to increased coal production and in Turkey - due to a sharp increase in hydropower production.

On the other hand, the decline in energy production in Europe has been continued. This is especially true for coal production in Germany and Poland, as well as crude oil in Norway and the Netherlands, where oil and gas resources are declining. As for the Middle East, US sanctions have reduced energy production in Iran by about 15%, and Saudi Arabia has cut crude oil production in line with the terms of the OPEC + agreement.

Against the background of slowing economic growth, the growth of energy consumption in the world slowed down compared to the average dynamics 2019 of + 2% per year in 2000-2018. Analysis of statistical data showed that energy consumption increased more slowly than last year in China 3.2%, which is the largest consumer in the world since 2009, in Russia - by 1.8% and India by only 0.8%. Decreases in energy consumption were observed in almost all OECD countries, including the United States (-1%), the EU (-1.9%), Japan (-1.6%), Canada and South Korea.

The only exception was Australia, where growth of 6.3% was recorded, which was caused by a sharp increase in gas consumption by liquefied gas plants, which turned out to be much higher than the historical average one. Consumption increased in Indonesia and Algeria, continued to grow in Saudi Arabia, Nigeria and South Africa, but decreased in Latin America (in Brazil did not change, in Mexico decreased slightly). US sanctions have reduced energy consumption in Venezuela and Iran. Thus, the growth of energy consumption in 2019 increased by 0.6%, which is much lower than the trend of previous years [1].

The growth of world electricity consumption in 2019 slowed down significantly (+ 0.7%)

In 2019, electricity consumption in the world grew much slower than in previous years (+ 0.7% compared to the average consumption of 3% / year in 2000-2018), such changes were due to slower economic growth and more moderate temperatures in a number of large countries. In 2019, the demand for electricity in China, which accounts for 28% of global electricity consumption, grew by 4.5% (10% / year in 2000-2018), and the decline in demand from industry was partially offset by high demand in utilities and service sectors. Demand has not changed in India and Russia.

In the United States, declining demand for electricity from utilities and industry, along with other factors, led to a 2.2% reduction in electricity consumption. Electricity consumption also decreased in the EU (-1.4%, in line with the slowdown in economic growth), Japan, South Korea and South Africa.

Ambitious programs to support renewable energy and reduce the cost of relevant technologies lead to an increase in the share of renewable energy sources in the world energy balance (+1.1 pp). In 2019, the share of renewable energy sources, including hydropower, in the global energy balance increased by 1.1 percentage points to almost 27%, which is in line with the positive trend that began in the 2000s. This growth is mainly due to the launch of new wind and solar power plants, as since 2000 the share of hydropower in the world energy balance as a whole remains at 15%. Falling wind and solar energy costs and ambitious climate change programs in the EU, the US, China, India, Japan and Australia have helped increase generating capacity and generate electricity from renewable sources. Favorable hydrological conditions have also led to increased electricity generation from renewable sources in China, India, Turkey, Russia, Iran and Nigeria [1]. Renewable energy now accounts for 35% of the energy balance in the EU, 27% in China, 21% in India and about 18% in the US, Russia and Japan.

2. Critical review of the literature

Analysis of the literature has shown [2, 5, 8, 10, 15] that scientists have conducted many studies on the impact of uncertainty, risk and crisis situations on the activities of energy companies and identify areas for their sustainable development. However, despite the development of the theory of crisis management of energy companies, a sufficient number of issues related to the development of a mechanism for sustainable development of energy companies in conditions of uncertainty remain unresolved. Thus, further theoretical and methodological and applied research on the development of theoretical foundations for the study of sustainable development of energy companies and a comprehensive criterion for its evaluation becomes relevant.

The transition to sustainable development of energy companies should be systemic and comprehensive.

In the scientific literature, the level of sustainable development is usually assessed from different points of view. Methods for assessing the sustainable development of existing energy companies can be classified according to the following characteristics:

-techniques based on the application of the theory of stability of systems, using mathematical indicators of stability, which take into account the factors of influence of external and internal environment on the activities of energy companies;

-techniques that are based on the principles of a systems approach, the result of which is the definition of an integrated indicator of stability, which allows you to assess the level of stability of different subsystems;

-methods based on the analysis of financial reporting forms of energy companies, the result of which is the forecasting of their bankruptcy;

-complex methods, which combine quantitative and qualitative indicators, resulting in threats to the stability of the system.

A number of scientists have made a great contribution to the development of the theoretical apparatus for assessing the sustainable development of energy enterprises. So, Tretyakova O.O., Alfiorova T.V., Pukhov Y.I. [2] analyzed the methods of assessing sustainable development of enterprises developed by scientists, which satisfies the author's definition of sustainable development - "a set of processes of positive change, embodying their technologies aimed at harmonizing relations between economic, environmental and social spheres to meet socio-economic needs systems in the long-run period."[3].

Methods of Ilichova IA [4] is characterized by a threefold approach to sustainable development. According to the author, the methodology should allow to assess the processes of positive changes occurring in the development process, while taking into account the balance of social, economic and environmental spheres of activity, which allows systems to exist indefinitely.

The main conclusions obtained from the analysis include:

- the complexity of most of the analyzed methods;
- the greatest preference is given to the economic aspect of sustainable development;
- the need to combine a static and dynamic approach in the process of developing methods for assessing sustainable development.

Indicators of statics, which characterize the state of the system at a particular time, will reflect its stability, and indicators of dynamics, such as growth rates, will characterize the degree of development of the energy company over a period of time.

Khudyakova T.A. conducted an analysis of methods for assessing the sustainable development of scientists, developed in the form of an integrated indicator. As a result of the study, the author formulated the following conclusions [5]:

- the integrated indicator should be based on probabilistic and statistical approaches, which will increase the accuracy of calculations in comparison with the methods proposed by most authors, based on expert estimates;
- integrated indicator should allow to assess and forecast the financial and economic stability of the enterprise, regardless of the input factors in the simulation model, i.e. when, as an input parameter for the analysis of economic stability is not the cash flow of the enterprise, and its profit, e.t.c.;

- integrated indicator of financial and economic stability of the energy enterprise should consist of indicators of financial stability and economic stability separately, in order to conduct a separate analysis in this context, which will correlate the generalized assessment with the assessment of individual aspects of economic stability;
- indicators included in the methodology for assessing financial and economic stability must be quantifiable;
- the use of an integrated indicator of financial and economic stability should make it possible to make a generalized comparative assessment of the activities of different microeconomic systems, to have a sign of relativity. The indicator of integral stability within different groups must have the same calculation method;
- the method of assessment and forecasting of financial and economic stability should fully take into account the dynamics of the input parameters of the model, and the resulting value of the level of financial and economic stability should be continuous throughout the definition;
- in order to interpret the level of financial and economic stability, it is necessary to have a scale of assessments with the characteristics of the established ranges.

In Makova M.M's method [6] both at the stage of calculation of components and at the stage of calculation of the integrated indicator the method of geometric means is applied.

The calculation mechanism allows us to conclude about the practicality of using this technique. The disadvantages of the methodology include the lack of environmental and social indicators that do not fully reflect the nature of changes in the relevant components.

Persky Y.K. Lepikhin V.V., Semenova O.V. [7] proposed a method based on the use of weights of the components of sustainable development, which largely justifies the uncertainty of the results.

Shalamova O.V. [8] advises a method based on the use of weights of the components of sustainable development, which largely justifies the uncertainty of the results. The methodology contains indicators that are grouped into 4 groups of components: economic, environmental, social, innovative.

The study of mechanisms and methods for assessing the sustainable development of energy companies, conducted by foreign [12, 13, 17-19] and domestic scientists, showed the following:

- the use of assessment methodology, developed on the basis of the approach of the system (set) of indicators of sustainable development, represents a large statistical base on all aspects (economic, environmental, social) of energy enterprises at this time. However, the availability of a large array of information presents certain difficulties for decision-makers in the process of developing energy policy;
- monitoring and evaluation of the achievement of sustainable development goals using integrated indicators has an indisputable advantage in the field of decision-making. The disadvantage of this method is the difficulty of determining the weights of the primary indicators without loss of significance and without undue subjectivity. The complex nature of the integrated indicator, despite the factor of subjectivity in the process of determining weights, proves, according to the authors, broader prospects for using this approach to assess sustainable development compared to the approach using the principle of a system of indicators.

An analysis of existing methods for assessing the level of sustainable development of energy companies and methods proposed by the UN Commission, the Organization for Economic Cooperation and Development, the World Bank, the European Community, the Institute for Applied Systems Analysis of NAS of Ukraine and MES of Ukraine [2-20].

The algorithm for calculating the level of sustainable development of energy companies is based mainly on indicators of financial sustainability, while we believe that it is advisable to consider sustainable development of energy companies in combination with economic, financial and socio-environmental points of view, as these processes are interrelated and affect the sustainable development of energy companies. In our opinion, it is not expedient to abandon the joint consideration of sustainable development of energy companies, which would cover all components of the system as a whole.

3. Methodology and results

We consider that it is expedient to use complex indicators of economic sustainability, financial and socio-environmental sustainability for the generalized assessment of sustainable development of energy companies; as such assessment will increase the efficiency of energy companies. It should be noted that the isolated components of sustainable development of energy companies are interconnected and are separate objects of management. Figure 1 shows the components of sustainable development of energy companies and their interaction.

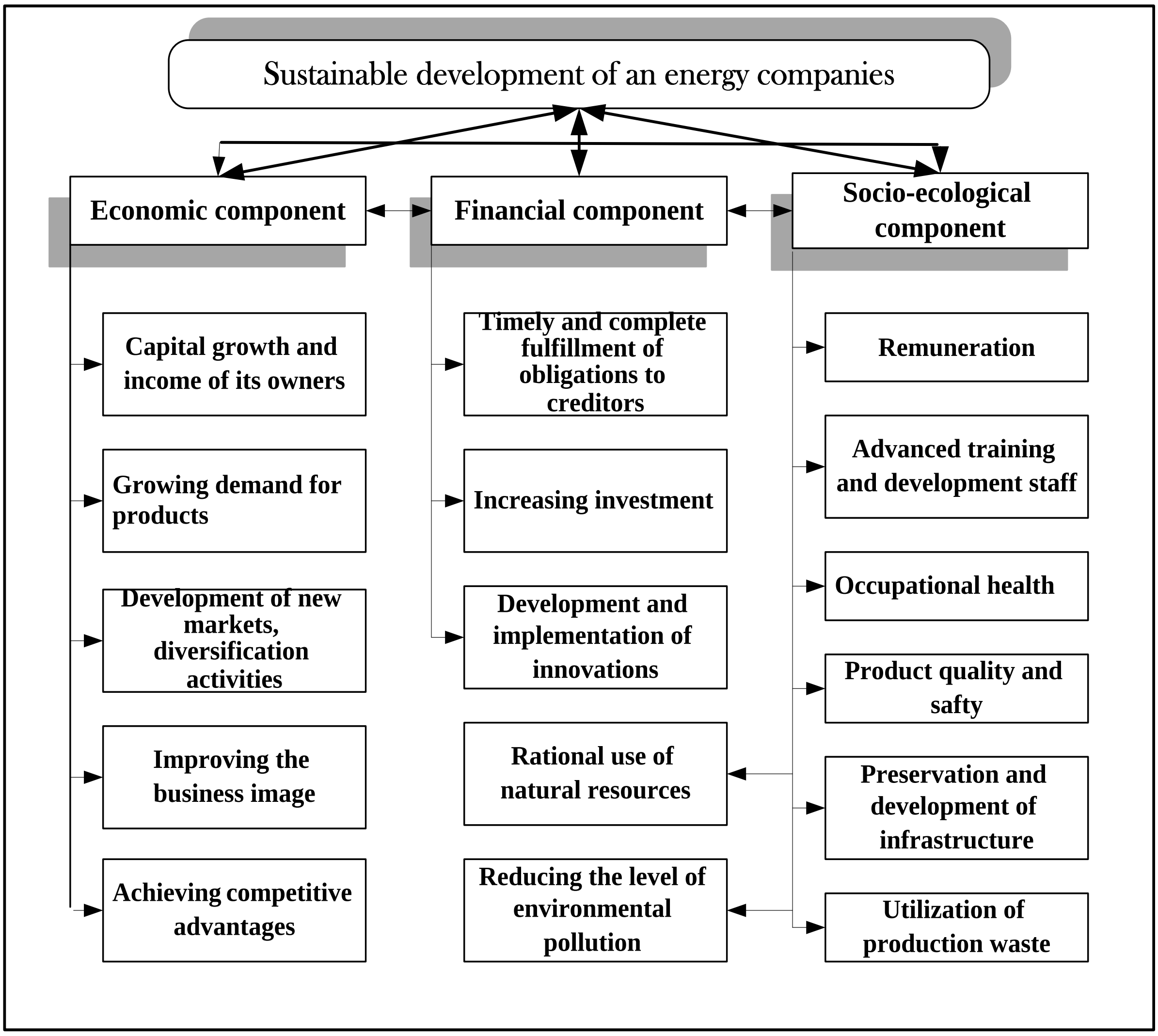

Fig: 1. Components of sustainable development of an energy companies
* developed by the authors

We believe that studies that take into account the whole set of factors will be subjective. These circumstances are taken into account when developing the author's approach to assessing the sustainable development of energy companies based on three factor models. The methodological aspect of sustainable development of energy companies is based on a comprehensive and systematic approach to research, which allows to present sustainable development of energy companies as a multicomponent phenomenon in the form of a set of factors of sustainable development and indicators that shape them.

Given the current situation in the country, namely fierce competition between producers, due primarily to the instability of the external environment, including inflation, rising unemployment, difficult political circumstances, lack of money in the population, the right choice of development depends on the future of a particular industry.

Since the sustainable development of energy companies is a set of economic, financial and socio-environmental sustainable development of energy companies in accordance with the indicators that characterize sustainable development, namely: capital growth and income of its owners, increasing demand for products, developing new markets products, diversification, improving business image, achieving competitive advantage, timely and full fulfillment of obligations to creditors, increasing investment, development and implementation of innovations, development and implementation of innovations, remuneration, training and development of personnel, labor protection, quality and product safety, preservation and development of infrastructure, utilization of production waste, rational use of natural resources, reduction of environmental pollution.

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We believe that the generalized criterion for assessing the sustainable development of an energy company can be defined as a function of individual criteria weighted by weights:

Generalized criterion for assessing the sustainable development of an industrial enterprise

$$K_{gen} = f(k_1, k_2, k_3, \ldots k_n; c_1, c_2, c_3, \ldots c_n), \tag{1}$$

where, k_n - individual criteria; c_n - weights.

To study the sustainable development of the enterprise, a generalized criterion of the following type is introduced:

$$K_{gen} = K(F_i C_i) = C_1 F_1 + C_2 F_2 + C_3 F_3, \tag{2}$$

where, F_i- indicators of enterprise activity; C_i - weights; F_1- indicators of enterprise activity, which characterize the economic component of sustainable development of the enterprise; F_2 - an indicator of the enterprise that characterizes the financial component of sustainable development of the enterprise; F_3 - performance indicators of the enterprise, which characterize the socio-ecological component of sustainable development

In this case, the condition must be met for the weights

$$\sum_1^3 C_i = 1 \tag{3}$$

Based on the above, the mathematical formulation of the problem of assessing the state of sustainable development of an industrial enterprise can be reduced to determining the indicator of the state of sustainable development of an industrial enterprise, its components that ensure equality:

$$\max K(F_iC_i)=\max(C_1F_1+C_2F_2+C_3F_3) \tag{4}$$

Such an equation must be satisfied provided that

$$P_i \geq P_{imin}, i \in I; P_j \leq P_{imax}, j \in J, (I+J)=n-m \tag{5}$$

At the same time, it is possible to apply the apparatus of fuzzy set theory to assess the sustainable development of the enterprise (at the levels of components F_1, F_2, F_3) [14].

By analogy with the allocation of risk areas of the set Fi of the enterprise is associated with the segment [0,1], which is divided into several disparate sub-intervals that characterize the degree of sustainable development of the enterprise for this component.

The values of the components F_1, F_2, F_3 are determined by the following algorithm:

as a result of the expert survey, the set of basic indicators P = {P1, P2, P3,… Pn}, which characterize the components of F_i;

on a given set of basic indicators P = {P1, P2, P3,… Pn} the ratio of the non-strict advantage $\tilde{R}$ with the function μR(Pi, Pj) ∈[0,1] is set as a result of the information received from experts who can professionally functional state of the enterprise .

For any pair of alternatives Pi, Pj∈P, the value of μR(Pi, Pj) is understood as the degree of advantage of Pi over Pj in the notation Pi ≥Pj. The equality μR(Pi, Pj)=0 can mean that μR(Pi, Pj)>0 or that there are alternatives.

The problem is to rationally choose the best alternatives from the set P, which has a fuzzy relative advantage $\tilde{R}$, ie there is a ranking of alternatives according to the following scheme:

A fuzzy relationship of strict advantage is formed

$$\tilde{R}^s = \frac{\tilde{R}}{\tilde{R}^T} \tag{6}$$

where, $\tilde{R}^T$, associated with $\tilde{R}$, due to the membership function

$$\mu_R(P_i, P_j)=\begin{cases}\mu_R(P_i, P_j)-\mu_R(Pj, P_i), \text{if} \mu_R(P_i, P_j)>\mu_R(Pj, P_i);\\ 0, \text{ if } \mu_R(P_i, P_j) \leq \mu_R(Pj, P_i).\end{cases} \tag{7}$$

This relationship can be presented as:

$$\tilde{R}^s=\frac{\tilde{R}}{\tilde{R}^T}, \tag{8}$$

where, $\tilde{R}^T$ - matrix of relations, which is formed by transforming the matrix $\tilde{R}$.

A fuzzy subset is constructed $P_R^{nd} \subset P$ non-dominant alternatives associated with $\tilde{R}$, which includes those alternatives that are not dominated by any others, and is determined by the membership function

$$\mu_R^{nd}(P_i) = \min_{P_j \subset P}\{1-\mu_{R^s}(P_j, P_1)\}=1-\max_{P_j \subset P}\{\mu_{R^s}(P_j, P_1)\}; P_i \in P \tag{9}$$

For any alternative $P_i \in P$ value $\mu_R^{nd}(P_i)$ understood as the degree of non-core indicators of this alternative. It is natural to consider rational the choice of alternatives that have the greatest possible degree of belonging to the set P_r^{nd}.

The alternative is chosen P^*, for which value $\mu_R^{nd}(P^*)$ maximum

$$P^*=\arg \max_{P_i \subset P} \mu_R^{nd}(P_i) \tag{10}$$

The selected alternative is removed from the set of alternatives P: P=P-{P*}. Repeat the procedure until P≠F.

Estimation of significance of C indicators for the generalized estimation of Fi according to Fishburne's formula [15].

$$C_i=\frac{2(N-i+1)}{N(N-1)}, i=\overline{1,N}, \tag{11}$$

where, N – set of natural numbers.

Construction of the indicator Fi according to the formula:

$$i = \sum_{K=1}^{N} d_k P_k \tag{12}$$

where, d - coefficient proportionality of alternatives.

Recognition of the current state of sustainable development of the enterprise on the basis of expert assessments. The results of recognition are presented in the table 1 by intervals Fi with an assessment of the degree of risk of bankruptcy.

Table 1. Criteria for assessing the level of sustainable development of an energy companies

Characteristic	Value range	Classification of the level of sustainable development of the enterprise
Criterion of sustainable development of an industrial enterprise Fi	0<Fi<0,20	Crisis situation
	0,21<Fi<0,30	Pre-crisis situation
	0,31<Fi<0,40	Unstable condition
	0,41<Fi<0,50	Satisfactory state of sustainable development
	0,51<Fi<0,60	The bifurcation interval of the stable state of sustainable development of the enterprise
	0,61<Fi<0,70	Satisfactory consistency
	0,71<Fi<0,80	Relative constancy
	0,81<Fi<0,90	Stable constancy
	0,91<Fi<1	The absolute state of sustainable development of the enterprise

Properly chosen vector of development of an industrial enterprise is an integral part of it, which ensures the viability of the organization, and this can only contribute to a comprehensive and in-depth assessment of sustainable development of the enterprise, which will find vulnerabilities and develop a set of measures to overcome negative consequences to improve the activities of developed sectors of the structure.

4. Conclusions

The methodical aspect of assessment of sustainable development of energy companies on the basis of three factor model is offered, which is based on the complex approach of research, which allows to present sustainable development of energy companies as a multicomponent phenomenon in the form of a set of factors of sustainable development.

The proposed indicators characterize the sustainable development of the energy company and are grouped by economic, financial and socio-environmental aspects. However, it should be noted that there is no single system of indicators, and therefore, depending on the interests of the owners of the energy company, its own system of factors and indicators is formed. The expediency of such a choice is explained by the size of the company, the presence of investors, work at the international level and so on.

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