https://doi.org/10.33271/nvngu/2022-1/170

A. V. Cherep[1],
orcid.org/0000-0001-5253-7481,
N. V. Katkova[2],
orcid.org/0000-0002-6199-4841,
I. S. Murashko[3],
orcid.org/0000-0002-4635-6921,
O. S. Tsyhanova[2],
orcid.org/0000-0002-0929-1436,
O. V. Hryshchenko[2],
orcid.org/0000-0002-9315-5030

1 – Zaporizhzhia National University, Zaporizhzhia, Ukraine
2 – Admiral Makarov National University of Shipbuilding, Mykolaiv, Ukraine, e-mail: nataliavkatkova@gmail.com
3 – Danube branch of "Interregional Academy of Personnel Management", Izmail, Ukraine

METHODOLOGICAL APPROACH TO ASSESSING THE SUSTAINABLE DEVELOPMENT LEVEL OF MACHINE-BUILDING ENTERPRISE

Purpose. To develop a methodological approach to assessing the level of sustainable development of a machine-building enterprise.

Methodology. To achieve this goal, a set of general scientific and special methods was used: induction and deduction, logical generalization, system analysis and formalization of complex structures, economic and mathematical modeling.

Findings. A methodical approach to assessing the level of the enterprise's sustainable development is proposed, which involves determining the integrated indicators of development of its subsystems, the overall integrated and four-dimensional indicator of sustainable development. On the basis of integrated indicators of economic, environmental, social and energy development, calculated using BSC-model indicators, a four-dimensional indicator of the level of the enterprise's sustainable development is formed, for which it is necessary to compare the degree of achievement of the goals of sustainable development of the enterprise with the previous year. This indicator allows determining further scenarios of enterprise development in accordance with the feasibility of attracting new resources and redistributing them between subsystems. This methodological approach was tried at a machine-building enterprise; the results obtained allowed us to conclude that in 2020 it was possible to achieve more goals of sustainable development in the economic and energy subsystems. The value of the integrated indicator points to a more sustainable development of the enterprise in 2020 than in 2019, the growth of the integrated indicator of sustainable development of the enterprise is due to the economic and energy subsystems.

Originality. The methodical approach to the complex assessment of the sustainable development level of machine-building enterprises is improved on the basis of the developed integrated indicators of economic, ecological, social and energy development, which, unlike the existing ones, allows determining the degree of achievement of goals for each subsystem of sustainable development; identifying ways of resources redistribution between the sustainable development subsystems on the basis of a four-dimensional indicator of the sustainable development level in order to use them most effectively; outlining priorities for further development.

Practical value. The use of the proposed approach will give companies the opportunity to determine the degree of achievement of goals for each sustainable development subsystem, ways to redistribute resources between them in order to most effectively use them, to form scenarios for further development of machine-building enterprises.

Keywords: *machine-building enterprises, sustainable development level, degree of achievement of goals, integrated indicator, four-dimensional indicator*

Introduction. In modern conditions of doing business and management, the achievement of sustainable development by enterprises is an important condition for their long-term successful functioning. Sustainable development of machine-building enterprises is possible under condition of maintaining a balance between the goals of economic growth, ensuring environmental and energy security, and reducing social inequality.

Formulation of sustainable development goals of the enterprise and assessment of the degree of their achievement is possible if there is an adequate system of indicators. Therefore, formation of a system of indicators for quantitative and qualitative measurement of achieving sustainable development of the enterprise as a whole and at the level of economic, ecological, energy and social components, as well as improving methodological approaches to their calculation is an urgent and important task.

Literature review. The works by many scientists, including Kharazishvili Yu. M., Lyashenko V. I. [1, 2], Averkina M. F. [3], Melnyk L. M. [4], Nesterenko O. O. [5], Sokil O. H. [6], Fedyna S. M. [7], Filipishina L. M. [8], Lepeiko T. I., Balanovich A. M. [9], Posylkina O. V., Svitlichna K. S., Bratishko Y. S. [10], and others [11,12] are devoted to the study of the problems of the methodology for assessing sustainable development both at the macro and micro levels.

Thus, Kharazishvili Yu. M., Lyashenko V. I. in order to monitor the state of sustainable development of Ukrainian industry proposed a structure of sustainable development, which includes social, environmental and economic components (a total of 30 indicators, which are divided into stimulants and destimulants) and methodology for identification of its level through modern integrated assessment [1]. Averkina M. F. for the diagnosis of sustainable urban development uses an integrated indicator of sustainable development, which is based on indicators: an integrated indicator of reproduction of socio-ecological and economic resources; integrated indicator of the use of socio-ecological and economic resources, integrated indicator of socio-ecological and economic security, integrated indicator of logistics of city development [3].

To assess the level of sustainable development of industrial enterprises, Melnyk L. M. offers the use of a methodological approach, which involves building a matrix of business indicators grouped by components of sustainable development (economic, social, ecological ones) and business processes (management, support, operational ones), and calculating the generalized level achieving sustainable development [4]. Filipishina L. M. determines the index "sustainability of development" of an industrial enterprise on the basis of geometric mean of the complex indicators of economic, environmental, social, risk and market stability [8]. Posylkina O. V., Bratishko Yu. S., Svitlichna K. S., researching the system of complex components for the assessment of sustainable socio-economic development of enterprises, distinguish economic and social components;

based on a group of indicators of socio-economic development, it is proposed to calculate the coefficient of synergy [10].

According to Sidorenko Yu. V., a comprehensive system of indicators for assessing the sustainable development of the enterprise includes the following groups: technical direction, financial direction, social direction and environmental direction. The author divides all groups of indicators into quantitative and qualitative. Hrigorska N. M. singles out the following indicators that characterize the components of economic stability: managerial, financial, innovative, marketing, production, business.

Despite significant scientific developments in the field of assessing the level of sustainable development of industrial enterprises, the issue of assessing the balance and proportionality of the directions of enterprise development, as well as determining the degree of achievement of goals for each subsystem of sustainable development, remains unresolved.

So, the constant development of socio-economic systems, new challenges and the complication of business conditions require further research on the issues of determining and justifying sustainable development indicators, as well as methods for calculating them.

Purpose. The purpose of the article is to develop the methodological approach to assessing the level of sustainable development of the machine-building enterprise.

Methods. To achieve this goal, a set of general scientific and special methods was used: induction and deduction, logical generalization, system analysis and formalization of complex structures, economic and mathematical modeling.

Results. The mechanism of sustainable development of the enterprise is designed to ensure balanced development in the relevant areas, including constant measurement of the degree of achieving sustainable development goals in areas. In the context of the formation of a mechanism for sustainable development of a machine-building enterprise using a balanced scorecard, the authors have built a system of indicators for monitoring and assessing the achievement of sustainable development goals by subsystems (economic, ecological, social and energy) [13].

To assess the level of sustainable development, to determine the proportionality of directions of enterprise development, it is proposed to use a methodological approach that involves calculating integrated indicators of sustainable development for each component and the enterprise as a whole, and forming on their basis a four-dimensional indicator of the sustainable development level, which allows us to determine further scenarios for the development of the enterprise (Fig. 1).

To assess the achievement of any goal, the actual value of the indicators that characterize the goal is compared with the target value: the smaller the difference is, the closer the company has come to the goal. Therefore, it is proposed to assess the degree of achievement of the set goals during the period in terms of components by determining the deviations from the target values for all indicators that characterize each component.

An integrated indicator of sustainable development is formed from the BSC-model indicators, and therefore each company will have an individual list of indicators.

In general, the integrated indicator of the sustainable development level for each subsystem is determined as follows

$$I_{ij} = \sqrt{(1-x_{1j})^2 + (1-x_{2j})^2 + \ldots + (1-x_{ij})^2},$$

where I_{ij} is the integrated indicator of the sustainable development of the i^{th} subsystem; i is subsystems of the j^{th} period; x_{1j}, x_{2j}, x_{mj}, are standardized indicators of achievement of goals of the j^{th} period.

The standardized value of the indicator is calculated as the ratio of the real value to the target value, if the target values go up

$$x_i = \frac{x_R}{x_T},$$

where x_T is the target value of the indicator; x_R is the real value of the indicator.

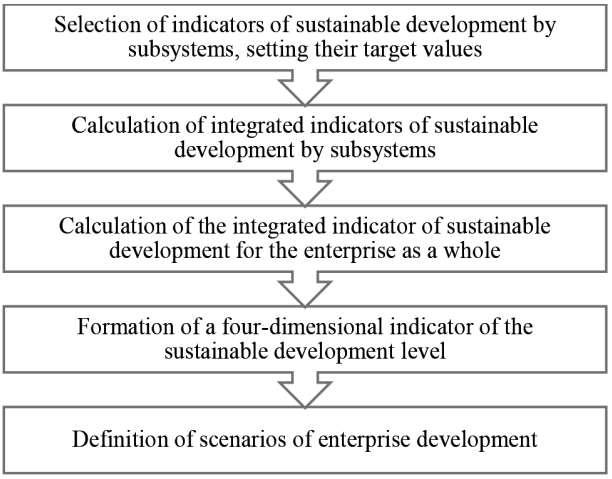

Fig. 1. General scheme for assessing the sustainable development of the enterprise

And if the target values are decreasing, then the standardized value of the indicator is calculated by the ratio of the target value to the real value

$$x_i = \frac{x_T}{x_R}.$$

The lower the value of the integrated indicator is, the more goals are achieved, the more sustainable the development of the enterprise in the study period is.

The integrated indicator of economic development of the studied enterprise LLC "Smart Maritime Group" is determined as follows

$$I_{econ} = \sqrt{\begin{array}{c}(1-PM)^2 + (1-ROA)^2 + (1-QR)^2 + (1-FAR)^2 + \\ + (1-CAT)^2 + (1-PA)^2 + (1-PDC)^2 + \\ + (1-PCAA)^2 + (1-NAC)^2 + (1-PNCO)^2 + \\ + (1-PNP)^2 + (1-SIP)^2 + (1-PUFA)^2 + \\ + (1-DRFA)^2 + (1-MT)^2 + (1-FAT)^2\end{array}},$$

where *PM* is standardized value of profit margin; *ROA* is standardized value of return on assets; *QR* is standardized value of quick ratio; *FAR* is standardized value of financial autonomy ratio; *CAT* is standardized value of current assets turnover; *PA* is standardized value of profitability of activity; *PDC* is standardized value of the percentage of dissatisfied clients; *PCAA* is standardized value of the percentage of customers who have applied again; *NAC* is standardized value of the number of attracted clients; *PNCO* is standardized value of the percentage of nonconformities in completed orders; *PNP* is standardized value of the percentage of nonconformities in projects; *SIP* is standardized value of share of innovations in production; *PUFA* is standardized value of the percentage of utilization of production fixed assets; *DRFA* is standardized value of depreciation rate of fixed assets; *MT* is standardized value of materials turnover; *FAT* is standardized value of fixed assets turnover.

The calculation of the integrated indicator of economic development of LLC "Smart Maritime Group" is given in Table 1. According to the results of the calculation of the integrated indicator of economic development, it is determined that during 2019–2020 its value decreased from 1.842 to 1.623, which indicates that in 2020 LLC "Smart Maritime Group" reached more target values of sustainable economic development indicators.

The integrated indicator of ecological development is calculated as follows

$$I_{ecol} = \sqrt{\begin{array}{c}(1-SEP)^2 + (1-VPE)^2 + (1-WG)^2 + \\ + (1-SEFM)^2 + (1-SEEP)^2 + (1-SIMPE)^2\end{array}},$$

where *SEP* is standardized value of share of ecological products; *VPE* is standardized value of volume of pollutants emissions in the air; *WG* is standardized value of waste generation; *SEFM* is standardized value of share of environmentally friendly materials used in production; *SEEP* is standardized value of share of expenditures on environmental protection; *SIMPE* is standardized value of share of actually implemented measures to protect the environment.

The calculation of the integrated indicator of environmental development of LLC "Smart Maritime Group" is given in Table 2.

The value of the integrated indicator of sustainable ecological development of LLC "Smart Maritime Group" during 2019–2020 is growing, which indicates that in 2020, compared to 2019, the company achieved fewer target values of indicators of sustainable ecological development.

The integrated indicator of social development is calculated as follows

$$I_{soc} = \sqrt{\begin{array}{c}(1-SAT)^2 + (1-SEPT)^2 + (1-SSE)^2 + (1-ET)^2 + \\ + (1-SLLS)^2 + (1-SECR)^2 + (1-SEMS)^2 + \\ + (1-SCPW)^2 + (1-SEC)^2 + (1-NCP)^2\end{array}},$$

where *SAT* is standardized value of share of employees who completed training and advanced training; *SEPT* is standard-

Table 1

The calculation of the integrated indicator of economic development of LLC "Smart Maritime Group"

No.	Indicator	Real value, x		Target value, x_T		Standardization of the indicator		$(1-x_i)^2$	
		2019	2020	2019	2020	2019	2020	2019	2020
1	Profit margin, %	8.99	7.56	10.30	11.10	0.87	0.68	0.016	0.102
2	Return on assets, %	1.80	3.00	7.90	8.11	0.23	0.37	0.596	0.397
3	Quick Ratio	0.98	0.98	1.00	1.00	0.98	0.98	0.000	0.000
4	Financial autonomy ratio	0.13	0.68	0.50	0.50	0.25	0.74	0.563	0.068
5	Current assets turnover	1.06	1.40	1.90	1.90	0.56	0.74	0.195	0.069
6	Profitability of activity, %	6.10	5.40	7.70	8.20	0.79	0.66	0.043	0.117
7	Percentage of dissatisfied clients, %	2.00	1.00	1.00	1.00	0.50	1.00	0.250	0.000
8	Percentage of customers who have applied again, %	44.00	59.00	65.00	70.00	0.68	0.84	0.104	0.025
9	Number of attracted clients, units	20.00	21.00	35.00	35.00	0.57	0.60	0.184	0.160
10	Percentage of nonconformities in completed orders, %	1.00	2.00	1.00	1.00	1.00	0.50	0.000	0.250
11	Percentage of nonconformities in projects, %	4.00	3.00	1.00	1.00	0.25	0.33	0.563	0.444
12	Share of innovations in production, %	9.00	10.00	20.00	40.00	0.45	0.25	0.303	0.563
13	Percentage of utilization of production fixed assets, %	87.00	95.00	100.00	100.00	0.87	0.95	0.017	0.003
14	Depreciation rate of fixed assets, %	65.00	71.00	30.00	30.00	0.46	0.42	0.290	0.333
15	Materials turnover	3.02	6.20	5.83	7.83	0.52	0.79	0.232	0.043
16	Fixed assets turnover	4.76	5.93	5.90	7.90	0.81	0.75	0.037	0.062
17	Total	–	–	–	–	–	–	3.393	2.636
18	Integrated indicator of economic development	1.842	1.623	–	–	–	–	–	–

Table 2

The calculation of the integrated indicator of ecological development of LLC "Smart Maritime Group"

No.	Indicator	Real value, x		Target value, x_T		Standardization of the indicator		$(1-x_i)^2$	
		2019	2020	2019	2020	2019	2020	2019	2020
1	Share of ecological products, %	10.05	11.92	12.00	24.00	0.84	0.50	0.026	0.253
2	The volume of pollutants emissions in the air, t	3.40	3.53	2.66	1.33	0.78	0.38	0.047	0.388
3	Waste generation, t	23.51	26.10	21.62	24.50	0.92	0.94	0.006	0.004
4	Share of environmentally friendly materials used in production, %	9.00	12.00	17.00	25.00	0.53	0.48	0.221	0.270
5	Share of expenditures on environmental protection, %	0.83	1.94	5.00	5.00	0.17	0.39	0.696	0.375
6	Share of actually implemented measures to protect the environment, %	72.00	85.00	100.00	100.00	0.72	0.85	0.078	0.023
7	Total	–	–	–	–	–	–	1.076	1.313
8	Integrated indicator of ecological development	1.037	1.146	–	–	–	–	–	–

ized value of share of expenses for personnel training; *SSE* is standardized value of share of satisfied employees; *ET* is standardized value of employee turnover; *SLLS* is standardized value of pay rate of

leading specialists; *SECR* is standardized value of share of employees complying with labor protection rules; *SEMS* is standardized value of share of equipment meeting safety and sanitation standards; *SCPW* is standardized value of share of actually completed planned labor protection work; *SEC* is standardized value of share of expenditures on charity; *NCP* is standardized value of the number of complaints from the population.

The calculation of the integrated indicator of social development of LLC "Smart Maritime Group" is shown in Table 3. The value of the integrated indicator of social development increases from 1.304 in 2019 to 1.419 in 2020, which indicates that the company in 2020 achieved fewer target values of indicators sustainable development compared to 2019.

The integrated indicator of energy development is determined as follows

$$I_{en} = \sqrt{\begin{array}{c}\left(1-EE\right)^2+\left(1-FE\right)^2+\left(1-IMSE\right)^2+\\ +\left(1-SOEC\right)^2+\left(1-SIOEC\right)^2\end{array}},$$

where *EE* is standardized value of energy efficiency; *FE* is standardized value of fuel efficiency; *IMSE* is standardized value of rate of implementation of measures to save energy; *SOEC* is standardized value of share of energy received from their own energy carriers; *SIOEC* is standardized value of share of income received from the sale of their own energy carriers.

The calculation of the integrated energy development indicator of LLC "Smart Maritime Group" is given in Table 4.

The value of the integrated energy development indicator decreases during 2019–2020 from 0.869 to 0.858, which indicates that LLC "Smart Maritime Group" achieved more target values of sustainable development indicators in 2020 compared to 2019.

To determine the overall level of sustainable development of the enterprise, it is proposed to calculate the integrated indicator of sustainable development on the basis of integrated indicators of economic, ecological, social and energy development according to the formula

$$I_{sd} = \sqrt{I_{econ}^2 + I_{ecol}^2 + I_{soc}^2 + I_{en}^2},$$

where I_{sd} is the integrated indicator of sustainable development of the enterprise; I_{econ} is the integrated indicator of economic development; I_{ekol} is the integrated indicator of ecological development; I_{soc} is the integral indicator of social development; I_{en} is the integrated indicator of energy development.

The lower the value of the integrated indicator of sustainable development is, the more sustainable development goals are achieved, the more sustainable the development of the enterprise is.

Table 3

The calculation of the integrated indicator of social development of LLC "Smart Maritime Group"

No.	Indicator	Real value, x		Target value, x_T		Standardization of the indicator		$(1-x_i)^2$	
		2019	2020	2019	2020	2019	2020	2019	2020
1	Share of employees who completed training and advanced training, %	28.00	28.60	30.00	30.00	0.93	0.95	0.004	0.002
2	Share of expenses for personnel training, %	11.00	15.00	20.00	20.00	0.55	0.75	0.203	0.063
3	Share of satisfied employees, %	70.00	73.00	90.00	90.00	0.78	0.81	0.049	0.036
4	Employee turnover	0.10	0.20	0.05	0.05	0.50	0.25	0.250	0.563
5	Pay rate of leading specialists, UAH	13500	15000	16000	20000	0.84	0.75	0.024	0.063
6	Share of employees complying with labor protection rules, %	96.00	95.00	100.00	100.00	0.96	0.95	0.002	0.003
7	Share of equipment meeting safety and sanitation standards, %	93.00	83.00	100.00	100.00	0.93	0.83	0.005	0.029
8	Share of actually completed planned labor protection work, %	95.00	91.00	100.00	100.00	0.95	0.91	0.003	0.008
9	Share of expenditures on charity, %	6.00	9.00	10.00	6.00	0.60	1.50	0.160	0.250
10	Number of complaints from the population, units	1.00	1.00	0.00	0.00	0.00	0.00	1.000	1.000
11	Total	–	–	–	–	–	–	1.700	2.015
12	Integrated indicator of social development	1.304	1.419	–	–	–	–	–	–

Table 4

The calculation of the integrated indicator of energy development of LLC "Smart Maritime Group"

No.	Indicator	Real value, x		Target value, x_T		Standardization of the indicator		$(1-x_i)^2$	
		2019	2020	2019	2020	2019	2020	2019	2020
1	Energy efficiency, UAH / kWh	39.63	78.57	45.30	81.00	0.87	0.97	0.016	0.001
2	Fuel efficiency, UAH / Gcal	120.90	142.70	122.00	150.00	0.99	0.95	0.000	0.002
3	Rate of implementation of measures to save energy	0.80	0.80	1.00	1.00	0.80	0.80	0.040	0.040
4	Share of energy received from their own energy carriers, %	5.00	11.00	12.00	20.00	0.42	0.55	0.340	0.203
5	Share of income received from the sale of their own energy carriers, %	2.00	3.00	5.00	10.00	0.40	0.30	0.360	0.490
6	Total	–	–	–	–	–	–	0.756	0.736
7	Integrated indicator of energy development	0.869	0.858	–	–	–	–	–	–

The calculation of the integrated indicator of sustainable development of LLC "Smart Maritime Group" is given in Table 5.

The value of the integrated indicator of sustainable development of LLC "Smart Maritime Group" is reduced during 2019–2020 from 2.632 to 2.588, which indicates an increase in the sustainability of its development.

Using the chain substitution method, it was determined which subsystems of LLC "Smart Maritime Group" had the greatest impact on the change in the value of the integrated indicator of sustainable development (Table 6).

According to the results of the calculation, it is determined that the greatest influence on increasing the sustainability of the enterprise has an economic subsystem: the integrated indicator of sustainable development is reduced by 0.149 due to the reduction of the integrated indicator of economic development. The reduction of the integrated indicator of sustainable development is also facilitated by the reduction of the indicator of energy development, but its impact is insignificant and is 0.004. The reduction of sustainability of development is due to the ecological and social subsystem of LLC "Smart Maritime Group".

These integrated indicators of economic, ecological, social and energy development indicate the degree of achievement of the goals of the enterprise, including the efficiency of their use of resources. Therefore, on the basis of integrated indicators it is possible to form a four-dimensional indicator of the level of sustainable development of the enterprise, which allows determining further scenarios of enterprise development in accordance with the feasibility of attracting new resources and redistributing them between subsystems.

Table 5

The calculation of the integrated indicator of sustainable development of LLC "Smart Maritime Group"

Indicator	Indicator value		Indicator value squared	
	2019	2020	2019	2020
Integrated indicator of economic development	1.842	1.623	3.393	2.636
Integrated indicator of ecological development	1.037	1.146	1.076	1.313
Integrated indicator of social development	1.304	1.419	1.700	2.015
Integrated indicator of energy development	0.869	0.858	0.756	0.736
Total	–	–	6.925	6.699
Integrated indicator of sustainable development	2.632	2.588	–	–

Table 6

Factor analysis of the integrated indicator of sustainable development of LLC "Smart Maritime Group"

Factor	2019	2020	Change in factor	Influence of factor
Integrated indicator of economic development	1.842	1.623	–0.219	–0.149
Integrated indicator of ecological development	1.037	1.146	0.109	0.047
Integrated indicator of social development	1.304	1.419	0.116	0.062
Integrated indicator of energy development	0.869	0.858	–0.012	–0.004
Integrated indicator of sustainable development	2.632	2.588	–0.044	–0.044

To form a four-dimensional indicator, it is necessary to compare the degree of achievement of sustainable development goals of the enterprise in the reporting year with the previous year, in particular to determine the growth rate of the indicator. The integrated indicator for each subsystem corresponds to four indicators of the ratio of integrated indicators of the current and previous years.

If the value of the ratio of the integrated indicator of a particular subsystem of the current year to last year is more than one, it indicates that the company in the current year has achieved fewer sustainable development goals than last year, which is associated, in particular, with the deterioration of resource efficiency and efficiency of operations. The value of the indicator below than one indicates an increase in the number of achieved goals of the enterprise, which was facilitated by the growth of efficiency in the use of all types of resources of the enterprise. And the value of the indicator equal to one indicates that in the current year the same number of goals was achieved as in the previous year.

Thus, the four-dimensional indicator of the level of sustainable development looks like this

$$SD = [E_{econ}; E_{ecol}; E_{soc}; E_{en}],$$

where SD is a four-dimensional indicator of the level of sustainable development; E_{econ} is the ratio of the integrated indicator of economic development of the current year to last year; E_{ecol} is the ratio of the integrated indicator of ecological development of the current year to last year; E_{soc} is the ratio of the integrated indicator of social development of the current year to last year; E_{en} is the ratio of the integrated indicator of energy development of the current year to last year.

The value of the ratio of the integrated development indicator for a certain subsystem of the current year to the last year, which is more than one, can be conditionally equated to the symbol "1", and one or less than one – to the symbol "0"

$$\begin{bmatrix} E_з > 1, & E_з = 1 \\ E_з \le 1, & E_з = 0 \end{bmatrix}.$$

Accordingly, it is possible to determine a four-dimensional indicator of the level of sustainable development of the enterprise. Then, for example, if the value of the ratio of integrated indicators of economic, ecological, social and energy development of the current year to last year is less than one, then the four-dimensional indicator should be [0; 0; 0; 0]. If the ratio of the integrated indicator of economic development of the current year to last year is higher than one, and the ratio of integrated indicators of ecological, social and energy development is one or less than one, then the four-dimensional indicator will look like [1; 0; 0; 0], and so on.

The proposed four-dimensional indicator of the level of sustainable development of the enterprise will determine the validity and direction of redistribution of resources between subsystems to achieve the goals of sustainable development.

The value of the ratio of the integrated indicator for a particular subsystem of the current year to last year, equal to "0", indicates the efficient use of resources, which contributes to their increase (e. g., profit in the economic subsystem, savings in the energy subsystem, etc.). In turn, this affects the degree of achievement of sustainable development goals, as well as provides opportunities to use surplus resources for the development of other subsystems. On the other hand, if the ratio of the integrated indicator of the current year to the previous year acquires the value "1", this indicates that this year the sustainable development goals were achieved less than in the previous year, which is caused by a lack of resources and ineffective ways of using them. For example, increasing the efficiency of energy use depends on the implementation of energy saving measures by the employees of the enterprise (high-quality ser-

vice and control over the condition of fixed assets, reduction of defects in production, and others) and additional financing for the introduction of energy-saving technologies.

Depending on the values of integrated indicators of economic, ecological, social and energy development, there are 16 scenarios for enterprise development and implementation of tactical and strategic goals of sustainable development of enterprise [14].

The value of the four-dimensional indicator of the level of sustainable development of LLC "Smart Maritime Group" indicates the failure to achieve the goals of ecological and social subsystems (Table 7). According to the results of the calculation, it is determined that the ratio of the integrated indicator of economic development of 2020 to 2019 is 0.881, ecological – 1.105; social – 1.089; energy – 0.987.

Such values of the ratios of the integrated indicators corresponds to the value of the four-dimensional indicator of the level of sustainable development [0; 1; 1; 0], which indicates the insufficient efficiency of the use of resources of the ecological and social subsystem.

Fig. 2 graphically shows the degree of achievement of sustainable development goals of LLC "Smart Maritime Group" by subsystems (dashed line shows the level of achievement of sustainable development goals of LLC "Smart Maritime Group" by subsystems, and solid – conditional version of enterprise development, when in the current year for all subsystems the same number of goals are achieved as in the previous year).

Thus, LLC "Smart-Maritime Group" can apply such measures to achieve sustainable development as: introduction of resource-saving technologies and programs for waste use; development and implementation of ecological products; introduction of a more efficient system of motivation and remuneration; training and professional development of personnel; inclusion of employees in the overall strategy of the company and raising their environmental awareness; organizational measures to reduce waste and production rejects, and others.

Conclusions. The proposed methodological approach to comprehensive assessment of the level of sustainable development of machine-building enterprises on the basis of developed integrated indicators of economic, ecological, social and energy development, in contrast to the existing ones, allows one to determine the degree of achievement of goals for each subsystem of sustainable development; on the basis of a four-dimensional indicator of the level of sustainable development, to identify ways of redistribution of resources between the subsystems of sustainable development in order to use them most effectively; outline priorities for further development.

An improved methodological approach to assessing the level of sustainable development of enterprises using integrated indicators of sustainable economic, ecological, social and energy development, as well as the overall integrated indicator of sustainable development was tested at LLC "Smart Maritime Group". The results allowed us to conclude that the company is more sustainable in 2020 than in 2019, the growth of the integrated indicator of sustainable development is due to the economic and energy subsystem (the company in 2020 managed to achieve more sustainable development goals for economic and energy subsystems).

Table 7

Determination of a four-dimensional indicator of the level of sustainable development of LLC "Smart Maritime Group"

Indicator	Indicator value		Ratio 2020 to 2019
	2019	2020	
Integrated indicator of economic development	1.842	1.623	0.881
Integrated indicator of ecological development	1.037	1.146	1.105
Integrated indicator of social development	1.304	1.419	1.089
Integrated indicator of energy development	0.869	0.858	0.987
Four-dimensional indicator of the level of sustainable development		[0;1;1;0]	

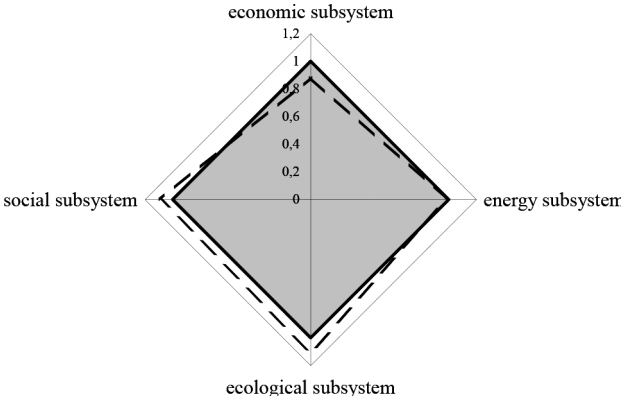

Fig. 2. The degree of achievement of sustainable development goals for the subsystems of LLC "Smart Maritime Group"

On the basis of the integrated indicators, a four-dimensional indicator of the level of sustainable development of the enterprise is formed, for which it is necessary to compare the degree of achievement of the goals of sustainable development by the enterprise with the previous year. This indicator allows determining further scenarios for the development of the enterprise in accordance with the advisability of attracting new resources and their redistribution between subsystems.

The approbation at LLC "Smart Maritime Group" indicates that the company uses financial and energy resources most efficiently, so to ensure sustainable development it is necessary to attract these resources for the development of ecological and social subsystem through the implementation of certain measures.

Acknowledgements. The study was performed in accordance with the general research topics of PJSC "Higher Educational Institution "Interregional Academy of Personnel Management": "Problems and prospects for the development of industrial and agricultural enterprises in Ukraine" (state registration number 0117U00024).

References.

1. Kharazishvili, Yu. M., & Lyashenko, V. I. (2017). Problems of assessment and integral indices of sustainable development of the industry of Ukraine from the standpoint of economic security. *Scientific journal "Economy of Ukraine", 2*(663), 3-23.

2. Kharazishvili, Yu. M. (2019). *System security of sustainable development: assessment tools, reserves and strategic implementation scenarios: monograph*. Kyiv. Retrieved from https://iie.org.ua/wp-content/uploads/2019/02/ Harazishvili_monograf_2019-ost.pdf.

3. Averkina, M. F. (2015). *Ensuring sustainable development of cities and agglomerations: theory, methodology, practice: monograph*. Lutsk: RVV Lutsk NTU.

4. Melnyk, L. M. (2017). Development of a system-integrated methodological approach to assessing the level of achieving sustainable development of industrial enterprises on the basis of business indicators. *Bulletin of ONU named after I.I. Mechnikov*, *11*(64), 136-141.

5. Nesterenko, O. O. (2017). Sedimentary development evaluation indicators and their effect on integrated reporting indicators. *Scientific Bulletin of Uzhhorod National University*, *15*(2), 44-50.

6. Sokil, O. H. (2017). Methodological provisions for the indicator substantiation of accounting-analytical support of agricultural enterprises sustainable development. *Young scientist, 12*(52), 762-767.

7. Fedyna, S. M. (2019). Forming the system sustainable development indicators for biosocial economy assessment. *The mechanism of economic regulation, 4,* 129-137. https://doi.org/10.21272/mer.2019.86.13.

8. Filipishina, L. M. (2017). Integral assessment of the sustainability of industrial enterprises. *Global and national economic problems, 19,* 280-285.
9. Lepeiko, T. I., & Balanovich, A. M. (2016). Comprehensive assessment of the level of development of industrial enterprises. *Problems of the economy. 4,* 136-143.
10. Posylkina, O. V., Bratishko, Yu. S., & Svitlichna, K. S. (2015). Diagnostics of sustainable social and economic development of pharmaceutical enterprises. *Management, economics and quality assurance in pharmacy, 3*(41), 44-50.
11. Shvets, V. Ya., Rozdobudko, E. V., & Solomina, G. V. (2013). Aggregated methodology of multicriterion economic and ecological examination of the ecologically oriented investment projects. *Naukovyi Visnyk Natsionalnoho Hirnychoho Universytetu,* (3), 139-144.
12. Katkova, N. V., & Matushevskaya, E. A. (2015). Methodical and practical aspects of defining the integrated indicator of the level of economic sustainability of industrial enterprises. *Business Inform, 1,* 252-257.
13. Katkova, N. V., & Murashko, I. S. (2021). Implementation the mechanism of the enterprise sustainable development using a balanced scorecard. *Effective economy, 1.* https://doi.org/10.32702/2307-2105-2021.1.88.
14. Katkova, N. V., & Murashko, I. S. (2019). The forming of scenarios of enterprise development on the basis of four-level indicator of sustainable development. *Technology Audit and Production Reserves, 2*(4(46)), 4-10. https://doi.org/10.15587/2312-8372.2019.165707.

Методичний підхід до оцінювання рівня стійкого розвитку підприємства машинобудування

А. В. Череп[1], *Н. В. Каткова*[2], *І. С. Мурашко*[3], *О. С. Циганова*[2], *О. В. Грищенко*[2]

1 – Запорізький національний університет, м. Запоріжжя, Україна
2 – Національний університет кораблебудування імені адмірала Макарова, м. Миколаїв, Україна, e-mail: nataliavkatkova@gmail.com
3 – Придунайська філія ПрАТ «Міжрегіональна Академія управління персоналом», м. Ізмаїл, Україна

Мета. Розробка методичного підходу до оцінювання рівня стійкого розвитку машинобудівного підприємства.

Методика. Для досягнення визначеної мети використано комплекс загальнонаукових і спеціальних методів: індукції та дедукції, логічного узагальнення, системного аналізу та формалізації складних структур, економіко-математичного моделювання.

Результати. Запропоновано методичний підхід до оцінювання рівня стійкого розвитку підприємства, що передбачає визначення інтегральних показників розвитку його підсистем, загального інтегрального й чотиривимірного показника стійкого розвитку. На підставі інтегральних показників економічного, екологічного, соціального та енергетичного розвитку, обчислених з використанням індикаторів BSC-моделі, формується чотиривимірний показник рівня стійкого розвитку підприємства, для чого необхідно порівняти ступінь досягнення цілей стійкого розвитку підприємством у порівнянні з минулим роком. Цей показник дозволяє визначити подальші сценарії розвитку підприємства у відповідності до доцільності залучення ним нових ресурсів і перерозподілу їх між підсистемами. Даний методичний підхід було апробовано на машинобудівному підприємстві; отримані результати дозволили зробити висновок, що підприємством у 2020 році вдалося досягти більше цілей стійкого розвитку за економічною та енергетичною підсистемами. Значення інтегрального показника вказує на більш стійкий розвиток підприємства у 2020 році, ніж у 2019 році, зростання інтегрального показника стійкого розвитку підприємства відбувається за рахунок економічної та енергетичної підсистеми.

Наукова новизна. Удосконалено методичний підхід до комплексного оцінювання рівня стійкого розвитку підприємств машинобудування на підставі розроблених інтегральних показників економічного, екологічного, соціального та енергетичного розвитку, що, на відміну від існуючих, дозволяє визначити ступінь досягнення цілей за кожною підсистемою стійкого розвитку; на базі чотиривимірного показника рівня стійкого розвитку визначити шляхи перерозподілу ресурсів між підсистемами стійкого розвитку з метою їх найбільш ефективного використання, окреслити пріоритети подальшого розвитку.

Практична значимість. Використання запропонованого підходу надасть підприємствам можливість визначати ступінь досягнення поставлених цілей за кожною підсистемою стійкого розвитку, шляхи перерозподілу ресурсів між ними з метою їх найбільш ефективного використання, формувати сценарії подальшого розвитку підприємств машинобудування.

Ключові слова: *підприємства машинобудування, рівень стійкого розвитку, ступінь досягнення цілей, інтегральний показник, чотиривимірний показник*

The manuscript was submitted 20.04.21.