

# **Analysis of the possibility of using KPIs in measuring the achievements of business entities from the energy sector – case study**

*Karolina Czerwińska, Andrzej Pacana*

---

**Summary:** Each performance measurement and management system should be updated and reorganized so that it can be adequate to the changes occurring in the economic entity and the sector in which it operates. In addition, the performance measurement system should evolve with the organization's changing strategy and continually updated management objectives. The purpose of the study was to analyze the possibility of applying key performance indicators in an economic entity from the energy sector and to indicate their role and importance in the context of effective management and monitoring of progress in achieving pre-defined objectives. In the study, a coherent set of KPIs was designed, which were used to evaluate the existing concepts in the business entity and, at the same time, served as guidelines for choosing new directions of improvement and development concerning, among others, reorganization and restructuring in the customer service model through the introduction of a training system and organization design (a system of values and employee motivation), as well as obtaining permanent savings in operating costs through reduction of own costs will make it possible to pursue an effective pricing policy.

**Key words:** key performance indicators, performance measurement system, improvement, quality engineering

## **Introduction**

Progressive globalization processes, dynamically changing market, increased competition and threats related to crisis phenomena require companies to develop and implement innovative management systems (Czerwińska and Pacana 2019: 3-4; Blind et al., 2021: 33-34; Martincevic and Kozina 2021: 1262-1263; Zwolenik and Bełch 2021: 19-20). For companies, maintaining a stable position and competitive advantage means choosing and applying an appropriate management strategy related to increasing efficiency and often innovation (Brzóska et al., 2011: 6-7; Ulewicz et al., 2016: 89-90; Grabowska, 2017: 105-106; Svikruhova et al., 2021: 831-833). Types of management strategies, as well as activities implemented in this plane, have been widely described in the literature (Fredriksson and Larsson, 2012; Kazmierczak, 2000; Legutko, 2009; Wilczarska, 2012; Antosz and Ciecńska, 2011; Antosz et al. 2013; Wolniak, 2021:100-102). One of the most important tools for monitoring the level of performance and management in organizations are key performance indicators (ang. Key Performance Indicators, KPI). They are to facilitate the assessment of the company's performance by measuring the degree to which the objectives established in it have been achieved - which in turn facilitates decision-making, appropriate prioritization of activities and improvement of the company's development strategy (Babcanova, 2012: 117; Parmenter, 2016: 33-34; Grabowska, 2017: 107-108; Banu, 2018: 906-907).

The purpose of the study was to analyze the possibility of applying key performance indicators in a business entity from the energy sector and to highlight their role and importance in

the context of effective management and improvement and monitoring of progress in achieving previously set objectives, as well as to present the direction of their evolution in the context of changing operating conditions for the analyzed entity.

### Key performance indicators in an energy business entity

The subject of consideration in the study was to indicate the possibility of implication of KPIs and to indicate their effectiveness in monitoring the progress in achieving pre-defined objectives. Therefore, it is worthwhile at the very beginning to refer to the explanation of the essence of key performance indicators. However, it is important to note that explicitly capturing KPIs is not straightforward. Analyzing the extremely rich literature in this area, one can notice the ambiguity of interpretation, as well as the frequent multifaceted treatment of.

KPIs are one of the tools of Business Performance Management, i.e. a group of concepts from the field of operations management, promoting improvement of the effectiveness of the organization's functioning with the use of measures, processes, monitoring systems and management of the organization's results. At the same time, KPIs are an integral part of a set of global best manufacturing practices known as World Class Manufacturing (WCM). In the literature there are over 2000 definitions of various KPIs functioning in organisations from all sectors (Valimirovic et al., 2011: 63-64; Parmenter, 2016; Piasecka-Gluszak, 2017; Gonzalez et al., 2017: 559-560). Selected KPI definitions are included in Table 1.

**Table 1. Selected definitions of key performance indicators**

Lp.	Note	Definition of
1.	Neely, Adams and Kennerly, 2002	A parameter to quantify the effectiveness and/or efficiency of past actions.
2.	Clifton, 2012	Any, measure, percentage, ratio or average that can help an organization quickly understand incoming data in the right context and at the right time.
3.	Reh, 2012	Kpi are measurable measurements, previously agreed upon, that reflect the key success factors of the organization.
4.	Kang, et al., 2015	A set of measurable and strategic parameters depicting the operational achievements of a company, playing a key role in the creation of a measurement system (achievements).
5.	ISO 22400-1:2014, 2014	The quantifiable level of achievement of the critical objective. ISO 22400 also states that key performance measures come directly from the aggregation function, physical measurements, data and other KPIs.
6.	Barone et. al., 2011	They are measures or indicators that assess performance against certain objectives. They are routinely used by the organization to measure both success in achieving strategic goals and the quality of.
7.	Tesoro and Tootson, 2000	KPIs can explain a set of numbers used to measure a process or outcome so that the effect within the organization is determined relatively easily.
8.	Marr, 2010	Key performance measures (KPIs) help organizations understand how well they are performing against their strategic objectives. In the broadest sense,

		a key performance measure provides key performance information that enables organizations or their stakeholders to know whether the organization is on the right track. Key performance measures are used to simplify organizational characteristics into a small number of key metrics to increase organizational effectiveness.
9.	Kaplan, 2009	KPIs or key performance measures are selected metrics that provide insight into business performance and enable decision makers to take action to achieve desired results. Organizations that measure performance identify several key success factors that address specific strategic objectives.
10.	Al-Mutairi, 2012	Key performance measures are commonly used by companies as a tool to assess performance. They form the basis of an achievement system that turns the company's strategic goals into short-term objectives. Establishing clear and actionable KPIs serves to manage performance well.
11.	Peng et al., 2007	A KPI is a tool used to convey knowledge about the relative health of a company or part of a company. A Kpi is a specific measure (a quantitative, periodic measurement of one or more processes) selected from among all collected or possible indicators in a company in such a way as to provide as much information as possible in a single measurement (key measurement).

Note: Own elaboration based on: Neely et al., 2002; Clifton, 2012; Reh, 2004; Kang, et al., 2015; ISO 22400-1:2014, 2014; Barone et. al., 2011; Tesoro and Tootson, 2000; Marr, 2010; Kaplan, 2009; Al-Mutairi, 2012; Peng et al., 2007.

The analysis of the definitions of KPIs contained in Table 1, contributed to the formulation of the definition of key performance indicators, which reads as follows: a key performance indicator is a carrier of information, in the form of an index, an absolute measure or statistics of a specific process, serving to quantify achievements (of the technical, organizational and economic sphere), identify priority processes, operations, activities and values mobilizing employees to achieve the objectives and corporate strategy. Given the wide range of KPI applications in organizations, in the authors' opinion, they are a convenient tool for building an effective performance measurement system.

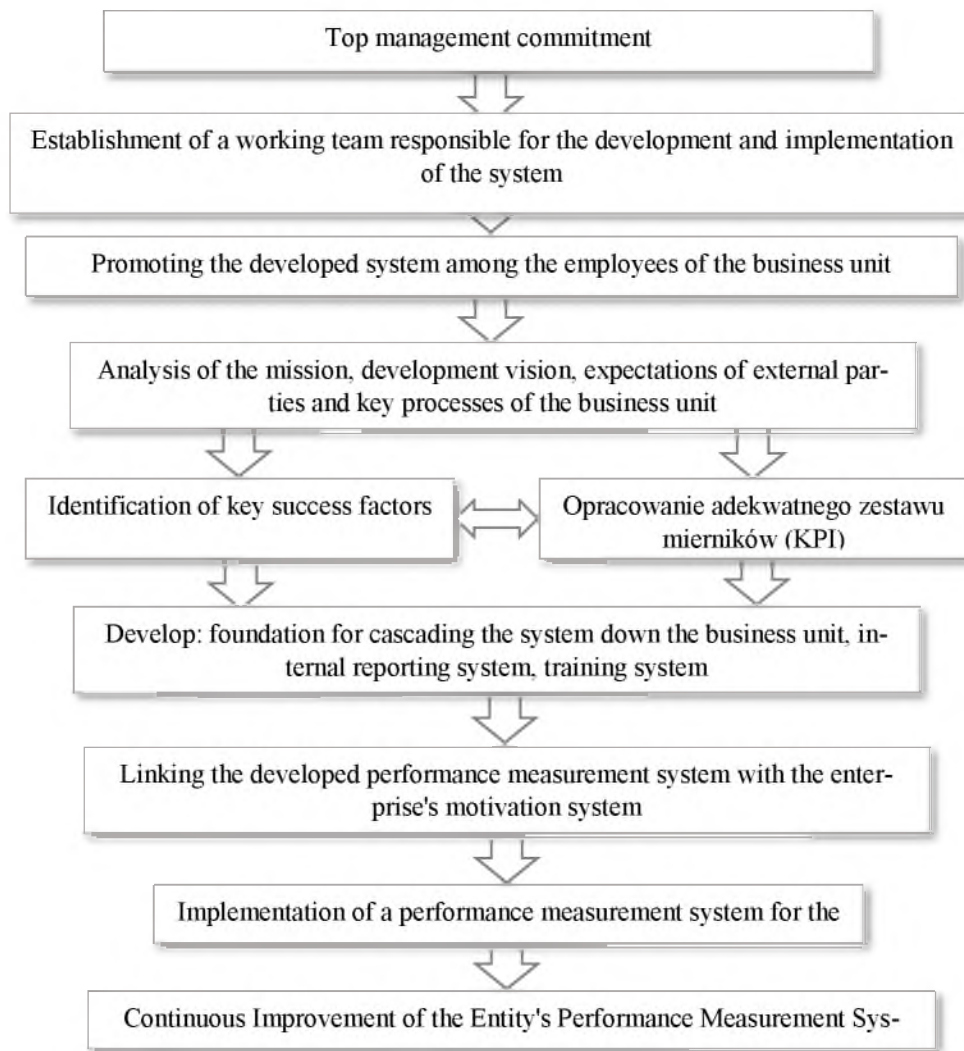
### **Methodology of building performance measurement system**

The measurement of the achievements of business entities can be carried out on many levels. It is possible to measure all economic aspects in the organization, i.e. processes, phenomena, streams, but the preparation and implementation of the performance measurement method should be adequate to the specificity of the organization. This action can be divided into two parts (Nowak 2012: 39):

1. thorough analysis of the economic entity and development of an appropriate performance measurement system,
2. implementation of the developed performance measurement system and its improvement and ensuring its adequacy.

The indicated two stages of activities can be divided into nine actions contributing to ensuring an appropriate level of effectiveness of the performance measurement system. These activities are shown in Figure 1.

**Figure 1 The main stages of building an effective performance system of an enterprise**



Source: own elaboration based on: Nowak 2012

An enterprise's performance measurement system should facilitate the effective quantification of all major areas of enterprise activity. A properly developed and implemented measurement system should be consistent with the company's strategy, oriented to the needs of external stakeholders and should be adequate in terms of: critical success factors, performance reporting, multi-faceted scope of measurement, critical measurement factors, and at the same time it should be oriented to employees' motivation and future.

### **Proposal of using KPIs within the performance measurement system**

The analysed business entity is located in Poland and considers trading in natural gas and electricity as its key area of activity. Due to the lack of a clearly defined performance measurement system in the organization, it was decided to propose the use of selected key performance indicators as part of activities improving the management of the unit. A one-year period of activity was examined.

Under the current Energy Law, transmission and distribution activities were separated from generation and trading activities (Journal of Laws 2020.833 of 2020.05.11), which forced operators to create a new and effective performance measurement system. The new system should be adapted to operate in free market conditions (Bartnik 2015: 20-21; Skoczylas and Wasniewski 2017: 185-186), and therefore redesigned in such a way that in the analyzed entity it is directed only to the numerical capture of phenomena related to commercial processes. On the basis of the presented premises, in the analyzed economic entity the concept of management by objectives has been introduced, which consists in the continuous pursuit of the achievement of the assumed provisions, taking into account the current conditions of the economic entity and its capabilities. This concept allows delegating the organization's goals and employees' responsibilities, making it possible to evaluate the degree of their realization and linking the results to the bonus system (Tschernitz and Gross 2011: 261; Mondy 2012: 456; Leśniewski 2016: 82-84; Czerwińska and Pacana 2020: 13-14). The organization's revised performance measurement system takes into account two areas: the internal and external areas of the business entity. Internal orientation refers to the measurement of the achievements of individual workplaces and organizational units and serves the management of the analyzed organization. On the other hand, in relation to the external area, the system is used to evaluate the results of the economic entity as a whole and is implemented for the owners.

In the group of proposed measures we can distinguish internally oriented measures and externally oriented measures in the classification of variable and constant. Selected performance measurement indicators from the presented groups are listed in Table 2.

**Table 2. Selected internally and externally targeted key performance indicators**

Internally Focused Key Performance Measures				
Entity as a whole		Organisational units		Workstation
Receivables turnover ratio		Number of tariff group customers acquired during the specified period, implementation of the orders of the Chief Operating Officer implemented for implementation during the period evaluated		Produce reporting reports on time to a quality standard
Unit sales margin				
Volume of gas sold				
Quantity of electricity sold				
Number of customers in given tariff groups at the end of the settlement period				
Degree of implementation of the sales plan				
Key performance indicators externally oriented - variables				
Meter	Calculation method	Unit of measurement	Target value	Scale of assessment within the defined level of achievement of the objective
Level of implementation of initiatives: - (1) Launch eServices for specific customer groups (A, B, C),	Evaluation of the implementation of the initiatives in accordance with the developed timetable and the effects of the activities carried out	pkt	100	Exceeding expectations - 110, Meeting expectations - 100, Satisfactory - 70, Moderate - 50,

- (2) launch e-invoicing for specific customer groups (A, B, C), - (3) upgrading of specific gas transmission sections (lots: 1, 2, 3, 4)				Weak - 25 Unsatisfactory - 0
Develop and refine a plan to maintain gas and electricity sales	Completion of the task on time	pkt	70	Exceeding expectations - 110, Meeting expectations - 100, Satisfactory - 70, Moderate - 50, Weak - 25 Unsatisfactory - 0
Value index of sales of new products and services	$\frac{A}{B} \cdot 100\%$ A - net profit, B - revenues from sales	%	X	X% and above - 110, X% - 100, X% - 70, X% - 50, X and less - 0
Level of customer satisfaction with service	Evaluation based on the result of the customer satisfaction survey (application of CSI - Customer Satisfaction Index)	%	70	80% and above - 110, 78% - 100, 76% - 70, 74% - 50, 72 and less - 0
Externally oriented key performance measures - fixed				
Meter	Calculation method	Unit of measurement	Target value	Scale of assessment within the defined level of achievement of the objective
The change in the number of customers in the domestic market during the year under review (as determined by measuring capacity orders)	$A + B1 \cdot C1 + \dots + B5 \cdot C5$ A - power ordered by customers, B1 .. B5 - difference in number of clients C1 .. C5 - assumed coefficient of ordered power	m <sup>3</sup> /h	X	X m <sup>3</sup> /h i więcej - 110, X m <sup>3</sup> /h - 100, X m <sup>3</sup> /h - 70, X m <sup>3</sup> /h - 50, X m <sup>3</sup> /h i mniej - 0
Prepaid receivables ratio over 60 days	$\frac{(A + B - C)}{D} \cdot 100\%$ A - value of receivables over 60 days past due,	%	X	X m <sup>3</sup> /h i więcej - 110, X m <sup>3</sup> /h - 100, X m <sup>3</sup> /h - 70, X m <sup>3</sup> /h - 50, X m <sup>3</sup> /h i mniej - 0

	B- value of bad debts written off, C - value of receivables recovered in a given period, D - revenue in a given period			
Prepaid receivables ratio over 30 days	$\frac{(A + B - C)}{D} \cdot 100\%$ A - value of receivables over 30 days past due, B- value of bad debts written off, C - value of receivables recovered in a given period, D - revenue in a given period	%	X	X m <sup>3</sup> /h i więcej - 110, X m <sup>3</sup> /h - 100, X m <sup>3</sup> /h - 70, X m <sup>3</sup> /h - 50, X m <sup>3</sup> /h i mniej - 0
Implementation of own costs	$\frac{(A - B)}{B} \cdot 100\%$ A - actual costs in a branch in a given settlement period B - costs planned in the branch in a given settlement period	%	X	X m <sup>3</sup> /h i więcej - 110, X m <sup>3</sup> /h - 100, X m <sup>3</sup> /h - 70, X m <sup>3</sup> /h - 50, X m <sup>3</sup> /h i mniej - 0

Source: own study

In Table 2, values for which commercial confidentiality applies are indicated as 'X'.

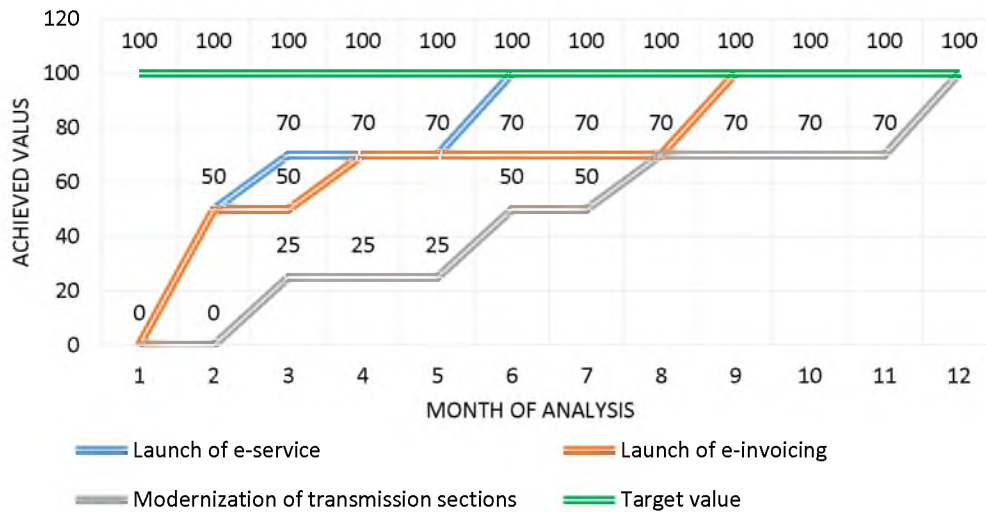
A separate group in the analysed entity are the internal indicators (Table 2), which are used to measure and evaluate processes for the needs of the top management of the organisation.

Externally-oriented indicators - fixed, are quantitative and qualitative in nature. These indicators are characterised by repetition in each analysed period. On the other hand, externally oriented indicators - variables, are characterized by their qualitative nature. This set of indicators is initiated according to changes in the structure of both internal, external conditions and needs. The configuration of the group of variable indicators is modified depending on factors such as: the initiatives of the supervisor, the implications determined by the update of the strategy in relation to the trading area, the progressive conditions of the external environment.

## Results and analysis

The research analyzed the results obtained by the business unit over a period of 2 years. Due to the selective ability to present results, the analysis presents key performance measures externally targeted in a group of variables. The results in terms of the level of implementation of the initiatives are illustrated in Figure 2.

**Figure 2. Level of implementation of planned initiatives**

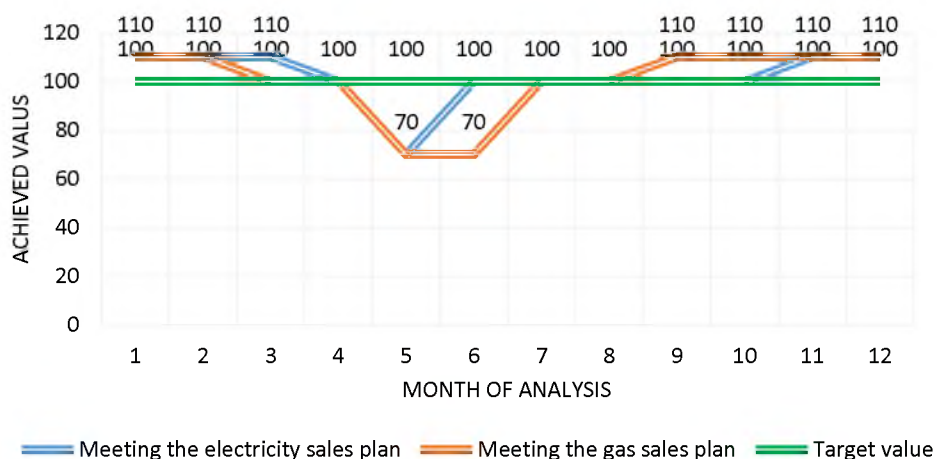


Source: own study

As shown in Figure 2, the utility has completed the activities necessary to implement the three planned initiatives (launching eServices for specific customer groups, launching eInvoicing for specific customer groups, upgrading four transmission segments). The most quickly implemented initiative was the launch of eServices. The process in the second month reached a moderate level of implementation - which meant launching the service to one of three groups of customers - individuals. In month 3, a service for large entrepreneurs was launched. In the fifth month, the goal was fully achieved. Activities concerning the launch of e-invoicing for all customer groups lasted 9 months. The initiative to upgrade certain transmission sections took 12 months, most likely due to the significant costs incurred by the company.

Sales is an important element in the activities of any business entity, because it largely generates profits that are information about the financial health of the organization. However, in order to achieve profits by obtaining a proper level of sales, it is necessary to plan it properly (Pindelski 2011:196-197; Cybulski 2010: 87; Adamowicz and Łuniewska 2015: 363). Data on the level of sales of natural gas and electricity are presented in Figure 3.

**Figure 3. Level of achievement of assumptions regarding the sales plan**



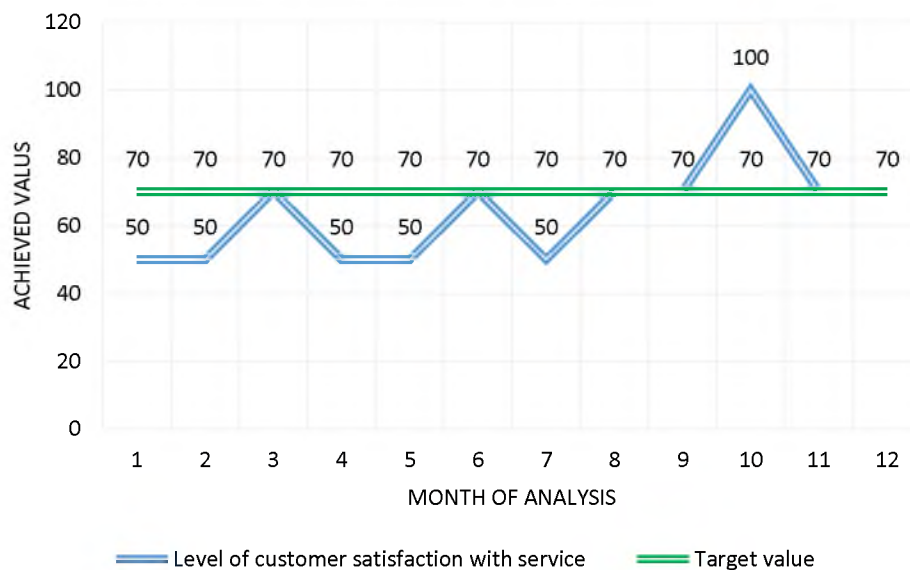
Source: own study



In the period under review, a maintenance plan for gas and electricity sales was developed, under which a sales target was set. Figure 3 shows that the planned level of sales was achieved; moreover, both gas sales (6 months) and electricity sales (4 months) exceeded expectations.

The company aims to maintain an appropriate level of satisfaction with the services provided, as one of the most important aspects affecting the development of the company is the customer's opinion and satisfaction with the services received. Customer satisfaction surveys are one of the basic tools enabling to build a long-term relationship between the customer and the business entity (Wolniak and Skotnicka 2008: 20-25). The result regarding the level of satisfaction among customers of the analyzed organization is shown in Figure 4.

**Figure 4. Level of customer satisfaction with service**



Source: own study

The level of customer satisfaction of the business unit is on average at a moderate level, which indicates the need for improvement in the way of providing service and customer care. Only in one month did the satisfaction level exceed the target value threshold.

The main goal that the organization should achieve in the future is to retain current customers by increasing customer satisfaction, attracting new buyers and increasing sales volumes. The achievement of the indicated objectives will be possible thanks to:

- reorganization and restructuring in the customer service model through the introduction of a training system and organization design (system of values and motivation of employees),
- gaining sustainable savings on operating costs by reducing the cost of ownership it will be possible to implement an effective pricing policy.

Taking into account the proposed activities aimed at functioning in new conditions of operation, the organisation should design an adequate group of key performance indicators to measure the effectiveness of the performed restructuring activities.

## Conclusion

A performance measurement system that is not adapted to the individual nature of the business unit contributes to a loss of control, which translates into an inability to effectively manage the organization. For this reason, it seems crucial to develop an adequate measurement system for the needs and specificity of the organization with the use of appropriate measures - KPIs. The correct development and positioning of measures in relation to the conditions and needs of a given economic entity will ensure the effective and reliable assessment of the objectives pursued by the entity. Therefore, the performance measurement system should be updated due to emerging changes not only in the company itself, but also in the environment. The use of KPIs has made it possible to prioritize activities, which facilitates rapid decision-making.

The study confirmed the effectiveness of using KPIs in a business unit in the energy sector. The proposed indicators made it possible to monitor the level of fulfillment of the established initiatives and modernization plans, and made it possible to identify the critical areas in the organization (low level of satisfaction). It was found that the shape and scope of the performance measurement system depends on the structure of factors that determine the functioning of a business unit. The study indicates the framework and directions of development of key indicators of the performance measurement system based on the premises resulting from changes in the environment.

## Bibliography

---

1. Adamowicz M., Luniewska S., Planowanie i budżetowanie jako narzędzie zarządzania finansami przedsiębiorstwa, Zeszyty Naukowe Uniwersytetu Szczecińskiego. Finanse, Rynki Finansowe, Ubezpieczenia, Rachunkowość w zarządzaniu jednostkami gospodarczymi, 2015 Nr 77.
2. Al-Mutairi S.H., Cost maintenance management, eWork and eBusiness in Architecture, Engineering and Construction. Proceedings of the European Conference on Product and Process Modelling, 2012.
3. Antosz K., Ciecierska B., Podstawy zarządzania parkiem maszyn w przedsiębiorstwie, Oficyna wydawnicza Politechniki Rzeszowskiej, Rzeszów 2011.
4. Antosz K., Pacana A., Stadnicka D., Zielecki W., Narzędzia Lean Manufacturing. Oficyna Wydawnicza Politechniki Rzeszowskiej, Rzeszów, 2013.
5. Banu GS., Measuring innovation using key performance indicators, 11th International Conference Interdisciplinarity In Engineering, Inter-Eng 2017, Procedia Manufacturing, 2018, Vol. 22.
6. Barone D., Jiang L., Amyot D., Mylopoulos J., Reasoning with key performance indicators. Proceedings of the 4th IFIP WG8.1 Working Conference on the Practice of Enterprise Modeling (PoEM11), 2011.
7. Blind K., Lorenz A., Rauber J., Drivers for companies' entry into standard-setting organizations, Ieee Transactions On Engineering Management, 2021, Vol. 68, I. 1.
8. Brzóska J., Karbownik A., Kruczek M., Szał A., Żebrucki Z., Strategiczna karta wyników w teorii i praktyce, Wydawnictwo Politechniki Śląskiej, Gliwice 2011.
9. Clifton B., Advanced Web Metrics. Indianapolis: John Wiley & Sons Inc, 2012.

10. Cybulski K., Zarządzanie działem sprzedaży firmy, Wydawnictwo Naukowe PWN, Warszawa 2010.
11. Czerwińska K., Pacana A., Analiza zarządzania ciągłością wiedzy w nowoczesnym przedsiębiorstwie, *Problemy jakości*, 2020, Nr 5.
12. Czerwińska K., Pacana A., Quality analysis in the supply chain of transported LNG, *Energy Policy Studies*, 2019, No. 2 (4).
13. Fredriksson G., Larsson H., An analysis of maintenance strategies and development of a model for strategy formulation - A case study, Göteborg: Chalmers University of Technology 2012.
14. Gabcanova I., Human resources key performance indicators, *Journal Of Competitiveness*, 2012, Vol. 4, I. 1.
15. Gonzalez E., Nanos EM., Seyr H., Valldecabres L., Yurusen HY., Smolka U., Muskulus M., Melero JJ., Key performance indicators for wind farm operation and maintenance, 14th Deep Sea Offshore Wind R&D Conference, Eera Deepwind'2017, *Energy Procedia*, 2017, Vol. 137.
16. Grabowska S., Kluczowe wskaźniki efektywności – studium przypadku, *Zeszyty Naukowe Politechniki Śląskiej, Seria: Organizacja i Zarządzanie*, 2017, z. 108.
17. ISO 22400-1:2014, Automation systems and integration – Key performance indicators (KPIs) for manufacturing operations management. Part 1: Overview, concepts and terminology, 2014.
18. Kang N., Zhao C., Li J., Horst J.A., Analysis of key operation performance data in manufacturing systems. *Proceedings – 2015 IEEE International Conference on Big Data*, 2015.
19. Kaplan R. S., *Measuring Performance*. Boston:Harvard Business School Publishing, 2009.
20. Kaźmierzak J., *Eksploatacja systemów technicznych*. Gliwice, Wydawnictwo Politechniki Śląskiej, 2000.
21. Legutko S., Trendy rozwoju utrzymania ruchu urządzeń i maszyn. *Eksploatacja i Niezawodność – Maintenance and Reliability*, 2009, 42 (2).
22. Leśniewski M. A., Menedżer w procesie zarządzania przez cele w systemie konkurencyjności przedsiębiorstw, *Acta Scientifica Academiae Ostroviensis. Sectio A, Nauki Humanistyczne, Społeczne i Techniczne, Wyższa Szkoła Biznesu i Przedsiębiorczości w Ostrowcu Świętokrzyskim*, 2016, 8 (2).
23. Marr B., *How to design Key Performance Indicators*, Management Case Study. London: The Advanced Performance Institute, 2010.
24. Martincevic I., Kozina G., Influence of digital technologies and its technological dynamics on company management, *Tehnicki Vjesnik-Technical Gazette*, 2021, Vol. 28, I. 4.
25. Mondy R. W., *Human Resource Management with My Management Lab*, Publisher, Pearson Higher Education, Global Edition 2012.
26. Neely A., Adams C., Kennerly M., *The Performance Prism: The Scorecard for Measuring and Managing Business Success*. London: Pearson Education Limited, 2002.
27. Nowak E., *Pomiar i raportowanie dokonań przedsiębiorstwa*, CeDeWu, Warszawa 2012.
28. Parmenter D., *Kluczowe wskaźniki efektywności (KPI). Tworzenie, wdrażanie i stosowanie*, Helion, Gliwice 2016.

29. Peng W., Sun T., Rose P., Li T., A semi-automatic system with an iterative learning method for discovering the leading indicators in business processes. International Workshop on Domain Driven Data Mining, 2007.
30. Piasecka-Głuszak A., Implementacja world class manufacturing w przedsiębiorstwie produkcyjnym na rynku polskim, *Ekonomia XXI wieku*, 2017, Nr 4(16).
31. Pindelski M., Strategia sprzedaży jako egzekucja strategii organizacji - powstanie barier wzrostu przedsiębiorstwa, *Prace Naukowe Uniwersytetu Ekonomicznego we Wrocławiu*, nr 218 Strategiczne i operacyjne problemy rozwoju i wzrostu przedsiębiorstwa, 2011, Nr 218.
32. Reh F. J. (2012). Key Performance Indicators (KPI). How an organization defines and measures progress towards its goals, 2012, <http://management.about.com/cs/general-management/a/keyperfmndic.htm> (dostęp: 18.08.2021).
33. Skoczylas W., Wasniewski P., Behavioral aspects of performance measurement systems in enterprises, *Neuroeconomic And Behavioral Aspects Of Decision Making*, 2017.
34. Svikruhova P., Kapsdorferova Z., Dobosova L., Katanikova R., Effective establishment of quality management systems and their impact on business performance, *International Journal For Quality Research*, 2021, Vol. 15, I. 3.
35. Tesoro F., Tootson J., Implementing Global Performance Measurement System, A Cookbook Approach. San Francisco, Jossey-Bass, 2000.
36. Tschernitz S., Gross T., Management by objectives-based groupware: requirements for efficient and effective achievement of objectives, *Idimt-2011: Interdisciplinarity In Complex Systems*, Schriftenreihe Informatik, 2011, Vol. 36.
37. Ulewicz R., Jelonek D., Mazur M., Implementation of logic flow in planning and production control, *Management And Production Engineering Review*, 2016, Vol. 7, I. 1.
38. Ustawa z dnia 10 kwietnia 1997 r. prawo energetyczne (Dz.U.2021.716), art. 9d.
39. Wilczarska J., Efektywność i bezpieczeństwo użytkowania maszyn. *Inżynieria i Aparatura Chemiczna*, 2, 2012.
40. Wolniak R., The concept of operation and production control, *Production Engineering Archives*, 2021, Vol. 27, I. 2.
41. Wolniak R., Skotnicka B., Wybrane metody badania satysfakcji klienta i oceny dostawców w organizacjach, Wydawnictwo Politechniki Śląskiej, 2008.
42. Velimirovic D., Velimirovic M., Stankovic R., Role and importance of key performance indicators measurement, *Serbian Journal of Management*, 2011, Vol. 6, I. 1.
43. Zwolenik P., Belch P., Zastosowanie wskaźnika OEE w ocenie efektywności maszyny wykorzystywanej w procesie produkcji mebli – studium przypadku [w:] *Wybrane wyzwania, problemy i rozwiązania logistyki XXI wieku*, red. P. Belch, A. Gazda, Rzeszów 2021.

**Karolina Czerwińska** - M.Sc., works in the Department of Machine Technology and Production Engineering, Faculty of Machinery and Aviation Construction of Rzeszow University of Technology. She is currently a student of doctoral studies in the discipline of Machine Construction and Operation. Scientific interests include an area of: quality management systems, quality engineering, manufacturing engineering.

ORCID: 0000-0003-2150-0963

**Andrzej Pacana** - DSc, PhD, Eng., Associate Prof.profesor, works in the Department of Machine Technology and Production Engineering, Faculty of Machinery and Aviation Construction of Rzeszow University of Technology. Scientific interests include issues related to quality management, environment and work security, logistics and quality engineering. He is an expert in providing consulting services in the area of management systems - he acts as a reviewer, trainer, lecturer and speaker at numerous seminars, open and closed trainings.

ORCID: 0000-0003-1121-6352