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Comparative Study of Sustainable Key Performance Indicators in Metallurgical Industry

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1. Introduction

The metallurgical industry faces many challenges in the recent global, competitive, and turbulent business environment. Sustainability is widely accepted as one of the most important approaches, which allows to reach a long-term success in the industry.

Metallurgical companies use reporting to measure, analyse and evaluate the sustainability strategy. This reporting should be based on key performance indicators (KPIs). The aim of the article is to identify and categorise the most often used sustainable KPIs and analyse methods of their evaluation in the metallurgical industry.

2. Literature review

Sustainability was presented as a new concept in "Our Common Future" report by the World Commission on Environment and Development (Brundtland Commission) in 1987 (World Commission on Environment and Development 1987).

Sustainability is practiced globally as a comprehensive strategy for improving the sustainability performance of the manufacturing industry (Li et al. 2012) and transportation (Chamier-Gliszczyński & Bohdal 2016), (Chamier-Gliszczyński & Bohdal 2016a). Although there exists a divergence of definitions of sustainability, most of them are based on

the Elkington's (2004) triple bottom line considering three fundamental sustainability dimensions: economic, environmental and social:

- Sustainability is a wise balance among economic development, environmental stewardship, and social equity (Sikdar 2003).
- Sustainability includes equal weightings for economic stability, ecological compatibility and social equilibrium (Goncz 2007).
- Sustainability is the complete plan of ethical action for an organization which is attempting to transform itself into sustainable, i.e. to become pro-environmental, pro-social, and traditional pro-economic (Lijo & Gopalakrishnan 2015).

This concept is increasingly reflected in corporations in order to derive specific sustainability performance indicators and to set related targets (Chamier-Gliszczyński & Bohdal 2016), (Kannegiesser & Gunther 2014).

Bateh et al. (2014) differentiate between internal and external sustainability. Internal sustainability is concerned with survival in a competitive market, which increasingly includes global competition. External sustainability takes into account societal needs that relate to quality of life issues worldwide.

Lijo & Gopalakrishnan (2015) suggest E3S model for sustainability, which contains four dimensions with the following components:

1. Economical – recycling natural resource, reusable packaging, long term customer relationship and loyalty, achieving scale economies, solution for resource scarcity, and competitive advantage (see also Chamier-Gliszczyński 2011).
2. Environmental – market pressure, life cycle assessment, product stewardship, value chain management, carbon credits, and customer perception.
3. Ethical – design consideration, utilitarian cost benefit, reduction of negative externalities, equitable responsibilities, and homogeneous business practices.
4. Social – organizational sustenance, building social identity, organizational social affiliation, psychological affiliation to social commitment, community support, and brand building.

3. Research methodology

Global Reporting Initiative (GRI) standards for sustainability reporting were used to carry out the comparative study. The GRI standards enable organizations to measure and understand their most critical impacts on the environment, society and the economy (Global Reporting Initiative 2016):

1. The economic dimension of sustainability concerns an organization's impacts on the economic conditions of its stakeholders, and on economic systems at local, national, and global levels.
2. The environmental dimension of sustainability concerns an organization's impacts on living and non-living natural systems, including land, air, water and ecosystems.
3. The social dimension of sustainability concerns an organization's impacts on the social systems within which it operates.

GRI defines the topic-specific standards for each dimension. Economic sustainability includes six topics, environmental sustainability eight topics, and social sustainability nineteen topics (see Table 1). Each topic contains one or more disclosures. For example, the environmental disclosures for Materials, Energy and Water topics are shown in Table 2.

Table 1. GRI sustainability topics (Global Reporting Initiative 2016)
Tabela 1. GRI obszary zrównoważonego rozwoju (Global Reporting Initiative 2016)

Economic Dimension	Environmental Dimension
Economic Performance	Materials
Market Presence	Energy
Indirect Economic Impacts	Water
Procurement Practices	Biodiversity
Anti-corruption	Emissions
Anti-competitive Behaviour	Effluents and Waste
	Environmental Compliance
	Supplier Environmental Assessment

Table 1. cont.
Tabela 1. cd.

Social Dimension	
Employment	Rights of Indigenous Peoples
Labour/Management Relations	Human Rights Assessment
Occupational Health and Safety	Local Communities
Training and Education	Supplier Social Assessment
Diversity and Equal Opportunity	Public Policy
Non-discrimination	Customer Health and Safety
Freedom of Association and Collective Bargaining	Marketing and Labelling
Child Labour	Customer Privacy
Forced or Compulsory Labour	Socioeconomic Compliance
Security Practices	

Table 2. GRI environmental disclosures – example of three topics (Global Reporting Initiative 2016)
Tabela 2. GRI przykłady poszczególnych obszarów środowiskowych (Global Reporting Initiative 2016)

Topic	Disclosure
Materials	Materials used by weight or volume
	Recycled input materials used
	Reclaimed products and their packaging materials
Energy	Energy consumption within the organization
	Energy consumption outside of the organization
	Energy intensity
	Reduction of energy consumption
	Reductions in energy requirements of products and services
Water	Water withdrawal by source
	Water sources significantly affected by withdrawal of water
	Water recycled and reused

GRI administers the GRI Sustainability Disclosure Database, which is a collection of all sustainability reports of which GRI is aware. To analyse sustainability KPIs and methods of their evaluation, top 15 steel-producing companies were selected (see Table 3).

The GRI column in Table 3 indicates the company has a sustainable report according to GRI. The KPI column shows, what

companies were selected for the detailed analysis. The selection criteria were:

1. The sustainability report is available in web sites of the company.
2. The sustainability report is in English language.
3. The report includes a comprehensive system of sustainable KPIs.

Table 3. Top 15 steel-producing companies in 2015, tonnage in million tonnes of crude steel production (World Steel Association 2016a)
Tabela 3. Wykaz największych przedsiębiorstw produkujących stal w 2015 roku, tonaż w mln ton produkcji stali surowej (World Steel Association 2016a)

Rank	Company	Country	Tonnage	GRI	KPIs
1	ArcelorMittal	Luxembourg	97.14	x	x
2	Hesteel Group	China	47.75		
3	NSSMC	Japan	46.37	x	
4	POSCO	South Korea	41.97	x	x
5	Baosteel Group	China	34.94	x	
6	Shagang Group	China	34.21		
7	Ansteel Group	China	32.50	x	
8	JFE Steel Corporation	Japan	29.83	x	
9	Shougang Group	China	28.55		
10	Tata Steel Group	India	26.31	x	
11	Wuhan Steel Group	China	25.78	x	
12	Shandong Steel Group	China	21.69	x	
13	Hyundai Steel	South Korea	20.48	x	x
14	Nucor Corporation	USA	19.62	x	
15	Maanshan Steel	China	18.82	x	

These criteria met only three companies and their reports:

1. ArcelorMittal (AM) – Annual Review 2015: Structural Resilience (ArcelorMittal 2016).
2. POSCO (PO) – POSCO Report 2015: Integrated Report of Economic, Environmental and Social Sustainability (POSCO 2016).
3. Hyundai Steel (HS) – Hyundai Steel Sustainability Report 2015 (Hyundai Steel 2015).

In addition, KPIs used by World Steel Association (WS) to report sustainability of the metallurgical industry at the global level (World Steel Association 2016b), were included to the comparative study.

5. Results and discussion

In the first step, sustainable KPIs from the analysed reports were assessed and categorised according to the GRI standards. The economic KPIs and their occurrence in the reports are shown in Table 4.

Table 4. Economic KPIs, based on the analysed sustainability reports
Tabela 4. Ekonomiczne kluczowe wskaźniki efektywności ujęte w raportach zrównoważonego rozwoju

GRI topic	KPI	WS	AM	PO	HS
Economic Performance	R&D investments	x	x	x	
	Economic Value Distributed (EVD)	x	x		x
	Direct economic value generated (revenues)		x	x	x
	Environmental investments		x	x	x
	Environmental costs			x	x
	Investments in STEM (Science, Technology, Engineering and Maths) projects		x	x	
	Number of beneficiaries of community projects		x		
	Social responsibility expenditures			x	x
	Donation to charity			x	
Anti-corruption	Number of Board self-assessments		x		
	Employees completed code of business conduct training		x	x	
	Employees completed anti-corruption training		x		
	Number of operations with a local confidential whistleblowing system		x		
	Complaints received via internal audit		x		
	Subsidiaries' implementation of compliance program			x	

The metallurgical industry representatives use KPIs only for measuring two GRI economic topics (of six defined): Economic Performance and Anti-corruption. They put the most emphasize on the direct and distributed economic value. Although the EVD includes all "responsible" investments, the metallurgical companies underline its economic sustainability using specific KPIs in the area of R&D, environmental and social

investments. R&D is necessary for the internal sustainability, and environmental and social investments especially for the external sustainability.

The environmental KPIs and their occurrence in the reports are presented in Table 5.

Table 5. Environmental KPIs, based on the analysed sustainability reports
Tabela 5. Środowiskowe kluczowe wskaźniki efektywności ujęte w raportach zrównoważonego rozwoju

GRI topic	KPI	WS	AM	PO	HS
Materials	Material efficiency	x			
	Raw materials used by weight		x		
	Steel scrap recycled		x		
	By-product recycling		x	x	x
Energy	Energy intensity	x	x		x
	Energy consumption		x	x	x
Water	Water intake		x	x	x
	Net water consumption		x		
Emissions	Greenhouse Gas (GHG) emissions	x	x	x	x
	Dust emissions		x	x	x
	NO_x emissions		x	x	x
	SO_x emissions		x	x	x
	Chemicals emissions			x	x
Effluents and Waste	Wastewater discharge			x	x
	Waste disposed (landfill, incineration)		x	x	
Environmental Compliance	Environmental Management Systems (EMS)	x	x		

The researched representatives use KPIs for measuring most GRI environmental topics (six of eight): Materials, Energy, Water, Emissions, Effluents and Waste, and Environmental Compliance. It indicates the environmental dimension is very crucial for the metallurgical industry due to very serious negative impacts on environment (Zwolińska 2013). Crucial topics are materials (with focus on by-product recycling), energy, emissions, and water because metallurgy belongs among industries with the biggest by-product production (especially slag, but also waste gases, sludge, and dust), energy consumption, emissions and water consumption.

The social KPIs and their occurrence in the reports are included in Table 6.

Table 6. Social KPIs, based on the analysed sustainability reports
Tabela 6. Społeczne kluczowe wskaźniki efektywności ujęte w raportach zrównoważonego rozwoju

GRI topic	KPI	WS	AM	PO	HS
Employment	Employee turnover rate		x	x	x
	Rate of return from parental/maternity leave			x	x
	Number of new hires			x	
	Retired employees			x	
	Retired employees who reached retirement age			x	x
Labour/ Management Relations	Number of strikes exceeding one week in duration		x		
	Number of formal consultations with the European Works Council		x		
	Employee satisfaction			x	
Occupational Health and Safety	Lost time injury frequency rate	x	x	x	
	Fatalities		x		
	Accidents		x	x	x
	Absenteeism rate		x		
	Industrial operations Certified o OHSAS 18001		x		x
Training and Education	Training time	x	x	x	
	Training expenses			x	
	Number of employees trained			x	
	Trainee satisfaction index			x	
Diversity and Equal Opportunity	Managers that are female		x	x	
	Female employees			x	x
	Employees by age			x	x
	Employees with disabilities			x	
Freedom of Association and Collective Bargaining	Employees covered by collective bargaining agreements		x		
Human Rights Assessment	Employees completed human rights training				
Local Communities	Volunteering hours			x	x
	Employee volunteer participation rate				x
Supplier Social Assessment	Global procurement suppliers evaluated against code for responsible sourcing		x		

This led authors to propose system for the aggregate evaluation of sustainable KPIs based on the Analytic Hierarchy Process (AHP) method. AHP method was chosen for two main reasons. Firstly, whole concept of sustainability is based on three main dimensions, which are further divided into different areas. Therefore, its basic logical structure corresponds with the hierarchical structure, which for its evaluation encourages the use of AHP method. This fact is confirmed by its relatively frequent application in the measurement and assessment of sustainability as it is shown in review articles (Tajbakhsh & Hassini 2015) and (Diaz-Balteiro et al. 2017). Secondly, AHP method is also relatively simple to understand and apply, and there are cheap, sophisticated and user-friendly software solutions. These benefits enable it to be used not only in a research work, but also in corporate practice.

6. Proposal of aggregate sustainability performance evaluation using AHP

Potential of AHP utilization in the sustainability measurement, analysis and evaluation was verified on the example of sustainability KPIs used by World Steel Association and its data series (World Steel Association 2016b).

The AHP is a multistage decomposition method used to solve decision-making problems involving more than one criterion of optimality developed by Saaty (2008). It belongs among the large family of the multi-criteria decision-making methods. The basic idea is to create a decision-making hierarchy and the subsequent evaluation of importance of the single links among the interconnected elements. These evaluations are represented by weights, which are determined on the basis of pairwise comparison. A detailed characteristic of the method and selected applications can be found in (Saaty & Vargas 2012). To verify AHP utilization in the sustainability performance assessment the Super Decisions software was used.

AHP model developed for the aggregated sustainability performance based on the World Steel Association KPIs and data from 2007 to 2015 is shown in Figure 1.

Provided the pairwise comparison matrices in Tables 7, 8, and 9, the global weights of the individual sustainable dimensions and KPIs are equal to the values in Table 10.

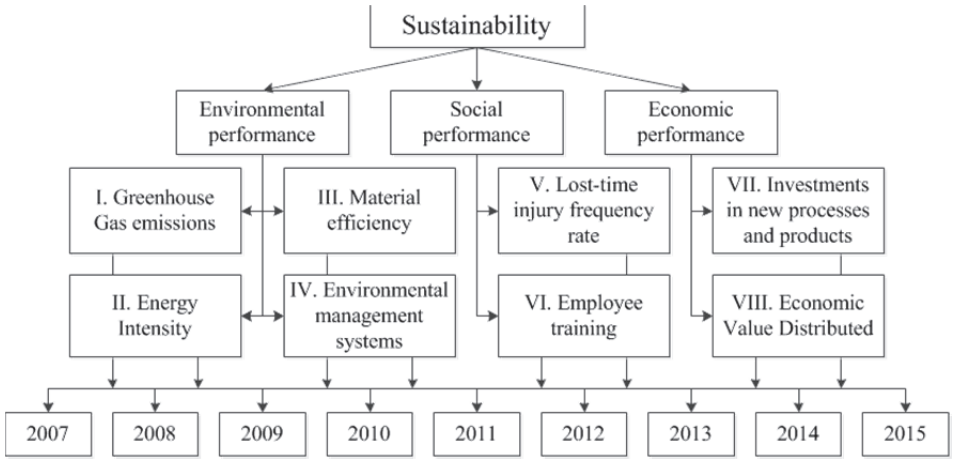


Fig. 1. AHP model of the World Steel Association sustainable KPIs
Rys. 1. Model AHP dla kluczowych wskaźników efektywności zrównoważonego rozwoju, World Steel Association

Table 7. Pairwise comparison matrix for the sustainable dimensions
Tabela 7. Macierz porównań parami dla wymiarów zrównoważonego rozwoju

Dimension	Environmental	Social	Economic
Environmental	1	2	1/2
Social	1/2	1	1/3
Economic	2	3	1

Table 8. Pairwise comparison matrix for the environmental dimension
Tabela 8. Macierz porównań parami dla wymiaru środowiskowego

Environmental KPI	I.	II.	III.	IV.
I.	1	2	3	4
II.	1/2	1	2	3
III.	1/3	1/2	1	2
IV.	1/4	1/3	1/2	1

Table 9. Pairwise comparison matrix for the social and economic dimensions
Tabela 9. Macierz porównań parami dla wymiaru społecznego i ekonomicznego

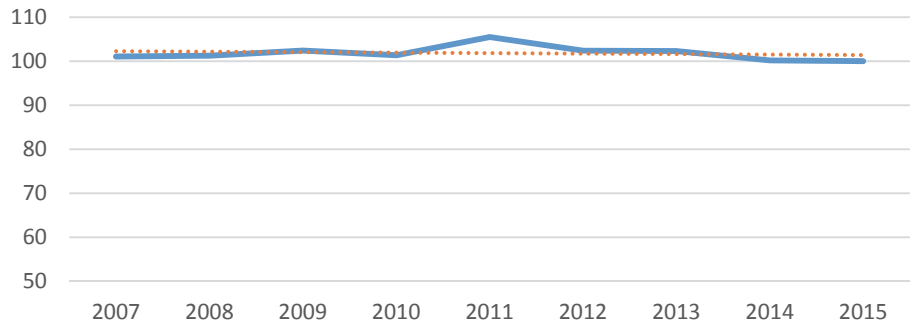
Social KPI	V.	VI.	Economic KPI	VII.	VIII.
V.	1	2	VII.	1	2
VI.	1/2	1	VIII.	1/2	1

Table 10. Global weights of sustainable dimensions and KPIs
Tabela 10. Globalne wagi wymiarów zrównoważonego rozwoju oraz kluczowych wskaźników efektywności

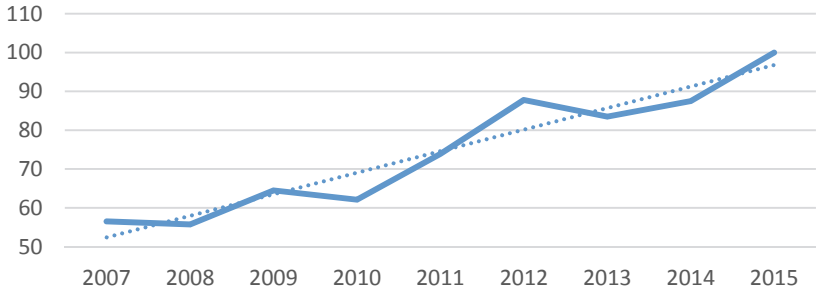
KPI	Weight (%)	Dimension	Weight (%)
I.	13.9	Environmental	29.7
II.	8.2		
III.	4.8		
IV.	2.8		
V.	10.9	Social	16.3
VI.	5.4		
VII.	36.0	Economic	54.0
VIII.	18.0		

The significance of the sustainability dimensions is in the following order: Economic (the most significant with weight of 54%), Environmental (29.7%), and Social (16.3%). The most significant KPIs are Investments in new processes and products (36%), Economic Value Distributed (18%), and Greenhouse Gas emissions (13.9%).

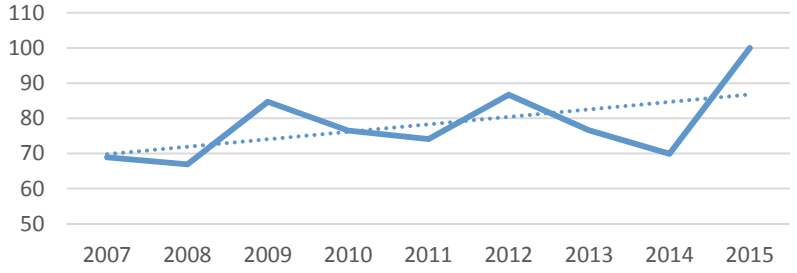
With respects to the global weights the AHP method allows to calculate the aggregated environmental, social, and economic performance (see Figure 2, 3, and 4) as well as the overall sustainable performance of the metallurgical industry (see Figure 5) in the analysed period. 2015 was determined as the base period.



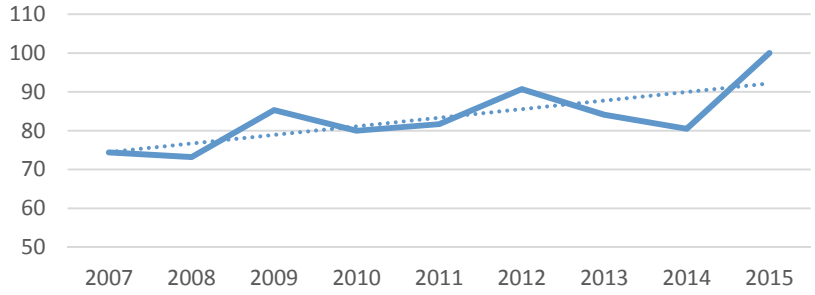
Rys. 2. Procentowa efektywność wymiaru środowiskowego w przemyśle metalurgicznym
Fig. 2. Environmental performance of the metallurgical industry [%]



Rys. 3. Procentowa efektywność wymiaru społecznego w przemyśle metalurgicznym
Fig. 3. Social performance of the metallurgical industry [%]



Rys. 4. Procentowa efektywność wymiaru ekonomicznego w przemyśle metalurgicznym
Fig. 4. Economic performance of the metallurgical industry [%]



Rys. 5. Procentowa efektywność zrównoważonego rozwoju w ujęciu całkowity dla przemysłu metalurgicznego
Fig. 5. Overall sustainability performance of the metallurgical industry [%]

It is obvious the overall sustainability of the metallurgical industry gradually rises in the analysed period. This growth is caused by the social and economic performance. On the contrary, the environmental performance stagnates in the period.

7. Conclusion

The comparative study of KPIs in the metallurgical industry allows to identify the most important categories and indicators in the economic, environmental, and social sustainability dimensions. It has been confirmed an essential role of the economic dimension in the form of the direct and distributed economic value and a large importance of the environmental factors headed by materials, energy, emissions, and water KPIs. The article has also proven the AHP method is a suitable tool for the aggregate evaluation of sustainability, not only in the metallurgical industry.

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Studium porównawcze wskaźników zrównoważonego rozwoju w przemyśle metalurgicznym

Abstract

The metallurgical industry faces many challenges in the recent global, competitive, and turbulent business environment. Contemporary, a sustainability belongs among the most important approaches, which allows to reach a long-term success in the metallurgical industry. In this study, the sustainability is understood as a balanced integration of an economic, environmental, and social performance. The aim of the article is to identify and categorise the most often used sustainable KPIs and analyse methods of their evaluation in the metallurgical industry. Global Reporting Initiative standards, World Steel Association sustainable KPIs, and sustainability reports of three global metallurgical companies were used to carry out the comparative study. It has been confirmed an essential role of the economic dimension in the form of the direct and distributed economic value and a large importance of the environmental factors headed by materials, energy, emissions, and water KPIs. Although the distributed economic value includes all "responsible" investments, the metallurgical companies underline its economic sustainability using specific KPIs in the area of R&D, environmental and social investments. From the social point of view, the metallurgical industry focuses especially on the employment, health and safety, and employee training KPIs. Based on the analysis it can be also stated that there is no aggregate evaluation used in the analysed reports. Therefore, the article proposes system for the aggregate evaluation of sustainable KPIs based on the Analytic Hierarchy Process (AHP) method. The AHP is a multi-

stage decomposition method that belongs among the large family of the multi-criteria decision-making methods. Potential of AHP utilization in the sustainability measurement, analysis and evaluation was verified on the example of sustainability KPIs used by World Steel Association and its data series. The article has proven the AHP method is a suitable tool for the aggregate evaluation of sustainability and their dimensions, not only in metallurgical industry.

Streszczenie

Funkcjonowanie współczesnego przemysłu metalurgicznego musi uwzględniać aspekt ekonomiczny, środowiskowy oraz społeczny w ujęciu koncepcji zrównoważonego rozwoju. Celem artykułu jest zidentyfikowanie, klasyfikacja oraz analiza wskaźników zrównoważonego rozwoju stosowanych w ocenie przemysłu metalurgicznego. W zaprezentowanych badaniach uwzględniono wytyczne do raportowania kwestii zrównoważonego rozwoju dla firm, kluczowe wskaźniki efektywności (KPIs) uwzględniane przez World Steel Association. Badania zostały przeprowadzone na przykładzie trzech globalnych przedsiębiorstwach metalurgicznych. Analiza sprawozdań udostępnionych przez przedsiębiorstwa pokazała, że w danych przedsiębiorstwach aspekt ekonomiczny stanowi wymiar podstawowy. Ujęcie środowiskowe zostało skoncentrowana na zużyciu materiałów, energii, wody i emisji zanieczyszczeń. Aspekt społeczny odniesiono do kwestii zatrudnienia, zdrowia, bezpieczeństwa i szkoleń pracowników zatrudnionych w przedsiębiorstwach metalurgicznych. Natomiast nie realizowana jest łączna ocena uwzględniająca wszystkie trzy aspekty zrównoważonego rozwoju. Realizując badania w przedstawionym artykule zaproponowano system łącznej oceny uwzględniający zrównoważone wskaźniki (ekonomiczne, środowiskowe i społeczne). System będzie bazował na wielokryterialnej metodzie hierarchicznej analizy problemów decyzyjnych AHP. Zaproponowana metoda umożliwia przeprowadzenie łącznej oceny ujmujące poszczególne wskaźniki zrównoważonego rozwoju. Wyniki badań zaprezentowane w artykule potwierdzają, że metoda AHP jest odpowiednim narzędziem do oceny przedsiębiorstw metalurgicznych w ujęciu koncepcji zrównoważonego rozwoju.

Słowa kluczowe:
zrównoważony rozwój, kluczowy wskaźnik efektywności,
przemysł metalurgiczny

Keywords:
sustainability, key performance indicator, metallurgical industry