DEVELOPMENT OF LONG-TERM SUSTAINABILITY PROGRAMMES FOR UKRAINIAN MINING ENTERPRISES UNDER UNSTABLE ECONOMIC CONDITIONS

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Abstract. The article deals with developing long-term sustainability programmes as a means of ensuring the effective functioning of mining enterprises. The authors focus on specific problems of Ukrainian mining enterprises activity, substantiation of implementing environmentally sustainable natural resource management. The system of strategic factors for ensuring sustainable development of mining enterprises under unstable economic conditions has been formed.

Keywords: sustainable development, sustainability, mining enterprises, mineral commodity base, economic instability.

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Introduction

The current mineral reserve base (MRB) of Ukraine does not meet the world market demands as to its qualitative parameters and industrial and economic significance. The low efficiency of the base is explained by worn out and obsolete production facilities causing low labour efficiency and profitability in mining, additional expenses for raw material mining and processing and high energy consumption of production. The problem of MRB competitive ability enhancement is extremely urgent, its solution affecting the future of many Ukrainian mining enterprises in the view of their poor financial potential.

One of the main reasons of negative tendencies in the country's MRB development is the lack of the necessary funds to support and develop it. High capital intensity of mining accompanied by long terms of capital circulation and the global economic crisis define the strategic goal of Ukraine's MRB development, namely, attraction of necessary investments. However, Ukrainian enterprises' strategies targeted at maximum possible investments do not possess any adequate mechanisms to ensure their optimum distribution among mining enterprises, and, which is more important, inside them.

While evaluating the mining industry's development prospects, one should underline that in general its conditions are rather challenging. It is the result of low competitive ability of most iron ore deposits in case of their mining and further mining at deep horizons, considerable obsolescence of basic industrial funds and low sustainability of the technologies applied. A number of serious problems facing an enterprise are due to the discrepancies in the designed capacity of main production areas and that of technological cycles. That is why, the

search for the prioritized investment objects at basic technological cycle stages at mining enterprises is a strategic scientific and practical task. It is obvious that this task solution demands some other principles of investment distribution considering the specific technical and economic conditions of different technical cycle stages. Besides, one should take into account a potential competitive ability of the whole technological chain starting from ore mining to end product manufacturing which allows us to detect some weak points and production reserves of basic technological cycles, these facts forming the basis of the investment policy.

Sustainability issues have been under careful consideration of many well-known Ukrainian and foreign scholars including Joseph Schumpeter (2007), M. Kondratyev (2002) (long-term equilibrium models), R. Kerry Turner (1993) (weak and strong sustainability), Herman Daily (2002) (economic theory of sustainable development), V. Herasymchuk (2007), O. Rayevneva (2006), B. Danilishin (1999), O. Yefremov (2008) and others. The analysis of these works indicates that in spite of their great theoretical and practical significance there appears a real necessity to extend the existing studies concerning long-term programmes for mining enterprises' sustainable and efficient development under unstable economic conditions.

The research aims at developing long-term sustainability programmes as a means of ensuring mining enterprises' efficient functioning under unstable economic conditions of the iron ore market.

Material presentation

One of the strategic tasks of our age is a necessity in the synthesis of a mining enterprise's optimal management strategy within the framework of a large-scale company (for example, PJSC "ArcelorMittalKryvyiRih"), which takes into account the specific features of technological cycles functioning under unstable conditions of the internal and external environment. The analysis of several mining enterprises' activity has revealed that, on the one hand, there is some internal uncertainty of expenses, volume and quantity indicators of technological cycles. On the other hand, one can see an external uncertainty in terms of demand for iron ore products accompanied by the reduced market prices for them (during 2016 1t of direct shipping ore cost maximum $48 and that pellets cost $62, compared to $135 in 2011). Experts say that by the end of 2016 the prices for iron ore products will fall by 10%. On the other hand, the strategic management methods applied at Ukraine's enterprises do not take into account a probability-based nature of mining and the technical and economic significance of technological cycles that leads to extremely high exploitation and, which is more important, investment expenses. For example, the cost price of 1t of concentrates (65% of iron content) makes $22. Under these conditions, the formation of a diverse mining enterprise's sustainability management strategy and its optimization calls for applying the decision theory and system analysis methods, the statistical analysis methods and models combined with heuristic and intellectual methods. At the same time, mining enterprises' economic efficiency within the framework of a large-scale company depends on the correspondence (adequacy) of the volume-quality indices of technological cycles and the cost-price of the end products (the basic indices forming potential profits) to the changeable market conditions. These indices form an enterprise's strategic goal, and possible ways of its fulfillment (development directions) are strategic alternatives under certain time and money expenditures. To achieve a strategic goal in case of the formed strategic alternatives it is

necessary to realize a package of investment projects at various stages of the technological cycles in mining. Thus, consideration of technical and economic significance of the cycles will allow us to increase an enterprise's efficiency by means of effective investment distribution.

Taking into account the above mentioned, long-term development plans are to predict and substantiate organizational, technical and financial measures in order to support and develop a mining enterprise's MRB (open-pit or underground mining) and to ensure the sustainable and efficient mining for the period of 10-15 years. That is why, the development plans look like MRB development strategies and programmes, business-plans and investment projects of further mining for certain iron ore deposits. A mineral reserve base is interpreted not only in terms of increasing mineral reserves, but it also includes the technical means for their mining and processing under unstable economic conditions as well as under unstable world market demands for Ukrainian products.

Basic technological goals of long-term and prospective planning of mining at modern mining enterprises include the following tasks:

- predicting mining intensity of deposits and sites mined; substantiation of a mining enterprise's designed efficiency and development of efficient mining schedules for an open pit or a mine;
- developing a long-term priority programme-schedule of mining the prospected and reserve deposits and their sites including the ones with relatively small reserves;
- predicting the raw material quality and concentration in terms of time as to every MRB element of an enterprise as well as the search for the premises for managing the reserves and the end product quality;
- determining the basic parameters of every mining facility forming a general ore flow to be concentrated, substantiating the main ways of complex mineral usage and producing new types of iron ore products;
- predicting mineral reserves growth including the ones previously excluded from the list of the industrial reserves; substantiating the amount of the main deposit's further prospecting as well as the sequence and methods of further investigation of targets and areas with evaluated undiscovered resources;
- predicting the ways of mineral delivery to the places of processing; substantiating the methods of deposit opening-up and mining systems, mining operation schedules and open-pit field mining procedure;
- substantiating the mining methods and technologies for deposits and their sites to develop the resources efficiently, predicting the necessity in technical means for mining as well as the necessity to update mining equipment and facilities, defining the ways for further technical advancements, improving a technological cycle structure;
- predicting the necessity to withdraw extra lands to dispose an enterprise's facilities (open pits, dumps, tailing ponds, subsidiary production, etc.) taking into account obligatory mined-land reclamation.

Strategic economic and management goals of long-term planning for developing mining operations at Ukrainian open pit mining enterprises include:

- finding the sales markets and determining the range of products, developing marketing forecasts;
- evaluating an enterprise's long-term financial activity, predicting current expenses and profits, calculating financial flows and investment efficiency;

- substantiating the amount of production reserves of various kinds and mining supplies and utilities regulation, an enterprise's structure, functions and hierarchy of elements of the production and labour management system, geoinformation flow schemes;

- predicting the personnel number and labour efficiency, planning payroll and financial rewards;

- developing and introducing modern energy efficient and sustainable measures and technologies for further deep horizon mining (400m and more) in further open pit mining to the designed levels;

- ensuring labour safety, developing general methods of industrial safety control to meet the current world standards.

The substantiation of mining enterprises' perspective MRB disposal is performed under uncertain conditions that is often explained by quite a large number of deposits or complex structured deposit sites aimed for mining, further mining or demanding preliminary exploration. Mining objects vary in reserve size and reliability rate. Every evaluated site is characterized by a unique mineral and qualitative ore composition, which determines its concentration rate that is raw ore consumption to produce a concentrate of the fixed quality. However, ores of certain deposits contain an irregular amount of basic and associated components, both useful and harmful. Infrastructure and production availability of various deposit sites is not the same, so the routes of the mined mineral transportation to the concentration sites can also vary in length. In most cases, main and assembly transportation to the production site of a mining enterprise is by railway, etc. Long-term planning task solution includes the substantiation of distributing capital works and operational expenses amount in terms of time to realize a mining enterprise's reconstruction and sustainability programme including environment-oriented measures to ensure sustainable development of mining and processing operations.

A general priority of the directed search for strategies of a mining enterprise's MRB support is often chosen by using a variance method. To perform the feasibility study of a deposit mining and further mining a number of operations is performed, the results of which should be presented in a form of a tree of goals, which includes separate significant stages of investigations and calculations. Algorthmization is the most difficult part of goal tree formation. To solve this problem, we suggest using an algorithm, the flow-diagram of which is on Fig. 1. The substantiation of the necessary volume of mining production is one of the most complicated and crucial points in long-term planning.

In particular, the open pit mining designing theory testifies to the fact that an open pit's capacity is determined as maximum as to its mining and technical indices under the maximum mining intensity as well as according to the demand in mineral commodities. In our case, this approach denotes that the necessary amount of the end products (A_{ep}) should be substantiated and approved by the person in charge (an enterprise's owner or manager considering the market investigations as to the prospects of iron-containing products sales.

In any case, it cannot exceed an enterprise's economic efficiency (A_e) which is maximum possible one as to mining intensity and geological conditions of a deposit:

1	Input Main specific function of a system	8	Preparation of data store to realize the model
2	Goal formation and statement	9	Algorithm formation to realize the model
3	Choice of strategic technical and technological variants of long-term programmes for a mining enterprise efficient	10	Preliminary estimation of the model correspondence to the mining production demands

	functioning to reduce production energy consumption		
4	. Formation of a structured formula of an economic and mathematical model of a mining enterprise sustainable development	11	Computer programming and realization of the model
5	Analysis of connections between the subsystem elements of the modeled system of mining production as to processes and production areas and local models formation	12	Result analysis and calculation visualization
6	Synthesis of local models	13	Evaluating the model correspondence to the current economic system
7	Forming a system of restrictions of the sustainable resource usage goal to ensure the minimum toxic and mining waste emission into the air	14	Choosing optimal technical and technological variants of a mining enterprise's sustainable development under unstable economic conditions and uncertain demands at the iron ore market

Fig. 1. Algorithm flow-diagram of "goal tree" formation in the strategy development of sustainable resource usage to ensure a mining enterprise's sustainability

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$$A_{ep} < A_e,$$

$$A_e = h_o \cdot S_a \cdot \frac{1 - L_m}{1 + P};$$

$$A_e = V_a \cdot L_b \cdot N_{ben} \cdot H_{ben};$$

$$A_e = Q_e \cdot \frac{L_{rm}}{\frac{L_b}{(1 + R_{cur})}}$$

That is why, at the preliminary stage one can perform a technological analysis of the designed decisions and the actual parameters and the mining intensity indices formed before the beginning of the planning: mining operation lowering rate (h_o); mineral loss (L_m) and pollution (P); working area advance velocity (V_a); block length (L_b); excavator block number at the horizon (N_b); working bench number (N_{ben}), bench height (H_{ben}); excavator capacity (Q_e); working area length along the rock mass (L_{rm}); current overburden ratio (R_{cur}); active mining area (S_a). Besides, the accumulated experience, previously conducted research and

promising iron ore mining technologies are analyzed and compared to the conditions formed at an enterprise. It allows us to substantiate the technical goals for further technological and economic calculations to define the prospects of ensuring and immediate introduction of mining enterprises sustainability strategies. An economic strategy development provides for a detailed analysis of the external environment changes, the results being compared to the formed internal potential of a mining enterprise to find extra possibilities and neutralize potential threats.

Considering the above-mentioned, the staged solution of scientific and practical tasks and the order of the search for MRB support and sustainability strategies based on the application of geoinformation systems and innovation research methods, nano- and neurotechnologies, in particular, is in Fig. 2.

Substantiation of iron-containing product amount

Initial data	Analysis of known mineral deposits and ore targets. Evaluation of iron ore mining technologies	Analysis of mineral processing technologies for competitive products manufacturing
1. Preliminary analysis of a mineral reserve base (MRB)	Data adequacy evaluation. Rejection of MRB objects as to their exploration degree	Evaluation of manufacturing technologies for end products and their mineral structure
2. Finding systematically important elements of a mining enterprise MRB	Evaluation of mining methods and technologies, mining and technical possibilities and mined ore quality	Analysis of technological balances of ore concentration at explored deposits
3. Formation of priority limit variants of deposit mining	Evaluation of mining priority of the explored deposits	Substantiation of restricting the mined raw ore amount and quality
4. Preliminary formation of a mining enterprise MRB support strategies	Technological evaluation of mining and reclamation schedules for explored deposits	Substantiation of the amount and processing technologies of raw ore and end products
5. Exploration programme formation	Evaluation of explored deposits amount and mining priority	Prediction of mineral processing technologies (including technology-related materials)
6. Investment proposals as to MRB development programme	Feasibility study of timing variants for mining output, capital works, prospecting, iron ore transportation directions	

Fig. 2. Directed search order of iron ore deposits' support and further mining at Ukrainian mining enterprises

Conclusions and suggestions

Thus, the proposed approach to the development of long-term and current sustainability programmes for Ukraine's mining enterprises will make it possible to enhance their production and economic efficiency and competitive ability considering the factors that ensure their further sustainable functioning (Fig.3) even under current unstable economic tendencies at the iron ore market. It will also facilitate the introduction of sustainability culture in mining according to the current highest international standards (Level BS Series 8900:2006; BS 8901:2007 «Sustainable management»). It will allow us to develop and introduce scientifically based complex strategies for Ukraine's mining enterprises in the nearest future.

<table>
<tr><th colspan="3">Factors ensuring a mining enterprise's efficiency</th></tr>
<tr><td colspan="3">Availability and observance of current standards in mining:
ISO 14001: 2004 "Environmental Management Standard"
ISO 9001: 2008 "Quality Management Systems. Requirements"
ISO 50001: 2011 – "Energy Management System"
OHSAS 18001: 2007 – "Labour Safety Management Systems - Requirements"</td></tr>
<tr><td>Technical:
- standard and actual lifespan of technological equipment;
- obsolescence ratio; energy consumption of production according to similar indicators of the world's iron ore producers;
- equipment reliability; unit flexibility
- shift-working ratio; number of hours of accident-free and fault-free operation</td><td>Technological:
- innovation of technological processes (energy efficiency and sustainability) and integrated mineral resource development;
- correspondence of the end product quality to the market demands (iron content increase and harmful admixture decrease including that of sulfur, phosphorus in iron ore products);
- availability of iron ore reserves ready for mining; observance of mining system parameters and indicators according to the previously approved projects</td><td>Organizational, including social:
- high qualification of a personnel (skills and abilities);
- introduction of scientific principles of labour organization in mining;
- observance of technological design standards and safety requirements; introduction of effective models of labour motivation and social security;
- nonproductive loss elimination; technological maintenance quality and major repairs of mining equipment;
- application of modern geoinformation systems and GPS technologies at every production stage to increase competitive ability of Ukrainian products at the iron ore markets under unstable economic conditions</td></tr>
<tr><td colspan="3">Financial and economic: availability of one's own financial resources; designed and actual expenses level per 1 UAH of the end products in relation to the main competitors producing similar products at the mineral market segment; capital productivity and capital-labour ratio; business environment indices; an enterprise's financial indices; minimum penalties for environment pollution; production profitability; stable increase of a mining enterprise's assets cost</td></tr>
</table>

Fig. 3. Indicators ensuring Ukrainian enterprises' further efficient iron ore mining under unstable economic conditions (compiled by the author)

References

Daily, H. (2002). Beyond growth: The economics of sustainable development. Kyiv: Intelsfera. [in Ukrainian].
Danilishin, B. M. (1999). Sustainable development with in the system of environmental resource restrictions. Kyiv: National Ukrainian Academy of Sciences. [in Russian].
Herasymchuk, V.H. (2007). Economic management of sustainable development: Ukraine and the world. Economist, 9, 7-9. [in Ukrainian].
Kondratyev, N.D. (2002). Business climate cycles and prediction theory: selected works. Moscow: Economics [in Russian].
Rayevneva, O.V. (2006). Enterprise development management: methods, mechanisms, models. Kharkiv: INZHEK. [in Ukrainian].
Schumpeter, J. (2007). Economic development theory. Capitalism, socialism and democracy. Moscow: EKSMO. [in Russian].
Turner, R. Kerry. (1993). Sustainability: Principles and practice. Sustainable economy and practice. London: Belhaven Press.
Yefremov, O. (2008). Stable or sustainable development – what to choose? Ukraine's Economy, No. 2, 85-90. [inUkrainian].