Mineral Economics
https://doi.org/10.1007/s13563-024-00436-z

ORIGINAL PAPER

The current state of the non-ore mineral deposits mining in the concept of the Ukraine reconstruction in the post-war period

Roman Dychkovskyi[1,2] · **Pavlo Saik**[1] · **Dariusz Sala**[2] · **Edgar Caceres Cabana**[3]

Received: 2 January 2024 / Accepted: 4 April 2024

Abstract

The study of quantitative and qualitative indicators of the non-metallic mineral deposits mining based on recognized methods of economic and technological assessment to determine the damages and the development of technical–technological measures for the providing the mining industry of construction and bulk materials from the crisis in the post-war period. To assess the state of non-ore mineral deposits, the authors of the article used the following research methods: critical analysis of literary sources, statistical processing of data on the mines functioning and the probability of their manifestation in specific mining and geological conditions. Based on the selected UNIDO method, which is used for the evaluation of high-budget projects, the quantitative performance indicators of the selected quarries of non-ore raw materials have been established. Systematization and visualization of the obtained results were carried out with the help of Excel calculation tables from the available software product MS Office. The main problems associated with the activity of mining enterprises that develop deposits of non-ore useful minerals are highlighted. Qualitative and quantitative values of the work of the selected mines have been prepared according to European standards, which serve as initial data for assessing the economic attractiveness and the possibility of their restructuring in the post-war period. A forecast of the development of the industry is provided on the example of individual technological units of entrepreneurial activity for the nearest period. Dependencies of changes in production capacity indicators of mining enterprises developing non-ore mineral deposits have been established. Data on the spatial distribution of reserves of construction and backfill materials (gravel, sand, clay) were studied. Using generally recognized international methods of assessing the efficiency of enterprises, changes in the priority of mine development were determined depending on the needs of the Ukrainian economy and the destruction of territories caused by military actions, that appeared due to the aggression of the RF. The effectiveness of the methodology was proposed and confirmed, which allows determining the operative parameters of mines, which are mining non-ore mineral deposits. It gives the possibility to assess the economic attractiveness of individual mines and subsequently predict the possibility of their restructuring for the introduction of the innovative equipment and technologies in accordance with generally recognized international standards.

Keywords Non-ore reserves · Open-pit mining · Construction and backfill materials · Statistical treatment · Economic evaluation · Investment attractiveness

✉ Roman Dychkovskyi
Dychkovskyi.r.o@nmu.one

✉ Dariusz Sala
sala@agh.edu.pl

Pavlo Saik
saik.p.b@nmu.one

Edgar Caceres Cabana
ecaceresca@unsa.edu.pe

1 Department of Mining Engineering and Education, Dnipro University of Technology, Yavornytskoho Ave 19, Dnipro UA-49005, Ukraine

2 Faculty of Management, AGH University of Krakow, Al. Mickiewicza 30, PL-30059 Krakow, Poland

3 Institute of Renewable Energy Research and Energy Efficiency, Universidad Nacional de San Agustin de Arequipa, San Agustin Street 107, PE-04000 Arequipa, Peru

Published online: 18 April 2024

Introduction

The development of scientific and technical progress driven by the world industry resulted in increasing consumption of raw materials and energy resources. Over the last hundred years, this process has accelerated significantly. It is worth noting that this trend will continue in the future (Visser and Brundtland 2019). The issues of economical use of energy, ore and non-ore fossil sources are not only relevant but are now gaining critical importance for our existence. Humanity must not provide its existence with fossil minerals but must care for the preservation of a livable environment for future generations (Moellerherm et al. 2022). Ensuring balanced development in the system "man—society—environment" in the paradigm of the functioning of the economies of individual countries is the primary task of further industrial development. It has now been proven that economic growth is not always caused by a corresponding increase in the extraction of non-renewable energy and non-energy fossil resources (Garkushenko 2015). In high-tech countries, the growth of gross domestic product was accompanied by the improvement of production technological chains and the introduction of more efficient equipment. However, completely abandoning non-renewable fossil sources from the humanity individual and technological activity soon is not possible.

Conducted research and obtained results demonstrate that today, the process of civilization development represents the growth of scientific and technical progress. In general, this leads to an increase in the need for greater consumption of energy raw materials, ore, and non-ore mineral deposits. Accordingly, we are responsible for controlling their production and consumption. (Smil 2019)-(Polyanska et al. 2023).

In this work, the authors analyze the state of non-ore mineral deposits, primarily construction and bulk materials, and explore the prospects for their development in Ukraine. These minerals are not only a commodity on the domestic and foreign markets; they also contribute to the development of the national economy and serve as a guarantor of its independence (Supeni et al. 2022). Military actions and the seizure of territories caused by the aggression of the RF against Ukraine not only created a certain political instability in our country, but also have a negative impact on the situation on the European continent and in the world. Carrying out an inventory of non-ore deposits caused by russia's military actions, with the aim of their restructuring and improvement of mining technological processes to stabilize the situation not only in Ukraine, but also in the whole world, is an urgent task. The main investigations of this article are directed to the solve of these tasks.

Ukraine has a variety of non-ore mineral deposits. These mineral deposits mining involves the extraction of valuable minerals and rocks that are not classified as ores. They are typically used in various industrial, construction, and manufacturing applications (Sobolev et al. 2020).

Let's consider the main types and stocks of non-ore mineral deposits in our country and methods of their development. Such non-ore minerals as clay, sand, gravel, gypsum, talc, pyrophyllite, barite, bentonite and other perform in all regions of Ukraine. Clays, sand, gravel, and gypsum are used in the ceramics, construction, pottery industries, agriculture, and for construction and infrastructure development. Talc and pyrophyllite except using in ceramics production it is necessary for the manufacturing of paints and plastics (Evans and Guggenheim 1988). Barite is essential in the oil and gas industry as a drilling mud additive (Dozet 1999). Bentonite is used in drilling fluids and as a sealing material (Sahara et al. 2008). Limestone is a key component in the production of cement and is found in several regions. The main mining deposits of this mineral are situated in the Carpathians, Podillya, and the Crimean Peninsula. Also, in Carpathian and Crimea mountings there is the main dolomite and zeolite deposits. It is necessary to mention, that the dolomite and zeolite are spread all over the Ukrainian territory. Dolomite is essential in the production of refractories, glass, and ceramics. Zeolite is used as adsorbents and catalysts in various industrial processes. (Liventseva 2022)-(Zucchini et al. 2017).

Non-ore deposits also include stocks of phosphate rocks, sulfur, salt, mineral waters, and other minerals. Phosphate rocks are used in the production of fertilizers, and mainly they are situated in the Kirovohrad region. Sulfur is used in the chemical industry. Ukraine is available mainly in chemical industry in medicine. These deposits are in various locations, including the western part of Ukraine and the Donbas region. (Liventseva 2022; Rajan and Edge 1980).

Apart from rock salt deposits, Ukraine has extensive salt deposits, especially in the Carpathian Mountains and the Donbas region. Ukraine is also well known for its natural mineral water deposits. The main popular recreative zones which also used the mineral water are: Truskavets, Schidnytsia, Morshyn, Mirgorod and others (Liventseva 2022; Fayvishenko 2021; Grytsenko 2015).

The Ukrainian's diverse geological makeup offers a wide range of mineral resources that contribute to its industrial and economic development. Unfortunately, the russian aggression have the huge destructive influence. So, the availability and status of these depos-its change over time, and it's necessary to exam current geological and mining reports for the up-to-dating the current information.

Let's insights the general considerations and factors that might influence mineral mining and extraction activities in Ukraine during the post-war period:

- Technical and technological condition. It is necessary to evaluate the enterprises state. They may have suffered physical damage to their infrastructure, including traces, processing equipment, transportation infrastructure (e.g., railways or roads), and electrical grids. The extent of this damage can range from minor to severe.
- Community engagement. The engaging with local communities and addressing their concerns is the crucial for social acceptance and sustainable mining operations (Maddah et al. 2022; Pylypenko et al. 2023);
- Personnel and workforce. The availability and expertise of the workforce can be affected by war. Skilled workers may have left the area, and recruitment/training may be necessary to rebuild the workforce. Safety training and awareness are critical in the post-war scenario (Maddah et al. 2022);
- Infrastructure rehabilitation. After the war, one of the first priorities is to rehabilitate damaged infrastructure, including transportation networks and mining facilities. Investment in infrastructure improvements can help facilitate mineral mining operations (Griadushchiy et al. 2007; Pavlenko et al. 2007);
- Security concerns. In post-war periods, there may still be security concerns in certain regions, particularly in areas that were directly affected by the conflict. Ensuring the safety of mining personnel and equipment is a top priority (Robert and Macgregor 2018);
- Environmental considerations. Increasingly, there is a focus on environmentally sustainable mining practices. It is necessary to require companies to adhere to strict environmental standards and responsible mining practices (Holden 1998);
- Regulatory environment. Government and local authorities research and scientific institutions have review and update regulations governing mining activities in the aftermath of conflict to promote transparency, environmental responsibility, and economic stability (Pavlenko et al. 2007; Hazzard-Donald 2017);
- Geological surveys and exploration. It is necessary to conduct geological surveys and exploration to identify new mineral deposits or assess the potential of existing ones. The mining process must be oriented on up-to-date technology and involving the technic of new technological level (Griadushchiy et al. 2007; Dychkovskiy and Bondarenko 2006; Shavarskyi et al. 2022);
- Technology and modernization. The mining industry must incorporate modern technologies and practices to enhance efficiency and safety in mineral extraction and processing (Dychkovskiy and Bondarenko 2006; Saik et al. 2018; Kuzmenko et al. 2023);
- Market demand. The demand for specific non-ore minerals, such as construction materials, industrial minerals, and specialty minerals, must fluctuate based on regional and global economic conditions. The mining sector must respond to market demand (Pavlenko et al. 2007; Suma 2020).
- Foreign trade. One of the main directions of the Ukraine non-ore mineral deposits mining is to engage in international trade agreements for the export of non-ore minerals, which can be an important source of revenue (Polyanska et al. 2023; Pylypenko et al. 2023; Sala and Bieda 2019);
- Investment and Financing. Attracting domestic and foreign investment is essential for revitalizing the mining sector. Governments may implement policies and incentives to encourage investment in mineral exploration and extraction (Pavlenko et al. 2007) (Sala and Bieda 2022) (Wang and Lo 2022).

The most up-to-date information on the current state of non-ore mineral deposits mining in Ukraine during the post-war period was also obtained from official government reports, industry publications, and news sources. It varies significantly by region within our country. Of course, it is not feasible to analyze all the mentioned non-ore mineral deposits. Therefore, as an example, we will consider one of the quarries that mines gravel and associated building and backfill materials. An economic justification of prospects and investment attractiveness for this mining enterprise was conducted.

Methods of the research

Economic estimation and investment attractiveness

To establish the economic possibilities of the non-ore mineral deposits mining functioning and to assess the possibilities of their investment attractiveness, it is proposed to apply the universally recognized UNIDO methodology. This method was unified by Nations Industrial Development Organization (UNIDO), and it is used for evaluating high-budget projects considering the long-term perspective. UNIDO's methodology for economic estimation is comprehensive and data-driven, aiming to provide evidence-based insights and recommendations to support sustainable industrial development and enterprise economic growth (Lipkin 2022; Dychkovskyi et al. 2013; Bayura 1996). Specific methodologies and approaches may vary depending on the context and objectives of individual projects and programs. The general overview of the methodology for economic estimation activities incudes the several stages.

At the first stage method predict data collection and its analysis. Besides the internal enterprise dates, it is necessary to collect the information from various sources, including statistical agencies, international organizations.

Data covers various aspects of mining industrial development, including manufacturing output, industrial employment, energy consumption, trade, investment, technology, and innovation. In our case data collection and analysis, we'll provide the information about the non-ore mineral reserves; technical, technological support, professional human resources and demand for raw materials on the market.

At the second stage it is necessary to conduct the data quality assessment and its standardization. Received data are standardizes to industry norms and tolerances adopted at the mining enterprise. In this stage we must assesses the quality, reliability, and consistency of the collected data to ensure its accuracy. Some data gaps and inconsistencies it is necessary to identify and address by using methods of mathematical statistics. collaboration with national governments and other stakeholders. This stage also may involve data adjusting, harmonizing and classification.

The third stage means the economic modeling and evaluating the investment attractiveness. The UNIDO method uses various economic models and analytical tools to estimate the economic impact of industrial development activities. This provides technical assistance and capacity-building support to enterprises to strengthen their data collection and analysis capabilities. Also, using UNIDO method it is possible to monitor the progress of industrial development projects and initiatives to assess their impact over time. Regular evaluations help adjust strategies and ensure that goals are being met.

Given that all mining enterprises are regarded as high-budget projects when assessing investment attractiveness, we also conducted research on how companies perceive investments during production restructuring. The effectiveness of the UNIDO method has been validated through coal mining operations. The method proposed by the authors of this article underwent rigorous testing to facilitate an extensive economic evaluation of mining enterprises. Its primary goal was to assess the feasibility of restructuring the mines owned by SC 'Pavlogadvugillia' (now recognized as company DTEK). This thorough assessment involved examining various factors, including the economic status of the mines, technical evaluations, and technological assessments. Both traditional and radical coal extraction technologies were considered during this process, ensuring a comprehensive evaluation of potential restructuring strategies and their feasibility within the company's operational framework. Consequently, there arises a pertinent question regarding the verification of open-pit mines engaged in the extraction of construction and other materials. (Griadushchiy et al. 2007; Dychkovskyi et al. 2013; Falshtynskyi et al. 2011).

Mathematical apparatus and results estimation

The evaluation of business projects, including the calculation of cash flows and the discounting of future cash flows to determine their current value, is the fundamental aspect of project appraisal and financial analysis. While UNIDO may not prescribe specific criteria for evaluating business projects, there are generally accepted principles and methodologies that can be applied.

One of the key concepts in evaluating cash flows is indeed discounting, which is used to determine the present value of future cash flows. Usually, it is expedient to provide the definitions including direct results with help of the discount coefficient (Dychkovskyi et al. 2013) (Dychkovskyi 2013):

$$E = \frac{1}{(1+p)^t} \tag{1}$$

where p the necessary financial value, attracted to the project (i.e. discount rate); and t is the project duration.

The detailed description of the methods is provided in papers (Bayura 1996; Shiryaev 2007; Zhdanova 2010). Author of the paper (Shiryaev 2007) evaluate investment efficiency relying upon following basic indices.

The Discounted Payback Period (DPB) is a financial metric used in capital budgeting and investment analysis to evaluate the time it takes for an investment to recoup its initial cost, considering the time value of money. It is an extension of the regular payback period, which doesn't consider the cash time value. The index helps determine pay-back period of investment project, i.e. year (month, day) when the project starts making profits to its owners:

$$DPT = \min n\left(\sum\nolimits_{t-0}^{n} \frac{CP_t}{(1+p)^t}\right) \geq \left(\sum\nolimits_{t-0}^{n} \frac{IP_t}{(1+p)^t}\right) \tag{2}$$

where "CP" is net annual cash flow during the period t; "IP" is a sum of capital investment to the project per t years; p is cash flow of capital attracted to the investment objects (i.e. discount rate); and t is the project implementation period.

Net Present Value (NPV) determines potential expected sum of cash which the project implementation will turn to enterprise or to owner

$$NVP = \sum\nolimits_{t-0}^{n} \frac{CP_t}{(1+p)^t}) \tag{3}$$

In this context, m is the number of months, and t sequential number of a month.

If net present value of the project is calculated more often than once a year, then formula (4) is applied. NPV calculation is of polemical character since may produce both positive and negative cash flows; it especially concerns initial stages of the project implementation. Hence, O.O. Shemetiev (Shemetiev 2009) proposes to use another dependence to determine the parameter when cash flows are negative:

$$NVP = \sum_{t-0}^{n} CP_t (1 + \frac{p}{m})^t \quad (4)$$

In the context of negative cash flow when (2) and (3) formulas are used, the obtained result is "distortion effect" of the investment project value. Hence, if calculations are applied in such a way, the process results in artificial raising of the project value. Eventual outcome may differ significantly from actual values of the initiative economic efficiency. That is why if negative cash flows are available, the paper uses mathematical approaches to calculate *NPV*, proposed by O.O. Shemetiev and (4) formula was applied for the evaluation of the proposed engineering solutions.

Selection of the expedient variant of investment project is determined by means of a value of *NPV* index which is often called financial strength. To make investment solution, fulfilling of $NPV > 0$ equality is sufficient condition. However, such a statement first concerns commercial projects since making maximum profit is their priority task. Analysis of other project may promote additional priorities (ecology, social policy etc.) (Shemetiev 2009).

Internal Rate of Return (*IRR*) is another index characterizing economic efficiency of investment project. The index determines maximum value of the attracted capital in terms of which the investment project is considered as expedient one. It is calculated as a value of discount rate when $NPV = 0$. Usually, discount rate values are determined with the help of graphic method (function of *NPV* dependence upon discount rate) or with the help of specific software:

$$\sum_{t=1}^{T} \frac{CP}{(1 + IRR)^t} = INN \quad (5)$$

where INN is investment value.

Moreover, Profitability Index is informative index as well. It is relative index demonstrating ratio between present value of cash flow and investment value. Investment may come into account as of the starting period of the project implementation if it is classic investment variant or with allowance for discounting if the investment is of a current nature during the whole period of the project implementation. The index is rather suitable while selecting one project from several alternative ones:

$$PI = \frac{\frac{CP_t}{(1+p)^t}}{I} \quad (6)$$

where I is initial amount to be invested (if classic investment is applied).

Having several indices, proposed by the United Nations Industrial Development Organization also as provided by other researches (Shiryaev 2007; UNIDO estimation report 2002; Dychkovskyi et al. 2021), one should take into consideration both advantages and disadvantages of each of the index use (Table 1).

Results and discussions

Calculation results

Taking into consideration advantages and disadvantages of the coefficients select the three evaluation parameters to determine investment attractiveness of the proposed technical and technological solutions for the abovementioned several non-ore mineral deposits mining companies:

- Discounted Payback (*DPB*);
- Net Present Value (*NPV*); and
- Profitability Index (*IP*).

It should be noted that the investment attractiveness of the objects was calculated in terms of both target indices and actual ones. The criterion for choosing enterprises was, first, openness to necessary data and the availability of already completed works by our scientists upon their request. For quarries (deposits/fields), we gathered and analyzed common information about geological, hydrogeological, mining, and technical conditions. To study the investment attractiveness of enterprises, we investigated the volume of industrial reserves, qualitative characteristics of the mined minerals, existing company productivity, characteristics of the mining and transport complex, possibilities of mineral processing, geosocial distribution, and company logistics location.

For mineral processing was investigated type of the crushing equipment (static or mobile) its competitivity and innovative design. Both static crushing equipment (SCE) and mobile crushing equipment (MCE) are two types of machinery used in the mining for breaking down large rocks, stones, and other materials into smaller pieces. The primary difference between them lies in their mobility and operational flexibility.

SCE is fixed in one place and is not designed to be moved once it's set up. It's typically installed in a specific location, such as at a quarry or a construction site, and remains stationary during its operational lifespan. It is usually larger and more powerful but lacks the versatility of being moved. This limitation means that it can only process materials within the vicinity of its installation point. The SCE requires a more permanent setup with foundations and infrastructure. Once installed, it operates in that location until it reaches the end of its operational life or requires relocation, which involves dismantling and reinstallation.

Table 1 Selection criteria as for the evaluation indices of investment attractiveness of projects

Coefficient	Selection criteria as for the investment project	Advantages	Disadvantages
Discounted Payback (*DPB*)	The alternative prevails when *DPB* is of minimum value	Rapid determination of the project payback period	The technique does not take into consideration the cash flows which are out of payback period Takes into consideration initial cash flows only
Net Present Value (*NPV*)	The alternative prevails when *NPV* is of maximum positive value (margin)	Rapid evaluation of the project implementation to compare with alternative projects	Basic calculation procedure does not take into consideration potential variations of cost of capital involved in the investment project (discount rate)
Internal Revenue Rate (*IRR*)	The alternative prevails when *IRR* is higher than (or at least is equal to) cost of capital	Calculation procedure is comparatively complicated; it is not accurate while applying graphic method	In certain cases, it has not any solution; sometimes, it may have several solutions
Profitability Index (*PI*)	Selection criterion is like that applied for *NPV*; a project with higher *PI* is considered as a more expedient one	The coefficient is relative; it helps select a project in terms of equal *NPV* values	There is no certainty while selecting two mutually exclusive projects

Mobile Crushing Equipment: As the name suggests, mobile crushing equipment is designed to be easily transported from one site to another. These units can be moved to different locations as needed, allowing for greater flexibility in crushing operations across various sites. It might be somewhat less powerful compared to static equipment; it offers greater flexibility. Its mobility allows it to be transported to different sites, making it suitable for a variety of projects and locations. Ideal for projects that require crushing materials in various locations. Designed for quick setup and takedown. They often come as self-contained units that can be easily transported to different sites, requiring less time and effort to get them operational.

Both types of equipment have their specific advantages and are used in different scenarios based on the nature of the project, material availability, and the need for mobility. Static equipment is more powerful and suitable for long-term operations in fixed locations, while mobile equipment offers greater flexibility and versatility to move from one site to another, catering to multiple project requirements.

The "geosocial distribution" and "company logistics location" refer to two interconnected aspects of a company's operational setup, especially in the context of supply chain management, distribution, and service provision.

Geosocial distribution refers to the strategic dispersion of products, services, or resources across various geographic and social (or demographic) areas. It involves analyzing and understanding the target markets, consumer behavior, and social demographics in different geographical locations. This understanding helps in optimizing distribution strategies, marketing efforts, and tailoring services or products to meet the specific needs or preferences of different social groups in diverse geographic areas.

This distribution approach considers not only the geographical aspects, such as distance, location, and regional differences, but also the social and cultural factors that influence consumer behavior and preferences in those areas. It involves using data on social demographics, consumer behavior, and geographical locations to effectively position products, services, or resources to meet the demands of specific groups in various areas.

Company logistics location refers to the strategic placement of facilities, warehouses, distribution centers, or operational hubs in specific geographical areas. Additionally, labor availability and regulatory considerations also play a role in choosing suitable logistics locations.

Both geosocial distribution and company logistics location are essential in optimizing a company's operations. Understanding consumer behavior, demographics, and geographic variations helps in targeting specific markets effectively. Simultaneously, strategically locating logistics hubs or facilities optimizes the movement of goods, reducing transportation costs and enhancing the overall efficiency of

Table 2 General information on the data availability and the availability of the corresponding indicator in each mining enterprise

Quarry (deposit\field)	Geological and hydrogeological conditions	Mining and technical conditions	The volume of industrial reserves	Qualitative characteristics of a mineral	Productivity m^3 / year	Mining and transport complex	Mineral processing, SCE*	Mineral processing, MCE**	Geosocial distribution and logistics location
Anadolske	±	±	+	±	±	±	+	+	+
Malyn	+	+	+	+	+	+	+	-	±
Mykytivske	±	+	±	+	+	±	+	-	+
Trikratske	+	-	-	+	-	±	±	±	-
Sofiivka	±	±	±	+	+	±	+	-	±
Boleslavchykske	+	±	+	+	+	±	±	-	±
Pischanske	+	+	±	+	+	±	±	-	±
Chaplinske	±	±	+	±	-	-	-	-	+
Liubymivske	±	±	+	±	-	-	-	-	+
Rybalske	+	+	+	+	±	±	±	+	+
Novoaleksandrivske	+	+	±	+	±	-	±	-	-
Shamraievske	+	+	±	+	±	±	±	-	+

*static crushing equipment

**mobile crushing equipment

Table 3 Target indices of profits and expenditures for the mining object # 1

Index	Implementation period of the project, number of a month									
	1	2	3	4	5	6	7	8	9	10
Profit*, UAH, mln	58,59	86,85	86,85	86,85	86,85	86,85	86,85	86,85	58,11	53,24
Expenditures **, UAH, mln	78,96	25,62	25,62	25,62	25,62	25,62	25,62	25,62	25,62	36,12
Net profit/ loss***, UAH, mln	-20,37	61,24	61,24	61,24	61,24	61,24	61,24	61,24	32,99	17,15
Net resource profit/loss (with accrual total), UAH, mln	-20,37	40,87	102,10	163,34	224,57	28,58	347,05	408,28	441,27	458,39

*Total profit is UAH—843,948 mln;

**UAN 320,04 mln—budget cost; UAH 35,400 mln—cost of key assets (i.e. powered system); UAH 24,2 mln—operating cost; UAH 37,200 mln-cost to take the powered system out of service;

***UAN 351688,0 mln—target profit

Table 4 Actual indices of profit and cost for the mining object # 1

Number of a month	1	2	3	4	5	6	7	8	9
Profit*, UAH, mln	58,61	46,31	48,43	45,55	13,84	13,06	15,75	12,87	14,22
Expenditures **, UAH, mln	78,96	24,99	24,78	24,99	22,47	22,47	22,47	22,47	22,47
Net profit/ loss***, UAH, mln	-20,35	21,32	23,65	20,60	-8,63	-9,43	-6,72	-9,60	-8,25
Net resource profit/loss (with accrual total), UAH, mln	-20,35	0,97	24,61	45,15	36,52	27,11	20,41	10,82	2,56
Number of a month	10	11	12	13	14	15	16	17	
Profit*, UAH, mln	13,65	17,87	53,42	56,11	21,71	21,90	22,49	23,25	
Expenditures **, UAH, mln	22,47	23,52	24,78	24,78	22,47	22,89	23,52	23,94	
Net profit/ loss***, UAH, mln	-8,82	-5,65	28,64	31,33	-0,76	-0,99	-1,05	-0,69	
Net resource profit/loss (with accrual total), UAH, mln	-6,27	-11,93	16,72	48,05	47,29	46,31	45,26	44,58	

* UAH 511,106 mln – expected profit;

** UAH 433,112 mln—total cost resulting from the project implementation by the mine; and

*** UAH 107,099 mln—total profit

the supply chain. These two aspects are interconnected and essential in developing a robust and responsive operational strategy for businesses.

General information on the data availability and the availability of the corresponding indicator in each mining enterprise is given in Table 2 (+—verifiable study of the indicator or its presence; ±—sufficient study of the indicator or the need to take it into account under certain conditions;—lack of information or the indicator itself at the mining enterprise).

Using the principles presented in works (Dyczko 2023, Dychkovskyi et al. 2018, Babets et al. 2023) regarding the prioritization of factors in the functioning of mining enterprises, the parameters that will determine the attractiveness for the investment project regarding its functioning in the concept of the Ukraine reconstruction in the post-war period were established. Before the study, it is necessary to accept the planned and actual financial costs during the implementation of the project. Based on commercial secrecy, one of the quarries was chosen and an investment attractiveness

Table 5 Net present value of the investment project (target values) for the mining object # 1

Number of a month	1	2	3	4	5	6	7	8	9	10
Discounting coefficient (15% rate of return)	1	0,988	0,975	0,963	0,951	0,939	0,928	0,917	0,905	0,894
Discounted profit/loss, UAH, mln	-20,35	60,48	59,72	58,99	58,25	57,54	56,83	56,13	29,86	15,29
Resource discounted profit/loss (with accruing result), UAH, mln	-20,35	40,13	99,86	158,84	217,10	274,66	331,49	387,62	417,48	432,79

Table 6 Net present value of the investment project (actual values) for the mining object # 1

Number of a month	1	2	3	4	5	6	7	8	9
Discounting coefficient (15% rate of return)	1	0,988	0,975	0,963	0,952	0,94	0,928	0,917	0,905
Discounted profit/loss, UAH, mln	-20,37	21,06	23,05	19,80	-9,08	-9,87	-7,22	-10,46	-9,11
Resource discounted profit/loss (with accruing result), UAH, mln	-20,35	0,69	23,77	43,55	34,48	24,49	17,24	6,78	-2,33
Number of a month	10	11	12	13	14	15	16	17	
Discounting coefficient (15% rate of return)	0,894	0,883	0,872	0,862	0,851	0,84	0,83	0,819	
Discounted profit/loss, UAH, mln	-9,87	-6,41	24,97	26,98	-0,65	-0,82	-0,86	-0,57	
Resource discounted profit/loss (with accruing result), UAH, mln	-12,20	-18,61	6,38	33,37	32,72	31,90	31,04	30,45	

effectiveness check was conducted for it. In our article, for convenience, we will call this mining enterprise "Mining object #1".

The planned indicators of the mining object # 1 shown, that the project was expected to be implemented for 10 months. In fact, the implementation of project for the extraction of reserves will last 17 months. General data on project implementation are given in Table 2 (planned data) and Table 3 (actual results).

The data confirm obviously that in terms of neither of the two cases, actual indices correspond to target ones. It can be concluded that the unstable political situation associated with russian aggression has a significant impact on the functioning of non-ore mineral deposits mining. To obtain reliable information, concerning actual value of the necessary capital investments and profits, it is required to calculate NPV resulting from the project implementation. Rate of return is still 15%. The calculation is performed on formulas (1) and (4) if values of the cash flows are positive and on formulas (1) and (5 if the values are negative. Tables 4 and 5, demonstrate calculation of discounting coefficient and NPV.

Providing the necessary calculations and having at your disposal the amount of discounted profit (NPV) for each investment period (in our case such a period is the month) we can proceed the calculation of generalized criteria for the investment attractiveness of the project and decision-making about the possibility of financial injections. As it was mentioned before such criteria are based on the following indicators:

– total discounted profit (NPV);
– project profitability index (PI);
– project payback period (DPB).

The results of calculations are given in Table 6.

Based on the calculated level of profitability index of the project were obtained results that show that the calculated and planned indicators of the level are differ from the actual results by more than 120 times. Accordingly, this indicates that the project is significantly influenced by external factors, which have the significant influence on its realization. Authors of the article concluded that, among other factors, the unstable economic situation in our country caused by Russian aggression led to this factor (Table 7).

Table 7 Indicators of the investment attractiveness of the project (planned and actual)

Index	Target value	Actual value
Total discounted profit, UAH, mln	432,79	30,45
Capital investment, UAH, mln	35,40	35,40
Payback period of the project, months	2	2
Profitability index of the project	12,23	0,86

Conclusions

The analysis of the current state of the non-ore mineral deposits mining in the concept of the Ukraine reconstruction in the post-war period and the results of the research allow us to draw the following conclusions:

– un-stable political situation caused by the russian aggression have the huge negative influence in Ukrainian economy including non-ore mineral deposits mining;
– conducted research of the investment attractiveness of the mining object #1 shown that the actual indicator of the total discounted profit turned out to be almost 120 times smaller than the planned one. At the same time, NPV according to forecast and actual values are positive values. The resulting difference in indicators is significant and indicates rather large-scale deviations from the planned steps of project implementation;
– the variation of the profitability index is similar to the change in NPV values, since when calculating this criterion, the value of the overall NPV indicator is taken into account in relation to the initial capital investment. The actual rate of return is much lower than planned. The final positive issue for making an investment decision is that the profitability index is greater than 0 ($PI > 0$);

– the payback period of the project is the same in terms of planned and actual values and is 2 months, but in this case, the main drawback of this method occurs, namely, that the profitability of the project beyond the payback period is neglected. This shortcoming can be observed quite vividly on the example of calculating the payback period based on the actual profitability indicators of the project, when the resource profit was positive starting from the 2nd month of project implementation, but in the 9th, 10th and 11th months of project implementation, the net resource profit was negative. Therefore, the criterion of the payback period of the project should not be considered when deciding to invest in the project in this situation.

The data of the economic evaluation of the investment project concluded that the proposed technical–technological solutions regarding the extraction of reserves of this extracting column of the mine object #1 are positive both in terms of planned and actual indicators. In fact, the term of project implementation in this case became a decisive factor in obtaining the final profit.

Further research is planned for economic assessment of similar investment projects for mining enterprises of Ukraine and foreign mines. Special attention will be paid to the economic evaluation of the introduction of new technological and technical support of the mining processes. These works are accompanied by the need for significant financial infusions and are also associated with significant financial risks.

Acknowledgements The presented results have been obtained within the framework of the research work 2022.01/0107 “Development of a resource-saving technology for extraction and processing of non-ore mineral raw materials in the war and post-war periods” supported by the National research foundation of Ukraine.

Author contribution All authors contributed to the study conception and design. Material preparation, data collection and analysis were performed by Roman Dychkovskyi, Pavlo Saik, Dariusz Sala and Edgar Caceres Cabana. The first draft of the manuscript was written by Roman Dychkovskyi and all authors commented on previous versions of the manuscript. Verification manuscript was made by Pavlo Saik. Investigation and text review by Dariusz Sala. Final research correction by Edgar Caceres Cabana. All authors read and approved the final manuscript.

Funding “This work will be support by AGH University of Krakow, Poland in IDUB fund for publishing”.

“Results of this papers have been supported by the National research foundation of Ukraine”

Data availability Not applicable.

Declarations

Authors declare no:
of potential conflicts of interest,
research involving Human Participants and/or Animals.

Ethics approval and consent to participate All authors express ethical approval and consent to participate.

Consent for publication All authors consent to publication.

Financial interests The authors have no relevant financial or non-financial interests to disclose.

Competing interests Authors declare no of potential conflicts of competing interest.

References

Babets D, Sdvyzhkova O, Shashenko O, Kravchenko K (2023) Optimization of support parameters for reusable mining excavations based on a neuro-heuristic prognostic model. Min Mach 3(41):200–211. https://doi.org/10.32056/KOMAG2023.3.5

Bayura D (1996) UNIDO Methodology. Ukrainian Investment Digest 49(321):21–34

Dozet S (1999) Barite-bearning Pleše Formation, Central Slovenia - Comparison of barite beds and barite occurrences in the Outer Dinarides area. Geologija 42(1):41–68. https://doi.org/10.5474/geologija.1999.004

Dychkovskiy R, Bondarenko V (2006) Methods of extraction of thin and rather thin coal seams in the works of the scientists of the underground mining faculty (National Mining University). Int Min Forum 2006 New Technol Solutions Undergr Min 21–25. https://doi.org/10.1201/noe0415401173.ch3

Dychkovskyi RO, Avdiushchenko AS, Falshtynskyi VS, Saik PB (2013) On the issue of estimation of the coal mine extraction area economic efficiency. Naukovyi Visnyk Natsionalnoho Hirnychoho Universytetu 4:107–114

Dychkovskyi R, Falshtynskyi V, Ruskykh V, Cabana E, Kosobokov O (2018) A modern vision of simulation modelling in mining and near mining activity. E3S Web of Conferences 60:00014. https://doi.org/10.1051/e3sconf/20186000014

Dychkovskyi R (2013) Scientific principles of technologies combination for coal mining in weakly metamorphosed rockmass. Thesis of the scientific degree of the doctor of the technique science. D NMU 410

Dychkovskyi R, Tabachenko M, Zhadiaieva K, Dyczko A, Cabana E (2021) Gas hydrates technologies in the joint concept of geoenergy usage. E3S Web of Conferences 230:01023. https://doi.org/10.1051/e3sconf/202123001023

Dyczko A (2023) Real-time forecasting of key coking coal quality parameters using neural networks and artificial intelligence. Rudarsko-Geološko-Naftni Zbornik 38(3):105–117. https://doi.org/10.17794/rgn.2023.3.9

Evans BW, Guggenheim S (1988) Chapter 8. Talc, pyrophyllite, and related minerals. Hydrous Phyllosilicates 225–294. https://doi.org/10.1515/9781501508998-013

Falshtynskyi V, Dychkovskyi R, Khomenko O, Kononenko M (2020) On the formation of a mine-based energy resource complex. E3S Web of Conferences 201:01020. https://doi.org/10.1051/e3sconf/202020101020

Falshtynskyi V, Dychkovskyi R, Zasedatelev O (2011) Economic indicators of BUCG on an experimental station in the SC "Pavlogradvugillia" conditions. Technical Geoinformational Syst Min 201–206. https://doi.org/10.1201/b11586-33

Fayvishenko D (2021) Export potential of the mineral water market in Ukraine. Ekonomika Ta Derzhava 1:48. https://doi.org/10.32702/2306-6806.2021.1.48

Garkushenko O (2015) Directions of environmental regulation of economy in Ukraine due to Ukraine-European Union Association Agreement. Economy of Industry 72(4):50–68. https://doi.org/10.15407/econindustry2015.04.050

Griadushchiy Y, Korz P, Koval O, Bondarenko V, Dychkovskiy R (2007) Advanced Experience and Direction of Mining of Thin Coal Seams in Ukraine. Tech Technol Econ Asp Thin-Seams Coal Min Int Mining Forum 2–7. https://doi.org/10.1201/noe0415436700.ch1

Grytsenko KP (2015) Morphology of sulphur-terminated compound deposits condensed on different substrates in vacuum. Semicond Physics Quantum Electron Optoelectron 18(4):433–437. https://doi.org/10.15407/spqeo18.04.433

Hazzard-Donald K (2017) Black Belt Hoodoo in the Post-World War II Cultural Environment. University of Illinois Press. https://doi.org/10.5406/illinois/9780252037290.003.0008

Holden TA Jr. (1998) Considerations for a Department of Defense Environmental Security Policy in Military Operations other than War. https://doi.org/10.21236/ada345002

Kuzmenko O, Petlovanyi M, Buketov V, Howaniec N, Smolinski A (2023) Mechanism of Interaction of Backfill Mixtures with Natural Rock Fractures within the Zone of Their Intense Manifestation while Developing Steep Ore Deposits. Sustainability 15(6):4889. https://doi.org/10.3390/su15064889

Lipkin M (2022) The Council of Mutual Economic Assistance and UNIDO: in Search of a Bright Industrial Future. Istoria 13(11 (121):1-23. https://doi.org/10.18254/s207987840022775-1

Liventseva H (2022) The mineral resources of Ukraine. Ukrgeologia 1–28. https://doi.org/10.21028/hl.2022.05.17

Maddah D, Salvi C, Vadi R, Mohammad M (2022) Risk Communication and Community Engagement in Action During Ukraine's War. Annals of Global Health, 88(1). https://doi.org/10.5334/aogh.3937

Moellerherm S, Kretschmann J, Tiganj J, Poplawski M (2022) Post-mining challenges and knowledge transfer for the Ukrainian coal industry. IOP Conference Series: Earth Environ Sci 1(970):012034. https://doi.org/10.1088/1755-1315/970/1/012034

Pavlenko I, Salli V, Bondarenko V, Dychkovskiy R, Piwniak G (2007) Limits to Economic Viability of Extraction of Thin Coal Seams in Ukraine. Tech Technol Econ Asp Thin-Seams Coal Min Int Min Forum 2007:129–132. https://doi.org/10.1201/noe0415436700.ch16

Polyanska A, Savchuk S, Dudek M, Sala D, Pazynich Y, Cicho D (2022) Impact of digital maturity on sustainable development effects in energy sector in the condition of Industry 40. Naukovyi Visnyk Natsionalnoho Hirnychoho Universytetu 6:97–103. https://doi.org/10.33271/nvngu/2022-6/097

Polyanska A, Pazynich Y, Sabyrova M, Verbovska L (2023) Directions and prospects of the development of educational services in conditions of energy transformation: the aspect of the coal industry. Polityka Energetyczna – Energ Policy J 26(2):195–216. https://doi.org/10.33223/epj/162054

Pylypenko HM, Pylypenko YuI, Dubiei YuV, Solianyk LG, Pazynich YuM, Buketov V, Smolinski A, Magdziarczyk M (2023) Social capital as a factor of innovative development. J Open Innov: Technol Market Complexity 9(3):100118. https://doi.org/10.1016/j.joitmc.2023.100118

Rajan SSS, Edge EA (1980) Dissolution of granulated low-grade phosphate rocks, phosphate rocks/sulphur (Biosuper), and superphosphate in soil. N Z J Agric Res 23(4):451–456. https://doi.org/10.1080/00288233.1980.10417868

Robert L, Macgregor DH (2018) The most important cartels in the war and post-war periods. Cartels, Concerns and Trusts 95–102. https://doi.org/10.4324/9781315122670-13

Sahara F, Murakami T, Kobayashi I, Mihara M, Ohi T (2008) Modelling for the long-term mechanical and hydraulic behavior of betonite- and cement-based materials considering chemical transitions. Physics and Chemistry of the Earth, Parts a/b/c 33:S531–S537. https://doi.org/10.1016/j.pce.2008.10.021

Saik P, Petlovanyi M, Lozynskyi V, Sai K, Merzlikin A (2018) Innovative approach to the integrated use of energy resources of underground coal gasification. Solid State Phenom 277:221–231. https://doi.org/10.4028/www.scientific.net/SSP.277.221

Sala D, Bieda B (2019) Life Cycle Inventory (LCI) Approach Used for Rare Earth Elements (REEs) from Monazite Material, Considering Uncertainty. Lanthanides. https://doi.org/10.5772/intechopen.80261

Sala D, Bieda B (2022) Stochastic approach based on Monte Carlo (MC) simulation used for Life Cycle Inventory (LCI) uncertainty analysis in Rare Earth Elements (REEs) recovery. ES Web of Conferences 349:01013. https://doi.org/10.1051/e3sconf/202234901013

Shavarskyi I, Falshtynskyi V, Dychkovskyi R, Akimov O, Sala D, Buketov V (2022) Management of the longwall face advance on the stress-strain state of rock mass. Min Mineral Deposits 16(3):78–85. https://doi.org/10.33271/mining16.03.078

Shemetiev OO (2009) A tutorial on anti-crisis management for owners and directors of firms. M Science & Education 664

Shiryaev AO (2007) Criteria for general evaluation of the effectiveness of investment projects. Economic and Math. Social and Economic Modeling Systems 12:95–100

Smil V (2019) Energy in World History. Energy in World History 223–256. https://doi.org/10.4324/9780429038785-6

Sobolev V, Bilan N, Dychkovskyi R, Caseres Cabana E, Smolinski A (2020) Reasons for breaking of chemical bonds of gas molecules during movement of explosion products in cracks formed in rock mass. Int J Min Sci Technol 30(2):265–269. https://doi.org/10.1016/j.ijmst.2020.01.002

Suma V (2020) Data Mining based Prediction of Demand in Indian Market for Refurbished Electronics. Electronics 2(2):101–110. https://doi.org/10.36548/jscp.2020.2.007

Supeni N, Istifadah I, Awwaliyah IN (2022) The effect of the russia-Ukraine war on stock price volatility of state-owned companies in the mining sub-sector on the Indonesia stock exchange. Int Soc Sci Hmm 1(2):233–241

Swindell GS (1996) Reserves and Performance of Canyon Sand Gas Wells. All Days 1970–1994. https://doi.org/10.2118/35204-ms

UNIDO estimation report. (2002). Industrial Development Report 2002–2003. Industrial Development Report 2(11):342. https://doi.org/10.18356/94674506-en

Visser W, Brundtland GH (2019) Our Common Future ('The Brundtland Report'): World Commission on Environment and Development. The Top 50 Sustainability Books 374. https://digitallibrary.un.org/record/139811?v=pdf. Accessed Dec 2023

Wang X, Lo K (2022) Political economy of just transition: Disparate impact of coal mine closure on state-owned and private coal workers in Inner Mongolia. China Energy Res Soc Sci 90:102585. https://doi.org/10.1016/j.erss.2022.102585

Zhdanova NA (2010) Evaluation of methods and techniques for determining the effectiveness of investments in energy-saving measures. Science and Economics 1(17):205–208

Zucchini A, Prencipe M, Belmonte D, Comodi P (2017) Ab initio study of the dolomite to dolomite-II high-pressure phase transition. Eur J Mineral 29(2):227–238. https://doi.org/10.1127/ejm/2017/0029-2608