Mining of Mineral Deposits
Volume 18 (2024), Issue 1, 54-66

MMD JOURNAL / MINING.IN.UA

https://doi.org/10.33271/mining18.01.054

Organization of processes for complex mining and processing of mineral raw materials from coal mines in the context of the concept of sustainable development

Ildar Salieiev [1*]

[1] *LLC "DTEK Energy", Kyiv, Ukraine*

**Corresponding author: e-mail SaleevIA@dtek.com*

Abstract

Purpose. The research purpose is to form the principles and procedures for developing an organizational concept of complex mining of minerals from coal mines using the example of a promising model of transition of the PJSC "DTEK Pavlohradvuhillia" mines to multi-product production of clean drinking water, utilization of methane, secondary coal from rock dumps and slurry reservoirs, low-grade thermal energy of mine groundwater and associated raw materials from desalination waste.

Methods. The instrumental basis of the research is the methodology of the process approach to organizing multi-product activities of an enterprise. In addition, an integrated approach is used, including an analysis of existing experience and available complex coal mining and processing technologies.

Findings. The paper presents the research results of the prerequisites for the development of innovative technological solutions related to the integrated use of mineral raw materials formed in the process of coal mining and processing. It has been revealed that at the present stage the technological, environmental and economic aspects of such innovations have been sufficiently developed, while the organizational issues regarding the balanced interaction of multi-product production units have poorly been studied. The necessity has been substantiated, as well as the content and sequence of actions have been determined for the development of an organizational concept of complex mining and processing of mineral raw materials in the conditions of PJSC "DTEK Pavlohradvuhillia".

Originality. The principles and procedures for developing an organizational concept of a multi-product enterprise, formed in the research process, provide further development of a methodological basis for searching and substantiating innovative solutions for complex mining of mineral resources from coal mines. They can be used to assess the efficiency and identify weaknesses in current processes for mining and utilization of coal, thermal energy, methane gas, groundwater, dry residue chemicals from desalination and coal mining waste, and to analyse and make changes to improve performance and reduce costs.

Practical implications. The proposed complex of organizational solutions based on the process approach tools to ensure the effective implementation of a promising production model for mining and processing of mineral resources in PJSC "DTEK Pavlohradvuhillia" coal mines provides an opportunity to predict the results and develop development strategies based on various scenarios, analyze the interaction of various factors and their influence on the results of the production complex functioning, while reducing costs for experiments and testing of various production technologies.

Keywords: *sustainable development, organization of production, field mining, process approach, organizational concept, workflow identification*

1. Introduction

The challenges of ensuring sustainable development of the coal industry have received a lot of attention, especially with regard to opportunities to address technological, environmental and economic issues. In particular, the main factors for developing measures to reduce the environmental impact of a coal enterprise on the environment in modern research include the following:

– industrial waste volumes: enterprises engaged in coal mining and beneficiation store waste in special dumps. Over time, however, these dumps can leak and pollute water resources [1], [2];

– water management: water resources are actively used for power generation, mine drainage and other technical processes. Used water and water waste contain toxic substances that pollute water resources [3]-[6];

– noise pollution: mines and coal-related industries can cause noise pollution that adversely affects human and animal health in areas remote from the plants; – amount of CO_2 emissions: coal industry is a major source of CO_2 emissions into the atmosphere. Technologies currently exist in the coal industry to reduce CO_2 emissions, but implementing such technologies on a large scale is challenging [7]-[9];

Received: 26 July 2023. Accepted: 25 January 2024. Available online: 30 March 2024

Mining of Mineral Deposits. ISSN 2415-3443 (Online) | ISSN 2415-3435 (Print)

– deforestation (destruction of biodiversity, in particular forests): the coal industry often requires large areas, leading to deforestation, which in turn causes increased CO_2 emissions into the atmosphere and can lead to subsidence of soil levels;

– landscape destruction: coal mining and beneficiation processes can result in the destruction of local landscapes and natural resources.

In addition, scientists and practitioners pay sufficient attention to research on ESG-strategy (Environmental, Social, and Governance) for the development of coal enterprises [10]-[12], considering the factors of functioning related to social aspects, such as:

1. Workability level: parameters that indicate labor productivity, employee satisfaction, attitudes towards safety and health in the workplace.

2. Relationships among operational staff: the ratio of women to men among employees, the degree of evenness by gender, the presence of diverse groups and social inclusiveness.

3. Management team: diversity indicators, including cultural and gender balance within the enterprise, as well as the experience and competence of the management team members.

4. Interaction with the community: indicators assessing the enterprise cooperation with local communities, impact on local development, respect for human rights and stakeholder relations.

5. Corporate culture: indicators reflecting employee ethical behavior, respect for human rights, diversification and other corporate culture aspects.

6. Social initiatives: indicators related to sponsorship and charity, internal and external social programs implemented by the enterprise in cooperation with public organizations.

These indicators help to assess the social aspects of coal enterprise activities, to formulate ESG-based goals and strategy, and develop policies and decisions aimed at achieving sustainable development goals [13]-[15].

Regarding technological innovation, it is advisable to pay attention to the research who classifies potential solutions focusing on 5 main directions of scientific-technical innovation, 3 main theories to be explored, and 12 key technologies that should be developed to achieve zero carbon emissions from coal mining and use [16].

One of the most promising directions of technological innovation for ensuring sustainable development, and not only for coal enterprises, is to ensure the maximum utilization of all resources involved or generated in the process of production and consumption of products [17]. The efficiency of using this type of technological innovation is determined through the cyclical (circular) material use (CMU) rate, which measures the share of material obtained and returned back to the economy in total resource use. CMU is defined as the ratio of circular material use to the overall resource utilization.

One of the most promising directions of technological innovation for ensuring sustainable development, and not only for coal enterprises, is to ensure the maximum utilization of all resources involved or generated in the process of production and consumption of products. The efficiency of using this type of technological innovation is determined through the cyclical (circular) material use (CMU) rate, which measures the share of material obtained and returned back to the economy in total resource use. CMU is defined as the ratio of circular material use to the overall resource utilization.

Circular resource utilization is determined by the amount of waste processed in recycling plants, minus imported waste intended for disposal, plus exported waste intended for disposal abroad. The highest CMU value means that primary raw materials are replaced by more secondary resources, thereby reducing the environmental impact of primary raw material extraction [18].

In particular, in the countries of the European Union, whose standards are the nearest strategic guidelines for us today, CMU is one of the most important indicators characterizing the level of implementation of sustainable development goals and on the basis of which the further strategy of EU countries is formed. Thus, for the period until 2030, the EU plans to more than double the value of this indicator compared to 2021 (Fig. 1).

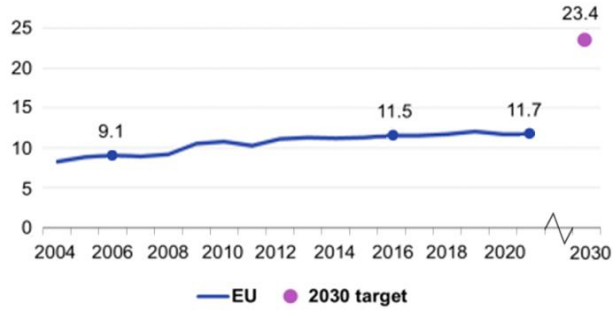

Figure 1. Circular material use rate, EU, 2004-2021 (% of input materials for internal use) Source: Eurostat (sdg_12_41) [19])

As part of this direction of implementing the sustainable development strategy, PJSC "DTEK" is exploring the possibility of implementing a promising model for the transition of mines to multi-product production of clean drinking water, utilization of methane, secondary coal from rock dumps and slurry reservoirs, low-grade thermal energy of mine groundwater and associated raw materials from desalination waste. The functional structure of this model includes: mine complex; a complex of cogeneration plant for coalmine methane-gas utilization; a complex for utilization of low-grade groundwater energy; sludge recycling complex for power generation; rock waste processing complex; mine water demineralization complex with desalination waste processing (Fig. 2).

Building a model of a production complex is essential in the research to understand its functioning, predict its development and optimise its operation [20]. The formation and implementation of the model is bound to be accompanied by a set of both significant and minor challenges. This is primarily due to the fact that the operation of a multi-product technological complex for mining and processing of mineral resources will generate additional environmental and social risks for the entire DTEK and will influence corporate strategy. The dynamism of the innovation and technology component should also be taken into account, which will influence the choice of technical equipment for the complex, its suppliers and requires the inclusion of additional variables and parameters reflecting the introduction of new technologies, processes or products.

And if, as shown above, the issues of technological, environmental and economic innovations to ensure the sustainable development of coal enterprises have been sufficiently studied, the issues of organizing their activities, ensuring the interaction of structural elements (functional blocks, units, individual performers, etc.) both within the production system itself, and with an external environment (market, consumers, competitors, government, etc.) are quite problematic.

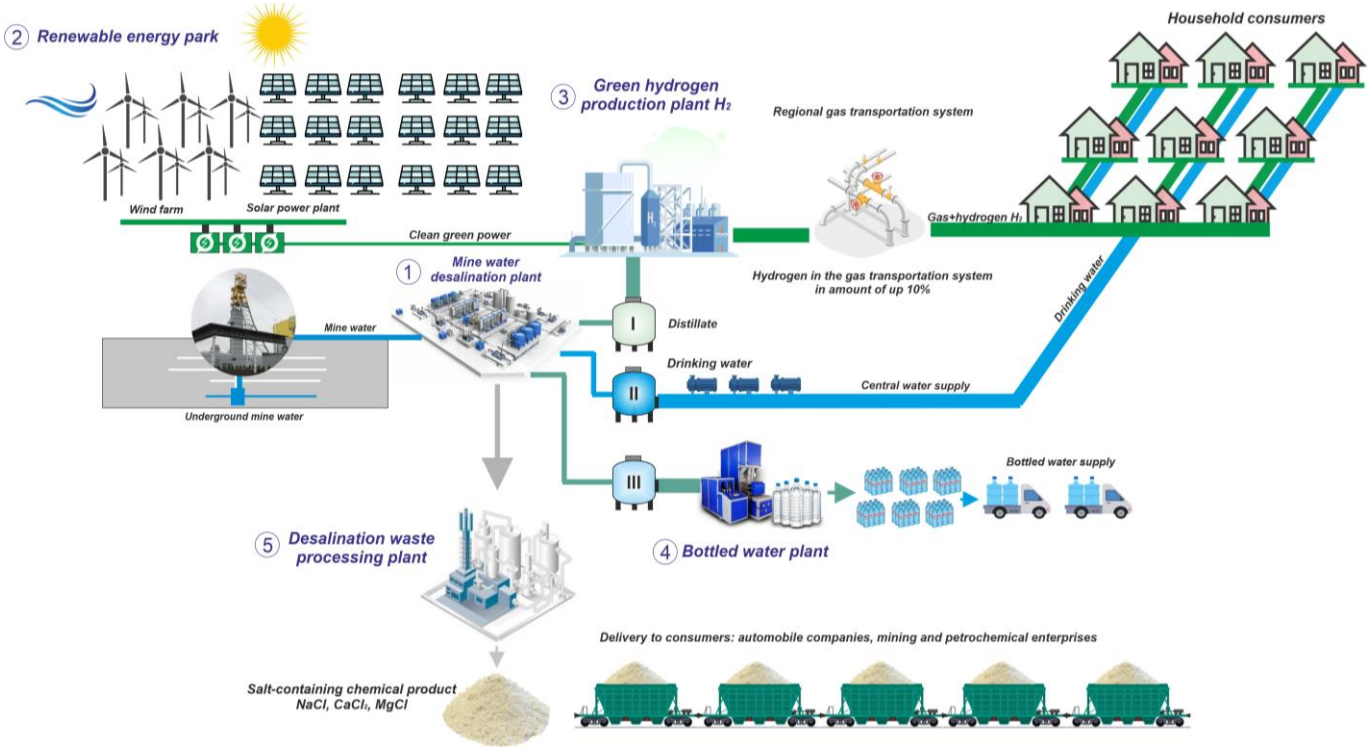

Figure 2. Promising model of the infrastructure for complex mining facilities and the use of mineral raw material resources of a coal mine

The purpose of this research is the formation of principles and procedures for developing an organizational concept of complex mining of minerals from coal mines using the example of a promising model of transition of the PJSC "DTEK Pavlohradvuhillia" mines to multi-product production of clean drinking water, utilization of methane, secondary coal from rock dumps and slurry reservoirs, low-grade thermal energy of mine groundwater and associated raw materials from desalination waste [21], [22].

The organizational concept is an approach to developing models and describing the processes of production complexes [23]-[25], focusing on the organizational structure and functions of the business system. This concept defines how different structural elements and their roles (functions) interact with each other within the framework of business processes.

The organizational concept includes the following elements, which are the objectives of this paper:

– organizational structure: it reflects the hierarchy, chains of command and relationships between the structural elements of the production system. Organizational structure models help to define how different roles and units interact in the processes;

– functional responsibilities: describe which specific responsibilities and functions are performed by different roles and units. This helps determine the distribution of work and interaction between employees;

– communication and relations: describe how employees and units exchange information, how feedback occurs, and how they collaborate with each other. This is an important aspect for effective communication and business process management.

The organizational concept helps to understand the structure of the production complex and the relationships between units, roles and functions. This improves the "visualization" of communications, coordination and efficiency of business processes within the business system for its modeling.

2. Process approach to organizing the work of the production complex for mining and processing coal and related mineral raw materials

From the point of view of the organization of functioning, the production complex for mining and processing of mineral raw materials from coal mines is a rather complex business system (BS), the management of which requires the use of effective methods of "visualization" of structural elements and measures of their interaction efficiency. In particular, this can be done by forming and studying a process model of the business system.

The construction of such a model is a complex stage of research in terms of the requirement of deep knowledge in industrial technology, economic theory and mathematics, requires taking into account more factors and their interrelationships to form a complete picture of the real situation at the enterprise and promote better management.

The theoretical and methodological basis for conducting scientific research, as well as the effective use of the process approach at modern enterprises, consists of numerous works of foreign and domestic scientists. Among them, first of all, it should be noted the conceptual works of such specialists as M. Hammer (in a team with J. Champy and L. Hershman) [26], [27], M. Robson and Ph. Ullah [28], T. Davenport [29], J. Harrington [30], E. Deming [31], B. Anderson [32], etc. The main provisions for modeling business processes have been studied and presented in the following publications by foreign scientists:

1. "Business Process Modeling, Simulation and Design" – the study of Manuel Laguna and Mor Leon [33], which provides a comprehensive overview of business process modeling and design methods.

2. "Business Process Modeling, Simulation and Optimization" – the study of Raymond Verbeek, Bart ter Haar Romeny and Marcel Heezen [34], which proposes methods for modelling, simulation and optimisation of business processes.

3. “Business Process Management: Concepts, Languages, Architectures” – the study of Mathias Weske [35] exploring concepts, languages and architectures related to business process management.

4. “Handbook on Business Process Management” – a work authored by Michael Rosemann and Jan vom Brocke [36], which examines the theoretical foundations and practical aspects of business process management in detail.

5. “Business Process Management: Concepts, Methods, and Information Systems” – a book authored by Wil van der Aalst [37], which presents a broad overview of methods for modeling, analyzing and managing business processes.

Among domestic developments are the works of such scientists as:

1. M. Tupkalo [38], L. Prykhodko [39], N. Fursova and I. Kozuniak [40], V. Dziuba and O. Zaitseva [41], who consider general theoretical and practical aspects of business process modeling.

2. T. Lepeiko [42], I. Pistunov [43], S. Kozyr, V. Sliesariev, and S. Us [44], who cover the basic principles and tools of business process modeling and management.

3. L. Taraniuk [45], O. Kryvoruchko [46], O. Vynohradova [47], O. Oleksandrova and O. Khludina [48], M. Holovnina and I. Korol [49], O. Polinkevych [50], who study the modelling of business processes at enterprises of different spheres and scales of activity.

Specialists distinguish several standardized process approaches that are used in different spheres and organizations.

A. *Process approach within the framework of the international standard ISO 9001, which defines the requirements for the quality management system*. One of the key principles of ISO 9001 is the process approach, which recognizes that all of organization activities are interrelated processes, which are aimed at achieving the organization’s goals and satisfying customer needs.

The process approach within ISO 9001 includes the following aspects:

1. Understanding and managing processes: the organization must identify all processes that affect the quality of a product or service and determine their interrelationships. Each process should be documented and responsibility for its execution should be defined.

2. Planning and defining process goals: the organization must set metrics and goals for each process to ensure that the required results are achieved. These goals should be determined taking into account customer needs and legal requirements.

3. Process implementation and control: the organization should ensure that all processes are properly implemented, including appropriate employee training, ongoing monitoring and evaluation of processes, and measures to ensure their effectiveness and compliance.

4. Process improvement: the organization must continuously improve its processes based on feedback, evaluation of results and implementation of improvements. To achieve this, a quality management system and constant updating of methods and practices are important.

The ISO 9001 process approach helps an organization to provide a systematic and structured approach to quality management. It helps to identify, understand and improve the organization key processes, thereby improving the efficiency and quality of goods or services.

The process approach also facilitates the identification of interactions between different processes and work groups in an organization. This helps in understanding the dependencies and impact of one process on another, as well as to avoid duplication of work.

Using a process approach within the ISO 9001 framework enables an organization to:

– eliminate inefficiencies and process losses that result in improved quality and productivity;

– focus on customer needs and fulfilment of customer expectations by making processes customer-centric;

– identify and manage risks and opportunities in processes.

– ensure continuous process improvement through the collection and analysis of data, as well as implementation of improvements.

Therefore, within the ISO 9001 standard, the process approach is a key element of a quality management system and helps an organization improve its processes, achieve objectives and reach a higher level of product or service quality.

B. *Lean Six Sigma process approach is a methodology combining Lean and Six Sigma to improve business processes*. Lean is a management philosophy that aims to eliminate any fuss, reduce unproductivity and optimize processes. Lean principles include focusing on customer needs, detecting and correcting losses, optimizing workflows, and using resources efficiently.

Six Sigma is a methodology aimed at reducing process variations and errors. It is based on statistical methods and tools that identify the causes of problems, detect and eliminate them, as well as improve productivity and quality. The combination of Lean and Six Sigma allows for significant improvements in process efficiency and quality. The implementation of Lean Six Sigma in an organization includes the following steps:

1. Goal setting. The initial step is to identify specific goals and key quality parameters that need to be improved.

2. Measuring. The next step is to collect and analyze data to assess the current state of the processes and identify potential problems and losses.

3. Analysing. The use of statistical methods and tools can identify the causes of problems and potential opportunities for improvement.

4. Improvement. Based on data analysis, process improvement measures are taken. Great emphasis is placed on efficient use of resources, optimising work sequences and reducing variation.

5. Control. The last stage includes defining control mechanisms for continuous monitoring of processes and time, identifying deviations from planned indicators.

The main Lean Six Sigma benefits include loss reduction, improved productivity and quality, reduced cycle time, cost optimisation and customer engagement. It is used in various industries, including manufacturing, finance, services and information technology to achieve improvements in various aspects of business.

C. *Lean Manufacturing process approach is a strategic approach to production activities aimed at maximizing customer value, efficient use of resources, reducing losses and optimizing processes*. Process management plays a key role within Lean Manufacturing, and includes the following aspects:

1. Determining value for the customer. The primary goal of Lean Manufacturing is to provide the greatest value to the

customer. This means understanding customer needs and producing goods or services that satisfy those needs.

2. Identifying and ensuring process flow. Lean Manufacturing aims to eliminate delays, unnecessary time and waste from manufacturing processes. This is achieved by using principles such as Just-in-Time (JIT), which involves supplying materials exactly when they are needed for production, and Kaizen – the continuous process improvement.

3. Employee engagement and efficient use of resources. Process management in Lean Manufacturing includes involving employees in identifying and solving problems, as well as using their knowledge and skills to ensure process efficiency. It is also important to use resources efficiently, avoid overproduction and minimize inventories.

4. Continuous improvement and innovation. Lean Manufacturing is based on the principle of continuous improvement. An organization should continuously analyse and evaluate its processes to find ways to improve them, and to draw attention to innovations and advanced technologies that can improve process quality and efficiency.

Lean Manufacturing process management helps an organization to use resources more efficiently, reduce losses, and improve product quality. As a result, the organization achieves greater competitiveness and satisfaction of customer needs.

D. *Process approach based on Total Quality Management (TQM)*. This is a philosophy and approach to process management, aimed at the implementation of quality in all aspects of organization activity. This is a strategic approach to quality management that involves the active participation of all members of the organization in achieving high quality.

Process management is one of the core elements of TQM and includes the following aspects:

1. Process definition and documentation. The organization should clearly identify all processes affecting the quality of the product or service and document their description and interaction.

2. Creating cross-functional teams. TQM implies the creation of cross-functional teams consisting of representatives of various departments and management levels. These teams work together to improve and optimize processes.

3. Analyzing and identifying the causes of problems. TQM teams use various data analysis tools and techniques, such as Pareto Charts, Scatter plots, Ishikawa diagrams, etc., to identify the root causes of problems and determine effective measures to address them.

4. Process improvement. TQM is based on the principle of continuous improvement. TQM teams work to implement improvements, reduce variation, increase efficiency, and remove unnecessary activities from the process.

5. Employee training and development. The organization is engaged in staff training and development to ensure understanding of TQM principles, process management methods and other quality tools.

Process management within the TQM framework promotes quality improvement, ensuring interdependence and coherence between different processes, as well as creating a culture of continuous improvement. As a result, the organization achieves better results, ensures high customer satisfaction and competitiveness.

E. *Process approach within the framework of Business Process Reengineering (BPR) is a strategic approach to transforming business processes to improve productivity, efficiency and quality. It involves radically transforming and redesigning business processes to achieve significant improvements in productivity, quality and efficiency*.

The main Business Process Reengineering principles are:

1. Understanding the customer goals and needs. Customer goals and expectations must be clearly defined before the redesign process begins. Such an understanding will help guide the redesign process towards meeting these needs.

2. Radical changes. BPR involves radical changes in organizational structures, processes, technology and culture. This may mean abandoning old ways of working and adopting new, more effective approaches.

3. Technological support. BPR often involves the use of advanced technologies, such as process automation, control systems, electronic document management, etc., to facilitate and simplify the execution of business processes.

4. Employee engagement. BPR implementation requires the active participation and involvement of employees at all levels. They should be included in the redesign process to ensure that changes are understood and accepted.

5. Measuring and evaluating results. BPR requires measuring and evaluating results to determine the effectiveness and success of the redesign. This allows the organization to confirm the improvements achieved and the achievement of the set goals.

Implementation of BPR can lead to significant improvements in efficiency, efficient use of resources, and increased competitiveness of the organization. However, this process also poses significant risks, as it requires changes in the organizational culture and operating environment. Therefore, it is important to have a clear strategy, a well-organized process and to involve all stakeholders for the BPR to be successful.

F. *Process approach within the framework of ITIL (Information Technology Infrastructure Library)*. This is a set of recommendations and best practices for IT service management. ITIL standardizes processes related to IT infrastructure management, operational changes, implementation of new services and other aspects of IT management. ITIL was developed by the UK government in the 1980^{s} and has since become the global standard for IT management.

The goal of ITIL is to ensure that IT infrastructure tools and processes are managed effectively, enabling organizations to maintain and deliver high-quality IT services. The main focus is on improving quality, productivity and efficiency through advanced methodologies and streamlined IT management processes.

ITIL includes a set of management products, which are practical documents describing procedures, guidelines and approaches to IT service management. These products cover a wide range of management areas, including elements such as configuration management, event management, problem management, change management, reliability management, availability management, and many others.

The main advantages of using ITIL include: standardizing IT management processes, improving quality and service, reducing risk, increasing efficiency, increasing customer satisfaction, reducing the cost of IT operations, and greater compliance with requirements of regulatory bodies.

ITIL can be used by any organization that has a need to manage IT services and deliver high-quality services to its customers. Many companies and organizations are implementing ITIL as a standard for their IT management process-

es, as well as introducing ITIL certification for their IT professionals to ensure compliance with industry standards and best practices.

G. *Process approach within the framework of CMMI (Capability Maturity Model Integration)*. This is a framework that defines process management principles to evaluate and improve software development systems. CMMI covers all stages of the software development lifecycle, effective risk management, project management and other aspects of software development. It was developed by the Software Engineering Institute (SEI) at Carnegie Mellon University and first published in 1993.

CMMI aims to improve the quality, productivity, and efficiency of project management and product development processes. It provides organizations with an assessment of their processes, as well as guidance for continuous improvement and development of effective practices. CMMI is based on maturity models with different maturity levels that measure spiral development and process stability.

The core components of CMMI include a set of processes that an organization can use to manage its projects and activities. These processes cover a wide range of aspects including configuration management, risk management, requirements management, issues management, change management, test management and more. The CMMI maturity level of organizations is determined by the classification of their processes and the degree of maturity.

CMMI focuses on a culture of continuous improvement and the development of effective practices. Implementing CMMI helps organizations improve product or service quality, reduce risks and errors, improve project planning and estimating, enhance customer support and user satisfaction, and improve workflow efficiency and productivity.

CMMI has different maturity levels, including Initial, Managed, Defined, Quantitatively Managed, and Optimizing. When an organization develops its processes and practices, it moves progressively to higher levels of maturity, indicating a high level of organizational discipline and process improvement.

CMMI implementation is a widely used approach in software development and project management. It enables organizations to improve the quality of their processes, provide greater project control and predictability, and achieve a high degree of achievement of organization's goals.

Thus, the essence of using a process approach (PA) in organizing the operation of a production complex for mining and processing of coal and associated mineral raw materials is to focus on the organizational processes occurring in its internal environment and recognise their importance in achieving strategic goals.

Thus, it is possible to determine the main aspects and advantages of using the process approach in organizing the activities of the production complex for mining and processing of mineral raw materials from coal mines, which are as follows:

– goal and results orientation: the process approach is aimed at achieving specific goals and measuring results in real time. This allows managers to be more conscious of achieving strategic goals and use effective tools to achieve them;

– focus on change and improvement: the process approach involves continuous review and improvement of business processes to increase efficiency and ensure quality of goods or services. This allows the business system to adapt to changes in market conditions, ensure sustainability and competitiveness;

– cross-functional approach: the process approach allows a system in which different functional elements work together, collaborating and sharing information to achieve a common goal. This helps improve communication, reduce congestion and optimize workflows;

– increasing control and visibility: the process approach increases control over key business processes by identifying and visualizing each step of the process, identifying its owners and determining key indicators to assess performance. This facilitates better decision-making and quicker response to change.

3. Results and discussion

An important stage of applying the process approach in business system research is the development of the organizational concept. At this stage, it is necessary to determine the fundamental principles of organizing the enterprise's business processes. These principles will serve as a basis for further detailed description and clarification of the enterprise's organizational structure. The organizational concept encompasses five main elements.

Firstly, it involves identifying the top-level primary business processes. Second, a concise description of these top-level processes is provided, describing their content, inputs, outputs, and those responsible for their implementation. In addition, a process map is developed to illustrate the second and potentially third level of business processes. A scheme for identifying responsibility centres for these business processes is also developed and ultimately serves as a prototype of the enterprise's organizational structure. Finally, a brief description of the functions performed by these responsibility centers is provided.

According to experts [38], [40], [45], several well-known models for identifying business process systems are currently proposed, based on: models of the business process system "Company's value chain" by M. Porter, the eight-process model of the BKG Profit Technology consulting company, the IBL (International Business Language) model of PricewaterhouseCoopers company, and the thirteen-process model of the American Productivity & Quality Center.

The value chain business process system model by Michael Porter (Fig. 3) is a conceptual framework developed to analyze and optimize business processes in an organization.

This model helps to understand the structure and functions of an enterprise, as well as to identify key elements that contribute value to the business process.

The Company's value chain model consists of 5 main sections:

1. Input links (procurement, suppliers). These are the first stages of the chain that supply the necessary resources, materials and services required for the operation of the enterprise.

2. Production (transformation). This link includes production operations, the processes of transformation from input resources into the finished product.

3. Output links (distribution and marketing). These are the processes associated with the sale of a product or service, including marketing activities, sales and logistics.

4. Supporting links (infrastructure, resource management). These links include functions that are required to support the whole chain, such as finance, human resource management, technology, quality management, and other aspects of resource management.

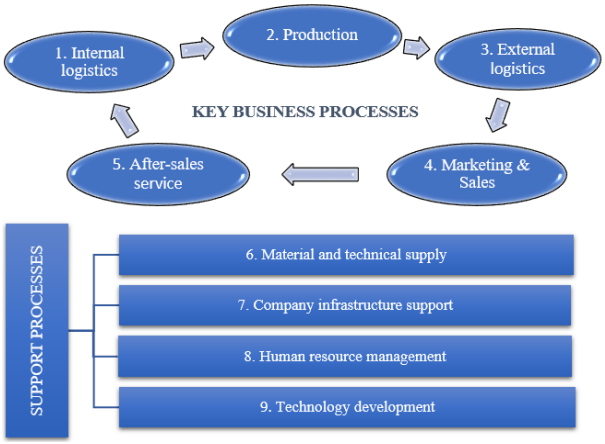

Figure 3. Identification of the business process system in M. Porter's Company Value Chain model

5. Outputs (fulfilment of consumer needs). The last stage of the chain is related to the delivery of the product or service to final consumers and the fulfilment of their needs.

The Company value chain model emphasizes the importance of collaboration between all chain elements, as well as increasing the value for the customer and high efficiency in terms of enterprise expenditures. This model helps to analyze how each link contributes to overall value creation and focuses on certain chain elements to improve their performance and provide a competitive advantage.

The eight-dimensional model of the BKG Profit Technology consulting company (Fig. 4) is a concept aimed at managing business processes and achieving improvements in the enterprise operation. The main difference between the eight-dimensional BKG Profit Technology model and Michael Porter's Company Value Chain model is the greater emphasis on internal aspects of managing and optimizing business processes.

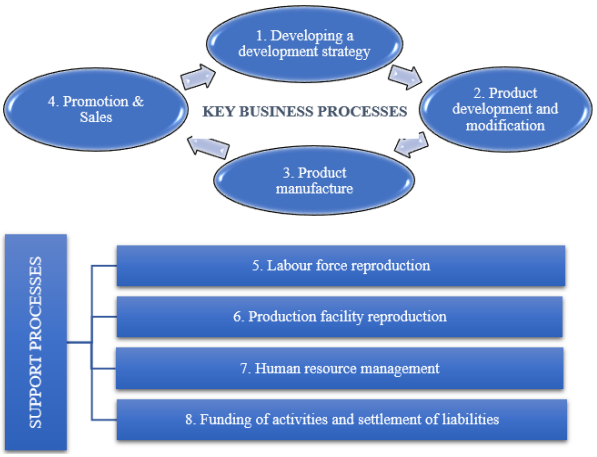

Figure 4. Identification of a business process system in the Eight-process model of the BKG Profit Technology consulting company

The main dimensions of the BKG Profit Technology model include:

1. Financial Dimension, which is focused on analyzing the company's financial performance and calculating the efficiency of business processes in terms of financial results.

2. Customer Dimension, which is aimed to analyse and improve customer interactions and customer satisfaction. It focuses on understanding customer requirements, ensuring service quality and meeting customer expectations.

3. Organizational Dimension, which refers to the structure and organization of the enterprise, personnel management and internal processes. The model includes analysis of communication, knowledge management and other aspects of organizational management.

4. Innovation Dimension that emphasizes the development and implementation of innovations, new technologies and problem solving through a creative approach.

5. Process Dimension, which focuses on analyzing and optimizing business processes within an organization. It includes process efficiency and effectiveness assessment, standardization, automation and improvement.

6. Project Life Cycle Dimension is focused on project management and project life cycle management from task setting to implementation and results monitoring.

7. Risk and Control Dimension aims to identify, assess and manage risks in a company operations, as well as to establish controls and ensure compliance with regulatory requirements.

8. Change Management focuses on managing the process of making changes to a company organizational structures and procedures, as well as to a company culture in order to adapt to changes in the external environment and achieve strategic goals.

The eight-dimensional BKG Profit Technology model is optimized for consulting companies and provides an integrated approach to managing business processes, risks and changes for success and competitive advantage.

The PricewaterhouseCoopers process model (Fig. 5) was not widely used because it was an internal tool or methodology used by PwC for its own internal processes or specific customer needs.

Figure 5. Identification of a business process system in the International Business Language (IBL) model of PriceWaterhouseCoopers

As sources indicate [48]: "PriceWaterhouseCoopers Company has adapted this concept for use in classifying and structuring business processes and has developed "International Business Language, IBL" based on this concept to ensure the dissemination of best practices. It allows processes in different areas of activity to be analysed and compared on a common basis. Value chain processes directly influence the product or service provided to the customer".

The thirteen-process model of the American Productivity & Quality Center (APQC), which is presented in Figure 6, is a popular tool for managing processes and improving the performance of organizations.

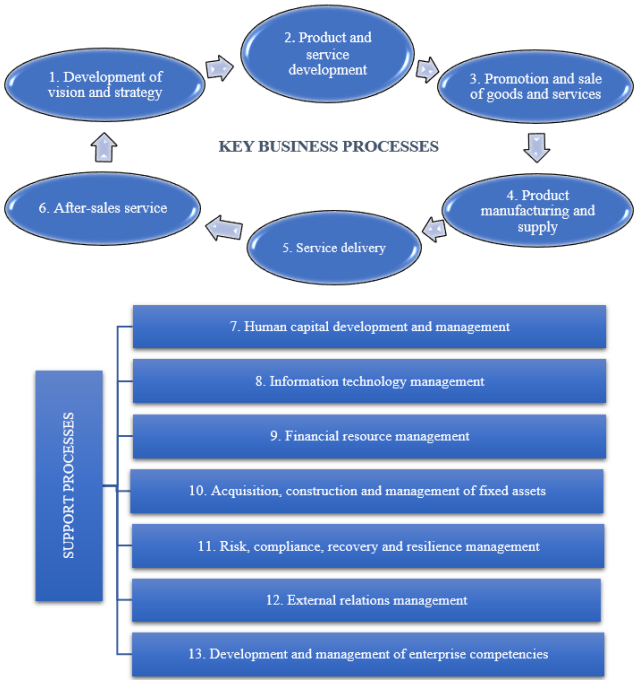

Figure 6. Identification of a business process system in the Thirteen-process model of the American Productivity & Quality Center

This model has its own peculiarities, the main of which are presented below:

1. Thirteen key processes. APQC has identified thirteen key processes that are the basis of the model. These processes include various aspects of business such as project management, marketing and sales, logistics, procurement, finance, and others.

2. Productivity measurement levels. APQC provides different productivity measurement levels for each of the thirteen processes. This allows the organization to accurately measure the effectiveness of its processes and identify areas for improvement.

3. Process maps. APQC has developed detailed process maps for each of the thirteen key processes. These maps provide a structured representation of processes and their elements, helping to identify dependencies between different stages and components.

4. Knowledge portal. APQC has a powerful online knowledge portal where organizations can find methodologies and best practices in process management that they have developed. This allows companies to learn from the experience of other successful organizations and use this knowledge for their own needs.

5. Focus on process improvement. APQC aims to help organizations improve the efficiency and productivity of their processes. They provide frameworks and guidelines on how to realize improvements and achieve greater efficiency in various aspects of the business.

These peculiarities make the Thirteen-process APQC model quite a popular process management tool for organizations of different sizes and industries. It provides a wide range of knowledge, methodologies and tools that can be used to improve productivity and achieve competitive advantages, and therefore best fulfils the requirements as the most comprehensive representation of the multi-product complex operation for mining and utilization of georesources.

Once the basic procedures have been determined, an abstract explanation of them is formulated. This is the second component of the organizational concept. The explanation scheme (Fig. 7) for each operating procedure includes the following elements.

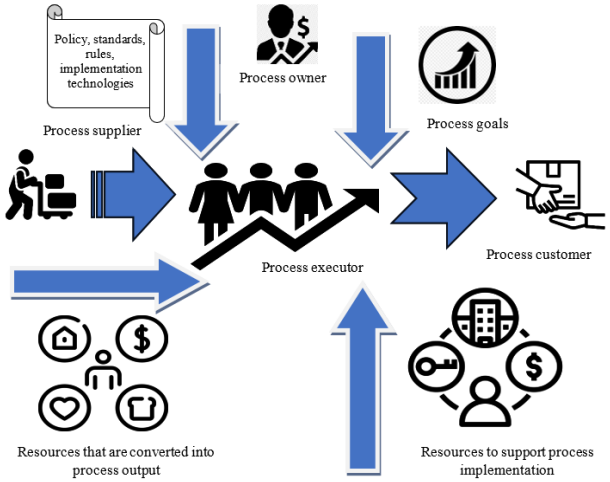

Figure 7. Individual business process identification elements

1. A process customer is a person or entity that perceives services or interacts with an enterprise (or organization) through different business processes.

Customers can be individuals (for example, residents, buyers) or legal entities (for example, other companies, partners, clients). They may receive products, services, solve problems or participate in any other business processes according to their needs and requirements.

Business process customers influence the operation and strategy of an enterprise, since their needs and requirements determine the type and quality of service delivery or goods production. It is advisable to study and consider customer behavior, habits, preferences and satisfaction, as well as to conduct marketing analyses and surveys to improve business processes and customer satisfaction.

Given the importance of customers to business, enterprises strive to create loyalty strategies and programs, improve customer service, and personalize communications to ensure customer satisfaction, engagement, and retention.

Therefore, the business process customer is the main actor towards whom the enterprise activity is directed, and his satisfaction and needs are important for the success and development of an organization.

2. Process goals are changes that occur during the execution of a process that are meaningful to the customer. By defining process goals, the question "What changes the pro-

cess?" can be answered. For example, the goal of the "Development of products and services" process is to ensure the availability and updating of a certain list of those marketable products that can be obtained from the processing of coal, thermal energy, methane gas, groundwater, dry residue chemicals from desalination and coal mining waste, etc. Its availability is determined by the commercial potential of the business system, and the key customer in this process is the marketing and sales unit (and related process).

3. A process result is a specific output or product that is obtained after executing a business process. This can be a physical product, service, document, report, decision, or other measurable or perceived outcome.

The business process result may have different values and meanings for different stakeholders, such as customers, employees, partners or internal departments of the enterprise. It is important that the result meet the requirements and expectations of the stakeholders and is in line with the objectives and strategies of the enterprise.

Thus, in a manufacturing business process, a team result may be a finished product or component that meets quality requirements and specifications. In a customer service business process, the result may be the delivery of high-quality service and customer satisfaction. In a business accounting process, the result can be an accurate financial report or balance sheet of the enterprise.

It is also important to track and measure the results of a business process to assess effectiveness, identify problems and improve the process. This can be done using key performance indicators (KPI), a specified quality criterion, customer requirements, or other evaluation methods.

Consequently, the business process result is an important baseline that shows how successfully the process is implemented and what values it creates for stakeholders.

4. Process resources are the various elements used to execute a business process. They can be material substances, finances, equipment, software, information, human capital and other resources necessary to implement the process and achieve its goals.

Main types of business process resources:

- ✓ Human capital. This includes all employees and workers involved in the execution of a business process. They may have different roles and responsibilities in the process and use their skills, knowledge and experience to achieve the goal.
- ✓ Financial resources. This includes the money needed to ensure financial sustainability and business process operation. These are funds to purchase equipment, pay staff salaries, pay for services, or budget the process.
- ✓ Material resources. This is equipment, materials, goods or other property required to perform a business process. For example, raw materials, machinery, tools and other materials may be needed to produce a product.
- ✓ Information resources. This is data, information and knowledge that are used to conduct a business process. This may contain databases, reports, statistics, documentation, and other information sources.
- ✓ Technological resources. These are software, hardware and other technological tools used to automate and optimize a business process. These can be Customer Relationship Management (CRM) systems, analytics software, computing systems, and other technological solutions.

The utilization and optimization of business process resources is an important aspect of an organization efficiency and success. Good management and efficient use of resources help to improve productivity, reduce costs and achieve business process goals.

5. Process suppliers are organizations, units or individuals that supply various resources, goods, or services required to perform a business process. They play an important role in providing the business process with the necessary materials, equipment, finance and other resources that are used to achieve the process goal.

Suppliers may be sources of raw materials, components, materials or goods that are used in the production process. They can also provide services such as transport, logistics and other services required to ensure a smooth and efficient process. Some suppliers may be internal units of the company, while others may be external suppliers with whom contracts or agreements are concluded.

It is important to establish and maintain effective relationships with suppliers who ensure that the right resources are delivered at the right time with the right quality. To achieve this, various supplier selection and evaluation strategies, such as auditing, quality assessment, standard setting, contracting, joint planning and cooperation, can be used.

Suppliers have a huge impact on the quality and efficiency of a business process. Successful supply chain management and cooperation with suppliers help ensure reliable supply, reduce costs, improve quality and achieve competitive advantages.

6. A process executor is a person or group of people who directly perform the work and tasks related to the business process implementation. They are responsible for executing specific activities, steps and stages of the process, implementing the plan, using the necessary resources, and ensuring that the process goal is achieved. Executors may have different roles and responsibilities within a business process. They may be employees working within the same enterprise or department, or external specialists providing services or collaborating with the enterprise. Executors may have different specializations and skills, enabling them to perform the required tasks effectively.

Business process executors can work independently, with teams, or interact with other process participants such as customers, suppliers, or other internal or external stakeholders. They can perform routine operations, make decisions, use resources, communicate with other participants, and view the results of their work.

Business process executors have a great influence on the quality and efficiency of the process. Their skills, abilities, motivation and cooperation can influence the outcome and success of the process. Effective executive management includes the proper assignment of tasks, providing support, motivation and training to ensure compliance with the defined goal and process quality.

In addition, communication and feedback between executors and all stakeholders are important to address problems, identify gaps and improve the process. Interaction and cooperation between executors and other participants can contribute to achieving better results and the business process goal.

7. A process owner is a person or group of people responsible for determining, managing and controlling a particular business process in an organization. They are involved in

planning, developing, implementing and continuously improving the process to achieve business goals set. The business process owner has full responsibility for the efficiency, quality and results of the process. They monitor the process, identify problems and propose appropriate measures to address them. They are also responsible for identifying and implementing best practices, strategies and innovations for continuous process improvement.

Business process owners cooperate with other participants in the organization, such as process executors, managers, analysts, and other stakeholders. They coordinate the work, communicating the goals, requirements and expectations of the process. They can also coordinate interactions with suppliers, customers, and other external parties that influence the process.

8. Business process indicators are metrics or parameters used to assess and measure the efficiency, productivity, quality, and other business process characteristics. Their use allows for an objective assessment and control over the process course, its results, and goal achievement adequacy.

Indicators can be quantitative or qualitative and reflect different aspects of the process. Quantitative indicators, such as the number of tasks completed, time or resources spent, production or sales volume, can be measured with specific numerical values. Qualitative indicators, such as customer satisfaction, product quality or cooperation with suppliers, can be assessed through evaluation, rating or other qualitative indicators.

The choice of business process indicators depends on the specifics of the process itself and the goals set. They should be specific, measure important aspects of the process, and be linked to business goals. Well-chosen indicators identify problems, assess the effectiveness of changes made, and ensure process improvement.

To use indicators effectively, it is necessary to set goals and measurement standards, collect and analyze data, compare them with goals, and analyze the results obtained. This enables monitoring and control of the process execution and appropriate management decisions to be made.

9. Process content is a set of activities, steps, tasks, rules, and resources that are required to implement a particular business process. It defines the sequence and logic of execution, the roles and responsibilities of the participants, the requirements and expectations regarding the results and quality of response actions.

Business process content includes all the necessary elements to ensure the successful process execution. This may include such components as:

- ✓ Actions & Steps: specific tasks and actions performed as part of the process. These may be routine operations, decision-making, communication with other participants, and others.
- ✓ Dependencies & Sequences: identifying sequence and dependencies between different actions and process steps. This allows to ensure a logical order and coordination of execution.
- ✓ Roles & Responsibility: assigning roles and responsibilities for different participants in the process. This determines who is responsible for performing specific actions and making decisions.
- ✓ Requirements & Standards: setting requirements and standards for quality, productivity, timing, costs, and other aspects that must be met within a process.
- ✓ Business Rules: setting the rules and restrictions required to execute a process. These can be safety rules, data storage rules, decision-making rules, etc.
- ✓ Resources: determining the necessary resources, such as human, financial, material, or informational resources, required to execute a process.

Business process content can be documented in the form of process maps, descriptions, execution standards, procedures and other documents regulating its execution. This allows process participants to have a clear understanding and perform the appropriate actions to achieve the process goal.

10. Process Structure is an organized sequence of steps, actions, and decisions that are performed to achieve a specific goal within a process. It provides a framework and logical organization for executing a process, defining the structural blocks, their relationships and the sequence of actions.

Business process structure can be visualized in the form of a process diagram or flowchart. It may contain the following elements:

- ✓ Stages: individual phases or steps to be performed as part of a process. Each stage can have its own tasks, solutions and work steps.
- ✓ Inputs: determining the necessary input data to start the process. These may be information, resources, documentation, or any other input necessary to implement the process.
- ✓ Baseline Results: defining the expected results and baseline data obtained after the completion of each step or the process as a whole. These may be production products, reports, solutions, documents, performance indicators, etc.
- ✓ Dependencies & Relationships: determining the dependencies between the different stages and actions of the process. These may be conditions, sequences, parallelism or dependence on other internal or external factors.
- ✓ Roles & Responsibilities: assigning roles and responsibilities for different participants in the process. Determining who is responsible for specific tasks and decision-making at each stage of the process.
- ✓ Resource Management: identifying the required resources, such as human, financial, material or informational resources, and managing them during the process.
- ✓ Business Rules & Restrictions: setting rules and restrictions that must be considered during the process execution. These may include safety rules, procedures, organizational policies, and constraints on resources, time, expenses, etc.

Business process structure helps to organize and understand the sequence of actions and decisions required to achieve the process goal. It also enables process analysis and optimization by identifying possible delays, blockages, deficiencies or unplanned costs.

The use of a business process structure helps organizations to improve efficiency, productivity and control of process execution, as well as ensure the achievement of set goals and requirements.

After completing the work on the organizational concept, all the necessary components will be formed to provide a complete representation of the main operations within the technological complex. Description of the composition of the top-level processes (denoted by integer (1.0, 2.0, ..., 6.0) symbols) and their corresponding components, which are lower-level processes for the Thirteen-process model (APQC) of a multi-product georesource extraction and utilization complex.

A process map provides a comprehensive understanding of the main operations performed by a business system, enabling an understanding of its activity and the sequential organization of the processes dedicated to serving the customers of these processes.

It should be noted that only the key processes of the company have been considered above, neglecting the inclusion of development and management processes, which also play an important role in its functioning.

Support processes are designed to support the core operations of an organization. They cover activities such as accounting services, legal assistance, IT services, document management and various other processes. The customers who use these processes are internal to the company.

Development processes are focused on changing or creating corporate resources. While the primary beneficiaries of key processes are customers, the development processes involve the use of the results by the company internally. Classifying development processes based on the tangible or intangible assets they generate, such as new knowledge resulting from research, fresh products, expanded business operations, and innovative organizational, information, or production technologies, has proven beneficial.

Processes related to the management of an organization or business. Management involves various processes such as goal setting, strategy development, monitoring and evaluation. It can be argued that management processes are related to each process in the above groups that are key to organizational growth. In addition, management ensures that all processes are consistent, both at the strategic and tactical levels. Therefore, management processes constitute the most extensive category of processes [49]-[54].

Organization or business development processes. They typically require the coordination of several units within a company and are extremely difficult to coordinate.

According to experts, the "Organizational concept" document should be approximately 10-20 pages [44], which is a fundamental basis for all further endeavors related to the construction and research of a process model.

The proposed concept and research conducted make it possible to create a scientific-theoretical basis for the integrated development and modernization of existing mining technologies with a parallel transition to multi-product production based on the creation of a multi-business industrial model for obtaining drinking water, salt-containing desalination products, utilization of associated thermal energy from mine gas methane, secondary coal from rock dumps and slurry reservoirs.

The considered set of solutions will ensure sustainable development and diversification of coal mining enterprises.

4. Conclusions

Construction of an organizational concept and study of a promising model of an industrial complex for mining and processing of mineral resources of coal mines based on the tools of the process approach provides many advantages, since it allows an accurate prediction of its behavior depending on various factors and scenarios, namely:

– the ability to predict results and develop strategies based on different scenarios;

– the ability to analyze the interaction of various factors and their impact on the production complex operation results;

– the ability to effectively control expenses and budget planning;

– the ability to predict demand and production planning;

– reducing the risk of making an unsuccessful decision;

– an opportunity to obtain a comprehensive view of the financial and production indicators of the production complex operation;

– reducing the cost of experiments and testing various production technologies.

The research conducted is aimed at developing a promising direction for complex mining of mineral raw materials from coal mines as part of DTEK's ESG strategy. In this direction, the main components of using the resource potential of coal-mining enterprises have been determined, aimed at obtaining technical and drinking water for own needs of production and local population, extracting secondary mineral resources from dry residue of desalination products, using geothermal groundwater energy, utilizing mine gas methane, obtaining associated valuable elements and materials from coal mining waste.

Funding

This research received no external funding.

Acknowledgements

I would like to extend my sincere appreciation to the Dnipro University of Technology for invaluable technical assistance throughout the course of this research.

Conflicts of interests

The author declares no conflict of interest.

Data availability statement

The original contributions presented in the study are included in the article, further inquiries can be directed to the corresponding author.

References

[1] Pavlychenko, A., & Kovalenko, A. (2013). The investigation of rock dumps influence to the levels of heavy metals contamination of soil. *Annual Scientific-Technical Collection – Mining of Mineral Deposits 2013*, 237-238. https://doi.org/10.1201/b16354-43

[2] Bondarenko, V., Kovalevska, I., Symanovych, H., Barabash, M., & Snihur, V. (2018). Assessment of parting rock weak zones under the joint and downward mining of coal seams. *E3S Web of Conferences*, *66*, 03001. https://doi.org/10.1051/e3sconf/20186603001

[3] Gorova, A., Pavlychenko, A., Kulyna, S., & Shkremetko, O. (2012). Ecological problems of post-industrial mining areas. *Geomechanical Processes During Underground Mining – Proceedings of the School of Underground Mining*, 35-40. https://doi.org/10.1201/b13157-7

[4] Bondarenko, V., Cherniak, V., Cawood, F., & Chervatiuk, V. (2017). Technological safety of sustainable development of coal enterprises. *Mining of Mineral Deposits*, *11*(2), 1-11. https://doi.org/10.15407/mining11.02.001

[5] Klimkina, I., Kharytonov, M., & Zhukov, O. (2018). Trend analysis of water-soluble salts vertical migration in technogenic edaphotops of reclaimed mine dumps in Western Donbass (Ukraine). *Journal of Environmental Research, Engineering and Management*, *2*, 82-93. https://doi.org/10.5755/j01.erem.74.2.19940

[6] Griadushchiy, Y., Korz, P., Koval, O., Bondarenko, V., & Dychkovskiy, R. (2007). Advanced experience and direction of mining of thin coal seams in Ukraine. *Technical, Technological and Economical Aspects of Thin-Seams Coal Mining, International Mining Forum, 2007*, 2-7. https://doi.org/10.1201/noe0415436700.ch1

[7] Bondarenko, V., Kovalevska, I., Cawood, F., Husiev, O., Snihur, V., & Jimu, D. (2021). Development and testing of an algorithm for calculating the load on support of mine workings. *Mining of Mineral Deposits*, *15*(1), 1-10. https://doi.org/10.33271/mining15.01.001

[8] Bondarenko, V., Kovalevska, I., Astafiev, D., & Malova, O. (2018). Examination of phase transition of mine methane to gas hydrates and their sudden failure – Percy Bridgman's effect. *Solid State Phenomena*, *277*, 137-146. https://doi.org/10.4028/www.scientific.net/ssp.277.137

[9] Pivnyak, G., Bondarenko, V., Kovalevs'ka, I., & Illiashov, M. (2013). *Mining of mineral deposits*. London, United Kingdom: CRC Press, Taylor & Francis Group, 382 p. https://doi.org/10.1201/b16354

[10] Pivniak, H.H., Pilov, P.I., Pashkevych, M.S., & Shashenko, D.O. (2012). Synchro-mining: Civilized solution of problems of mining regions' sustainable operation. *Naukovyi Visnyk Natsionalnoho Hirnychoho Universytetu*, *3*, 131-138.

[11] Bazaluk, O., Ashcheulova, O., Mamaikin, O., Khorolskyi, A., Lozynskyi, V., & Saik, P. (2022). Innovative activities in the sphere of mining process management. *Frontiers in Environmental Science*, *10*, 878977. https://doi.org/10.3389/fenvs.2022.878977

[12] Vagonova, O.G., & Volosheniuk, V.V. (2012). Mining enterprises' economic strategies as derivatives of nature management in the system of social relations. *Naukovyi Visnyk Natsionalnoho Hirnychoho Universytetu*, *2*, 127-134.

[13] Stukalo, N., Lytvyn, M., Petrushenko, Y., & Omelchenko, Y. (2020). The achievement of the country's sustainable development in the conditions of global threats. *E3S Web of Conferences*, *211*, 01029. https://doi.org/10.1051/e3sconf/202021101029

[14] Pivnyak, G.G., & Shashenko, O.M. (2015). Innovations and safety for coal mines in Ukraine. *Naukovyi Visnyk Natsionalnoho Hirnychoho Universytetu*, *6*, 118-121.

[15] Kulikov, P., Aziukovskyi, O., Vahonova, O., Bondar, O., Akimova, L., Akimov, O., & Akimov, O. (2022). Post-war economy of Ukraine: Innovation and investment development project. *Economic Affairs (New Delhi)*, *67*(5), 943-959. https://doi.org/10.46852/0424-2513.5.2022.30

[16] Li, Q. (2021). The view of technological innovation in coal industry under the vision of carbon neutralization. *International Journal of Coal Science & Technology*, *8*(6), 1197-1207. https://doi.org/10.1007/s40789-021-00458-w

[17] Bondarenko, V.I., Symanovych, H.A., Kovalevska, I.A., Shyshov, M.V., & Yakovenko, V.H. (2023). Geomechanical substantiation of parameters for safe completion of mining the coal reserves adjacent to main workings. *Naukovyi Visnyk Natsionalnoho Hirnychoho Universytetu*, *1*, 46-52. https://doi.org/10.33271/nvngu/2023-1/046

[18] Kovalevska, I. (2006). Minimizing coal losses when extracting thin coal seams with the use of auger mining technologies. *International Mining Forum 2006: New Technological Solutions in Underground Mining*, 27-34. https://doi.org/10.1201/noe0415401173.ch4

[19] *Circular material use rate*. (n.d.). Electronic resource. Retrieved from: https://ec.europa.eu/eurostat/statistics-explained/index.php?title=File:Circular_material_use_rate,_EU,_2004-2021_(%25_of_material_input_for_domestic_use).png

[20] Bondarenko, V.I., & Sai, K.S. (2018). Process pattern of heterogeneous gas hydrate deposits dissociation. *Naukovyi Visnyk Natsionalnoho Hirnychoho Universytetu*, *2*, 21-28. https://doi.org/10.29202/nvngu/2018-2/4

[21] Salieiev, I.A., Bondarenko, V.I., Symanovych, H.A., & Kovalevska, I. (2021). Development of a methodology for assessing the expediency of mine workings decommissioning based on the geomechanical factor. *Naukovyi Visnyk Natsionalnoho Hirnychoho Universytetu*, *4*, 10-16. https://doi.org/10.33271/nvngu/2021-4/010

[22] Bardas, A., & Horpynych, O. (2014). Corporate governance of vertically integrated coal and methane mining holdings. *Progressive Technologies of Coal, Coalbed Methane, and Ores Mining*, 457-464. https://doi.org/10.1201/b17547

[23] Bondarenko, V., Kovalevs'ka, I., & Fomychov, V. (2012). Features of carrying out experiment using finite-element method at multivariate calculation of mine massif – combined support system. *Geomechanical Processes During Underground Mining – Proceedings of the School of Underground Mining*, 7-13. https://doi.org/10.1201/b13157-3

[24] Kovalevs'ka, I., Symanovych, G., & Fomychov, V. (2013). Research of stress-strain state of cracked coal-containing massif near-the-working area using finite elements technique. *Annual Scientific-Technical Collection – Mining of Mineral Deposits 2013*, 159-163. https://doi.org/10.1201/b16354-28

[25] Bondarenko, V., Salieiev, I., Kovalevska, I., Chervatiuk, V., Malashkevych, D., Shyshov, M., & Chernyak, V. (2023). A new concept for complex mining of mineral raw material resources from DTEK coal mines based on sustainable development and ESG strategy. *Mining of Mineral Deposits*, *17*(1), 1-16. https://doi.org/10.33271/mining17.01.001

[26] Hammer, M., & Champy, J. (1993). *Reengineering the corporation: A manifesto for business revolution*. New York, United States: Harper Collins, 223 p.

[27] Hammer, M., & Hershman, L. (2010). *Faster cheaper better: The 9 levels for transforming how work gets done*. New York, United States: Crown Business, 320 p.

[28] Robson, M., & Ullah, Ph. (1996). *A practical guide to business process re-engineering*. Vermont, United States: Gower, 159 p.

[29] Davenport, T. (1993). *Process innovation: Reengeneering work information technology*. Boston, United States: Harvard Business School Press, 352 p.

[30] Harrington, J. (2006). *Process management excellence*. Chicago, United States: Paton Press LLC, 140 p.

[31] Deming, E. (1986). *Out of the crisis*. Cambridge, United States: Massachusetts Institute of Technology, 524 p.

[32] Anderson, B. (1999). *Business process. Improvement toolbox*. Milwaukee, United States: ASQ Quality Press, 233 p.

[33] Laguna, M., & Marklund, J. (2013). *Business process modeling. Simulation and design*. New York, United States: CRC Press, 523 p. https://doi.org/10.1201/b14763

[34] Verbeek, R., Ter Haar Romeny, B., & Heezen, M. (2014). *Business process modeling. Simulation and optimization*. New York, United States: Springer, 543 p.

[35] Weske, M. (2007). *Business process management: Concepts, languages, architectures*. Potsdam, Germany: Springer, 372 p.

[36] Vom Brocke, J., & Rosemann, M. (2015). *Handbook on business process management*. Berlin, Germany: Springer, 420 p. https://doi.org/10.1007/978-3-642-45103-4

[37] Wil van der Aalst, W.M.P. (2013). *Business process management: Concepts, methods, and information systems*. New York, United States: Springer, 120 p.

[38] Tupkalo, M. (2016) *Metodolohichni osnovy biznes-inzhynirynhu suchasnykh protsesno-oriientovanykh pidpryiemstv*. Kyiv, Ukraine: Derzhavnyi universytet telekomunikatsii, 283 s.

[39] Prykhodko, L.M. (2011) Istorychnyi rozvytok pohliadiv na udoskonalennia biznes-protsesiv. *Visnyk Natsionalnoho Universytetu "Lvivska politekhnika"*, *684*, 191-193.

[40] Fursova, N.Ye., & Kozuniak, I.P. (2018). *Modeliuvannia biznes-protsesiv: Teoriia ta praktyka*. Kyiv, Ukraina: Kondor, 244 s.

[41] Dziuba, V.V., & Zaitseva, O.V. (2019). *Upravlinnia biznes-protsesamy: metodolohiia, modeli ta informatsiini tekhnolohii*. Odesa, Ukraina: Instytut kompiuternykh nauk, 122 s.

[42] Lepeiko, T.I., & Kotlyk, A.V. (2009). *Reinzhynirynh biznes-protsesiv*. Kharkiv, Ukraina: Kharkivskyi natsionalnyi ekonomichnyi universytet, 80 s.

[43] Pistunov, I.M. (2021). *Modeliuvannia biznes protsesiv*. Dnipro, Ukraina: NTU "Dniprovska politekhnika", 130 s.

[44] Kozyr, S.V., Sliesariev, V.V., & Us, S.A. (2022). *Modeliuvannia ta reinzhynirynh biznes-protsesiv*. Dnipro, Ukraina: NTU "Dniprovska politekhnika", 163 s.

[45] Taraniuk, L.M. (2011) Motodolohiia reinzhynirynhu biznes-protsesiv promyslovykh pidpryiemstv. *Mekhanizm Rehuliuvannia Ekonomiky*, *1*, 111-119.

[46] Kryvoruchko, O.M., & Sukach, Yu.O. (2012). *Menedzhment biznes-protsesiv avtotransportnykh pidpryiemstv*. Kharkiv, Ukraina: Kharkivskyiy natsionalnyi avtomobilno-dorozhnii universytet, 244 s.

[47] Vynohradova, O.V. (2006). *Reinzhynirynh biznes-protsesiv torhivelnukh pidpryiemstv*. Donetsk, Ukraina: DonNUET, 183 s.

[48] Oleksandrova, O.M., & Khludina, O.I. (2018). Modeli realizatsii biznes-protsesiv v upravlinni okhoronoiu zdorovia. *Visnyk Natsionalnoho Universytetu "Lvivska Politekhnika"*, *895*, 77-85.

[49] Holovnina, M.M., & Korol, I.P. (2019). Modeliuvannia biznes-protsesiv malykh i serednikh pidpryiemstv. *Ekonomichnyi Analiz*, *29*(1), 136-144.

[50] Polinkevych, O.M. (2014). *Mekhanizmy adaptatsii biznes-protsesiv promyslovykh pidpryiemstv do novoi ekonomiky*. Lutsk, Ukraina: Lutskyi natsionalnyi tekhnichnyi universytet, 448 c.

[51] Bondarenko, V.I., Samusya, V.I., & Smolanov, S.N. (2005). Mobile lifting units for wrecking works in pit shafts. *Gornyi Zhurnal*, *5*, 99-100.

[52] Kovalevs'ka, I., Vivcharenko, V., & Snigur, V. (2013). Specifics of percarbonic rock mass displacement in longwalls end areas and extraction workings. *Annual Scientific-Technical Collection – Mining of Mineral Deposits 2013*, 29-34. https://doi.org/10.1201/b16354-6

[53] Pivnyak, G.G., Pilov, P.I., Bondarenko, V.I., Surgai, N.S., & Tulub, S.B. (2005). Development of coal industry: The part of the power strategy in the Ukraine. *Gornyi Zhurnal*, *5*, 14-17.

[54] Kovalevs'ka, I., Fomychov V., Illiashov, M., & Chervatuk, V. (2012). The formation of the finite-element model of the system "undermined massif-support of stope." *Geomechanical Processes During Underground Mining – Proceedings of the School of Underground Mining*, 83-90. https://doi.org/10.1201/b13157-14

Організація процесів комплексного видобування та переробки мінеральної сировини вугільних шахт у контексті концепції сталого розвитку

І. Салєєв

Мета. Метою дослідження є формування принципів та процедур побудови організаційної концепції комплексного видобування корисних копалин вугільних шахт на прикладі перспективної моделі переходу шахт ПрАТ "ДТЕК Павлоградвугілля" на багатопродуктове виробництво чистої питної води, утилізацію метану, вторинного вугілля породних відвалів та шламових резервуарів, низькопотенційної теплової енергії шахтних підземних вод і супутньої сировини з відходів опріснення.

Методика. Інструментальну основу дослідження складає методологія процесного підходу до організації діяльності багатопродуктового підприємства. Окрім того використовується комплексний підхід, який включає аналіз наявного досвіду та доступних комплексних технологій видобутку і переробки вугілля.

Результати. У роботі представлено результати дослідження передумов розробки інноваційних технологічних рішень, повязаних із комплексним використання мінеральної сировини, що утворюється в процесі видобутку та переробки вугілля. Визначено, що на сучасному етапі достатньо опрацьованими є технологічні, екологічні та економічні аспекти таких інновацій, натомість організаційні питання щодо забезпечення збалансованої взаємодії різнопродуктових виробничих блоків досліджені слабо. Обґрунтовано необхідність та визначено змістовність і послідовність дій щодо розробки організаційної концепції комплексного видобутку та переробки мінеральної сировини в умовах ПрАТ "ДТЕК Павлоградвугілля".

Наукова новизна. Сформовані в процесі дослідження принципи та процедури побудови організаційної концепції багатопродуктового підприємства надають подальшого розвитку методологічній базі пошуку й обґрунтування інноваційних рішень щодо комплексного видобування корисних копалин вугільних шахт; дають змогу оцінювати ефективність та ідентифікувати слабкі місця в поточних процесах видобутку й використання вугілля, теплової енергії, газу метану, підземних вод, хімічних речовин із сухого залишку продуктів опріснення і відходів вуглевидобутку, проводити аналіз та вносити зміни для поліпшення продуктивності і зниження витрат.

Практична значимість. Запропонований, на основі інструментів процесного підходу, комплекс організаційних рішень для забезпечення ефективної реалізації перспективної моделі виробництва з видобування та переробки мінеральних ресурсів вугільних шахт ПрАТ "ДТЕК Павлоградвугілля" надає можливість прогнозування результатів і розробки стратегій розвитку на основі різноманітних сценаріїв, аналізу взаємодії різноманітних чинників і їх впливу на результати функціонування виробничого комплексу та знизити ви-трати на експерименти й тестування різноманітних виробничих процесів.

Ключові слова: *сталий розвиток, організація виробництва, розробка родовищ, процесний підхід, організаційна концепція, ідентифікація робочих процесів*

Publisher's note

All claims expressed in this manuscript are solely those of the authors and do not necessarily represent those of their affiliated organizations, or those of the publisher, the editors and the reviewers.