



# Improving the Management of a Mining Enterprise a Condition for Increasing the Efficiency of Hard Coal Production

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## Abstract

The paper contains considerations regarding the possible impact of changing the approach to the management of mining enterprises on the improvement of their efficiency. The definitions of management, efficiency (along with its basic measures, such as productivity and profitability) and rationality of management were presented in the introduction. Next, the role of the three determinants of effective production in a mining enterprise were presented, including: reliable identification of resources, assessment of their necessity, rules for organizing ongoing works and implementation of production planning methods aimed at minimizing the costs of operations. The practical implementation of the defined determinants is presented on the example of four basic functions of process management, such as organizing, planning, leading and controlling. The special role of the process approach to cost management in the lifecycle of each longwall working while adopting a rational reduction of operating costs in mining enterprises is underlined.

Keywords: mining enterprise, process management, efficiency, productivity, costs

## Introduction

Mining in Poland is a special industry, because it largely determines the nature of energy, and even the entire Polish economy. Hard coal, together with lignite, are the basic energy raw materials that provide Poland with a very high degree (70–80%) of energy independence. With reference to hard coal, the following values can be quoted:

- in 2017 – for 170.1 TWh of total electricity produced, the volume of energy produced from hard coal amounted to 84.0 TWh, which constituted approximately 49.4% [<https://wysokienapiecie.pl>],
- in 2016 – for 416 900 TJ of total thermal energy produced, the volume of energy produced from hard coal amounted to 280 200 TJ, which was approximately 67.2% [Program, 2018].

Despite the fact that energy production is expected to increase in the future based on sources other than coal (renewable energy sources – RES, natural gas, nuclear energy), it will still remain the basic energy resource. Among factors contributing to that situation there is [Turek, 2014]:

- uncertainty about the stability of supplies and prices of alternative energy carriers, caused by frequent disturbances of the socio-political situation in countries that are their main producers (Middle East, Russia),
- high cost of energy obtained from renewable energy in comparison to coal, lack of stability in the supply of energy from RES in our conditions and the still unresolved problem of storage of surplus energy.

Industry specialists often emphasize the fact that there is no alternative for coal yet, and that Polish power industry will be forced to rely on it for many years.

It should also be emphasized that mining industry is still a significant employer. About 500,000 people in Poland financially support themselves working in this sector, including people employed in mines, as well as employees of mining-related enterprises and their families. In addition, the coal sector is a significant tax payer. The mining machinery and equipment segment is well-known abroad, and Polish producers have been widely recognized on global markets for many years.

The restructuring measures implemented since 2016 and the persistently high prices of hard coal on global markets have contributed to the fact that very good financial results were achieved in the industry in 2017. The result on net sales amounted to PLN 2999.6 million, the result on sales of coal was PLN 2718.6 million, and the accumulation per ton of coal sold amounted to PLN 41.00/Mg (in 2015 all these values were negative and amounted to: PLN –4460.9 million, PLN –2032.6 million, –28.34 PLN/Mg, respectively). In order for the industry to achieve equally favourable results in the future and be permanently profitable, it is necessary, among other things, to change the approach to mining enterprises (mines) management. This approach must take into account all aspects that a modern way of managing the organization should reflect [Bijańska, Wodarski 2017a].

Among many recommendations to contribute to the profitable functioning of individual mining enterprises and the entire industry, the most frequently repeated state-

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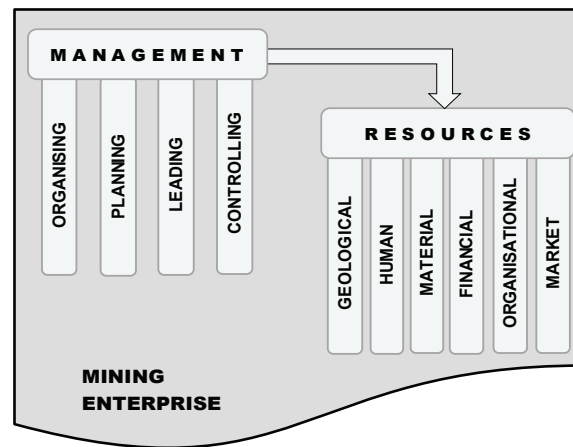


Fig. 1. Diagram of the management model of a mining enterprise [Source: own elaboration]  
Rys.1. Diagram modelu zarządzania przedsiębiorstwem wydobywczym

ment is: reduce costs to improve operational efficiency. It is certainly right, but is it enough? Is there also a need to change the philosophy and approach to management of mining enterprises and mines within them, especially in the aspect of designing action strategies, operational plans and cost management? The considerations contained in this paper are an attempt to answer such a question.

### Management and efficiency concepts

There are many definitions of the term ‘management’, formulated most often by a large group of scientists dealing with management issues. Depending on the area of research that has been carried out, all definitions accentuate different aspects. However, certainly all of them are derived from the most general formulation, which management defines as art or practical rational application of specific means to achieve the set goals using available resources.

According to the definition prepared by the American scholar, Ricky W. Griffin, management is a set of actions, the so-called management functions aimed at the resources of the organization (human, financial, factual, informative), used with the intention of achieving specific organization goals, carried out on the basis of specific methods and ways aimed at their implementation [Griffin, 1998]. These functions cover the whole area of the organization’s activity, they are interconnected and interrelated. In the scientific literature on management there are various functions that make up the management process. Most often, however, they include the four functions provided by Griffin:

- organizing,
- planning,
- leading,
- controlling.

Functions are implemented in a specific company in the right way and directed to all resources at its disposal. They should serve to achieve the assumed, hierarchical goals. They are interrelated and always interdependent

– incorrect approach to only one of them will cause the enterprise (or, more broadly, the organization) to be improperly managed.

The idea of the general, broad definition of management presented above with regard to the mining company and all the resources it most often has, is illustrated in the diagram in Figure 1.

It should be clearly emphasized that in the case of a mining enterprise, it is always a very important condition of its operation that the highest level of safety of conducting works in un-derground excavations is ensured.

The ‘Management Encyclopaedia’ defines effectiveness as ‘the result of actions taken, de-scribed by the relation of the results obtained to the expenditures incurred’. Efficiency is also a ‘measure of effectiveness and performance, understood as a measure of the extent to which the set goals are achieved’ [<https://mfiles.pl/pl>].

The very concept of operational efficiency is a universal category, not always defined precisely and unambiguously. It can be considered according to different reference points depending on the needs and specificity of the organization. Currently, it is assumed that the measurement of effectiveness of operations should be conducted using both financial and non-financial indicators – both quantitative and qualitative. However, it would be problematic to adopt a uni-form methodology for measuring the effectiveness of an activity – each organization, depending on the purpose and scope of its operation, should form individual criteria for measuring effectiveness, appropriately select the metrics and tools with which this measurement will be carried out [Rydzewska-Włodarczyk, Sobieraj, 2015].

The performance is assessed by means of indicators (relative values), defining the relation of costs and revenues, it is the relation of the results to the incurred expenditures in the form of a numerical result, which shows what the result is generated by the incurred expenditures. The obtained result is an effectiveness index, also called

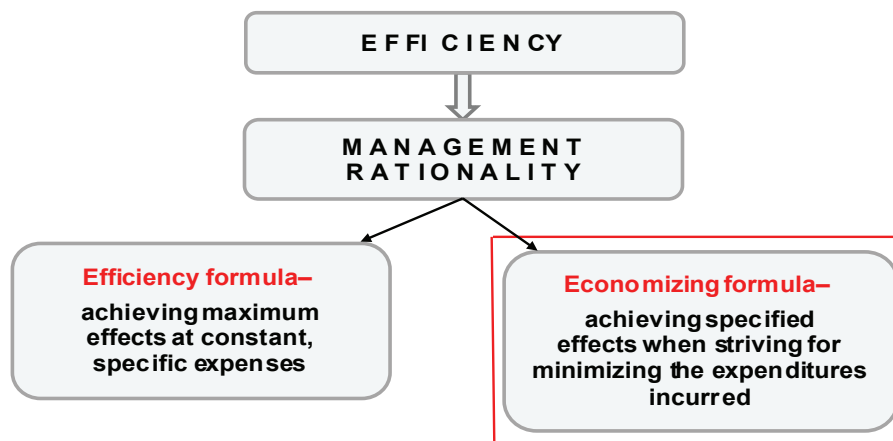


Fig. 2. Formulas for determining the rationality of management [Source: Dubiński et al., 2017]  
Rys. 2. Formuły do określenia racjonalności zarządzania

an efficiency indicator. The two key indicators are productivity and profitability.

Productivity, as one of the measures of operational efficiency, is a commonly used term that can be expressed by various indicators. Most often it is the ratio of the amount of product manufactured / sold or the value of the product sold in a given period to the amount of used or consumed input resources of the production system – material:

- material – e.g. the quantity and / or value of materials used, energy consumed, fixed assets,
- financial – e.g. value of fixed or working capital engaged in production,

and intangible (human) – e.g. number of employees, working time (number of days / hours worked), labour costs. The indicators defined in this way define the so-called partial productivity – materials, energy, fixed assets, capital, labour. In general [Durlik, 1993]:

$$\text{Productivity "P"} = \frac{\text{Effects "E"}}{\text{Expenditures "N"}} \quad (1)$$

Profitability, referring to financial quantities, defines the difference between the obtained effects and incurred expenditures:

$$\text{Profitability "R"} = \text{Effects "E"} - \text{Expenditures "N"} \quad (2)$$

The notion of efficiency is also closely related to the concept of management rationality. The theory of rationality of management defines the effectiveness of the functioning of the enterprise by comparing effects and expenditures, and thus as a result of the business activity of the enterprise. Rationality of management includes two formulas – efficiency and economizing (Figure 2) in its theory. The efficiency formula assumes achieving the maximum effects at constant fixed expenditures. The economizing formula anticipates achieving certain effects while striving to minimize the costs incurred.

The product (the performance) of mining enterprise is commercial coal. Its quantity (production) can be increased, but in the absence of sales opportunities, increasing the volume of commercial coal production can have disastrous financial consequences. In order to increase efficiency, it is necessary to take advantage of the latter option – lowering the expenditures incurred. That is, using the methods of operational management, find the right way to use re-sources at hand, enabling the achievement of the assumed profit level [Dubiński et al., 2017; Wodarski et al., 2017].

#### Determinants of mining production efficiency

The three basic requirements, decisively affecting efficient production in a mining enterprise, are:

- to identify all resources available and to determine the size necessary to conduct business on this basis,
- on the basis of owned resources – proper organization of works and planning of the production volume,
- implementation of production planning and implementation methods aimed at minimizing the costs of operations.

If the production activity of a mining company (mine) is to be carried out effectively, the first step in this direction should be to create a certain kind of a detailed ‘necessary data base’ characterizing resources (geological, human, material, financial, market), organizational and spatial structure of functioning and current way of doing business [Bijańska, Wodarski 2017b]. This issue is extremely important in two aspects.

The first one concerns geological resources – consideration of their size must be made only in conjunction with market conditions. In addition to ‘standard’ information on the deposit, such as the size of resources in particular recognition categories, parameters and conditions

for depositing seams, occurring natural hazards and their scale, it must also contain as detailed information as possible about coal types and their quality parameters (calorific value, sulphur, ash and moisture content) in particular seams or seam parameters. This information, correlated with data on market conditions regarding the scale of demand and commercial coal sales opportunities with specified assortments and quality parameters, should constitute the main basis for planning and making decisions on the operation of a given seam or its part, and the size of the future extraction. It is assumed that only those deposits can be effectively exploited whose coal will find the buyer and in such quantities that it can be sold in its entirety. Coal extracted even at a relatively low cost, which cannot later find a buyer, will not bring any economic benefits.

The second aspect concerns all other resources considered in technical terms. It is determined whether the enterprise (mine) has the appropriate spatial structure and technical equipment (machines and devices, facilities, networks, installations) and the right number of employees with specific professional qualifications to have a technical possibility to fulfil the required scope of operation, carried out under safe conditions.

The size of all resources at the company's disposal is then the basis for determining the manner of organizing the opening-up and preparatory works, and then the mining works. Considering the fact that each component of resources implies the necessity of incurring costs related to its maintenance, a detailed analysis of the suitability of their further maintenance should be made. For example:

- in the spatial structure, only the number of workings providing access from the surface (shafts, pitches), levels, capital and department headings should be preserved, which will be necessary for safe mining operations in terms of planned exploitation,
- as far as technical equipment is concerned, one should strive for a condition in which only such machines, devices, facilities, networks and installations useful in the production process will be maintained, whose technical condition will allow for practically failure-free operation,
- in the organization of work of each mine belonging to a mining enterprise and its branches, all changes that can be made to increase the effective working time must be considered,
- with regard to the scope of planned works and the establishment of appropriate technical equipment, the size of the necessary employment should be specified, including the required professional qualifications, while analysing the possibility of using employees of external companies.

Any unnecessary resource components should be liquidated. If the goal of the pursuits is to achieve the pos-

sibility of effective functioning, then the commonly approach, according to which only those components that are inextricably redundant are reduced, leaving many that 'may someday come in handy', must be changed. This is due to the fact that something 'left just in case' involves certain, often significant, costs – repairs, inspections, power, depreciation, taxes, employing more employees – increasing the expenditure necessary to incur.

The result of such analyses may also be the need to supplement the existing resources, for example by:

- driving of the main excavations,
- obtaining modern machines and devices of a certain type,
- supplementing the employment status of employees with specific occupational qualifications (by increasing the number of employed personnel or external companies).

The third, absolutely necessary requirement to be met are activities aimed at minimizing the incurred costs. They should be preceded by an accurate identification of the sources and size of costs, with the specification of the division into fixed and variable costs [Michalak, 2016]. The cost planning itself takes place on the basis of technical and economic plans (PT-E), using different forms, the essence of which is to capture and present costs in a generic manner. Cost budgeting is based on ex post cost analysis. Therefore, the starting point for monthly cost planning is the annual PT-E, often in the financial scope developed on the basis of the results of historical analyses, sometimes to a small extent corrected by current production assumptions or discretionary indicators. Also, the so-called keys are not used, enabling planning and settlement of indirect costs of underground and surface accompanying processes. The calculated unit cost of production thus obtained is a simple quotient of total costs and extraction volumes, and apart from comparative values, there is no significant value for management processes in a mining company or in a mine. Due to the project-type of mining production, a cost accounting system should be used to enable the assessment of the profitability of production and individual projects in an ex ante approach [Jonek-Kowalska (red.), 2013].

It follows that in order to be able to determine the costs of planned projects, existing solutions regarding the identification of sources and costs should be supplemented with the planning function taken on a 'zero cost' basis. This will be the starting point for making decisions about the legitimacy of exploiting specific deposits, seams or their parts, and controlling costs in a process approach. It is possible to obtain it in the developed concept of cost accounting in terms of process [Prusek et al., 2017].

**The role of management functions in the increase of coal production efficiency**

Organization (enterprise) management can be implemented in various ways. The most frequently defined approaches to the management method are: general, management by objectives (functional) and process. The process approach to management will be the subject of further deliberations.

In the process management of a mining enterprise, it is perceived not by the prism of the organizational scheme and the cells included in it, but by the goals that are realized in it. Generally speaking, the process approach is to identify all processes carried out in the enterprise, to define mutual relationships between them and to manage them. In a mining enterprise, a process can be understood as a cycle of operations that process specific input resources into products intended for recipients and that contain added value. The operational process should, among others (Glis-zczyński, 2013):

- be a chain of activities that convert measurable input resources into measurable output products,
- have a measurable goal,
- be reproducible and thus possible to be formally described.

Process management means not only planning processes, but also their continuous monitoring and improvement by introducing corrections when the results are different than expected. The assumptions of the new concept of cost management in terms of the process will be presented on the basis of management functions: organization, planning, leading and controlling.

### **Organising**

In order to properly plan the amount of extraction and determine its costs, it is necessary to identify the resources in advance as described in the previous paragraph. All resources should be identified and the legitimacy of maintaining them should be identified or the scope of the need to supplement them in terms of the planned operation should be identified together with the assessment of the impact of these operations on the amount of costs incurred [Turek, Michalak, 2012].

The final result of resources identification and analysis of their status should be an unambiguous determination of whether the enterprise (mine) is organized in such a way that with a certain level of employment (own employees and external companies), spatial structure (arrangement of vertical and horizontal excavations), organizational system and possessed property (or necessary to be purchased), is able to carry out effective production activities, without incurring unreasonable costs, e.g. due to excessive employment or possession (maintenance) of unnecessary property assets [Jonek-Kowalska, 2017].

Gathering accurate information about the resources that the company has or can have at its disposal is funda-

mental to the correct implementation of another management function, which is planning.

### **Planning**

In order to obtain the possibility of proper management of the company, its activity must be well planned – the program and order of tasks, works and activities to be implemented must be defined. It can be done well only if a detailed understanding of the conduct of operation constituting the course of particular processes in the operational aspect – current production and strategic – investment, or future-oriented, is made.

In the process approach to the issue of management, it is necessary to develop a ‘map’ of – the basic, auxiliary and accompanying processes – together with the accurate recognition of their structure and elements. Based on the knowledge of the so-called principles of ‘mining art’ and ‘necessary data base’ created for specific mines, each of them, in particular the basic and auxiliary processes, should have specific conditions, in which they will be implemented, the number of necessary operations and component operations, the order of their occurrence. It is only on the basis of such information that it is possible to properly plan their duration, as well as the number of employees needed and material equipment, i.e. two volumes that have a decisive impact on the performance indicators and costs of coal production [Jonek-Kowalska I., Turek M., 2016]. For this reason, they should be determined with particular care. As already indicated, the extraction volumes planned on this basis should take into account the product sales opportunities – hard coal.

The planned duration, number of employees needed and material equipment of each longwall working allows for precise recognition of direct costs throughout the entire life cycle. These costs will include labour, material and energy costs, depreciation of fixed assets, repairs, leases and rentals, directly related to each excavation in all phases of its existence. Then, using the so-called the settlement key, it is necessary to specify the indirect costs, also referring directly to the specific excavation. Knowing both types of costs, it is possible to determine the unit cost of extracting coal from this excavation before the launch of any operations [Turek, 2013].

In order to facilitate the preparation of such cost calculations, special formulas of so-called spreadsheets were created for each phase of the existence of the longwall working. All information regarding works related to drilling and reinforcement of excavations, operation and decommissioning are entered to them. After the target IT connection with the valuation of direct costs included in the operating financial and cost systems, it will be possible to quickly obtain the necessary information on the costs of the planned works.

The process approach to cost management also forms the basis for assessing the effectiveness of both individual

intentions and the entire mining plant. It is also undoubtedly useful, e.g. to determine the size [Prusek et al., 2014]:

- costs incurred for maintaining the existing mine infrastructure (depreciation, maintenance and operating costs),
- costs of materials, energy and renovations incurred in connection with the production – which is important in determining the amount of expenditure necessary to pay for the assessment of the economic viability of ‘creating’ a new selection product,
- costs of external companies’ services – which is important in determining the amount of outlays related to the employment of own or external employees.

It should also be added that in planning issues it is also important to, in addition to planning the current operating activity, take into account the needs related to investment activities, both in terms of replacement, regarding the purchase of machinery and equipment necessary for current production and future-oriented, related to the company’s plans for the next years [Bąk, 2008, Sierpińska-Sawicz, Bąk 2016, Bijańska, Wodarski, 2014, Matyjaszek et al., 2018].

### **Leading**

Traditional cost accounting currently used in mining enterprises does not allow for the implementation of a motivational management function [Bąk, Michalak 2018]. The remuneration system is not related to the effects of work, because there is no original reference point in the form of the planned extraction costs from specific workings.

In developed cost planning sheets, for individual works, e.g. drilling a roadway, reinforcement or liquidation of a mining excavation (most often a longwall), operating a seam, there are such items as:

- their implementation period, determined i.a. on the basis of technological time of work,
- the number of employees at individual shifts,
- the amount of different materials necessary for their implementation.

On their basis, in some cases it is easy to determine different ranges and effects of the works being performed, such as the volume of the daily production, and the daily advance of the driven working. Then, based on the data contained in the sheets, it is possible to develop motivational pay or bonus systems, based on the effects of work, related to e.g.:

- effective time of operation of technological lines or machines are a part of them,
- determining the number of employee brigades performing individual work, taking into account the safety of conducting works in terms of meeting the requirements of applicable regulations,
- rational and consistent with the planned size con-

sumption of necessary materials, in connection with technological and geological-mining conditions in which they are implemented [Jonek-Kowalska I., 2014].

The use of cost planning sheets and related IT tools allows for easy preparation of calculations regarding various variants of solutions in terms of size, periods and workload assignment as well as for subsequent control of the obtained results of the variant adopted for implementation.

### **Controlling**

Another issue regarding the identification of process sources to improve production efficiency is the ability to check the effectiveness of its operation on an ongoing basis and, if necessary, introduce the necessary organizational improvements. A significant support in this respect may be the use of developed calculation sheets. Due to the fact that they contain data entered separately for individual coal production processes and their phases in relation to a specific excavations, using IT tools it is easy to see where the discrepancies between assumptions and results occur. The analysis of the assumptions and sizes of particular parameters adopted at the planning stage and the possible easy conversion of results obtained in other variants of the adopted assumptions will enable:

- quick correction – if not correctly determined or
- enforcement of the correct implementation of the adopted assumptions – if it is found that they have been correctly determined.

### **Summary**

The considerations regarding the impact of the new approach to management of a mining enterprise on the improvement of coal production efficiency clearly show that in pursuit of this objective, the priority must be the emphasis on rational reduction of costs. Reducing costs, or the outlays incurred, determines the increase in efficiency.

Rational reduction means that it should not be based on the fact that ‘when we do not do something, we will not incur costs’. The new approach, which is undoubtedly process-based cost management, allows an approach to lowering costs by ‘not doing something because it is not profitable’. And most importantly – obtaining such knowledge is possible before the commencement of works and incurring related expenses. Acting sufficiently in advance, it is possible to assess the economic viability of the assumed technical undertakings related to the start-up of a mining excavation. The use of so-called calculation sheets and appropriate IT tools makes it possible to evaluate the effectiveness of various implementation options easily.

It should be emphasized that the implementation of the proposed process cost management system may in the future significantly contribute to improving the efficiency of mining enterprises.

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#### *Poprawa zarządzania przedsiębiorstwem wydobywczym warunkiem podniesienia efektywności produkcji węgla kamiennego*

*Artykuł zawiera rozważania dotyczące możliwego wpływu zmiany podejścia do zarządzania przedsiębiorstwami górnictwem na poprawę ich efektywności. Na wstępie przedstawiono definicje zarządzania, efektywności (wraz z podstawowymi miernikami, takimi jak wydajność i rentowność) oraz racjonalność zarządzania. Następnie przedstawiono rolę trzech czynników determinujących efektywną produkcję w przedsiębiorstwie wydobywczym, w tym: rzetelną identyfikację zasobów, ocenę ich konieczności, zasady organizacji prowadzonych prac oraz wdrożenie metod planowania produkcji mających na celu minimalizację kosztów operacyjnych. Praktyczna implementacja zdefiniowanych determinant została przedstawiona na przykładzie czterech podstawowych funkcji zarządzania procesami, takich jak organizowanie, planowanie, prowadzenie i kontrolowanie. Podkreślono szczególną rolę podejścia procesowego do zarządzania kosztami w cyklu życia każdej ściany, przy jednoczesnym przyjęciu racjonalnej redukcji kosztów operacyjnych w przedsiębiorstwach wydobywczym.*

*Słowa kluczowe: przedsiębiorstwo górnicze, zarządzanie procesami, wydajność, wydajność, koszty*