

# INTRODUCTION TO A METHODOLOGY OF COST MANAGEMENT IN A COLLIERY FROM A PERSPECTIVE OF LONGWALL LIFE CYCLE

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## Abstract

The main objective of the article is to present the basic assumptions of the methodology of cost management adjusted to the specificity of underground mining production. In order to achieve the stated objective, the article begins with the characteristics of mining production conducted by a longwall system. Next, there is cost analysis and assessment of the longwall life cycle with the inclusion of the launch, exploitation, and liquidation phases. The phases creating the cycle indicate the course of the basic production process of hard coal. On the basis of the conclusions drawn from the research conducted and the diagnosis of the cost management condition in Polish mining enterprises, the basic requirements are there to formulate the cost management for an underground hard coal mining plant (colliery). These became the grounds for elaborating the basic assumptions of methodology of cost management in the context of longwall life cycle. The present cost accounts were an inspiration for examining the methodology; notably the most useful accounts for hard coal mining are: the cost account in the longwall life cycle, an activity-based cost account, a target-cost account, and a continuous-improvement cost account. It is assumed that particularization and development of the presented assumptions will determine:

- ✓ total and unit costs of particular longwalls' functioning,
- ✓ costs for longer perspectives than in a balance sheet year, in a depiction of particular longwalls as well as the whole colliery,
- ✓ total and unit costs in a process depiction,
- ✓ the excavation effectiveness from particular longwalls, and
- ✓ the effectiveness of particular processes that are a part of mining production.

Currently, the methodology is being tested and developed in the largest Polish mining enterprise, which consists of 15 collieries.

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**Keywords:** Costs in hard coal mining, cost account, longwall life cycle

## Introduction

Hard coal mining is an industry with specific cost conditions. Some of them result from objective production conditions, and others, related to the Polish mining enterprises, are connected with social and political conditions. The production cost determinants are related to the dependence of mining conditions on factors of a natural character which are not influenced by the collieries and are not controlled by them. These are mostly mining-geological conditions such as the depth of layers and thickness and inclination of deposits, as well as natural hazards, mostly including gas, ash, tremor, and water threats and many others of lower significance. An unfavorable impact of the aforementioned factors increases the excavation costs of hard coal. The cause increase is a result of bearing higher costs for preventative measures, for mining damage prevention, and also for mining process slowdown due to more difficult work conditions and increased hazards for mining teams.

The basic mining production circumstances above, which are a part of resource excavation in a longwall, are not of a standard, repetitive character. Consequently, an individualized approach is required, both towards the cost account and towards the effectiveness of the assessment of production. Therefore, in this article there is a cost analysis and assessment conducted in the longwall life cycle on the basis of a chosen colliery, which serves as a starting point for formulating recommendations concerning cost planning and the effectiveness of the assessment of production in the longwall life cycle.

In order to achieve the stated goals, in the first part of this article, the characteristics of the longwall life cycle are presented. Next, the cost accounts used in Polish mining enterprises with needs resulting from the specificity of the basic processes of mining production are confronted. Based on the results of such a confrontation—in the form of an assessment of theoretical cost accounts—the basic assumptions concerning the methodology of cost management in a colliery are elaborated upon. In the conclusion, recommendations that will enable the improvement of the current accounting-IT solutions in compliance with the requirements of management accounting will be offered.

The considerations conducted in the article are a response not only to the current needs of the Polish mining industry, but also to the lack of theoretical solutions concerning cost management adjusted to mining production, mostly including underground mining. The literature available on this topic and foreign enterprises' practices both suggest typical methods for investment projects assessment such as *Net Present Value* or *Internal Rate of Return* (Rubio, 1992; Dehghani, Ataee-pour, 2012; Kustra, 2012) for cost planning and a production profitability assessment in the newly

launched longwalls. However, these solutions only support the decision-making process in regards to a longwall launch; they do not create grounds for full cost management involving: cost planning, calculation, and control, as well as the motivation based on the results of cost control. In connection with the above, a process approach is very often suggested to be introduced in the hard coal mining industry (Suppen et al., 2006), that is activity-based cost management (Zhang and Liu, 2008; Qian and Miao, 2008; Zheng, 2008; Ai-bin et al. 2009), specifically.

### **Characteristics of mining production**

Hard coal may be extracted by a surface or underground mining method, depending on the depth of deposits. The first method is used when deposits are located no deeper than 300 meters underground. The second method is used to extract coal from deposits located much deeper, even at the depth of 1000 meters.

In the surface-methods approach (commonly referred to open-cast mining) the upper layers of soil and rocks are destroyed using explosive materials and then removed with the help of excavators and trucks. When the coal deposit is revealed, it is drilled, crushed and extracted. Next, the extracted resource is loaded on big trucks or conveyor belts and transported to coal processing plants, to a storehouse, or to the final recipient. An advantage of the surface method is its low cost of excavation and possibility to extract a greater part of the deposit. However, its biggest drawback is the considerable scale of natural environment degradation.

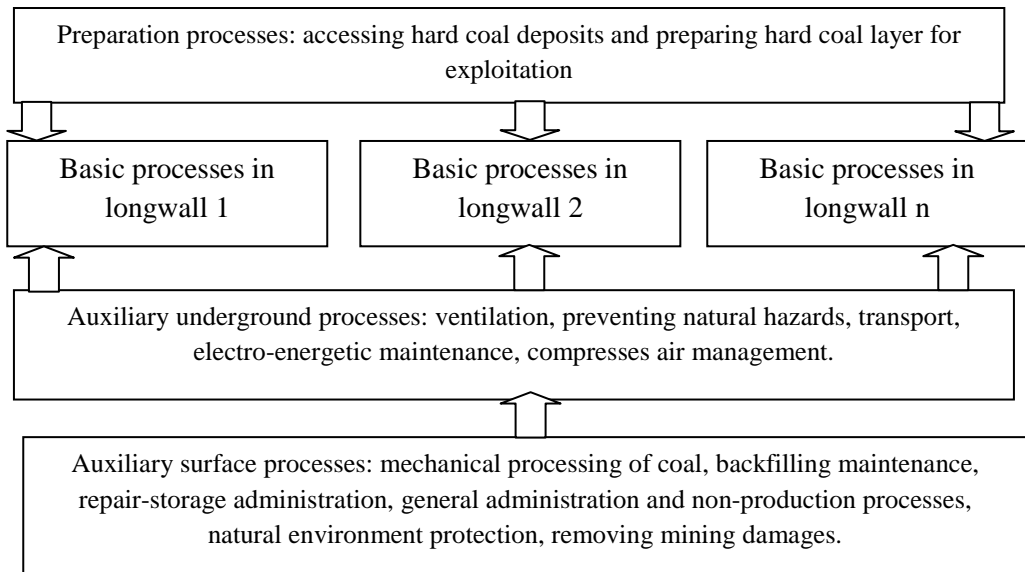
The underground method consists of drilling the accessing, developing, and excavating longwalls under the earth's surface. At that time coal may be extracted by room and pillar or a longwall system. With room and pillar excavation the deposits are exploited by drilling a chain of rooms in the coal layer which are secured by coal pillars for the purpose of ceiling support. The pillars may even consist of up to 40% of the coal in the deposit. In the further stages this part of coal may also be extracted.

The longwall technique excavation is a full coal extraction from a layer's segment, called a longwall face, using mechanized coal-cutting machines. During coal excavation the ceiling is temporarily supported by hydraulic linings. After coal extraction from the deposit, there is very often a controlled collapse conducted. The basic advantage of the underground method is the ability to conduct excavation from deposits located very deep and in urbanized areas. The disadvantage, on the other hand, is the high costs of such resource mining.

The open-cast method is used in the U.S. and Canada. In Europe, Asia, and Africa an underground method is predominately used. In Poland hard coal is extracted using the underground method and the longwall

system; therefore in the final sections of this article, the considerations related to cost management only refer to this method and this system.

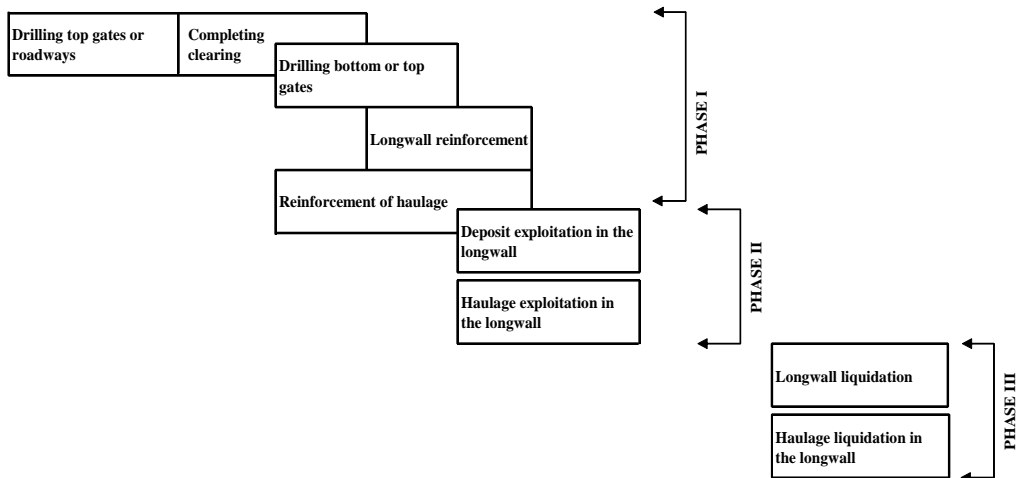
In the course of mining production, conducted by the underground method in a longwall system, there are four basic distinguished groups of production processes. These are preparation processes (Turek, 2010d), which allow the conduction of excavation, basic processes, which occur in a cyclic way in the launched longwalls, and auxiliary processes, which take place underground and on the surface. A detailed depiction of the processes is presented in figure 1.



**Fig. 1.** Division of processes in the underground mining production  
**Source:** own worka

According to figure 1, the core of mining production consists of the basic processes taking place in the particular longwalls. Launching new longwalls provides the continuity of hard coal excavation. The auxiliary underground processes enable the current maintenance of the longwalls and provide proper work conditions for mining teams. The auxiliary processes on the surface are mostly connected with the mechanical processing of the resources mined, their storage, and the administration of the mining enterprise.

The longwall life cycle consists of the three phases: launch (I), exploitation (II), and liquidation (III). The stages are the parts of the aforementioned phases and are presented in figure 2.



**Fig. 2.** Phases of longwall lifecycle

**Source:** Jonek-Kowalska, I. Ocena możliwości poprawy efektywności wydobywania węgla kamiennego, [in:] Turek M. ed. Analiza i kosztów w górnictwie węgla kamiennego w Polsce w aspekcie poprawy efektywności wydobywania. Warszawa: Difin, 2012, p. 171.

The process of a longwall launch starts with drilling, which consists of completion, modernization, or reconstruction of development longwalls leading to a proper longwall where excavation is going to take place. The development longwalls may be drilled in the accessed layers (basic drifts, technological drifts, and in the case of inclined layers, inclined drifts), in the exploitation areas (field pits) or in the wall areas (wall pits or wall clearing). Drilling is indicated by operations repeated in a cyclic way which include: dredging minerals (Turek, 2009), output loading and supply, casing construction and longwall face airing, control of longwall direction and inclination, reconstruction (extension) of transporting appliances, transport of materials and tools, and controlling and preventing danger stemming from natural hazards.

In the frames of drilling, the longwalls constructed are equipped with machines, appliances, and technical measures necessary for their functioning. Beside the drilling itself, in the preparation processes there is also maintaining the development pits and getting them ready for excavation and in a proper state determined by the law of work safety and hygiene, which mostly involves the reinforcement, reconstruction, and modernization of the development longwalls.

The second part of preparation process is reinforcement, consisting of casing the machines and appliances in the prepared wall clearing which create a mechanized complex. A typical mechanized wall complex includes: sets of powered supports of appropriate support capacity, winning machine (depending on the layer's thickness, a longwall coal-cutting machine or coal

planer), face and collecting comb conveyor, and drift sections of powered supports.

After finishing the preparation work, the second phase of longwall existence begins: exploitation (Turek, 2010b). This consists of dredging the coal minerals and an output transport. As the longwall face moves forward, in this phase, machines, appliances, and technical measures also have to be moved in order to conduct further excavation (Turek, 2010c). In the course of exploitation there are also conservation and overhaul work conducted as well as assembling and reinforcement work aimed at maintaining a continuous excavation and providing safety for the excavation.

The last stage of the longwall life cycle is its liquidation, consisting of disassembling machines and appliances, as well as finishing exploitation and diking the wall clearing (Turek, 2010a). In the final section of this article there is cost assessment and analysis made regarding the particular phases of a longwall life cycle. The aforementioned phases of longwall existence indicate the course of the basic extraction process conducted by the underground method and the longwall system. The process is accompanied by a range of underground auxiliary processes and those conducted on the surface. In the final section of this article, due to the large scope of the topic described, there are only a cost analysis and assessment presented that accompany the particular phases of longwall existence, treating the costs accompanying the auxiliary processes as the costs that require a separate analysis and assessment. However, there is an assumption made about their assignment to the particular longwalls, partly connected with the functioning of a particular longwall and partly connected with the activity of the whole colliery, calculated with the use of properly selected allocation keys.

### **Exposition of costs in the longwall life cycle**

Cost assessment and analysis in the longwall life cycle was conducted on the basis of data from the examined colliery in the largest Polish mining enterprise. In table 1 the value of costs are presented, borne in the subsequent phases and stages. The explanation for the particular cost positions is included at the end of the article in the form of a cost terms glossary.

**Table 1** The value of costs in the examined longwall life cycle [in USD]

Phase/stage	Cost type							Total
	salaries	materials	energy	machines leasing	overhaul	amortization	other	
<b>Launch, including:</b>	3 947 660	4 687 875	168 834	161 603	1 224 362	327 124	167 970	10 685 428
Drilling roadway a	566 941	727 264	35 492	42 873	29 601	7 971	7 186	1 417 329

Drilling roadway b	666 772	876 967	40 644	61 383	63 852	31 998	8 298	1 749 913
Clearing	592 192	201 126	32 126	52 970	63 236	0	1 602	943 251
<b>Exploitation</b>	10 208 171	3 685 509	796 072	1 042 045	1 562 813	796 499	239 829	18 330 938
<b>Liquidation</b>	1 159 770	488 243	105 300	61 399	122 952	648 327	26 883	2 612 875
<b>Total (launch+ exploitation +liquidation)</b>	<b>15 315 601</b>	<b>8 861 628</b>	<b>1 070 206</b>	<b>1 265 048</b>	<b>2 910 127</b>	<b>1 771 950</b>	<b>434 682</b>	<b>31 629 241</b>

Source: own work based on data from the examined colliery

According to the data included in table 1 and presented in chart 1, the most costly phase of the longwall life cycle is exploitation. This is mostly a result of being the longest period of this phase and of the considerable engagement of human resources in its course. The phase of launching is also cost consuming; it usually lasts shorter than exploitation but requires high material outlays. The least costly is the liquidation phase which consumes about 8% of the total costs of longwall existence. Such cost structure is typical for most longwalls in collieries. An exception may be the longwalls that are launched in frames of the new deposits and require widely conducted preparation works. At that time the share of the first phase in the total costs may be dominant.

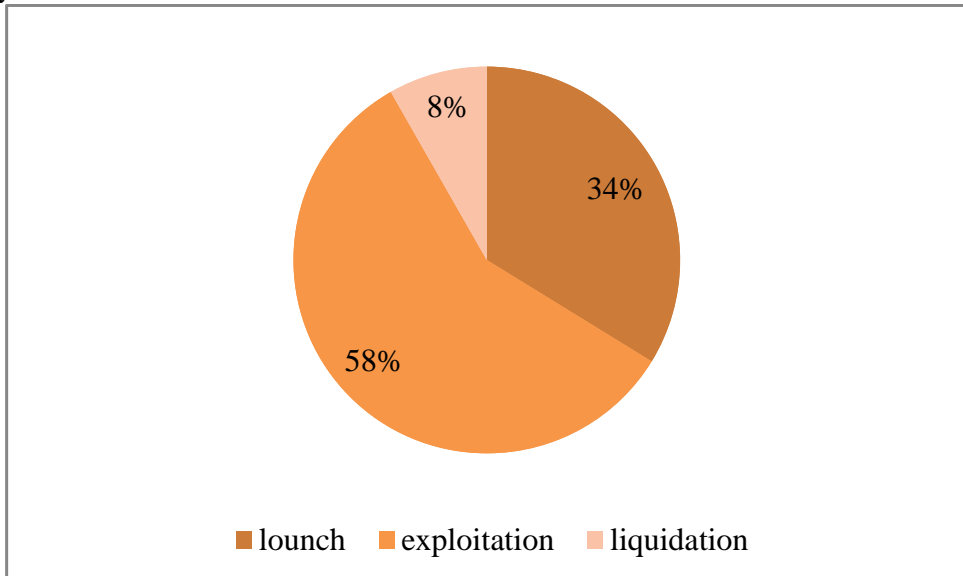
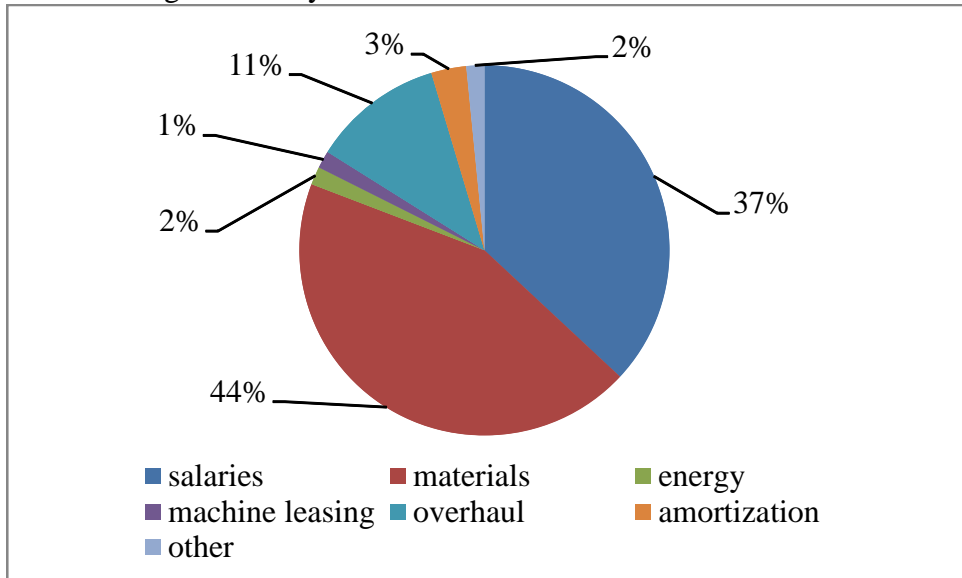


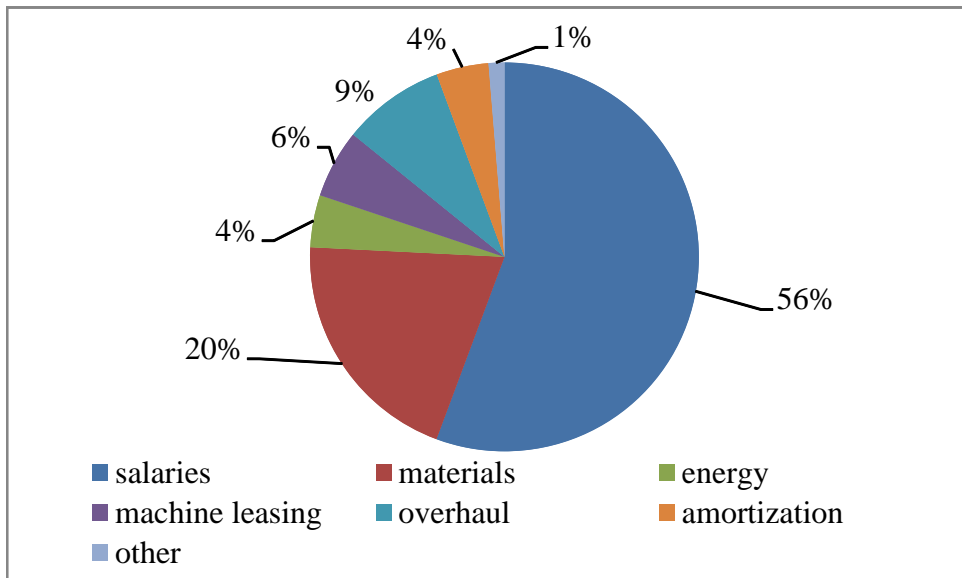
Chart 1. Cost structure in particular phases of the longwall life cycle

Source: own work based on data from the examined colliery

A typical cost hierarchy is the only common cost feature of longwalls in collieries. Each longwall and each life cycle phase is specific for a different period of existence and different mining conditions, and for what follows it, a different level and share of generic costs in its course. In charts 2-4 there is a generic cost structure presented in the particular phases of the examined longwall life cycle.

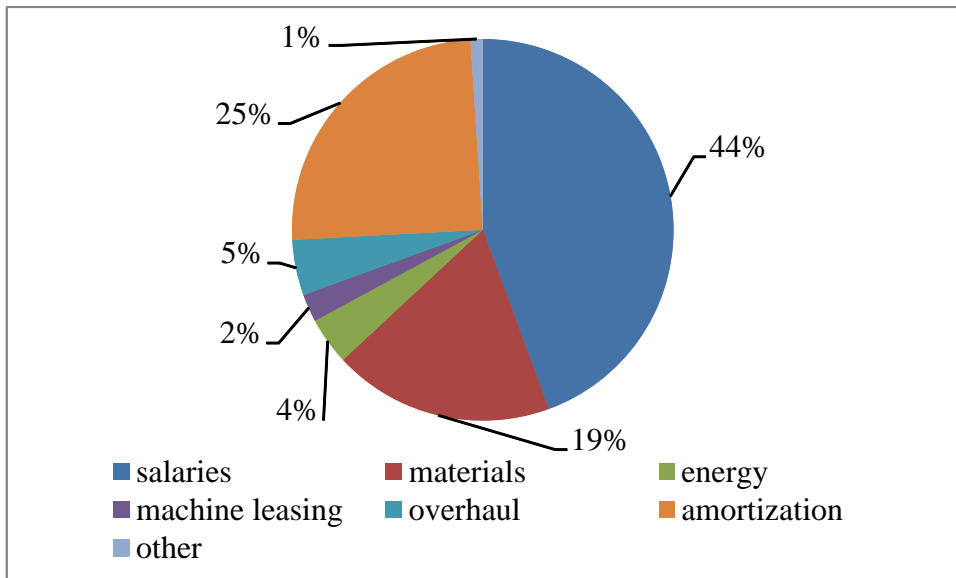


**Chart 2.** Generic cost structure in the launch phase  
**Source:** own work based on data from the examined colliery



**Chart 3.** Generic cost structure in the exploitation phase  
**Source:** own work based on data from the examined colliery





**Chart 4.** Generic cost structure in the liquidation phase  
**Source:** own work based on data from the examined colliery

In the launch phase, the highest share in costs is for the materials used in the course of preparation and reinforcement work, as well as for salaries with surcharges for employees working in the realization of the work. A considerable share in the structure also comes from the costs for overhauls due to a significant engagement of fixed assets. In turn, in the exploitation phase, the costs for salaries dominate, which constitutes over half of the total costs. It is also a phase characterized by a significant cost share of materials usage. In the liquidation phase the highest share in costs is for salaries with surcharges as well as for amortization and materials.

On the basis of the example above and research conducted earlier (Turek and Jonek-Kowalska, 2012) on costs in longwalls and on characteristics of the basic production processes in underground collieries, the following conclusions can be made:

- each longwall is specific for different mining-geological conditions and the intensity of natural hazards,
- each longwall has its own, unique cost characteristics,
- costs in a generic configuration are divided in a different way in each phase of the longwall life cycle, although there may be a general regularity observed concerning a domination of some cost groups (e.g. salaries in the exploitation phase), and
- particular months of longwall life cycle are burdened unequally with generic costs, generated in the particular phases of the longwall life cycle.

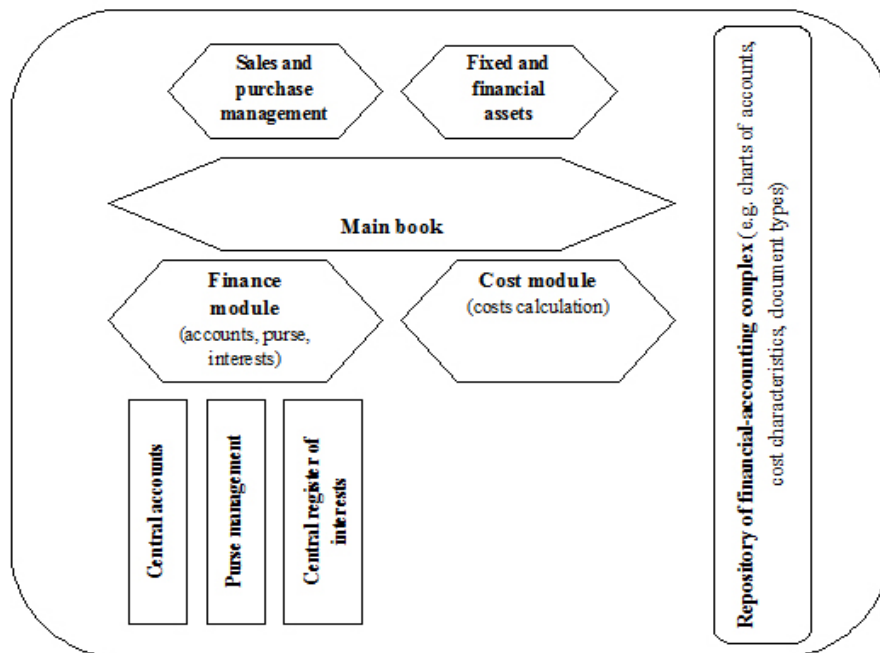
## **Current application of cost accounting existing in the hard coal mining in Poland**

According to the conclusions stated in the previous point, the basic processes of hard coal production are of a unique project character where the main phases in a project approach can be distinguished. In this case, it is necessary to use the individualized techniques of cost planning in cost management and a profitability account. However, these days in the three largest mining enterprises in Poland, cost planning is conducted on the basis of technical-economic plans made by the top management level and in separate collieries using a generic approach (Sobańska, 2006) in the form of continuous budgeting where costs are updated on the grounds of general-economic ratios and consideration by managers supported by mining experience (Jonek-Kowalska and Turek, 2012).

The costs accounts used for this purpose, as well as the comprehensive and extensive analyses and reports made on their basis, are only useful for financial accounting and reporting. These are mostly systematic cost accounts (Kobiela-Pionnier, 2010) which include, among others, a generic cost account (Nowak et al., 2004) in a very centralized approach, on the level of colliery and enterprise. As a result, there may be an answer to the question of whether the colliery is non-profitable but the reasons for non-profitability cannot be determined as they are localized in the basic and/or auxiliary production processes.

Such an approach makes it impossible to make rational managerial decisions as there is no profitability evaluation made before launching a particular longwall. Such decisions may be considered as completely random, only aimed at maintaining production continuity.

In the three largest mining enterprises financial accounting and reporting is conducted using complex financial-accounting; one of the parts of the IT system supporting management is called SZYK 2 (fig. 3), which is a system elaborated and modified by Centralny Ośrodek Informatyki Górnictwa SA – COIG SA (General IT Centre for Mining JSC).



**Fig. 3.** Scheme of SZYK 2 financial-accounting complex  
**Source:** own work based on data from COIG SA.

An analysis of the rules of this system and the scale of its use by the mining enterprises suggests that the costs of mining production are currently evidenced in a generic approach and occur according to the places of their creation with inclusion of the place in the organizational structure of a colliery, enterprise, and process that they are related to (Turek and Jonek-Kowalska, 2012; Jonek-Kowalska and Turek, 2012). However, all the reports and analyses are mainly conducted on the basis of generic approach. One exception is a WKS-C report—cost statistics of the basic production processes—but its main drawback is the fact that this report aggregates all data at the level of colliery and enterprise. Nevertheless, in mining enterprises, production is conducted in the area of several to about a dozen longwalls, specific for different and unique mining conditions and different cost levels at the same time. Each longwall is launched, exploited until the moment of the minerals’ exhaustion, and then liquidated. However, the period of its existence and the length of time for each aforementioned phase are quite varied and mostly depend on the mining-geological conditions as well as the intensity of natural hazards accompanying the underground exploitation.

According to the above, using only systematic cost accounts, which generally include a generic approach, in Polish mining enterprises is inappropriate and only useful in financial accounting and reporting.

Therefore, in the final section of this article there are directions for cost account improvements indicated in the Polish hard coal mining using contemporary cost accounts adjusted to the requirements of management accounting and as an answer to the concrete needs of the enterprises with specific production conditions.

### **Needs identification of Polish mining enterprises in regards to cost accounting**

As mentioned in the introduction, Polish mining enterprises use only systematic cost accounts, which allow financial accounting and reporting to be conducted. A consequence of such approach is a lack of information about:

- ✓ total and unit costs of the functioning of particular longwalls,
- ✓ costs in a perspective longer than a balance year, evidence of particular longwalls, and the whole colliery,
- ✓ total and unit costs in a process approach,
- ✓ the excavation effectiveness of particular longwalls,
- ✓ the effectiveness of particular processes that are a part of mining production,
- ✓ cost planning of launching a particular longwall, and
- ✓ the effectiveness account of a particular longwall in an *ex ante* and *ex post* approach.

As a result of the lack of information above, executives are not able to make rational and economically effective decisions because they do not have the necessary data at their disposal to make such decisions (Roslender and Hart, 2002; Langfield-Smith, 2008). Additionally, mining enterprises in Poland are currently in a very difficult economic-financial situation (Jonek-Kowalska, 2012). More serious, negative symptoms are: systematically rising unit production costs. Increasing debt and the drastic reduction of sales size result from the non-competitive price of the Polish resource (Jonek-Kowalska, 2011).

One of the basic reasons excavation costs increase, apart from deteriorating exploitation conditions, is the still high cost of salaries rising in time but not connected to work effects. Nevertheless, such a connection is only possible when there is a system created in the enterprise that enables work pricing and at the same time creates a basis for pro-effective motivation. These days obtaining information about production effectiveness is possible at the level of the colliery. Consequently, it is not possible to determine the influence of separate activities and processes on the resultant effectiveness and to indicate the responsibility centers for the costs borne in the course of these activities and processes.

The above defects and imperfections of the cost management system are also confirmed by the questionnaire research conducted among 214

employees of the production preparation and production economics divisions in Polish mining enterprises in 2012. In the research, the interviewees considered the main disadvantages of the existing cost management system to be a lack of cost planning possibilities in the long view, a lack of motivational function, and a lack of effectiveness assessment possibilities in the *ex ante* approach (Jonek-Kowalska, 2013). The criticism of the current solution and a postulate of the changes in that matter also appear in the works of M. Sierpińska (Sierpińska, 2006; Sierpińska and Kustra, 2004), K. Czopek (Czopek and Tyrała, 2004; Czopek and Tyrała, 2003; Czopek and Tyrała, 2006) and A. Lisowski (Lisowski, 2001; Lisowski, 1995; Lisowski, 1988; Lisowski, 2003; Lisowski, 2004).

The circumstances above cause the activity effectiveness improvement in the way of production cost rationalization being a prior task. Nevertheless, without a detailed determination and elimination of sources of non-effectiveness this task cannot be achieved. In its realization a deep modification of the current cost accounts would be helpful, oriented around:

1. enabling cost planning, evidence, calculation, control in a process approach adjusted to the specificity of mining production in a long-term perspective,
2. providing a possibility for the effectiveness assessment of mining production in a process-project approach (in particular for a longwall) in *ex ante* and *ex post* variant.

Literature studies in the area of management accounting should select cost accounts suitable for the needs described above and provide a realization of the aforementioned objectives. The selected cost accounts along with a justification for their inclusion are presented in table 2.

**Table 2** Contemporary cost accounts as the answer to the needs of Polish mining enterprises in the area of management accounting

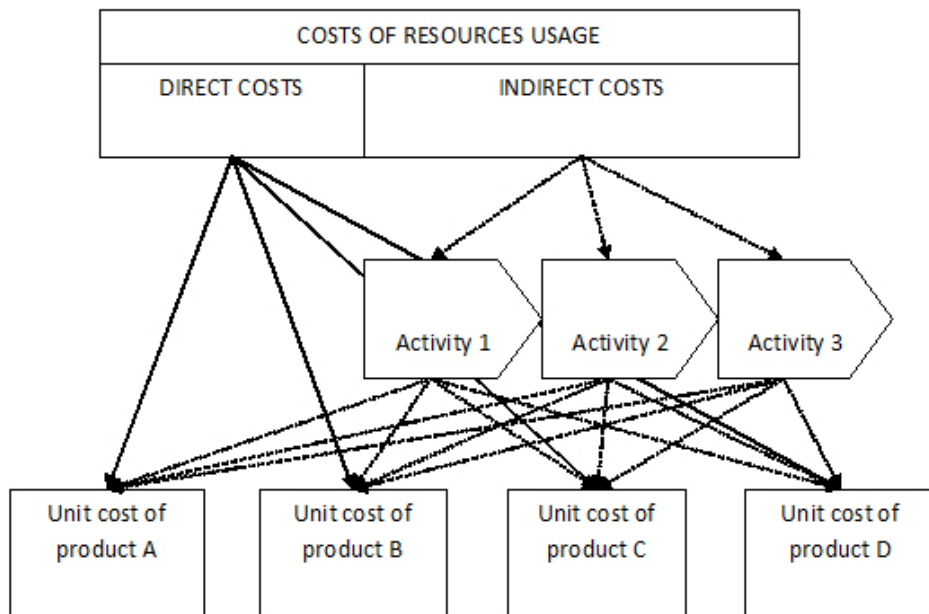
<b>Selected cost account</b>	<b>Justification of choice</b>
Cost account in longwall life cycle	Inclusion of phases, also revealed in the longwall life cycle and long-lasting cost evidence, considerably exceeding the balance sheet year.
Activity-based cost account	Applying a process approach to costs in the form of the selection of processes and activities to which resource use is assigned. Creation of the possibility to calculate indirect costs, constituting a significant part of mining production costs, in particular processes and activities.
Target-cost account	Enabling a calculation of mining production effectiveness before making a decision about its start.
Continuous-improvement cost account	Orientation on searching for sources of non-effectiveness in processes and activities as a part of mining production and maintaining quality at the same time.

**Source:** own work

Cost account in a longwall life cycle was elaborated in connection with necessity to look at costs and effectiveness in the context of all phases of the product life cycle, from the moment of its conception and creation, through the market introduction and finishing with the withdrawal from the market (Duhanik, 2002; Smith, 1998; Szychta, 2010). Such an account may and should be made before making a decision about the production launch. At that time the enterprise evaluates in advance in a long-term perspective the costs and revenues (Nowak, 2008) that are connected with a particular product, gaining information about the potential production effectiveness. The aforementioned categories are planned for each phase allowing the inclusion of revenues, costs, and results in a yearly and/or monthly depiction, typical for systematic cost accounts, with a determination of their approximate time of existence.

The cost account described above has become an inspiration for the conception of cost account modifications that are used in the Polish hard coal mining industry, mostly due to the phases of cost evidence. The phase character is typical for the course of the basic mining processes. In the longwall life cycle there may be three basic phases distinguished: launch (I), exploitation (II), and liquidation (III), presented in figure 2.

Apart from the phase character of mining production, it is also important to include the process character. This, in turn, is possible thanks to using an activity-based cost account (Kaplan and Anderson, 2004; Cooper and Kaplan, 1991; Cooper and Kaplan, 1992; Cohen et al., 2005). In this account costs are assigned to the aforementioned processes and activities taking place in them, through an indication of the resources used for them. There are four basic stages distinguished in this account. The first one is to define the processes and activities. The second one is to determine the costs of particular processes and activities by assigning both direct and indirect costs to them. However, the latter costs need a proper calculation, which takes place in the third stage of an activity-based cost account, called a determination of activity carriers. These are the parameters: allocation keys and creating an amount of activities, while at the same time creating the level of costs connected to them. After their determination there is a fourth stage of the activity-based cost account: a calculation of the indirect costs of the activities in particular products through assigning an amount of the activity cost to them, which is a quotient of the indirect costs of activities and the number of units of cost activity carriers. The scheme of the activity-based cost account's functioning is presented in figure 4.



**Fig. 4.** Scheme of activity-based cost account's functioning

**Source:** Gorczyńska, A. Współczesne rachunki kosztów jako odpowiedź na zindywidualizowane potrzeby przedsiębiorstw, [in:] Jonek-Kowalska I. ed. Zarządzanie kosztami w przedsiębiorstwach górniczych w Polsce. Stan aktualny i kierunki doskonalenia. Warszawa: Difin, 2013, p. 46.

In mining production the use of an activity-based cost account is assumed not in relation to the products because of the fact that hard coal is a relatively homogenous product<sup>54</sup>, but rather in relation to the particular longwalls in order to enable the calculation of the unit cost of excavation from a particular longwall, before launch, during exploitation, and in *ex post* approach, after its liquidation.

Taking into account the need to assess the effectiveness of the excavation from single longwalls, using a target-cost account (Boer and Ettlie, 1999; Nowak, 2003; Piosik, 2006) or the continuous improvement cost account (Jaruga et al., 1999) is also suggested for the Polish hard coal mining industry. The first of the aforementioned accounts allows users to shape the effectiveness of a particular product in the whole life cycle. The next stages of this account is to indicate:

- ✓ target price, accepted by the product recipient and which can be obtained in particular market conditions,

<sup>54</sup> Differences in quality mainly result from natural deposit features such as: calorific value, ash and sulfur contents.

- ✓ target income, determined by the level of the expected return rate from the production launched or on the basis of return on sales of similar products,
- ✓ acceptable unit cost, which guarantees the achievement of the expected target income (it is a maximum level of unit cost),
- ✓ target cost, determined based on the resource possibilities and organizational conditions existing in the enterprise.

If the target cost is lower or equal to target price the enterprise should make a decision about the production launch. Otherwise, production will be non-profitable and should not be started.

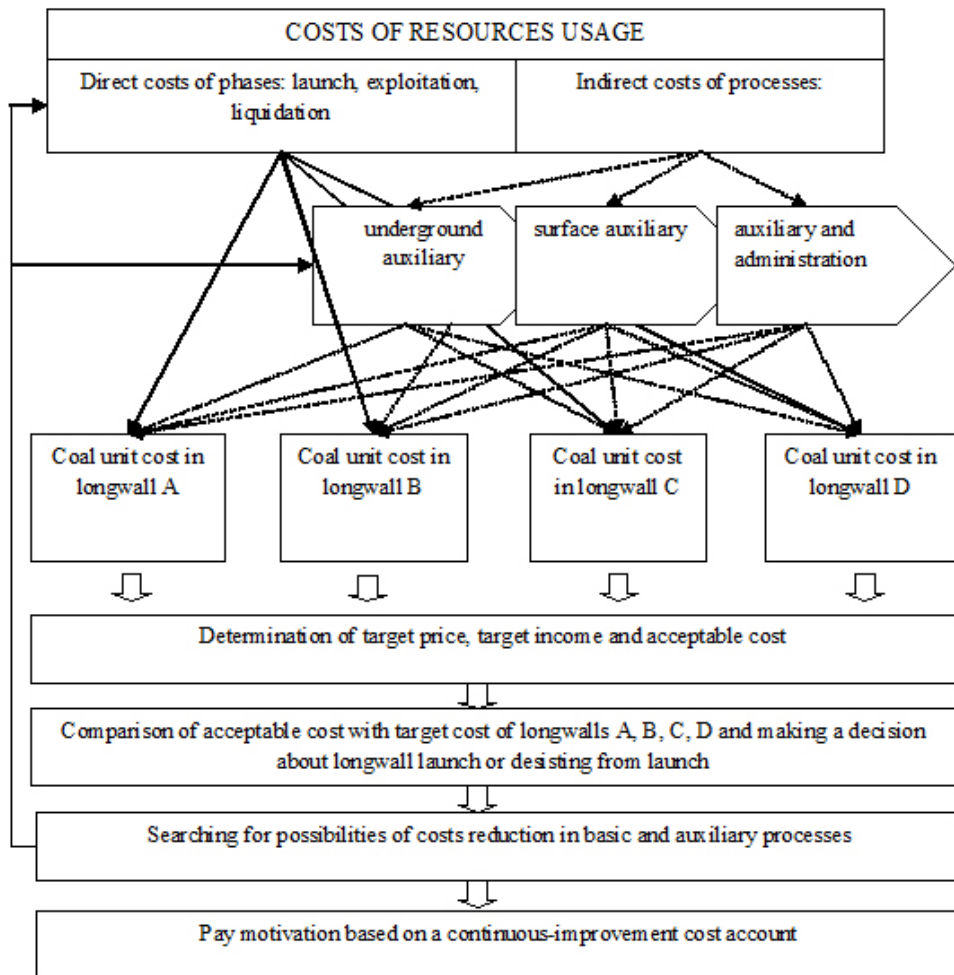
The second of the aforementioned cost accounts is the continuous-improvement cost account, which consists of a constant search for ways to decrease costs in the enterprise in terms of the processes and activities realized. However, the possibilities are divided into two groups: activities undertaken within three months of production launch and activities undertaken in order to achieve the assumed yearly sales budget. The first group of activities should provide a quick achievement of value for the real unit production costs equal to the target costs, and the second group of activities should provide the achievement of the income indicated in the yearly sales budget of the enterprise. Such an approach to cost rationalization should be correlated with a motivational system of enterprise so that the employees feel the need to search for possibilities of costs optimization.

The use of the aforementioned cost accounts would enable users to conduct a profitability account in a process approach in mining enterprises in a prospective and retrospective variant. This would provide not only a cost reduction but also a rationalization and an economization of the managerial decisions made and at the same time would improve production effectiveness. Moreover, mining enterprises also could use the possibilities provided by applying a continuous improvement cost account for elaborating upon the basic assumptions of the pro-effective motivational system, which, currently, does not function at all in mining enterprises.

### **Discussion of cost accounting in a longwall life cycle**

Based on the contemporary cost account characterized in this article, the conception of a cost account in longwall life cycle was explained in detail and adjusted to the current needs of Polish mining enterprises. The scheme of this account's functioning is presented in figure 5.





**Fig. 5.** Scheme of the functioning of a cost account in a longwall life cycle

**Source:** own work

According to figure 5, the direct costs in the cost account in a longwall life cycle are assigned to the particular longwall, with a separation of the subsequent phases: launch, exploitation, and liquidation. The indirect costs are determined on the basis of the auxiliary processes accompanying basic production, which include underground auxiliary processes, on the surface and administration processes.

After determining the unit production costs from a single longwall using a target-cost account, a potential assessment of the excavation effectiveness is made. Based on the results a decision is made about excavation launch or resignation. The process approach to costs is also possible thanks to using the continuous-improvement cost account, and at the

same time searching for sources of non-effectiveness in the particular processes and activities. Their elimination, resulting in a costs reduction, may be connected with a motivational pay system that reinforces the pro-effective attitudes of employees.

The conception suggested in regards to the costs borne in the longwall life cycle is currently being tested in one of the collieries belonging to the largest Polish mining enterprise. Testing is conducted in two phases. The first phase includes consultation of the detailed theoretical spreadsheets of cost planning, calculation, and control in the longwall life cycle with the employees of technical and economic divisions within a chosen colliery. The second phase of testing is connected with expanding the IT tools that support cost management in the longwall life cycle. These tools will be prepared by COIG SA on the basis of and in compliance with the existing IT systems. The goal of this phase is to maximally simplify the procedures of cost management and adjust the tools that support the course of this process to the needs of the final recipients. It is assumed that the success of the conception presented will guarantee the following: application of the existing IT and accounting solutions in the Polish mining; cooperation of theoreticians and practitioners in deciding on the final solutions; and maximization of the solution's functionality and usability.

In future research there needs to be a detailed cost analysis and assessment planned related to the auxiliary processes, and an explanation of the rules of their assignment to the particular longwalls. This will allow users to assess the profitability of excavation in a particular longwall and the whole colliery. Closing this stage may, in turn, constitute the grounds for determining motivation rules. In this explanation there would be the results of cost control in longwall life cycle used, which would be a basis for an employee bonus system.

### **Conclusion**

According to the conclusions described in the previous point, the basic processes of hard coal production are characteristic of those of unique projects, with the possibility to distinguish the main phases in a process approach. In such cases, it is necessary to use the individualized techniques of cost planning in cost management and a profitability account. However, currently in the three largest mining enterprises in Poland, cost management is conducted on the basis of technical-economic plans, determined at the enterprise level and in separate collieries by a generic approach (Sobańska, 2006) in the form of continuous budgeting, in which costs are updated on the grounds of general-economic ratios and the considerations of managers with mining experience (Jonek-Kowalska and Turek, 2012).

The cost accounts used for that purpose, as well as comprehensive and detailed analyses and reports made on their basis, are only useful for

financial accounting and reporting. These are mainly systematic cost accounts (Kobiela-Pionnier, 2010), mostly including a generic cost account (Nowak et al., 2004), in a very centralized depiction, at the level of colliery and enterprise. In effect, there may be an answer to the question of why the colliery is non-profitable, but only looking at the basic and/or auxiliary production processes, the reason cannot be determined.

Such an approach makes it impossible to make rational managerial decisions because no profitability assessment of the undertaking was made before the decision to launch a particular longwall. Consequently, such decisions may be considered to be completely random, only aimed at maintaining the continuity of production.

On the basis of considerations made and the needs of the Polish hard coal mining industry in the area of management accounting, it has been determined that the contemporary, optimal cost accounts for this sector are: cost account in a product life cycle, activity-based cost account, target-cost account, and continuous-improvement cost account. Their modification and compilation enabled the elaboration of the conception of a cost account in a longwall life cycle, in which direct costs—including their phase character—and indirect costs are assigned to individual longwalls. Such an approach allows the user to conduct a profitability account before making a decision about the excavation launch. Pro-effective activities of Polish mining enterprises may also be supported by a continuous-improvement cost account connected with a motivational pay system.

### **Cost terms glossary**

**materials:** material, fuel, deviations from evidence price of materials, purchase costs of materials,

**energy:** electric energy, compressed air,

**overhaul:** service repairs and maintenance of fixed assets, mechanical workshop services,

**amortization:** amortization of fixed assets,

**mining machine leasing:** rental of coal-cutting machines and appliances, rental of heading machines and appliances, rental of other mining appliances,

**services:** services of electric energy distribution and supply, hazards prevention and liquidation, transporting services, other services connected with mining production, services of final product storage, work safety, and hygiene services,

**other costs:** transfer to employee benefit fund, attest and legalization costs, sub-station, station and switching station maintenance costs, business trips.

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