GOSPODARKA SUROWCAMI MINERALNYMI – MINERAL RESOURCES MANAGEMENT

2024 Volume 40 Issue 1 Pages 151–166

DOI: 10.24425/gsm.2024.149300

PATRYCJA BĄK[1], MARIAN TUREK[2]

The identification of drivers influencing the production volume in coal mines

Introduction

The Law on special solutions to counteract supporting aggression against Ukraine and to protect national security (Law 2022) was published in the Journal of Laws. According to the provisions of Article 8, under the threat of heavy fines, a complete ban is introduced on the introduction of coal originating from Russia or Belarus into the territory of Poland or movement to another country through its territory.

According to various sources, between approximately 8.5 and even 10 million tons of Russian coal entered Polish market in 2022, which was mainly used for heating purposes by heating companies and private households (especially in the northern regions of the country). A ban on the continuation of these imports requires the identification of other sources of fuel these could be either imports from other countries or an increase in mining volumes

✉ Corresponding Author: Patrycja Bąk; e-mail: pbak@agh.edu.pl
[1] AGH University of Krakow, Poland; ORCID iD: 0000-0001-9109-3369; Scopus ID: 55651726700; Researcher ID: ELJ-8332-2022; e-mail: pbak@agh.edu.pl
[2] Silesian University of Technology, Zabrze, Poland; ORCID iD: 0000-0002-0357-200X; Scopus ID: 35203947200; e-mail: marian.czeslaw.turek@polsl.pl

by domestic mines. However, both of these alternatives require a certain amount of time to be realized. Finding new foreign suppliers entails new contracts, which can be all the more difficult as many other countries, like Poland, no longer want to buy Russian coal. There is also the issue of negotiating appropriate prices.

A possible decision to increase domestic mining is linked to other problems. This requires, first and foremost, that new portions of the deposits that could be mined be made available and cut in advance, which often entails several years of underground roadworks and significant financial outlay for their implementation and for the appropriate technical equipment of the newly prepared mining faces. With appropriate financial support from the state, this may be possible, but not in every mine as there are a number of other considerations that determine the volume of extraction that can be achieved, particularly if there is a desire to increase it. This is the problem addressed in this study.

1. The production capacity of hard coal mines

The production capacity of a mine is the amount of output that can be achieved in an assumed time interval (most often a day), defined in tons of mined coal or merchantable coal. This is determined by the resultant (lowest) production capacity of the individual links in the production process, which include (Figure 1) (Bąk 2012):

a) Vertical transport – in the case of shafts, these are the capacities for transporting coal excavated material to the surface, which depend on the number and type of individual shaft hoists (skips, cages, skip-cages) and their technical and operational characteristics (travel speed, loading and unloading times), and in the case of declines, on the parameters of the excavated material haulage conveyors built into them.
b) Horizontal transport – the transport capacity of the winning delivery vehicles (parameters of the delivery vehicles) and the bulk delivery vehicles on the main transport routes

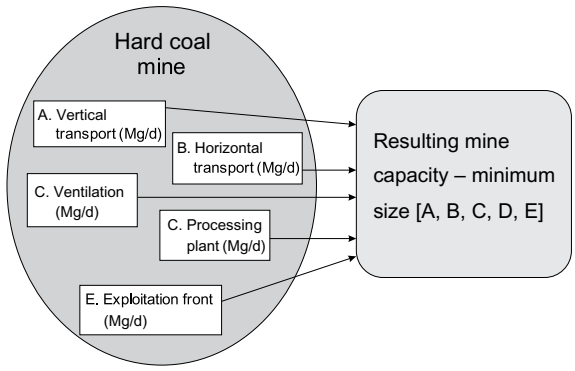

Fig. 1. The links in the production process that determine the mining capacity of a coal mine (Bąk 2012)

Rys. 1. Powiązania w procesie produkcyjnym decydujące o zdolności wydobywczej kopalni

(parameters of the delivery vehicles or the transport capacity of the wheeled delivery vehicles).

c) The mine's ventilation system – determined by the parameters of the installed main fans and the capacity of the air flow paths, which determines the amount of fresh air that can be supplied to the working faces and the amount of waste air discharged from them and thus the number of these faces.

d) Exploitation front – the amount of net coal production that can be achieved, which depends on the number and parameters of the mine faces (usually longwalls) and, to a small extent, on the number and parameters of the corridor work faces (galleries). From a theoretical point of view, there is a certain difference between the representation of the mining distribution when calculating the mine production capacity and taking into account the mining front and the distribution in the mining plan. In the former case, the entire front possible to be created in the planned period as a result of the opening and preparatory works should be presented, and in the latter case, only that front, both active and reserve, which is needed in the mining plan limited by factors outside the mining front. Where other mining works constrain the extraction volume, the distribution of mining works for capacity calculation will be the same as the distribution of works resulting from the planned extraction.

e) Processing plant – volume defined by the quantity of extracted coal (so-called raw coal) transported to the surface from the pits, which can be processed into a commercial product of defined grades and quality parameters, depending on the processing technologies used and the parameters of the technical equipment and their actual operating time.

Coal production includes the finished production, i.e. the amount of coal that is received after it has passed through the processing plant – so-called commercial coal.

In Polish mines, practically always, the parameter determining the size of the production capacity is the capacity of the mining front. In a few cases, it may happen that the capacity of the front is limited by the number or parameters of shafts that do not provide an adequate transport or ventilation capacity. Therefore, assuming a mine has the following features:

- Machinery and equipment for transporting excavated material in horizontal workings (galleries) and in vertical workings (shafts) are characterized by technical parameters that make it possible to perform its haulage from the faces to the processing plant without interruption.
- The installed main ventilation fans and the capacity of the fresh and exhaust air flow paths allow all work areas to be ventilated in such a way as to meet the requirements of the relevant occupational safety regulations.
- The processing plant is characterized by technical parameters enabling raw coal to be enriched and commercial coal of appropriate quality to be produced without disruption.

Further consideration will be given to the factors influencing the capacity of the mine front.

2. Basic and specific factors influencing the volume of output obtained at a mine

Every enterprise must have certain physical, personal and financial resources in order to operate. In the case of a mining company, however, it is most important to have certain geological resources – A mine can only operate where there are coal seams that are technologically and technically viable (Mäkitie et al. 2022).

Assuming that the basic factors influencing the mine's production results (mining volumes) will be the resources held, their quality parameters, the natural hazards present and the human and material resources held, four groups can be identified (Lyczko 2021):

A. geological resources considered together with the properties of the rock mass in which they lie;
B. natural hazards present in the exploited deposit;
C. human resources – mine employees;
D. technical equipment used in the operating process.

In addition to this, a number of further factors can be identified for each of these groups that characterize them in more detail and are called specific factors (Figure 2).

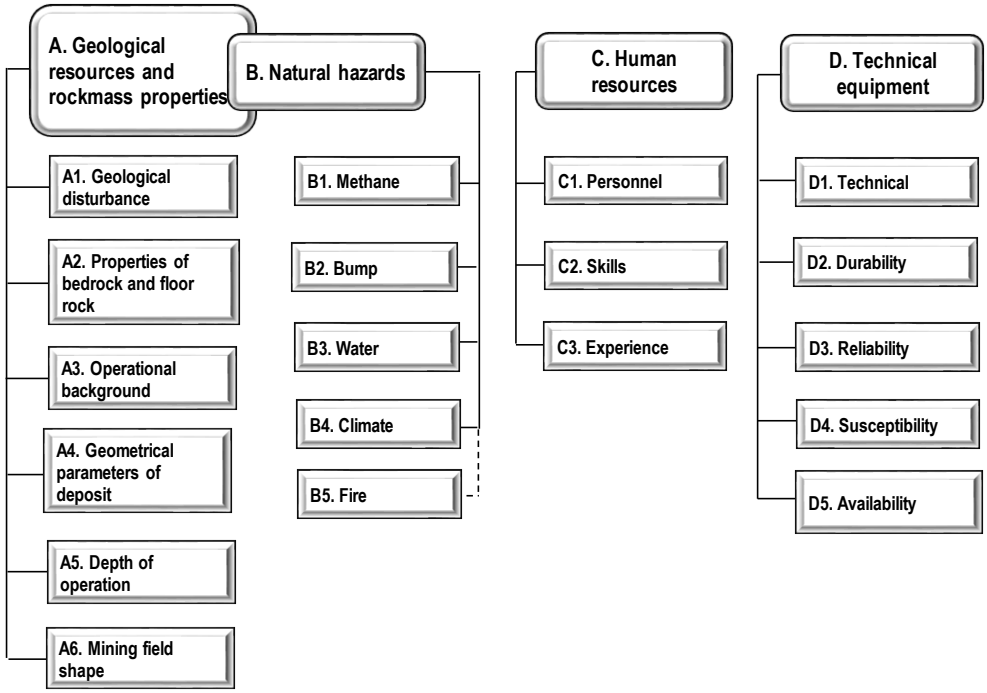

Fig. 2. Aggregate summary of factors influencing the mining capacity of the exploitation front of a coal mine
Source: own work based on (Lyczko 2021)

Rys. 2. Zbiorcze zestawienie czynników wpływających na zdolność wydobywczą frontu eksploatacyjnego kopalni węgla kamiennego

With regard to geological resources, the specific factors are:

A1. geological disturbances that may be present in the deposit;
A2. strength properties of the bedrock and floor rocks lying adjacent to the exploited deposit;
A3. background of previous mining operations – left-over, produced mining edges;
A4. geometrical parameters of the deposit being exploited, in particular its thickness; which determines the height of the wall;
A5. depth of deposit;
A6. shapes of the mining fields that can be cut, having a decisive influence on the panel and wall lengths.

With regard to the natural hazards that may be present in the exploited deposit, those that have the greatest impact on the ability and speed of mining operations have been singled out as specific factors:

B1. methane hazard;
B2. bump hazard;
B3. climate hazard;
B4. water hazard;
B5. fire hazard.

Three factors have been identified in relation to human resources, which are the workers employed in the mining operations:

C1. personnel – the number of employees (in-house or external) that can be employed;
C2. skills – the ability to perform specific tasks and solve problems;
C3. experience – professional competences acquired during employment.

With regard to physical resources – technical equipment (explanations according to (Będkowski and Dąbrowski 2006)):

D1. technical condition – determination of the degree to which the equipment or machine is capable of continuing to perform the task for which it was intended;
D2. durability – the property characterizing the ability to maintain the required serviceability and availability under specified service conditions until the contractual limit state is reached;
D3. reliability – the property characterizing the certainty of meeting the requirements of use and operation under specified conditions and over a specified period of time,
D4. vulnerability – the set of properties (characteristics) that determine good adaptability to operation under existing conditions;
D5. utilization rate – understood as the effective use of the length of possible working time per day (month, year).

3. Influence of individual factors on the extraction volume achieved

3.1. Geological structure of the deposit, its geometrical parameters and the natural hazards present

When assuming that the output of a mine can be increased, it is first necessary to determine the size of the operable (recoverable) coal reserves lying in the deposit. However, it is not sufficient to simply state that there is sufficient coal, it is also necessary to take into account the geological conditions of the deposit. Planning the volume of mining, in addition to all the safety aspects of performing the work, should also take into account:

- the presence of any disturbance in the bedding of the seam, the strength parameters of the roof and bedrock;
- the geometrical parameters of the deposit, particularly including its thickness as well as its slope;
- the possible need to limit the progress of a longwall resulting from the scale of the natural hazards present (especially methane and rock-bump hazards) or the considerations for protecting surface facilities.

The occurrence of numerous disturbances in the excavated pit walls and/or the poor strength of the rocks located in the roof or floor completely exclude the possibility of assuming large extraction volumes. This can be confirmed by the results of the study contained in previou work (Matuszek 2021). It contains detailed data (copies of dispatcher's reports) on stoppages and interruptions of eight longwalls of one of the mines in the years 2015–2018. The longwalls were operated under varied geological and mining conditions, differed in geometrical parameters, technical equipment and organization of work (three- or four-shift systems). Only periods of normal running of the longwalls (without their start-up and preparation for decommissioning) were taken into account in the breakdowns. This data enables the compilation of the number of minutes of stoppages for each longwall, grouped according to eighteen different reasons. In addition, for each longwall, it is also possible to compile a summary of the total nominal duration of all production shifts during the entire period of its normal run.

In the case of two of these, the number of minutes of downtime caused by rockfall and geological disturbances occurring is of particular note:

- In the first wall, for which nominal working time was over 279,000 minutes, break time was over 33,600 minutes, which represented over 12% of nominal time.
- In the second wall, for which nominal working time was over 152,000 minutes, break time was over 12,100 minutes, which accounted for almost 8% of nominal time.

It could also be noted that in the case of the first longwall, mainly for geological reasons, there were as many as ninety-eight production shifts during the period of its run, during which, not even one ton of coal was obtained; with a four-shift work organization, this means that the longwall shearer stood idle for almost twenty-five days. In addition to such

extreme situations, it often happened that out of a nominal 330 minutes of work, the work actually lasted only 60 to 120 minutes.

Another specific factor related to the properties of the rock mass is the presence of mining occurrences. In mines, mining is often carried out in the vicinity (under or over selected parts of the deposit or in partially unselected areas). Leaving parts of the deposit, for various reasons, results in the formation of so-called exploitation edges. Previously selected portions of the deposit, produced edges and residual seams are known as exploitation edges, causing changes in the state of the rock mass (Chlebowski et al. 2017). First and foremost, they adversely affect roadways, which can manifest as tightening or uplifting of the bottom. In addition, especially in seams prone to rock bump, they cause an increase in stresses in the rock mass, increasing its seismic activity. Under such conditions, it would be impossible to assume an increase in mining volumes.

Another factor is the geometric parameters of the deposit, particularly its thickness and slope (longitudinal and transverse). The thickness of the seam under certain conditions, e.g. in the absence of geological disturbances, sufficiently strong roof rocks and the possibility of using mechanized support of sufficient height can be equated with the height of the longwall (Turek 2007).

The importance of the weight of longwall height on the amount of production obtained can be illustrated as follows. A 200 m longwall, having a progression of 5 m/d, operated on average twenty-two days per month and having an average height of 2.5 m, can produce about 71,500 tons of coal per month. If the height is increased by only 0.1 m, this figure increases by almost 3,000 tons, and with an increase of another 0.1 m, more than 5,700 tons more coal can be obtained (Figure 3).

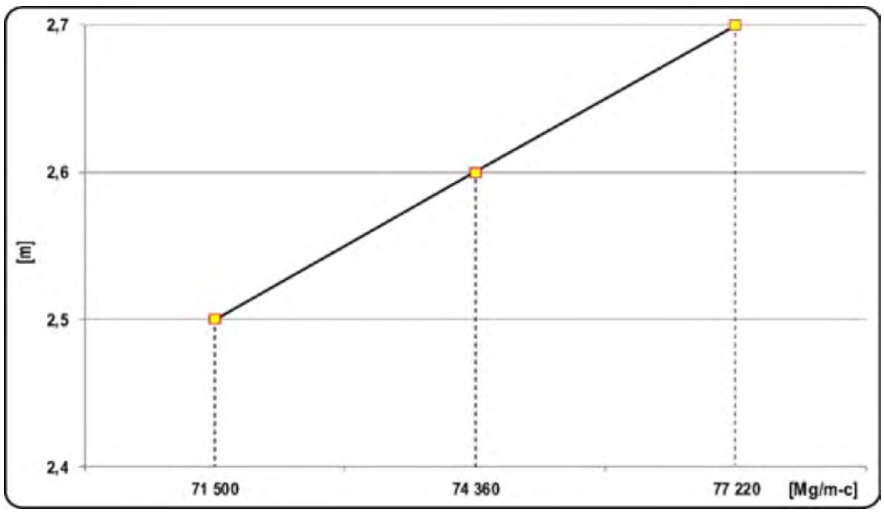

Fig. 3. Monthly extraction volumes obtained in an example wall depending on its height
Source: own work

Rys. 3. Miesięczne wielkości ekstrakcji uzyskane w przykładowej ścianie w zależności od jej wysokości

Steep longitudinal and transverse slopes in the seam, especially longitudinal slopes exceeding 25°, often require additional technical and organizational safeguards that can impede rapid longwall progress.

The depth of the deposit (another specific factor identified) is also very important in terms of the type of mining performed. As the depth increases, the pressure of the rock mass increases, exacerbating the threat of rock bumps and the difficulty in maintaining the dimensions of the mine workings, and often leading to an increase in the amount of methane released. In addition, climatic conditions also deteriorate and fire hazards increase. All of this necessitates an increase in the scope of appropriate prophylaxis against these hazards and can even lead to the need for significant advances in ongoing mining work.

The last mentioned factor concerning the geological resources and their characteristics is the possibility of separating mining plots in the deposit with shapes that allow the cutting of longwalls with large panel lengths, exceeding 1,000 m. If the cutting fields have to be limited by, for example, strong geological disturbances, protective pillars, the boundaries of the mining area, then planning to obtain large production volumes from them is only possible for a short period of time – a longwall with a short panel length will quickly come to an end.

In addition to this, the shape of the isolated field should allow for the cutting of longwalls of sufficient length, exceeding at least 200 meters. This is mainly due to the fact that when a particular mechanized shearer is built into a longwall, the amount of output from it mainly depends on the capacity of the mining machine (almost always a roadheader) – this increases as the length of the longwall increases.

The next group of basic factors determining the amount of extraction achieved, inseparable from the characteristics of the deposit being exploited, are the natural hazards present in the deposit, particularly: methane, rock overthrowing, water, climate and fire (Augustyniak 2021; Burtan et al. 2018; Tutak and Brodny 2019).

Two of these are particularly dangerous (Turek 2010; Krause and Łukowicz 2012; Krause and Dziurzyński 2015; Kamyk and Krzemień 2018):

- Methane, associated with the presence of methane in the rock mass and its release as a result of mining activity, usually increases strongly with increasing depth of mining. At great depths there is often the so-called dynamic effect of free methane, trapped in the zones of tectonic disturbances under high pressure of the overlying rocks.
- Rock bumps, where rock bumps are understood as a dynamic phenomenon caused by a shock to the rock mass, which results in the violent destruction or damage of an excavation or its section. This involves the total or partial loss of functionality of the workings or the safety of their use.

With regard to the safety of the workings, the severe increase of these hazards often completely eliminates the possibility of achieving large extraction volumes. In many cases, it is required to limit the progress of the longwall, necessary for degassing or de-stressing the exploited seam, to apply so-called coordinated mining, which prevents the formation of

additional stresses in the rock mass. There may even be cases of abandonment of mining in batches with the highest risk.

When mining under water-hazardous conditions, it may be necessary to stop mining because of the need to pump out or drain water that has accumulated in goafs or in failing overburden layers. If this is not possible, safety pillars should be left intact around water bodies or water-bearing faults, which can significantly reduce the mine's operational reserves (Kabiesz 2008).

The presence of a climatic hazard may also prevent an increase in mining volumes. According to regulatory requirements, there are three degrees of climatic risk in underground mines, with only rescue work permitted in workings classified as third-degree risk. On the other hand, in the first and second degrees of danger, devices are used to lower the air temperature and working hours are reduced (Szlązak 2011).

In coal seams characterized by a high propensity for spontaneous combustion, so-called endogenous fires often occur. Admittedly, one of the preventive measures to counteract this risk is to maintain a high degree of longwall progression, but this may not be feasible if there is a concurrent risk of methane or rock bump. Then, in the event of a fire, the entire region is most often shut down and dammed.

The considerations to date regarding the possible impact of geological factors and natural hazards present are summarized collectively in Table 1.

3.2. Human resources and technical equipment available

If the geological conditions of the deposit and its parameters are favorable and the natural hazards present are not a significant impediment to the extraction of the deposit, human resources and technical equipment are the next two main factors in a mine that influence the possibility of achieving certain coal extraction volumes.

The term 'human resources' refers to the staff employed by a company (mine), and in fact to their work. In this respect, particularly in the case of an underground mine, it is not so much the number of employees available that is of paramount importance, but also the skills and work experience they possess (Michalak and Zochorek 2022a, b).

When wishing to assume a certain amount of extraction (or an increase in extraction), in terms of human resources, the following should be taken into account first and foremost:

- The number of workers, either in-house or from third-party companies, who may be available to carry out specific works. This is mainly important in terms of safety rules for working in underground workings. In many cases, regulations and instructions specify the necessary manning of the work to be performed, and there can be no question of not conducting certain work due to a shortage of personnel;
- Skills and professional preparation of workers – for work in underground mine workings, it is not possible to supplement personnel by employing people who do not have

Table 1. Summary of the main geological factors and natural hazards present that determine the volume of extraction

Tabela 1. Zestawienie głównych czynników geologicznych i występujących zagrożeń naturalnych, które determinują wielkość wydobycia

Item	Specification	Impact on extraction volumes		
		None	small	strong
1.	Disturbances in the deposit	without disturbances	single disturbances (faults up to 1 m)	numerous disturbances, faults > 1.0 m
2.	Floor rock class[1]	III, IV	II, V	I, VI
3.	Bedrock class[1]	I	II	III
4.	Background of mining operations	no or relaxation of the whole mining field	single edge or residual below to 30 m or more than 60 m from the longwall field, or approaching the gallery	edge or residual up to 30 m below or 60 m above the longwall field and the combined adverse impact edges
5.	Edging longwall field	both sides surroundings with undisturbed soil	one-sided surrounding with goaf	both sides surrounded with goafs
6.	Seam thickness	$2.0 \leq m \leq 3.5$ m	$1.5 \leq m \leq 2.0$ m and $3.5 < m \leq 4.5$ m	$m > 4.5$ m and $m < 1.5$ m
7.	Deck pitch	$n \leq 10°$	$10° < n < 25°$	$n \geq 25°$
8.	Depth	$h < 800$ m	800 m $< h <$ 1000 m	$h >$ 1000 m
9.	Panel length	$w >$ 1000 m	600 $< w <$ 1000 m	$w <$ 600 m
10.	Methane hazard	non-methane	I and II category	III, IV category
11.	Bump hazard	none	Grade I	Grade II
12.	Water hazard	none	Grade I	Grade II, III
13.	Climate hazard	none	Grade I	Grade II
14.	Group the spontaneous combustibility of coal	I	II, III	IV, V

[1] According to the method of A. Kidybiński (1982).

Source: own work.

the required professional preparation with regard to completed schools or specialized courses (this also applies to the ability to operate machinery and equipment of modern mechanized shearers).

- The professional experience of the workers, which is necessary due to the fact that they work underground, in specific conditions, is often not entirely predictable.

The last of the basic factors identified, the technical equipment that can be used to mine the deposit, is equally important in determining the size of the planned output. At present, in the Polish coal mining industry, coal seams are mined practically exclusively by longwall system with the use of mechanized longwall shearers (Świątek and Stoiński 2019). For this reason, considerations concerning the significance of technical equipment for the volume of output achieved can only relate to the machinery and equipment included in these shearers.

If all the conditions analyzed so far do not prevent an increase in mining volumes, the mine must have suitable equipment, as characterized in previous work (Szurgacz and Brodny 2020).

- good technical condition, not showing signs of wear and tear to an extent which significantly jeopardises its trouble-free operation;
- maintaining the required serviceability and operational reliability for the planned period of the longwall operations, under defined geological and mining conditions;
- susceptibility, i.e. appropriate adaptation to the geological-mining conditions of the mine face, e.g.
  - with a mechanized support of the required strength and height to allow clean removal of the deck;
  - with a mining machine (usually a roadheader) with the required feed speed and clearance over the conveyor, and mining units with the appropriate diameter and depth of cut;
  - with longwall and face conveyors with parameters enabling smooth extraction of the coal stream.

Failure to meet any of the above conditions will always result in greater or lesser disruption to the mining operation.

In terms of mining volumes, there is another factor inherent to technical equipment concerning the effective use of working time. According to the regulations in force, the normative working time of a miner underground, calculated from entering the shaft cage to go underground to exiting the shaft cage after departure, is 7.5 hours per day (450 minutes). From this is deducted the time required to reach and return from the coalface at the end of the work, resulting in a so-called nominal working time of 320 to 300 minutes, depending on the distance of the wall from the shaft. At coalfaces, work is most often organized in a system of three mining shifts and one maintenance shift. Then, with the working time in force, breaks of around two hours often occur between mining shifts. In some mines, this is prevented by creating so-called ‘inter-shifts’, but most often, the sum of the nominal working times of the mining shifts is at most 75–80% of the day. It can therefore be seen that by simply changing the face occupancy system, an additional 250–300 minutes of running time can be gained.

However, it must be borne in mind that the desire to make such a change must involve an increase in the number of underground crew members. Even if this were possible, it would entail a large increase in labor costs.

4. The economic aspect of the possibility of increasing mining volumes in mines

For economic reasons, decisions to increase the output of a particular mine should not be taken without first performing an analysis of their profitability (Jonek-Kowalska 2017, 2018). It may turn out that, as a result of a number of projects, the output of the mine will increase, but the cost of their implementation and/or subsequent realization will be so high that the unit cost of producing one ton of commercial coal will be much higher than the selling price or the import price. Such a situation absolutely must not occur.

Any increase in mining volumes may only apply to mines with sufficiently large reserves of operable coal. It is rather unlikely that these resources will lie in lots that have already been accessed and cut for mining. If reaching them involves mining at greater depths, this may involve, for example, the requirement to deepen shafts or build a new level. Apart from the fact that these are very costly mining ventures, it will only be possible to obtain the first tons of coal after several years. Furthermore, there is no guarantee that it will still be needed then.

As already mentioned, the descent of mining to greater depths is most often associated with an increase in the status of existing natural hazards, particularly including methane, rock bumps and climatic hazards. In order to ensure safe operating conditions, this will require an extension of the prophylaxis applied. Prior to planning the volume of extraction, it is necessary to conduct a prior appraisal as to whether an increase in the category or degree of hazard will result in the need to limit the progress of the longwalls or introduce shortened working hours.

An increase in the volume of extraction can be achieved either by opening new extraction areas (increasing the number of longwalls) or by introducing changes in the organization of work that increases effective working time. In both cases, it will most often be necessary to increase the number of in-house employees or the range of services provided by external companies.

The commissioning of new (additional) longwalls will also require the purchase of very costly modern mechanized longwall shearers, which must include machinery and equipment with parameters precisely tailored to the operational needs, including the size and support of the mechanized support, the feed speed and diameters of the roadheader's cutting units, the capacity of the conveyors.

All the projects listed above (summarized in Table 2) require financial outlays, often amounting to tens of millions of zlotys. They will then be charged to the costs of extracted coal by depreciation, labor, materials, rent and services. The decision to increase the

volume of mining should therefore be preceded by a very thorough analysis of its economic viability.

Table 2. Sources of additional costs for coal mines planning to increase existing output volumes

Tabela 2. Źródła dodatkowych kosztów dla kopalń planujących zwiększenie istniejących wolumenów wydobycia

Item	Necessary actions or existing circumstances	Range of costs incurred
1.	Making new resources available	Construction (shaft deepening), level construction, cutting of the deposit – capital expenditure, materials, labor costs
2.	Exacerbation of existing natural hazards	Extension of the existing scope or the implementation of new risk prevention principles – investment expenditure
3.	Increase in employment	Hiring additional staff or increasing the services of external companies – labor costs, hiring costs and services
4.	Equipping pits with modern highly efficient machinery and equipment	Purchase of equipment – mechanized longwall shearers, extraction conveyors – capital expenditure

Source: own work.

Conclusions

1. The introduction of a ban on coal imports from Russia or Belarus has created the need to find an additional 9–10 million tons of thermal coal to cover the needs of the domestic market in the near future. This is possible either by increasing its imports or by increasing output in our mines.
2. With the exception of a few mines, the mining capacity is determined by the production capacity of the accessible mining front, i.e. the amount of output that can be obtained from the cut pits (longwalls).
3. The main factors determining the amount of coal to be extracted from a mine are the coal reserves, especially the operable reserves, located in a rock mass with specific properties, the natural hazards present, and the human resources and technical equipment available.
4. Each of the above factors should be analyzed in detail before deciding on a possible increase in extraction. A number of additional, most relevant specific factors have been identified for these. Their importance stems from the fact that any one of them may cause the intended increase not to be realized, particularly by interfering with or limiting the progress of the longwall.
5. In addition to this, it is very important to carry out analyses in advance regarding the economic viability of taking measures to increase extraction volumes. More often than

not, these require significant financial outlays, which can result in high extraction costs later on.

6. It should also be noted that, should it be decided to take measures to increase the production capacity of any of the mines, due to their high costs, it will also be necessary to provide adequate financial support from the state.

REFERENCES

Augustyniak, I. 2021. Research on permeability and filtration coefficient in the assessment of hydrogeological conditions and the state of water hazards in underground mines *(Badania przepuszczalności i współczynnika filtracji w ocenie warunków hydrogeologicznych i stanu zagrożeń wodnych w kopalniach podziemnych)*. *Czasopismo Bezpieczeństwo Pracy i Ochrona Środowiska w Górnictwie* 11 (*in Polish*).

Bąk, P. 2012. Formal and legal aspects in planning of the mining production process *(Aspekty formalnoprawne w planowaniu procesu produkcji górniczej)*. *Przegląd Górniczy* 68(9) (*in Polish*).

Będkowski, L. and Dąbrowski, T. 2006. *Basics of operation, part II: Basics of operational reliability (Podstawy eksploatacji, część II: Podstawy niezawodności eksploatacyjnej)*. Warszawa: WAT (*in Polish*).

Burtan et al. 2018 – Burtan, Z., Chlebowski, D. and Kapusta M. 2018. *The scale and conditions of disasters induced by the occurrence of natural hazards in the coal mining sector in Poland (Uwarunkowania i skala występowania katastrofogennych zagrożeń naturalnych w polskim górnictwie węgla kamiennego). Czasopismo Bezpieczeństwo Pracy i Ochrona Środowiska w Górnictwie* 7, pp. 3–11 (*in Polish*).

Chlebowski et al. 2017 – Chlebowski, D., Burtan, Z., Cieślik, J. and Zorychta, A. 2017. State of stress and strain at the workface front under the old excavation edge (*Stan naprężenia i wytężenia w czole frontu ścianowego prowadzonego pod krawędzią eksploatacji zaszłej*). *Zeszyt Naukowe IGSMiE PAN* 99, pp. 159–170 (*in Polish*).

Jonek-Kowalska, I. 2017. Variability of market conditions as a source of risk in the planning of mining production and its economic results *(Zmienność uwarunkowań rynkowych jako źródło ryzyka w planowaniu produkcji górniczej i jej ekonomicznych rezultatów*). *Journal of the Polish Mineral Engineering Society* 2, DOI: 10.29227/IM-2017-02-23 (*in Polish*).

Jonek-Kowalska, I. 2018. How do turbulent sectoral conditions sector influence the value of coal mining enterprises? Perspective from the Central – Eastern Europe coal mining industry. *Resources Policy* 55(C), pp. 103–112, DOI: 10.1016/j.resourpol.2017.11.003.

Kabiesz, J. 2008. The results of coexistence of natural hazards in mines (*Skutki współwystępowania zagrożeń naturalnych w kopalniach*). *Prace Naukowe GIG. Górnictwo i Środowisko/Główny Instytut Górnictwa* ed. spec. 7 (*in Polish*).

Kamyk, A. and Krzemień, K. 2018. Risk reduction alternatives for methane ignition and explosion based on panel of experts in the areas of longwall exploitation in coal mines (*Koncepcje redukcji poziomu ryzyka wystąpienia zapłonu i wybuchu metanu na podstawie eksperckiej oceny jego czynników w rejonach ścianowych kopalń węgla*). *Systemy Wspomagania w Inżynierii Produkcji* 7(1), pp. 181–196 (*in Polish*).

Kidybiński, A. 1982. Basics of mining geotechnics (*Podstawy geotechniki kopalnianej*). Katowice: Wyd. Śląsk (*in Polish*).

Krause, E. and Łukowicz, K. 2012. Influence of the mine ventilation network structure on the efficiency of the methane drainage (*Wpływ struktury kopalnianej sieci wentylacyjnej na skuteczność ujęcia metanu*). *Prace Naukowe GIG. Górnictwo i Środowisko / Główny Instytut Górnictwa* 4, pp. 95–108 (*in Polish*).

Krause, E. and Dziurzyński, W. 2015. Designing the exploitation of hard coal seams in conditions of combined methane and fire hazard (*Projektowanie eksploatacji pokładów węgla kamiennego w warunkach skojarzonego zagrożenia metanowo-pożarowego*). Katowice: Wyd. GIG (*in Polish*).

Lyczko, A. 2021. Factors determining the volume of production in mining faces on the example of Polska Grupa Górnicza SA (*Czynniki determinujące wielkość produkcji w przodkach wydobywczych na przykładzie Polskiej Grupy Górniczej SA*). Doctoral thesis (unpublished). Katowice: GIG (*in Polish*).

Mäkitie et al. 2022 – Mäkitie, T., Hanson, J., Steen, M., Hansen, T. and Andersen, A.D. 2022. Complementarity formation mechanisms in technology value chains. *Research Policy* 51(7), DOI: 10.1016/j.respol.2022.104559.

Matuszek, Ł. 2021. *A new method of planning production volumes in a hard coal mine* (*Nowa metoda planowania wielkości produkcji w kopalni węgla kamiennego*). Doctoral thesis (unpublished). Katowice: GIG (*in Polish*).

Michalak, A. and Zochorek, M. 2022a. Salary motivators from the perspective of underground mine workers employed in blue-collar and managerial positions in a selected mining enterprise. *Zeszyty Naukowe Politechniki Śląskiej. Organizacja i Zarządzanie* 166, pp. 533–543, DOI: 10.29119/1641-3466.2022.166.34.

Michalak, A. and Zochorek, M. 2022b. The relationships between managers and the people answering to them as an incentive system component based on the example of a mining company. *Zeszyty Naukowe Politechniki Śląskiej. Organizacja i Zarządzanie* 167, pp. 317–333, DOI: 10.29119/1641-3466.2022.167.23.

Świątek, J. and Stoiński, K. 2019. Case Analysis of Damages to Control Hydraulics of the Leg in the Powered Roof Support Section. *IVth International Innovative Mining Symposium, E3S Web Conf*. 105, DOI: 10.1051/e3sconf/201910503013.

Szlązak, N. 2011. Prediction of climatic hazards in mine airways (*Prognozowanie zagrożenia klimatycznego w wyrobiskach górniczych*). *Górnictwo i Geoinżynieria* 35(4), pp. 79–99 (*in Polish*).

Szurgacz, D. and Brodny, J. 2020. Adapting the powered roof support to diverse mining and geological conditions. *Energies* 13(2), pp. 1–22, DOI: 10.3390/en13020405.

Turek, M. 2007. *Technical and organizational restructuring of hard coal mines* (*Techniczna i organizacyjna restrukturyzacja kopalń węgla kamiennego*). Katowice: GIG (*in Polish*).

Turek, M. 2010. *Basics of underground exploitation of hard coal seams* (*Podstawy podziemnej eksploatacji pokładów węgla kamiennego*). Katowice: GIG (*in Polish*).

Turek, M. and Bąk, P. 2022. The production capacity of hard-coal mines in terms of meeting the needs of the domestic energy sector. *Gospodarka Surowcami Mineralnymi – Mineral Resources Management* 38(3) pp. 49–65, DOI: 10.24425/gsm.2022.142793.

Tutak, M. and Brodny, J. 2019. Forecasting methane emissions from hard coal mines including the methane drainage process. *Energies* 12(20), pp. 1–28, DOI: 10.3390/en12203840.

Act of April 13, 2022 on special solutions in the field of counteracting support for aggression against Ukraine and protecting national security (*Ustawa z dnia 13 kwietnia 2022 roku o szczególnych rozwiązaniach w zakresie przeciwdziałania wspieraniu agresji na Ukrainę oraz służących ochronie bezpieczeństwa narodowego*). Dz.U. 2022, poz. 835 (*in Polish*).

THE IDENTIFICATION OF DRIVERS INFLUENCING THE PRODUCTION VOLUMEIN COAL MINES

Keywords

quality parameters, production capacity, hard coal mine, geological structure of the deposit

Abstract

According to various sources, between approximately 8.5 and even 10 million tons of Russian coal entered Polish market in 2022, which was mainly used for heating purposes by heating companies and private households (especially in the northern regions of the country). A ban on the continuation of these imports requires the identification of other sources of fuel – these could be either imports from other countries or an increase in mining volumes by domestic mines. However, both of these alternatives require a certain amount of time to be realized. Finding new foreign suppliers entails new contracts, which can be all the more difficult as many other countries, like Poland, no longer want to buy Russian coal. And then there is the issue of negotiating appropriate prices.

A possible decision to increase domestic mining is linked to other problems. This requires, first and foremost, that new portions of the deposits that could be mined be made available and cut in advance, which often entails several years of underground roadworks and significant financial outlays for their implementation and for the appropriate technical equipment of the newly prepared mining faces. With appropriate financial support from the state, this may be possible but not in every mine as there are a number of other considerations that determine the volume of extraction that can be achieved, particularly if there is a desire to increase it.

The aim of this publication is to present, analyse and identify factors that directly influence the volume of hard coal production, taking into account the dynamically changing market environment.

IDENTYFIKACJA CZYNNIKÓW WPŁYWAJĄCYCH NA WIELKOŚĆ PRODUKCJI W KOPALNIACH WĘGLA KAMIENNEGO

Słowa kluczowe

zdolność produkcyjna, kopalnia węgla kamiennego,
parametry jakościowe, budowa geologiczna złoża

Streszczenie

Według różnych źródeł w roku 2022 na polski rynek trafiło od około 8,5 do nawet 10 milionów ton rosyjskiego węgla, który był głównie wykorzystywany do celów grzewczych przez firmy ciepłownicze oraz prywatne gospodarstwa domowe (szczególnie w północnych rejonach kraju). Zakaz kontynuacji tego importu wymaga określenia innych źródeł pozyskania paliwa – mogą nimi być albo import z innych krajów, albo zwiększenie wielkości wydobycia przez krajowe kopalnie. Obydwie te alternatywy wymagają jednak określonego czasu na ich zrealizowanie. Znalezienie nowych dostawców zagranicznych pociąga za sobą konieczność zawarcia nowych kontraktów, co może być o tyle trudne, że wiele innych państw, podobnie jak Polska, nie chce już kupować rosyjskiego węgla. A oprócz tego pozostaje jeszcze kwestia wynegocjowania odpowiednich cen.

Z innymi problemami jest związana ewentualna decyzja o zwiększaniu krajowego wydobycia. Wymaga to przede wszystkim wcześniejszego udostępnienia i rozcięcia nowych partii złóż, które mogłyby być eksploatowane, z czym wiąże się konieczność często kilkuletniego prowadzenia robót chodnikowych oraz poniesienia znaczących nakładów finansowych na ich realizację i na odpowiednie wyposażenie techniczne nowo przygotowanych przodków wydobywczych. Przy odpowiednim wsparciu finansowym ze strony państwa może to być możliwe, lecz nie w każdej kopalni – istnieje bowiem szereg innych uwarunkowań determinujących wielkości wydobycia możliwe do uzyskania, szczególnie w przypadku chęci jego zwiększenia.

Celem niniejszej publikacji jest przedstawienie i analiza oraz identyfikacja czynników, które wpływają bezpośrednio na wielkość produkcji węgla kamiennego z uwzględnieniem dynamicznie zmieniającego się otoczenia rynkowego.