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Decommissioning of lignite mines in Poland – legal regulations regarding assurance of financial means

Introduction

This article initiates a series of papers dedicated to the evolution of theory and practice regarding the management of closures of mining operations and the decommissioning of related activities. In several cases, it covers the entire process, commencing with the first regulations in Poland (slightly later than in most other countries) and ending when the mine was closed and the liquidation process was in progress. The primary objective of this paper is to acquaint the interested reader with the process of closing Polish lignite mines within the legal and financial context. It will be achieved by:

1. Showing the specificity and importance of mining in general, especially hard coal and lignite.
2. Comparing the regulations regarding the lignite mines decommissioning in Germany and Poland – the biggest lignite producers in the European Union (EU).

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3. Presenting the current state of Polish lignite mining and the costs of lignite mine liquidation.

Subsequent papers will discuss the selected problems introduced here in detail. The first of them will be dedicated to technical aspects of planning decommissioning activities from the earliest phase of mine development. Another discussion will focus on the financial aspects, examining their impact on the financial reporting of mining companies. It is also assumed that a separate paper will present various options for financial assurance for decommissioning liabilities. The final one will present conclusions and recommendations regarding the necessary actions to secure adequate financing of decommissioning liabilities in emerging sectors, such as nuclear power plants, as well as solar and wind energy facilities.

The authors' interests focus on opencast lignite mining. Thus, the article presents the evolution of the legal framework that has always played a crucial role in the enforcement of organized and deliberate closure of lignite mines. Particular attention is paid to ensuring that financial resources are available for the processes under consideration. Of course, for any such regulations to be effective, they must provide for the accumulation of the necessary financial means prior to long-term decommissioning. This entire process must begin when it is difficult to pinpoint exact timelines and costs, making the task for regulators extremely challenging. Therefore, the need to reconcile the uncertainty of distant expenses with the requirement of precise provisions of applicable legal regulations is a great challenge.

1. Decommissioning processes in mining – state of research

Decommissioning in the mining industry presents a complex managerial challenge. As such, it has become a subject of numerous studies in Poland since 1990 and in most developed countries for several decades prior to that. They originated from various disciplines, spanning from environmental studies to various branches of law. Technically, the first paper identified appeared in 1944, referring to a fluorspar mine in Colorado, USA (Coward et al. 1944). In 1987, the first scientific journal dedicated, among others, to the area under discussion was founded – the *International Journal of Mining, Reclamation, and Environment*. Only in 2024 was a journal entirely devoted to mine closure launched, with the opening article titled “What is good mine closure?” (Littleboy et al. 2024). Interest in financial assurance for mine closures specifically was predominately paid by Australian regulatory bodies and researchers (Tiemann 2022). Ndaguba and Malaris identified 2,078 papers published between 2002 and 2021 covering topics related to mine closures (Ndaguba and Malaris 2023).

Financial and legal problems associated with the closures of mines, mainly hard coal mines, in Upper Silesia have drawn the attention of various scholars in Poland (Jarosz 2009; Peplowska et al. 2024). The issues of estimating the costs of decommissioning lignite mines are presented in a cross-sectional manner (Naworyta 2010; Uberman and Uberman 2010; Uberman 2019). Problems of decommissioning of hard coal mines in Germany

(Oei et al. 2020), as well as experience from the decommissioning of lignite mines in Germany in terms of scope of works and costs, have been widely discussed in German literature (Drebenstedt and Kuyumcu 2014; Schrems and Fiedler 2022). Recently, two interesting studies on forecasting financial outlays in Upper Silesia mines have been published (Chmiel 2023; Smoliński 2024). Securing financing for the process of mine closures in the lignite industry has also been incidentally discussed (Wronski et al. 2016; Uberman 2019). In a broader perspective, decommissioning obligations in rock mining in Poland have been analyzed (Kaźmierczak et al. 2015, 2019). A specific possibility of applying a real options approach in decision-making regarding the decommissioning of mines was also analyzed in a PhD dissertation (Mróz 2015).

2. Decommissioning processes in mining, main reasons, particularities and specific importance

To provide a context for the main subject of this paper, a broader background is presented, outlining specific problems associated with the liquidation of both opencast and underground mines. Here, only the main reasons for closures and particularities resulting from the enormous diversity of mining plants are provided.

The most apparent cause for closing mines is the exhaustion of mineral resources. The operational life of a mine is, by definition, limited by the amount of non-renewable mineral resources in the deposit. However, the history of European mining shows that depletion of resources is rarely the reason for closing a mine. In practice, mining ends for other reasons (or a combination of these):

1. Economic, i.e., falling prices and/or rising costs.
2. Technical and technological, e.g., as a result of substitution or the disappearance of the use of raw materials as final products, etc.
3. Environmental and social, e.g., location near dynamically developing towns/cities or in the vicinity of areas with high environmental values.
4. Political reasons.

The liquidation of hard coal mines in England in the 1980s was politically motivated (Polityka 2015), and in Germany, hard coal mines were closed due to high labor costs (Oei et al. 2020). Surface damage caused by underground mining also contributes to the closure of mines. A particular paradox was evident, especially in the complex European coal basins. With the development of the raw material industry, people began to migrate to mining areas in search of work. As a consequence, they settled *en masse* above the exploited deposits. These processes resulted in the creation of very densely populated areas in Europe, such as the Ruhr area in Westphalia, the Lille area in France, and Upper Silesia in Poland. A side effect of underground exploitation was mining damage to buildings and infrastructure. Over time, as industrial centers developed, residents became increasingly independent of mining and began to view the presence of mines more as a problem than as a life-supporting

factor. Nowadays, descendants of miners oppose the presence of underground activities. As coalfields are densely populated, hard coal mining has become less and less profitable over time. Of the three European basins mentioned above (Ruhr, Lille, Upper Silesia) hard coal is still extracted only in Poland, i.e. in the Upper Silesian Coal Basin. However, this is happening in increasingly challenging environmental and economic conditions, and under growing pressure from environmental activists (Pełowska et al. 2024).

Mining in Poland has historically played an important economic and social role. In addition to Upper Silesia (Jarosz 2009), several other Polish areas experienced a similar fate. For example, the Lower Silesian Coal Basin in the Wałbrzych region was liquidated in the 1990s. This was mainly due to low profitability resulting from outdated technology, challenging geological conditions of the deposit, and environmental issues. In turn, in the 1990s, sulfur mines in Poland were closed for reasons other than those related to sulfur mining. In this case, it was due to a significant drop in its prices on world markets caused by the growing global supply of sulfur resulting from the desulfurization of fossil fuels (Burchard et al. 2000).

In the former East Germany, shortly after reunification in 1990, the process of liquidation of most opencast lignite mines and chemical plants using lignite began. In this case, the causes were both economic and environmental (Braunkohle 2010; Drebenstedt and Kuyumcu 2014). Due to the large number of lignite opencast mines, their surface area, mining damage, and environmental pollution, this process continues to this day. The scale and duration of the liquidation of the mentioned German lignite mines is unprecedented in Europe.

Regardless of the reasons, mine closure is a very complex and difficult process. Because each deposit is different, each mine also has its own specificity. Therefore, it is challenging to develop a uniform model for the liquidation of mines, even within seemingly homogeneous groups, such as metal ore mines, salt mines, lignite opencast mines, or aggregate mines (Littleboy et al. 2024). However, it is possible to identify groups of problems related to their closure. In underground mines, the vast surface area is still subject to liquidation. It consists of a shaft, crew service buildings, administrative buildings, processing plants, and other technological facilities. Heaps of waste rock are located near the shafts. The reclamation of coal heaps is a complex problem due to the type of material – stored Carboniferous rocks may spontaneously combust even many years after their recultivation (Ciesielczuk 2015; Gogola et al. 2020).

The liquidation of the underground part of the mine creates many geotechnical and water problems. After closing, their underground voids (excavations) fill with water, which often causes uncontrolled subsidence of the ground surface. It can also result in flooding of previously dry areas above the mine.

In the case of opencast mines, surface objects are still liquidated after their closure. However, they differ in both size and type in relation to underground mines. There are no shaft towers, no hoisting machines, and crew service buildings are usually smaller than in underground mines. In large surface mines (e.g., lignite opencasts), when the decision to liquidate is made, external dumps, as objects created in the initial phase of exploitation, are

usually already reclaimed (e.g., Naworyta 2013). On the contrary, the final excavations and the internal overburden dumps located there are still awaiting recultivation. In turn, mining machines (both basic and auxiliary) may be transferred to other opencasts or mines, or liquidated on site. Another direction in mining equipment management is the use of open-air museums, which present, among others, excavators weighing from several hundred to several thousand tons (e.g., Frydrychowicz et al. 2024; Kasztelewicz et al. 2025).

During the liquidation process, large and deep final excavations of opencast lignite mines are filled with water in a controlled or spontaneous way. In the first case, water is supplied from the dewatering of neighboring opencasts or nearby rivers. In the second case, the final excavations are filled with water flowing directly from the surrounding sediments. The quality of water in future reservoirs depends not only on the way they are filled but also on other factors. For example, the presence of sulfur in lignite-bearing deposits may cause water acidification. This will make it difficult, or even stop, the development of living organisms in a post-mining reservoir for many decades. Of course, the walls of the excavation must be profiled appropriately before it is filled with water to prevent subsequent landslides. It is expensive, but it must be done and is a key element in closing lignite mines (Naworyta 2010).

Reclamation of internal and external overburden dumps is carried out successively as the area becomes unnecessary in the lignite mining process. The method of recultivation depends on administrative decisions. As a result of recultivation, post-mining areas are transformed into various land uses, including agricultural, forest, water, and recreational areas. The direction of reclamation depends on several factors, the most important of which are the needs of local communities (Naworyta 2013; Frydrychowicz et al. 2024; Kasztelewicz et al. 2025).

Detailed problems of physical liquidation of lignite mines will be the subject of another publication, currently under preparation.

3. Legal regulations regarding mines decommissioning – evolution in Germany 1980–2024

In both Poland and Germany, lignite is a significant component of the energy mix. Due to prevailing environmental policies, most lignite mines and lignite-fired power plants in these countries are expected to close within the next decade or so. Therefore, the legal regulations regarding the liquidation of mines in Germany are first characterized. Next, it is necessary to analyze some similarities and main differences in the applicable legal provisions of the two largest lignite producers in the EU, i.e., Germany and Poland.

The mine closure plan is an integral part of the overall mine operation planning process. In Germany, as in Poland, before obtaining a concession for the exploitation of a mineral, a plan for the future liquidation of the mine must be presented. The Federal Mining Law, in its current form, has been in force in Germany since 1980 (BBG 1980). It was amended several times, but its main shape remained unchanged. In Poland, following the fall of the

communist system in 1989, the first Geological and Mining Law was enacted, addressing the needs of the free market (Pigig 1994). It was systematically amended, and the most important changes were introduced by the Act of 2011 (Pigig 2011). In the course of legislative work systematically introduced by the EU, changes were made to the regulations of member states concerning, among other things, the Environmental Impact Assessment procedure. Gradually, public participation in the process of planning and liquidation of mines also increased.

The planning process of mining projects in Germany takes place on two levels – spatial and mining (Figure 1). Due to the specific nature of large-scale lignite mining and its role in the German economy, special legal tools have been created to regulate this process. For example, the reclamation and development of post-mining areas are subject to the provisions of the Federal Mining Act (BBG 1980), which requires the preparation of a frame operation plan and a mine closure operation plan. Its Polish equivalent is the deposit development plan. The mentioned frame operation plan must be consistent with the provisions of the lignite plan, particularly in relation to active mines and the reclamation plan, where mining has already been completed. The lignite plan and the reclamation plan, as instruments of spatial planning, belong to the regional planning system and are regulated separately for each land by an appropriate Spatial Planning Act (e.g., LPIG NW 2005; RegBkPIG 2012).

In German lands where lignite mining plays a significant role, such as Brandenburg or North Rhine-Westphalia, a Lignite Committee is established (Figure 1). This body presides over the planning process and makes decisions on contentious issues (RegBkPIG 2012; LPIG NW 2005). The Lignite Committee consists of elected representatives from private companies and towns/cities covered by the plan, representatives of craft and industry chambers, trade unions, agricultural unions, the Lusatian minority (in Brandenburg), nature protection organizations, and the Evangelical Church, all of whom have equal voting rights. It should be emphasized that the above-mentioned acts (RegBkPIG 2012; LPIG NW 2005) exclude persons who are direct beneficiaries of lignite mining from the membership of this committee. In summary, the Lignite Committee establishes regional or specific subcommittees and working groups to help shape views on local issues related to lignite mining in Germany.

The mine closure operation plan differs from the frame operational plan (Figure 1). Simply put, the first one covers the final stage of mine operation in a given area. On average, it lasts 15 years, depending on the specific case involved. Before a project is approved, it is mandatory to conduct an environmental impact assessment. This process is carried out with the participation of stakeholders whose well-being may be impacted by the project's provisions. Then, the State Mining Office sends the prepared preliminary project to the relevant communes and offices, taking into account the project's scope, and sets a deadline for submitting applications and comments (Figure 1).

Naturally, the obligation to close a mine, including its reclamation and to eliminate the long-term effects of exploitation rests with the mining company – this follows from the principle of causality. The condition for the approval of the frame operation plan and

the mine closure operation plan by the State Mining Office is the creation of security for these purposes. In Germany, a mining company is subject to the general regulations set out in applicable commercial law and accounting rules. Hence, provisions must be made for liquidation liabilities, which are theoretically secured by the company's assets. This is based on the provisions of the German Commercial Code regarding “unknown obligations towards third parties” (§ 249 in: HGB, 1897).

Currently, in view of the planned closure of lignite mines in Germany by 2038, a heated discussion is underway in the public sphere. The question arises as to whether the presented legal instruments, which in practice have the nature of accounting entries, will prove sufficient to meet the aforementioned needs. Doubts arise both about the accuracy of the estimates and the sufficiency of the financial resources that companies can allocate to the liquidation of

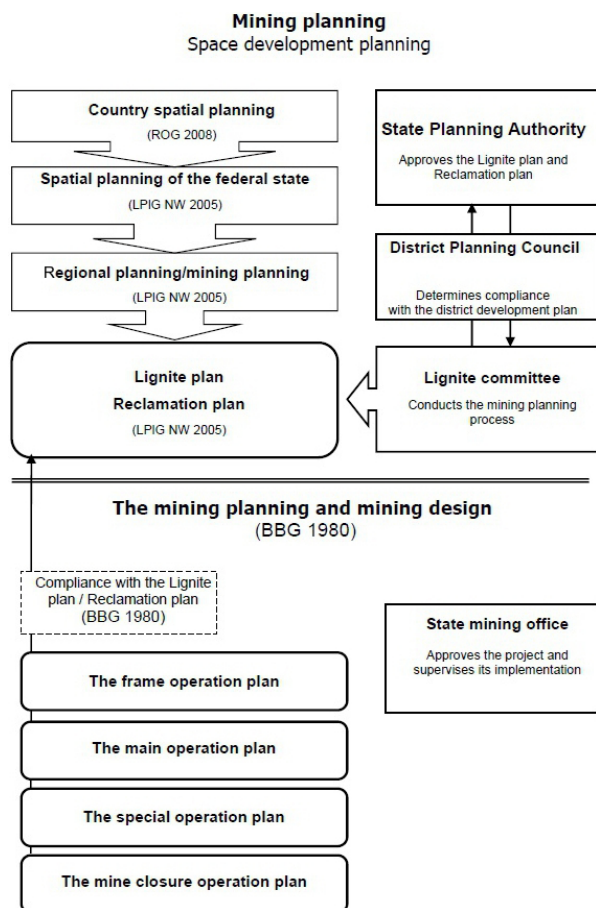


Fig. 1. Diagram of the planning process for lignite mining projects at the planning and mining level in the Rhine Basin (ROG 2008; BBG 1980; LPIG NW 2005)

Rys. 1. Schemat procesu planowania przedsięwzięć górniczych na płaszczyźnie planistycznej i górniczej w Zagłębiu Nadreńskim

lignite mines. This is because the mines are actually run by corporations primarily engaged in conventional electricity production. Their profits are negatively impacted by rising operating costs, mainly due to the EU Emissions Trading System (EU ETS). In the case of the largest energy producer (RWE Power joint stock company) in Germany, the liabilities related to the closure of mines overlap with the costs of decommissioning nuclear power plants. As a result, there are justified concerns that the costs of eliminating the effects of lignite mining will be passed on to German society (Wronski et al. 2016; Schrems and Fiedler 2022).

4. Legal regulations regarding mines decommissioning – evolution in Poland 2001–2024

After 1945, Polish mining legislation failed to address the economic and financial challenges associated with mine closures despite the fact that lignite mines, both underground and opencast, had already begun to close in the 1950s. The costs of decommissioning the above-mentioned mines were relatively low at the time and were incurred by the communist-type enterprises operating under the country's centrally planned economy. Only in 1982, just before the economic and social transformation in Poland (in 1989), were these costs regulated within the framework of the principles of financial management for state-owned enterprises. Legal regulations governing the financial management of state-owned enterprises were included in the Act of February 26, 1982, and supplementary regulations – a consolidated text (Financial Management of State-Owned Enterprises 1986). According to these regulations, enterprises extracting minerals using the opencast or borehole method, whose activities involve the creation of heaps or dumps or land degradation, may establish a reclamation fund from surcharges on operating costs. Unfortunately, only one ministry (Chemical and Light Industry) used this instrument. It was defined that the fund could be used for the following purposes:

- ◆ covering the costs of mine decommissioning and securing them;
- ◆ financing projects aimed at the development of post-mining areas and heaps/dumps.

One of the first decisions made in 1989 by the first free-market Polish government after the fall of communism was to reduce the number of special-purpose funds. This concerned two funds operating in the mining industry: the Mining Damage Fund and the Reclamation Fund, which were abolished. As a consequence, the costs of mines closed before the implementation of the new solution were covered primarily by the State Treasury. This approach was applied mainly to the Lower Silesian Coal Basin, the Tarnobrzeg Sulfur Basin, and the Upper Silesian Coal Basin. In the first two basins, mining activity has been completely halted, and in the third, complex coal extraction is still ongoing, albeit in a few underground mines. The funds needed for this purpose were guaranteed in the National Budget Act and supplemented by grants and loans from the National Fund for Environmental Protection and Water Management, as well as foreign

loans and grants. However, it quickly became apparent that the law in force during the first years of transformation (i.e., in the 1990s) did not sufficiently regulate the process of mine liquidation, leaving the state as the sole party responsible for the necessary actions (Uberman and Uberman 2010).

The aforementioned problem was noticed, but for many years, there was a lack of systematic regulations. However, on December 9, 1991, the Minister of Finance issued a notice on the Act of January 31, 1989, on the financial management of state-owned enterprises. It was indicated that the possibility of establishing a liquidation fund was reflected in Article 9 of this Act: “Enterprises extracting minerals using the opencast method and other enterprises conducting economic activity accompanied by the formation of heaps or land degradation. They can create a reclamation fund from surcharges on operating costs. The fund’s resources are allocated to the financing of non-investment projects aimed at the development of post-mining areas and heaps”. On March 9, 1991, the Act amending the Mining Law was passed (Mining Law, 1991). It specified requirements concerning the obligations of an entrepreneur in the event of a mine closure. Article 12f (item 2) of this Act stated that the application for a concession should be accompanied by proposals for the protection of the natural environment and the method of restoring its original state after the end of mineral extraction, including the method of financing such projects. The general definition of requirements, without specifying the rules for collecting funds for a mine liquidation, meant that these provisions were rarely applied in practice. This gap was to be filled by later regulation, namely the Act of February 4, 1994 (Pgis 1994). Article 17 indicates the possibility of requesting financial security in the event of claims that may arise as a result of the exploitation specified in the concession. However, the use of funds to cover the entrepreneur’s obligations in the event of mine liquidation was possible only in justified cases, and establishing financial security was not obligatory. Moreover, the application of this provision in practice was practically impossible due to the lack of implementation regulations regulating the functioning of the financial security fund (Uberman and Uberman 2010).

The new Constitution of the Republic of Poland of April 2, 1997, adopted after the fall of communism, created a new basis for legal regulations concerning the closure of mines (Constitution 1997). According to Article 5, “The Republic of Poland (...) ensures the protection of the environment, guided by the principle of sustainable development.” While Article 68(4) emphasizes that “Public authorities must (...) prevent negative effects of environmental degradation”. This is in line with Article 86, which expands this obligation to all citizens: “Everyone is obliged to care for the state of the environment and is responsible for its deterioration”. The provisions presented above shifted the burden of mine closure regulations to issues of sustainable development and environmental protection. It is worth noting here that mineral deposits themselves are considered a component of the natural environment that deserves specific protection. In 2001, a new Environmental Protection Law came into force (Poś 2001). It defines the principles of environmental protection and the conditions for using its resources, as well as a number of basic concepts important from the point of view of closing mines, including:

1. Environmental compensation – a set of activities including, in particular, earthworks, soil reclamation, and afforestation leading to the restoration of the environmental balance of the site; compensation for the damage caused to the environment through the implementation of the project and the preservation of landscape values.
2. Environmental protection – taking or refraining from actions aimed at maintaining or restoring the natural balance; in particular, it consists of:
 - ◆ rational use of the environment and management of its resources in accordance with the principle of sustainable development,
 - ◆ pollution prevention,
 - ◆ restoring natural elements to their proper state.
3. Natural balance – a state in which there is a balance in the interaction of humans, the components of living nature, and the system of habitat conditions created by the components of inanimate nature.
4. Sustainable development – socio-economic development in which the process of integrating political, economic, and social activities while respecting the sustainability of basic natural processes, in particular with a view to ensuring that basic needs can be met by communities or citizens of both present and future generations (Mróz 2015).

The first attempt at a systemic approach to securing financing for mine liquidations was undertaken on November 26, 1998, with the enactment of the Act on the Adaptation of Hard Coal Mining (1998). This Act concerned the adaptation of hard coal mining (as well as other forms of mining activity) to the operation in the conditions of a market economy and the specific rights and tasks of mining communes. Article 17 included an order to establish a mine liquidation fund from January 1, 2000, to which the equivalent of 3–10% of the depreciation write-offs of each mine was to be transferred. In general, the above-mentioned provisions were temporary, as they expired on December 31, 2002 (Uberman and Uberman 2010). However, they were in effect until 2015, specifically in the case of the liquidation of hard coal mines, which is not the subject of this article.

New regulations concerning the issue of mine closure for the entire Polish mining industry, including the collection of funds for this purpose, were introduced in the Act of July 27, 2001, amending the Geological and Mining Law (Dz.U. 2001). These provisions (Article 26c) concerned entrepreneurs who obtained a concession for the extraction of minerals from deposits and for the non-reservoir storage of substances, as well as the storage of waste in the rock mass, including works in underground mines. The wording of point 5 in Article 80 has been changed, specifying the obligations of the entrepreneur, who must: “take the necessary measures to protect the environment and to reclaim land and develop areas after mining activities”.

The change in wording of point 5 in Article 80 was implanted to define the entrepreneur’s obligations as follows: “take the necessary measures to protect the environment and rehabilitate land and develop areas after mining activity”. In turn, Article 26c, paragraph 2, point 2 specifies the rules for calculating the contribution to the mine liquidation fund in the following way:

- ◆ an entrepreneur extracting minerals using an underground or borehole system, conducting non-reservoir storage of substances, or storing waste in the rock mass, including works in underground mines, was obligated to allocate to the fund the equivalent of 3% to 10% of depreciation write-offs on fixed assets of the mining plant determined in accordance with the income tax regulations;
- ◆ an entrepreneur extracting minerals using the opencast method (e.g., lignite) was obliged to pay the equivalent of 10% of the exploitation fee to the fund (Uberman and Uberman 2010, 2015).

The funds specified in the above amount were to be collected by the entrepreneur in a separate bank account for each mine. If a single company operated several mines, a separate bank account would need to be maintained for each of them. Finally, contributions to the mine closure fund were defined as tax-deductible costs. The introduction of obligatory funds for mine closure was a desirable solution, although not entirely satisfactory. Simply put, it did not always ensure the implementation of the entire mine closure project. Due to this, many doubts have arisen regarding some specific solutions.

It should be noted that the regulations clearly state that the liquidation fund applies to the mine, not the entire complex around it. The mine does not include many of the mine's technical infrastructure facilities, e.g., administrative and social buildings, warehouses, workshops, parking lots, water and sewage networks, etc. In some mines, the mine objects do not include processing plants, dumps, or storage areas. One of the most important problems is the principle of calculating contributions to funds. There is no direct connection between the exploitation fee (in the case of opencast mines) or depreciation (in other cases) and decommissioning expenses. There was also a reservation about the requirement to create separate funds for each mine, which, in the case of opencast mines (enterprises grouping several, sometimes small, mines), increases the costs of operating the fund and prevents the freedom of its use within the enterprise.

Article 17 of the Geological and Mining Law (Pgig 2001) authorizes the government to establish additional security regarding liabilities that may arise from activities covered by the concession. This is a separate legal instrument from the decommissioning fund discussed above. It is also designed to handle a broader range of liabilities, including those arising not only from mine closure (which is defined as an exceptional purpose) but also from ongoing operations such as noise generation. The form and amount of the guarantee are specified in the concession. It should be noted here that the establishment of claims is not obligatory in every case, as evidenced by the wording of Article 17, section 1: “granting a concession may depend on establishing a warranty for claims...”. However, this provision is quite rarely used in practice, so it has little significance as a source of financing for decommissioning works (Uberman 2019).

The latest Geological and Mining Law was adopted in 2011 (Pgig 2011, No. 163, item 981). It introduced two significant changes in the mine liquidation process. This Act specifies that “the fund's financial means may also be collected in the form of treasury bills or bonds issued or guaranteed by the State Treasury” (sec. V, art. 128 p. 2). Previous regulations only

allowed the use of bank accounts, the profitability of which was and still is very low. It is necessary to emphasize that, in the case of the fund's resources, they are usually frozen for a very long period. Therefore, a safe investment is to buy treasury bonds with the longest maturity, i.e., the most profitable. They often allow for almost complete protection of the accumulated funds from the negative effects of inflation.

On the other hand, a potentially more serious problem relates to the value of installments paid to the fund. They should amount to at least 10% of the exploitation fee. Unfortunately, apart from the introduction of the statement “not less than 10%”, there is no direct indication of how to determine the correct amount to be paid. However, the purposive interpretation of the applicable regulations clearly indicates that this amount should be sufficient to finance all decommissioning works after the end of the mine's operation. The value of contributions to the liquidation fund should be calculated in accordance with the fundamental principles of financial science. Thus, the value of means accumulated in the fund account at the time of the expected end of exploitation should have been equal to the value of the expected amount of expenses related to mine liquidation, updated on the same day (Jarosz 2009; Kaźmierczak et al. 2015).

Closure financing should be derived from the accumulation of set-aside capital (reserves) during the production phase. However, the cost of decommissioning is then unknown. It becomes evident very late when production is nearing its end, and the associated benefits are low. Consequently, in a period when closure financing should be secured, mining enterprises are not obliged to estimate the value to be secured. The only exception is made by entities obliged to apply International Financial Reporting Standards (IFRS), which have to disclose the full value of decommissioning liabilities in their accounts and thus need to estimate their value at the earliest stage. The solution adopted by Polish regulations detached the value of contribution to the only financial security instrument in place (Obligatory Mine Decommissioning Fund – FLZG) from estimated decommissioning expenditures while linking it to the exploitation charge (in the case of opencast mines). Financial means accumulated in this manner, even if payments to the funds are made for the entire exploitation period, are, in the case of lignite mines, nowhere near real needs. This also refers to entities under IFRS, as they are not required to provide any additional warranties regarding decommissioning expenditures, relying entirely on a given company's financial credibility. Therefore, it can be stated that the existing regulations in Poland do not provide for a meaningful warranty of financial sources for mine closures, leaving this area nearly exclusively to the ability of mining enterprises.

5. Polish lignite mining sector as a subject of decommissioning regulations

Lignite extraction in Poland has evolved to approximately 50 million tons (Mt) per year. Due to the systematically growing share of renewable energy in the national energy system,

lignite mining is showing a decreasing tendency. In 2023, Polish lignite production totaled 57.7 Mt (Widera et al. 2024a), and by 2024, it had decreased to 42.5 Mt (PIG 2023; Naworyta and Urbański 2025). Germany remains the largest producer of lignite in the EU. This is confirmed by the fact that in 2023, a total of 102 Mt of lignite was mined in Germany, of which over 90% was used to produce electricity (DEBRIV 2024). In addition to the two leaders in lignite mining in the EU (i.e., Germany and Poland), it is also exploited in several other EU member states. According to data from 2022, lignite was mined in Bulgaria – 35.5 Mt, the Czech Republic – 33.4 Mt, Romania – 18.2 Mt, Greece – 14.3 Mt, Hungary – 4.9 Mt, Slovenia – 2.4 Mt and Slovakia – 0.87 Mt (Eurocoal 2024).

Lignite mining has a long tradition in what is now Poland. Its organized exploitation began in the mid-19th century and industrial exploitation in the early 20th century in what was then Germany. After World War II, lignite mining developed rapidly, driven by the demand for electricity. The previously existing Turów, Konin, and Sieniawa mines were expanded, and new Adamów and Bełchatów (one of the largest in Europe) mines were built. Over the last nearly 80 years, lignite has been the primary source of electricity in Poland, second only to hard coal, with a share of over 35% in the late 1980s, falling to 21% in 2023. To meet the needs of the energy industry, as much as 42–73 million tonnes of lignite were mined annually (e.g., Widera 2021; Naworyta and Urbański 2025).

Poland is very rich in lignite deposits (PIG 2023). Over 150 large and small deposits have been documented in central and southwestern Poland. Ninety-one of them are registered by the Polish Geological Institute as extractable and profitable. Their total proven extractable resources (geological resources) have been calculated at approx. 23.1 Bt. However, in currently exploited deposits (economic resources), they amounted to slightly over 900 Mt, which would allow for 20 years of further extraction (PIG 2023).

At the beginning of 2025, four lignite mines in Poland were operational, namely Bełchatów, Turów, Sieniawa, and Konin. The first two of these mines account for close to 95% of total lignite production (more than 40 Mt), while Sieniawa (more than 1 Mt) and Konin (close to closure – less than 1 Mt) currently play a supplementary role (Kasztelewicz et al. 2025). They supply only three lignite-fired power plants: Bełchatów, Turów, and Pątnów. In the case of lignite from the Sieniawa Lignite Mine, a significant portion of it is first transported and then burned in the Pątnów power plant near Konin, located over 230 km away (Frydrychowicz et al. 2024; Widera et al. 2024a, 2024b; Kasztelewicz et al. 2025). The total installed capacity of these power plants is 8,201 MW, with details as follows: 1,118 MW – Pątnów, 1,981 MW – Turów, and 5,102 MW – Bełchatów (Naworyta 2022; Naworyta and Urbański 2025). It is worth noting that the Bełchatów energy complex is among the top polluters in the EU, particularly due to its CO₂ emissions into the atmosphere.

The decommissioning regulations presented above were introduced at a time when the Polish lignite mining sector was approaching a phase of decline. Although lignite production remained at a high level of over 60 million tonnes until 2018, the implementation of new investment projects was subsequently suspended. In the 21st century, no mine has been built

on previously undeveloped lignite basins or regions in Poland. However, there were intense discussions about a project, for example, the exploitation of lignite from the Gubin deposit (near the border with Germany), which was ultimately abandoned. At the same time, in the lignite-based energy sector, only a few projects of modernization rather than development nature were implemented (Pronobis 2023; Widera et al. 2024b).

Table 1. Estimated contribution of the Polish lignite sector to decommissioning funds (FLZG) in the years 2002–2023

Tabela 1. Szacunkowy wkład polskiego sektora węgla brunatnego w fundusze likwidacyjne (FLZG) w latach 2002–2023

Year	Lignite production (Mt)	Contribution to the FLZG (M PLN)	Minimal payment to the FLZG (PLN/t)	Exploitation charge (PLN/t)
2002	58.24	7.63	0.131	1.31
2003	60.92	7.98	0.131	1.31
2004	61.19	8.57	0.140	1.40
2005	61.61	8.63	0.140	1.40
2006	60.85	9.19	0.151	1.51
2007	57.71	8.71	0.151	1.51
2008	59.50	9.16	0.154	1.54
2009	57.06	8.90	0.156	1.56
2010	56.52	9.38	0.166	1.66
2011	62.89	10.44	0.166	1.66
2012	64.30	10.67	0.166	1.66
2013	66.14	11.31	0.171	1.71
2014	64.00	11.26	0.176	1.76
2015	63.14	11.43	0.181	1.81
2016	60.27	11.09	0.184	1.84
2017	63.06	11.86	0.188	1.88
2018	61.14	11.68	0.191	1.91
2019	52.85	10.36	0.196	1.96
2020	47.00	9.45	0.201	2.01
2021	54.85	11.35	0.207	2.07
2022	57.68	12.46	0.216	2.16
2023	42.51	9.52	0.224	2.24
Total	1,293.42	221.03	–	–

Own calculations based on data from the Polish Geological Institute (PIG 2024)

Between 2002 and 2023, approximately 1.3 billion metric tons of lignite were mined. Taking into account the applicable levels of exploitation charges and assuming their 10% share in the FLZG, it can be estimated that the amount collected was 221 million PLN (Table 1). Adding up nominal payments over such a long period is usually considered biased, as it does not allow for drawing meaningful conclusions. In this particular case, however, it does provide some useful information. Inflation was relatively low for most of this period, but it began to rise around 2020, prompting banks to offer higher interest rates. Another issue is the incomplete use of funds allocated for the closure of mines in the period in question.

Summarizing the above circumstances, it can be assumed that at the end of 2023, the Polish lignite mining sector had accumulated a total of approximately 200–250 M PLN in decommissioning funds. This value should be compared to closing expenses. As an indication (without disclosing confidential information), it can be stated that in the case of one of the smallest mines, the investment is in the range of 1.0–1.5 B PLN. So, they were five to seven times greater than the funds collected by the entire lignite sector (Table 1). It is, therefore, absolutely clear that in the case of Polish lignite mining, the FLZG regulations have not fulfilled their purpose. The funds collected therein are so small in relation to the needs. Thus, the financing of the mine closure processes has been secured by funds from other sources to date.

The above-mentioned insufficient financing of the FLZG results from the late introduction of appropriate legal regulations. For example, the period of paying mandatory contributions (i.e., exploitations charges) will cover at most 30% of the total time of lignite extraction in the Turów mine, assuming 1904 as the year of its commencement and the planned 2044 as the year of its closure. Of course, the difference is too big to be covered by extending the contribution period. Even if individual opencasts are analyzed, e.g., the Józwin IIB opencast in the Konin mine, revenues and expenses are still not balanced. Throughout the entire period of lignite mining in this opencast (2003–2023), contributions to the FLZG were mandatory and totaled slightly over 12 million PLN (Table 2). Unfortunately, this will only allow us to finance the liquidation of buildings and some elements of mining infrastructure, but there will be no funds for long-term reclamation works, including filling the opencast with water.

Conclusions with discussion

The Polish lignite mining sector is a notable example of legal provisions governing mine closures. Our and future generations will have to face the consequences of lignite mine closure, as the process of closing the first mines is ongoing. In the Adamów mine, mining was completed in 2021, and in the Konin mine, mining will most likely end in 2026–2027. In turn, around 2040, lignite extraction is expected to end in the Bełchatów and Turów mines.

Table 2. Contributions to the decommissioning funds (FLZG) made by the mine/opencast in the years 2002–2023

Tabela 2. Wpłaty kopalni/odkrywki na Fundusz Likwidacji Zakładu Górniczego (FLZG) w latach 2002–2023

Year	Bełchatów (1980–)		Szczerców (2009–)		Turów (1947–)		Adamów* (1964–2021)	
	lignite production (Mt)	contri- bution to the FLZG (M PLN)	lignite production (Mt)	contri- bution to the FLZG (M PLN)	lignite production (Mt)	contri- bution to the FLZG (M PLN)	lignite production (Mt)	contri- bution to the FLZG (M PLN)
2002	34.008	4.46	–	–	8.724	1.14	4.714	0.62
2003	34.564	4.53	–	–	10.099	1.32	4.543	0.60
2004	35.233	4.93	–	–	10.824	1.52	4.412	0.62
2005	35.225	4.93	–	–	11.913	1.67	4.477	0.63
2006	32.988	4.98	–	–	12.158	1.84	4.907	0.74
2007	30.923	4.67	–	–	11.522	1.74	4.970	0.75
2008	32.906	5.07	–	–	12.104	1.86	4.431	0.68
2009	31.772	4.96	0.267	0.04	11.013	1.72	4.414	0.69
2010	25.040	4.16	7.858	1.30	10.276	1.71	4.418	0.73
2011	25.013	4.15	13.560	2.25	10.418	1.73	4.560	0.76
2012	29.187	4.85	10.974	1.82	10.335	1.72	3.612	0.60
2013	32.939	5.63	9.115	1.56	9.549	1.63	4.266	0.73
2014	26.637	4.69	15.756	2.77	7.728	1.36	4.416	0.78
2015	25.053	4.53	17.028	3.08	7.328	1.33	4.292	0.78
2016	16.235	2.99	23.935	4.40	7.533	1.39	3.453	0.64
2017	16.734	3.15	27.805	5.23	6.869	1.29	2.939	0.55
2018	12.180	2.33	34.644	6.62	6.593	1.26	0.796	0.15
2019	4.374	0.86	36.414	7.14	5.018	0.98	0.895	0.18
2020	2.538	0.51	33.360	6.71	5.067	1.02	0.715	0.14
2021	2.889	0.60	37.953	7.86	8.827	1.83	0.060	0.01
2022	3.524	0.76	40.735	8.80	9.881	2.13	–	–
2023	2.139	0.48	30.867	6.91	7.799	1.75	–	–
Total	492.101	78.196	340.271	66.493	201.578	33.924	71.290	11.364

* In the case of the Adamów mine, all opencasts were presented together.

** In the case of the Konin mine, all opencasts were presented together.

Own calculations based on data from the Polish Geological Institute (PIG 2024)

Konin** (1945–)		Pątnów III (before 1960–2011)		Pątnów IV (2003–2023)		Sieniawa I (1950–2018)		Sieniawa II (2018–)	
lignite production (Mt)	contri- bution to the FLZG (M PLN)	lignite production (Mt)	contri- bution to the FLZG (M PLN)	lignite production (Mt)	contri- bution to the FLZG (M PLN)	lignite production (Mt)	contri- bution to the FLZG (M PLN)	lignite production (Mt)	contri- bution to the FLZG (M PLN)
3.472	0.45	7.306	0.96	–	–	0.013	0.00	–	–
3.455	0.45	8.016	1.05	0.210	0.03	0.035	0.00	–	–
3.839	0.54	3.512	0.49	3.327	0.47	0.039	0.01	–	–
3.220	0.45	4.664	0.65	2.072	0.29	0.041	0.01	–	–
4.598	0.69	4.636	0.70	1.487	0.22	0.072	0.01	–	–
3.859	0.58	2.847	0.43	3.517	0.53	0.067	0.01	–	–
3.339	0.51	2.655	0.41	3.932	0.61	0.133	0.02	–	–
2.565	0.40	1.879	0.29	4.986	0.78	0.165	0.03	–	–
2.925	0.49	2.561	0.43	3.287	0.55	0.150	0.02	–	–
2.442	0.41	0.624	0.10	6.181	1.03	0.090	0.01	–	–
3.897	0.65	–	–	6.220	1.03	0.072	0.01	–	–
4.349	0.74	–	–	5.808	0.99	0.113	0.02	–	–
4.007	0.71	–	–	5.351	0.94	0.107	0.02	–	–
3.777	0.68	–	–	5.584	1.01	0.073	0.01	–	–
3.861	0.71	–	–	5.187	0.95	0.070	0.01	–	–
4.202	0.79	–	–	4.428	0.83	0.084	0.02	–	–
3.648	0.70	–	–	3.171	0.61	0.061	0.01	0.050	0.01
3.642	0.71	–	–	2.214	0.43	–	–	0.296	0.06
3.521	0.71	–	–	1.585	0.32	–	–	0.213	0.04
3.544	0.73	–	–	1.219	0.25	–	–	0.359	0.07
2.210	0.48	–	–	0.797	0.17	–	–	0.531	0.11
0.477	0.11	–	–	0.467	0.10	–	–	0.763	0.17
74.849	12.694	38.700	5.512	71.030	12.146	1.385	0.228	2.212	0.47

In 2001, the first legal regulations were introduced in Poland, aimed at ensuring specific financial security for the liquidation processes of mines, including lignite ones. Only after more than 20 years of operation two significant shortcomings were identified. The first one relates to closure planning, which becomes fairly well-defined only towards the end of the exploitation phase. Then, it is too late to collect the funds necessary to close the mine. The second one concerns the financing of a mine closure, which should come from the accumulation of capital set aside (reserves) from the beginning of lignite production. However, the exact time of the end of exploitation is not known, and thus, the cost of liquidation is uncertain.

Mining companies are not obligated to estimate the value of funds secured in the event of their liquidation. The solution adopted in Polish regulations involves contributing to the Obligatory Mine Decommissioning Fund (FLZG), linked to the exploitation charge in the case of an opencast mine. The financial means accumulated in this way, even if payments to the FLZG are made for the entire period of mining operation, are far from the actual needs of a lignite mine. Therefore, the Polish government financially secured the process of closing mines by consolidating them with the lignite-fired electricity generation sector, effectively shifting the costs to other companies.

The effects of the interaction between lignite mining, especially lignite-fired power plants, and the natural environment meant that this industry became the primary area of interest for government intervention in the physical liquidation of lignite mines. The specific nature of decommissioning processes in the mining sector is often associated with the far-reaching and long-term impact of mining activities on the natural environment, as well as with the fact that the lifespan of each power plant is closely tied to the limited availability of non-renewable mineral resources.

Mining, including lignite mining, is not the only industry that has a negative impact on the environment. Steelworks, chemical plants, and large-scale agriculture, among others, can be equally harmful. On the other hand, depletion of mineral resources (e.g., lignite deposits) is rarely a reason for mine closure. Mining usually ends due to a combination of factors such as market changes or technological advances. In recent decades, Polish governments have slowly begun to realize this. Therefore, the best example here is nuclear power plants, which are intended to replace coal- or lignite-fired power plants that are being closed in the future.

Finally, closing the hard coal and lignite sector means that Poland is currently planning to build 6 nuclear power plants. As the experience from lignite mining presented in this paper shows, appropriate mechanisms should be created now to secure financial resources for the entire process of closing nuclear power plants. Indeed, it must recognize a few significant differences, such as the issue of used fuel cells or a difference in the market value of reclaimed land. However, without precise and enforceable legal regulations in this area, the development of the Polish economy will not be sustainable. The costs of closing nuclear power plants must be financed from the profits made during their operation. Otherwise, the costs of their liquidation will be borne by future generations, as is the case with Polish lignite mines.

The authors wish to thank two anonymous reviewers and the Gospodarka Surowcami Mineralnymi – Mineral Resources Management editors for their helpful suggestions and corrections that contributed to improving the quality of the article.

The Authors have no conflict of interest to declare.

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**DECOMMISSIONING OF LIGNITE MINES IN POLAND –
LEGAL REGULATIONS REGARDING ASSURANCE OF FINANCIAL MEANS**

Keywords

mineral resources, lignite mines, mining project life-cycle management,
managing a mine closure process, nuclear plants

Abstract

This article presents the evolution of legal regulations, which have played a key role in enforcing the obligation of planned mine closure. Particular attention is paid to ensuring financial resources for this purpose. Any legal regulations, in order to be effective, must provide for the necessary funds, which should be collected before the commencement of the closure process. It is difficult to determine its exact time frame and costs, which makes the task highly challenging to decision-making bodies. There is a need to match uncertain, distant expenses with precise legal provisions. The example of Polish lignite mining shows the effectiveness of decommissioning regulations. Not only will we face the effects of its closure, but also the next generation will. Unfortunately, it was not until 2001 that regulations were introduced to provide financial security to support mine closures. However, they have shortcomings because the mine closure process is planned only at the final stage of extraction rather than being initiated much earlier. Therefore, the funds collected in the Obligatory Mine Decommissioning Fund (FLZG), usually 10% of the so-called exploitation charge, are insufficient. In the case of Polish mines, payments to the FLZG cover only part of the liquidation works. Administrative actions eliminate these negative effects of the legal regulations presented above. The Polish government has secured financing for the mine liquidation process by consolidating them with lignite-fired power plants. Currently, Poland plans to build six nuclear power plants. In their case, such a consolidation step will be impossible. Therefore, taking into account the experience from lignite mining, a financial mechanism for securing their decommissioning should be created now.

**LIKWIDACJA KOPALŃ WĘGLA BRUNATNEGO W POLSCE –
UREGULOWANIA PRAWNE DOTYCZĄCE ZABEZPIECZENIA ŹRÓDEŁ FINANSOWANIA**

Słowa kluczowe

zasoby mineralne, kopalnie węgla brunatnego, zarządzanie cyklem życia projektu górniczego,
zarządzanie procesem zamykania kopalń, elektrownie jądrowe

Streszczenie

W artykule przedstawiono ewolucję przepisów, które odgrywały ważną rolę w egzekwowaniu obowiązku likwidacji kopalń. Szczególną uwagę zwrócono na zapewnienie środków finansowych na ten cel. Wszelkie regulacje prawne, aby były skuteczne, muszą przewidywać mechanizm zgroma-

dzenia tych środków przed rozpoczęciem procesu likwidacji. Trudność dotyczy możliwości określenia jego dokładnych ram czasowych i finansowych, co sprawia, że zadanie to jest niezwykle trudne. Istnieje bowiem konieczność dopasowania niepewnych, odległych wydatków do precyzji wymaganej od przepisów prawa. Na przykładzie polskiego górnictwa węgla brunatnego przedstawiono efektywność omawianych regulacji. Nie tylko nasze, ale i kolejne pokolenie zmierzy się ze skutkami jego zamknięcia. Niestety, dopiero w 2001 roku wprowadzono szereg przepisów mających na celu zabezpieczenie finansowe likwidacji kopalń. Zasadniczą ich wadą jest to, że obowiązek szczegółowego planowania procesu likwidacji kopalni przypada dopiero na końcowy etap wydobywania, a nie dużo wcześniej. Dlatego środki zgromadzone w Funduszu Likwidacji Zakładu Górniczego (FLZG), zwykle gromadzone w wysokości 10% opłaty eksploatacyjnej, są niewystarczające. W przypadku polskich kopalń wpłaty do FLZG pokrywają tylko część kosztów prac likwidacyjnych. Te negatywne skutki przedstawionych powyżej luk prawnych są niwelowane przez działania administracyjne. Polski rząd zabezpieczył finansowanie procesu likwidacji kopalń poprzez ich konsolidację z elektrowniami opalanymi węglem brunatnym. Obecnie planowana jest w Polsce budowa 6 elektrowni jądrowych, w których przypadku takie postępowanie będzie niemożliwe. Dlatego już teraz, uwzględniając doświadczenie z górnictwa węgla brunatnego, należy stworzyć mechanizm finansowego zabezpieczenia ich likwidacji.

