Consolidation of Mining Enterprises as a Chance to Make the Polish Mining Industry Profitable

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Abstract

The aim of this article is to prove the eponymous thesis that the consolidation of mining enterprises and the integrated management system guarantee the profitability of the Polish mining industry. The evidence to validate this thesis includes the results provided by the post-optimal analysis developed as part of a production-rationalisation approach for the purposes of managing a coal company. Due to the broad scope of the issue, the paper presents one of several adjustments that would make it possible to adjust coal mine production and sales plans to real market situations both in terms of quantity and quality.

Keywords: optimisation, post-optimal analysis, consolidation

Introduction

It is in the national interest to have an effective and prosperous energy sector, to optimally utilise its resource base of primary energy carriers, and to ensure domestic energy security. For this reason, there should be no internal competition between the companies of the state's strategic sector, even though such are the conditions of the free market economy. Competition between mines or between formalised mine groups (companies and holding companies) is absurd, because they are state-owned enterprises having the same owner. As a shared national resource, coal is not there to generate competition. Competition only makes sense in regard to foreign coal (mines) or between private owners. The definition of competition as put forward by Stankiewicz states that competition is understood as a phenomenon where the participants compete with one another in pursuit of similar goals, which means that actions undertaken by some to achieve specific goals make it difficult (and sometimes even impossible) for others to attain the same goals [8]. A. Noga [7] perceives competition as an act or process of action of entities seeking to obtain benefits which are being pursued by others at the same time and under the same conditions and rules. The essence of this competition is to eliminate rivals operating in the same industry and to acquire their clients [7]. Thus, what competition actually means is rivalry, which should not take place between Polish mines. Quite the opposite, Polish mines should unite as one robust economic organisation.

This leads to the conclusion regarding the model of organisational operation of the mining sector. Managing the entire mining industry as if it were one enterprise offers a greater chance for its profitability, and, above all, for the profitability of individual mines. Under today's market conditions, if an unprofitable mine or a mine operating within a small group conducts its business single-handedly, it is on the road to liquidation. In turn, the liquidation of an enterprise which is the main employer in a commune or region generates long-term social costs. Therefore, all liquidation-related decisions should factor in the difference between the total of the social costs and the technical liquidation costs, and the total losses incurred due to unprofitable coal mining. Currently, Poland is not in a position to abandon coal, because 90% of its energy sector is coal-based, and because coal ensures Poland's energy security for many years to come. Replacing domestic energy sources with expensive renewable sources in an effort to fulfil the conditions of the EU climate and energy package takes time. Accordingly, all efforts should focus on streamlining management and ensuring more rational and environmentally friendly use of coal [2].

To prove the eponymous thesis, this article presents the research results provided by the post-optimal analysis performed by the author as part of a production-rationalisation approach for the purposes of managing a coal company [1, 3].

General description of the proposed approach

The developed production-rationalisation approach is a combination of the results of optimising coal production and sales programmes (using the SIMPLEX algorithm) with the algorithmically developed multi-aspect post-optimal analysis. The optimisation model developed and adapted to the conditions of a group of mines (companies) is as follows [1, 3]:

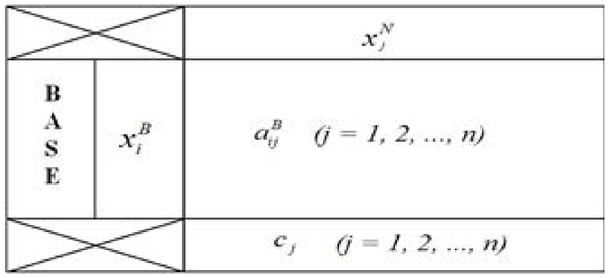

Fig. 1. The general form of the SIMPLEX table; Source: Own elaboration
Rys. 1. Ogólna postać tablicy SIMPLEX; Źródło: opracowanie własne

Objective function (quality coefficient):

$$F = \sum_{i=1}^{r_j}\sum_{j=1}^{p}\sum_{k=1}^{m_{ij}} (c_{ijk} - kjz_{ijk}) \cdot x_{ijk} - \sum_{j=1}^{p} Ks_j \rightarrow \max \qquad (1)$$

Constraints:

$$\sum_{i=1}^{r_j}\sum_{j=1}^{p}\sum_{k=1}^{m_{ij}} x_{ijk_n} \le Z_k \quad \text{for each k,} \qquad (2)$$

$$\sum_{i=1}^{r_j}\sum_{n=1}^{m_{ij}} x_{ijk_n} \cdot b_{ijk_n} \le Qs_j \quad \text{for each j,} \qquad (3)$$

$$\sum_{i=1}^{r_j} \beta_{ij} = 1 \quad \text{for each j,} \qquad (4)$$

$$x_{ijk} \ge 0 \qquad (5)$$

where:
c_{ijk} – price of the ij-type of coal accepted by the k demand group;
kz_{ijk} – unit variable cost of the i type of coal in the conditions of the j mine;
Ks_j – total fixed cost of production in the conditions of the j mine;
x_{ijk} – net production of the ij-type of coal accepted by the k_n demand group;
Z_k – demand of the k group of recipients;
Qs_j – total aggregate gross production of the j mine;
i – coal type index, i = 1, 2, ..., r_j,
j – mine index; j = 1, 2, ..., p,
k_n – demand group index; k = 1, 2, ..., m_{ij}, where m_{ij} means the size of the k_n set for ij type of coal;
b_{ij} – gross/net conversion factor;
β_{ij} – the share of the production of a given type of coal in the total gross production of the mine.

What is important is that in order to accurately reflect the phenomenon of underutilisation of the production capacities typical in market and competition conditions, in each case the criterion function must take into account the division of total costs into fixed and variable costs. Given the interests of any mining company operating in the current market conditions, the most appropriate and viable optimisation is one based on the profit criterion, as it allows the company to refrain from fully meeting the demand unless it is profitable. This can be formally factored in in the optimisation task by placing inequality constraints (2).

In the case of production optimisation in the mining industry, it would be warranted to use the cost minimisation function as a quality coefficient, which would require the placement of equality constraints regarding the demand (3). Hence, in the case of cost minimisation, the criterion function would be the following:

$$F = \sum_{i=1}^{r_j}\sum_{j=1}^{p}\sum_{k=1}^{m_{ij}} kjz_{ijk} \cdot x_{ijk} + \sum_{j=1}^{p} Ks_j \rightarrow \min \qquad (6)$$

The above model leads to a solution in the form of an annual optimal production plan for the company. Although formally optimal (in terms of the linear quality coefficient), the resulting solution does not necessarily have to be the most advantageous from the point of view of the company's interests. At this point, it is necessary to analyse the effects of the desirable optimal-plan adjustments that would make it possible to rationally revise the plan given the prevailing conditions. Adjustments to the optimal plan are made as part of the post-optimal analysis, which constitutes a multi-faceted tool allowing for the fulfilment of the practical conditions mentioned in [3] that are relevant from the decision-maker's point of view. The author confined himself to presenting the algorithm of the adjustment procedure (related to the subject of this publication) along with the numerical example of how the procedure can be used in practice.

The essence of the post-optimal analysis of the SIMPLEX algorithm solutions.

The starting point for the post-optimal analysis involves the optimal solution, namely the SIMPLEX final tableau (Fig. 1) containing the end-to-end set of balance equations and the coefficients of objective function sensitivity to changes in decision variables. The general form of the SIMPLEX tableau is shown in Figure 1.

The key to the figure is as follows:
a^B_{ij} – constraint coefficients forming the A matrix;
x^B, x^N – vectors of basic and nonbasic decision variables, respectively;
c – vector of objective-function coefficients (of shadow prices).

Tab. 1. Technical and economic coefficients for mines „A"- „G"; Source: Own elaboration
Tab. 1. Wskaźniki techniczno-ekonomiczne kopalń „A"-„G"; źródło: opracowanie własne

Specification	„A"	„B"	„C"	„D"	„E"	„F"	„G"
Max. Extraction [ton netto]	1,454,750	793,500	966,000	2,760,000	2,599,000	2,944,000	2,645,000
Average Extraction [ton/day]	5,500	3,000	4,200	12,000	11,300	12,800	11,500
Unit cost [PLN/ton]	131.2	139.4	132.68	136.5	137.2	138.3	134.4
Fixed cost [%]	69.51	72.22	68.95	73.4	71.31	69.37	69.38
The cost of drying [PLN/ton]	40.00	40.00	40.00	40.00	40.00	40.00	40.00
The cost of enriching [PLN/ton]	5.82	6.99	11.25	3.87	10.94	8.58	10.99

The formal starting point for the post-optimal analysis is, therefore, the optimal solution, which – in relation to the basic and nonbasic variables and the quality coefficient – is represented by the following equations [3]:

$$x^B = \left[A^B\right]^{-1} \cdot B - \left[A^B\right]^{-1} \cdot A^N \cdot x^N \quad (7)$$

$$J = c^{BT} \cdot \left[A^B\right]^{-1} \cdot B - [[c^{BT} \cdot \left[A^B\right]^{-1} \cdot A^N]^T - c^N]^T \cdot x^N \quad (8)$$

where:
A^B, A^N – submatrixes of the A matrix (A – matrix of the constraint coefficients);
B – vector of the right-hand sides of the equation;
c^B, c^N – subvectors of objective-function coefficients;
J – objective function (quality coefficient).
The post-optimal analysis will directly use the formulas obtained after substitutions and reductions [3]:

$$x^B = x^{BO} = x^{BO} - A^O \cdot x^N \quad (9)$$

and

$$J = J^O - c^{OT} \cdot x^N \quad (10)$$

where:
x^{BO} – vector of the optimal values of basic variables;
c^O – shadow prices of nonbasic variables, ≥ 0 for maximisation of the quality coefficient and negative for minimisation;
A^O – matrix of optimal-solution coefficients;
J^O – optimal value of the quality coefficient.

The post-optimal analysis can be used to change selected decision variables while maintaining the feasibility of the solution, i.e. maintaining the positive values of all variables and taking into account their mutual relations expressed with the formula (9). As indicated by the relationship (10), the shadow prices can be used to estimate the economic effects of departing from the optimal solution as a result of an increase in nonbasic variables [3]. What is also important is that the adjustments of production plans can be made without having to solve the problem (start the optimisation procedure) again from the beginning, substantially reducing the calculation time.

Algorithm for the allocation of coal export sales between mines

The optimal coal production and sales plan adjustment involving the allocation of export sales between mines was devised in order to prove that such a solution is economically viable as it lowers the unit cost of extraction [4, 6]. This strategy is essentially similar to the "producer-recipient relation" adjustment [3].

From a computational point of view, the algorithm for allocating export sales to (a) mine(s) is produced by increasing the value of the nonbasic variable corresponding to the coal type accepted by the recipient (importer).

The balance relation between the nonbasic variable and basic variables based on the coefficients of a selected SIMPLEX tableau column is as follows:

$$x_i^B = \overline{x}_i^B + a_{ij}^O \cdot x_j^N \quad (11)$$

where: – a new adjusted value of the basic variable.

After adjusting the defined variable value x_j^N, the new basic variables will take the following form:

$$\overline{x}_i^B = x_i^B - a_{ij}^O \cdot x_j^N \quad (12)$$

The calculation procedure for the proposed strategy is as follows [3]:

1. From the system of equations (12), the one is chosen for which the quotient:

$$\frac{x_i^B}{a_{ik}^O} > 0 \quad (13)$$

is the smallest and positive. It is the maximum value by which it is possible to increase the nonbasic variable without exceeding the constraints of the model.

2. If the change is satisfactory to the decision maker, the required adjustment to the i basic variable is made by increasing the k nonbasic variable by the value $\frac{x_i^B}{a_{ik}^O}$ This yields a minimum decrease in the value of the quality coefficient. In the case of thus determined value of the nonbasic variable, the remaining values of the basic variables are calculated according to the formula (12), and the calculation procedure is completed.

Tab. 2. Optimal production plan after the correction of the „distribution of export sales mines”
Tab. 2. Optymalny plan produkcji po korekcie „rozdziału kopalniom ilości sprzedaży na eksport”

Company „Alpha”				
Max. Extraction: 15,949,350 ton		Profit: 336,470,277 PLN		
Sold: 11,423,865 ton		Company reserves: 1,975,083 ton		
Mine „A”				
Max. Extraction: 1,454,750 ton		Profit: 25,690,063 PLN		
Sold: 697,902 ton		Mine reserves: 0 ton		
Name of consumer group	Coal size grade	adjusted amount of sales [ton]	The basic amount of sales [ton]	Difference + increase – decrease [ton]
Dust kettles	fine coal I	264,764	264,764	0
Dust kettles	fine coal II	317,135	317,135	0
Grates 4	slurry	16,002	16,002	0
Export 7	cobble	100,000	0	100,000
Dumping coal	cobble	60,023	160,023	–100,000
Dumping coal	nut coal	21,821	21,821	0
Dumping coal	fine coal IIA	675,004	675,004	0
Mine „B”				
Max. Extraction: 793,500 ton		Profit: 29,945,649 PLN		
Sold: 312,673 ton		Mine reserves: 430,040 ton		
Name of consumer group	Coal size grade	adjusted amount of sales [ton]	The basic amount of sales [ton]	Difference + increase – decrease [ton]
Grates 3	fine coal II	112,673	112,673	0
Export 2	coaking coal	200,000	0	200,000
Dumping coal	coaking coal	50,787	250,787	–200,000
Mine „C”				
Max. Extraction: 1,110,900 ton		Profit: 49,931,963 PLN		
Sold: 996,546 ton		Mine reserves: 114,354 ton		
Name of consumer group	Coal size grade	adjusted amount of sales [ton]	The basic amount of sales [ton]	Difference + increase – decrease [ton]
Export 5	coaking coal	130,740	130,740	0
Coking plants 3	coaking coal	865,806	865,806	0
Mine „D”				
Max. Extraction: 3,174,000 ton		Profit: 76,964,349 PLN		
Sold: 1,823,055 ton		Mine reserves: 1,330,689 ton		
Name of consumer group	Coal size grade	adjusted amount of sales [ton]	The basic amount of sales [ton]	Difference + increase – decrease [ton]
Export 1	coaking coal	24,324	24,324	0
Export 2	coaking coal	87,359	287,359	–200,000
Export 3	coaking coal	233,299	233,299	0
Indv. consumers 2	cobble	40,512	40,512	0
Indv. consumers 3	fine coal IIA	703,929	703,929	0
Grates 3	fine coal II	9,207	9,207	0
Coking plants 2	coaking coal	78,136	78,136	0
Coking plants 1	coaking coal	598,899	398,899	200,000
Chamber grates 1	fine coal IIA	47,390	47,390	0
Dumping coal	fine coal I	20,256	20,256	0
Mine „E”				
Max. Extraction: 2,988,850 ton		Profit: 56,384,293 PLN		

Name of consumer group	Coal size grade	adjusted amount of sales [ton]	The basic amount of sales [ton]	Difference + increase – decrease [ton]
Export 2	coaking coal	32,877	32,877	0
Export 8	nut coal	38,855	38,855	0
Indv. consumers 2	cobble	115,197	215,197	100,000
Dust kettles	fine coal I	206,231	206,231	0
Dust kettles	fine coal IIA	1,545,235	1,545,235	0
Dust kettles	fine coal II	863,778	863,778	0
Grates 4	slurry	52,258	47,178	5,080
Chamber grates 2	slurry	3,377	3,377	0
Dumping coal	slurry	31,042	36,122	–5,080
Mine „F”				
Max. Extraction: 3,385,600 ton		Profit: 63,522,321 PLN		
Sold: 2,815,660 ton		Mine reserves: 0 ton		
Name of consumer group	Coal size grade	adjusted amount of sales [ton]	The basic amount of sales [ton]	Difference + increase – decrease [ton]
Export 7	cobble	75,551	175,551	–100,000
Export 8	nut coal II	51,881	51,881	0
Export 9	fine coal II	998,845	998,845	0
Indv. consumers 2	cobble	167,968	67,968	100,000
coking plants 1	coaking coal	51,240	251,240	–200,000
Dust kettles	fine coal I	243,520	243,520	0
Dust kettles	fine coal IIA	23,675	23,675	0
Dust kettles	fine coal II	1,202,980	1,202,980	0
Dumping coal	coaking coal	486,532	286,532	200,000
Dumping coal	nut coal	8,999	8,999	0
Dumping coal	slurry	74,409	74,409	0
Mine „G”				
Max. Extraction: 3,041,750 ton		Profit: 34,031,639 PLN		
Sold: 1,925,301 ton		Mine reserves: 0 ton		
Name of consumer group	Coal size grade	adjusted amount of sales [ton]	The basic amount of sales [ton]	Difference + increase – decrease [ton]
Export 7	cobble	62,570	62,570	0
Export 9	fine coal IIA	206,632	206,632	0
Indv. consumers 3	fine coal II	611,153	611,153	0
Dust kettles	fine coal IIA	12,155	12,155	0
Dust kettles	fine coal II	999,365	999,365	0
Chamber grates 2	fine coal II	33,426	33,426	0
Dumping coal	cobble	43,785	43,785	0
Dumping coal	nut coal	15,194	15,194	0
Dumping coal	coaking coal	1,057,470	1,057,470	0

Tab. 3. Profit/loss of company and mines (excerpt from optimal plan for coal production and sales [3])
Tab. 3. Zysk/strata spółki i kopalń (fragment optymalnego planu produkcji i sprzedaży węgla [3])

Specification	Profit/loss [PLN]
Company „Alpha”	336,570,099
Mine „A”	4,843,298
Mine „B”	−4,880,293
Mine „C”	49,931,963
Mine „D”	77,472,349
Mine „E”	76,118,501
Mine „F”	99,051,641
Mine „G”	34,031,639

The above value or the one assumed by the decision maker is used to increase the basic variable (sales) reflecting the relation between the mine and a specific recipient , and to adjust the remaining basic variables. If the decision-maker's goal is to link a specific recipient to a specific mine on an exclusive basis, then the condition of the mine being able to satisfy the recipient's demand both in terms of quantity and quality must be met. The decision-maker then has to weigh the resulting losses against the benefits provided by the above strategy.

Analysis of the possibilities for, and consequences of, adjusting the allocation of export sales volumes between mines

A case study involving a real-life coal company is presented to exemplify a selected optimal-plan adjustment. The name of this company and the names of its constituent mines have been changed intentionally. The analysed hard coal company "Alpha" comprises seven "A" – "G" mines, whose production capacities and technical and economic indicators are shown in Table 1 [3]. Due to space constraints, the extensive optimal production plan for the company has not been attached (for details, see paper [3]). The article confines itself to a numerical example of how the algorithm of the selected adjustment procedure can be applied in practice.

On the basis of the post-optimal analysis algorithm described above, the author decided to allow mines "A" and "B" to export coal. These mines have not been provided with this possibility in the optimal coal production and sales programme [3]. In light of the above, the "A" mine was allocated 100,000 tonnes of export sales, and the "B" mine - 200,000 tonnes. The optimal production plan for the mines resulting from the above-mentioned strategy is presented in Table 2.

Impact assessment for the assumed export sales adjustment

The applied adjustment of the allocation of export sales between mines has caused the following changes in comparison to the optimal plan [3]:

1. For the "A" mine, the inventory level on the dumping coal dropped by the volume of the allocated export sales. The mine has gained a new recipient called "Exports 7." In consequence, the profit of the mine increased by 530.4%, and the sales volume rose by 16.7%.

2. In the case of the "B" mine, the additional amount of sales for the new recipient called "Exports 2" came from the dumping coal. As a result of the assumed exports allocation, the sales increased by 177.5%, and the profit rose by 714%. The "B" mine has achieved a positive financial result. According to the optimal plan, the "B" mine was unprofitable (Table 3).

3. As for the "C" and "G" mines, the optimal plan remained unchanged.

4. The sales volume and production reserves in the "D" mine remained unchanged. The profit dropped by 0.66%, which was due to a decrease in the volume of coking coal sales for the "Exports 2" recipient by 200,000 tonnes and the reallocation of this volume to the "Coking plants 1" recipient.

5. In the case of the "E" mine, the coal sales to the " Indv. consumers 2" recipient fell by 3.4%, generating a production reserve of 100,000 tonnes. This resulted in a 25.9% drop in the profits of the mine.

6. Sales in the "F" mine decreased by 6.6%. This was caused by a 200,000 t drop in the volumes of coal sold to the "Coking plants 1" recipient. The unsold coal was transported to the dumping coal. Furthermore, the volume of sales to "Exports 7" decreased by 100,000 tonnes at the expense of increasing the coal sales to " Indv. consumers 2." Consequently, the profit of the mine decreased by 35.8%.

The company's profit earned owing to the applied adjustment fell by 0.04%; sales remained unchanged; production reserves increased by 5.3%. It should be noted that all mines proved to be profitable after the implementation of the above strategy. Turning the loss-making "B" mine into a profitable operation cost the company only PLN 99,882 PLN. This also proves that managing a group of mines brings much better financial results than managing a single mine. It can be assumed that if the entire mining sector was treated as a company (concern) and if Polish mines or coal companies competed only with foreign mines and not with one another, the mining industry could become profitable.

Summary

Based on the presented example, the obtained results prove that proper management of a group of mines can bring measurable benefits. If this measure was applied throughout the mining industry, the sector in question could become financially sound again. A centralised management system and the consolidation of mining enterprises could be a chance to make the Polish mining industry profitable.

Because the profitability of individual hard coal mines is currently highly varied, capital concentration and integrated management (holding companies or concerns) are the only solutions that can guarantee the highest efficiency of the industry [5].

Also, additional benefits could be obtained from the development of coal processing into liquid fuels, gas, and advanced organic chemicals [2].

Today, coal is Poland's cheapest domestic energy resource and should remain pivotal to our energy security. Preserving coal production should help to maintain employment not only in mines, but also in the whole spectrum of mining-related facilities and services.

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Literatura – References

1. Fuksa D.: Metoda oceny wpływu zmiennego zapotrzebowania odbiorców węgla kamiennego na efektywność funkcjonowania wielozakładowego przedsiębiorstwa górniczego. Wydawnictwo AGH, Kraków, 2012
2. Fuksa D.: Przyszłość polskiego węgla. Inżynieria Mineralna, z. 2 (38), Wyd. Polskiego Towarzystwa Przeróbki Kopalin, Kraków, 2016, s. 9–16
3. Fuksa D.: Racjonalizacja decyzji produkcyjnych w spółce węglowej z wykorzystaniem analizy postoptymalnej. Wydawnictwa AGH, Kraków, 2016
4. Fuksa D.: Wpływ uwarunkowań rynkowych na podejmowanie decyzji cenowych w kopalniach węgla kamiennego. Inżynieria Mineralna, z. , Wyd. Polskiego Towarzystwa Przeróbki Kopalin, Kraków, 2017, s.
5. Lisowski A.: Górnictwo węgla kamiennego w Polsce - krytyczna ocena sposobu przeprowadzenia rynkowej transformacji i dyskusja problemów wciąż oczekujących na rozwiązanie 2006–2013. Główny Instytut Górnictwa, Katowice 2013
6. Magda R.: Kierunki racjonalizacji jednostkowego kosztu produkcji w przedsiębiorstwie górniczym. Inżynieria Mineralna z. 2 (38), Wyd. Polskiego Towarzystwa Przeróbki Kopalin, Kraków, 2016, s. 145-152
7. Noga A.: Dominacja a efektywna konkurencja, SGH, Warszawa, 1993
8. Stankiewicz M. J.: Konkurencyjność przedsiębiorstwa [w:] Budowanie konkurencyjności przedsiębiorstwa w warunkach globalizacji, Dom Organizatora, Toruń, 2005

Konsolidacja przedsiębiorstw górniczych szansą na rentowność polskiego górnictwa

Celem niniejszego artykułu jest potwierdzenie postawionej w temacie tezy, że konsolidacja przedsiębiorstw górniczych i zintegrowany system zarządzania są gwarancją rentowności polskiego górnictwa. Dowodem na poparcie tej tezy są przedstawione wyniki uzyskane przez autora w oparciu o analizę postoptymalną opracowaną w ramach metody racjonalizacji decyzji produkcyjnych dla potrzeb zarządzania spółką węglową. Ze względu na obszerność zagadnienia przedstawiono jedną z kilku korekt pozwalających na dostosowanie planów produkcji i sprzedaży węgla kopalń do realnych sytuacji rynkowych, zarówno w sensie ilościowym jak i jakościowym.

Słowa kluczowe: optymalizacja, analiza postoptymalna, konsolidacja