Influence of structure and ownership of lignite opencast mine and power plant bilateral monopoly on its operation

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2006

Influence of structure and ownership of lignite opencast mine and power plant bilateral monopoly on its operation[1]

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ABSTRACT: Lignite mine and power plant can operate as two separate entities, two entities in one holding or joint venture and as the one vertically integrated energy producer. Each of these solutions has the influence on operation of this tandem including realization of its individual and joint objectives, price negotiation, transactional costs, irreversible investments (sunk costs), different access to information (asymmetric information), cooperation or rivalry, possibility of opportunistic behaviour and other threats, which can be used against the second side. An attempt has been made to show these problems from the point of view of economic effectiveness based on a bilateral monopoly (BM) model and game theory approach with usage of pit optimisation methods. Advantages and disadvantages of different solutions have been presented as well as rational incentives to vertical integration due to inherent conflict of individual and group rationality in BM. This conflict of interest can lead to Pareto sub optimal solution in case of lack of cooperation between both sides. Concentration on lignite price can lead to waste of potential profit and decrease of mineable reserves - excavation of smaller pit, which is optimal only to the mine but not to the whole BM.

1 ORGANIZATIONAL AND OWNERSHIP STRUCTURES OF BILATERAL MONOPOLY

Lignite mines and power plants can operate as:

I. two separate entities (having the same or different owners),
II. two entities operating in one holding (with joint owner) or as a joint venture and
III. the one vertically integrated energy producer.

We can find in Poland, now or in the past, examples of almost all listed solutions. In the first category there used to be pairs of separate firms: lignite mines and power plants having the same owner – the state treasure. Lignite prices in the past were regulated or confirmed by the President of The Energy Regulatory Office, so the freedom of economic decisions was restricted (Jurdziak, 2005a). Now after freeing of lignite prices (since the 1st of January 2003) still exists two pairs of separate entities, which belong to different owners (to a certain extent). There are KWB “Adamow “ SA and KWB “Konin” SA (owned in 100% by the state treasure) and ZE PAK SA which is owned (in 41.8%) by private investor, employees (8.2%) and the state treasure (50%). Two left pairs of mine and power plant are a part of the state owned holding BOT “Gornictwo i energetyka” SA created on the 9th of March 2004 which has 69% shares in mines and power plants “Belchatow” and “Turow” and one power plant “Opole” (burning hard coal). According to Polish law such holding structure implicates that mines and power plants are associated enterprises what put additional obligation on such entities regarding selecting and reporting of transfer prices (inter-company pricing) in transaction between them (Jurdziak, 2006c). There is not any example of the vertically integrated lignite based energy producer in Poland but the RWE Rheinbraun from Germany can be a good example. In this firm integration of mines and power plants is so close that management resigned from lignite price at all and treats the mine as a cost centre in the value chain of energy production. It will be shown that such solution restricts optimisation of the mine and the whole BM.

Since the 1.01.2003 lignite prices can be freely negotiated between power plants and mines (Jurdziak, 2005a). This new situation should open the area of research and analysis of BM operation and the role of lignite price in relation of both sides on a free market. Freeing of lignite prices is a part of electric energy market liberalization plan and has created the new situation for several entities on this market. In Poland about 40% of electric energy is produced from burning lignite so it is important to analyze this new

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[1] **Proceedings of the Fifteenth International Symposium on Mine Planning and Equipment Selection MPES/06. Ed. by M. Cardu [et al.]. Torino, Italy, 20-22 September, [Vol. 1. Galliate, (NO): FIORDO 2006] s. 26-31.**

situation. It is especially important due to several decisions dealing with privatisation and reorganization is taken before any economic analysis is done or model created in order to find out the best solution.

2 INHERENT CONFLICT OF INDYWIDUAL AND GROUP RATIONALITY

2.1 Negotiation in bilateral monopoly as a game

The lignite price negotiation between mine-mouth power plant and opencast lignite mine can be treated as a bargaining game. Due to an optimal adjustment of shape and size of the ultimate pit to economic conditions on the electric energy market (e.g. prices of electricity) and costs in both firms can improve joint profits of BM (Jurdziak 2004a,b) the game is non-zero sum. Cooperation between both sides of BM influences the level of payoffs and it is worth to reach an agreement. Therefore it has been proposed to treat this negotiation as a cooperative, two-stage, two-person, non zero-sum game (Jurdziak, 2006a, b). In the first stage the ultimate pit maximising joint profits of BM should be selected and in the second one the split of profit ought to be decided together with calculation of the transfer price of lignite. In the mine two lignite prices would exists: the optimal price for which the optimal ultimate pit is selected and which is used for economic evaluation of mining activity effectiveness and the transfer price used for mutual clearing of accounts between both sides – the division of maximal profits according to agreed proportions of shares between both sides.

2.2 Asymmetry of information and the predominant strategy of lignite mine

In BM of a mine and a power plant this is the mine, which has the information advantage over the power plant. This advantage results from the knowledge of the lignite deposit. The mine knows the quality of lignite in the area of planned excavation and can forecast its cost based on data about the shape and size of the deposit as well as the amount of overburden and lignite. Of course this knowledge is only estimated due to the discrete identification of deposit features. Nevertheless the mine has this knowledge and the power plant not. This knowledge alone does not create any advantage especially in short term. At best it can be used as an excuse for difficulties with meeting agreed targets (regarding time, amount and quality of supplied lignite).

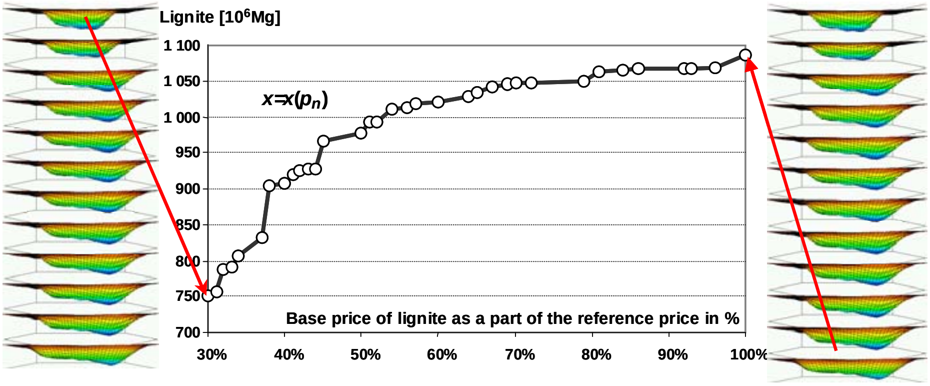

Figure 1. The long run lignite supply from the mine to power plant – the relation between lignite price (presented as a part of the reference price in %) and the optimal ultimate pit maximising non-discounted net cash flows (presented as the amount of lignite inside pit) for 34 nested pits generated for the “Szczercow” deposit.

However in the long run the mine can for each lignite price find out the best ultimate pit maximising the net, non-discounted cash flows using Lerchs-Grossmann optimisation technique (Fig.1).
In the alternative approach L-G ultimate pits can be replaced by the set of optimal schedules within optimal pits generated in optimisation software (e.g. NPVScheduler). Even though this approach is better because of usage of discounted values and schedules but it is much more complicated due to the scale of detail planning connected with generation of optimal excavation schedules for several lignite prices.

The possibility of the optimal adjustment of shape and size of the left for excavation part of the deposit creates the predominant strategy for the mine. The power plant decreasing the lignite price during negotiation never knows if the mine optimally adjusting to it does not resign from the excavation of the current pit in aid of excavating the smaller one but bringing more profit (due to its optimality) than the previous pit with smaller price. Due to the changes are not linear sometimes the small decrease of lignite price can lead to big difference in size and shape of the pit (Fig. 1). In consequence instead of expected increase of the power plant profit both the mine and the power plant can have lower profits.

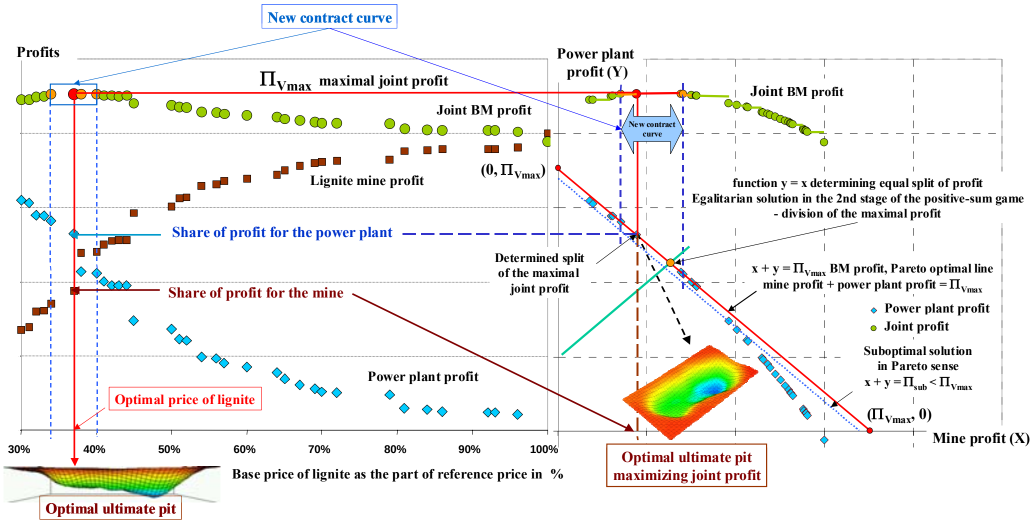

Figure 2. Split of profit in BM for 34 nested pits from the “Szczercow” deposit.

For each of nested pits it can be found two lignite prices: p_{iE} and p_{iK} for which the mine and the power plant (respectively) attain break-even points (their revenues cover costs). There is also the lignite price p_i, which maximises net value of this pit Π_{iK} in comparison to profits of the rest of nested pits. Such price exists due to this pit is one of nested pits generated in parameterization process and it is therefore the optimal for the given price. This price, which can be called border price, is the lowest lignite price for which this pit offers the highest profit Π_{iK}. If the next border price $p_{(i+1)}$ for the next pit (i+1, a greater one) is lower then p_{iK} then for the prices from interval $[p_{(i+1)}, p_{iK}]$ it is better for the mine to excavate one of next pits. For prices from border prices interval $[p_i, p_{(i+1)}]$ profit of the mine is linearly increasing from Π_{iK} and the pit i is the best (gives the highest net cash flow from other pits). For the border price $p_{(i+1)}$ the net cash flows $\Pi_{(i+1)K}$ is greater and it is better for the mine to excavate the next pit (i+1) than the previous one.

The existence of the predominant strategy of the mine means that it can dynamically adjust the ultimate pit (or the schedule in the alternative solution) to the negotiated price.

2.3 Dynamic adjustments of the shape and size of the ultimate pit as a real option

In many lignite mines such dynamic adjustments of the shape and size of the ultimate pit (the schedule in the alternative approach) to the new conditions (the change of lignite price is only one of possible reasons of such action) is not at all considered. In such case the game is zero-sum, the interests of power plant and mine are completely opposed and there is no incentive for cooperation. It is worth to do everything what can be done (including threats, strikes, putting pressure etc.) to increase (for the mine) or to decrease (for the power plant) the lignite price if the mine is going to excavate the one and only ultimate pit (or realise the one and only schedule). There are no reasons for such strenuously sticking to the only one solution. The value of the mine and, of course, the value of the whole BM can be increased by dynamic and elastic adjustment to changes in economic conditions. The real option valuation technique gives additional value for potential elasticity of management in changing their minds after new information come up and the economic environment changes. This is exactly the case. It is worth to re-optimise the pit (prepare the

new optimal schedule) if the mine gets more information about the deposit or the economic conditions change e.g. lignite price is lowered. Modern 3D software make this process much more easy and not so expensive as traditional manual and only 2D designs.
The mine having possibility of elastic adjustments to new lignite prices has the information advantage over the power plant and can use the predominant strategy of the optimal adjustment to the new situation.

2.4 Lignite price contours

The joint BM profits for the particular pit (being the sum of power plant and mine profits) is constant and does not depend of lignite price ($\Pi_{iK}(p)+\Pi_{iE}(p)=\Pi_{iV}(p)$=const). The mine profit $\Pi_{iK}(p)$ for the lignite price p from the break-even prices interval (p_{iE}, p_{iK}) increases from 0 up to Π_{iV} and the power plant profit decreases from Π_{iV} down to 0. This means that on lines $x+y=\Pi_{iV}$=const in the positive quarter of coordinate system we can place lignite prices starting from p_{iE} up to p_{iK} in intervals proportional to the quotient $(p_{iK}- p_{iE})/\mathrm{SQRT}(2\Pi_{iV}^2)$. It is enough therefore to find out break-even prices for each of nested pits (Jurdziak, 2004a, b).

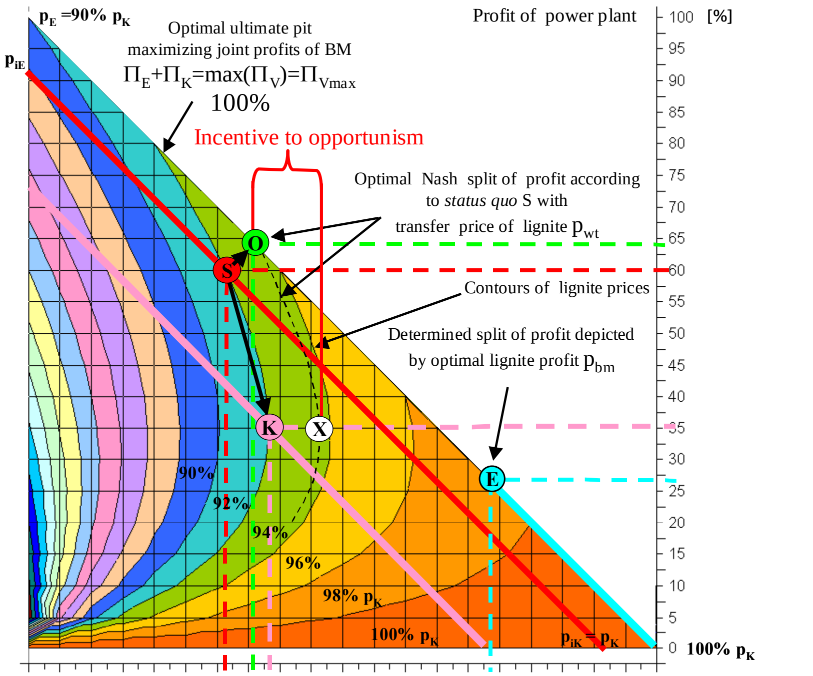

Figure 3. Usage of lignite price contours in profit division in BM and demonstration of the inherent contradiction of individual and group rationality. Lignite contours are drawn every 2%.

$$p_{iE} = \frac{c_K(x_i)}{x_i}, \; p_{iK} = \frac{p_e e(x_i) - c_E(x_i)}{x_i} \qquad (1)$$

where $c_K(x_i)$ is the total cost of excavating the pit i having x_i amount of lignite, p_e is the expected future price of electric energy, $e(x_i)$ is the amount of electric energy produced from x_i amount of lignite, $c_E(x_i)$ is the total cost of energy production form supplied lignite.
The maximal joint profit which can be attained in BM in given economic conditions from excavation of the optimal ultimate pit is equal $\Pi_{Vmax} = \max\{\Pi_{iV}\}$. Profits from this and other pits and shares of these profits falling to the power plant Π_{iE}(p) and the mine Π_{iK}(p) for different lignite prices p on Figure 3 are expressed as the percent of maximal profits Π_{Vmax}. Similarly the lignite price is expressed as a percent of

the break-even lignite price for the power plant p_{iK}. This price due to the simplified assumption regarding direct proportionality of the lignite productivity $e(x_i)$ and total power plant costs $c_E(x_i)$ from the amount of lignite x_i is stable p_{iK}=const=p_K. It has been also assumed that the break-even lignite price p_{iE} for the mine changes from 65% up to 90% of p_K - 90% for the optimal ultimate pit, and 65% for the smallest pit. It is assumed that for each number from 0 up to Π_{Vmax} it can be found the optimal ultimate pit bringing exactly this profit. Such assumptions are arbitrary and can be far from the real situation. Usually number of nested pits is restricted (in the "Szczercow" case it was 34 pits) and the profit and break-even prices changes are not linear (Fig.1). However it is used only to demonstrate the influence of pit selection on joint profits and the negotiated price on split of profit. It also illustrates growing incentive to opportunism with the increase of difference between the optimal and the negotiated price (Fig.3).

2.5 Incentive to opportunism

Suppose that the actually excavated pit is not optimal and gives only 91% of the maximal profit and the negotiated earlier price (92%p_K) determines status quo point S. In such situation the mine has two solutions. Preferring cooperation it can select the pit optimal for the BM (giving 100% of Π_{Vmax} profit) and calculate the new transfer price for the Nash solution (point O), which will be a bit higher (about 1.8% p_K) what improves its share of profit from 31% up to 36%. The power plant share of profit also increases from 60% to 64% (the movement from point S to O, Fig.3). Alternatively, behaving opportunistically (e.g. if there is no cooperation), the mine can select the variant optimal only for itself (excavation of the smaller pit - the movement from point S to K, Fig.3). The choice of the predominant strategy means the increase of its shares of the long-term profit from 31% up to 38%. Unfortunately for the power plant it means decrease of profit from 60% down to only 35%. The excavated pit would generate joint profits on the much lower level, which equals only 73% of the maximal profit (BM would loss 18% of potential profits). The mine opportunism could be even not noticed due to both the actual lignite price and contracted annual amount of lignite is not changed. Only the ultimate pit is different so the changes would be seen only in long run as the shorter period of pit excavation, what can be explained by more difficult geological conditions than expected before.

The difference between profits attained by the mine selecting the Nash bargaining solution (point O) and choosing the predominant strategy (point X) creates the incentive to opportunistic behaviour (Fig.3). This incentive decreases with the increase of the lignite price approaching the optimal lignite price (movement of point O in direction of point E). In the "Szczercow" case the egalitarian solution (equal split of profits) lies on the new contract curve – optimal and egalitarian points are close to each other (Fig.2). It is therefore necessary to check for each deposit and each set of economic conditions how big is the inherent conflict of individual and group rationality in order to reduce it and prevent opportunistic behaviour through the appropriate transfer price selection.

3 EVALUATION OF DIFFERENT BM STRUCTURE AND OWNERSHIP SOLUTIONS

Analysis of different BM organizational and ownership structures (Tab.1) leads to conclusion that because of the inherent conflict of individual and group rationality only the full vertical integration of the lignite mine and the power plant can secure realisation of the optimal solution – excavation of the optimal ultimate pit maximising joint BM profits. In any other structure the incentive to opportunism can appear. It magnifies with the increase of the difference between the optimal lignite price and the price established during negotiation. It is therefore important for the power plant to know the optimal price and to have equal access to all necessary information. Asymmetry of information also leads to opportunism.

Two different owners of BM sides having opposed interests increase the threats of non-cooperative behaviours and realisation of the solution, which is not optimal in Pareto sense.

The difference between optimal and suboptimal profits Π_{Vmax}-Π_{Vsub} creates a premium for elastic adjustment to new conditions (e.g. new information about the deposit or better forecasts of the future electricity demand). It can be treated and valued as the real option to change the scale of BM operation.

Integration of lignite mines and power plants does not create any threats to electric energy market and energy consumers due to the pit optimal for BM is greater than the pit optimal only for the mine and the energy supply increases. There will be also other positive synergy effects for consumers (e.g. decrease of transactional costs) increasing economic effectiveness of the integrated energy producer (Jurdziak, 2005b).

Table 1. Advantages and disadvantages of different BM structure and ownership solutions (Jurdziak, 2005c).

	A **State owned BM**	**B** **Competing BM**	**C** **Bilateral Holding**	**D** **Integrated energy producer**
Ownership :	1 owner e.g. State Treasure	2 different owners	1 owner	1 owner
Structure:	2 firms in BM	2 firms in BM	Holding of firms, 2 profit centres	1 firm, 2 cost centres
Accounting:	separate	Separate	separate	common
Price of electric energy:	Regulated, long term	Market	Market	Market
Lignite price:	Regulated or confirmed by President of URE	Freely negotiated	Agreed transfer price	Lack of e.g. in Rheinbraun or the optimal price
Objectives of BM sides:	Management or trade unions objectives realisation	Profit maximisation	Profit maximisation	Cost minimisation
Common objectives:	Government objectives realisation	Doubtful	Owner's profit maximisation	Owner's profit maximisation
Transactional costs:	High	Very high	High	Low
Information:	Information asymmetry, access possible	Information asymmetry, access strictly controlled	Equal access within agreed procedures	Full and equal access to information
Possibility of opportunistic behaviour:	YES	YES, very high	Yes but restricted by the holding management	Small – e.g. through excessive costs
Advantages:	Possibility of activity coordination on the country basis	Local effectiveness	Big capitalization	Common objectives, effectiveness econ. big capitalization
Disadvantages:	State ownership, manual control, lack of effectiveness	Conflict of interests, rivalry instead of cooperation	Conflict of interests, bureaucracy	Elimination of lignite price creates problems with economic evaluation of mine
Threats:	Group interests domination	Suboptimal solutions realisation	Possibility of suboptimal solutions realisation	Difficulties in BM and mine development optimisation
Examples:	Mines and power plants before 2003r.	KWB Konin S.A. & ZE PAK SA	BOT „Gornictwo i Energetyka" S.A.	RWE Rheinbraun

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