THE MEANING OF GEOSTATISTICAL RESEARCH IN THE LIGHT OF THE CONCEPT OF ASSESSING VALUES OF LIGNITE DEPOSITS

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Abstract: The article presents the role of geostatistical research in identification (and minimization) of a geological risk against the background of the concept presented, aiming at assessing the value of lignite deposits from the perspective of integrated entities, i.e. mines and power stations. A detailed review of the solutions in geostatistics is to prove their usefulness and convince about the purposefulness of their application. The issue of optimization of sampling the deposit is important in defining its value, and at the same time its future development. In addition, on each stage of the chain of creating the value, the areas were defined of uncertainties and a number of risk which are attached with reference to the solution proposed of assessing the deposit value.

Keywords: geostatistics, lignite, mining, power engineering, risk analysis

1. INTRODUCTION

The value of a national lignite deposit is determined by a wide spectrum of factors, starting from its quantity and quality parameters through electricity generated on the basis of this fuel. When estimating its value one should take into account an exact recognition and then later development – future welfare of functioning of a deposit as a mining entity. Providing the natural lignite deposit for assessment, these activities should be coordinated in a so called chain of creating values from the deposit to the final product being the energy obtained therefrom. It forces the necessity to analyse the interdependence towards the whole surrounding of the project on each stage

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through its development and exploitation with a direct recipient and processor of fuel into electricity. Such an approach imposes a concept of analysis of a deposit value in mining-energy complex. It is recommended to include the geostatistical methods in assessing the lignite deposits.

2. REVIEW OF GEOSTATISTICAL RESEARCH INTENDED FOR ANALYSIS OF THE GEOLOGICAL RISK ASSESSMENT

While analysing the value of lignite deposit, an important aspect is geostatistical research. It is connected with the fact that sampling on each stage of documenting, aims at recognizing quality parameters of the fossil in a given location so as to be able to obtain information on a deposit with a larger certainty and the manner of placing the samples collected may result in significant consequences in the issue of economics (Carrasco and others, 2004). Improper selected net of holes is included into the sources of geological risks (one of many in the chain of creating the value) (Jurdziak and Wiktorowicz, 2008a). Therefore a key issue is optimization of recognizing and sampling deposits and as a consequence estimating the resources of the deposits intended for exploitation so that the estimated values were encumbered with the least possible error. Simultaneously one should remember that costs resulting from sampling of the deposit should be adequate to the benefits involving the possibility to steer the quality of spoil directed to the power station (Naworyta, 2008). Geostatistical methods are used to solve the above problems (Clark, 1987; Mucha, 1994; Namysłowska-Wilczyńska, 2006; Clark and Harper, 2001).

Proposals of solutions concerning optimization of sampling the deposit in their papers were presented by, i.e.:

− Walton and Kauffman (1982) to present the method of selecting the location for additional drilling holes, they recognized that variance of estimation may be reduced most by means of drilling in the areas of high uncertainty,

− Gershon (1987) to compare different approaches to the issue with the one of their own based on the theory of geostatistics, proposed the algorithm allowing to select such locations of drills which minimize the variance of estimation with a definite condition of limiting the number of holes and costs of the drills performed,

− Szidarovszky (1983) presented two models which allow to realize the task involving the selection of optimum locations of additional searching holes: 1) minimizes the variance of estimation with a simultaneous limitation concerning the number of additional measuring points or additional costs of measurement, 2) minimizes the number of additional points or costs with preservation of upper limits adopted for variance of estimation. The model were based on the theory of kriging and the solutions were based on a proper algorithm.

The proposed solution did not include the geometry of a deposit nor drilling holes in the 3D space. The aspect, whereas, was taken into account by Soltani and Hezarkhani (2013) dealing with optimization of location of additional directional research holes.

In Poland the works were conducted intended for defining an optimum network of sampling of lignite deposit, by means of review of placement of the holes existing. The structure of variability of the quality parameters of the deposit was also taken into account and their values were assessed using the method of block kriging to adopt different dimensions of blocks (Naworyta and Mazurek, 2007). The analyses were conducted for two parameters: contents of sands and sulphur in lignite. It was stated that recognition of the contents of sulphur is sufficient. In case of examining the contents of sand, no justification was also found for densification of the network of boreholes. It was affected by a larger variability of the parameter, extreme values and low auto-correlation. Financial outlays being the consequence of performing additional drills turned out to be not proportionate to the benefits resulting from the improvement in assessing the parameter. In the next paper, Naworyta (2007) was looking for an answer to the question: whether the selection of the sampling network is possible in the way so as to estimate average values of all interesting parameters of natural lignite deposit with an identical exactness. While comparing the results of estimation after double and triple dilution of the network of holes, changes were observed in a standard error of block kriging. It turned out that the network with the smallest number of holes is sufficient for recognizing the structure of sulphur variability. Whereas, the estimation of the contents of sand even in case of the best variant of the network is charged with a significant error. The results referring to the issues of selecting the network of sampling Polish deposits of natural lignite presented in the above papers were confronted in the article by Pactwa (2015) with the results of the statistical and geostatistical analysis of quality data describing one of the lignite parameters (furnace value). The material for experiment covered the data from sampling of Pole Szczerców (the Bełchatów deposit). An influence of dilution of the network of holes was observed on the characteristics of variability of the analysed parameter and the value of estimation error.

One should remember that the conclusions presented in the papers refer to the defined deposit and there is no possibility to generalize on their basis. In case of estimating the resources of the fossils, it is difficult to gain definite solutions, but it is reasonable to search for such of them which could be implemented and support the profitability the mining production.

Next to kriging, for the interpolation of the deposit parameters, the conditional simulation is used recommended to define the analysis of the risk connected with exceeding critical values of the deposit and assessing the forecast error of prediction (Naworyta and Benndorf, 2012). Conditional simulation uses the geostatistical pa-

rameters to create a number of quality models of a deposit, each of which being equal-ly probable (Jurdziak and Kawalec, 2011; Jurdziak and Wiktorowicz, 2008b).

3. PERSPECTIVES OF DEVELOPMENT OF NATIONAL DEPOSITS OF NATU-RAL LIGNITE

More difficult conditions for the mining-energy industry to function connected with its high capital-absorptiveness, long period of return on investment and approxi-mate estimates of recognizing the deposit cause that this is the activity encumbered with a very high risk. The existing mines have problems with finding means to make available new deposits, and the financing for the construction of new mining-energy complexes encounters a number of obstacles. However, one should remember that the national energy raw minerals are and will be the most important trumps for Poland in the 21st century and will allow to preserve energy independence which is so im-portant in the present geopolitical situation. A significant argument speaking for the construction of the power stations combusted with natural lignite is the lowest pro-duction costs of energy from the fuel and the knowledge concerning obtaining energy from the natural raw mineral. Due to the resources being exhausted in the presently exploited deposits after 2020, the level of excavation drops dangerously, however taking into account the national total geological balance resources 22,68 bn Mt (as of 31.12.2013 for Bilans zasobów, 2014), lignite will fulfil the role of the guarantor for the energy security of the state. To confirm the words, the investments are planned in the national energy sector, i.a. in the construction of new power plant in conventional energy sector.

4. CONCEPT OF ASSESSING VALUE OF THE DEPOSIT IN THE CHAIN OF CREATING VALUES

The goal of the article is to place the geostatistical methods in the proposal of the assessment methodology of national deposits of natural lignite in the perspective of vertically integrated entities of the mines and power stations. The value is understood not as the value of the sale-purchase transaction, but wider as the social value for the inhabitants of the mining regions. The proposed methodology shall cover the revalori-zation methods of the area with reference for it to be used for mining-energy invest-ments. The complex analysis will be conducted on many stages, by the diagram (Fig. 1), i.a. to include the sources of uncertainty proposed in the paper by Uberman (2012) or aspect of vector map of the surface cost model (Dudek et al., 2014). The authors of the article know the rankings developed earlier of deposits and methods on the basis of which they were created (i.a. Uberman and Ostręga 2008). The concept presented

may be treated as an alternative for the previous ones, i.a., due to the pressure which was put on the application of geostatistical methods.
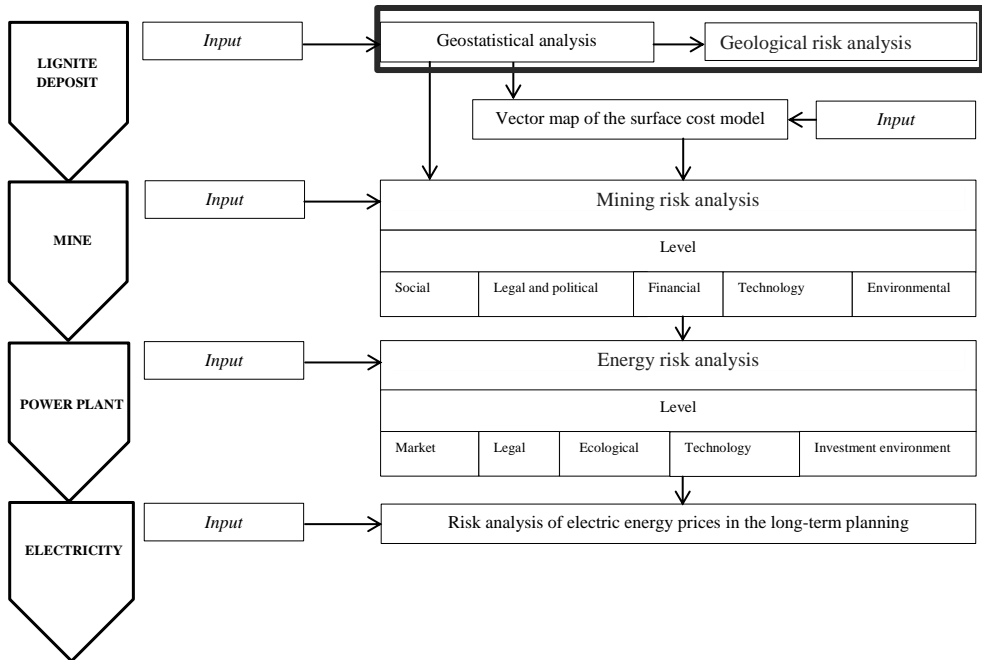

Fig. 1. Placement of the geo-statistical methods against the background of the assessing concept of the value of natural lignite deposits (based on Woźniak, 2010)

Proposed assessment of deposit values will include:

1. geostatistical analyses allowing to minimize the geological risk, being one of the factors affecting the assessment of deposit value. Covering: analysis of variability (semivariogramms) and estimation of the values of deposit parameters with reference to the influence of changes in density of sampling onto the values of parameters estimated and the size of an error.
2. implementation of the model of vector map of the surface cost model
3. analysis of mining risk in the aspect of:
   3.1 the area of the profitable deposits to be excavated (inflows into the commune budget due to the exploitation fees, increase in employment, development of outsourcing in the region, advantages of changing the environment after reclamation) – defined from the survey polls
   3.2 legal and political conditions
   3.3 possibility to obtain the credit for the needs of financing the future investments
   3.4 cost – connected with the functioning of the future mining entity

  3.5 technological – proper selection of the system of exploitation and machine park

  3.6 environmental – connected with intervention of mining technology in the natural environment (the risk is perceived here not as the environment devastation: intervention in the environment, change of the surroundings, consequences of cover exploitation, settlement of the soil, hydrological changes, change in the level of water, etc., occupying the areas for the external excavation heap but as taking the risk connected with the activity of the mine and the profits originating therefrom for the later change in the surroundings in connection with the direction of reclamation

4. analysis of the energy risk in the aspect of:

  4.1 market– connected with the energy market liberalization, releasing and uncertainty as to the future price of energy

  4.2 legal and political conditions

  4.3 ecological – necessity to buy out permits for CO_2 emission within EU ETS, uncertainty as to the prices of the permits

  4.4 technological

  4.5 investment surrounding

5. analysis of costs and subsidies to renewable energy resulting from the support with certificates

6. scenarios of lignite energy and energy mix development.

5. CONCLUSION

The review of the geostatistical research performed indicates for its significant meaning in the issue of optimization of the deposit sampling. It was indicated as early as on the stage of recognizing that badly selected network of holes is included into the sources of the geological risk (one of many in the proposed chain of creating value). Placement of the geostatistical methods in the early stage of the proposed concept of assessing the value of the deposit may thus be of importance for the future development. The presented outline of the concept of the value assessment of the natural lignite deposit will be specified in the future and in consequence implemented by potential entrepreneurs in the mining-energy sector. The proposed approach may contribute to extend the life of the present lignite field, which is the chance for the inhabitants (job post), development of the companies associated with the mining and energy industry.

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