Model for the selection of the optimal location of a thermal power unit according to the external coal conveyance criterion

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Model výberu optimálneho umiestnenia tepelnej jednotky podľa vonkajších uhoľných kritérii prevozu

Aggravated working conditions in Serbian underground coal mines, and increasingly worse natural conditions (increased depths of deposits, expressed tectonics, large inflows of underground waters etc.) resulted in higher exploitation costs which are at the threshold of profitability. This inevitably leads to the conclusion that it is necessary to link mines to thermal power plants and facilities. The Soko and Lubnica mines can operate cost-effectively if they ground their production on the needs of a thermal power-heating plant (TETO) which would supply the towns of Bor and Zaječar with the power. This paper deals with finding an optimal location of a TETO using model for the optimal external coal conveyance from a mine to a thermal power unit.

Key words: *model, coal conveyance, criterion*

Introduction

Underground coal mines in Serbia pertain to the group of mines having small production and difficult natural conditions. In addition to that, long-standing delay in modernization of every stage of the exploitation has led to the obsolescence of the technology and to a very low utilization rate of a deposit. As a result of this, there are great losses in the production of every ton of coal.

A number of analyses, made for the needs of these mines, have shown that those can subsist only if they had the assured placement of coal in the market. Previously, the consumers of this coal were industrial and large-scale consumers, with a very small share in the production of the electric power. Since in a number of towns and regions, there is a need for the construction, of capacities for a centralized system of thermal energy supply, this means that several mines have an open possibility to solve, for a longer period of time, the issue of placing their coal in the market without big oscillations.

The aim of this paper is to point out to the possibility of placing the coal from two mines (Soko and Lubnica) for the needs of one thermal power-heating plant (TETO) which would supply with energy two towns in Eastern Serbia. The focus was put on making a model for the selection of the optimal location of a TETO according to the coal conveyance criterion with a view to supplying this facility.

Main assumptions of making the model for the selection of the most suitable location of a TETO

The development of Bor and Zaječar towns also requires a stable supply with all forms of needed energy. This includes the reliable supplying apartment houses and industrial facilities with thermal energy for heating, as a supplementary unburdening of the power energy producers (Electric Power Industry of Serbia – EPS) in the area of these towns. The existing facilities in the above towns cannot completely meet the requirements; since they cannot guarantee the capacities, they have large costs and depend on oscillations in energy supply.

On the other hand, the coal mines Lubnica and Soko jointly dispose of mining reserves which could ensure, from domestic resources, the secure and reliable supply with energy resources of a small-capacity, up to 80 MW, thermal power plant. This issue is not new, it was considered on many occasions, there was even created a joint venture of the town of Zaječar and the Czech company ENERGO-MORAVIA. A few

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steps were made to this end, but there was no big progress due to the fact that the mining reserves in the Lubnica mine were not correctly defined, although it was intended to be the main coal provider. In the meantime, the beforementioned Czech company bankrupted.

Bearing in mind the mutual interest both of coal mine and the local self-governments of towns Bor and Zaječar, it was necessary to reactivate this initiative with slightly changed conditions. We primarily mean the enlargement of the scope of users, by including the town of Bor, and finding a new location which would give a rational solution for the supply of both towns, but which would be optimal in respect of coal conveyance from the mines Soko and Lubnica.

In order to make it possible, it is necessary to make a study which would result in the optimal location of a thermal power-heating plant. The findings of the study would be based on a number of criteria where the most important are:

- Specific costs of coal conveyance,
- Costs of the transmission of the thermal energy from a TETO to consumers by thermal pipe systems,
- Amount of initial investments into a TETO,
- Environmental protection,
- Required investments into mines,
- Possibility of using the electric energy obtained in the process of the co-generation etc.

In making the study, the results obtained also in the process of the operation of the joint ventures Energo-Moravia and the town of Zaječar would be used. Also, the existing technical documentation of the PE Underground Exploitation of Mines and of the Soko and Lubnica mines would be utilized.

Bearing in mind the complexity of the operation and the existence of many influencing parameters, the model for solving this and related issues was developed at the Department for haulage at the Faculty of Mining and Geology. The model for the selection of the best location consists of several main blocks:

A. Determining needs, potential and coal reserves of a TETO

In this block it is envisaged to determine input parameters according which it is necessary to define the most suitable solutions for locating a thermal power unit based on the needs of the population and on the potential of the mines Soko and Lubnica. Therefore, it is necessary to define the following steps in this part of the model:

- determining the necessary power of a TETO,
- specified calorific power of fuel for the needs of a TETO,
- Mining reserves of the Soko Mine,
- Mining reserves of the Lubnica Mine,
- determining the share ratio of coal from certain mines in order to achieve the specified calorific power,
- Necessary variety of coal for the optimized operation of a TETO.

The most delicate issue in this part of the model is determining the real ratio between needs, wishes and potentials of a mine, i.e. of a supplier with power fuels.

B. Determining and analysis of possible locations and conveyance variants

This model block virtually consists of two units, for which it is necessary, in further development, to establish mutual relations. The first part refers to the determination of possible locations of a TETO, and possible variants of conveyance are analyzed in the second part. The most significant items of the B block are as follows:

- Locations of TETO which are suitable in respect of the distance from a power consumer,
- Locations of TETO which comply with the requirements of the environmental protection,
- Possible locations of TETO with suitable infrastructure,
- Possibilities of truck coal transportation,
- Variants of the combined coal conveyance,
- Possibilities of a hydraulic coal conveyance,
- Possibilities of coal conveyance from a mine to a TETO, with the involvement of third parties (transportation services).

Each of possible variants has a number of sub-variants, i.e. it has a number of possible solutions within one possibility. This especially applies to the possibilities of the transportation, where each of the 4 main variants has 3 sub-variants on the average.

C. Techno-economical analysis of possible variants

For the techno-economical analysis of previously defined possible locations of a thermal power-heating plant and of defined variants of coal conveyance from a mine to thermal power units, the following steps are required:

- Techno-economical analysis of each variant of truck transportation,
- Techno-economical analysis of possible variants of the combined transportation,
- Techno-economical analysis of the hydraulic coal conveyance,
- determining the average price of the third party transportation service,
- ranking according to minimal specific costs of coal conveyance.

The techno-economical analysis provides reliable information about technical possibilities and specific costs per unit of a product or a service. However, for a correct and final decision, it is also necessary to perform a multi-criteria analysis, which would include some criteria that are not stated through the techno-economical analysis.

D. Multi-criteria analysis for determining an optimal location of a TETO

For the purposes of the model for the selection of the most suitable location of a TETO, in this part the following issues are defined:

- determining the criteria for the analysis and their quantification,
- determining the Importance Coefficients for each criterion,
- applying the methods of the multi-criteria decision-making,
- Ranking variants according to the methods of the multi-criteria analysis.

The main issue emerged at the beginning of working on the multi-criteria analysis was to determine Importance Coefficients for each criterion. After analyzing mutual influences of all of the criteria, the following Importance Coefficients have been determined:

1. specific costs of coal conveyance..... 0.55
2. costs of thermal energy transmission from a TETO to consumers.. 0.15
3. environmental protection..... 0.10
4. required investments into mines..... 0.05
5. Amount of initial investments into the TETO..... 0.15

As multi-criteria decision-making methods, the PROMETHE method was selected as the main method, and matrix method as the control one. The Department for mine haulage at the Faculty of Mining and Geology in Belgrade has positive experiences in applying these methods.

Conclusion

The need for using all energy resources in Serbia and the quite unfavourable situation in regard to the heating of medium-size towns, have led to the idea that several regional thermal power units should be constructed. Thereat it would be necessary to direct them to use domestic coal as the power fuel. In order to make sure that this is economically, environmentally and anthropologically justifiable, it is necessary to determine the optimal location of a TETO, along with bearing in mind, in the first place, the issue of coal conveyance, as one of the most influencing parameters. In order to make such decision, it is necessary to apply a model which would include all parameters and criteria, whereby the appropriate importance is attached to each of them.

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