

Review paper

RANKING OF POTENTIAL COAL DEPOSITS IN ORDER TO MAKE INVESTMENT DECISIONS TO OPEN NEW MINES IN SERBIA

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Abstract: For investments in the field of coal exploitation in the Republic of Serbia, in the future investment analyzes show significant results, although the "Green Agenda" aims to reduce until the end of this process in 2050. New ore and mineral deposits are also emerging, which will also require the opening of new mines in the future, and the choice of investment variant by ranking potential deposits directly depends on the amount of reserves but also on high environmental standards.

Keywords: Ranking of potential coal deposits, Green Agenda, investment decision making, opening of underground mines in Serbia;

1 INTRODUCTION

Mining in the Republic of Serbia is regulated by the Law on Mining and Geological Research with bylaws. This law, which defines the sector of mineral exploitation, is harmonized with other systemic laws that regulate other areas, such as: agricultural land, water, forests, nature, traffic, concessions, as well as a set of legislation called the "Green Agenda" the areas of environmental protection and safety and health at work are regulated.

The Ministry of Mining and Energy of the Government of the Republic of Serbia is responsible for all permits, from the right of inquiry, the beginning of exploitation and the period of exploitation. Also, it is responsible for inspection activities, i.e. mining inspection and other activities prescribed by law.

Other ministries of the Government are especially involved in the exploitation of mineral resources, through the issuance of conditions, consents and permits, as follows:

- Ministry of Environmental Protection;
- Ministry of Labor, Employment, Veterans and Social Affairs;

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- Ministry of Economy;
- Ministry of Agriculture, Forestry and Water Management.

For investments in the field of coal exploitation in the Republic of Serbia, in the future there are investment analyzes that there will be an increase, as shown by the results, although the "Green Agenda" aims to reduce until the end of this process in 2050. New deposits of ores and minerals are also appearing, which will also require the opening of new mines in the future, and the choice of the investment variant will directly depend on the amount of reserves in the deposits, but also on the environmental impact assessment.

Mineral resources are an important factor in the overall economic and social development of every country, including Serbia. According to the data of the Statistical Office of the Republic of Serbia from 2018, the share of mining in the gross domestic product in the previous period was 2015 – 2,1%, 2016 – 2,0% и 2017 – 2,1%. According to the data from the Draft Terms of Reference for the development of the Strategy, in 2018 the share is 2.1% of GDP. According to the structure, about 90% of the estimated 2% of GDP consists of energy mineral raw materials (coal, oil and natural gas) and copper as a metallic mineral raw material. The remaining 10% by structure consists of the production of lead and zinc and non-metallic mineral raw materials, mainly stone aggregate, sand and gravel and raw materials for the cement industry (Official Gazette RS, 2010).

By examining the connection between making investment decisions on the opening of inactive coal deposits in which larger coal reserves are concentrated for the underground exploitation system, we come to a causal relationship. Activation of underground exploitation on the basis of correctly made investment decision, in accordance with high standards of environmental protection, potential in deposits would enable perspective development of economy in Serbia, where several variant solutions are analyzed using adequate research methods.

Ranking of new coal deposits is an adequate choice of investment decision, as a methodological procedure, based on the balance of reserves in deposits that have not been researched in Serbia, whose primary goal is to contribute to the analysis of potential before opening mines. and protection of the environment, preservation of human decision-making rights, preservation of the health of citizens, but also enrichment of mining science

2 "GREEN AGENDA" AND COAL EXPLOITATION

2.1 Green agenda, energy crisis and mining

The "Green Agenda for the Western Balkans" is a new economic paradigm, but also a strategy for the growth of the region's economy, which is a transition or transition from the traditional model to a sustainable economy, in line with the European Green Plan.

By signing the Declaration on the Green Agenda, the Western Balkan countries pledged at the Sofia Summit on 10th of November 2020 to implement measures in the field of climate change prevention and pollution, energy development, transport, and circular economy, as well as biodiversity development, sustainable agriculture, and production food.

The implementation of the "Green Agenda" should gradually include all socio-economic factors that affect the decarbonization of each country in the region in order to transition, which would be fair. The public dialogue on energy transition began immediately after the adoption of the new Energy Law and Strategy in 2015. New technologies and digitalization have accelerated many movements and created conditions for this process. In the spring of 2021, Serbia adopted a set of five new laws that represent a "green package".

At the end of 2021, the world was hit by a major energy crisis. China bought all the coal stocks in the EU because Europe wanted to move to the "green plan", it sold it, changed the political establishment in Germany, changed the decision to use the Nord Stream 2 gas pipeline, shut down nuclear blocks and breakdowns in France, and The political situation in Ukraine is a problem that has led to an increase in energy prices being a multiple economic blow to all economies of the world (the price of electricity is 4-6 times higher, and the price of natural gas 5-9 times). When crises arise, each country struggles with challenges in its own way. Those countries that have left the exploitation of coal in a certain volume of exploitation, will manage to overcome all the challenges with the least economic blows to the state budgets. Without mining, i.e., coal exploitation in the participation in the energy mix of every energy state policy, a transition that would give realistically economically justified results cannot be provided. Therefore, a balance must be found between the "Green Agenda" and the opening of the mine. Exclusivity leads to major economic crises, in which only developed and large economies can win that battle. That balance is that making an environmental impact assessment becomes an important factor in making investment decisions when opening a mine

2.2 Underground coal mining and the possibility of building new mines

We stated that the Ministry of Energy and Mining, as well as other ministries of the Government of the Republic of Serbia, are responsible for the exploitation of mineral raw materials, issuing conditions, consents and permits. The preparation of documentation for the opening of new mines requires considerable costs, time to comply with all procedures, the unpredictability of the beginning of the project. The Rulebook on the content of mining projects contains all the elements related to the Law on Geological Research and Mining, the obligation to implement environmental protection measures for economic entities.

When analyzing the possibility of building new mines in potential deposits (Ristic, 2010), certain factors are decisive, such as: natural and geological conditions that define

the application of modern technological solutions for underground exploitation and coal reserves for longer service life.

In the considered examples of quantities of potential coal deposits, it is estimated that in the same applications it is a question of high-tech mechanization and adequate equipment at the basic technological phases. On the given examples of the amount of potential, under the same technical-technological solutions, making an investment decision directly affects the volume of investment and the advantage in ranking the opening of new mines.

3 FINANCING OF THE PROJECT IN THE FIELD OF UNDERGROUND COAL EXPLOITATION IN THE REPUBLIC OF SERBIA

The legislative framework is the current Law on Mining and Geological Research, adopted in 2015, (Official Gazette of RS, 2015) with amendments in April 2021. (Tomic, 2021), and it regulates, among other things, measures and activities of mineral policy and the manner of its implementation, the method of classification of resources and reserves of mineral resources and groundwater and geothermal resources, exploitation of mineral reserves and other geological resources, construction, use and maintenance of mining facilities, plants, machinery and equipment, mining operations, mining waste management, remediation procedures and reclamation of abandoned mining facilities, as well as supervision over the implementation of this law. Mineral policy and development plan in the field of mining includes (SAI, 2019) application of modern technologies in the construction of mining infrastructure and mining facilities in order to ensure safety and security and health at work, ensuring secure supply of the economy and market of the Republic of Serbia with minerals and other geological resources. Union in the field of mining, promotion of mining in order to create favorable conditions for investment in the field of sustainable development of the mining industry. The mineral policy and the plan for the development of geological research and mining are implemented through the implementation of the strategy for the management of mineral and other geological resources of the Republic of Serbia. The Ministry of Mining and Energy supervises the implementation of the Law on Mining and Geological Research Serbian (Chamber of Commerce, 2021).

The main reasons for amending the Law adopted in April 2021 are the adoption of modern, transparent regulations, which will provide greater security for investments, through clearly defined procedures, security, and sustainability of activities in terms of research and exploitation, with emphasis on safety and human health., environmental standards, as well as resource bases for our domestic production.

The most important energy resource in the Republic of Serbia, in addition to hydro potential (Djerdap) and coal, has its role in the production of electricity in the coming

decades. Today in Serbia, coal exploitation is mainly obtained from the surface exploitation system (mines RB Kolubara, TE-KO Kostolac) and from underground exploitation (mines JP PEU-Resavica), and underwater exploitation Rudnik Kovin (Brankovic, 2019).

Conditions of exploitation, changes in economic conditions, competition and increasingly difficult profit-making, have brought underground coal mines into a difficult situation that requires reorganization, new technological solutions for exploitation and reclamation of exploitation fields.

Research, forecasting and analysis methods have become a necessity to make good investment decisions within the entire energy sector. For companies to survive in the field of coal exploitation, in space and time in which stimulating and limiting factors operate, it is necessary to take into account the influence of environmental factors that affect growth, organizational structure, management function and general relations with the environment.

In the case of underground mines, the task of making investment decisions is to define the conditions of underground exploitation under which coal exploitation in Serbia will be possible, with the limitations expressed in the new regulations of the "green package".

This paper deals with the opening of small new mines with potential reserves, operation and activation of new coal deposits with larger reserves and natural and geological conditions favorable for the application of modern technological processes of excavation and production of mining facilities, equipping and commissioning with investments in the environment. Priorities for the choice of opening pits and exploitation fields, ie. the decision which project will be financed and in what order will be made on the basis of the ranking of the project, i.e. the potential. Due to the lack of the necessary amount of financial resources and the change in business conditions in the conditions of the "Green Agenda", it is necessary to make a new investment decision. Three deposits with potential reserves are listed, for which the investment decision will be influenced and shown by the ranking methodology, which deposit has an advantage when opening.

Table 1 State of reserves in some potential deposits (t)

Serial number	Coal deposits	C2 category reserves in (t)
1.	"Poljana"	58.900.000
2.	Ćirikovac (deeper part)	60.700.000
3.	"Zabela-Kosa"	50.000.000
In total		169.600.000

1. Characteristics of the "Poljana" deposit

The deposit is located south of about 4 km from the town of Pozarevac and belongs to the Kostolac coal basin. It is located near important railway and road roads and potential consumers (TE-Kostolac and TE-Morava). Certified balance reserves amount to 58.9

million tons, and natural-geological conditions allow the application of a highly productive mechanized wide-head excavation method. Estimated production capacity, working with two mechanized excavations is 700,000 t / year. with the possibility of increase.

2. Characteristics of the coal deposit "Ćirikovac"

This coal deposit is located near Požarevac and belongs to the Kostolac coal basin. It is characterized by the proximity of a large consumer of TPP Kostolac, and it relates to other parts of the Republic of Serbia by roads and railways. The remaining geological reserves of coal have been verified in size for categories B + C1 about 149 million tons, and categories C2 about 162 million tons. Preliminary analysis calculated the exploitation reserves of coal that can be excavated by an underground system with the use of mechanized wide-face excavation in the amount of 60.7 million tons. Study analyzes envisage a capacity of 1.5 million per year, while the author believes that this capacity should be dimensioned at about 700,000 t / year. with the work of two mechanized excavations.

3. Characteristics of coal deposits "Zabela-Kosa"

This deposit is located between Despotovac and Svilajnac, within the Despotovac coal basin, and is connected by roads and railways with major centers and consumers in the Republic of Serbia. The proximity of a larger consumer of TPP "Morava" (Svilajnac), about 20 kilometers away, gives him a special advantage.

When defining the ranking criteria, we start from the position that the criterion is a factor, ie a rule for choosing one of a set of alternatives, and its influence on the ranking result depends on their weighting factor (Miletic, 2016).

When considering the criteria, they include natural-geological, socio-social, economic and safety aspects of the importance of the considered coal deposits. The following criteria were determined by detailed analyzes:

- Balance reserves of coal (Criterion S1) represent the determined reserves of coal in the reservoir that are expected to be excavated by the underground exploitation system, and this criterion is assigned a weighting factor of 0.25 (it affects 25% of the ranking result);
- The possibility of mechanization and automation (Criterion S2) directly depends on the specific natural-geological conditions in the subject deposit. This criterion has a weighting factor of 0.20;
- Estimated production capacity (Criterion S3) depends on the applied technological solution of exploitation and participation of mechanization and automation of technological phases. This criterion has a weighting criterion of 0.20;

- The amount of investment (Criterion S4) depends on the applied equipment for exploitation, technological process, projected capacity and type and size of infrastructure facilities, and it is assigned a weighting factor of 0.20;
- The number of employees (Criterion S5) depends on the applied technological process, intensity and capacity of excavation, and each new mine needs to employ a certain number of workers by education, qualifications and training, which directly affects the reduction of unemployment in areas where it opens. mine. This criterion is assigned a weighting factor of 0.10;
- Environmental protection (Criterion S6) depends on the applied system of exploitation and intensity of works, and the applied mechanization and it is assigned a weighting factor of 0.05 (with 5% share on the ranking result).

In this consideration, the ELECTRE method was applied, which is a method of multi-criteria decision-making based on comparing alternatives in pairs.

ELECTRE starts from the decision matrix and the weight of the criteria, and in nine steps the problem is solved, i.e. the best alternative is chosen.

Steps in solving this method are:

- Step 1. consider a normalized decision matrix;
- Step 2. determining the weighted normalized decision matrix;
- Step 3. Determining the sets of agreement and disagreement;
- Step 4. determining the consent matrix;
- Step 5. calculating the discrepancy matrix;
- Step 6. calculating the dominance matrix by agreement;
- Step 7. calculating the dominance matrix by discrepancy;
- Step 8. determination of the aggregate dominance matrix;
- Step 9. eliminate fewer desirable alternatives.

Table 2 Basic conditions of potential coal deposits

DEPOSIT-COAL MINING (INACTIVE)			
PARAMETER	„Poljana“	„JamaĆirikovac (deeper part)“	„Zabela-Kosa“
Balance reserves (million tons)			
in total	58,9	149,5	24,7
for mechanic. excavation	34,5	60,7	18,5
		4,0	
Layer thickness (m)	7,0	5,0-9	2,93
		4,8	3,14
Slope (°)	2-8	5-10	10-20
Estimated production capacity (t/year)	700.000	700.000	230.000
Century. exploitation. (year)	33	50	80
Invest period. construction (year)	3	3	4
Investment. (million EUR)	45,0	47,1	46,1
Number of employees	600	384	230

Ranking results

By defining alternatives and criteria, an evaluation matrix is formed. In this case, the criteria have a qualitative structure, which cannot be precisely determined or changed, and it is necessary to form a qualitative scale with five levels Table 3 and Table 4 (Roy, 1991).

Table 3 Qualitative scale

Qualitative values	Very weak	Poor	Medium	High	Very high
Numerical values	1	2	3	4	5

Table 4 Quantification decision matrix

Alternatives / criteria	C1	C2	C3	C4	C5
Extremity type	max.	max.	max.	max.	max.
A1	3	5	4	4	5
A2	5	3	3	4	2
A3	1	2	2	3	2

The calculated results of the analysis indicate the following:

- A1 dominates A2, A3;
- A3 does not dominate any action.

The results show that the best alternative is A1 (Poljana), followed by A2 (Ćirikovac) and in the last place alternative A3 (Zabela - Kosa).

For the analysis of the obtained results, the starting element is the most attractive coal deposit and it is the deposit "Poljana" - Alternative A1. It is characterized by the largest reserves of coal for mechanized wide-head mining and opportunities to achieve the largest production capacity. Its advantages are in the uninhabited area of the exploitation field and relatively favorable communication with the largest consumers, as well as other technological phases can be mechanized and introduce a high degree of automation and remote monitoring.

Next is the deposit (Alternative A2) "Ćirikovac", which has larger reserves of coal, but has certain limitations in terms of the use of highly productive mining machinery in smaller parts of the exploitation areas.

The Zabela-Kosa deposit (Alternative A3) is characterized by relatively larger coal reserves, favorable communications and a high degree of exploration, but basic natural and geological conditions (layer thickness, types of accompanying rocks and tectonics) preclude rational application of methods with complex mechanization.

3.1 Elements of the investment program for the opening of active underground mines

Each investment program for the opening of mines, i.e. active underground deposits has its own content that has the same elements (Sokolovic, 2010) and they are:

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1. GENERAL INFORMATION ABOUT THE PROJECT AND INVESTOR
 2. BRIEF DESCRIPTION OF THE METHOD OF BUILDING THE MINE
 - 2.1. General data on the exploitation field
 - 2.2. Location of the deposit and exploitation field
 - 2.3. Geological characteristics of the deposit
 - 2.4. Coal exploitation and preparation plan
 - 2.4.1. Choice of technical solution
 - 2.4.2. Division of the pit and selection of the excavation method
 - 2.4.3. Transport and delivery
 - 2.4.4. Description of equipment and raw materials
 - 2.4.5. Description of ventilation
 - 2.4.6. Description of drainage
 3. VALUE OF COAL IN THE DEPOSIT
 - 3.1. Commercial range of coal
 - 3.2. Coal market analysis and price
 4. PRODUCTION CAPACITY AND LIFE OF OPERATION
 5. BUDGET OF WORKS ON CONSTRUCTION OF MINING FACILITIES
 - 5.1. Costs of energy and raw materials
 - 5.2. Required cash flows and number of employees
 - 5.2.1. Structure and number of employees
 - 5.2.2. Mine operating costs
 - 5.2.3. Expected arrival of the mine
 - 5.2.4. Investment investments in mine construction
 - 5.2.5. Project evaluation and payback period
 6. ASSESSMENT OF THE JUSTIFICATION OF MINE CONSTRUCTION

These elements of the investment program are an important factor in making investment decisions. The elements that directly affect the assessment of justification are the

financial and economic analysis, given through Chapters 5 and 6, and are conditioned by Chapter 2.

Indirect elements of the investment program under 3., 4. are an integral part of the program summary under items 5 and 6 and therefore it was important to do an analysis to rank investment decisions 1,2,3 for opening the proposed potential deposits "Poljana", "Ćirikovac" and "Zabela-Kosa", as shown by the assessment justification for mine construction.

4 MAKING AN INVESTMENT DECISION

The analysis of the available investment program for the opening of three new mines with increased reserves and natural and geological conditions that allow the use of highly productive machinery for coal exploitation should be given priority. A total of 3 new coal deposits were analyzed and their ranking by perspective for activation in terms of production was performed. Applied methodological procedure for ranking investment decisions for opening new coal deposits, which has not been researched in this way in the Republic of Serbia. Therefore, this data processing has the character of an original research, which gives a scientific contribution. The research within this paper has expanded the practical and theoretical knowledge on the application of methods in solving the problem of sustainable development of underground coal mines. By assessing the economic and environmental parameters for the conditions of new coal deposits, their ranking was performed from the aspect of sustainable development of underground exploitation in them. The ranking made here indicates to decision makers to pay attention to making investment decisions and to give importance when introducing sustainable business, but also when assessing the functioning of this business system. It is obvious that economic and environmental aspects are the most important for sustainable development, and the most influential criteria for ranking aspects are increasing the profit and productivity of mining companies. **The obtained research results proved that the most attractive coal deposit is "Poljana", which is characterized by significant coal reserves for mechanized wide-ranging excavation and opportunities for achieving the highest production capacity.** Next, there are deposits in the order of the investment decision, "Ćirikovac" and "Zabela-Kosa". For the complex ranking of coal deposits, the most influential criterion is the determined coal reserves in the deposit, which can be excavated using highly productive excavation machinery. Other criteria: possibility of mechanization and automation, production capacity, amount of investment, number of employees and environmental protection rely directly on the first criterion. Existing models of multicriteria decision-making methods are suitable for ranking the most important indicators for decision-making on the prospects for the exploitation of new coal deposits in the Republic of Serbia.

The analysis of the performed research within the topic of this paper revealed the following facts which emphasize the social significance of the assessment study on the opening of underground coal mines:

- Coal reserves provided for underground mining systems;
- The position of coal as an energy source for electricity production in times of crisis;
- Coal markets in Serbia and the need for quality coal;
- Built infrastructure facilities;
- Employment of domestic labor and prevention of population migration
- Mining tradition as an important element of mine development;
- Locations of mines in underdeveloped areas;
- Reducing the country's energy dependence.
- Strict adherence to all environmental standards, defined by the approved environmental impact assessment study of the project and investment decision making

5 CONCLUSIONS

According to the data available to world statistics, coal is one of the key energy sources for a stable and secure supply, thanks to significant reserves of over 870 billion tons, and at the same time they are widespread on all continents. It is estimated that the established coal reserves in the world are sufficient for over 100 years of exploitation. The new political and economic paradigm of the "Green Agenda" envisages a reduction in the use of coal with a tendency to suspend exploitation until 2050 and a shift to environmentally "clean" energy sources. This process is called energy transition.

In European countries (European Union), there is real chaos when it comes to coal production and consumption, especially now in times of energy crisis. In the last few years, coal production has decreased from 420 to 380 million tons per year, but at the same time there has been an increase in coal imports, which reached 180 million tons.

The state of energy reserves in the Republic of Serbia by type and amount of coal shows that in the coming decades, coal will continue to be an important energy source in the production of electricity, in order to maintain the energy system. All plans for further development of the energy sector in Serbia envisage, if not increasing the volume of coal production, then maintaining this level, which ensures energy independence in energy supply and construction of new thermal energy facilities with high environmental standards.

In the Republic of Serbia, the most important energy raw material is coal, whose share in the total energy mix is over 70%, while in coal reserves it has 88%, with the largest share being lignite. Given the current state of technology in the field of mineral exploitation, it can be concluded that 60% of available coal reserves can be excavated by surface mining and the rest by underground mining.

The conducted research proved the need and emphasized the importance of the development of underground exploitation in the energy sector of the Republic of Serbia, in order to balance the system and explained the inevitability of opening new mines with modern technological solutions. The scientific contribution is contained in the methodological procedure of ranking new coal deposits in the Republic of Serbia for the activation and construction of new mines by making a good investment decision.

In Serbia, coal deposits of the underground exploitation system are characterized by characteristics defined by natural - geological conditions, which have a decisive influence on the choice of technological solutions for the exploitation and application of modern equipment, and thus rational work. Ranking of mines from the aspect of achieving production, technical and economic and environmental parameters is a multi-phase and complex process.

In order to research, a detailed review of the state of underground coal mining in the Republic of Serbia was made, through a proposal for three potential deposits, its importance for the energy system and explained the need to develop this industry, opening new now inactive coal deposits production.

Based on the situational analysis, resource potentials of underground mines, equipment, general and special characteristics of business, within the investment program, the opening of underground mines in the coming period is defined, with all the elements.

Acquired experience shows that the opening of underground coal mines is accompanied by financial investments in the preparation of new excavation fields, facilities, as well as the purchase of necessary equipment, employees, etc. The results of the research prove that underground coal exploitation in the economic system of the Republic of Serbia has its significance, but also elements from the investment program for making investment decisions, ranking the most attractive deposits. The results of the research showed the connection between practice and theory and the possibility of obtaining an adequate investment decision.

Sustainable coal production affects the increased production of electricity and increases the income of companies in the energy field and economic development, especially in times of energy crisis. In the Republic of Serbia, there is intensive economic development, the opening of a number of economic production facilities, requires appropriate amounts of electricity, so that this would not be a limiting factor of economic development, a balance must be found.

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