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Research Paper

Optimal Surface Exploitation Planning for the New Lignite Mine in Sibovc, Kosovo

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Abstract: Coal remains a major classical primary energy source and is expected to maintain a dominant role in electricity generation throughout the first half of the 21st century, particularly in Europe. The Balkan Peninsula, and Kosovo in particular, holds significant lignite reserves over 12 billion ton placing the country among the most resource-rich globally. Despite this geological potential, Kosovo's current lignite production remains modest, underscoring the opportunity for expansion to meet growing domestic energy demands and contribute to the regional energy market. The Kosovo Energy Corporation (KEK) plans to increase production to 15 million ton annually by modernizing existing infrastructure and developing new mines, notably the New Sibovc Mine under the N1 alternative. This approach emphasizes efficient resource exploitation, avoids economically marginal areas, and aims to reduce operational losses. As lignite currently supplies approximately 97% of Kosovo's electricity, the further development of the coal sector is vital for ensuring long-term national energy security.

Key words: *Lignite, exploitation, Sibovc, New mine, Kosovo.*

Introduction

Coal belongs to the group of classical primary energy sources. Energy resources represent the fundamental basis for planning and implementing a country's energy strategy. The European Union of Coal Producers (EUROCOAL) predicts that coal in the future, namely until the first half of this century, will be a significant and dominant factor within the framework of energy sources for the production of electricity, and that with the increase in electricity needs there is a tendency for coal production to increase. With the modernization of existing capacities and the implication of new innovative technologies in the coal production process, the own needs of our country, as well as the wider European market region, will be met.

Coal basins are widespread in the Balkan Peninsula and Central Europe, and represent a major contribution to the total balance of coal reserves at European and global levels. During the Tertiary geological period, the largest accumulation of plant material for the formation of major coal reserves occurred in Europe. Of these reserves, the largest amount, about 70%, belongs to lignite-type coal, while about 30% to coal, which in the near future, precisely until the first half of this century, coal will be an important and determining factor in the framework of sources for the production of electricity, and the continuous increase in the need for electricity also conditions the trend of increasing coal production. Lignite coal production in Europe is presented according to data from Euro Coal (Figure 1).

According to available data for 2023 (Figure 2), global lignite production has reached around 337.3 million ton (Mt), with Germany taking the first place as the main producer, followed by Turkey and Poland (IEA). Meanwhile, Kosovo has contributed with a modest amount of 6.9 Mt, despite having large lignite reserves, estimated at over 12 billion ton. This discrepancy between the geological potential and the current level of production indicates an untapped opportunity in the further development of the energy sector in the country (Hyseni & Muzaqi, 2021). In this context, it is reasonable to aim for an increase in production to 15 Mt per year, relying on existing technical capacities and identified resources, in order to meet the strategic objectives of the Kosovo Energy Corporation (KEK). The young Republic of Kosovo sits atop the fifth largest geological lignite reserve on the planet (Arifi & Spath, 2018). Kosovo, in relation to the area and the number of inhabitants with its coal potential of over 12 billion ton of lignite, is the country with the greatest perspective of developing energy capacities for its own and wider needs (Ymeri, 2015).

The Kosovo Basin represents one of the largest and most extensive coal basins of the Balkan Peninsula. Due to its importance and colossal reserves, over the years it has been the subject of study

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for many local and foreign researchers from various fields. The first studies during the Second World War were of a general geological nature, within the framework of compiling geological maps covering this basin. The most complex and voluminous studies began after the Second World War, around 1950 and continue to this day, mainly in the central and northern part where the main concentrations of coal reserves were located (Mirash, Bardhe and Sibovc coal fields).

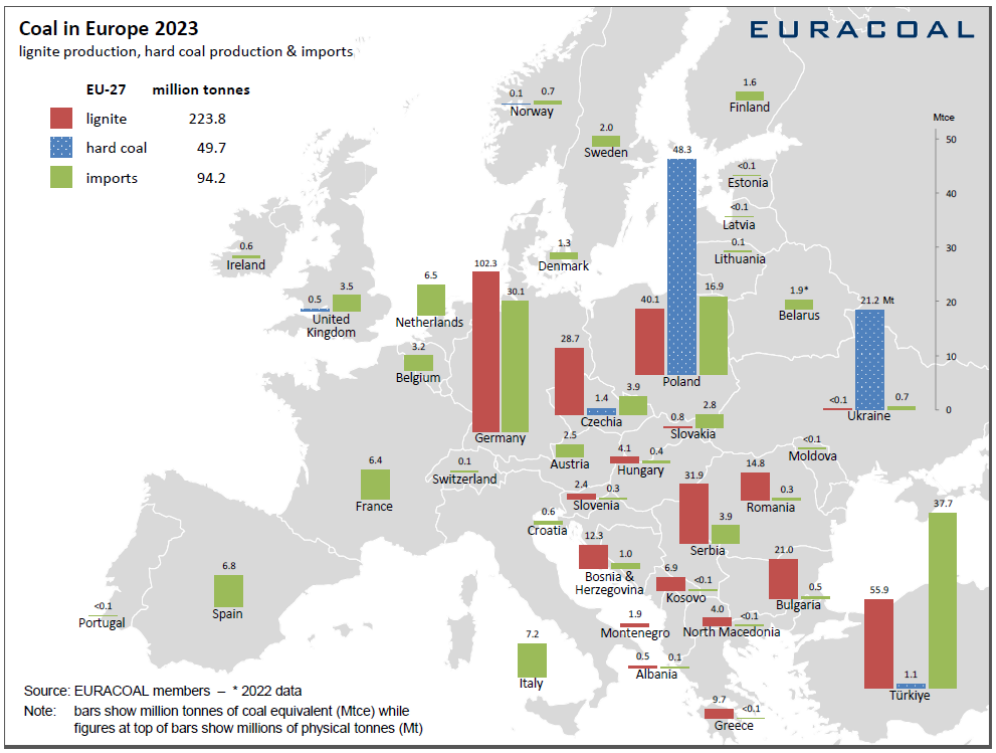

Figure 1. Coal (lignite) production in Europe for 2023

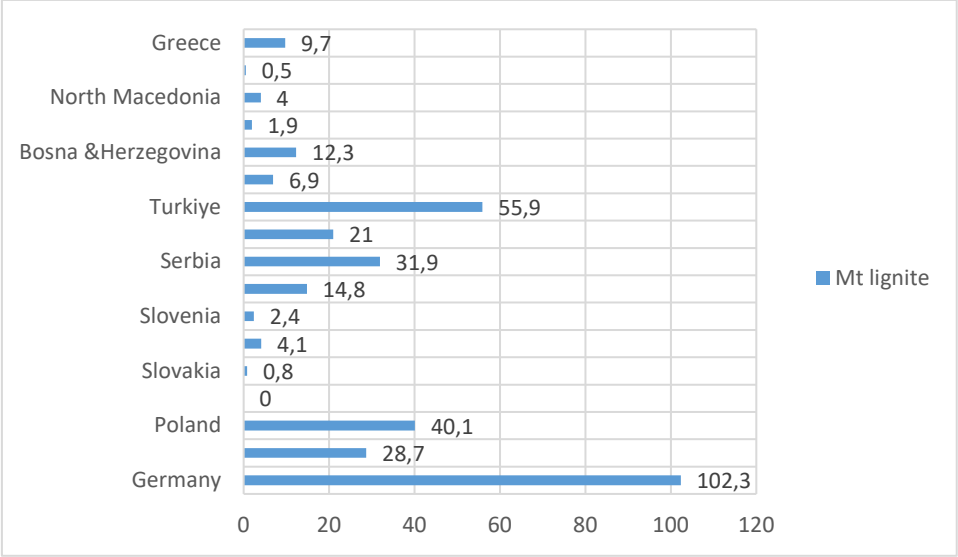

Figure 2. Lignite production by country for year 2023

Considering that the Republic of Kosovo secures about 97% of its electricity needs from the existing The Kosovo A and Kosovo B power plants, which use lignite as raw material, the strategic and development plans of the Kosovo Energy Corporation (KEK) foresee the opening of new surface mines in the Kosovo coal basin. The main goal of these plans is to ensure a stable supply of raw materials for existing power plants, as well as for new planned capacities for thermal energy production. To achieve this goal, it is required to increase lignite production capacities and build new plants for its processing

and enrichment. Kosovo possesses significant reserves of lignite, with over 12 billion ton of identified geological reserves, making it the main source of electricity for the country, despite its negative impacts on the environment (Hajra, 2014). According to geological research data, four coal basins have been identified in the territory of Kosovo: the Kosovo Coal Basin, the Dukagjini Basin, the Drenas Basin and the Skenderaj Basin (Figure 3). Among them, the Kosovo Coal Basin is the largest both in terms of surface area and the amount of lignite reserves it contains.

Within this basin, three main fields with high potential for exploitation have been identified: Sibovci Field, Jug Field and D Field (Bytyqi & Goskoli, 2012). In these areas, the opening of three new surface mines is foreseen, where advanced technologies for excavation, transport and storage of lignite will be applied.

In this paper, the focus will be on the treatment of the Kosovo Coal Basin, namely the new mine planned in the Sibovci area. This basin represents the largest and most important area in terms of lignite reserves in the Republic of Kosovo, as well as the most studied from a geological-mining and practical perspective, because several mining sectors have been opened and exploited within it over the years.

The Kosovo Coal Basin contains over 12 billion ton of lignite, formed in the geological time of the Pliocene (Morina et al., 2012). Its central area, known as the "Kosovo Coal Basin", extends over an area of about 270 km². The thickness of the coal seams in this basin reaches up to 100 meters, while the average thickness is about 45 meters (Haxhiu et al., 2013).

The average discovery coefficient for this basin is 1:1.85, indicating a favourable ratio between the amount of cover (overburden) and the mineral body. The depth of occurrence of lignite seams varies from surface outcrops to 310 meters below ground level.

The average quality parameters of lignite in this basin are as follows:

- Low energy value (ETU): 7,400 kJ/kg
- Sulphur content (S): less than 1%
- Non-combustible matter (L): 45-47%
- Moisture (H): 18%

These data show that lignite from this basin represents an energy source of strategic importance for the energy sector of Kosovo, justifying investments in opening new mines such as the one in the Sibovc Field.

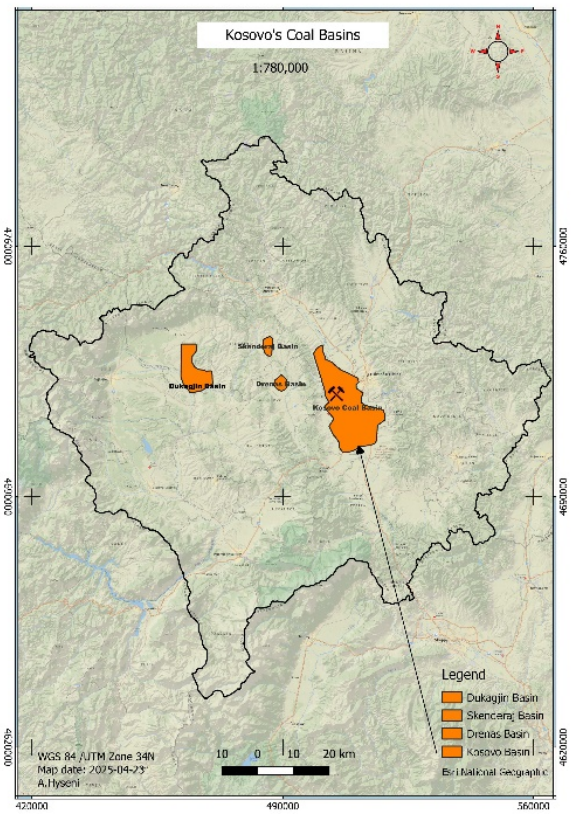

Figure 3. Main coal basins in Kosovo

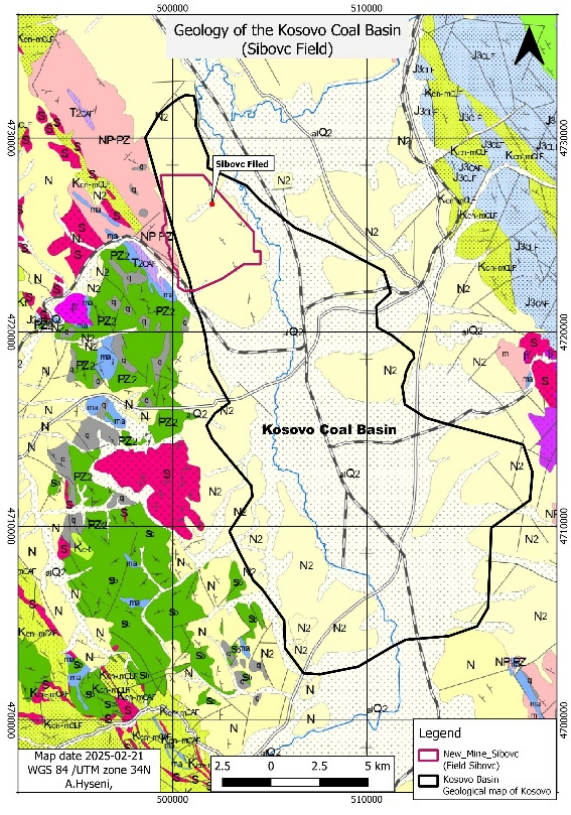

Figure 4. Geology of the Kosovo and Sibovc basin

Geology of the Sibovc deposit

The Sibovc opencast mine or deposit belongs to the Kosovo Coal Basin, which can be identified with the Kosovo Plain, which has a longitudinal north-south extension and a rise towards the west, while the general extension of the basin is northwest - south southeast.

The Sibovc deposit is located on the western side of the Kosovo Tertiary Basin ((Figure 4). This deposit is currently undergoing geological research and assessment for the development of a new opencast mine for the extraction of lignite (Mirena, 2022).

Geologically, the Sibovc coal basin is a Pliocene formation created by freshwater sedimentation, resulting from the displacement between two parallel faults. Tectonic structures in this region lie in a NNW-SSE direction (Mirena, 2019).

The Sibovc mine represents the largest coal deposit in Kosovo, with total reserves of 990 million ton (Mt), of which 830 Mt are considered exploitable. The deposit covers an area of 19.7 km² (Figure 5). The overburden layer reaches a thickness of up to 50 meters, while the coal layer exceeds 55 meters in thickness. The overburden to coal ratio is favourable at 0.9:1 (m^3/t), making extraction efficient. The exploitation of these coal reserves represents a significant challenge for the next 50 years, with an expected annual production of up to 15 Mt (Authors' Group, 2019). Geological and exploration studies conducted so far in this basin have revealed that the lignite layers that represent its geological structure are in fact horizontal or almost horizontal layered deposits and are characterized by a low discovery coefficient, which makes the exploitation of the balanced reserves available in the basin very profitable (Ahmeti & Duraku, 2023). The depletion of lignite reserves in the South-West Sibovci Field Surface Mine has led to the necessity of opening the new Sibovci North Mine to meet consumer demands for lignite. For this, a detailed mining project was drafted in 2019.

The New Sibovc deposit has an average altitude of 620 m above sea level and fluctuates between 500 m and 750 m. The angle of dip of the lignite layer ranges from 100÷40 with a general dip in the direction from southeast to southwest. The floor of the coal layer consists of non-layered clays with a high content of sand and clayey sandstones in the deepest part up to the vicinity of the coal layer. The direct floor consists of green clays with the presence of oily clays and sands. The thickness of the clay is about 50 m. The Sibovc mining field in the west direction generally follows the border of the lignite deposit. In the Northeast direction it is defined by the diagonal orientation North-West-Southeast in the main direction of the Sitnica River flow and is curved in the Southeast in the southern direction along the border of the exploited mine Brandi. The southern border is along the exploited mines Bardhi and Mirashi (Figure 6). Within the surveyed area several geological landslides have been identified and additional cracks have been presented. Most of these structural failures have been observed on the western border of the northern field.

Current use of the Sibovci deposit area There are a number of villages, the most important being Hadja, Shipitull, Leshkoviqi and Sibovci. Most of the surface of this field is used for agricultural purposes.

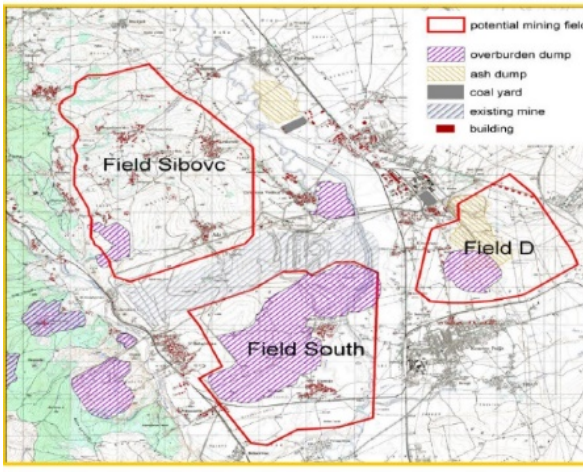

Figure 5. Sibovc Field, South Field and D Field

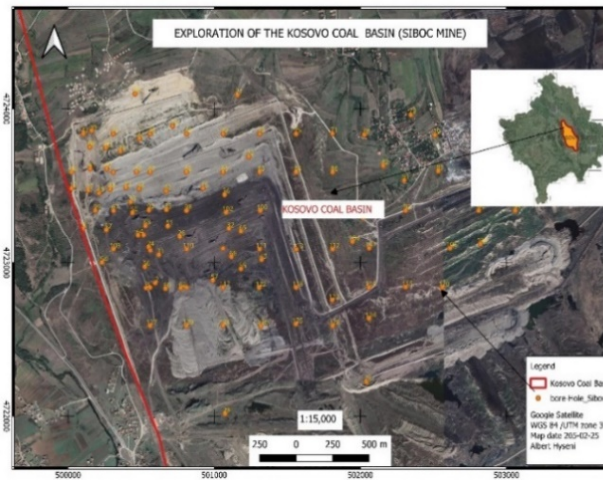

Figure 6. Deep drilling exploration in Sibovc

Material and methods

The exploitation of mineral raw materials in the Sibovc Mining Field is carried out on the basis of the mining project documentation, which includes a series of technical and engineering solutions in accordance with legal requirements and professional standards. The documentation is divided into two main phases: conceptual and operational. The conceptual documentation includes conceptual studies, elaborates and expertise that provide approximate estimates of the exploitation method, the life of the works, the costs and the economic feasibility of the project. The operational documentation contains concrete and detailed solutions for each segment of the mining facility, including: mine contouring, exploitation methods, technical and technological parameters, protective measures, drainage and transportation.

Results and Discussions

Alternatives for the exploitation of the new mine in Sibovci

In this paper, we focus on the Sibovc lignite deposit and its surface exploitation system with the aim of optimizing lignite production (Hyseni & Haliti, 2025). In the Master Plan for the Sibovc Mining Field, it is emphasized that: "If the consumption of raw coal is clearly reduced, the basic project including long ladders would no longer be optimal and would result in a specific increase in production costs". For the opening, preparation and exploitation of the new Sibovc Field mine according to the documentation (Technical Planning, KEK, 2019), three alternatives have been considered:

Alternative N1

- Continued development of the Sibovc-JP mine in a northerly direction;
- No relocation of the southern part of Hada is required from a technological point of view, but planned in time for social reasons;
- No additional equipment is required in the first five years except for necessary repairs to existing excavation, transport and stacking equipment,
- Planning the equipment of the career with additional conveyors with belt widths of 1600 and 1800 mm for all grades due to the progress of the mine,
- Replacement of obsolete coal excavators and conveyor belts in the normal process of purchasing two or three compact excavators with digging capacity and technical and constructional characteristics similar to the SR 1300 and SchRs 650 type excavators;
- Relocation of parts of the village of Sibovc and land acquisition in accordance with the development of the mine.

Alternative N2

- Opening the Hada section in parallel with the continuation of the Sibovc - JP mine. The objective is to develop a mine with a long Sibovc-Jug front;
- Immediate relocation of the entire village of Hade is required;
- Start with mobile or discontinuous equipment (contractor) for heavy overburden management for coal discovery in the Hada region;
- Urgent provision of overburden excavators and conveyor systems

(First commissioning in 2025) due to the required parallel work of Sibovc-JP and the opening of the Hada section).

Alternative N3

- Additional conveyor systems for overburden transport in 2025/2026 due to the required redesign of the Sibovc-JP overburden transport (from the eastern to the western border);
- Application for submission of a permit request prior to the commencement of any mining activities;
- Replacement of obsolete coal excavators and conveyor belts through the normal process of purchasing two or three compact excavators of similar capacity such as SRs 1300/ SchRs 650 (2026/28).
- Relocation of parts of the villages of Sibovc and Leshkoshik and acquisition of land in accordance with the development of the mine.

Considering the potential development of the Sibovc mining field and the current development of the Sibovc South-West mine, for the future development of mining activity we have selected Alternative N1 with the above-mentioned characteristics for the detailed study.

Exploitation of surface lignite ore according to Alternative N1

The exploitation of the New Sibovci Mine according to alternative N1 actually represents the continuation of the exploited Sibovci-J-P mine in the north direction (Figure 7). All main (front) conveyors should be extended with the advancement of mining works in the career. In the center of the 1st system in the cover, the height of the step is higher than the technical height of the excavator excavation. In this part, auxiliary equipment should be engaged in the work processes, i.e. discontinuous shovel-truck excavator system, to clean possible concrete and other waste from the houses and shorten the block height to a maximum of 21 m. The material will be stacked in the western part of the former Bardhi mine. The length of the first step in the cover of the existing mine is 1600 m (Sector 0).
The development of the mine will continue in a Northerly direction (Sectors 0 to 3) exploiting the best part which results in very favourable geological coefficients or cover/lineage ratios (prevailing with a value of 1.0, while in sector 3 it is only 0.6) throughout the life of the mine. It is not necessary to excavate the hills north of Hade and furthermore it is not necessary to relocate the village of Leshkoshik and most of the village of Hade.

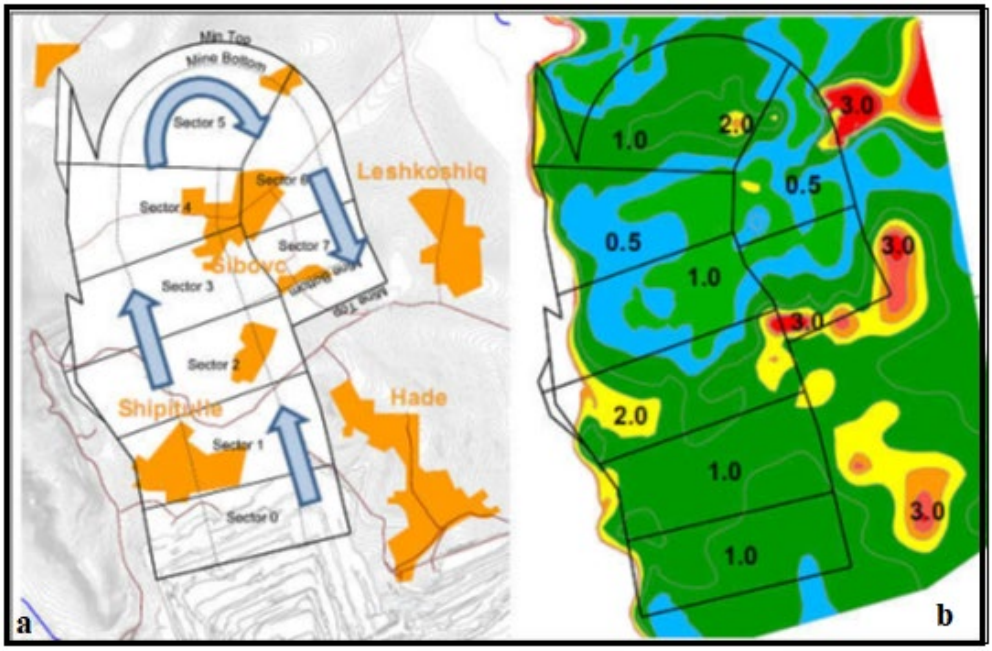

Figure 7. Alternative N1- Mine Development and Discovery Coefficient in the Sibovci Field
a. *Mine development* **b.** *Geological coefficient of discovery*

Starting from Sector 0 which is like the existing Sibovci–SW open pit mine, the mine will be operated with parallel mining operations until the beginning of Sector 4. At the end of Sector 4 the mine switches to clockwise rotation operations. In Sector 6 the mine operation switches from circular front mining operations to longitudinal or parallel front mining operations in the South direction. The discovery coefficient varies between 0.8 and 1.0. The western boundary of the mine in sectors 6 and 7 has already been excavated within sectors 3 and 4. For this reason the cover systems will only excavate the pillar which is blocked under the main conveyors. During the first 5 sectors the mine will not be extended in the east direction (due to the eastern ring slope system with the front conveyors in place). Starting from the completion of sector 5, the mine can be expanded in the east direction. Then, the front conveyors will be installed in the western edge slope system, which will enable the expansion of the mine in the east direction.

The annual mine advancement of the N1 mining alternative on average is 100 meters. The general plan for the advancement of the mining works is given in Figure 8. In this alternative, it is not necessary to exploit the mine in the economically unfavourable parts of the deposit, as well as in the area of the previous underground exploitation. Within the framework of alternative N1, it is also not necessary to excavate the hills north of the Hade village and, moreover, it is not necessary to relocate the village of Leshkoshik and most of the Hade village. Considering the annual demand for coal for Kosovo's total thermal energy capacity is 400 Mt by 2065. For this reason, in the described scenario N1 of mine

exploitation, 378 Mt m^3 of waste must be removed, which leads to an excellent average discovery coefficient of 1.0.

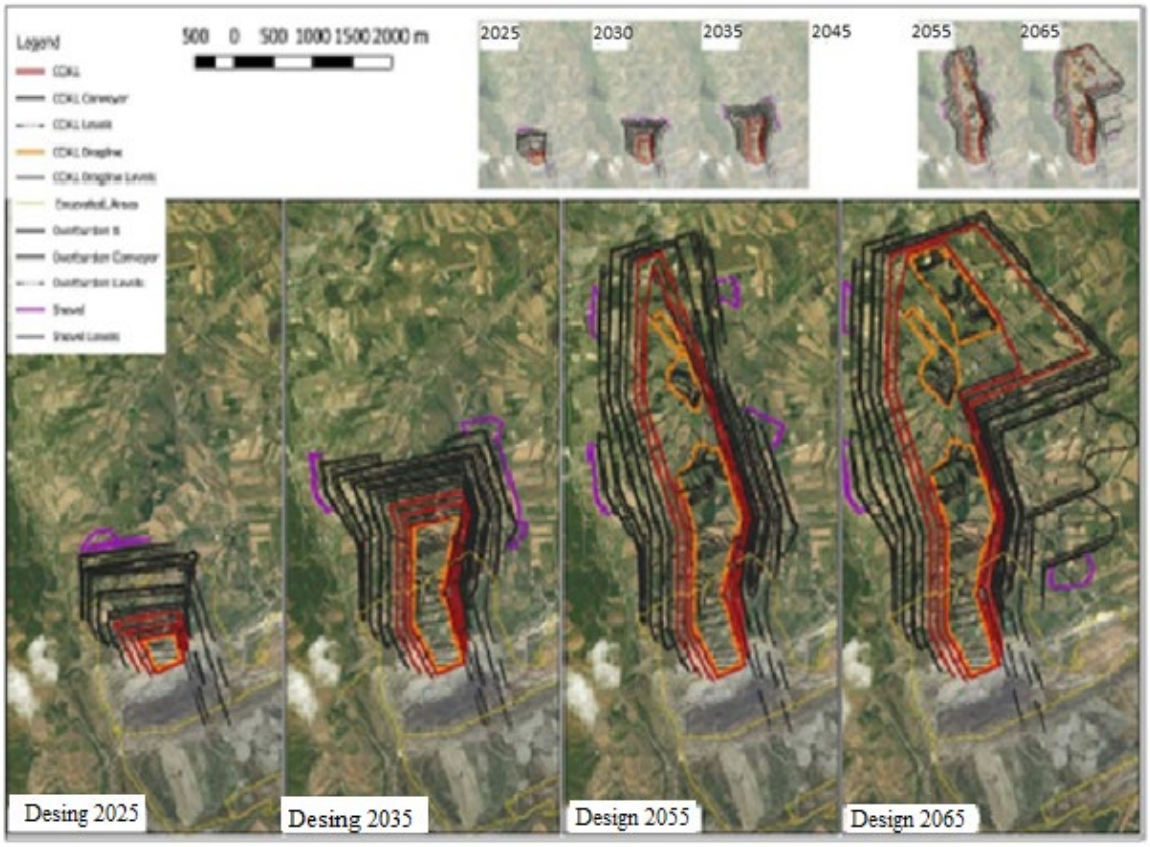

Figure 8. Mining works advancement plan

Conclusion

The Republic of Kosovo possesses one of the largest lignite reserves in Europe, with over 12 billion ton located mainly in the Kosovo Coal Basin. Despite this large geological potential, current production levels remain relatively modest. As Kosovo relies on lignite for approximately 97% of its electricity production, the sustainable and strategic development of this resource is essential for national energy security. This study has highlighted the importance of the Sibovc deposit, particularly the New Sibovc Mine, as a major potential for future energy production.

Through comprehensive geological assessments, the Sibovc deposit has been identified as economically and technically viable for long-term exploitation. Among the proposed development strategies, Alternative N1 has been selected for its efficiency, minimal environmental impact and optimal exploitation ratio. This alternative allows for continuous expansion without the need for major village relocations or excavation of economically unsustainable areas, thus balancing economic development with social responsibility.

The implementation of Alternative N1, supported by modern mining technologies and infrastructure investments, is expected to ensure a stable supply of lignite until at least 2065, ensuring the reliable operation of existing and future thermal power plants. Furthermore, the strategic exploitation of the Sibovc field will strengthen Kosovo's role in the regional energy market, while providing a model for the responsible development of mineral resources in the Western Balkans.

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References

Hyseni A, Haliti R, (2025), Enhancing the efficiency of lignite exploitation in the Kosovo mining field. Proceedings 16th Conferences with Internacional participation, Ljubljana, pp. 27

Ahmeti H, Duraku V, (2023) Formation of the Geometry of the Side Slopes from the Geotechnical Aspect for the Recultivation of the Degraded Area from Coal Mining. *Journal of Ecological Engineering 24(1),195–204*.DOI: https://doi.org/10.12911/22998993/156001

Mirena A, (2022) Coal reserves and quality of Sibovc for long -term supply needs in the corporation energy of Kosovo. Master Thesis. Faculty of Geosciences University "Isa Boletini" Mitrovicë.

Mirena A, (2019) Deep geological drilling research in southwest Sibovc (Inkos Sh.A. Institute-Obiliq). Prishtine

Arifi B, Spath Ph, (2018) Sleeping on coal: Trajectories of promoting and opposing a lignite-fired power plant in Kosovo. *Energy Research & Social Science 41*,118–12. https://doi.org/10.1016/j.erss.2018.04.012

Ahmeti H, Duraku V, (2018) Endangering Residents in Shipitull Village by Landslide at the Surface Mining in South West Sibovc. *Journal of Civil & Environmental Engineering 8* (ISSN: 2165-784X), 1-8. DOI: 10.4172/2165-784X.1000315.

Hyseni A, Muzaqi E, (2021) Sulphur content at the coal deposit in Sibovc**.** *International Multidisciplinary Geosciences Conference IMGC202*1, Mitrovicë.

Ymeri A, (2015) Geological-sedimentological assessment and petrographic features of the Kosovo coal basin. Albanian PhD Thesis. Faculty of Geosciences and Mining University Tiranë.

Hajra H, (2014) Physico-chemical characteristics of Kosovo basin coals and their impact on the environment. Albanian PhD Thesis. Faculty of Geosciences and Mining University Tiranë.

Cehlar M, Rybar R, Pinka J, Haxhiu L, Beer M, (2013) Analysis of suitability for development of new mining field in north part of Kosovo lignite basin- Sibovc. *Arch. Min. Sci., 58(2), 557–568.* DOI:10.2478/amsc-2013-0038.

Morina I, Dragusha B, Dvorani S, Reisbeck F, (2012) Chemical characteristics of lignite ash from power plant Kosova A and local geological settings in Kosova near Prishtina. https://wseas.com/journals/ead/.

Haliti R, (2024) Statistika në inxhinierin minerare: Prishtinë, pp. 205

Bytyqi A, Goskoli E, (2012) Opportunities and Prospects of Coal exploitation in the area of Sibovc. *Universitas Publishing House Petroşani–România, 2012 13, 20.*

Adedeji B.B, Olufemi A.O, (2007). Computational Economic Analysis for Engineering and Industry. Printed in the United States of America, pp. 220.

Schernikau L, (2016) Economics of the International Coal Trade Why Coal (Second edition) Germany, pp. 362.

Ratan R.T, (2014), Surface and Underground Excavations Methods, Techniques and Equipment. London, pp. 904.

2019 Përgatitja e planit të detajuar të prodhimit dhe investimeve për minierën e re ne KEK. Prishtinë. (Technical Planning, KEK, 2019).

2023 International Energy Agency (IEA), Coal Information. https://euracoal.eu/info/euracoal-eu-statistics/.