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CURRENT STATE OF COAL MINES OF THE EP BIH CONCERN AND LONG TERM PLAN OF COAL SUPPLY FOR THERMAL POWER PLANTS "TUZLA" AND "KAKANJ"

TREKUTNO STANJE U RUDNICIMA KONCERNA EP BIH I DUGOROČNI PLAN ISPORUKA UGLJA PREMA TE "TUZLA" I "KAKANJ"

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Abstract: It is a well-known and correct fact that "the coal has a strategic and irreplaceable role in the electricity production system of Federation of BiH and that this will stay in the future period". In favour of this fact goes the development policy of EPBiH, which has already started with the design and construction of new/replacement thermal power plant units in Tuzla and Kakanj. The new unit 7 in Tuzla is a cogeneration unit, which will burn lignite coals from coal mine "Kreka". Construction of the unit 7 in Tuzla is scheduled to start in 2017. Also, the decision has been made to construct a new/replacement cogeneration unit 8 in Kakanj, which should take over the electricity production from old units in that thermal power plant. Strategic plan of EPBiH for the future is to have two highly efficient cogeneration units (built according to BAT technologies and with efficiency greater than 42%), one in Tuzla and one in Kakanj, which would satisfy the market needs. The construction of new/replacement units, which will burn domestic coals, will ensure a secure market of coal and long term security. This paper analyses the general state of coal mines and presents the long term projections of coal supply for thermal power plants of EPBiH.

Keywords: coal, mines, production, long term plan, thermal power plant

Sažetak: Naveliko je poznata i tačna konstatacija „da ugalj u sistemu proizvodnje električne energije na nivou Federacije BiH ima stratešku i nezamjenjivu ulogu i da će tako ostati i u narednom periodu“. U prilog tome ide i razvojna politika EPBiH koja je uveliko krenula u projektovanje i izgradnju novih/zamjenskih blokova u Tuzli i Kakanju. Termoblok 7 u Tuzli je kogenerativni, spaljivat će lignite iz RU „Kreka“. Također, donesena je odluka da se u Kakanju gradi novi/zamjenski, kogenerativni blok 8 koji bi trebao preuzeti proizvodnju iz trenutnih blokova. Strateški plan EPBiH je da u budućnosti ima samo dva visokoeffikasna kogeneracijska bloka (izgrađena u skladu s BAT tehnologijama i sa stepenom efikasnosti većim od 42%) jedan u Tuzli a drugi u Kakanju, koji će kapacitetom zadovoljiti potrebe tržišta. Izgradnja novih/zamjenskih blokova koji će koristiti domaće ugljeve osigurat će rudnicima Koncerna EPBiH siguran plasman i dugoročan rad. Rad sagledava opšte stanje u rudnicima i prezentira dugoročne projekcije isporuka uglja prema termoelektranama EPBiH.

Ključne riječi: ugalj, rudnici, proizvodnja, dugoročni plan, termoelektrana

INTRODUCTION

All seven mines in the EPBiH Concern mainly operate to supply the needs of Elektroprivreda BiH, but they are also important for the industry, broad and general coal consumption in Bosnia and Herzegovina. EPBiH, as basic consumer of domestic coal, burns 80-95% of coal produced in those mines in its thermal power plants. Coal mines "Kreka", "Đurđevik" and "Banovići" supply coal to the thermal power plant "Tuzla", while the thermal power plant "Kakanj" is supplied with coal from the mines of Central Basin "Kakanj", "Breza", "Zenica", "Bila" and "Gracanica".

Each mine in the EP BiH Concern is specific and different. Some of them use surface exploitation systems, others use underground methods and the third use both. In the process of removing the first layers in surface mining continuous and discontinuous systems are applied. Underground mines exploit one or more layers of lignite or black coal. In the layers that are sufficiently flat, the method of the broad forehead is used, in one or more floors, or digging methods of obtaining coal, and works at the head range from manual to completely mechanized. The coal layers that steeply incline are exploited by using chamber methods with numerous variations depending on geological and geotechnical problems at each mine.

Some mines still have large reserves while others are almost depleted beyond economic exploitability. Quality of

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coal varies extensively with a wide range of calorific value, moisture, ash and sulphur content. Each mine has a number of its own unique problems, issues and challenges, and what is common for them all is that they badly need capital for land, infrastructure, equipment, servicing liabilities to the state and suppliers, surplus of workers and a large percentage of disabled people. In this situation, the Concern mines, compared to the coal mines in the world with similar equipment and similar size, have low productivity. This has created the necessity of launching a new restructuring program of the mines within the EPBiH Concern.

After 5 years of operation under the EPBiH Concern, those mines have not been consolidated and restructured as it was originally conceived. For longer time, there are numerous problems in the coal mines that adversely affect and limit the dynamic development of the mines, such as:

- A substantial delay in removing the first layers, distorted geometry of the open pits, the angle of the working slopes is not within the projected limits;
- Production is realized by using outdated technology, with great problems and difficulties in introducing new equipment in the underground mines and harsh working conditions due to greater depths, pressures and the emergence of water and gases;
- A surplus of workers and the problem of fluctuation and lack of the production workers, their unfavourable age and qualification structure, with a high number of disabled workers (> 21%) and workers with reduced working capacity;
- Delay in the preparatory works as a result of the lack of funds for the purchase of equipment, spare parts and other necessary raw materials.

Because of the all above-mentioned (except for the mine "Gračanica"), the situation in the mines is very complex.

- The mines are in a difficult financial situation and operate with losses.

- The business operations of the mines are economically unsustainable.
- The production price of coal to EPBiH is greater than sales price, which creates a continuous pressure to make changes in the prices of coal and electricity.
- The processes of coal production are not optimized.
- A large number of employees in relation to the volume of coal production and revenues - low productivity.
- Coal mines have substantial unsettled and outstanding obligations to the state (taxes, contributions) and suppliers.
- Insufficient production of coal with required quality to supply the existing and planned production and thermal capacity.
- Occupational safety is not at the required level.

1. CURRENT SITUATION IN THE MINES - KEY INDICATORS

1.1. Coal reserves

Balance sheet coal reserves at the level of the EPBiH (Table I) represent only 48.45% of the total geological reserves, off-balance sheet reserves are 17.47% and potential ones are 34,08%, which is a result of the low scope of research [1].

Out of the total of 853.9 million tons of coal in the exploitation reserves, mines that are of strategic importance for the Concern contain 78% of total coal reserves ("Kreka" 54%, "Kakanj" 18.1% and "Breza" 5.38%).

1.2. Coal quality

Lignite coals that are exploited in mines of the Concern are with an average calorific value between 7,500 to 12,600 (kJ/kg) [2]. The coal contains 0.2-1.0% of sulphur, 5-9% of ash, and 35-53% of humidity [2]. Black coals have an average calorific value of 16.750 (kJ/kg) but also a significant percentage of sulphur (2-6%), ash (10-45%) and

Table I: Total coal reserves of EPBiH (000) t

No.	Mine	Balance sheet (A+B+C ₁)	Off Balance sheet (A+B+C ₁)	Potencial (C ₂ +D ₁ +D ₂)	Total geological	Exploit (A+B+C ₁)	Exploit. as of December 31, 2008
1.	Coal Mine Kreka	743,954	322,833	59,407	1,126,194	456,008	462,809
2.	Black Coal Mine Đurdevik	60,183	4,963	0	65,146	54,524	51,990
3.	Black Coal Mine Kakanj	256,536	56,525	127,604	440,665	204,839	154,562
4.	Black Coal Mine Breza	49,244	23,928	0	73,172	28,098	45,953
5.	Black Coal Mine Zenica	179,843	59,931	721,369	961,143	131,800	120,918
6.	Black Coal Mine Bila	26,808	10,373	25,354	62,535	16,091	9,509
7.	Coal Mine Gračanica	10,657	0	0	10,657	10,657	8,167
Subtotal of lignite		754,611	322,833	59,407	1,136,851	466,665	470,976
Subtotal of black coal		572,614	155,720	874,327	1,602,661	435,352	382,932
In total EPBiH Concern		1,327,225	478,553	933,734	2,739,512	902,017	853,908

Source: The study of energy sector in Bosnia and Herzegovina (2008)

humidity (10-25%), which reduces the scope of their use, particularly if we take into consideration a long-distance transportation and environmental issues [2]. The coal from the mine "Đurđevik" has the best average coal calorific value while lignite coals from the mines "Kreka" and "Gračanica" have the lowest average calorific value. General overview of the average coal quality from the mines is shown in Table II.

Table II: The quality of the coal mines

No.	Mine	Hd (GJ/t)	Moisture (%)	Ash (%)	Sulphur (%)
1.	Coal Mine Kreka	11.31	38.7	13.06	0.61
2.	Black Coal Mine Đurđevik	17.95	9.42	25.77	2.3
3.	Black Coal Mine Kakanj	12.5-16.07	5.7-9.16	35.49-42.75	1.4-3.85
4.	Black Coal Mine Breza	14.428	6.61	30.99	2.54
5.	Black Coal Mine Zenica	17.619	12.58	22.32	3.65
6.	Black Coal Mine Bila	14.503	15.84	24.65	4.69
7.	Coal Mine Gračanica	10.746	32.43	17.06	2.95

Source: The study of energy sector in Bosnia and Herzegovina (2008)

1.3. Production

Indicators of coal production [3] in the displayed period significantly deviate from the plans and have a downward trend since 2011, when maximum production was reached. After that period, coal production has begun to decline, which was further worsened by natural disasters in 2014.

The main causes of the decline in production are identified: accidents with serious consequences that have affected the further course of production and operation of the mines.

- Coal mine "Kreka"
After the flooding that happened in 2014 the mine "Kreka" suffered great damage: complete sinking of the surface crater of the open pit mine "Šikulje" in Lukavac; sinking of the mining site and activation of landslides in the open pit mine "Dubrave"; sinking of

the old craters of the former open pit mine Lukavačka Rijeka that are located above the underground mine works of the mine "Mramor" in Mramor as well as sinking and devastation of railway track facilities "Railway transport". A part of the equipment was destroyed and the other is currently under overhauled or has already been overhauled. Due to the damage cause to this mine, it has not been fully recovered yet. The funds needed to stabilize coal production amounts to about 160 million BAM.

- Black Coal Mine "Zenica"
In September 2014, there was a devastating rock burst with fatal consequences in the "Raspotočje" mine, which is why the federal mining inspection banned all works on the sites in the eastern part of the 8th tectonic terrace of the main coal seam. Preparing the new site for coal exploitation using long-wall mining method is in the process. Purchase and installation of new equipment is planned for the mid-2017. The mine still has not recovered from the consequences of the rock burst.
- Black Coal Mine "Breza"
There was an accident in the mine pit "Sretno" on May 6, 2012. A fire caused by oxidation destroyed most of the mine pit. The mine pit was closed immediately after the accident, and repairs of the damage caused by the fire began in the fall of 2012. The coal mining in this pit has been continued but the consequences caused by this accident halted development of mining operations, which resulted in a slow recovery.

The total coal production in the mines is shown in Table III.

1.4. Total number of employees

From the moment of integration of the mines and EPBIH and until the end of 2015, the total number of employees [3] was reduced by 18% (-1,841 employees) and it was (mostly) the result of natural outflow of employees (Table IV). Stimulating severance packages were accepted by a very insignificant number of employees. This trend is recorded at the mines that are engaged in the surface mining but also in those engaged in underground mining.

Table III: Coal production in the mines (000) t

No.	Mine	2009	2010	2011	2012	2013	2014	2015
1.	Coal Mine Kreka	2,507	2,317	2,643	2,496	2,109	1,871	1,808
2.	Black Coal Mine Đurđevik	446	523	597	586	481	466	526
3.	Black Coal Mine Kakanj	1,174	1,076	1,118	1,163	1,080	1,101	1,008
4.	Black Coal Mine Breza	400	429	463	472	462	456	473
5.	Black Coal Mine Zenica	308	198	319	337	348	292	271
6.	Black Coal Mine Bila	92	95	103	117	160	177	137
7.	Coal Mine Gračanica	268	253	255	307	264	349	304
TOTAL		5,195	4,891	5,498	5,478	4,904	4,712	4,527

Source: Analysis of the Mine Management, 2015

Table IV: Total number of employees

No.	Mine	2009	2010	2011	2012	2013	2014	2015
1.	Coal Mine Kreka	4,014	3,872	3,657	3,475	3,225	3,010	2,754
2.	Black Coal Mine Đurđevik	1,148	1,147	1,106	1,037	972	945	904
3.	Black Coal Mine Kakanj	2,126	2,092	2,024	1,952	1,989	1,906	1,747
4.	Black Coal Mine Breza	1,199	1,255	1,265	1,268	1,252	1,262	1,212
5.	Black Coal Mine Zenica	1,465	1,423	1,439	1,508	1,504	1,469	1,452
6.	Black Coal Mine Bila	299	292	280	276	280	354	357
7.	Coal Mine Gračanica	209	210	210	209	200	199	193
TOTAL		10,460	10,291	9,981	9,725	9,452	9,145	8,619

Source: Analysis of the Mine Management, 2015

However, in the mines that exclusively use underground coal exploitation methods, the number of employees has actually increased. The reason lies in the fact that underground mines have more exploitation machinery which requires a large number of employees (four-brigade system). The final number of employees in the mines will be defined by the new Restructuring program of the mines, which is being created.

1.5. Operation of the mines

Overview of the mining operations [3] was developed for the period 2010-2015, from which it can be concluded that the situation in the mines is very complex and that the mines have experienced great difficulty in their business operations. Although, by the end of 2015, more than 308 million BAM has been invested in the mines of the

Concern [3] (152.5 mil. BAM based on the decision on recapitalization of the mines by the parent company and 155.6 million BAM on the basis of the Law on Financial Consolidation of the Mines from the Budget of the Federation of Bosnia and Herzegovina, this situation has not changed and the mines have continued with unprofitable business operations.

The consequence of the production decline is the trend of the increasing in the total loss after 2012, which reached its maximum level of 107.7 million BAM in 2015 (Table V), with the mines "Kreka", "Breza" and "Zenica" being leaders in this because of the above-mentioned reasons [3]. A significant concern is that more than a half of the total losses belongs to the strategic mines "Kreka" and "Kakanj", which are the largest suppliers of coal for thermal power plants of EPBIH and on which the construction of new/replacement units in Tuzla and Kakanj is based.

Table V: Results of the coal mine

Year/Mines		Kreka	Đurđevik	Kakanj	Breza	Gračanica	Bila	Zenica	Ukupno
2010	Revenues	131.5	47.0	66.0	36.4	12.6	8.3	19.2	321.0
	Expenditures	162.6	45.7	74.2	44.4	12.5	8.5	39.3	387.2
	Result	-31.1	1.3	-8.2	-8.0	0.1	-0.2	-20.1	-66.2
2011	Revenues	144.4	46.6	70.3	44.5	13.5	8.5	34.9	362.7
	Expenditures	161.9	52.4	82.5	46.7	13.4	8.8	49.0	414.7
	Result	-17.5	-5.8	-12.2	-2.2	0.1	-0.3	-14.2	-52.1
2012	Revenues	130.5	45.1	75.4	44.6	15.4	9.7	35.8	356.4
	Expenditures	158.0	44.9	79.9	44.8	14.8	10.7	45.5	398.6
	Result	-27.5	0.1	-4.5	-0.2	0.5	-0.9	-9.7	-42.2
2013	Revenues	116.9	39.5	74.9	41.2	16.5	15.7	48.6	353.3
	Expenditures	155.9	43.5	79.1	44.1	16.0	15.6	54.4	408.6
	Result	-39.0	-4.0	-4.2	-2.9	0.5	0.1	-5.8	-55.3
2014	Revenues	94.7	37.2	72.3	31.0	19.1	16.3	36.7	307.3
	Expenditures	127.7	42.9	85.9	40.3	17.6	17.9	59.5	391.8
	Result	-33.0	-5.7	-13.6	-9.3	1.5	-1.6	-22.8	-84.5
2015	Revenues	90.3	35.4	63.5	28.3	19.2	14.3	35.1	286.1
	Expenditures	123.3	43.0	85.3	51.0	14.3	19.9	56.9	393.7
	Result	-33.0	-7.6	-21.8	-22.7	4.9	-5.6	-21.8	-107.6

Source: Analysis of the Mine Management, 2015

In the reports of independent auditors and Audit Committee [3], following statements are true for the majority of the mines:

- Continuous operation with a loss and a liquidity problem, which can cause uncertainty in continuing operations,
- A large amount of accumulated loss and a significant loss in relation to the share capital,
- Large liabilities (to the state, suppliers and creditors)
- Potential (unexpressed) obligations (litigations, interests, concessions, re-cultivation ...)
- Overvalued assets.

2. PLAN OF THE COAL DELIVERY TO THERMAL POWER PLANTS OF EPBIH

On the basis of the stated required coal quantities and quality that are necessary for the realization of the power balance by 2035. mixtures and the total amounts of coal to be burned in the thermal power plants "Kakanj" and "Tuzla" (Table VI) have already been projected. Mixtures of the coal based on the type and calorific value were dictated by the projection of the total amount of coal needed by the thermal power plants.

Commissioning of the unit 7 in the thermal power plant "Tuzla" and the unit 8 of the thermal power plant "Kakanj", the total coal need [4] will amount to almost 7 million tons (4.177 million tons for the thermal power plant "Tuzla" and 2,814 million tons for the thermal power plant "Kakanj").

2.1. Thermal power plant "Tuzla" - a long-term delivery plan

Coal for the thermal power plant "Tuzla" is purchased from Coal Mine "Kreka" lignites (Facilities: Šikulje, Dubrava, Marble), Black Coal Mine "Banovići", black I and black II, Black Coal Mine "Đurđevik" black I, black I sediment and black II, Lignite Mine "Stanari" lignite, and Coal Mine

"Gračanica". On April 1, 2016, transport of coal from the mine "Stanari" was suspended.

Units 3, 4 and 5 of the thermal power plant "Tuzla" are originally designed for one coal type - lignite, which resulted in the selection of technology and equipment at the coal delivery point that is not strictly designed for mixing and homogenization [5]. Today, the coal for these units is provided by combining the lignite from the mine "Kreka" (facilities Dubrava, Šikulje, Mramor) and black coal from the mine "Banovići I", in the approximate weight ratio of (75-80):(20-25)%, respectively, as well as from the Lignite Mine "Stanari", Coal Mine "Gračanica", black coal M1 Višća and black coal M1 "Đurđevik" – residue up to 3 mm. Unit 6 of the thermal power plant "Tuzla" is designed to burn coal with characteristics of black coal with higher quality that is ensured by providing black coal from the mine "Banovići" and black coal II from the mine "Đurđevik". Future block 7 of the thermal power plant Tuzla will be supplied with the lignite from the open pits "Šikulje" and "Dubrave". The coal supply projection (Table VII) to the thermal power plant "Tuzla" [4] was created in one scenario and is characterized by the following elements:

- Maximum production of lignite in the thermal power plant "Tuzla" ranging from 3.16 to 3.18 million tons, will be reached in 2024, and at that level will be maintained until the 2035.
- New unit 7 of the thermal power plant "Tuzla", which will start its operation in 2021, will be supplied with lignite from the open pits "Šikulje" and "Dubrave" in equal ratio of 1.5 million tons. Annual needs of unit 7 are projected to approximately 2.6 million tons of lignite. In the planning period, the open pit mines "Šikulje" and "Dubrave" will supply unit 7 of the thermal power plant "Tuzla" and continue with deliveries to unit 5 at a ratio of 81.5: 18.5% in favour of unit 7.
- According to the current plans unit 5 of the thermal power plant "Tuzla" will not ceased to operate. In

Table VI: Structure of coal supply for the thermal power plants "Tuzla" and "Kakanj" 2016-2035 (000) t

Thermal Power Plant	Coal type	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032	2033	2034	2035
TPP Tuzla	Lignite	2,223	2,149	2,208	2,263	2,261	2,263	3,100	3,138	3,161	3,162	3,167	3,169	3,170	3,172	3,173	3,174	3,176	3,177	3,179	3,180
New unit		0	0	0	0	0	640	2,073	2,517	2,578	2,579	2,581	2,583	2,584	2,586	2,587	2,588	2,590	2,591	2,593	2,594
Old units		2,223	2,149	2,208	2,263	2,261	1,623	1,027	621	583	583	586	586	586	586	586	586	586	586	586	586
TPP Tuzla	Black	1,585	1,531	1,590	1,571	1,571	1,360	1,021	1,008	996	996	997	996	996	997	996	996	997	996	996	997
Black		741	719	738	718	718	509	322	195	183	183	184	183	183	184	183	183	184	183	183	184
Black II		844	812	852	853	853	851	699	813	813	813	813	813	813	813	813	813	813	813	813	813
TPP Tuzla	Black+Lignite	3,808	3,680	3,798	3,834	3,832	3,623	4,121	4,146	4,157	4,158	4,164	4,165	4,166	4,169	169	4,170	4,173	4,173	4,175	4,177
TPP Kakanj	Subtotal	2,030	2,112	2,048	2,052	2,064	2,064	2,061	2,026	2,201	2,784	2,733	2,767	2,812	2,812	2,813	2,813	2,813	2,813	2,814	2,814
New unit	Black	0	0	0	0	0	0	0	0	291	1,097	1,346	1,381	1,381	1,381	1,381	1,382	1,382	1,382	1,382	1,383
Old units	Black	2,030	2,112	2,048	2,052	2,064	2,064	2,061	2,026	1,910	1,687	1,387	1,386	1,431	1,431	1,432	1,431	1,431	1,431	1,432	1,431
TOTAL EPBIH		5,838	5,792	5,846	5,886	5,896	5,687	6,182	6,172	6,358	6,942	6,897	6,932	6,978	6,981	6,982	6,983	6,986	6,986	6,989	6,991

Source: Analysis of development and investment in EEO JP EPBIH

- the new plan it will continue to operate until 2035. The coal mixture for this block will be provided partly from the open pit "Dubrave" and "Šikulje", partly from the underground mine "Mramor" and partly with the black coal type I in the amount of approximately 180.000 tons out of which 120.000 tons from the mine "Đurđevik" and 60.000 tons from the mine "Banovići".
- In 2016. due to lack of coal and in order to meet its needs, the thermal power plant "Tuzla" secured 136.000 tons of coal from the mine "Stanari". Besides that, a deficit of 100.000 tons in the period 2016-2019, will be solved by providing lignite from Coal Mine "Gračanica". According to the current plans,
 - the mine "Kreka" will be able to meet the needs of the thermal power plant "Tuzla" from the year of 2019.
 - The demand for black coal (Black I and Black II), up to the closure of units 3 and 4 in the thermal power plant "Tuzla", will be at the level of 1.5-1.6 million tons, after which it will fall to the level of needs of units 5 and 6 (approximately 1 million tons), which will also continue to operate (Table VIII). Black coals of types Black I for unit 6 will be supplied by the mines "Đurđevik" and "Banovići" in the ratio of 48:52%.
 - The maximum coal supply (lignite + clack) to the thermal power plant "Tuzla" will amount to 4.18 million tons and will be reached after the start of the unit 7 (Table IX).

Table VII: Structure of lignite supply from the mines for the thermal power plant "Tuzla" 2016-2035 (000) t

Coal mine	Coal type	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032	2033	2034	2035
KREKA	Lignite	1,987	2,034	2,093	2,263	2,261	2,263	3,100	3,138	3,161	3,162	3,167	3,169	3,170	3,172	3,173	3,174	3,176	3,177	3,179	3,180
New unit	Lignite	0	0	0	0	0	640	2,073	2,517	2,578	2,579	2,581	2,583	2,584	2,586	2,587	2,588	2,590	2,591	2,593	2,594
Old units	Lignite	1,987	2,034	2,093	2,263	2,261	1,623	1,027	621	583	583	586	586	586	586	586	586	586	586	586	586
Open pit Dubrave	Lignite	1,040	970	970	1,020	1,020	990	1,470	1,496	1,520	1,522	1,525	1,525	1,525	1,525	1,525	1,525	1,527	1,528	1,530	1,531
New unit	Lignite	0	0	0	0	0	320	1,040	1,266	1,298	1,300	1,300	1,300	1,300	1,300	1,300	1,300	1,302	1,303	1,305	1,306
Old unit	Lignite	1,040	970	970	1,020	1,020	670	430	230	222	222	225	225	225	225	225	225	225	225	225	225
Calorific value	(GJ/t)	9.293	8.735	8.735	9.440	9.440	9.500	9.500	9.500	9.500	9.500	9.500	9.500	9.500	9.500	9.500	9.500	9.500	9.500	9.500	9.500
Open pit Šikulje	Lignite	718	684	743	683	661	973	1,450	1,462	1,491	1,490	1,492	1,494	1,495	1,497	1,498	1,499	1,499	1,499	1,499	1,499
New unit	Lignite	0	0	0	0	0	320	1,033	1,251	1,280	1,279	1,281	1,283	1,284	1,286	1,287	1,288	1,288	1,288	1,288	1,288
Old unit	Lignite	718	684	743	683	661	653	417	211	211	211	211	211	211	211	211	211	211	211	211	211
Calorific value	(GJ/t)	9.300	8.800	8.800	9.430	9.430	9.500	9.500	9.500	9.500	9.500	9.500	9.500	9.500	9.500	9.500	9.500	9.500	9.500	9.500	9.500
Mramor	Lignite	229	380	380	380	380	300	180	180	150	150	150	150	150	150	150	150	150	150	150	150
Old units	Lignite	229	380	380	380	380	300	180	180	150	150	150	150	150	150	150	150	150	150	150	150
Calorific value	(GJ/t)	11.400	11.390	11.340	11.400	11.400	11.400	11.400	11.400	11.400	11.400	11.400	11.400	11.400	11.400	11.400	11.400	11.400	11.400	11.400	11.400
GRAČANICA	Lignite	100	115	115	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Old units	Lignite	100	115	115	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Calorific value	(GJ/t)	10.000	10.000	10.000	10.000	10.000	10.000	10.000	10.000	10.000	10.000	10.000	10.000	10.000	10.000	10.000	10.000	10.000	10.000	10.000	10.000
STANARI	Lignite	136	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Old units	Lignite	136	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Calorific value	(GJ/t)	9.000	9.000	9.000	9.000	9.000	9.000	9.000	9.000	9.000	9.000	9.000	9.000	9.000	9.000	9.000	9.000	9.000	9.000	9.000	9.000
New unit	Lignite	0	0	0	0	0	640	2,073	2,517	2,578	2,579	2,581	2,583	2,584	2,586	2,587	2,588	2,590	2,591	2,593	2,594
Old units	Lignite	2,223	2,149	2,208	2,263	2,261	1,623	1,027	621	583	586	586	586	586	586	586	586	586	586	586	586
Total	Lignite	2,223	2,149	2,208	2,263	2,261	2,263	3,100	3,138	3,161	3,162	3,167	3,169	3,170	3,172	3,173	3,174	3,176	3,177	3,179	3,180

Source: Analysis of development and investment in EEO JP EPBIH

Table VIII: Structure of black coal supply from the mines to the thermal power plant "Tuzla" 2016-2035 (000) t

Coal mine	Coal type	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032	2033	2034	2035
ĐURĐEVİK (Old units)	Black	546	511	511	511	510	510	510	510	510	510	510	510	510	510	510	510	510	510	510	510
	M1 and residue	170	142	142	142	140	140	120	120	120	120	120	120	120	120	120	120	120	120	120	120
Calorific value	(GJ/t)	11.642	11.500	11.510	11.540	11.540	11.750	11.900	12.056	12.071	12.071	12.071	12.071	12.071	12.071	12.071	12.071	12.071	12.071	12.071	12.071
	Black II	376	369	369	369	370	370	390	390	390	390	390	390	390	390	390	390	390	390	390	390
Calorific value	(GJ/t)	15.109	15.109	15.109	15.500	15.500	15.500	15.500	15.500	15.500	15.500	15.500	15.500	15.500	15.500	15.500	15.500	15.500	15.500	15.500	15.500
BANOVIĆI (Old units)	Black	1,039	1,020	1,079	1,060	1,061	850	511	498	486	486	487	486	486	487	486	486	487	486	486	487
	Black I	571	577	596	576	578	369	202	75	63	63	64	63	63	64	63	63	64	63	63	64
Calorific value	(GJ/t)	12.300	12.300	12.300	12.300	12.300	12.300	12.300	12.300	12.300	12.300	12.300	12.300	12.300	12.300	12.300	12.300	12.300	12.300	12.300	12.300
	Black II	468	443	483	484	483	481	309	423	423	423	423	423	423	423	423	423	423	423	423	423
Calorific value	(GJ/t)	16.500	16.500	16.500	16.383	16.383	16.383	16.461	16.461	16.461	16.461	16.461	16.461	16.461	16.461	16.461	16.461	16.461	16.461	16.461	16.461
SUBTOTAL	Black I	741	719	738	718	718	509	322	195	183	183	184	183	183	184	183	183	184	183	183	184
SUBTOTAL	Black II	844	812	852	853	853	853	851	699	813	813	813	813	813	813	813	813	813	813	813	813
TOTAL	Black	1,585	1,531	1,590	1,571	1,571	1,360	1,021	1,008	996	996	997	996	996	997	996	996	997	996	996	997

Source: Analysis of development and investment in EEO JP EPBIH

Table IX: Structure of black coal & lignite supply from the mines to the thermal power plant "Tuzla" 2016-2035 (000) t

Coal mine	Coal type	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032	2033	2034	2035
KREKA (Old units)	Lignite	1,987	2,034	2,093	2,263	2,261	2,263	3,100	3,138	3,161	3,162	3,167	3,169	3,170	3,172	3,173	3,174	3,176	3,177	3,179	3,180
GRAČANICA (Old units)	Lignite	100	115	115	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
STANARI (Old units)	Lignite	136	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
ĐURĐEVİK (Old units)	Black	546	511	511	511	510	510	510	510	510	510	510	510	510	510	510	510	510	510	510	510
BANOVIĆI (Old units)	Black	1,039	1,020	1,079	1,060	1,061	850	511	498	486	486	487	486	486	487	486	486	487	486	486	487
SUBTOTAL	Lignite	2,223	2,149	2,208	2,263	2,261	2,263	3,100	3,138	3,161	3,162	3,167	3,169	3,170	3,172	3,173	3,174	3,176	3,177	3,179	3,180
SUBTOTAL	Black	1,585	1,531	1,590	1,571	1,571	1,360	1,021	1,008	996	996	997	996	996	997	996	996	997	996	996	997
INTOTAL TPP "TUZLA"	Lignite+black	3,808	3,680	3,798	3,834	3,832	3,623	4,121	4,146	4,157	4,158	4,164	4,165	4,166	4,169	4,169	4,170	4,173	4,173	4,175	4,177

Source: Analysis of development and investment in EEO JP EPBIH

By the commissioning of the unit 7 (450 MW) of the thermal power plant "Tuzla" in 2021, all existing units that are currently in operation will have had over 40 years of operation, as follows: unit 3 (100 MWe) - 56 years, unit 4 (200 MW) - 50 unit 5 - 47 years, and unit 6 (223 MWe) - 43 years.

As all the units are close to the end of working time, the planned unit 7 is (essentially) a replacement unit for units 3, 4 and 5 of the thermal power plant "Tuzla" (which uses lignite and black coals low calorific value), while the replacement of unit 6 of the thermal power plant "Tuzla" (which burns black coals) is new unit 1 (350 MWe) of the thermal power plant "Banovići". However, according to the current opinions, the operation of the unit 5 and 6 will be extended and the final decision on the coal supply for the thermal power plant "Tuzla" will be known after the final decision on the construction of unit 7. It will resolve all doubts about the coal supply coal supply for the thermal power plant "Tuzla".

2.2. Thermal power plant "Kakanj" - a long-term delivery plan

Coal delivered to the units of the thermal power plant "Kakanj" is supplied from the mine "Kakanj", "Breza", "Zenica", "Gračanica" and "Bila". Lately, it occasionally receives coal from the mine "Banovići" and "Đurđevik", mainly as a substitute for coal from the mines "Kakanj" and "Miljevića".

Units are not originally designed to burn a mixture of black coals of the calorific power raging from 9,800 to 16,700 (kJ/kg), with the total moisture content of 8-26%, which, in principle, matches the mixture of coals from the mines "Kakanj", "Breza" and "Zenica" in the approximate weight ratio of 70:20:10. Units 5, 6 and 7 of the thermal power plant "Kakanj" were reconstructed in the last decade. During designing process, in addition to the base mixture K:B:Z = 70:20:10, the actual coals that have recently been delivered to the thermal power plant "Kakanj" should be taken into account, or that are planned to be delivered in the near future. For example, during the reconstruction of the boiler in unit 6 of the thermal power

plant "Kakanj", which was carried out in 2010, the basic design of the boiler has taken into account the expected mixture of coals Kakanj: Breza: Zenica: Gračanica: Bila: Livno: Banovići = 55: 20: 9: 7: 3 : 1: 5 by weight [5]. The present coal supply balance for the thermal power plant "Kakanj" (Table X) was made according to available data and documents that are updated and according to them the new/replacement unit 8 in the thermal power plant "Kakanj" will be supplied with the mixture of coals Kakanj: Breza: Zenica in the ratio 70: 20: 10.

Coal supply projections in the long term are characterized by the following elements:

- Old units of the thermal power plant "Kakanj" will be supplied in accordance with present dynamics and projected mixture that dictates the total amount of coal from the mines.
- New unit 8 of the thermal power plant "Kakanj" will start its operations in 2024. Unit number 5 of the thermal power plant "Kakanj" will be stopped after being in operation for 58 years.
- The maximum production will be reached after the commissioning of the unit 8 and will amount to approximately 2.8 million tons and will be maintained at this level until 2035. By 2024, the mines will have been restructured and will have been able to meet the needs of the thermal power plant "Kakanj".
- Black Coal Mine "Kakanj" plans to open another open pit mine "Repovački stream". Together with the open pit mine mine "Vrtlište" and the underground mine "Haljinići", it will be able to deliver 1.5 million tons of coal to the thermal power plant "Kakanj".
- By the end of 2019, the modernization processes in the mines "Breza" and "Zenica" will have been completed and it will ensure meeting the planned projections.

By the planned start of the unit 8 of the thermal power plant "Kakanj" in 2024, all units that are currently in operation will have been over 35 years old, as follows: unit 5 (110 MWe) – 55 years, unit 6 (110 MWe) - 47 years and unit 7 (110 MW) - 35 years.

Table X: Structure of the coal supply from the mines to the thermal power plant "Kakanj" 2016-2035 (000) t

Coal mine	Coal type	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032	2033	2034	2035
KAKANJ	Black	1.170	1.170	1.150	1.120	1.120	1.120	1.120	1.120	1.194	1.544	1.483	1.500	1.500	1.500	1.500	1.500	1.500	1.500	1.500	1.500
-New unit	Black	0	0	0	0	0	0	0	0	204	768	942	967	967	967	967	967	967	967	967	967
-Old unit	Black	1.170	1.170	1.150	1.120	1.120	1.120	1.120	1.120	990	776	541	533	533	533	533	533	533	533	533	533
-Calorific value	(GJ/t)	12,347	12,393	12,482	12,300	12,300	12,300	12,300	12,300	12,300	12,300	12,300	12,300	12,300	12,300	12,300	12,300	12,300	12,300	12,300	12,300
BREZA	Black	440	480	450	430	430	430	430	420	460	570	570	570	570	570	570	570	570	570	570	570
-New unit	Black	0	0	0	0	0	0	0	0	58	219	269	276	276	276	276	276	276	276	276	276
-Old unit	Black	440	480	450	430	430	430	430	420	402	351	301	294	294	294	294	294	294	294	294	294
-Calorific value	(GJ/t)	13,000	14,000	14,000	14,000	14,000	14,000	14,000	14,000	14,000	14,000	14,000	14,000	14,000	14,000	14,000	14,000	14,000	14,000	14,000	14,000
ZENICA	Black	190	232	218	222	229	229	226	201	252	340	340	347	392	392	393	392	392	392	392	393
-New unit	Black	0	0	0	0	0	0	0	0	29	110	135	138	138	138	138	138	138	138	138	138
-Old unit	Black	190	232	218	222	229	229	226	201	223	230	205	209	254	254	255	254	254	254	254	255
-Calorific value	(GJ/t)	15,000	15,000	15,000	15,000	15,000	15,000	15,000	15,000	15,000	15,000	15,000	15,000	15,000	15,000	15,000	15,000	15,000	15,000	15,000	15,000
GRAČANICA	Lignite	100	100	100	150	155	155	155	155	155	180	190	200	200	200	200	200	200	200	200	200
-New unit	Lignite	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
-Old unit	Lignite	100	100	100	150	155	155	155	155	155	180	190	200	200	200	200	200	200	200	200	200
-Calorific value	(GJ/t)	10,000	10,000	10,000	10,000	10,000	10,000	10,000	10,000	10,000	10,000	10,000	10,000	10,000	10,000	10,000	10,000	10,000	10,000	10,000	10,000
BILA	Lignite	130	130	130	130	130	130	130	130	140	150	150	150	150	150	150	150	150	150	150	150
-New unit	Lignite	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
-Old unit	Lignite	130	130	130	130	130	130	130	130	140	150	150	150	150	150	150	150	150	150	150	150
-Calorific value	(GJ/t)	16,000	16,000	16,000	16,000	16,000	15,500	15,500	15,500	15,500	15,500	15,500	15,500	15,500	15,500	15,500	15,500	15,500	15,500	15,500	15,500
SUBTOTAL	New unit	0	0	0	0	0	0	0	0	291	1.097	1.346	1.381	1.381	1.381	1.381	1.382	1.382	1.382	1.382	1.383
SUBTOTAL	Old unit	2.030	2.112	2.048	2.052	2.064	2.064	2.061	2.026	1.910	1.687	1.387	1.386	1.431	1.431	1.432	1.431	1.431	1.431	1.432	1.431
INTOTAL	TPP KAKANJ	2.030	2.112	2.048	2.052	2.064	2.064	2.061	2.026	2.201	2.784	2.733	2.767	2.812	2.812	2.813	2.813	2.813	2.813	2.814	2.814

Source: Analysis of development and investment in EEO JP EPBIH

In the process of creating new technical documentation for the unit 8 of the thermal power plant "Kakanj" previously planned mixture of the black coals will be reviewed. On the basis of the current available coal reserves and calorific value of the Central basin coal, a mixture of black coals as well as the power of the future block will be projected. The new unit will be built in accordance with the requirements and conditions of environmental protection, according to the EU regulations. Consequently, the results will affect the new coal supply balance for the thermal power plant "Kakanj".

3. CONCLUSION

After many years of exploitation of the coal mines of EP-BIH Concern (in some of the mines for over 130 years) it can be said that the era of exploiting shallow and cheap coals has finished a long time ago. The exploitation of the deeper coal deposits by using outdated equipment accompanied with ruined geo-mechanical and mining and geological parameters as well as bulky and non-optimized organizational structure of the mines, they entered a zone of unprofitable business operations, which has resulted in the continuous accumulation of debts and obligations to the state, suppliers and creditors.

Due to the liberalized electricity market in BiH and the fact that EP BiH does not have a monopoly status any more, electric power in Bosnia and Herzegovina has become astock exchange goods. The price of this product will

no longer depend on national policies but on the market conditions. By not accepting new business conditions or by slowing down the process of adaptation to the rapid change, EPBIH, together with the mines, will inevitably experience a collapse from which it will be difficult to recover. Knowing that the production of thermal power plants will remain dominant in the future, the time has come to think differently about the mining part of the EPBIH. The mines must be restructured and modernized in order for to save from decay firstly and then to ensure their independent operations.

As the Action plan for restructuring and modernization of coal mines in the Federation of Bosnia and Herzegovina (FMERI 2004) has not been developing according the planned schedule due to a lack of funding, the situation in the mines has additionally been made more complex and complicated. The unfavourable structure of employees, lack of the financial investments and technological lag in the process of coal exploitation has led the mines into unfavourable situation. Investments carried out have managed to keep the production continuity with the primary intention to meet the needs of electrical energy balance. Consequently, EPBIH as a parent company in the EPBIH concern (deeply aware of the situation), made a decision in 2015 to enable the mines to be able to operate independently, in order for the mines to reach the production cost of coal that is lower than 4.7 (KM/GJ).

In this regard, the two key processes have been launched:

- The process of recapitalization of the mines - the third investment cycle (investing over 330 million BAM in the mines by the end of 2019), and
- Restructuring process in the mines.

Both processes are currently being implemented.

The second part of the paper presents a plan of long-term coal supply projections to the thermal power plants of the EPBiH from seven mines that are the part of the EPBiH. The plan is adjusted relative to the projections stated in the Long-term Development Program of EPBiH and depends largely on the final deadline for introducing new/replacement units in production. Each change in the deadline of introducing new units will dictate the dynamic of the suspension of the old units, which will directly affect the coal supply balance. It should be noted that besides supplying the coal to the EPBiH, the mines also supply other consumers and industry, and those amounts of coal are not shown in this balance sheet.

Bosnia and Herzegovina is a member of the Energy Community and, pursuant to the signed contract; it is required to implement the Third energy package and to implement energy and climate policy of the EU. As the old units of the thermal power plants "Kakanj" and "Tuzla" will not be able to achieve the required standards and investing in the filters installation will be unprofitable, there is an opportunity for development of another scenario, as follows:

EPBiH will shut down the old units and construct two new thermal units in accordance with the BAT principle and the environment protection conditions and requirements as well as the EU regulations. These units will have systems for desulphurization, effective filter systems for solid particles, high boiler energy efficiency, cogeneration facilities and a number of other technological elements.

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BIOGRAPHY

Edin Lapandić was born on January 11, 1971 in Banovići. He was awarded a doctoral degree in technical sciences in the field of mining in 2008. He is currently employed in JP EPBiH as a leading associate for the development of the mines.

He has been engaged in the scientific research in the field of energy and mines for two decades. He is an author and co-author of one book, 38 scientific papers and one technical improvement. He has participated in many scientific meetings, symposia and congresses and was a member of 7 scientific committees. As a planner, associate and auditor, he has participated in the creation of over 60 projects, studies, elaborates, programs and other documentation. He lives and works in Sarajevo.