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THERMO-ENERGY POTENTIAL OF BOSNIA AND HERZEGOVINA - TODAY AND PROJECTIONS FOR THE FUTURE

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Brief resume of the works

Thermal power capacity of Bosnia and Herzegovina is based on significant domestic sources of primary energy. Bosnia and Herzegovina with its small area is emboded with important amounts of lignite and brown coal reserves. All forecasts estimate that exploatable reserves of coal in BiH present reliable base for planning of electricity production from coal according to current rate of 65%:35% to the other resaurces - at least for the next 50 years, taking into account also expected grow of electricity consumption in BiH of 4% per year. Coalmining in BiH dated from end of 19 Sentury, and the full development reached at the end of eighties of last sentury. The most important reserves of coal are located in so called coal basens: Tuzla (coalmines: Kreka, Banovici, Djurdjevik and Ugljevik), Srednja Bosna (coalmines: Kakanj, Breza, Zenica and Bila), Bugojno (coal mine Gračanica), Livno-Duvno (coal mine Tušnica), Gacko (coal mine Gacko), Miljevina (coal mine Miljevina) and Doboj-Banja Luka (coal mine Stanari). There are some minor geological reserves on other locations, but they haven't been properly explored (Ramići, Lješljani, Mesići, Čelinac-Kotor Varoš, Bukovac-Bušletić near Doboja, Mrkonjić Grad-Šipovo, Ozren-valley of Spreča, Majevica-mineral coal and other). Coal will keep its leading role as basic fuel for electricity generation in the next 20 years, not only in Bosnia i Herzegovina but also in the World. Bosna i Hercegovina posseses important reserves of coal, and preciase amounts must be identified by additional investigations on coalmines. Existing technology in thermal power plants in Bosnia and Herzegovina is to be modernized, which is particularly important for new coal-based power plants to be constructed. Thus, clean coal technologies must be applied, and adopted to the specific domestic coal combustion behaviours. At this, particular attention should be focussed to the environmental issue.

Key words: *thermal power capacity, coal reserves, degree of exploration, qualitative characteristics, water supply, stag and ash disposal, environment protection*

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1. Introduction

Thermal power capacity (TPC) includes the sources of primary energy that can be transformed into secondary and useful energy sources (heat, mechanical and electrical power) by energetic-technological processes that are technically possible and financially justified. Among other, these are energetic processes in thermal power plants, nuclear power plants, thermal power plants - heating plants, industrial power plants, heating plants and other plants and engines for direct and indirect transformation of primary into other forms of energy. Needs for electricity are increased in the World, at least for two reasons: grow of enhabitants and requirements for growth of GPD. Consequently, growth of needs for electricity is faster than growth of inhabitants, Figure 1.

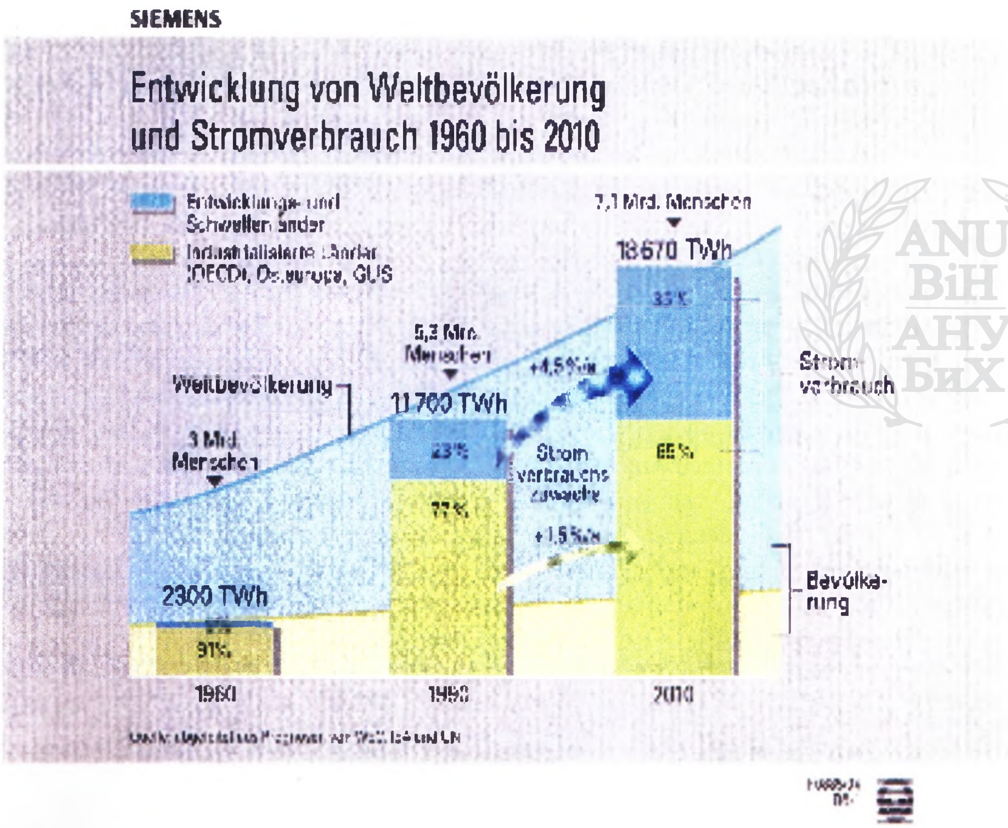


Figure 1. Global increase of needs for electricity

It is evident that fulfilling those needs requires building of new energy capacities, Figure 2. In the case of fossil fuels based power plants, the reserves of fossils are being exhausted, accompanied by emissions of sulphur and nitrogen oxides, as well as carbon dioxide as the most influent green house gas. Bosnia and Herzegovina has no documented reserves of oil and natural gas. Minor reserves of uranium have been discovered, which could be used as possible fuel in nuclear thermal power processes. The available sources of primary energy as basis of TPC are being used for production of electric power, technological steam and electric power in industrial power plants and for production of heat energy in heating plants and households. For this reason, significant reserves of unconventional sources of primary energy should be added to the coal reserves, such as: energetic wood and other biomasses, geo-thermal energy, solar energy and wind energy. It is necessary to emphasize the importance of rational exploitation of biomasses from forestry and agriculture, which will present important parts of the economy in the future development of Bosnia and Herzegovina.

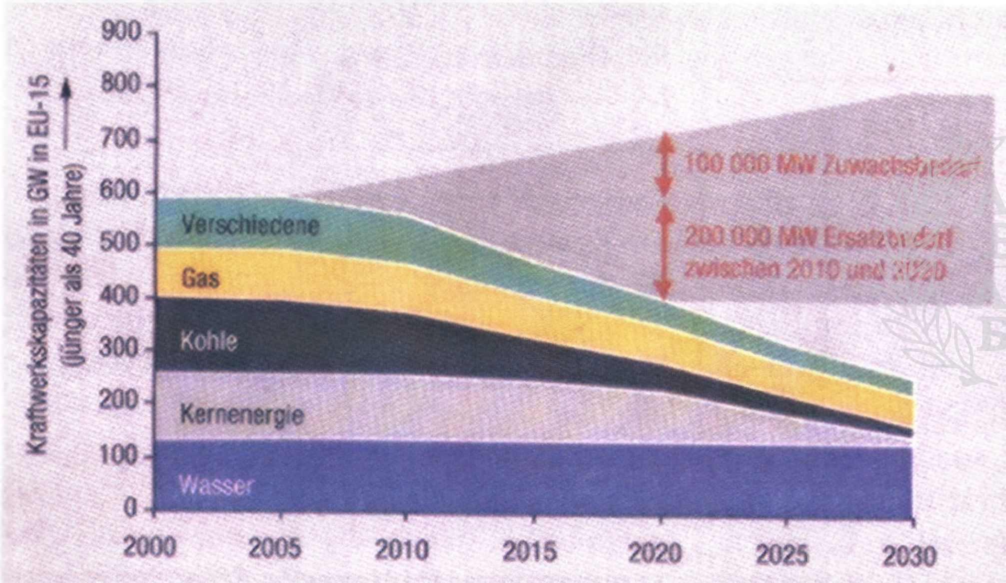


Figure 2. Till 2020 new 300 GW of new electricity capacities are required in EU 15, [1]

From all fossils, Bosna and Hercegovina posseses important reserves of coal. Coal is the most embedded fosils in the World, and it is important that large reserves of coal in the World lay in the no politicly risky regions. In comparison to other fosils; gas and oil, it results in more convenient and a stable price of coal, Figure 3. For that reason, the most part of electricity in the world today is produced on the base of coal.

From 1990., share of coal in total electricity generation is 39%, and all forecasts show that coal will keep this role for the next 20 years, Figure 4. Share of coal in total electricty generation in some countries of EU is much larger (Germany, Poland, …), and also in Bosnia and Herzegovina.

Sustainability indicators of existing Bosnian coal-based power plants, namely time and energy availability, efficiency, reliability as well as environmental issue, are far behind of that in developed countries, [3, 4]. The main reason is oldness of the power plant equipment, and bed combustion process inside the pulverised coal fired boilers. Generally, coal fired in Bosnian thermal power plants are low-valuable domestic coal types with low and variable heating value, high percentage of moisture or ash, high percentage of sulphur and unfavourable carbon/hydrogen ratio in some cases, as well as expressed slagging and fouling behaviours due to unfavourable ash composition. Besides, design solutions of the pulverised coal fired boilers are not convenient for the temporary operation conditions. All mentioned influents to a lower reliability, availability, efficiency, power range variability, and environment issue of most Bosnian coal fired power plants, including high nitrogen and sulphur emission and CO_2 emission as well, [5]. These shortcomings could be overcome in two ways; either by continuing of the reconstruction the existing coal fired thermal power units or by building up the new ones.

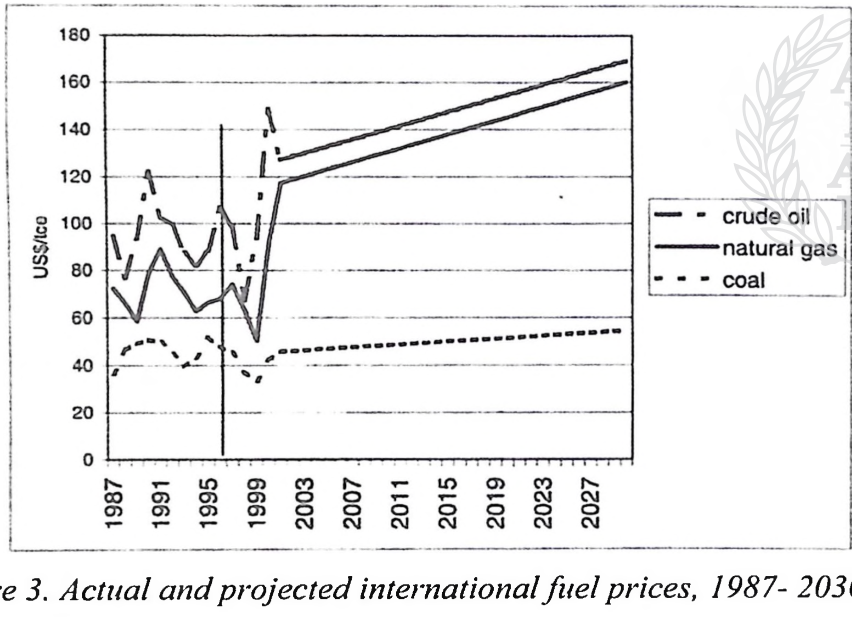


Figure 3. Actual and projected international fuel prices, 1987- 2030., [2]

Whatever of the mentioned approaches is selected, more information on domestic coal types combustion behaviours are required, to identify specific problems of combustion of domestic coals, and then to undertake appropriate measures.

Taking into account that secure and economical production of electricity is basic precondition for further sustainable development of energy power sector of Bosnia and Herzegovina, as well as the fact that liberalized electricity

market in Europre requires environmental friendly electricity production, then modernization of the coal based power system in BiH is necessary.
A number of factors influents to the decision making regarding modernization of reminder of coal-based power units in BiH and building the new ones. Particular attention is to be focused to the present condition of energy power stations, longterm forecast of consumption and production of electricity - both in BiH and the region, environment issue and prices on the liberalized market (price of electricity, fuels, CER etc.).
There is no doubt that electric power, neither today nor in the near future, can fully rely on unconventional power sources. However, it should be taken in consideration that in the developed industrial country about 60% of total energy is used in low temperature conversion (<100°C). This exactly emphasizes possibility and need for increased exploitation of restorable power sources with aim of increased environment protection and decrease of consumption of classic primary sources and electric power. Energetic capacities on alternative primary sources, as well as savings in power consumption can be considered a new classic energy source that has appropriate value in capacity of construction of new power structures based on classic primary sources.

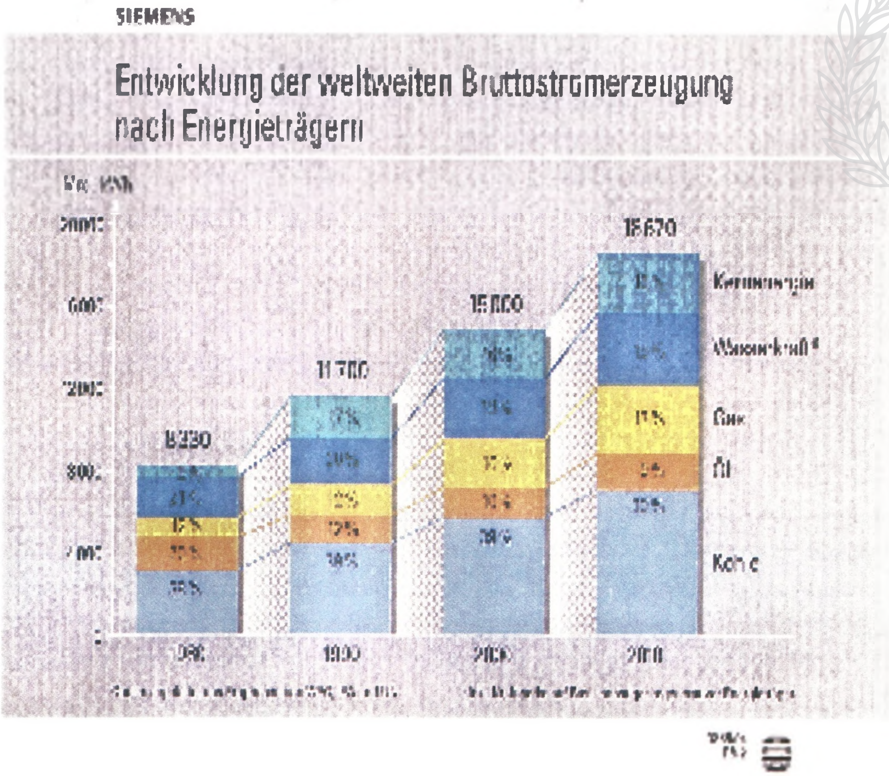


Figure 4. Share of coal in total electricity generation in the World is 39%

Concrete plans and programs for construction of new thermal power structures should be based on reliable data about fuel characteristics, cooling water, stag and ash disposal, as well as requirements in terms of environment protection. Besides that, it is necessary to accurately define the consumption need for electric and heat power, i.e. it is necessary to assess the need for construction of power networks. All the above said has to be defined by special research studies and based on them preliminary designs will be produced for each power structure together with obligatory feasibility studies. So far on the level of the entity the following studies have been realized: Feasibility Study for TPP Stanari of 420 MW installed power and TPP-HP Doboj (reconstruction of the existing heating plant in Doboj, with installation of new power block of power of 34,8 MWe in condensing regime), Preliminary Feasibility Study for TPP Gacko II (variant solution). These solutions have been harmonized with the phase Spatial Plan of the entity.

2. Reserves and investigations of coal in B&H

2.1. Previous and current situation

Bosnia and Herzegovina with its small area is emboded with important amounts of lignite and brown coal reserves. All forecasts estimate that exploatable reserves of coal in BiH present reliable base for planning of electricity production from coal according to current rate of 65%:35% to the other resaurces - at least for the next 50 years, taking into account also expected grow of electricity consumption in BiH of 4% per year.
Coalmining in BiH dated from end of 19 Sentury, and the full development reached at the end of eighties of last sentury. The most important reserves of coal are located in so called coal basens: Tuzla (coalmines: Kreka, Banovici, Djurdjevik and Ugljevik), Srednja Bosna (coalmines: Kakanj, Breza, Zenica and Bila), Bugojno (coal mine Gračanica), Livno-Duvno (coal mine Tušnica), Miljevina (coal mine Miljevina) and Doboj-Banja Luka (coal mine Stanari). There are some minor geological reserves on other locations, but they haven't been properly explored (Ramići, Lješljani, Mesići, Čelinac - Kotor Varoš, Bukovac - Bušletić near Doboja, Mrkonjić Grad - Šipovo, Ozren - valley of Spreča, Majevica - mineral coal and other). Coalmine Kamengrad, in basen Kamengrad, works with a smaller capacity after 1990, while coalmine Mostar, in basen Mostar, is closed. Till 1990., almost all coalmines in BiH were organized into the unique company „Titovi rudnici uglja" - Tuzla, as an exlusive coal supplier of TPP Tuzla and TPP Kakanj. Only coal mine Gacko and coalmine Ugljevik, which supply TPP Gacko and TPP Ugljevik, respec-

tivlly, were incorporated into unique electricity utility of Bosnia and Herzegovina EP B&H. Till 1990, coalmines in BiH had 31.000 employees, and annual production were reached 18 million tones. During 1992/1995, the production was reduced to 10÷15%. In 2007, it was produced 9,852 million tones or 54,3% of production in 1990, with 15.250 employees. Only coal mine Gacko and coalmine Ugljevik reached the same production as in in 1990.. In December 1995., according to Dayton peace agreement, energy sector in B&H were reorganized, resulting in three electricity utility; JP EP B&H (Sarajevo), with TPP Tuzla and TPP TE Kakanj; EP HZ HB (Mostar) without thermal power plants, and EP RS (Trebinje) with TPP Gacko and TPP Ugljevik.
Today, except Gacko and Ugljevik, there are 14 coalmines companies in B&H, with 27 production capacities, of which 11 are underground coalmines. Some of the coalmines are closed or work with very small capacity (Mostar; Kamengrad; Miljevina; Dobrnja; Bukinje). TPP Tuzla uses coal from coalmines Kreka, Banovići and Đurđevik, while TPP Kakanj is mainly supplied with coal from coalmines Kakanj, Breza and Zenica - and partially from Bila, Gračanica and Livno.
Almost all mentioned coalmines have problems in their dealings. Especially big problem is for underground mining. The attention should be focused on revitalization of the coalmines from one side, and on reorganization and restructuring from the other side.

Some forign partners have worked out two studies for coalmines in FBiH:

1. Fisibility Study on coalmines Srednja Bosna and Tuzla, Marston&Marston Inc., St. Louis, St.Missouri, USA, 06. 2000. god; sponsored by USTDA;
2. Program of modernization of coalmines in FBiH, DMT-Montang Consalting, Essen, Njemačke, 06. 2002.god; sponsored by MfWuMEuV des Landes Nordrhein-Westfalen

Both studies suggested reorganization of the coalmines, by their joining into one holding company, or by their including with thermal power plants into energy power system of JP EP BiH. By this, it would be ensured longterm and reliable supply of TPP Tuzla and TPP Kakanj under condition of liberalised electricity market.

2.2. Potential for further development of coal sector - coal reserves

Table 1 presents preview of coal reserves in B&H [7, 9, 10, 16], based on the data from the coalmines. Quality of coal, first of all calorific value, is key factor for defining the price of the coal on the coalmine in EUR/tone or EUR/GJ. However, some of the data presented in Table 1 differ siginificantly from some earler data, and also from the data on geological reserves issued by Ministry for energy, industry and mining. Thus, data from Table 1 should be taken with causion. For that reason, it is necessary to reinvestigate coal reserves in BiH and confirm real reserves, so that potential investors have no dilemmas regarding investing in this sector.

All data about coal reserves in BiH are based on standards from 1979 - from period of ex-SFRJ. In above mentioned studies it is emphasized that those standards are reliable and even stricter then in some countries today, so they are relevant. It is indicative for example that above mentioned Study on coalmines Srednja Bosna and Tuzla, Marston & Marston Inc., based on own approach to the economy of the coalmines, has affirmed that there was available 465.3 million tone of balanced and 335 million tone of exploitable reserves of coal in F.BiH in 2000, with exploitable losses of 28%, that is much differ relating data given in Table 1. Explanation for this lies in the fact that Marston&Marston did not include in their consideration coal reserves from coalmines which are not interesting as energy potential for TPP Tuzla and TPP Kakanj (Livno, Kongora, Bugojno, Kamengrad, ...), which directly reduced real coal reserves. The mentioned confirm emergency of checking the data on coal reserves, and also a scientific approach in determination of exploitable losses, to define precisely exploitable reserves before serios planning and building new coal-based power plants. It must be taken into account also that this checking will take certain time andfund.

The basic thermal power capacity of EPRS is based on reserves of brown and lignite coal. Reserves of these coals are mostly located in four major coal basins: Ugljevik, Gacko, Stanari and Miljevina. Relatively small geological reserves of coal can be found in some other locations, but the degree of exploration is low (Ramići, Lješljani, Mesići, Čelinac-Kotor Varoš, Mrkonjić Grad-Šipovo, Ozren-valley of Spreča, Majevica - mineral coal and other). On some coal deposits not even basic characteristics have been determined, such as chemical composition of coal and mineral admixtures (ash), not to mention special characteristics needed for the selection of firebox types for combustion boilers, air protection plants (electric filters, FGD, DENOx), transport, clinker and ash disposal, and especially clinkering and abrasion characteristics of coal and its ash. After a feasibility study is finished, estimated or calculated coal sources are classified as "probable" or "proved" coal reserves.

No.	Name of coalmine and type of coal	COAL RESERVES (000 t)								
		Balance $(A+B+C_1)$	Non balance $(A+B+C_1)$	Potential $(C_2+D_1+D_2)$	Total geological	Exploatable $(A+B+C_1)$	H_d (GJ/t)	Moisture (%)	Ash (%)	Sulphur total (%)
BOSNIA AND HERZEGOVINA										
Total lignite (L) in BiH		*1.412.973*[7]	*414.929*[7]	*1.386.488*[7]	*3.214.390*[7]	*1.004.593*[7]				
		1.498.602,22	*422.538,51*	*1.547.729,44*	*3.468.870,18*	*1.033.561*				
Total brown coal (B) in BiH		*1.102.718*[7]	*206.834*[7]	*1.101.689*[7]	*2.411.241*[7]	*648.039*[7]				
		1.201.295	*214.315*	*1.156.022*	*2.571.632*	*751.175,08*				
Total in BiH		*2.515.691*[7]	*621.763*[7]	*2.488.177*[7]	*5.525.631*[7]	*1.652.632*[7]				
		2.699.897,22	*636.853,51*	*2.703.751,44*	*6.040.502,18*	*1.784.736,08*				
Preview of some coalmines										
1	Gacko (L)	338.333	65.979	100.000	504.312	297.000	10,11	37,45	16,61	1,55
2	Ugljevik (B)	285.117	25.092	119.700	429.909	73.271	13,174	31-33	18-32	3,3-6,3
3	Stanari (L)	108.395,226	32.615,516	9.622,927	150.633,669	58.710	7,735-10,465	52-48	15,6-4,0	0,14-0,19
4	Miljevina (B)	21.204	15.846	40.130	77.180	19.08	11,7-14,8	18,27-23,22	21,98-28,73	2,37-2,39
5	Kreka (L)	743.954	322.833	59.407	1.126.194	456.008	11,31	38,7	13,06	0,61
6	Banovići (B)	194.085	13.935	0	208.020	162.429	16,18	16,09	24,14	1,74
7	Đurđevik (B)	60.183	4.963	0	65.146	54.524	17,95	9,42	25,77	2,30
8	Kakanj (B)	256.536	56.525	127.604	440.665	204.839	12,5-16,07	5,7-9,16	35,49-42,75	1,4-3,85
9	Breza (B)	49.244	23.928	0	73.172	28.098	14,428	6,61	30,99	2,54
10	Zenica (B)	179.843	59.931	721.369	961.143	131.000	17,619	12,58	22,32	3,65
11	Bila (B)	26.808	10.373	25.354	62.535	16.091	14,503	15,84	24,65	4,69
12	Gračanica (L)	10.657	0	0	10.657	10.657	10,746	32,43	17,06	2,95
13	Tušnica (L)	76.201	1.111	0	77.312	68.528	11	39	13	2,23
	Tušnica (B)	16.274	0	1.865	18.139	11.433	15	16,5	18	4
14	Kamengrad (B)	112.001	3.722	120.000	235.723	68.671	13,003	22,60	24,19	4,08
15	Bugojno (L)*	14.651	0	1.280.105	1.294.756	12.893	11,36	32,88	19,43	2,45
16	Kongora (L)*	206.411	0	0	206.411	129.765	7,38	35,06	27,50	1,25
Total BiH lignite (L)		*1.051.874 +*	*323.944 +*	*1.339.512 +*	*2.715.330 +*	*677.851 +*				
		446.728,226	*98.594,516*	*208.217,443*	*654.945,669*	*355.710*				
Total BiH brown coal (B)		*894.974 +*	*173.377 +*	*996.192 +*	*2.064.543 +*	*677.885 +*				
		306.321	*40.938*	*159.830*	*507.089*	*73.290,08*				
Total BiH		*1.946.848+*	*497.321 +*	*2.335.704 +*	*4.779.873 +*	*1.355.736 +*				
		753.049,226	*139.532,516*	*368.047,443*	*1.162.034,669*	*429.000,08*				

Table 1. Preview of coal reserves in BiH, [7, 9, 10,16]

Based on internationally accepted recommendations (JORC, 1999), the coal reserves in basins of Republic of Srpska can be classified in the following manner:

- Category A and B of balance reserves corresponds to "calculated" coal resources; Category C_1 of balance reserves corresponds to "estimated" or "calculated" coal resources, depending on a deposit degree of exploration;
- Category C_2 of reserves corresponds to "assumed" coal resources.

The coal reserves are presented in Table 2 in accordance with exploration categories for the four significant mining basins. It is important to notice that the balance reserves amount to above 735 million tons and together with approximately 270 millions tons of potential reserves it totals in more than one billion tons of coal for potential exploitation. The factor of loss has to be taken in consideration in order to get efficient reserves.

x 10^3 t

Coal basin	Balance reserves				Potential reserves C_2+D_1	Surplus balance reserves A+B+C_1
	A	B	C_1	A+B+C_1		
Ugljevik	24.541	82.824	177.752	285.117	119.700	25.092
Gacko	45.752	166.278	126.303	338.333	100.000	65.979
Stanari*	5.115,6	32.913,7	71.365,8	108.395,2	9.622,9	32.615,5
Miljevina	1.893	6.791	12.520	21.204	40.130	15.846
Total	79.301,6	299.359	294.535,7	753.049,2	269.452,9	139.532,5

*An Elaborate was prepared for Stanari coal basin [10] and it has been approved by the Commission for technical control - revision (record no. 165/2005 dated August 23rd 2005)

Table 2. Balance reserves of major coal basins

When it comes to the total balance and potential reserves, lignite coal (Gacko, Stanari) is more represented than brown coal (Ugljevik, Miljevina). Data on the coal reserves are given based on the latest valid solutions issued by authorized governmental bodies for verification of coal reserves and based on official documents on certain coal mines. All verifications were carried out before 1991 (apart from Stanari coal basin), and no additional exploration were done recently due to the war activities, but taking in consideration that there was no major coal production, these data can be considered sufficiently correct. Degree of exploration of the coal reserves in certain locations are presented within Table 2. It can be concluded that a half of coal reserves have been explored, which means that additional investments are required in direction of promotion of reserves to higher exploration categories. As presented in Table 3, degree of balance reserves exploration ranged from

37,6 % (Ugljevik) to 62,7 % (Gacko) or about 50 % for the four coal basins together. Degree of deposits exploration in general amounts to 64,8 %, and ranges from 27,5 % (Miljevina) to 83,7 % (Gacko).
However, exploration of some coal deposits in individual mining basins is very different. For example, exploration of balance reserves in the deposit of "Ugljevik -Istok" is 53,1 % with high participation of C_1 reserves category (46,9 %), even though the coal from this deposit is foreseen for "TPP Ugljevik II". On the other hand, exploration of balance reserves in "Mezgraja" coal shaft amounts to 78,3 %, and this deposit is foreseen for supply of TPP "Ugljevik III". "Peljave - Tobut" deposit as well has only determined coal reserves of C_1 category (38,15 x 10^6 tons).

Degree of exploration		Ugljevik	Gacko	Stanari*	Miljevina
Exploration of balance reserves	$\frac{A+B}{A+B+C_1}$, %	37,6	62,7	35,8	40,9
	C_1 u $(A+B+C_1)$, %	62,3	37,3	65,838	59,1

*An Elaborate was prepared for Stanari coal basin [2] and it has been approved by the Commission for technical control - revision (record no. 165/2005 dated August 23rd 2005)

Table 3. Degree of exploration of major coal basins

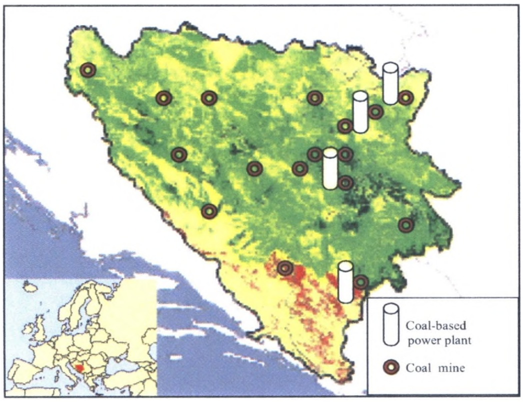
Investigation drilling carried out in the period of 1946 - 1993 determined the borders of spreading and the quality of coal layer in Stanari lignite basin, and at the same time defined litological composition and geometric characteristics of attached litological members. All major morphological factors in the wide area of Stanari coal basin have been separated and outlined based on inspection of the available litological profiles of drill holes, with consultation of geological and hydro-geological basements (geological and hydro-geological map, geological and hydro-geological profiles) and grain size testing. *Elaborate on classification, categorization and calculation of coal reserves of Stanari coal basin - condition on December 31st 2004* has been produced for the area of Stanari coal basin by the National Institute for Geological Research "Geozavod" Zvornik, which was approved by the Commission for technical control - revision (record no. 165/2005 dated August 23rd 2005), and after that the competent ministerial body verified the coal reserves and quality by a corresponding document. Balance coal reserves of A+B category in Ostružnja deposit have been classified as "calculated coal resources". Balance reserves of C_1 category and reserves of C_2 category have been classified as "estimated coal resources" as there haven't been and coal quality testing. "Calculated coal resources" in Ostružnja deposit (reserves of A+B category can be classified as "probable coal reserves". Exploitation reserves can be roughly estimated based on assumed exploitation loss of 10%. Therefore, in total this brings us to 27,3 millions tons of the "probable coal reserves" and 24,57 millions tons of exploitation coal reserves. The estimated resources amount to 18,58 millions tons of coal.

The current power complex of Gacko consists of Gračanica Mining Site and the thermal power plant with one block of installed power of 300 MW (Mine and TPP Gacko) which it's been operational since 1983. Total power capacity of this basin is based on major reserves of lignite coal. The confirmed balance reserves amount to 338,33 millions tons, and refer to a deposit of opened type Gračanica Mining site 17.500.103 tons, and the future Gacko Mine deposit. The coal deposit is quite well explored, and its characteristics are demonstrated through the coal layers as follows: major, thickness ranges from 11 to 25 m, then first foothill of about 13 m and second foothill of about 10m, as well as roof series of about 40m. Geological reserves and coal quality in Gacko coal basin are confirmed with the condition on December 31st 1987 (decision no. 06-310-478/88, dated October 12th 1988). Further construction of thermal power blocks in Gacko, first of all the Mine and TPP Gacko II, is based on the explored coal reserves. Detailed mining-geological investigation works have been carried out with regard to the planned construction of TPP Gacko, and a detailed Study on selection of the location for the second phase of Gacko Mine has been prepared and revised. Based on this Study, it is possible to start preparation of the preliminary design and the investment program for opening of a uniform mining site - Gacko planned for the future coal supply of power block TPP Gacko I. Technical design TPP Gacko 2x300 MW was prepared during the construction of TPP Gacko I, which provided technical solutions for thermal power block TPP Gacko II. A number of infrastructural structures were built during the first block construction and these structures will serve for the second construction phase. Realization of the Preliminary Feasibility Study is ongoing by NERS in order to provide the economical-financial estimate of the possible variant solutions for the project realization of Gacko II, through a joint investment, which would enable qualitative coal characteristics that would provide reliable work of the constructed power block (TPP Gacko I) for the long time period of 30 years, including revitalization, as well as provision of the required technology and equipment for the mine that will permanently provide the defined coal quality needed for designing of a new boiler for a new block, better adapted to the real coal characteristics. According to the available

data, it is possible to notice relatively well exploration of Gacko coal basin: degree of exploration of balance reserves is 62,7%, and participation of category reserves in the balance reserves amounts to 37%.
Exploration of coal reserves in Miljevina coal basin is insufficient and amounts to 41 %. Degree of exploration of the entire "Miljevina" deposit is even lower and amounts to only 27%. However, taking in consideration the exploration started in 1991 and 1992 the exploration degree is much more favourable. Namely, during these detailed geological investigations in the eastern part of the basin (Debelo Brdo - Daničići) 25 drill holes or 4803,5m were successfully drilled, and a geological map was made in scale of 1:2500 on the area of approximately 6 km^2. Out of 25 drilling holes, coal is found in 21 of them, and thickness of the coal layer ranges from 1,4 to 20,54 m. The samples from these drill holes were sent to Tuzla before the war, but the results have never been delivered to "Miljevina" Mine, and it would be useful to actualize this issue. Based on the above said, a major part of potential reserves (40,1 x 10^6 tons) could be promoted into balance reserves.
The adopted legal regulations and other measures for protection of coal reserves from further devastation has created conditions for further exploitation of the existing surplus balance reserves, including modern processes of coal gasification as well. The mentioned measures should be provided within the strategy for development of power, i.e. power utility, as it was included in the Spatial Plan of both entities in Bosnia and Herzegovina.

3. Quality of coal in Bosnia and Herzegovina

The most recent estimates assume that 60% of the coal in Bosnia and Herzegovina is lignite and 40% is brown coal. According to the heating power, Bosnian brown coal is similar to sub-bituminous coal. The coalmines map of Bosnia and Herzegovina with the existing coal-based power plants marked is given in Figure 5.
Characteristics of Bosnian lignite and brown coals widely varies from one coal basin to the other, and even amongst different coalmines within the same coal basin. Generally, Bosnian coal types are low valuable coals, with high content of CaO in ash, high content of sulfur and low net calorific value. Thus, calorific value of Bosnian coal is between 7 and 21 GJ/kg, Figure 5. Research into specific problems of combustion of domestic coals, being carried out at Mechanical Engineering Faculty of University in Sarajevo [5], is to be resulted in a reliable database of Bosnian coal combustion behavior, accentuated to the ash deposition characteristics and pollutant emissions under different combustion conditions, Figures 6 and Figure 7.



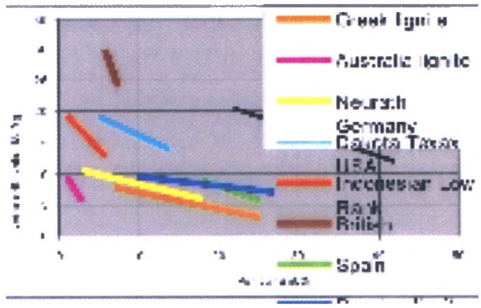


Figure 5. Left: Map of coalmines of Bosnia and Herzegovina; Right: Average calorific value of Bosnian coals in comparison with some world coal types

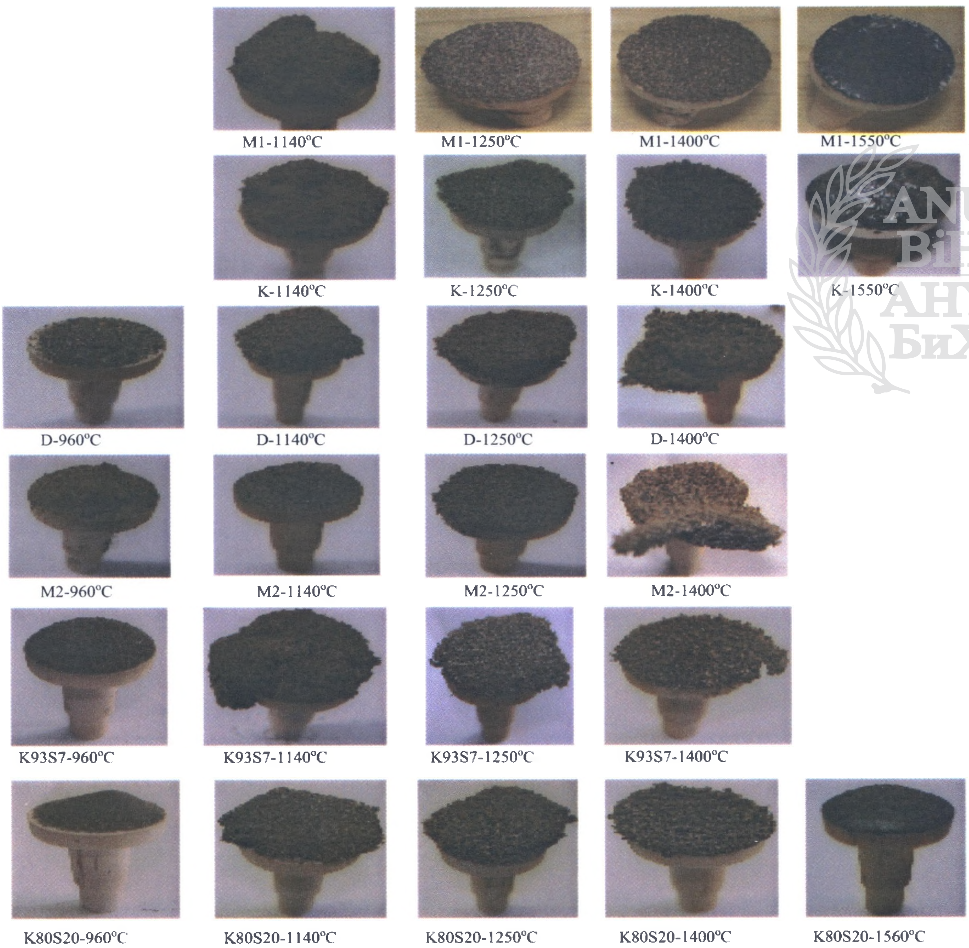


Figure 6. Ash deposit samples for the coal types tested, [5]

The aim is sustainability improvement of coal-based electricity production in Bosnia and Herzegovina, responding to the requests of liberalized energy market. Co-combustion behaviors of domestic coals and biomass – predominantly wooden residues, are being tested also within this research. This part of research presents first tests of co-combustion of domestic coal and biomass aimed to application in power plants, which offers opportunities for further reducing carbon dioxide emission and achieving better energy efficiency. Therefore, the research is presented as precondition for adoption clean coal technologies in Bosnia and Herzegovina.

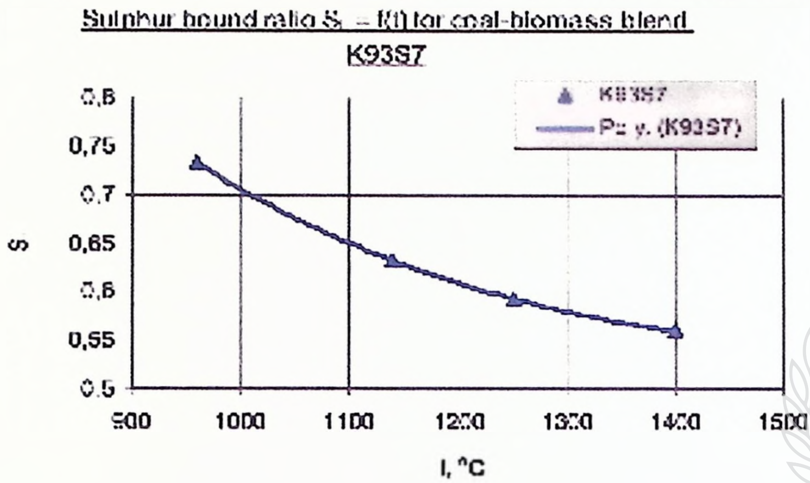


Figure 7. Sulfur bound ratio in the test facility as function of temperature for coal-biomass blend K93S7, [5]

Different variants of basic characteristics of coals in some mining basins are presented in Table 4. Majority of the characteristics refer to the average conditions defined for designing of boiler plants, taking in consideration exploitation conditions in mines and contouring of a corresponding deposit. In general, it can be said that the thermal power capacity of EPRS is based on the coal of predominantly low quality. The coal heating capacity ranges form 6.000 to 13.000 kJ/kg. Higher quality can be expected only in „Mezgraja" deposit of Ugljevik basin, which exploitation would partly be carried out with mining method. The coal quality decrease is contributed by ballast materials (humidity and ashes) and major sulphur content in coal, ash (A^r=7 do 8 %) and extremely low content of total sulphur (S_t=0,18%), and particularly combustible sulphur 0,06 %. Heating capacity of this coal decreases high content of humidity, about 50 %.

Location of coal - sample definition and characteristics		Coal characteristics								
		H_d^r, kJ/kg	W^r, %	A^r, %	S_k^r, %	S_g^r, %	C^r, %	H^r, %	N^r, %	O^r, %
TPP UGLJEVIK I „Bogutovo selo“ Mining Site	Guaranteed composition (GC)	10476	33,0	25,0	5,4	4,8	27,2	2,2	0,6	7,2
	Improved composition (IC)	12142	33,0	18,0	6,3	5,6	31,7	2,5	0,7	8,5
	Aggravated composition (AC)	8792	33,0	32,0	4,5	4,0	22,7	1,8	0,5	6,0
TPP UGLJEVIK II „Ugljevik Istok“ Mining Site	Guaranteed composition (GC)	10479	31,0	18,8		3,3	27,2	2,6	1,1	9,2
	Improved composition (IC)	12326	31,0	14,8		3,9	31,2	2,2	1,3	11,0
	Aggravated composition (AC)	8788	31,0	22,3		2,5	23,0	2,3	0,8	7,9
GACKO Mining basin	Ministry decision dated December 31st 1987	10110	37,45	16,61	1,55	-	-	-	-	-
TPP GACKO I „Gračanica“ exc. Site	Project (GC)	10362	40,0	12,0	-	0,5	30,6	2,4	0,5	14,0
	Project (IC)	11618	35,0	8,0	-	1,0	33,7	2,7	0,6	18,0
	Project (AC)	9106	44,0	16,0	-	0,1	35,8	2,1	0,5	11,5
TPP GACKO I - boiler reconstruction	Guaranteed composition (GC)	7437	41,8	16,65	-	0,75	22,78	2,05	0,5	9,52
	Improved composition (IC)	8285	40,5	17,41	-	0,68	24,08	2,66	0,5	12,90
	Aggravated composition (AC)	6690	39,95	19,14	-	0,61	20,54	2,02	0,5	8,68
TE GACKO II Study on selection of the Mine location	Average composition	7014	37,72	21,8	-	0,4	-	-	-	-
	Bottom limit	8417	34,00	17,5	-	0,4	-	-	-	-
	Upper limit	5611	43,0	26,6	-	0,4	-	-	-	-
STANARI MINE	Average value	9310	50,04	7,41	0,18	0,06	28,82	2,54	10,80	
MILJEVINA MINE Project for new power plant "Maglić"	Deposit average	12620	18,28	28,74	2,39	1,42	38,73	3,48	0,49	11,79
	Upper limit	13280	18,41	-	2,68	-	-	-	-	-
	Bottom limit	10362	18,53	36,10	2,08	0,85	28,97	2,66	0,31	16,99

Table 4. Summary of coal characteristics,[9]

Aggravation of the coal quality in Gacko basin is particularly typical, comparing to the coal required by the design for TPP "Gacko I" and comparing to the verified reserves according to the decision of the B&H Ministry of energetics for conditions on December 31st 1987. Changes in the coal quality can be easily noticed by comparison of the data in Table 4. The coal heating capacity has decreased for about 3000 kJ/kg, and ash content in the coal has increased from 12 % to 17 - 22 %

An important coal characteristic is chemical composition of ash. Chemical analyzes for the considered coal types are presented in Table 5. This parameter also shows aggravation of ash composition comparing to the design requirement, particularly content of CaO which has a dominant role when heating surfaces of boilers are clinkered and dirtied. This kind of condition was notices in TPP "Ugljevik", and it was particularly distinct in the case of TPP „Gacko". The installed capacities of these thermal power blocks have decreased due to very clinkering features of these coals, in spite of introduction of radical cleaning procedures of heating surfaces.

Locations and definition of coals composition		**Chemical analysis of ash, %**									
		SiO_2	**Fe_2O_3**	**Al_2O_3**	**CaO**	**MgO**	**SO_3**	**P_2O_5**	**TiO**	**Na_2O**	**K_2O**
TPP UGLJEVIK I „Bogutovo selo" Mining Site	GC	33,9	18,3	16,6	10,35	3,6	13,9	0,28	0,43	1,45	1,05
	from	17,3	11,0	7,7	3,65	2,65	5,5	0,12	0,17	0,55	0,22
	to	41,8	28,8	24,1	29,8	6,6	28,1	0,64	0,7	2,09	1,75
TPP UGLJEVIK II „Ugljevik Istok"	GC	17,1	11,0	4,9	36,2	3,25	25,6	0,18	0,23	1,03	0,5
TPP GACKO I PK -project-	GC	12,5	5,5	6,4	58,0	2,6	12,8	0,23	0,21	0,80	0,28
TPP GACKO I - reconstruction project-	GC	9,79	2,12	2,41	72,78	1,98	10,34	0,11	0,19	0,05	0,33
	IC	9,22	3,6	6,0	64,43	1,7	13,53	0,4	0,18	0,61	0,33
	AC	6,73	1,85	2,37	79,46	1,33	7,61	0,1	0,08	0,35	0,12
Study for TPP GACKO II	average	20,35	6,05	11,35	47,27	1,26	12,11	0,2	0,43	0,37	0,55
	from	6,0	3,0	4,0	35,0	0,8	6,0	0,0	0,15	0,2	0,1
	to	30,0	11,0	15,0	80,0	3,5	18,0	0,5	0,75	0,7	0,8
STANARI	average	48,99	0,85	32,22	8,64	4,10	3,22	0,05	1,04	0,11	0,89
MILJEVINA	average	40,33	5,71	19,21	19,37	0,79	10,31	0,39	0,62	0,93	0,60

Table 5. Chemical analyses of coal ash from Table 4.[9]

Brown coal:

(1) ○ Ugljevik I - design (SC)
(2) ⬭ Ugljevik I - real coal, average for 29 samples
(3) ● Ugljevik I - design (waeker content)
(4) ◉ Ugljevik I - design (better content)
(5) ⬭ Ugljevik II - design (better component)
(12) ⬠ Miljevina

Lignite coal:

(6) □ Gacko I - design (GC)
(7) ▣ Gacko - Study, deposit
(8) Gacko I - reconsruction (GC)
(9) ▮ Gacko I - reconstrction (IC)
(10) ▭ Gacko I - reconstruction (AC)
(11) ⬟ Stanari - deposit cross section

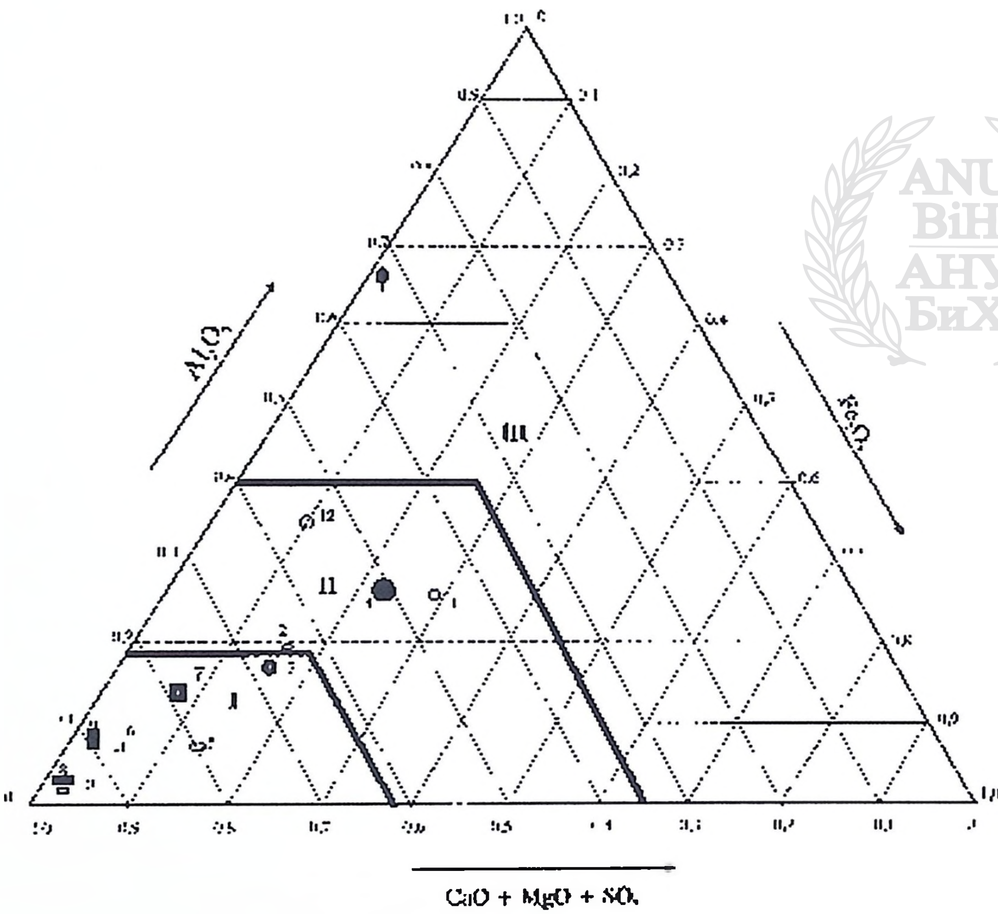


Figure 8. Characteristics of clinkering features of coals in Table 4. according to Altman diagram, [9]

Worse quality of coal is evident and that determines the need for further exploration of their characteristics with aim of additional definition of reaction features (kinetic and dynamic parameters) of coal in the process of combustion in space and fluidized layer. The above mentioned is needed, in order to enable competent selection of a furnace or types of boilers in the process of designing of future thermal power plants, then impact parameters related to environment protection, taking in consideration high content of sulphur and ash in the considered coals (apart form Stanari lignite). This will ensure correct selection of a plant for separation of ashes, sulphur and nitrogen for flue gases, including the possible selection of boilers with fluidized combustion, as well as clinkering features of the subject coals types with known methods based on ashes chemical composition and special process testing for creation of ashes and determination of temperature for initiation of clinkering in laboratory and plant conditions.
Analysis of chemical composition of our coals through clinkering method (R_s), dirtying factor, silicate modulus (K_{SiO2}) and base factor (K_1=B/A), and based on practical experiences it can be concluded that these coals fall under the group of extremely or moderately inclining to clinkering (apart from Stanari coal). Triple diagrams of condition and particularly Altman triangle is practical for assessment of clinkering features. When composing Altman triangle, the portions of some components are calculated from data on complete chemical composition of ashes (Table 5) which sum amounts to 100% with appreciation of the relation $A1_2O_3+Fe_2O+(CaO+MgO+SO_3)=1$. This kind of diagram has been constructed for the subject types of coal and is presented in Figure 8. All analyses of coals from the basins of Ugljevik, Gacko and Miljevina fall under the group of extremely (I) or moderately (II) clinkering coals. The lignite coal from Stanari is not inclined to clinkering (item 11 in group II on the diagram). All coal samples from Gacko Mine and "Ugljevik-Istok" Mining Site for TPP "Ugljevik II" are very inclined to clinkering and dirtying of a boiler heating surfaces (group I in Altman diagram).

4. Analysis of needs and possibilities of utilisation of thermal energy potential in B&H

4.1 Current situation

Approximately 80% of produced coal in Bosnia nad Herzegovina is delivered to 4 existing coal-based power plants - with 9 units, of total capacity of 1765 MW_e, and annual production of 15039 GWh, Table 6.

Although some of the power units was recently reconstructed and modernized (TPP Tuzla unit 4 and 5, TPP Kakanj units 5 and 7, TPP Gacko), present park of thermal power plants in Bosnia and Herzegovina is worn, both thank to the year of commissioning and technology applied. The most recent unit in the park is TPP Kakanj unit 7 - 230 MW, commissioned in 1988. Equivalent MW of TPP Tuzla is 27.46 years old, and TPP Kakanj 22.66 years, taking into account modernized units also.

Thermal power plant	*Generator*	*Comissioned*	*Power installed (MW)*			*** Possible production*
			No.	*Generator Power*	*Station Power*	
TUZLA	*G3**	*1966*	1	100	100	462
	*G4**	*1971*	1	200	200	1078
	G5	*1974*	1	200	200	1078
	G6	*1978*	1	215	215	1103
	total		4		715	3721
KAKANJ	*G5**	1969	1	110	110	627
	G6	1977	1	110	110	478
	G7	1988	1	230	230	1227
	total		3		450	2332
GACKO	*G1*	1983	1	300	300	1412
UGLJEVIK	*G1*	1985	1	300	300	1521
Total TPP in BiH			9		1765	15039

Table 6. Existing thermal power plants in BiH

4.2 Forecast for electricity demands and development of park of thermal power plants in BiH till 2020

Current consumption of electricity in Bosnia and Herzegovina, arranged according to companies and category of consumers, is given in Table 7.
Considering total electricity consumption in Bosnia and Herzegovina in 2006, Table 7, and taking into account a realictic estimation of annual grow of electricity consumption of 4% in the next 10-12 years, total consumption in BiH in 2020 is expected to be 19000 GWh. Therefore it is necessary to provide preconditions for fulfilling sach demands. Taking into consideration also opportunities for export of electricity, it is possible only by investing into Energy power system of Bosnia and Herzegovina, in three basic components: Production (including coalmines), high voltage lines for electricity transmittion and distribution system. With completion of reconstruction and modernization of remaining power units, construction of

new coal-based power plants is crucial point, Table 8. It must be emphasized here that it is planned to shut down only one unit in BiH till 2020: TPP Tuzla unit 3 - 100 MW.

No	Category of consumers	Consumption MWh		
		MH EP RS a.d. Trebinje	**JP EP HZ HB d.d. Mostar**	**JP EP BiH d.d. Sarajevo**
1	Direct ≥110kV	*199.520*	1875.030	542.897
2	35 kV	*87.650*	173.800	337.992
3	20 (10) kV	*325.990*	126.115	540.829
4	110, 35, 20(10) kV	613.160	2.174.945	1.421.718
5	Householders	1.502.180	672.611	1.742.175
6	Other 0,4 kV	465.640	231.210	637.419
7	Public light	41.220	21.019	59.592
8	Low voltage 0,4 kV	9.320	924.840	2.439.186
9	Net consumption	2.622.200	3.099.785	3.860.904
10	Transfer losses	42.070	69.730	159.000
11	Distribution losses	7.010	260.812	404.000
12	System losses	153.650	330.542	563.000
13	Gross consumption	3.463.540	3.430.327	4.423.904
14	Total BiH-(RS+FbiH)	(3.463.540+7.854.231) = 11.317.771 MWh		

Sources : Annual report 2006.: EP RS, EP BiH, EP HZ HB

Table 7. Electricity consumption in BiH by consumers

Additionally, for purpose of diversity of electricity sources and flexibility of energy power system, as well as some other effects like improving environmental issue, it is recommended working out Fisibility Study of construction of a Combined Cycle Gas Turbine (CCGT) in TPP Kakanj - Kakanj A 100 MW. Certain activities on this study, including detail thermal calculations of one option of such unit in TPP Kakanj, are already done, TPP Kakanj CCGT 100 MW (70 MW GT+30 MW PT), [3].

It must be emphasized here that new thermal power plants in Bosnia and Herzegovina have to be based on state-of-the-art technologies, so called clean coal technologies, adopted as far as combustion system is concerned to the specific domestic coal behaviours. Only by this approach, with needed level of reorganization of energy power sector, electricity utilities in Bosnia and Herzegovina will successfully meet chalanges of incoming open European electricity market.

No	Name of TPP	No and power of generator (MW)	Power installed (MW)	Annual production (MWh)	Year of comissioning
1.	TPP Stanari	1x410	410	2916	2012
2.	TPP Gacko 2		Table 9		2013-2015
3.	TPP Ugljevik 2	1x300	300	1601000	2014-2017
4.	TPP Tuzla, unit 7	1x370	370	2047000	2013
5.	TPP Kakanj, unit 8	1x250	250	1260000	2013
6.	TPP Bugojno 1	1x300	300	1630000	2013
7.	TPP Kongora	2x275	550	3000000	2013
8.	TPP Tuzla B-1	1X500	500	2640000	2017
9.	TPP Bugojno 2	1x300	300	1630000	2017
10.	TPP Kamengrad 1	1x215	215	1190000	2017

Table 8. Preview of planned construction of new coal-based power plants in BiH till 2020

Thermal power potential based on coal, as a non-renewable source of energy and big and valuable national treasure, deserves to be valued as such. On the other hand, that is also constant source of energy during entire year and it does not depend on hydrologic conditions, and it just partially depends on meteorological conditions. Besides power utility company, on usage of this potential, other important society subjects have rights (industry and households, including town heating on domestic energy fuel independent on import problems). Certainly, national consensus has to be achieved through creation and implementation of a long term strategy for development of energy-power in Bosnia and Herzegovina, which is now pending (completed preliminary plan, on bases of which public discussion is going on).

Further analyses of possibilities for usage of coal potential starts from assumption that the largest part of coal will be used for production of electric power in Thermal Power Plants (TPP) and TPP-HP or industrial power plants. Planning to build thermal power facilities is possible if based on available balances, and in a long term based on potential coal reserves, calculating production life span of these facilities foreseen to be 40 years. Based on detailed calculations and analyses, included in Table 9 are installed powers and possible production of electric power on verge of TPP that are already constructed (600 MW, 2.993 GWh), TPP planed for construction until year 2020. (min. 1084,8 MW, min. 5718,8 GWh), as well as TPP which construction is possible under certain conditions after year 2020 (1.120 MW, 5.963 GWh).

Thermal Power Plant		Power on generators		Available power on output TPP, MW	Annual production on output TPP for 5740 h/year, GWh
		Installed, MW	Available, MW		
TPP Ugljevik I		300	285	266	1.521
TPP Gacko I		300	267	246	1.412
Total of TPP constructed		600	552	512	2.933
Planned power plant construction until year 2020.					
TPP Stanari (Figure 9)		420	410,30	388,80	2.232
TPP-TO Doboj	Condesation operations	34,8	34,8	31,50	180,8
	Toplification operations	27,5	27,5	24,77	142,2
TPP UgljevikII		300	300	279	1.601
TPP Gacko II	Option I	330	330	297	1.705
	Option II	2x330	660	594	3.409,6
	Option III	2x250	500	450	2.583,0
Total of new TPP until year 2020 (with option I for TPP Gacko II)		1084,8	1075,10	996,30	5.718,8
Possible thermal power plant construction after year 2020					
TPP Miljevina I		110	110	101	580
TPP Ugljevik III		300	300	279	1.601
TPP Gacko III		300	300	279	1.601
TPP Ugljevik IV		300	300	279	1.601
TPP Miljevina II		110	110	101	580
Total thermal capacity		1.120	1.120	1.039	5.963
Ovreral thermal energy capacity		2.455	2.407	2.233	11.681,8

Table 9. Complies of installed power and possible production of electric power on output of some existing and planned TPP

From Table 9 one can notice that it is possible to reach overall construction of complete mentioned thermal power capacity up to installed power of 2455MW in 11 energy blocks in four TPP, including TPP Stanari and TPP-HP Doboj. That is not particularly imposing number, only 86% of presently installed power TENT A+B in Obrenovac and probably with lower economic effects.

Inclusion of already noted TP facilities in average life span plans of development and certain programmes of construction need to be based on serious and comprehensive research, studies and design works. In deed, based on executed and required span of research, for each power facility, adequate technical documentation with feasibility studies or construction feasibility has to be completed. Certain financial means for this purpose should be put aside in yearly investment plans. This kind of documentation should be adequate for relevant government bodies for planning and making decisions on construction and realisation of finances.

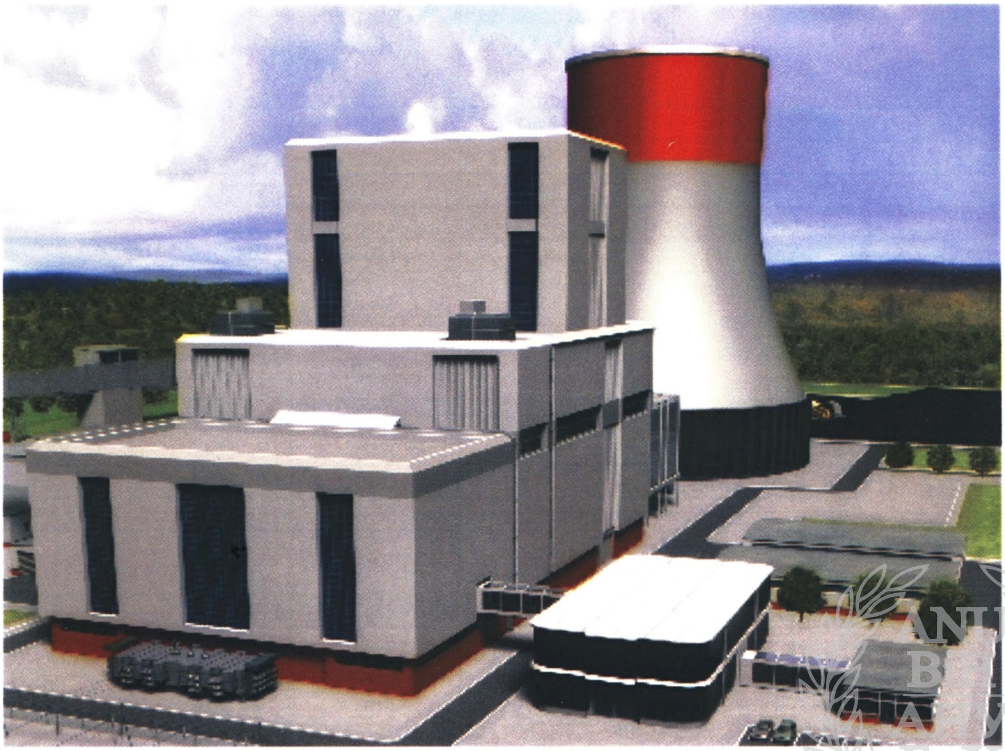


Figure 9. Planned facility for construction -TPP Stanari power 420 MW, [12]

Besides highlighted need to calculate quality characteristics of coal, it is necessary to pay attention to technologic conditions which might be limiting factors for development of thermal-energy in coal pools here. In this case it is primarily meant to provide enough water for cooling, disposal of huge amount of coal ash from TPP, adequate protection of environment, and preservation of air quality in particular.

Providing water to thermal-energy facilities which will be constructed until year 2020 is mostly resolved.

Cooling TPP Stanari is resolved by using dry cooling towers and providing technical water from wells in area around TPP. TPP-TO Doboj has at their disposal water from river Bosna, which completely fulfils all technical and ecological criteria.

Providing water for new energy blocks 2 x 300 MW in Ugljevik (TPP Ugljevik III and IV) is not possible to resolve safely from surrounding area. Therefore it is necessary to think about other solutions and provide required amount of water from river Drina or river Sava which has been discussed during design of TPP Ugljevik I. One of the excepted solutions also needs to include water production company bases. Alternative to a solution above, which figures water cooling systems with wet cooling towers, is consideration for introduction of cooling systems with dry cooling towers. It is clear that the last solution hinders economic block (rising of pressure in condensation systems) so at the same time technical-economic analyses for both possible solutions has to be completed.

For TPP Gacko III with installed power 1 x 300 MW it is possible to find solution for water supply within surrounding water streams, it is considered to go towards rising of dam "Klinja" for 2 meters or building new accumulation "Gračanica". In any case with these solutions it is necessary to pay attention to energetic values of Gornji Horizont potential.

Supply of untreated water for future TPP Miljevina I and II is possible to provide by building smaller accumulation on river Bistrica which runes through Miljevina. Up till now, for this location there has not been any study documentations completed so, this should be done in foreseeable future.

Disposal of linker and ash becomes, for our conditions, more and more important factor in investment and running costs of thermal power plant, but the problem is not any smaller from perspective of environment protection, spread of dry ash, water and ground pollution caused by seepage from land fill, as well as provision of land, including parts of agricultural land, to be used for storage of large quantities of linker and ash.

As it can be seen from Table 4, our coals (apart from lignite from Stanari) have relatively large content of ash. If only balance quantities of coal were to burn with 20% excavation and other losses (exploitation reserve), land for storage of 125 million tones of linker and ash is needed.

In respect to this, it is necessary for above mentioned problems to be considered and researched thoroughly and find adequate solutions so that hindrance to exploitation of thermo power potential of coal, including usage of existing and taking upon new technologies for ash consumption as a row material for civil engineering and construction, cement industry etc.

In any case that is excepted practice which is implemented in well developed industrial countries.

Burning of fossil fuels in thermo blocks has important impact on material and energy exchange with surrounding area. Beside other contestants in this exchange (industry, motor transport etc.), thermal power also provides considerable factor in hindering natural balance to circular processes in biosphere. Impact to this balance does not refer only to emission of polluting masteries (sulphur oxides and Nitrogen, heavy particles) but also on increase of CO_2 and decrease of O_2 in atmosphere.

5. Environment issue

5.1 Legal framework / legislative and regulations /

Bosnia and Hercegovina is already ratified or aims to retify the following contracts, protocols and conventions:

1. Contract on Energy policy and protocol of energy policy on energy efficiency and environmental issue / signed on 14 June 1995, ratified in 2000;
2. Framework Convention of United Nations on climate change / ratified in 2000;
3. Convention on border-crossing transports of dangares waste and its disposal / ratified in 2000
4. Convention on protection of Mediterannean Sea from pollution / ratified in 1998 /
5. Kyoto Protocol

Bosnia and Herzegovina ratified on 27. July 2006 Agreement on establishment of energy community, which should prepare SEE region, so and BiH, for functioning of energy sector according to the EU principles which basic elements are given as follows:

<u>AQUIS communautaire on energy</u>, for purpose of Agreement, signifies:

Directive 2003/54/EC of European Parliament and Council on common rules of internal market of electricity,

1. European Parliament and European Parliament and Council on commen rules of internal marketof natural gas, and
2. Regulation 1228/2003/EC of European Parliament and Council on conditions of approaching to the net due to overbording exchange of electricity.

For implementation of this Chapter, European commity will adopt the measures which will adjust the measures AQUIS communautairea described in this Chapter, taking into consideration institution framework of this Agreement and specific situation of every contractual party. According to the Anex, every contractual party is obligated to implement this Chapter nine monthes after entering into force of the Agreement latest.

<u>AQUIS communautaire on environment, every contractual party will implement:</u>

1. Directive of Council 85/337/EEC about evaluation of effects to environment of certain public and private projects, and completed by Directive of Council 97/11/EC and Directive 2003/35/EC of European Parliament and Council after entering into force of the Agreement.

2. Every contractual party will implement Directive of Council 1999/32/EC on decreasing of sulphur content in certain liquid fuels and supplemental Directive 93/12/EEC from 31. December 2011.
3. Every contractual party will implement Directive 2001/80/EC of European Parliament and Council about limitation of certain pollutants into air from large facilities for combustion till 31. December 2017.
4. Every contractual party will implement article 4(2) of Directive 79/409/EEC of Council about saving of wild birds upon entering into force of this Agreement.

AQUIS communautaire for renewable resources:
Every contractual party will submit to the European committee their plans of implementation of Directive 2001/77/EC of European Parliament and Council on promotion of electricity from renwables in internal electricity market and Directive 2003/30/EC of European Parliament and Council on promotion of utilisation of biofuels and other renewable fuels for transport, within one year from the date of entering into force of this Agreement. European committee will expose plans of every Contractual party to the Ministry Council for adoption.

5.2 Projection of effects on environment of new thermal power plants in BiH

Environmental issues have significant influence to the trend in coal consumption today. Improving the existing and introducing the new advanced combustion technologies in coal-fired systems are required to increase efficiency and improve environmental issues. Energy power system of Bosnia and Herzegovina is based on coal; however, sustainability of the coal-based power plants is still lower in comparison with those ones in industrialized countries. The problem is basically addressed to the combustion of domestic coals.
Taking into account above mentioned, in modernization of existing and construction of new coal-based thermal power plants in Bosnia nad Herzegovina, particular attention should be focussed to the environmental issue.
According to the prevailing opinion today, antropological carbondioxide as green house gas is main contributer to the global warming and climate change. This problem could be escalated in future, and basic tool for mitigation of global warming is construction and utilisation of high-efficient energy technologies. Coal is an important contributer to the CO_2 emission. In Figure 10, CO_2 emission from TPP Tuzla in 2007 is given, [6]. Generally, Bosnia and Herzegovina should identify present situation about CO_2 and other emissions from their power plants as well as project the future emissions for period till 2030, to be able to define their emission quotas, which will be base for the

coming negotiations, and thus avoid situation that those emission quotas to be limiting factor in future development of coal-based power sector in B&H.

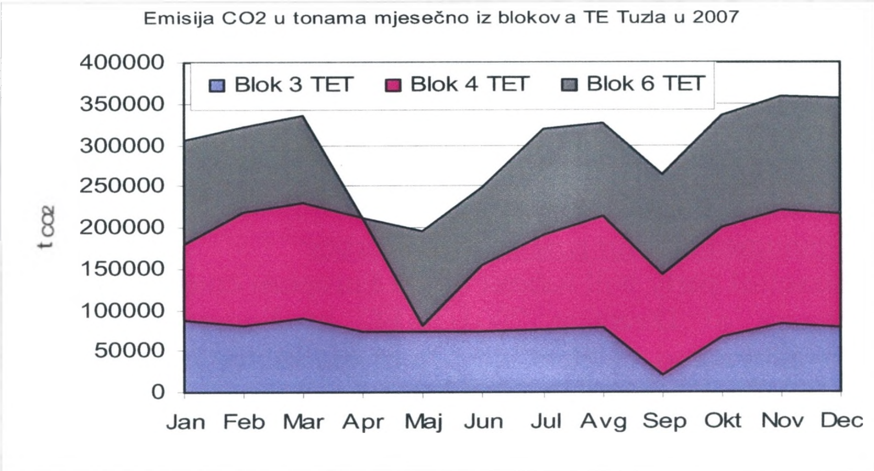


Figure 10. TPP Tuzla, CO_2 emission in 2007 [t/month]

In this line, it is necessary to elaborate several scenarios of development of thermal energy power sector of BiH; some of emissions from thermal power plants in BiH according to one of those scenario – *Scenario 1*, are given in Figures 11-16. This *Scenario 1* includes operation of existing power plants TPP Tuzla and TPP Kakanj till their shuting down as well as operation of the following new thermal power plants to be commissioned till 2020:

- TPP Tuzla unit 8, 370 MW, comissioning 2013, coal: blend of lignites Kreka;
- TPP Kakanj unit 7, 250 MW, comissioning 2013, coal: blend of coal from Srednja Bosna basen with 70% of Kakanj coal per mass;
- TPP Kongora, 2x275 MW, comissioning 2013, coal: Kongora coal;
- TPP Bugojno, 2x300 MW, comissioning 2013/2017, coal: Bugojno coal;
- TPP Tuzla B1, 500 MW, comissioning 2017, coal: blend of Kreka lignite and Banovići brown coal with 70:30 mass ratio;
- TPP Kakanj A, 100 MW, comissioning 2017, Combined Cycle Gas Turbine (CCGT), fuel: natural gas.

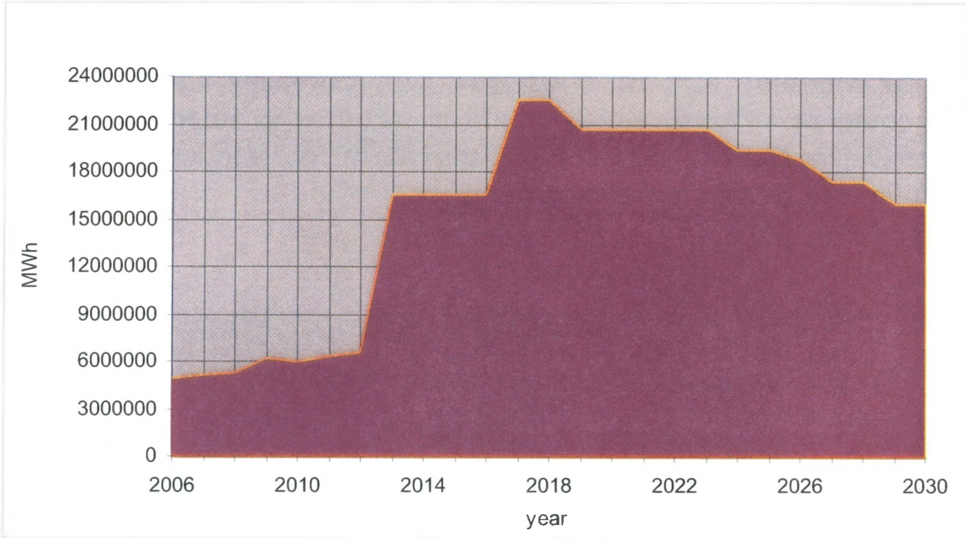


Figure 11. Annual electricity production in TPP in period 2006 - 2030, Scenario 1

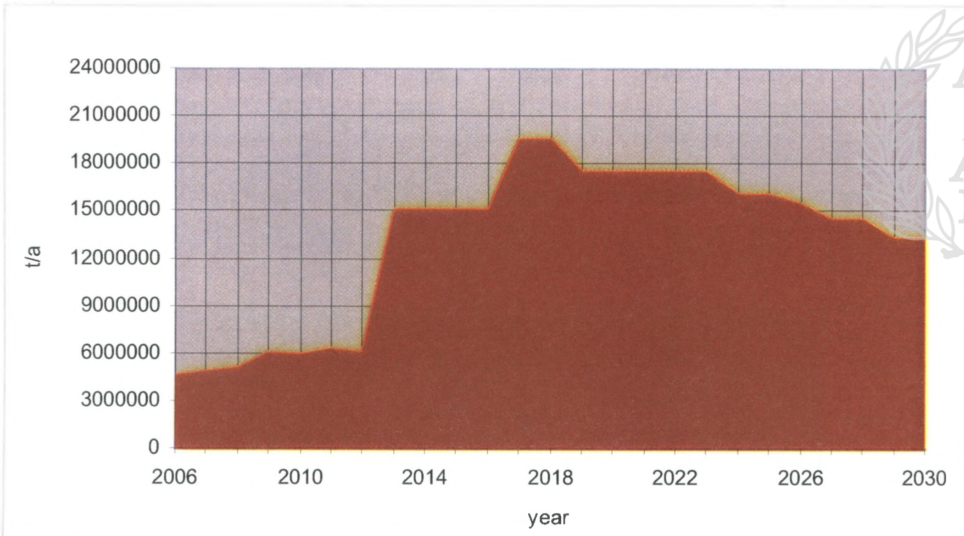


Figure 12. Annual coal consumption in TPP in period 2006 - 2030, Scenario 1

In emissions calculation performed according the CORINAIR methodology, it was used net efficiency of the new power plants in condensing regime of 43%, and net efficiency of CCGT unit in condensing regime of 58%. Emission limit values for SO_2 and NO_x were taken from EU Directive 2001/80/EC, [8]; thus emission limit values for SO_2 is 200 mg/m_n^3 normalised at 6% O_2 in dry flue gas, while for NOx is also 200 mg/m_n^3 normalised at 6% O_2 in dry flue gas - both for coal-based power plants, and 50 mg/m_n^3 for NOx normalised at 15% O_2 in dry flue gas - for CCGT units. However it must be emphasized here that with a good forecast of future emission limit values based on comming agreement of BiH with European Comission, those values could be relaxed, which would be resulted in important savings in investments for DeSOx and DeNOx measures in construction of new thermal power plants in Bosnia nad Herzegovina.

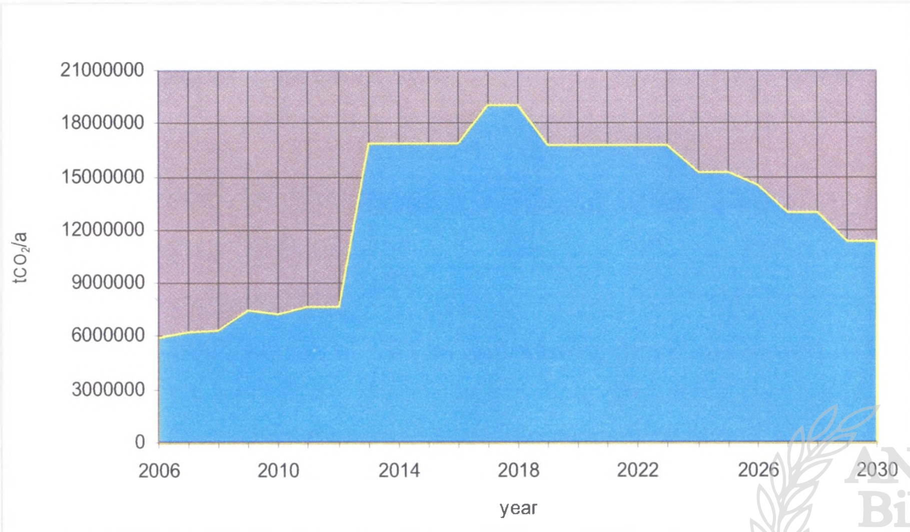


Figure 13. Annual CO_2 emission in tones from TPP in period 2006 - 2030, Scenario 1

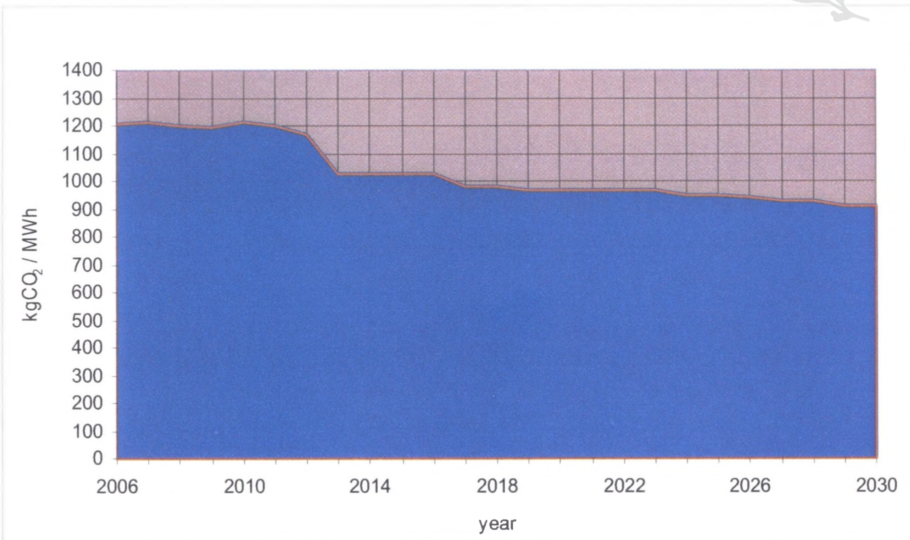


Figure 14. Specific CO_2 emission in kg/MWh from TPP in period 2006 - 2030, Scenario 1

Exploitation of a thermal power facility is unavoidably followed by certain environment impacts; therefore it is necessary to analyze this aspect in all phases of preparation of documents for these kinds of facilities, including pre-investment documentation, which aim is to make preliminary decisions in terms of further project development. Within a preliminary feasibility study for construction of any planned thermal power facility, the basic task and aim of all analyses regarding environment protection, is to present all potential impacts of a planned structure over environment and to provide the necessary protection measures that will keep harmful effects of a thermal power plant work within the permitted limits. The Law on Spatial Planning defines measures and activities in the field of spatial and urban planning and construction for environment protection parallel with energetic development. In accordance with that, construction of these kinds of structures (which are a part of energetic infrastructure) is done in accordance with the Spatial Plan, as well as based on the development plant of that very power infrastructure. In that sense, the first step has to be selection of the most favourable micro-location for construction of a TPP having in consideration ecological, technical and financial criteria.

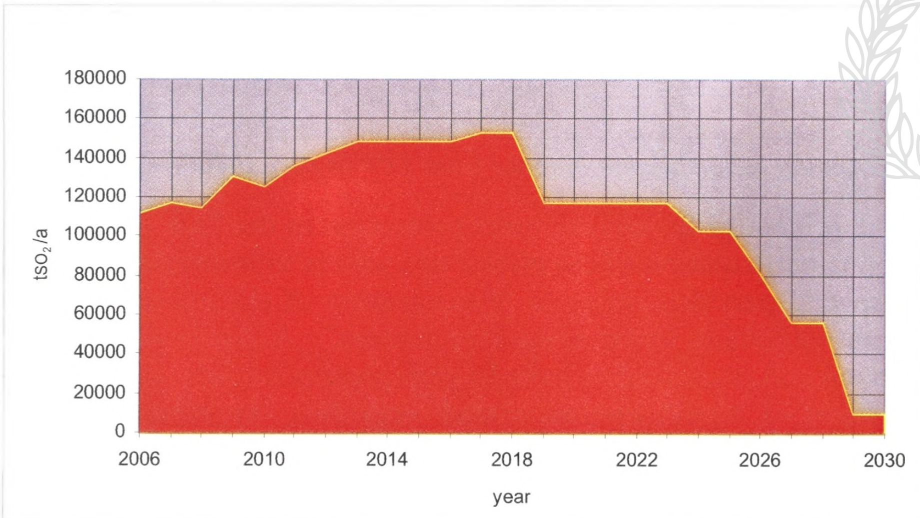


Figure 15. Annual SO_2 emission in tones from TPP in period 2006 - 2030, Scenario 1

Analysis of environment protection from harmful impacts of the subject structure presents multidisciplinary approach to the analysis of the existing condition of environment quality, the analysis of a new structure contribution and includes the following parts: detailed monitoring of the existing environment condition; definition of criteria and basements for the environment impact analysis; identification of types and quantities of polluting substance emitted to environment based on technical solutions of certain systems of a TPP; analysis of the existing environment pollution and determination of the location ecological capacity; analysis of the new facility contribution and total level of pollution after being put in operation; presentation of the measures for mitigation of the TPP harmful environment impact in normal run and in a case of an accident and presentation of a system for environment quality monitoring.

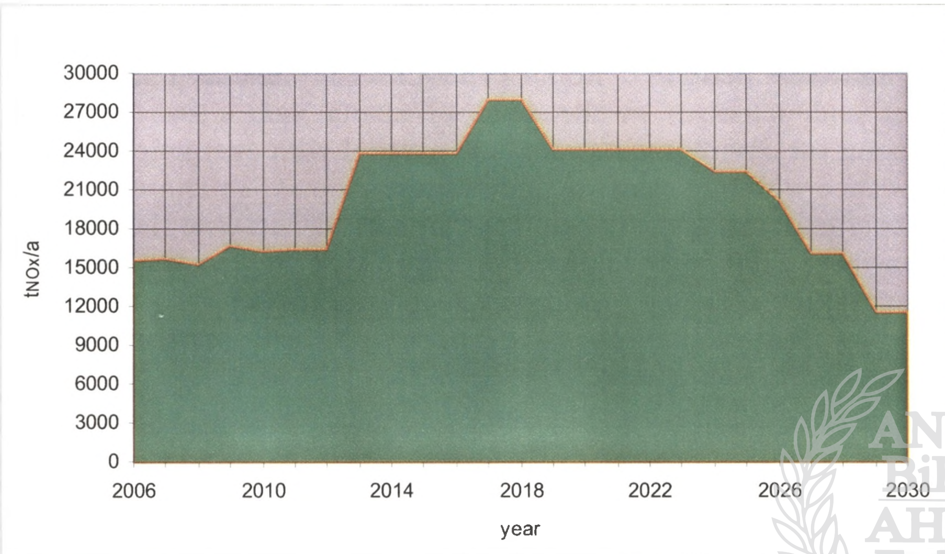


Figure 16. Annual NO_x emission in tones from TPP in period 2006 - 2030, Scenario 1

One of the principles for environment protection in the Law on Environment Protection is participation of the public and access to information, Article 10, and the special part that refers to "Participation of the public and access to information regarding environment protection". According to Article 10, every citizen and organization have to gain appropriate access to information in possession of administration bodies regarding environment protection, including information on dangerous substances and activities in their communities as well as the possibilities of participation in decision making process. In that sense participation of the public is foreseen in the process of adoption of a certain project through an Environment Impact Study, or in the course of preparation of a Feasibility Study. Taking in consideration modern legislation on environment protection in the course of preparation of conceptual solution for a thermal power plant the proposed technical solutions have to encompass all necessary protection measures which will enable that this facility is acceptable from the point of view of economy as well as ecology.

Although 753 millions of balance and 270 millions tons of potential reserves of coal of mainly lower quality with increased content of ashes and sulphur in the coal material, that is major national good, and the strategy of energy development, especially power utility development depends on it. The current level of the built thermal capacities amounts to 600 MW, and there are another 1120 MW for further construction of thermal capacities, under certain conditions.

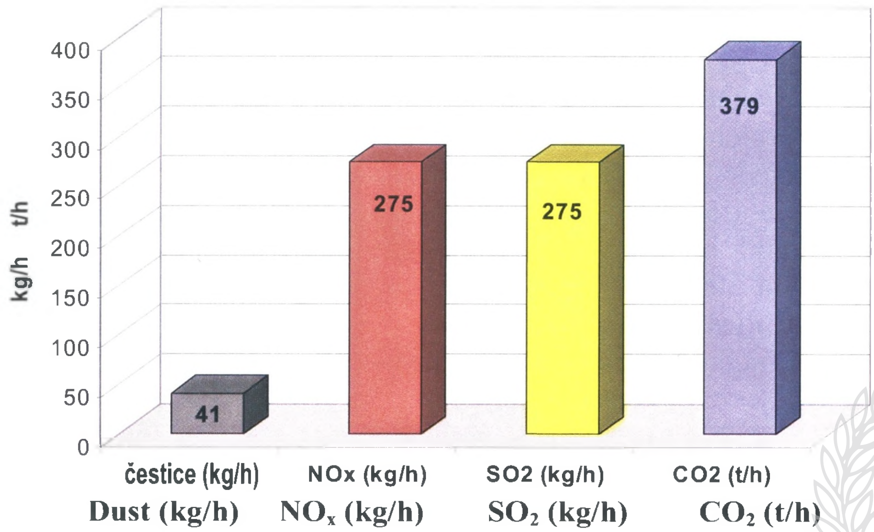


Figure 17. Emission mass flows of TPP Stanari (full load and design coal), [12]

It is necessary to additionally increase the exploration of coal reserves in general (with exception of Stanari lignite deposit) in order to create favourable condition for rational exploitation of this energy potential, with the final aim to promote coal reserves into higher exploration categories. Parallel to this activity it is necessary to increase the definition level of qualitative characteristics of coal on the majority of coal locations (preparation of coal for combustion: grinding capacities, kinetic and dynamic parameters in space and fluidized layer, clinkering features of coal (ashes), as well as features related to environment protection).

Feasibility studies have to be prepared for all potential thermal power plants, and these studies would be a basement for their inclusion into spatial planning documents and they would define opened issues for every facility that requires precise answers based on additional programmed exploration and study-designing working out. Several feasibility studies have been produced in the past years ([11], [12] and [17]). It has been proven that from technical point of view, it is necessary to determine all conditions for potential locations that could become limiting factors for the development of thermal power. First of all, this refers to solving of problems related to water supply (TPP Stanari), disposal of big quantity of clinker and ashes (TPP Gacko II) and protection of the living environment (TPP Ugljevik II).

6. Conclusions

Coal will keep its leading role as basic fuel for electricity generation in the next 20 years, not only in Bosnia i Herzegovina but also in the World. Bosna i Hercegovina posseses important reserves of coal, and preciase amounts must be identified by additional investigations on coalmines. Existing technology in thermal power plants in Bosnia and Herzegovina is to be modernized, which is particularly important for new coal-based power plants to be constructed. Thus, clean coal technologies must be applied, and adopted to the specific domestic coal combustion behaviours. At this, particular attention should be focussed to the environmental issue. Only by this approach, with needed level of reorganization of energy power sector, electricity utilities in Bosnia and Herzegovina will successfully meet chalanges of incoming open European electricity market. Finnaly, several scenarios of development of coal-based power sector in BiH are to be elaborated to be able to define the emission quotas which will be base for the coming negotiations, and thus avoid situation that the emission quotas to be limiting factor in future construction of thermal power plants in BiH.
The concept of "sustainable development" means exploitation of natural goods in a manner that enables satisfaction of the present generations needs without endangering the future generations possibilities to use these goods satisfy the needs of their development. This concept was declared the basement of the 21st century development policy ("Agenda"), and it should be applied in all countries that long for preservation or improvement of the life quality of their citizens. As for developed countries, provision of technological development requires engagement of additional finances and additional activities that would enable preservation of the natural environment from further exhausting and degradation, or even contribute the revitalization. Having that in consideration, it is necessary to apply the model of integrated techno-economical and ecological analysis of acceptability for construction of the facilities that represent wide interest for the society development, but also represent possible polluters of the environment. Ecological criteria become equally important factors in decision making process in these analyses as well as in Studys. This is a crucial issue when it comes to a facility located in preserved area in ecological sense, which has to be maintained to the same extent after the construction and during the facility operation.

Here in Bosnia and Herzegovina, there is no organized and qualified institute or any other similar scientific-research institute or designing organization. We are suggesting the Power Institute to be formed and adequately equipped. This institute would study the problems of energy and gather and train young scientists and professional staff and would be responsible for connections with professional institutions in other developed countries. In that sense, it is necessary to give stimulus to Faculties of Mechanics, Electrical Engineering and Mining for more active researches of energy problems both through scientific-teaching process and scientific-researching work.

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