ENERGOPROJEKT
ENTEL a.d.

Contract No. 53-EN/15

PUBLIC ENTERPRISE
ELECTRIC POWER INDUSTRY OF SERBIA, BELGRADE

TPP KOSTOLAC B

ENVIRONMENTAL IMPACT ASSESSMENT STUDY FOR THE CONSTRUCTION OF THE NEW UNIT B3 AT THE TPP KOSTOLAC B

Approved by the Project developer
Public Enterprise
Electric Power Industry of Serbia, Belgrade

Study developer
Energoprojekt Entel a.d. Beograd

COPY:

S15011

December 2016

ENERGOPROJEKT
ENTEL a.d.

Ugovor br. 53-EN/15

INVESTOR:	PUBLIC ENTERPRISE ELECTRIC POWER INDUSTRY OF SERBIA
FACILITY:	TPP KOSTOLAC B, UNIT B3 CM KOSTOLAC – Village: Cadastral lot No. 303; City of Pozarevac, CM Drmno: Kat. par. br. 651, 680, 681, 684, 1394, 696, 698, 695, 694, 692, 691, 687, 686, 685, 496, 104, 102, 100, 99/1, 772, 821/1, 70, 69, 68, 67, 66, 65, 64, 63
TYPE OF DOCUMENT:	ENVIRONMENTAL IMPACT ASSESSMENT STUDY
LABEL AND NAME OF PROJECT SECTION:	
FOR CONSTRUCTION/EXECUTION OF WORKS	New build
DESIGNER:	ENERGOPROJEKT ENTEL a.d. Beograd
RESPONSIBLE PERSON:	Mladen Simovic, B.Mech.Eng.
<seal> ENERGOPROJEKT ENTEL a.d. BEOGRAD	<signature>
RESPONSIBLE DESIGNER:	Djordjina Milovanovic, M. Sc. El. Eng.
LICENCE NUMBER:	
<personal seal>	<signature>
PROJECT SECTION LABEL:	S15011
COPY:	
PLACE AND DATE:	BELGRADE, December 2016

0.2 VOLUME CONTENTS

GENERAL PAGES		
	DOCUMENTS PREPARATION PARTICIPANTS	
	DECISION APPOINTING THE RESPONSIBLE DESIGNER AND INTERNAL AUDITOR	
	LIST OF DOCUMENTS USED	
	LIST OF DOCUMENTS ABOUT THE LEGAL PERSON – DOCUMENTATION DEVELOPER	
TEXTUAL DOCUMENTATION		
1.	**INTRODUCTION**	**1**
1.1	Obligation, objective and purpose of study development	1
1.2	Preliminary explanations of the Project	1
1.3	Project developer data	3
2.	**DESCRIPTION OF THE PLANNED PROJECT LOCATION**	**5**
2.1	Project location	5
2.2	Exploration area	5
2.3	Compliance of the project with the spatial - planning documentation	8
2.4	Geomorphological characteristics of the terrain	8
2.5	Hydrological characteristics of the terrain	10
2.6	Geological characteristics of the terrain	14
2.7	Soil characteristics of the terrain	17
2.8	Hydrogeological characteristics of the terrain	19
2.9	Seismic characteristics of the terrain	23
2.10	Climatic characteristics of the terrain	24
2.11	Water supply sources	26
2.12	Flora and fauna	28
2.13	Landscape	36
2.14	Immovable cultural property	37
2.15	Archaeological site *Viminacium*	38
2.16	Population and democratic features	41
2.17	Commercial buildings and infrastructure facilities	42
2.18	Ambient conditions at the TPP Kostolac B location adopted for designing	43
3.	**PROJECT DESCRIPTION**	**44**
3.1	Project Scope and Boundaries	44
3.2	Description of Thermal Power Plant Kostolac B	44
3.2.1	*Technical characteristics of TPP Kostolac B*	*44*
3.2.2	*Review of Measures for Protecting the Environment from the Operation of TPP Kostolac B*	*50*
3.2.3	*Emission of Pollutants from Power Units B1 and B2 into Environment*	*51*
3.2.4	*Environmental Protection Management and Monitoring*	*53*
3.3	Description of Project for Power Unit B3 of TPP Kostolac B	55
3.3.1	*Description of Previous Project Implementation Activities*	55
3.3.2	*Technical and Technological Concept of Power Unit*	56
3.3.3	*General layout solution of the unit B3 TE Kostolac B*	60
3.3.4	*Overview of technical-technological solution for the Unit B3*	61

3.3.5	*Raw materials and products*	119
3.3.6	*Review of system for waste material treatment and emission into environment*	161
3.3.7	*Cumulative effects with the existing or planned activities on location*	193
3.3.8	*Direct influence of the Project to the human health*	198
4.	**PRESENTATION OF THE MAIN ALTERNATIVES CONSIDERED BY THE PROJECT DEVELOPER**	203
5.	**PRESENTATION OF THE ENVIRONMENT CONDITION AT THE SITE AND NEARBY SURROUNDINGS**	206
5.1	Display of criteria for environment evaluation	206
5.2	Air quality	212
5.3	Soil quality	220
5.4	Surface water quality	221
5.5	Groundwater quality	223
5.6	Ionizing radiation	224
5.7	Noise	225
5.8	Health status of population	226
6.	**DESCRIPTION OF POSSIBLE IMPORTANT ENVIRONMENTAL AND HEALTH IMPACTS OF THE PROJECT OF CONSTRUCTION OF TPP KOSTOLAC B UNIT B3**	230
6.1	Review, classification and evaluation of possible impacts	230
6.2	Description of possible environmental impacts of the Unit B3 during the construction phase	232
6.2.1	*Traffic and transport*	233
6.2.2	*Waste generation*	234
6.2.3	*Construction and other site machinery operation*	234
6.2.4	*Space occupation and its intent conversion*	235
6.2.5	*Changes in social structure of the area*	235
6.2.6	*Summary evaluation of environmental impact during construction phase*	235
6.3	Description of possible environmental impacts of unit B3 operation	237
6.3.1	*Air quality impact*	237
6.3.2	*Water quality impact*	265
6.3.3	*Impact on land quality*	271
6.3.4	*Impact on the noise level, vibrations, heat and radiation*	271
6.3.5	*Impact on people's health*	274
6.3.6	*Impact on eco-system*	278
6.3.7	*Impact on living organisms (flora and fauna)*	279
6.3.8	*Impact on climate*	283
6.3.9	*Impact on landscape*	284
6.3.10	*Impact on the objects of cultural heritage*	284
6.3.11	*Impact on social and economic elements*	285
6.3.12	*Transboundary pollution transport*	285
6.3.13	*Summarized analysis of environmental impact*	294
7.	**ENVIRONMENTAL IMPACT ASSESSMENT IN CASE OF ACCIDENT**	297
7.1	Subject and Scope of Accident Analysis	297
7.2	Accident Risk Identification	297
7.3	Analysis of Accident Consequences	303
7.3.1	*Identification of Potential and Selection of Reference Accidents*	303
7.3.2	*Accident Consequences Assessment*	303

7.3.3	*Risk assessment*	307
8.	**DESCRIPTION OF THE MEASURED ENVISAGED TO PREVENT, REDUCE AND, WHERE IS IT POSSIBLE, ELIMINATE ANY SIGNIFICANT ADVERSE IMPACT ON THE ENVIRONMENT**	311
8.1	General requirements and the aim of protection measures	311
8.2	Project environmental protection measures	313
8.2.1	*Measures to protect air*	313
8.2.2	*Measures of waste water management*	315
8.2.3	*Ground and underground water protection measures*	315
8.3	Storing and handling hazardous materials measures	316
8.4	Measures to be taken in case of accident	317
8.5	Protection measures during the construction (civil works)	323
8.6	Protection measures for archaeological site Viminacium	323
8.7	Noise protection measures	324
9.	**PROGRAM OF ENVIRONMENTAL INFLUENCES MONITORING**	326
9.1	Purpose and aim of environmental monitoring	326
9.2	Determining the environment status before the functioning of the project	326
10.	**NON-TECHNICAL SUMMARY OF THE ENVIRONMENTAL MPACT ASSESSMENT STUDY**	331
11.	**DATA ON TECHNICAL DEFECTS**	332

APPENDICES

APPENDIX 01:	LAYOUT OF UNIT B3 FACILITIES AT THE TPP KOSTOLAC B
APPENDIX 02:	PROCESS FLOW DIAGRAM OF UNIT B3 AT THE TPP KOSTOLAC B
APPENDIX 03:	UNIT B3 EQUIPMENT LAYOUT– TPP KOSTOLAC B
APPENDIX 03-01:	FACILITIES OF THE MAIN TECHNOLOGICAL SYSTEM OF UNIT B3 AT TPP KOSTOLAC B
APPENDIX 04:	LAYOUT OF EXTERNAL PIPE CONNECTIONS OF THE WASTE WATER TREATMENT PLANT
APPENDIX 05:	SPATIAL PLAN OF SPECIAL PURPOSE – GYMPSUM TRANSPORT CORRIDOR
APPENDIX 06:	EXTERNAL TRANSPORT AND DISPOSAL OF ASH, SLAG AND GYPSUM INTO OCM DRMNO INCL. THE LANDFILL
APPENDIX 07:	CROSS SECTIONS OF THE DISPOSAL CASETTE
APPENDIX 08:	C&I EQUIPMENT LAYOUT INCL. CONTROL ROOMS LAYOUT
APPENDIX 09:	BLOCK DIAGRAM OF SUPERVISORY CONTROL SYSTEM OF AUXILIARY FACILITIES AND SYSTEM
APPENDIX 10:	BLOCK DIAGRAM OF THE UNIT SUPERVISORY CONTROL SYSTEM
APPENDIX 11:	SEWAGE NETWORK LAYOUT

0.3 DOCUMENTATION PREPARATION PARTICIPANTS

Design documentation:

INVESTOR:	**PUBLIC ENTEPRISE ELECTRIC POWER INDUSTRY OF SERBIA, BELGRADE**
FACILITY:	**TPP KOSTOLAC B, UNIT B3**
TYPE OF DOCUMENTATION:	**ENVIRONMENTAL IMPACT ASSESSMENT STUDY**

prepared by Energoprojekt Entel, a joint stock company for design, consulting and engineering services in the areas of energy, water, telecommunications and environmental protection, Belgrade, under the contract No. 23-EN/15. Preparation participants are listed below:

HEAD OF PROJECT /	Dragan Mitrovic, B. Mech. Eng.
RESPONSIBLE DESIGNER:	333 2999 03

PROJECT QUALITY MANAGER:	Miodrag Simikic, B. Mech. Eng.
	330 2975 03

RESPONSIBLE DESIGNER:	Djordjina Milovanovic, M.Sc. El. Eng.

DESIGNERS:	Djordjina Milovanovic, M.Sc. El. Eng.
	Ana Mitic, M.A. Env. Protection Biljana Mijuskovic, B.Eng. Forestry Zorana Zivkovic, B. Chem. Eng. Danila Vojnovic, M.Sc. Chem. Eng. Dragan Mitrovic, B. Mech. Eng. Svetlana Kovacevic, B. Mech. Eng. Mirjana Pekovic, B.El.Eng. Anja Todorovic, B.Civ.Eng.

INTERNAL AUDITOR:	Dr Sanja Petrovic Becirovic, Sc. D. Mech. Eng.

0.4 DECISION APPOINTING THE RESPONSIBLE DESIGNER AND INTERNAL CONTROLLER

<square filing seal>
AKCIONARSKO DRUŠTVO
ENERGOPROJEKT ENTEL
Br. 180
01. 07. 2015. god
BEOGRAD

Pursuant to Article 128a of the Planning and Construction Law (Official Gazette RS, No. 72/09, 81/09, 24/11, 121/12, 132/14 and 145/14) and the Regulation stipulating the content, development method and procedure and technical documentation audit according to facility class and purpose (Official Gazette RS, No. 23/15) for the development of the Environmental Impact Assessment Study for the Construction of the TPP Kostolac B Flue Gas Desulphurization Plant, cadastral lots: 303, CM Kostolac Village, Municipality of Pozarevac, the following persons are appointed:

RESPONSIBLE DESIGNER

Djordjina Milovanovic, M.Sc. El. Eng.	

INTERNAL AUDITOR

Dr Sanja Petrovic Becirovic, Sc. D. Mech. Eng.	

DESIGNER:	**ENERGOPROJEKT ENTEL a.d. Beograd**
RESPOINSIBLE PERSON:	**Mladen Simovic, B.Mech.Eng.**
<seal> ENERGOPROJEKT ENTEL a.d. BEOGRAD	<signature>
DOCUMENTATION LABEL:	**S15011**
PLACE AND DATE:	**BELGRADE, JULY 2015**

0.5 LIST OF DOCUMENTS ABOUT THE LEGAL PERSON – DOCUMENTATION DEVELOPER

DOCUMENT:	Copy of company registration
INSTITUTION:	Business Registers Agency
CODE AND DATE:	MB 07470975, 21.09.2015.

DOCUMENT:	Decision determining the compliance with technical documentation development conditions
INSTITUTION:	Ministry of Construction, Transport and Infrastructure
CODE AND DATE:	351-02-01630/2014-07, 15.01.2016.

DOCUMENT:	Decision determining the compliance with the conditions necessary to perform fire protection improvement activities
INSTITUTION:	Ministry of Interior Affairs, Fire Police Directorate
CODE AND DATE:	217-142/02, 23.02.2002.

DOCUMENT:	Certificate of approval for management systems according to standards SRPS ISO 9001:2008 (QMS), SRPS ISO 14001:2005 (EMS) and SRPS OHSAS 18001:2008
INSTITUTION:	Lloyd’s Register Quality Assurance
CODE AND DATE:	PIR0368507, 29.12.2013.

DOCUMENT:	Certificate of approval for management systems according to the standard ISO 50001:2011 (EnMS)
INSTITUTION:	Lloyd’s Register Quality Assurance
CODE AND DATE:	PIR0368507/C, 27.12.2013.

DOCUMENT:	Certificate of approval for management systems according to the standard ISO 27001:2013 (ISMS)
INSTITUTION:	Lloyd’s Register Quality Assurance
CODE AND DATE:	BEO0368507/D, 30.10.2015.

0.6 LIST OF DOCUMENTATION USED

1. Technical specification of CMEC for the Unit B3 (350 MW) Building Permit Design development at the site of the TPP Kostolac B
2. Conceptual solution for the Construction of the 350 MW Unit B3 at the Site of the TPP Kostolac B, Energoprojekt Entel, Beograd, December 2016
3. Feasibility Study with the Preliminary Design – Construction of the 350 MW Unit B3 at the site of the TPP Kostolac B, Energoprojekt Entel, Beograd, November 2013
4. Preliminary Fire Protection Design for the 350 MW Unit B3 at the site of the TPP Kostolac B, Energoprojekt Entel, Beograd, November 2013
5. Preliminary Design of the Amended External Ash, Slag and Gypsum Transport System from Unit B3 at the site of the TPP Kostolac B, Energoprojekt Entel and Mining Institute, Belgrade, February 2016
6. Preliminary Design of the Ash, Slag and Gypsum Landfill from Unit B3 at the site of the Kostolac B – OCM Drmno, Energoprojekt Entel and Mining Institute, Belgrade, February 2016
7. Preliminary Design of the Third Coal Yard Line for Unit B3 Coal Transport at the site of the TPP Kostolac B, Energoprojekt Entel and Mining Institute, Belgrade, February 2016
8. Environmental Impact Assessment Study for the Construction of Unit B3 at the site of the TPP Kostolac B, Faculty of Mechanical Engineering, University of Belgrade, 2013
9. PE EPS Seveso Plant Safety Report, TEKO Kostolac Branch, TPP Kostolac B, EKO TOK doo, Belgrade, January 2016
10. Spatial Plan of the Special Purpose Area – Kostolac Coal Basin, 2012
11. Report on the Strategic Environmental Impact Assessment for the Spatial Plan of the Special Purpose Area – Kostolac Coal Basin, 2012
12. Reports on periodical measurements of pollutants air emission for the TPP Kostolac B stack, 2010-2015, Mining Institute, Belgrade, 2015
13. Reports on continuous pollutants air emission measurements from the TPP Kostolac B stack, 2010-2015, TPP Kostolac B
14. Reports on imission measurements around the TPP Kostolac B, 2010-2015, Pozarevac Public Health Institute
15. TEKO Kostolac Environmental Report for 2012, 2013, 2014 and 2015, TPP Kostolac B
16. Noise Measurement Report for 2012, 2013 and 201, Pozarevac Public Health Institute
17. Analysis of the health status of the Branicevo District population for 2012, 2013 and 2014, Pozarevac Public Health Institute
18. Transboundary particulate matter, photo-oxidants, acidifying and eutrophying components, EMEP Status Report 2015.
19. Updated Preliminary Design incl. Feasibility Study of the Drmno Open Cast Mine Expansion for the capacity of $9x10^6$ tons p.a., Volume II: Environmental Impact Assessment Analysis of the Drmno Open Cast Mine, Faculty of Mining, University of Belgrade, 2010
20. Birds and Bats Survey for the Kostolac Wind Farm Development Project, Final Report, Netinvest and Fauna C&M, November 2015
21. EuropeAid/137116/IH/WKS/RS: Construction and Commissioning of Waste Water Treatment Plant at TPP Kostolac B, Volume 3 – Employer’s Requirements
22. Feasibility Study incl. Preliminary Design of the TPP Kostolac B (Existing Units B1 and B2 and New Unit B3) Wastewater Treatment, Energoprojekt Hidroinzenjering, Beograd, 2013.
23. Dejan Hrvić, Momčilo Petrović, Vojin Kostić: Measurements of Electric Field Strength and Magnetic Induction under Overhead High Voltage Power Lines, UDK: 621.317.42: 621.317.32, BIBLID:0350-8528(2008-2009),19.p. 237-247

TEXTUAL DOCUMENTATION

1. INTRODUCTION

1.1 Obligation, objective and purpose of study development

According to the Planning and Construction Law (Off. Gazette RS No. 72/2009, 81/2009 and 24/2011, 145/14) for thermal power plants larger than 10 MW , building permit is issued by the Ministry in charge of construction (under Article 133 of the Law), based on the Building Permit Design and accompanying documentation, which, *inter alia*, contains the environmental impact assessment.

Special document outlines the list of projects/facilities for which the environmental impact assessment is mandatory (List I of the Regulation establishing the list of projects for which an environmental impact assessment is mandatory and projects for which an environmental impact assessment may be required, Off. Gazette RS, No. 114/2008). Facilities generating electricity, with the capacity over 50 MW are on List I. Consequently, an environmental impact assessment is required for the latter.

Environmental Impact Assessment Law (Off. Gazette No. 135/04, 36/09), stipulates the environmental impact assessment procedure for projects with potential substantial environmental impacts, comprising:

- Defining the content of the environmental impact assessment study by the competent authority, following a request submitted by the Investor,
- Implementation of the stakeholder engagement process during all stages of the Study,
- Cross-border notification for projects with potential substantial environmental impacts on another country by the competent authority,
- Implementation of the study development and approval procedure, resulting in approval or rejection of the study by the competent authority,
- Monitoring and other issues essential to assess the project's environmental impact.

In line with the above, the Environmental Impact Assessment Study for the construction of the new unit - TPP Kostolac B3 (hereinafter referred to as “the Study”), was prepared according to the above laws, as well as in accordance with the Regulation stipulating the content of the environmental impact assessment study (Off. Gazette RS No. 69/05) and the Decision stipulating the scope and content which has been obtained from the relevant Ministry.

1.2 Preliminary project considerations

To ensure further development and construction of the Serbian power system, PE Electric Power Industry of Serbia (as one of the ways to cover the forecasted electricity demand) analysed the possibility and feasibility of expanding a thermal power capacity at the existing location of the TPP Kostolac B, by building a new, state-of-the-art unit with the best parameters under available conditions and location limitations.

Under the basic concept outlined in the Drmno Open Cast Mine Investment Program, construction of a thermal power capacity in two phases at the location of the TPP Kostolac B was envisaged. Phase I included 2x350 MW units, with an area secured and infrastructure developed for generation capacity increase at the same location, implying the construction of new units (at the time, two more 350 MW units).

In Electric Power Industry of Serbia's view, feasibility of Unit B3 construction was considered based on the economic analysis results, determining energy effects of its operation at the power system level. This analysis was informed by the data on forecasted demand and loads of the Serbian power system in the future on the one hand, and possibility of the available generation capacities meeting the said demand, on the other hand, taking into account current new build and decommissioning plans. This methodology allows for the calculations to take into account different technical features and generation capabilities of the considered thermal and hydro power plants.

Phase II of the TPP Kostolac B construction began in 2009-2010, by developing the documentation entitled “Preliminary Design for the Construction of a New Thermal Power Facility utilising the Open Cast Mine Drmno Coal” (Energoprojekt ENTEL, Mining Institute). Integral analysis of all aspects covered by previous activities resulted in a conclusion that in Phase II, TPP Kostolac B can build a unit of up to 600 MW. In view of this, between 2011 and 2012 a “Pre-Feasibility Study with the General Design for the Construction of the New Unit B3 at the Site of the TPP Kostolac B” was prepared (Energoprojekt ENTEL, Mining Institute). This documentation considered two Unit B3 capacity variants, 350 MW and 600 MW.

Following the power analysis results, the construction of Unit B3 of 350 MW was suggested, to cover the base part of the load diagram, with an average annual engagement of 7,500 effective operating hours. For this project, the next stage of technical documentation was carried out – “Feasibility Study and Preliminary Design” (Energoprojekt ENTEL, Mining Institute, 2013), including the Environmental Impact Assessment (Faculty of Mechanical Engineering and Faculty of Mining and Geology, University of Belgrade, 2013).

Decision issuing the location permit, No. 350-01-01132/2013-05 dated 23.12.2013 was obtained for the designed Unit B3, by the Ministry of Construction, Transport and Infrastructure, as well as special conditions and opinions of other competent institutions.

The environmental impact assessment study for the Unit B3 construction project, informed by the above technical documentation (Feasibility Study and Preliminary Design) was approved on 30 December 2013 by the Ministry of Energy, Development and Environment, for a period of two years.

Bearing in mind that the validity of the Decision issuing the location permit and the Decision approving the environmental impact assessment study for the Unit B3 construction project expires after 2 years, and that the construction has still not started, Electric Power Industry of Serbia has carried out the location permit extension procedure. As a result, a new Decision issuing the location permit was obtained, No. 350-01-00917/2015-14 dated 13 August 2015, setting out the conditions required for the development of technical documentation for obtaining a building permit, with possible phased construction of Unit B3. (Appendix 1).

On the other hand, on the basis of the *Intergovernmental Agreement on Economic and Technical Cooperation in the Field of Infrastructure*, concluded between the Peoples’ Republic of China and the Republic of Serbia, in 2010 a Framework Contract Agreement was signed with the Chinese company CMEC (China Machinery Engineering Corporation) to implement the package project at the company *Termoelektrane i Kopovi Kostolac*.

Phase I of this package project involved the revitalization of Unit B1, construction of Units B1 and B3 desulphurization plant, a port on the Danube River, a road and a railway. A separate contract was signed for Phase I and its implementation is in its final stage.

Phase II of the Package Project Kostolac B Power Plant involves the construction of a new unit B3 (350 MW) and production capacity expansion of the Drmno open cast mine from 9 to 12 million tons per year.

In view of the above, to facilitate the implementation of Phase II of the Contract Agreement, in November 2013, EPS signed a Contract Agreement for the construction of Unit B3 with the Chinese company - China Machinery Engineering Corporation (CMEC). The contract agreement became effective in January 2015.

Meanwhile, CMEC, in accordance with applicable regulations of Serbia, started preparing a Building Permit Design, according to the technical specification, which is part of the contract agreement. Accordingly, the technical solutions described in the 2013 Preliminary Design were amended. Similarly, the current Unit B3 construction design includes an expansion of the coal yard by developing a third coal yard line and a coal crushing plant to meet the needs of the new unit.

The above amendments are subject of the updated technical documentation for the Unit B3 construction project (Conceptual Solution and Preliminary Design), which also resulted in the need to re-implement the environmental impact assessment procedure. Due to the above, EPS, as the project developer, addressed the competent Ministry requesting the scope and content of the environmental impact assessment study for the construction of Unit B3 at the site of the TPP Kostolac, on cadastral lot 303 CM Kostolac-Village (application No. 353- 02-00798/2016-16 date 14 April 2016). The decision stipulating the scope and content of the Environmental Impact Assessment Study, No. 353-02-00798/ 016-16 dated 22 August 2016, was issued by the Ministry of Agriculture and Environment, Appendix 2.

Documentation inputs for the Study are given under the General Documentation, Part 0-3 Design Documentation Development Inputs.

1.3 Project developer data

Investor and project developer of the new 350 MW Unit B3 at the site of the TPP Kostolac B is the Public Enterprise Electric Power Industry of Serbia, Belgrade.

Basic data about the project developer are listed below:

Full name:	Public Enterprise Electric Power Industry of Serbia
Incorporation:	Serbian Government Decision dated 1 July 2005
Ownership structure:	100% owned by the Republic of Serbia
Registration:	Decision by the Business Registers Agency of the Republic of Serbia BD 80380/2005
Identification number:	20053658
TIN:	103920327
Activity:	• Electricity trade • Coal production • Electricity generation • Electricity distribution
Address:	Carice Milice br. 2, 11000 Beograd
Phone number and e-mail:	Phone: + 381 11 202 46 00 Fax: + 381 11 262 71 60 e-mail: milorad.grcic@eps.rs

Cadastral lots covered by the Project for which the Environmental Impact Assessment Study is being prepared are as follows:

Municipality of Pozarevac, CM Kostolac – Village: **Cad. lot No. 303.**

City Municipality of Kostolac, CM Kostolac Village: **Cad. lot No. 2120.**

City of Pozarevac, CM Drmno: **Cad. lot No. 99/1, 100, 102, 104, 651, 655, 659, 660, 667, 671, 672, 673, 678, 679, 680, 681, 683, 684, 685, 686, 687, 691, 692, 694, 695, 696, 697, 698, 699/1, 700, 701, 702, 703, 705, 706, 707, 709, 1394.**

City of Pozarevac, CM Drmno: **Cad. lot No. 49, 50, 51, 52, 53, 54, 55, 56, 57, 58, 59, 60, 61, 62, 63, 64, 65, 66, 98, 111, 186, 187, 188, 189, 192, 193, 194, 195, 196, 197, 198, 199, 200, 201, 239, 240, 241, 242, 243, 244, 245, 246, 250, 251, 285, 286, 287, 288, 289, 495, 496, 507, 513, 515, 519, 759, 760, 762, 763, 764, 765, 766, 789, 821/1, 821/6, 821/9.**

City of Pozarevac, CM Drmno**: Cad. lot No. 294_1, 295_1, 296_1, 297_1, 298_1, 299_1, 300_1, 301_1, 302_1, 303_1, 304_1, 305_1, 306_1, 307_1, 308_1, 309_1, 310_1, $311/1_1$, 523_1, 2917_1.**

City of Pozarevac, CM Klicevac**: Cad. lot No. 408_2, 420_2, 421_2, 557_2, 558_2, 558_2, 559_2, 560_2, 561_2, 562_2, 563_2, 564_2, 565_2, 565_2, 566_2, 567_2, 567_2, 568_2, 569_2, 570_2, 571_2, 572_2, 573_2, 574_2, 575_2, 594_2, 595_2, 596_2, 603_2, 604_2, 605_{12}, 606_1, 607_1, 608_1, 609_2, 610_2, 611_2, 612_2, 613_2, 614_2, 615_2, 616_2, 617_2, 618_2, 619_2, 620_2, 621_2, 622_2, 623_1, 624_1, $639/1_1$, $639/2_1$, 640_1, $641/1_1$, $641/2_1$, 642_1, 643_1, 644_1, 645_1, 646_1, 647_1, 648_1, 649_1, 650_1, 651_1, 652_1, 653_{12}, 654_{12}, 655_{12}, 656_1, 657_1, 658_1, 659_1, 660_1, 661_1, 662_1, 663_1, 664_1, 665_1, 666_1, 667_1, 667_1, 668_1, 669_1, 670_1, 671_1, 672_1, 675_1, $676/1_1$, $676/2_2$, 677_1, $678/1_1$, $678/2_1$, 679_1, 680_1, 681_1, 682_1, 683_1, 684_1, 685_1, 686_1, 687_1, 688_1, 1528_{12}, 1540_2, 1576_2, 1577_2, 1578_{12}, 1579_{12}, 1580_{12}, 1518_{12}, 1582_1, 1602_1.**

2. DESCRIPTION OF THE PLANNED PROJECT LOCATION

2.1 Project location

TPP Kostolac B is located near the village and open cast mine Drmno and archaeological site Viminacium. Thermal power plant location belongs to the Municipality of Pozarevac in the Branicevo District. It is some 60 km away from Belgrade in the east-southeast direction, while it is some 11 km away from the city of Pozarevac. Furthermore, it is 2.5 km away from the Danube. The largest town in the vicinity of the thermal power plant is the town of Pozarevac with about 75,000 inhabitants (metropolitan area). Figure 2.1-1 shows the geographical position of the TPP Kostolac B.

Figure 2.1-1: Geographical position of the TPP Kostolac B

2.2 Exploration area

The actual exploration area may be considered from a broad and narrow perspective, subject to the types of impacts to be analysed by this Study. The area of interest for understanding the natural characteristics (general geology, hydrogeology, climate, hydrology), as well as the potential environmental impact of the project is the so-called area of the Kostolac mining and energy basin. Analysed technological process as well as natural terrain features (geological features, hydrological regime influenced by mining operations) indicate that the potential environmental impacts may occur within the area stretching north of Pozarevac, towards the Danube, which from a morphological perspective is a limited plateau with 2 horsts (Pozarevacka Greda due west and Bozevacka Kosa due east). Position of the exploration area is shown on Figure 2.2-1.

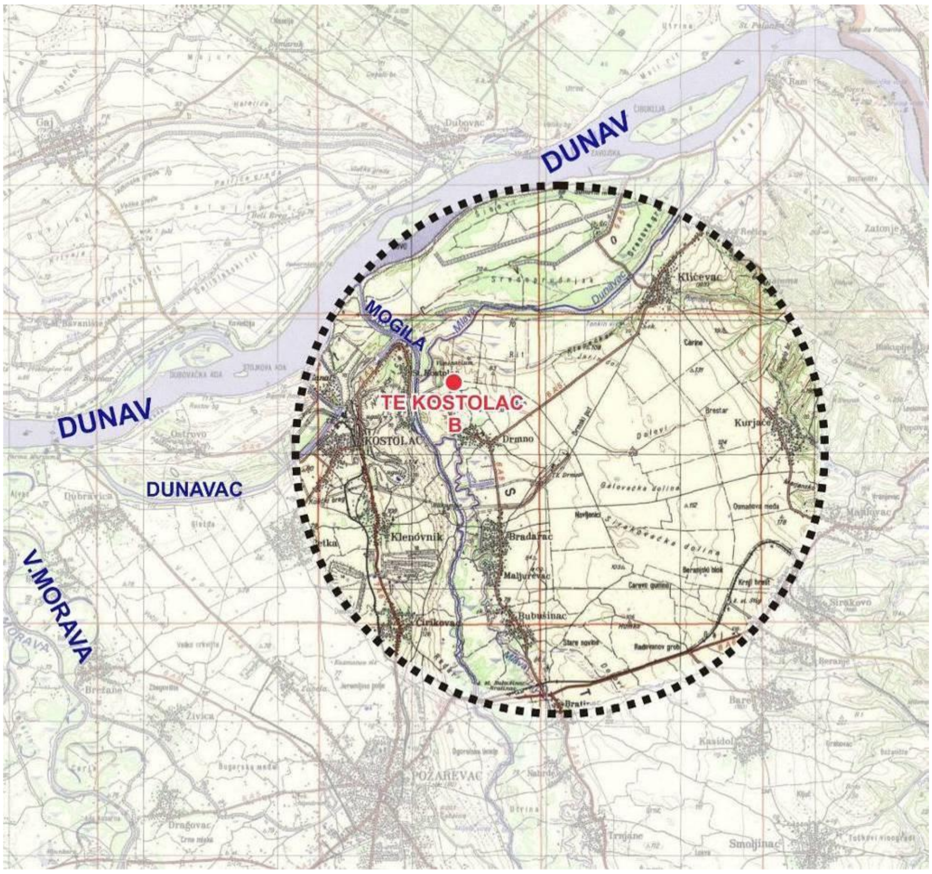


Figure 2.2-1: Exploration area

From a narrow perspective, the exploration area is the area of the TPP Kostolac or part of the associated enclosed thermal power plant area, covering some 1.7 hectares, where development of the future flue gas desulphurization plant is planned (Figure 2.2-2). The study also analysed the dislocated parts of the future facilities planned for FGD gypsum disposal and the third coal yard line.

From a broader perspective, the exploration area includes the area influenced by the plant. Given the nature of possible impacts, flue gases have the most far reaching impact. Impact assessments were performed by modelling the diffusion of pollutants in the atmosphere, in the area of 50 x 50 km, where TPP Kostolac B is located in the center of the square (Figure 2.2-3).

When it comes to potential project impacts on territories of neighbouring countries, it should be noted that the new unit is located some 15 km away due east and northeast from the border with the Republic of Romania.

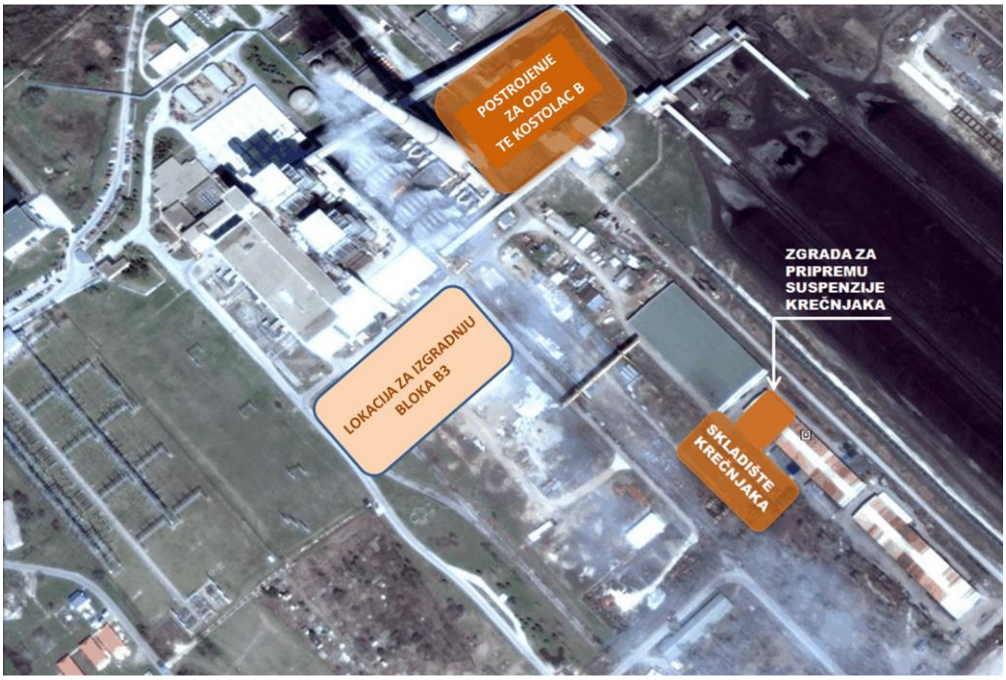


Figure 2.2-2: Area inside the TPP Kostolac B location planned for Unit B3 construction

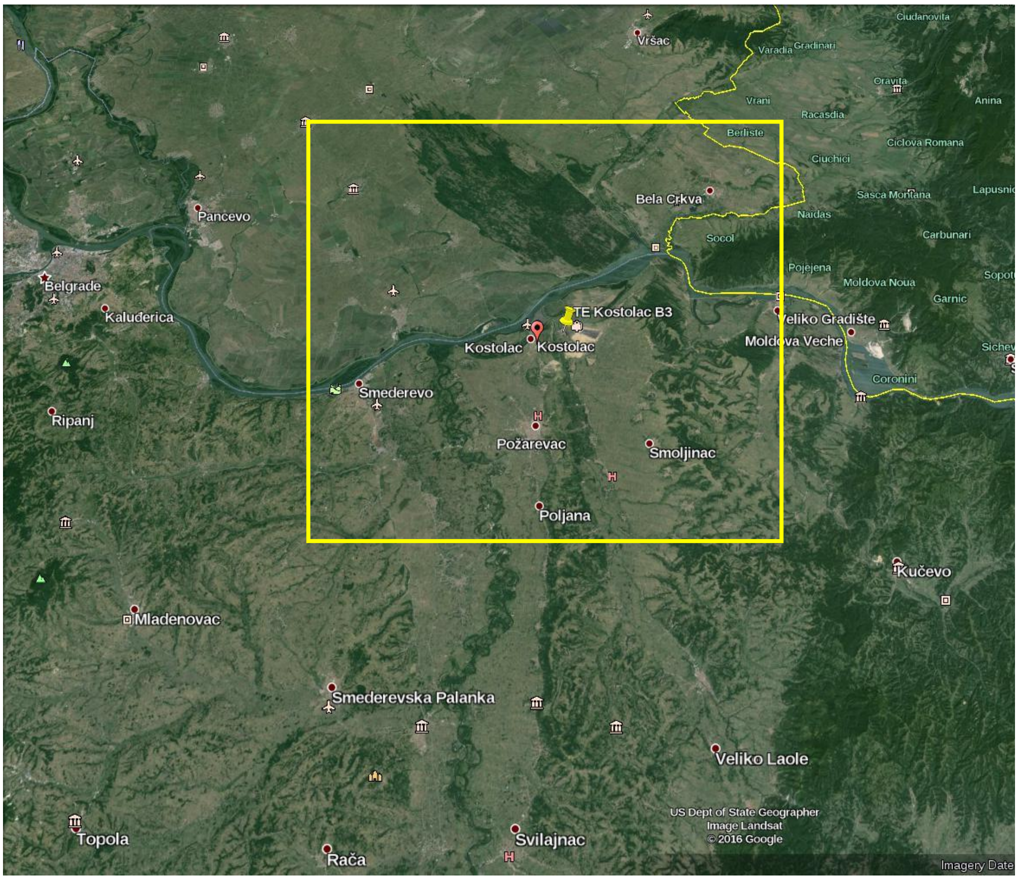


Figure 2.2-3: Area covered by air pollution modelling

2.3 Compliance of the project with the spatial – planning documentation

The Spatial Plan of the Republic of Serbia defines the Kostolac Basin area (including energy and mining facilities) as an area of special purpose.

The Assembly of Pozarevac made a Decision adopting and implementing the spatial plan for the TPP Drmno on 28 September 1982 (Off. Gazette of the Municipality Pozarevac, No.13/82). Furthermore, it also adopted a Decision implementing the Spatial Plan for the TPP Drmno area on 31 October 2006, stipulating that the Spatial Plan of the TPP Drmno (Off. Gazette of the Municipality Pozarevac, No.13/82) remains fully valid.

The Serbian Government adopted a Decree establishing the Spatial Plan for the Special Purpose Area of the Kostolac Mining Basin (SPSP), published in the Official Gazette RS, No. 1/13. SPSP for the Kostolac Mining Basin establishes the basic concept of development, utilization, organization, planning and improvement of the area for the period until 2022.

The above spatial plan envisages the construction of a new Unit B3 at the TPP Kostolac B, after Unit B2, with the capacity of up to 600 MW and supercritical steam parameters, and its commissioning from 2019/2020. It also anticipates capacity increase of the mine, to the coal production of 12 million tons annually. Location of the future ash, slag and gypsum landfill from the new unit is inside the area of the open cast mine Drmno, which needs to be aligned with overburden removal and dumping.

Available free bays at the Drmno 400 kV switchyard provide good conditions to connect the new unit to this facility.

2.4 Geomorphological characteristics of the terrain

From a geomorphological perspective, the Kostolac Basin area is influenced by a number of factors, while natural conditions have changed significantly over time due to energy facilities and their regular operation. More broadly, the Kostolac Basin is a lowland area, containing low terraced hills. Prominent plains are Stig, Danube (riparian area belonging to Kostolac along the Danube) and lower Pomoravlje, including two horsts: Pozarevacka Greda and Bozevacka Kosa.

Stig is a fertile plain with terrain elevations mostly below 100 m.a.s.l. It stretches between Pozarevacka Greda and Bozevacka Kosa. It is the broadest inside the zone around rivers Mlava and Mogila, where it is up to 10 km wide. Over Klepacka Kosa it transitions into the Dunavac and Danube alluvium. Lowlands may also be found west of the Pozarevacka Greda, with terrain elevations below 100 m, whose northern part towards the Danube belongs to the Danube region, while its southern most part to the Morava River (Figure 2.4-1).

Pomoravlje is a wider plain that lies between the Velika Morava River in the west, Pozarevacka Greda in the east and the Danube estuary in the north.

Danube region covers the alluvial plain of the Danube which was once flooded and is now protected by an embankment.

Pozarevacka Greda (its western horst) is located in the central part of the area. It is a branch of the Carpathian Mountains, extending in the north-south direction from Svilajnac in the south until the Danube near Drmno in the north. Prominent features of this horst are the Lester Heights, east of Kostolac (175 m), and Cacalica (200 m) on the eastern edge of the town of Pozarevac.

Figure 2.4-1: Basic geomorphological elements inside the considered area
(Based on GoogleEarth image)

Bozevacka Kosa (its eastern horst) is located in the east area, representing an eastern boundary of the Kostolac Mining Basin. From the villages of Klicevac and Recice, it gradually rises and stretches to the south towards a wider hilly area. Erosion has cut several (mostly in loess) larger and smaller gullies (cuts) along the horsts with sub-vertical sides, up to 20 m high.

Long-term surface coal mining in the area of the Kostolac Mining Basin, development of industrial and power facilities, as well as landfills of various materials, have altered the existing terrain morphology. Figure 2.4-2 shows the location of the Kostolac A and B thermal power plants, open cast mines (OCM) Drmno, Klenovnik and Cirikovac with associated overburden, slag and ash landfills.

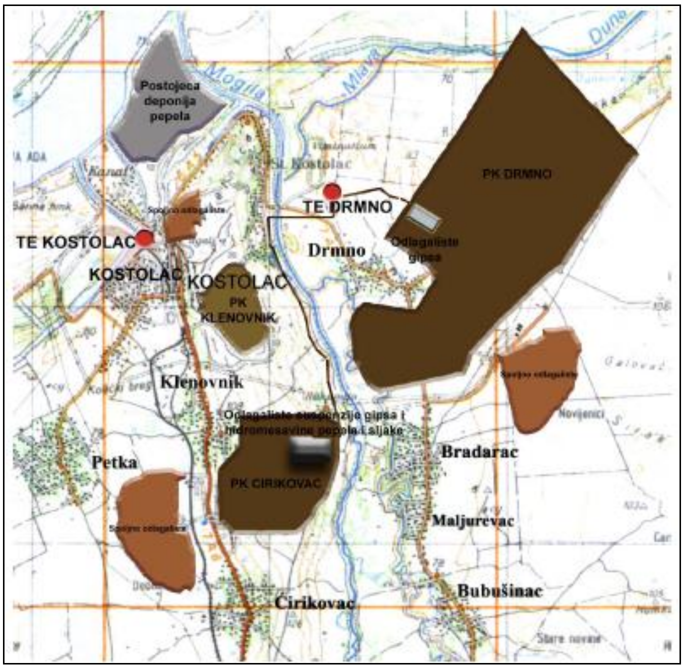


Figure 2.4-2: Map man-made morphological forms created by the mine and power plant operation

Relief variations are similar in the Stig plain, south and east of the OCM Drmno and overburden dump. Outside overburden dump inside the OCM Drmno is shown on Figure 2.4-3.

Figure 2.4-3: Outside overburden dump inside the OCM Drmno

In addition, the terrain inside the Velika Morava River area, and partly inside the Mlava River area (as typical lowland rivers which have often changed their beds in the past, making a large number of islands), is morphologically altered as a result of riverbed regulation works due to power plant construction and gravel extraction.

2.5 Hydrological characteristics of the terrain

Hydrographic network in the Kostolac Mining Basin is highly developed, including the Danube with the Dunavac and Velika Morava and Mlava tributaries (Figure 2.5-1).

The Danube inside the Kostolac area is 1200 m wide. It contains several islands: Dubovska Ada, Ada Stojkova, Zilovo, Cibuklija, Zavojska and the longest branch – Little Danube or Dunavac. The depth of the Danube bed ranges from 7 to 17 m. After the construction of the Djerdap HPP, the Danube level has raised, its depth increased, while its water level now ranges from 69.5 to 70 m. A dike system was developed along the Danube, to protect its riparian area from floods. Its average annual flow is 5,490 m^3/s with the specific discharge up to 10.4 l/s per square kilometre.

Dunavac (or Little Danube) extends from Dubravica to Recica, along a stretch of some 24 km. Ada Ostrovo and the village of the same name are located between Dunavac the Danube. In recent literature, Little Danube is also called Dunavac, and it is divided into the Upper, Middle and Lower sections (Figure 2.5-2).

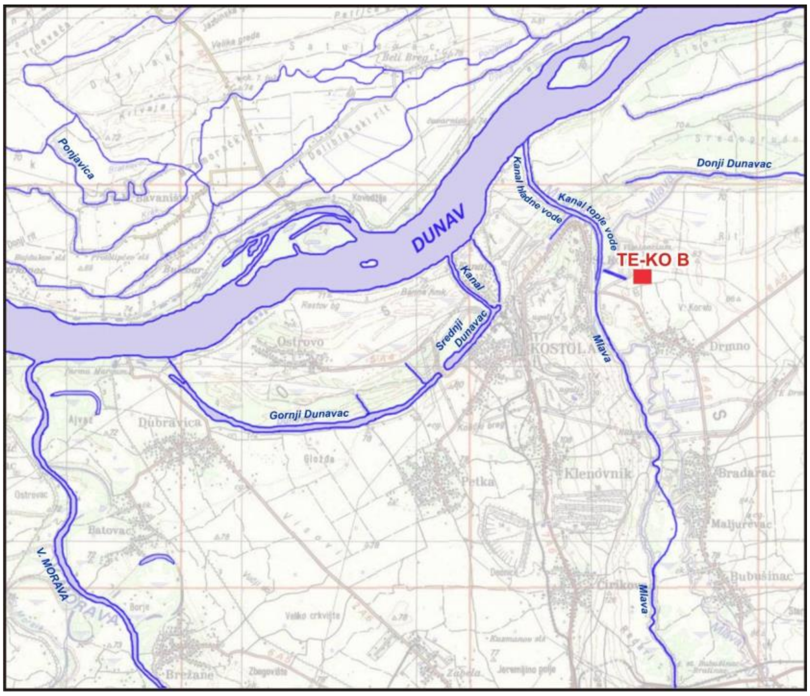


Figure 2.5-1: Hydrographic map of the wider exploration area

Figure 2.5-2: Danube watercourse inside the ash landfill and TPP Kostolac B area

Upper Dunavac (Pecanski Dunavac) with a length of 8 km, is separated from the Danube and Middle Dunavac by dikes. Water regime in the Upper Dunavac is regulated by the pumping station and is maintained at a level 67.20 m.

Middle Dunavac with a length of 1700 m is connected by a channel (also 1700 m long) with the Danube, influencing its water level. Figure 2.5-3 shows the Lower and Middle Dunavac.

Figure 2.5-3: View of Dunavac from the dike separating it to its Upper and Middle sections

Lower Dunavac | **Middle Dunavac and Kostolac power plants in the background**

Lower Dunavac, from the mouth of the Mlava River to the village of Klicevac, it is practically dry at low water levels, along a 12 km long section. Its bed serves to receive surface and ground water from the surrounding terrain, while its level is regulated by a pumping station near a place called Ram.

Mlava is the second largest river inside the explored area. It is formed from a strong Zagubica Spring, located at some 325 m above sea level, joining the Danube some 78 km after its source. East of Pozarevac, left arm called Orlovaca separates from the Mlava River, also called Mogila downstream. Mlava River is now regulated downstream from Petrovac. The new bed joins the Danube near the TPP Kostolac B (Figures 2.5-4 and 2.5-5). A protective dam was built on the right bank, which is part of the protection system against the Danube.

Figure 2.5-4: TPP Kostolac B position compared to the old and new Mlava River course

Figure 2.5-5: Mlava River

Several hundred metres upstream of the thermal power plant | ***Topla Mlava*, after hot water discharge**

Mlava belongs to the rivers with a rain-snow regime of mild continental variant. Its confluence mostly belongs to a highland area characterized by watercourses with relatively large longitudinal falls. In the catchment area, upstream of Gornjak, all watercourses are characterized by very large differences between extremely high and low water levels. Thus, in some watercourses, the ratio of Q_{max} and Q_{min} reaches the value of one thousand. At the farthest downstream section (Mogila), comprising 1,749 km^2 or 96% of the territory Mlava Basin, average annual flow is 12.9 m^3/s.

Cold and hot water channels - TPP Kostolac B uses large amounts of cooling water from the Danube (2 x 25.650 m^3/h) per unit, making a total of 51.300 (Figure 2.5-6).

Figure 2.5-6: Cold water channel

After cooling, this water (return cooling water channel) is discharged into the Mlava River via a pipeline system (Figure 2.5-7). The discharged water is hot, increasing the Mlava River temperature, which along this section, becomes the habitat of numerous species of fish and aquatic organisms in the winter months.

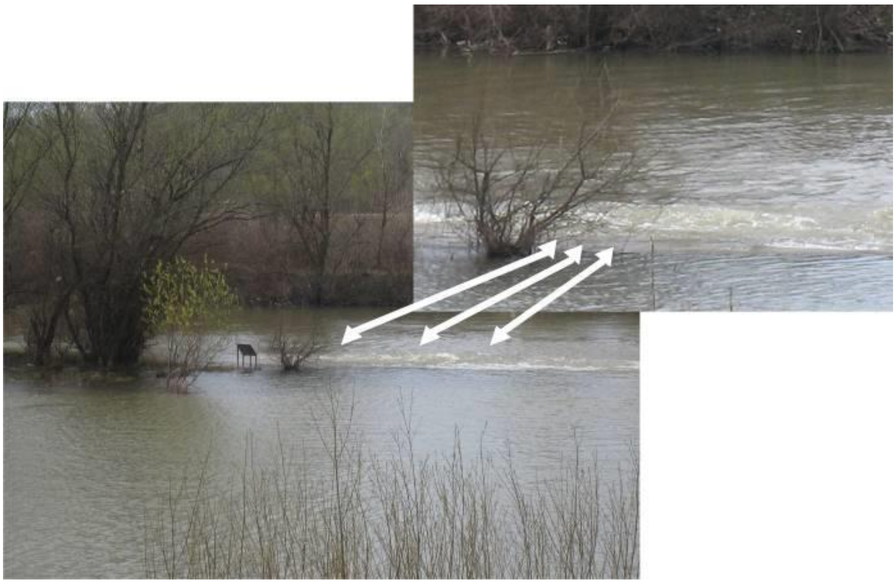


Figure 2.5-7: Mlava River inside the TPP Kostolac B area hot water discharge point from the pipeline

Velika Morava is a typical lowland river, formed near Stalac from South and West Morava, flowing into the Danube near the village of Dubravica, at 66.6 m.a.s.l. Prior to riverbed regulation and dike development it often overflowed, changed its course, thus making a large number of islands and oxbows. Velika Morava basin covers an area of 37.444 km^2, with a mean annual flow of 257 m^3/s and specific discharge up to 6.7 l/s/km^2. The minimum and maximum flow rates are 25 m^3/s and 2,350 m^3/s, respectively. Nowadays, Velika Morava watercourse has a serious problem with siltation (on average some 8.735 x 10^3 tons per year) and emergence of high groundwater levels.

2.6 Geological characteristics of the terrain

TPP Kostolac B is located inside the Kostolac Mining Basin in the south-eastern part of the area. In the narrow sense, it includes the Municipality of Pozarevac area. In the broad sense, it covers an area between the Morava River in the west, Golubarske Mountains to the east, the Danube in the north and Resava River and the town of Svilajnac in the south, covering an area of some 400 km^2.

The Kostolac Mining Basin terrain comprises the sediments of Tertiary and Quaternary age. Most important explorations into the geological characteristics of the considered area are related to coal. Figure 2.6-1 presents the reference geological column of the terrain, while Figure 2.6-2 shows its geological map. Below is a brief description of the main lithological units making up the explored terrain.

Pannon (M31) - The presence of sediments of the Pannonian age on the surface of the Drmno deposit and its immediate surroundings has not been ascertained. However, based on paleontological core tests from boreholes in the western and eastern part of the Kostolac Mining Basin, sediments of the Pannonian age were identified. Pannonian sediments are built of clay, marl, sand, alevrites, gravel, clay and coal.

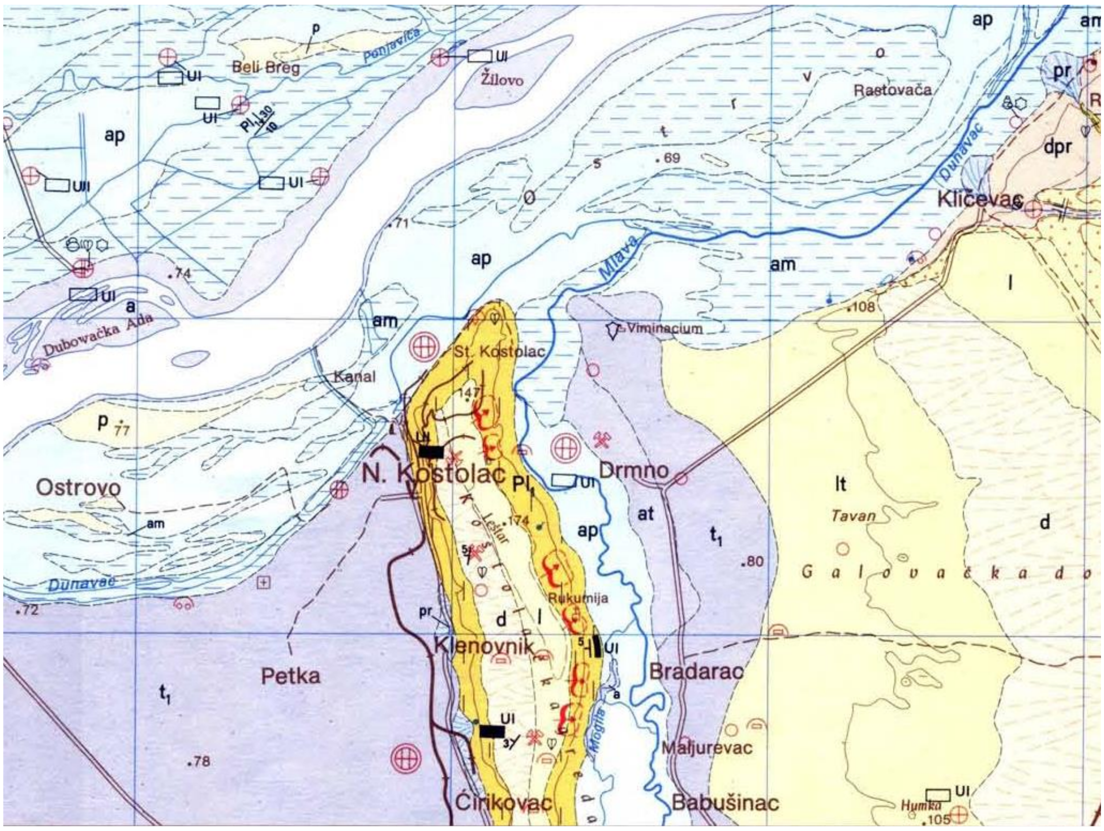
Pontian (M32): Pontian sediments inside the exploration area extend continuously after the Pannonian sediments. Due to large lithological similarities (clay-sand sediments) and absence of paleontological material, their boundaries cannot be ascertained, i.e. their vertical distribution. Pontian layers include formations of Lower Pontian (1M32) (clay-sand series) and Upper Pontian (2M32) (clay series with three coal layers).

Lower Pliocene (Roman) (Pl1): It is present in the part of the exploration area between the Pontian and the Quaternary loess deposits. It is built from clastic sediments (gravel, sand, siltstone and clay) reaching maximum thickness of 120 m.

STAROST				GRAFIČKI PRIKAZ	DEBLJNA (m) od - do	LITOLOŠKI OPIS
KENOZOIK (Kz)	KVARTAR (Q)	HOLOCEN (Q_2)			0,1 – 43,5	Sivi pesak i šljunak različite granulacije
					0,3 – 34,9	
		PLEISTOCEN (Q_1)			0,3 – 45,9	Les eolskog i barskog porekla sa lesoidnim glinama
	TERCIJAR (Tc)	Roman (Pl_1)			do 120	Šljunak, pesak, gline i alevrit
		MIOCEN (M)	GORNJI PONT ($^2M_3^2$)		0,7 – 56,3	Pesak i gline
					0,1 – 11,2	II ugljeni sloj Ugalj sa proslojcima ugljevite gline
					0,1 – 125,6	Pesak raznih granulacija i gline
					0,2 – 40,9	III ugljeni sloj Ugalj sa proslojcima ugljevite gline, gline, glinovitog peska
			D. PONT ($^1M_3^2$)		>150	Pesak i gline sa proslojcima uglja
			PANON (M_3^1)		>200	Gline, laporci, peskovi, alevriti i šljunkovi, ugljevite gline i ugalj

Figure 2.6-1: Geological column

(According to V. Matic, ILMS Institute, Faculty of Mining and Geology, University of Belgrade)



LEGEND:

ap	Alluvium, flood facies: sand and siltstone	**dpr**	Klicevac series: gravels, sands, siltstone and sinter
am	alluvium, abandoned water course: sand and siltstone	**p**	Aeolian sand
a	Alluvium, basin facies: gravel and sand	**t1**	Alluvium gallery(7-12): gravel, sand, siltstone
at	Alluvium: gallery (3-5m), siltstone	**l**	Aeolian sand
lt	Loess gallery (23-35m): gravel and loess siltstone	**lp**	Aeolian loess sand
pt	Proluvium: gravel, sand and siltstone	**Pl1**	Sand, clay and coal
d	Deluvium: loess siltstone and sand		

Figure 2.6-2: Geological map showing the broader exploration area
(Based on OGK SFRJ 1:100.000)

Loess and loess deposits (l) deposited in marsh and swamp areas and on land, cover most of the terrain, reaching a thickness of 6 to over 20 m. In the valleys of the Danube, Dunavac and Mlava rivers, they are partially or completely eroded. In the floor section, loess facies profile begins with loess of swamp origin, some 2 m thick, with a high clay content and structure atypical for loess. Loess of typical grain size distribution and structure (vertical porosity) is most frequent, indicating that it was formed when silty and silty-sandy material was carried by wind and deposited on the surface. Some loess sections have very high sand content, while others are rich in concretions, the so-called loess dolls. Loess deposits discovered in the lithological profile of the OCM Drmno are shown in Figure 2.6-3.

Figure 2.6-3: Loess sediments inside the open lithological profile at the OCM Drmno

Alluvial terrace (at) reaches a thickness of 5 to 15 m, extending between Drmno and Bradarac and to the northeast. It is formed from gravel (Geological Map on Figure 2.16). Due south and east, gravel turns into sand, while its thickness reduces. Towards the north, the gravel layer extends all the way to the Danube. In the Mlava River valley, sand and gravel thickness increases, however, also with an increase of the clay component.

Holocene (Q2) - eolian sand deposits belong to Holocene (transition between Pleistocene and Holocene), together with deluvial, proluvial and alluvial sediments. Aeolian sand (p) is morphologically formless: it occurs in the alluvial plain of the Danube, with the characteristics of eolian sediments, while its genetic association with alluvium floor is obvious. Its thickness is from 1 to 5 m. Deluvial lacing (d), in the vicinity of Klicevac, is built of sand and alevrites of loess habitus, while proluvial cones (pr) are built mainly from sand and siltstone with poor grain classification. Danube alluvium is built from: gravels, sand and bed facies, followed by sands and flood siltstone facies (ap) and sands and siltstone lenses.

2.7 Pedological Characteristics of the Terrain

In pedological terms, the most common soil types in the broader area of Kostolac basin are alluvial moulds, chernozem, cambisols, vertisols and metamorphic vertisols which belong to the group of climatogenic and topogenic land. A pedological map of the broader exploration area is presented in Figure 2.7-1.

The subject location is characterized by distribution of metamorphic vertisol and vertisol. Alluvial and diluvial soil are located in the lowest parts of the terrain near rivers and streams. The rule for the deposition of the particles brought by water depends on the length of the river and width of its valley. By its physical and chemical characteristics, alluvial and diluvial soils are suitable for cultivation of all field crops i.e. vegetables.

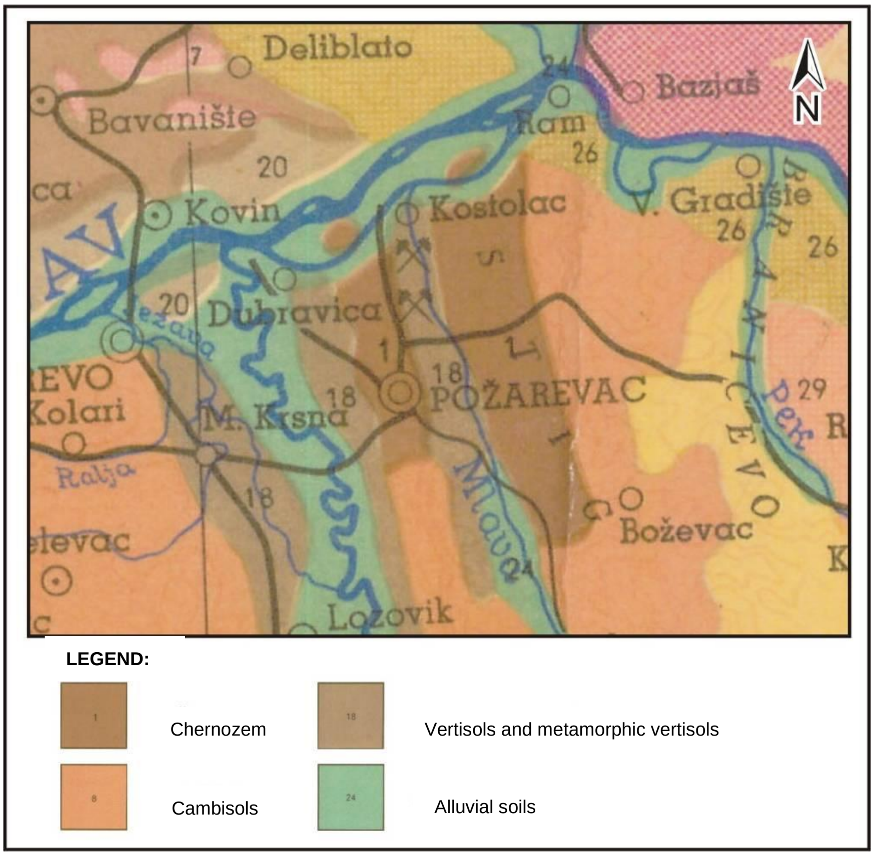


Figure 2.7-1: Pedological map of the broader exploration area
(based on the Regional pedological map of the Western and Central Serbia)

Chernozem and leached chernozem are zone types of soil developed on loess basis under dry climatic conditions. A chernozem profile has 3 characteristic horizons: humus accumulation (A), transitional (AC) and mother rock (C). A depth of a humus layer is 40 - 80 cm. Color of the humus is dark brown when dry, and almost black when wet (Figure 2.7-2). Leached chernozem occurs under influence of heavy precipitations and highly tilted terrain. It contains less humus than chernozem. By its particle size distribution, chernozem in the Danube region falls under the loam and light loam, with an almost constant percentage of clay in depth. Due to the small amounts of humus and its rapid decrease with depth, the color of the chernozem is lighter and its potential fertility also changes in comparison with deep chernozem in the Pannonian Plain. For its favourable physical and chemical properties, chernozem belongs to fertile soils, the most suitable for agricultural crops.

Cambisols are characteristic for areas with moderate climate. They occur at lower altitudes and hill foot within the area having more precipitations than the area of chernozem. Morphologically, cambisol profile is characterized by A-(B)-C type. Its composition is clay loam or heavier, stable moulder and small-grain structure. The amount of humus in the topsoil horizon of this soil ranges between 2 - 4 % and it belongs to larger production capacity lands by its water and physical properties.

Figure 2.7-2: View of the field with developed chernozem

Vertisols are found on slightly waved terrains, low hills and slightly tilted river terraces. Morphologically, vertisols belong to A-AC-C soil type. Humus A horizon is well-developed and intensely black and 40 – 70 cm deep. By its texture, vertisol falls under heavy clay, light or medium clay soils where the clay fraction is significantly superior to the sand fraction. Due to high contents of clay, this soil is sticky when wet, and hard with cracked surface when dry. Adequate contents of humus, up to 5% and a large proportion of clay both give potential fertility to this type of soil.

2.8 Hydrogeological Characteristics

Kostolac coal basin, in hydrological and hydrodynamic terms, is a very complex basin. Recent research done primarily in order to evaluate possibilities for dewatering of open cut mine Drmno, generally defined spatial position of aquifers, while aquifer regime and their hydraulic connection to surface flows of the Mlava and the Danube were less researched.

The analysis of data and the survey results obtained in the past, gave an overview of general hydrogeological conditions of this area.

The rock masses on the Drmno bed, based on the values of permeability parameter, are divided into the rock mass with the function of hydrogeological collector, or with the function of hydrogeological insulator, that is to the rock mass in which aquifer is formed and to the impermeable rock mass. Hydrogeological collectors, viewed from the surface, are:

- Loess,
- Gravel, sand, gravel and sand,
- Sand,
- Fine-grained sand, silt

Schematic view of lithological profiles via open cut mine Drmno in a south-to-north direction is shown in Figure 2.8-1.

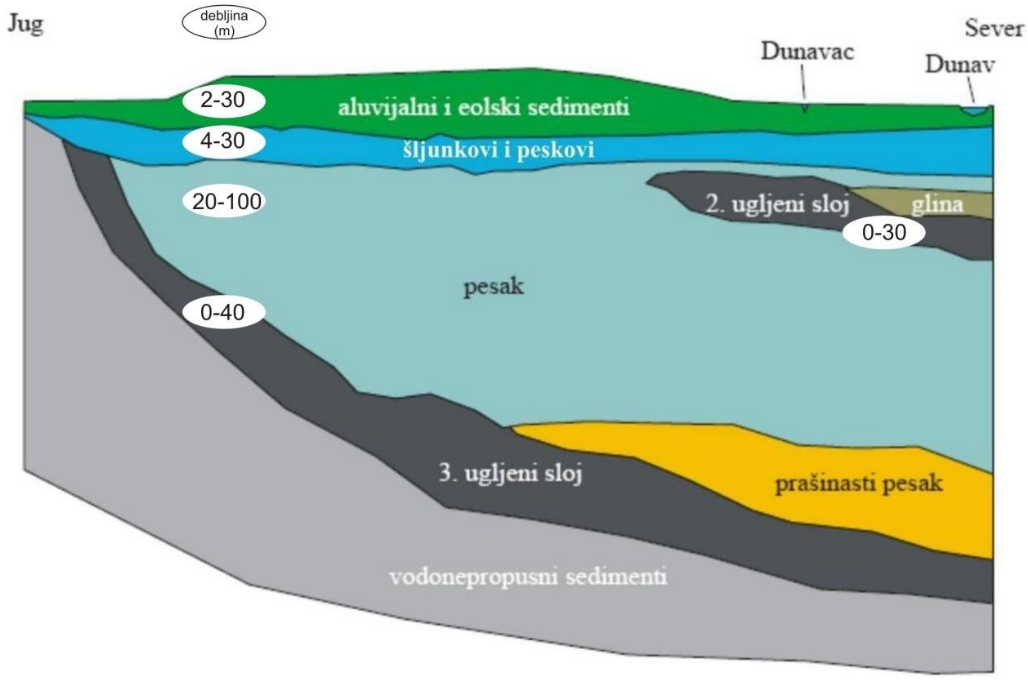


Figure 2.8-1: Schematic lithological profile over open cut mine Drmno in south-to-north direction, to the Danube
(taken from the Project of open cut mine Drmno survey, Faculty of Mining and Geology, University of Belgrade, 2004)

Within the exploration area, in the broader area of thermal power plant, the following aquifer types were formed:

(i) Aquifer formed in alluvia of the Mlava and Danube

The Mlava to west and the Danube to north are boundaries of aquifer formed in the alluvial sediments. Thickness of alluvial gravel inside the river complex ranges from 0.5 to 30 m. A level of the aquifer is at a depth of 2 - 3 m from the surface and it is in a direct hydraulic connection with the deeper aquifer formed in gravel-sandy sediments of Drmno deposit, making together Drmno's aquifer. Infiltration of water from the Mlava, the Danube and the water in the alluvium aquifer is the main source of recharge water for Drmno's Aquifer. Hydrogeological parameters of alluvial gravel, derived from the results of grain size analysis of the samples, have the following limits:

- Filtration coefficient (K) in m/s: 9.5×10^{-5} – 1.6×10^{-2}
- Impermeability coefficient (T) in m^2/s: 6.8×10^{-6} – 1.6×10^{-1}
- Specific yield (μ): 0.032 – 0.32.

(ii) Aquifer in loess

Loess is widespread in the entire coal-bearing area, except in the alluvium of the rivers Danube and the Mlava. Its thickness is from 1 to 40 m, with a drop of floor surfaces from southeast to northwest. Scattered aquifer formed in the loess does not have particular significance in the overall issue of dewatering of the mine Drmno and it is not treated separately in the lowering of groundwater level for mining works. The filtration coefficient of loess sediments ranges from 1.4×10^{-9} to 2.7×10^{-5} (based on the results of grain size analysis), the ratio of vertical filtration for surface parts of loess ranges from 1.12×10^{-6} to 1.5×10^{-3} m/s. This aquifer has a free level and it is fed by rainfall, which accumulate on the loess border - swamp loess.

(iii) Aquifer formed in the gravels and sands (Drmno's Aquifer)

The most important for coal mining is the aquifer formed in Pliocene sands and gravels. The boundary of the aquifer on the east side follows the Bozevacka greda. Towards the west, Drmno's Aquifer, or the upper water aquifer of the coal layer III of the Kostolac coal basin, disperses in some places to the Morava river alluvium but it is mostly present in Pozarevacka greda (open cut mine Cirikovac), and to the northwest it goes under the Danube River (it follows the II coal layer toward Kovin). Horizontal distribution of sands is continuous, while the lack of gravel is in the central part of the Drmno bed. Thickness of sand and gravel is from 5 to 125 m. The main characteristics of aquifer geometry is a continuous decline in footwall surface from east to west and from south to north. Level of the aquifer is sand-point in natural conditions, while in terms of drainage in the area around the open cut mine Drmno it has a free level. Hydrogeological parameters of the sediment, where this aquifer is formed, are within the following scopes:

- Filtration coefficient (K) m/s: $2.7\times10^{-7} – 1.8\times10^{-3}$
- Impermeability coefficient (T) m^2/s: $8.8\times10^{-9} – 1.1\times10^{-3}$
- Specific yield (μ): 0.04 – 0.22.

(iv) Aquifer in dusty and sandy sediments on the roof of coal layer III

In the floor level of gravel-sand deposits and on the roof of coal layer III, the silty sandy layer occurs, with a thickness of about 45 m northwest. Farther to southeast of open cut mine Drmno this layer emerges and coal in this region lies directly beneath the gravel. A strong heterogeneity is evident in the vertical distribution of these sandy and silty sediments. Within the silty sandy horizon, an aquifer is formed from the sand-point level, which is in a direct hydraulic connection with aquifers formed in the upper sediments. Hydrogeological parameters of these aquifer sediments (obtained from the results of grain size analysis) are within the following scopes:

- Filtration coefficient (K) m/s $1.4\times10^{-8} – 9.0\times10^{-6}$
- Impermeability coefficient (T) m^2/s $4.2\times10^{-8} – 2.7\times10^{-5}$
- Specific yield (μ) 0.03 – 0.05.

(v) Aquifers in silty and sandy sediments lying under the third coal layer

According to the literature data, discontinuously developed silty-sandy horizon rests in the floor of coal layer III with thickness from 3 to 5 m, in some places stratified in layers of gray blue clay. The aquifer is at a depth of 90 to 100 m (sand-point) with the pressures of 5 - 8 bar. Local occurrence of these aquifers in some parts of the open cut mine Drmno imposes the need for pressure relief in these areas, to ensure the stability of the mine floor level and future domestic waste.
The hydrogeological parameters of this aquifer (obtained from the results of grain size analysis) are within the following scopes:

- Filtration coefficient (K): $1.5\times10^{-6} – 1.9\times10^{-4}$ m/s
- Impermeability coefficient (T): $4.5\times10^{-6} – 9.5\times10^{-4}$ m^2/s
- Specific yield (μ): 0.05 – 0.08.

<u>Impermeable rock mass</u>

Relatively impermeable rock masses include swamp loess and impermeable include sandy clay of the Mlava and the Danube, then the clay directly in the floor and roof of coal and the second and third coal layer. Swamp loess is a floor insulator to deposited loess on dry ground, the collector of free aquifer. Thickness of swamp loess is up to 2 m, it has no tube-like porosity and differs from roof loess by the higher content of clay component. Its filtration coefficient is from 4.1×10^{11} to 2.5×10^{-8} m/s.

Coal makes silty sandy floor of the collector and in southeastern parts of the direct floor layer of the sandy gravel collector.

<u>The groundwater regime</u>

The groundwater regime in the broader area of the thermal power plant is formed under the influence of the following factors:

- Surface flows (the Danube, the Mlava) which are the natural boundaries of coal mine Drmno and which together with Dunavac make the main recharge sources of aquifers formed in deeper gravel and sandy sediments. The Mlava river bed is regulated in the zone of TPP Kostolac B and open cut mine Drmno. Hypsometrically, it is higher than the old river bed and along the right bank it has an embankment designed for 100-year flood,
- Vertical balance infiltration of precipitation, evaporation, evapotranspiration,
- Intensive drainage of overlying layers of coal with dewatering wells, (Figure 2.8-2),
- Discharge of groundwater along open cut mine Drmno contours.

Figure 2.8-2: Decreasing level of groundwater by a network of drainage wells

Under the influence of aforementioned factors, groundwater form and oscillate at depths different from the terrain surface. Based on observations of groundwater levels in wells and piezometers at different times, it can be concluded that groundwater levels fluctuate mainly in the hydrogeological collector made of fine-grained sand. The gravel hydrogeological collector is mostly drained and groundwater level in it is registered exclusively in the eastern part of the open cut, (Figure 2.8-3). The groundwater level in the roof layer oscillate over time, depending on the extent of the influence of some of these factors.

Figure 2.8-3: Open cut mine Drmno - level of groundwater found at the bottom of the mine

2.9 Seismic Characteristics of the Terrain

Based on the seismic map of Serbia (Figure 2.9-1), this area belongs to the seismic intensity of 7th degree of the MCS scale (Mercall – Cancani - Sierberg scale). This level corresponds to the following description of events: difficulty in standing; furniture brakes down; slight damage to well designed and constructed buildings; small to medium damage on well-constructed building structures; considerable damage to poorly constructed and inadequately designed structures; some chimneys collapse; noticeable to people while driving.

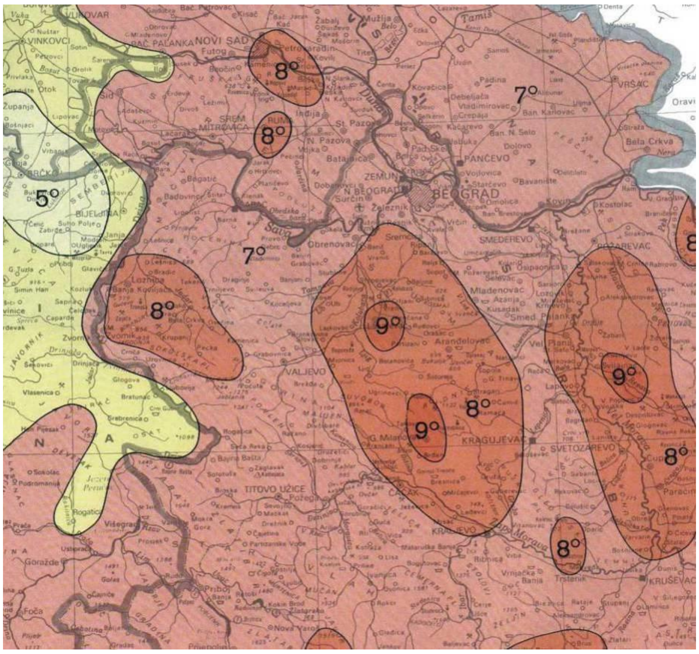


Figure 2.9-1: Seismic map of Serbia
(A regional map of Association for seismology SFRY, Belgrade, 1987)

2.10 Climate Characteristics

The area of TPP Kostolac B, as a part of Kostolac coal basin complex, is under influence of temperate continental climate where steppe-continental climate of the nearby Banat has its significant effect as well. The basic features of this climate are cold and dry winters and warm summers with highly prevailing Kosava (south-eastern wind). Kosava blows in this area approximately one hundred days a year.

The basic source of data for analysis of climate are long-term measurements carried out by the Republic Hydrometeorological Service of Serbia at major meteorological station Veliko Gradiste, 25 km east of the power plant, which is representative in terms of climate for the subject area. Below in the text, there are mean monthly and annual temperatures and relative air humidity, monthly and total annual amount of precipitations and annual wind rose for period from year 1983 to year 2012.

Air temperature

Mean annual air temperature is 11.4°C, and mean annual temperature variation amplitude is 21.7°C. The coldest month is January, with a mean temperature of 0.3°C, and the warmest month is July with a mean temperature of 22.1°C. According to the diagram (Figure 2.10-1) air temperature from January to July rises constantly, and it drops from August to January.

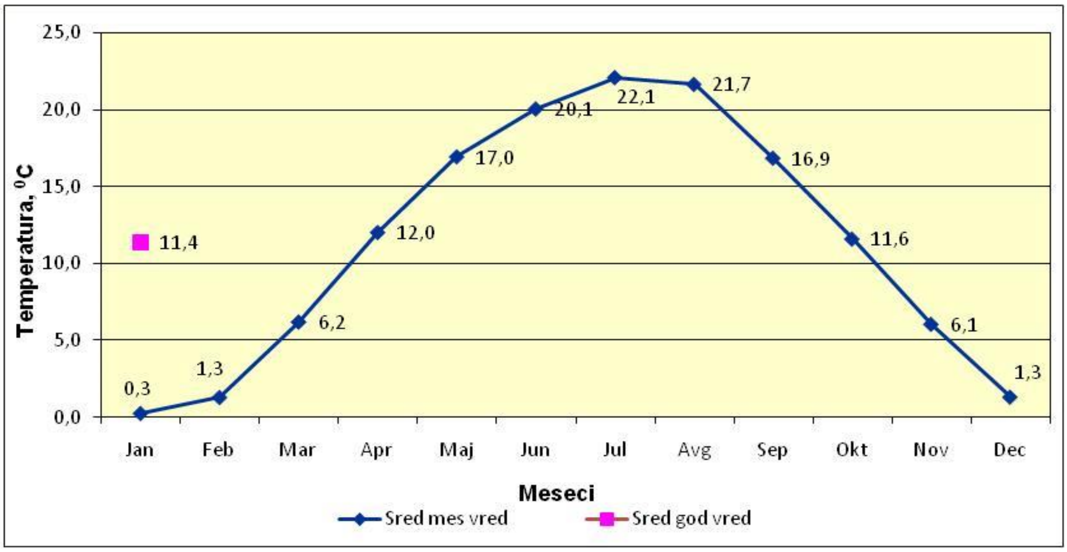


Figure 2.10-1: Mean monthly and mean annual air temperatures for period 1983 - 2012 (Veliko Gradiste meteorological station)

Mean monthly temperature in spring is slightly below 11°C, while in autumn it is about 15°C. Temperatures below 0°C occur from September to May, while in a period from November to March, the mean monthly minimum temperature is about -8°C. The fist frosts occur in mid-October, and the last in early April.

Humidity and fog

Relative humidity (in %) is a ratio between vapor contents in the air at defined temperature and maximum amount of vapor which air could accept at the same temperature when transiting to saturated state. In Figure 2.10-2, it can be seen that the highest values of relative air humidity are in autumn and winter months, and they range from 68 to 85%, and these values are the lowest in summer, ranging from 69 to 71%. Mean relative humidity is 75% in ground levels and therefore this area belongs to the moderate wet. When comparing annual changes in relative air humidity and air temperature, it can be noticed that these are inversely proportional.

A number of days with fog which lasts more than one day is 19 on average. More than two days' fog occurs once in five years on average. Fog most often occurs in autumn.

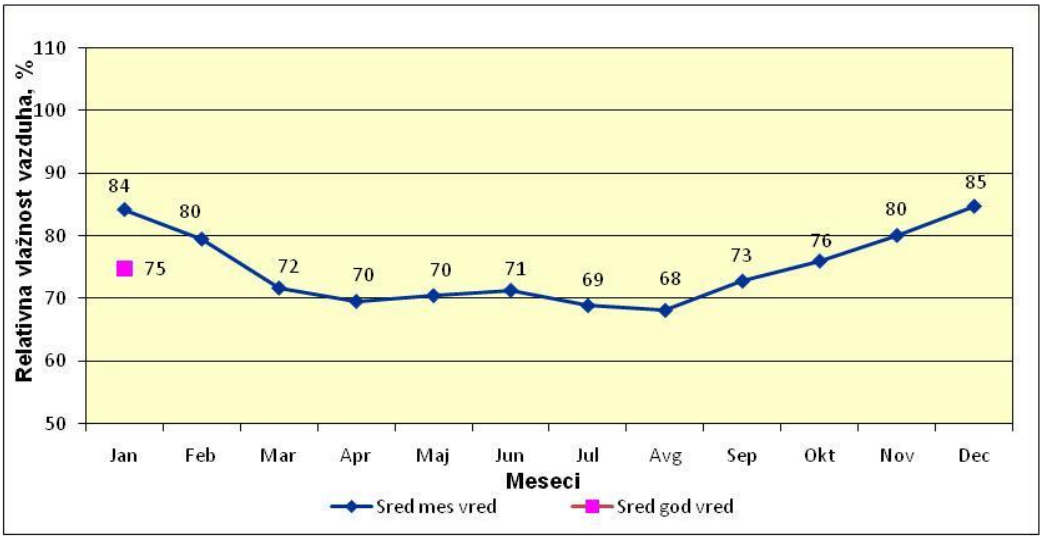


Figure 2.10-2: Mean monthly and mean annual values of relative air humidity for period 1983 - 2012 (V. Gradiste meteorological station)

Precipitation

Annual distribution of precipitation clearly differs two maximums and two minimums. The primary maximum occurs in June and secondary in September, while primary minimum occurs in March and secondary in November (Figure 2.10-3). A mean total amount of precipitation for the area of MS Veliko Gradiste is 641 mm. The characteristic for this area is very dry winters with small amount of snow. Summer is characterized by brief and strong rainfalls. The average number of days with precipitation in a year is 134. The ground is covered in snow about 35 days a year, with the height of snow being from 15 to 30 cm, maximum 60 – 100 cm.

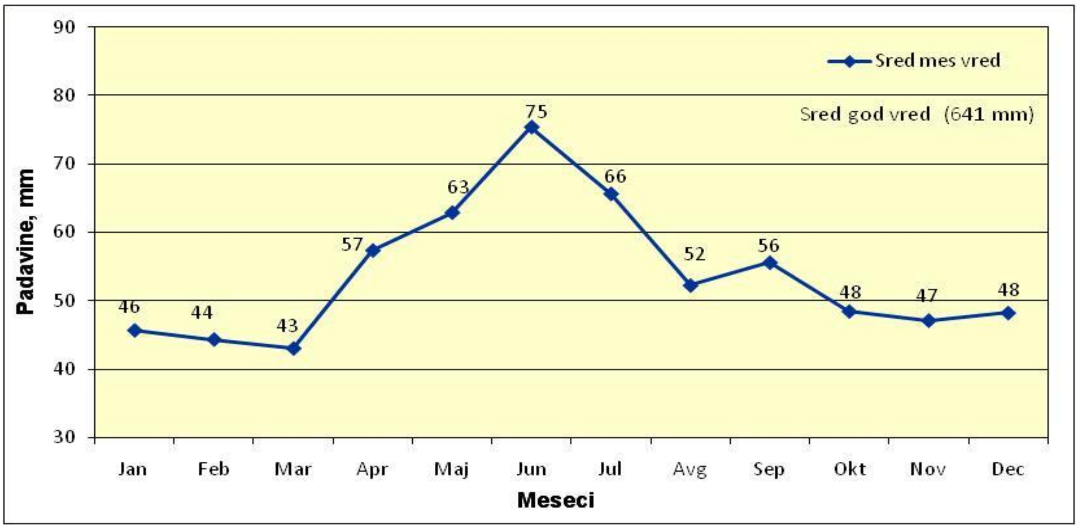


Figure 2.10-4: Mean monthly and mean annual precipitation for period 1983 - 2012 (V. Gradiste meteorological station)

Wind

In the area of MS V. Gradište, winds blowing from east-southeast and southeast directions prevail, and then there are winds blowing from west and west-northwest directions. Figure 2.10-5 shows mean several years' wind rose and mean values of wind speed.

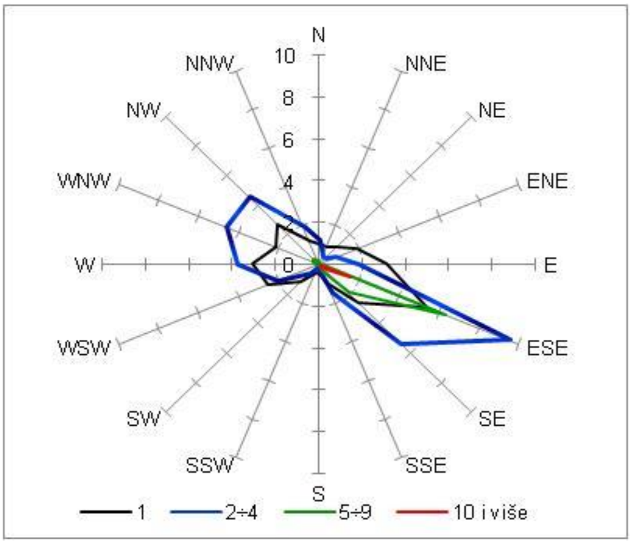


Figure 2.10-6: Wind distribution by directions and speeds for period 1983 - 2012
(V. Gradiste meteorological station)

The strongest winds blow from east-southeast direction, with the average speed above 5 m/s, and from southeast direction with the average speed 4 m/s.

2.11 Water supply source

TPP Kostolac B is supplied with drinking and raw water (for the purpose of CWT) from the local sources (4 wells) located near the thermal power plant, northwest of the main unit facility. In the exploration area, the backbone of water supply is Kostolac city system based on exploitation of groundwater from alluvial aquifers of the Danube.

The City of Kostolac is supplied from the spring called Lovac which is located in the city itself near TPP Kostolac A, i.e. Minel factory. In its vicinity, there are sewage pipelines Ø 600 mm. The main water intake building is an old German well KB - 1 from year 1942, 22 m deep. This well was sit to a depth of 22 – 16 m. The second well BB - 1 was built in 1968, but due to the reducing yield, it was excluded from use. In 1998, a new well BB - 2 was built very close, and in 2001 another new well was built.

At a distance of about 1 km from the source Lovac near the football stadium, another well was built but it was excluded from the system due to increased concentrations of nitrate (above the MRL). City Kostolac with TPP Kostolac A, Stari Kostolac, Drmno village, the village Klenovnik and mine Ćirikovac are connected to this source.

Bradarac water system

Bradarac water system is used for water supply of the mine Drmno and Bradarac village. There are about 250 households in Bradarac village. The source was constructed in the eastern part of the village and consists of 2 wells 20 m deep, which capture the river which is in connection with the river Mlava. There is a fence around the zone of immediate source protection.

Source Zabela

Late in 1994, the Detention and Rehabilitation center Zabela built exploitation well B1 for their own auxiliary supply in the immediate vicinity of the Detention and Rehabilitation center. During the growing season, within the complex of Zabela, well B6 is used for irrigation.

Potential source Petka

On the right bank of Dunavac, about 700 m far from the village Petka, there is a potential source of Petka. By the exploration works carried out in the period from 1981 to 1983 and from 1985 to 1987, the source of Petka was defined as a future site for the water supply of the town of Kostolac and surrounding villages. Water intake structures would capture aquifer formed in the alluvial gravel-sand sediments of the Velika Morava.

It should be noted that the groundwater regime at this location is under the dominant influence of Dunavac, i.e. Kalište water supply station operating mode. This water supply station keeps water level in the regulated Dunavac bed at elevation 76 m.a.s.l. ± 0.5 m. Considering such operation mode of pumping stations and significantly higher levels of ground water in the area, Dunavac is practically a drain to which aquifer water gravitate from a wider area.

Analysing water exploration wells, piezometers and individually drilled wells in Petka village (these wells capture the same aquifer which would be captured by wells at the source of Petka) found the presence of manganese, magnesium, nitrate, and organic matter with levels over the maximum permissible prescribed by the Regulations for Drinking Water (Official Gazette of the FRY no. 42/98). Therefore the source of Petka in the foreseeable future cannot be used as the water supply to consumers.

Pozarevac bases its water supply on sources Meminac and Kljuc, while Kostolac aquifer system relies on the source of Lovac. The captured groundwater after being treated with chlorine is supplied to consumers without any additional treatment. The quality of supplied water is regularly controlled by the Department of Health Pozarevac and it has satisfactory quality.

Source Meminac

This source is located at the entrance to the town of Pozarevac nearby so called industry zone. It is about 2.5 km far from the Velika Morava river and about 300 meters from the main road Ljubicevo-Pozarevac on the right. This source has been exploited since 1962 and 10 wells were built on it (B-1 to B-10). From the well, water is transferred to a collection tank and then to the distribution network being previously treated with chlorine. Wells in this spring capture aquifer in the gravel deposits that are at a depth of 5 - 15 m. Groundwater levels in a nearby zone around the source are at elevation about 70.5 m.a.s.l. (terrain elevation is about 79.0 m.a.s.l.). Immediate source protection area is properly fenced.

Source Kljuc I

This source was formed in the period 1982 - 1985. The spring has 11 wells. The nearest well is 600 m far from the river Velika Morava. The wells capture gravel aquifer 9 - 12 m thick. The source is connected to the city network via steel pipeline and beside Pozarevac, Cirikovac village and town and military post Zabela are connected as well.

The sources of drinking water in the wider research area are based on the exploitation of ground water from shallow aquifers, formed in alluvial deposits in the vicinity of surface water of the Mlava, Dunavac, the Danube and the Velika Morava. All the above mentioned sources are located significantly far from the site of the project (TPP Kostolac B with associated disposal of gypsum) and taking into account the expected flow pattern which is under the direct influence of open cut mine Drmno drainage, these may not be directly affected by the project.

On the other hand, regionally, the water supply of the research area is based on the exploitation of water from the shallower parts of the underground environment and therefore it should be generally accepted that it will be justified during planning, design and construction of the project to foresee and implement protection measures for groundwater which would prevent project activities to cause deterioration of the current situation.

2.12 Flora and fauna

Considering it is located within the TPP Drmno complex, being in operation for more than 20 years, both the area for construction of new block B3, as well as immediate surrounding of the location within the complex, have been completely anthropogenically modified. It is understandable that the present vegetation was reduced to the toughest ruderal species and fauna to synantropic species. In the area of the TPP there are no protected plant or animal species or particularly valuable arboreal flora and plant communities.

The broader environment, south of the Danube, encompasses the area of settlements: Drmno, Kostolac, Bradarac, Maljurevac and Klenovik and to the north, parts of the Special Nature Reserve Deliblatska Pescara and Ramsar site Labudovo Okno.

Please note that the area Dubovac - Ram was declared a special IBA area - YU 34 SE, as one of the most important habitats, resting and wintering area for migratory waterfowl in Europe. Deliblatska Pescara, Labudovo Okno and IBA Dubovac – Ram are under the special protection regime and there are numerous plant and animal species that were affected by current particulate emissions and flue gas from the TPP Kostolac B, but estimates of the negative impact have not been made.

The current vegetation is a result of geological, orographic, climatic, hydrologic, edaphic and very high anthropogenic impacts.

The broader surrounding area is settled by very diverse flora and fauna given below.

Aquatic Fauna

The quality analysis of the macroinvertebrate community in the coastal part of the Danube, at the level of TPP Kostolac B, Dunavac and surrounding ponds and part of the river Mlava at the mouth of the Danube showed the presence of the 11 most important macroinvertebrate groups: Turbellaria (worms), Diptera (flies), Chironomidae, Oligochaeta (ankles worms),

Hirudinea (leeches), Isopoda (shrimp), Heteroptera (bugs), Odonata (dragonflies), Ephemeroptera (water color), Coleoptera (beetles) and Mollusca (molluscs).
The most important types of macroinvertebrate communities are:

Turbellaria
Planaria sp.
Diptera
Atherix marginata
Limnophila sp.
Tabanus sp.
Chironomidae
Chironomus spp.
Oligochaeta
Tubifex spp.
Limnodrilus sp.
Stylaria sp
Hirudinea
Hirudo medicinalis
Hellobdela sp.
Isopoda
Asellus aquaticus
Heteroptera
Nepa sp.
Gerris sp.
Notonecta sp.

Odonata
Libellula depressa
Onychogomphus forcipatus
Calopteryx splendens
Calopteryx virgo
Anax imperator
Gomphus spp.
Ephemeroptera
Caenis spp.
Ephemerella sp.
Coleoptera
Hydrophilus sp.
Gyrinus sp.
Dytiscus marginalis
Potamophilus sp.
Mollusca
Unio sp.
Lymnaea peregra
Planorbis spp.
Viviparus sp.

The largest macroinvertebrate communities of coastal part of the Danube, Dunavac and the mouth of the Mlava are different groups of insect larvae (Diptera, Chironomidae, Heteroptera), Oligochaeta (earthworms) and Mollusca (molluscs) which are also characterized by the largest mass fraction. The dominant presence of taxa listed in the immediate surrounding area of TPP Kostolac B is conditioned by bottom facies, content of organic and inorganic micropollutants in sediment and water quality.

Figure 2.12-1: River snail, Viviparus sp.
(Photo: fund of Faculty of Biology)

Pisces (fish)

In the broader area, two types of biotopes can be distinguished (rivers, ponds and canals) with different fish stocks. Along with construction of the HPP Djerdap and the formation of the reservoir with the same name, significant slowdown occurred in this sector of the Danube, which due to increased sedimentation and facies changes in the bottom resulted in modification of the composition of the fish population.

In the Danube and Mlava, downstream from TPP, dominating types are indigenous cyprinids Alburnus, alburnus - bleak (Figure 2.12-2), Rutilus rutilus - common roach, Leuciscus idus - gap, Aspius aspius - asp, Abramis brama - bream, Abramis ballerus - bleam, Cyprinus carpio - carp. Prey fish which could be seen are Perca fluviatilis - perch, Stizostedion lucioperca - zander, Esox lucius - pike and Silurus glanis - catfish. Less common are: Gymnocephalus schraetzer, Blicca bjoerkna - silver bream.

Figure 2.12-2: Alburnus alburnus (Bleak)
(Photo: fund of Faculty of Biology)

It is specific that due to construction of dams in Djerdap, in this part of the Danube course, there are no longer representatives of migratory species Acipenseridae (Huso huso - sturgeon, Acipenser nudiventris - sim, Acipenser stellatus - starry sturgeon), while due to the changes in facies bottom Acipenser ruthenus is rarer.

In the middle course of the Mlava, to hot water inflow, beside the above mentioned types, there are the following types: Leuciscus cephalus - chub, Chondrostoma nasus - nase, Barbus barbus - barbel and Barbus peloponnesius – stream barbel.

Surrounding canals and ponds are the dominant habitat types for: Scardinus erythrophthalmus – common rud, Tinca tinca - tench, Carassius Carassius - crucian carp. Misgurnus fossilis - loach, which is a protected species, can be rarely found.

Among non-native species, the following are dominating: Carassius auratus - Prussian carp, Lepomis gibossus- sunfish, Ictalurus nebulosus - bullhead, Arystichthys nobilis - bighead carp, Hypophthalmichthys molitrix - white bighead carp, Ctenopharyngodon idella - white amur.

Amphibia (amphibians)

Tranquillity of the Mlava at the mouth of the Danube, channel Dunavac nearby and the bank of the Danube with the surrounding pools are favorable for amphibians communities, most of which are green frogs (Rana ridibunda) and Fire-bellied toad (Bombina Bombina). Presence of the Danube newt (Triturus dobrogicus) is specific as well as a small newt (Triturus vulgaris). In a few bushes and grass, the existance of green croaker (Xyla arborea) was noted. Two toad species were noted - the green toad (Bufo viridis) and common toads (Bufo bufo).

Terrestrial fauna

Mammalia (mammals)

In the villages around TPP Kostolac B, among mammalian taxa, synantropic species Mus domesticus - domestic mouse and Rattus norvegicus - gray rat are dominating. In the surrounding agrophytocenoses and meadows, there are mainly small rodents and insectivores that are well adapted to cultivated areas. The most common are: Cricetus cricetus - hamster (Figure 2.12-3), Microtus arvalis - Polish voles, Apodemus flavicollis - mouse, Apodemus sylvaticus - field mouse. The protected species are: Mustela nivalis - weasel, Crocidura leucodon - bicolored shrew and Talpa europea - ordinary mole.

Slopes of Deliblato toward the Danube are habitats for many species of which the protected are: Spermophylus citellus - ground squirrel, Tulp Europea - ordinary mole, Felix slivestris - wild cat and Myoxus glis – edible dormouse.

Among game animals on the right bank of the Danube there is hare (Lepus europaeus), while on the left bank, in Dragic Hat, there are numerous wild boars (Sus scrofa), roe deer (Carpeolus carpeolus) and deer (Cervus elaphus), which has a certain economic value.

Figure 2.12-3: Hamster (Cricetus cricetus)
(Photo: fund of Faculty of Biology)

Aves (birds)

The data on avifauna are generally obtained by observing the field on several occasions and from the Natural History Museum experts.

For avifauna, given the objectives of this study, of particular importance are areas of Dunavac on the right bank of the Danube, parts of Deliblatska Pescara, Labudovo Okno and IBA Dubovac - Ram, influenced by TPP Kostolac B.

In some parts of Dunavac, Nycticorax nycticorax - heron and Areda cinerea- grey heron are nesting (Figure 2.12-4), while in the loess sections of the left bank of the Danube there is one of the largest colonies in the Balkans of species Riparia riparia – martin and in part of Dubovac there are colonies of small cormorant (Phalacrocorax pygmeus) and little egrets (Egretta garzetta).

The largest population among the protected species are Riparia riparia - martin, Hirudo rustica - barn swallow, Merops apiaster - bee-eater, Larus ridibundus - river seagull, Phalacrocorax pygmeus - pygmy cormorant, Vanelus vanelus - lapwing, Ciconia ciconia - white race, Areda cinerea - gray heron, Gavia immer - great cormorant, Nycticorax nycticorax – night heron.

The dominant prey birds are: Falco tinunculus - kestrel, Falco vespertinus - gray kestrel, Falco subbuteo Hobby - hawk, Buteo buteo - buzzard, Accipiter nisus- hawk, Accipiter gentilis - goshawk and Haliaetus albicillia - tailed eagle.

Labudovo Okno area is one of the largest staging and wintering areas for many migratory species of ducks (Anas sp.) and geese (Anser sp.). According to the winter count, occasionally there are a few thousands of them.

Figure 2.12-4: Grey Heron (Ardea cinerea)**
(Photo: fund of Faculty of Biology)

Reptilia (reptiles)

The fauna of reptiles in wide area of TPP Kostolac B is relatively poor and it is caused by a large percentage of degraded habitats. The presence of three types of snakes was detected: Aesculapian snake (Coluber caspius, Figure 2.12-5), and two species of water snake – grass snake (Natrix natrix) and dice snake (Natrix tesselata). Most common lizard species are wall lizard (Podarcis muralis), green lizard (Lacerta viridis), sand lizard (Lacerta agilis) and blindworm (Anguinus fragilis). In the ponds along the Danube and in Dunavac, pond turtles are common (Emys orbicularis**), as well as forest tortoise (Testudo hermani).

Figure 2.12-5: Aesculapian snake (Coluber caspius)**

Insecta (insects)

Composition of the insect fauna is caused by the relatively low habitat diversity and structure of the habitats (dominant agro-ecosystems and degraded habitats in the vicinity of TPP Kostolac B). The most abundant insect groups such as Coleoptera (beetles), Hymenoptera (jackets), Lepidoptera (butterflies) and Diptera (flies) are mainly present in trophic communities of cultivated crops (agro-ecosystems), mainly as pests. In the surrounding water basins there are common different groups of dragonflies (Agriidae, Aeshnidae, Gomphidae) and mosquitos Aedes spp. and Culex spp.

Flora and Vegetation

The indigenous forest vegetation, once developed in the area closer to TE Kostolac B, was replaced by meadows with grass communities rich with ruderal forms, which were later converted into agrophytocenose which composition is dictated by crop rotation, population needs and market demands. Indigenous floristic composition has been preserved only in the rudimentary part of the boundary on damp and barren terrain.

On the banks of the Mlava, Danube and channels, there are woody forms: Populus nigra - black poplar, Alnus glutinosa – alder, Salix alba - white willow, Salix fragilis - brittle willow, while considerably rare is Populus alba - white poplar. In flood, wet areas along the coast especially along the channels and ponds, the dominating are: Phragmites communis - reed and Typha latifolia, and as for herbaceous plants in these habitats, the sporadically seen are: Ranunuculus repens - water buttercup, Agrostis sp - drosera and Pastinaca sativa - wild parsnip. Figure 2.12-6 shows bushy vegetation along the Mlava River.

Figure 2.12-6: Bushy vegetation along the Mlava River

In the surrounding channels and ponds, the dominanting submerged plants are the following: Ceratophyllum demersum, Elodea canadensis, Myriophyllum spicatum and several types of Potamogeton. As for macrophytes, the most frequent are Polygonum amphibium and the emersed macrophytes Scripus lacustris and Butomus umbellatus.

Nymphea alba - white water lily and Nuphar lutea - yellow water lilies, protected species, are seen in parts of the Labudovo Okno (Dubovac, Cibuklija, Dolnica).

In the area of boundaries between agricultural fields, the most often seen shrub vegetation is Crategus monogyna - hawthorn, and rarely seen is Cornus sanguinea - dogwood. Along the roads and in the area of boundaries, ruderal and weed vegetation is a dominant form of herbaceous vegetation. The most common types are Cichorium intybus, Sonchus arvensis, S. olearaceus, Eryngium campestre, Arctium lappa, Artemisia vulgaris, Urtica dioica, Cirsium arvense, Carduus acanthoides, Crepis biennis, Stenactis annua, Symphytum officinale, Chenopodium album, Linaria vulgaris and others. All the aforementioned species are rapidly expanding in the sites as they are very resistant and adapted to anthropogenic influences.

Annual weed best adapted to the ash disposals and degraded habitats are as follows: Polygonum aviculare, Polygonum persicaria, Chenopodium album, Chenopodium botrys, Sisymbrium orientale, Erigeron canadensis, Artemisia scoparia and Pycreus glomeratus. Dominating monocarpic perennial, herbaceous plants are Daucus carota and Verbascum phlomoides, and Tussilago farfara and Calamagrotis epigeios can be seen as well.

In parts of the mine where water is still, some pioneer species occurred such as Phragmites communis - reed and Alnus glutinosa - alder.

The forests in Deliblatska Pescara were formed as a result of intensive planting of monocultures of acacia (Robinia pseudoacacia) and red pine (Pinus nigra) for stopping the sand. On the dune relief with the conserved parts of the steppes, there are protected species such as Adonis vernalis - wild flowers, Helychrisum arenarium - dwarf everlast, Stipa pulcherrima – feather grass and Iris arenaria - dwarf irises.

On the right bank of the Danube in the environment of TPP Kostolac B, there are gallery forests and fragmented forest and shrub habitats. There are some individual trees and shrubs such as poplar (Populus nigra var. Italica), black locust (Robinia pseudoacacia), elm (Ulmus campestris), linden (Tilia cordata), maple (Acer pseudoplatanus), hawthorn (Crataegus monogyna), fiddle (Cornus mas), elder (Sambucus nigra).

The dominant plant communities in the surrounding uncultivated areas are Polygono-Chenopodietalia, Phragmition communis and Salicion albe.

<u>Habitat types</u>

Recording the actual state on the field provided assessment of habitat types with grades from 0 to 5, in accordance with the Habitat Directive (The Council Directive 92/43/EEC on the Conservation of Natural Habitats and of Wild Fauna and Flora – “The Habitat Directive“).

The grades given to habitats are listed in Table 2.12-1, and these refer only to the surrounding of TPP Kostolac B.

Table 2.12-1: Habitat types surrounding TPP Kostolac B

Code	Type of the habitat	Grade of habitat (0-5)
24	Freshwater	
24.15	River course	4
24.5	The river banks with deposits of silt	3
22.13	Permanent eutrophic lakes, ponds and pools	4
4	Forests	
41.8 x 83.324	Mixed deciduous forest group x acacia groups	3
31.8D	Shrub vegetation	2
8	Agricultural and cultivated land *	
82.11	Fields	1
85.32	Gardens	1
85.4	Green space between houses	1
86.3	Active industrial areas	0
87.2	Ruderal species	1
BUILDINGS 1	Dense residential area and some buildings	0
STREET 1	Paved streets and other paved and concrete surfaces	0
ROAD 1	Unpaved streets, gravel surface	0

* The dominant habitat type.
1 The marked categories are areas which can be found on the field, but which cannot be classified based on vegetation and typology of habitat types within the existing system and therefore general designations are used for them (Building, Street, Road).

The listed grades of different habitat types on the field record the actual state. Higher grades for some habitat types indicate their higher importance for environmental protection.

Protected species

The hunting area Stig permanently or temporary hosts several kinds of game, classified in accordance with Act on Hunting into permanently protected game kinds, into kinds protected only during a defined period of prohibited hunt – closed season for protected game kinds and into game kinds which are out of protection regime.

Among game kinds, protected permanently from hunting, the following live and stay all the time: otter, ermine, weasel, peregrine falcon, common buzzard, Eurasian sparrow hawk, white stork, black stork, eagle owl, Blakiston's fish owl, tawny owl, scops owl, little owl, hooded crow, northern lapwing, peewit, black-headed gull, little grebe, black kite, great egret, songbirds except hooded crow, Eurasian magpie, Eurasian jay, and rook and all other birds which are temporary in the hunting area, usually during migrations.

The kinds protected during a defined period of prohibited hunt, which live in this hunting area are as follows: European roe deer, wild boar, rabit, European badger, beech marten, European pine marten, muskrat, common pheasant, grey partridge, mallard, Eurasian teal, Eurasian coot, common wood pigeon, Eurasian woodcock, common quail, European turtle dove, Eurasian collared dove, ring-necked turtle dove, grey heron, Eurasian jay, rook, northern goshawk and other kinds which are temporary (during migrations) in the hunting area.

Game kinds which are bred in this hunting area are European roe deer, wild boar, rabbit, common pheasant, grey partridge, mallard.

Protected natural areas

Within the area under influence of TPP Kostolac B, the following area are defined as protected natural areas:

- Special Nature Reserve Deliblatska Pescara, which encompasses small river island Zilava and which is assigned I (the first) protection level, and
- The area which is in the international and national list of areas significant for conservation of diversity of birds (Important Bird Areas – IBA). It is named as Labudovo Okno, and entered into the international list under 033, and in national list RS016IBA. This area is also significant for conservation of diversity of plants - IPA (Important Plant Areas). Most part of IBA, starting from the Danube left river bank towards the north through Zilava small river island, has been declared as an internationally significant area as per Ramsar Convention. The south border of SNR Deliblatska pescara overlaps with south border of internationally significant area for diurnal butterflies of PBA (Prime Butterfly Areas). From the south border of the protected area – Special Nature Reserve Deliblatska Pescara towards north, there is an area which is significant as an ecological area and which is a part of ecological networks, namely, a possible part of Emerald Network, the European ecological network for conserving wild flora and fauna and their natural habitats.

2.13 Landscape

The research area is a rural type area. The relief is of a plain type which makes the landscape low dynamic. Characteristics of the landscape are dominated by elements of vegetation and agricultural land with facilities for mining and industrial activities. The Mlava river course gives the only dynamics to a view of the landscape. The view of the landscape is a low quality and low sensitivity.

The surface of the research area and Drmno deposit, before the construction of the lignite open-cut mine and TPP Kostolac B, was typical for the rich agricultural plains of Stig, with prevalent arable land planted with wheat, corn and other crops to the oases of vineyards and woods and villages consisting of several buildings and gardens for each household. Now they have seen significant technogenic scars and the following distinctive structures:

- cavity of the open cut mine, partially filled by internal overburden dump, from which the smoke, generated by the endogenous fires or by burning of unexcavated parts of coal layer or coal impurities in deferred overburden mass, runs with more or less intensity (Figure 2.13-1);
- elevation of external overburden dump, which is partly rehabilitated;
- complex of TPP Kostolac B with coal deposits of up to 600 000 t and other facilities within TPP, such as chimney and GPO (Figure 2.13-2);
- excavators, spreaders and other machinery in the work of excavation and coal and tailings.

Drainage facilities – lines of wells, pipelines and other are less striking but make new features visible above the ground surface of coal deposit of open cut mine Drmno.

The results of ancient anthropogenic activities, such as a cave in the area of the sanctuary i.e. chapel of St.Petka are hardly noticeable.

Figure 2.13-1: Landscape of the broader surrounding area around TPP Kostolac B and open cut mine Drmno

Figure 2.13-2: Landscape of the closer surrounding area around TPP Kostolac B

2.14 Immovable Cultural Monuments

Within the broader area around TPP Kostolac B, the following sites categorized as immovable cultural monuments have been recorded:

- Church of Saint George (Crkva Svetog Georgija) build in 1924, located in Stari Kostolac, approximately 1.8 km in north-west direction from TPP Kostolac B (Figure 2.14-1).
- Rukumija – archaeological facility from the Bronze Age and the monastery. Today's monastery is from the time of Duke Milos Obrenovic (from 1852) and it is located near the village Bradarac, 5 km south from the TPP Kostolac B (Figure 2.14-2).

In the closely surrounding area of the thermal power plant, there is Viminacium – a site near the villages Stari Kostolac and Drmno – which is an old military and civil settlement from the Roman period.

Figure 2.14-1: St. George Church

Figure 2.14-2: Rukumija Monastery

2.15 Archaeological site Viminacium

In the immediate vicinity of the boundaries of TPP Kostolac B and area foreseen for construction of plant for flue-gas desulfurization (FGD), there is an enclosed area of the archaeological site Viminacium. The eastern boundary of TPP Kostolac B is the southwestern boundary of the site.

Viminacium is one of the most important archaeological sites in Serbia under the protection of the state since 1949, as a monument of culture - archaeological site. In 1979, the Serbian Assembly declared Viminacium as a cultural heritage of great importance (Official Gazette of SRS 14/79).

Viminacium occupies a territory of approximately 450 ha, beneath arable land surfaces. The objects and fragments from the Roman period are scattered within arable ridges and thus endangered due to agricultural activities in the fields. Moreover, the site has become endangered with further extension of open cut mine Drmno which further caused displacement of excavations (aqueducts).

The area of the former Roman city and military camp Viminacium, includes the territory of the villages of Stari Kostolac and Drmno. The core of the site is located on the stretch Cair, where the remains of a Roman military camp and settlement, originating from the second half of the first century, were found in late 19th century.

With the commencement of construction of TPP Kostolac B on the territory of the southern necropolis of Viminacium in 1977, extensive protective research works were carried out. Open cut mine Drmno expands towards the camps and town and still requires protective archaeological works in the east of military camps and settlements.

On the wide area in the plain, along the right and left banks of the Mlava, near its confluence with the Danube, there is a number of other smaller settlements, burial grounds and fortifications from ancient and early Byzantine period. Numerous archaeological findings that were discovered during more than a century of research, testify to the extremely long time span of human activity in this area, from the 12th century BC to the 17th century AD.

The site consists of three major facilities: (1) the Roman city, the capital of the Roman province Moesia Superior from 1st to 6th century, (2) the military camp and (3) the large burial grounds.

Eastwards from TPP Kostolac B, there are two locations: Roman bath (spa) about 2 km far from the thermal power plant site (Figure 2.15-1) and the northern gate of the camp (port Pretoria) about 3 km far away.

Figure 2.15-1: Roman bath (spa) about 2 km far from TPP Kostolac B eastwards

Within the boundaries of TPP Kostolac B, there are three conserved memories in two locations and a small archaeological finding in the third location. Position of excavations in relation to the power plant is shown in Figure 2.15-2.

Figure 2.15-2: Position of the Viminacium archaeological excavation within the boundaries of TPP Kostolac B

Memory marked as G-4816 is one of the most representative buildings of its kind on the burial ground of Viminacium. It is a cross-like memory with 11 graves. At 1.5 m from the south-eastern corner of the memory G-4816, there is the second memory G-4815 with nine graves.

Two memories are about 300 m far northwest from the area foreseen for plant for FGD, Figure 2.15-3.

Figure 2.15-3: Two memories

During the archaeological excavations in 1985, the memory with sarcophagi was found. The tomb is rectangular, oriented in the east-west direction, with the entrance on the west. The memory is located about 200 m northwest from the site of the future plant for FGD and it is shown in Figure 2.15-4.

Figure 2.15-4: Memory with sarcophagi

In the central part of the future plant for FGD, there is a small archaeological excavation, shown in Figure 2.15-5.

Figure 2.15-5: Archaeological excavation within the area foreseen for plant for FGD

In February 2008, the Serbian Ministry of Culture issued a detailed regulation plan for Viminacium with the long term protection of the site. During the next sixty to eighty years it is planned to make general regulation of Viminacium, in three phases, from permanent protection of archaeological sites, through its architectural reconstruction, to erection of new facilities for a variety of accompanying events.

2.16 Population and demographic characteristics

The thermal power plant Kostolac B is located in the Municipality of Pozarevac (Branicevo), which occupies the area of 491 km^2 and is characterized by a considerable population density (156 residents per km^2). Nowadays, about 75 000 people live in this area, where about 45 000 in Pozarevac, and about 11 000 in Kostolac. There are two cities and 24 villages on the territory of the municipality.

The nearest populated location in relation to TPP Kostolac B is represented by twenty facilities (barracks) immediately against the western boundary of the power plant facility. The city of Kostolac is 3 km far from the thermal power plant on the west.

The settlement nearest to TPP Kostolac B is a village called Drmno, with about 900 people (2011 census), 1.5 km far from the location on the southeast. Other settlements in the vicinity of the power plant are Stari Kostolac (1.3 km far on the west of the plant), Bradarac, Klenovnik, Petka, Ostrovo and Klicevac.

According to status in 2013, a share of population being 65 years old and more in total number of people for Branicevo District, is 21.8%, which shows that the population living on the territory of the district is older (people who are 65 and more account for more than 10%). Population aging index for the territory of Branicevo District is 1.64, which indicates aging of the nation (index is over 0.40).

Index of the functional/dependent population of Branicevo is 0.6, which indicates the social and economic consequences of aging, i.e. disharmonious age structure of the population. On territory of the district in year 2014, a low birth rate was recorded (less than 15.0 /1 000), while the overall mortality rate was high (18.6 per mille).

A common characteristic for this area is a continuous migration of younger people either to cities or abroad. Therefore, population in Pozarevac and Kostolac is increasing, while the population of the villages is stagnating or declining.

2.17 Economic facilities and infrastructure facilities

The economic facilities located in the close surrounding of TPP Kostolac B are as follows:

- TPP Kostolac A (100+210 MW) and present ash dump for both thermal power plants
- Middle Kostolac island, with area 246 h
- Open cut mine Drmno, about 2 km far from the power plant on the east
- Open cut mine Cirikovac, about 6 km far from the power plant on the south
- Open cut mine Klenovnik, about 3 km far from the power plant on the southwest, where exploitation of the coal has been ended
- Oil-gas fields, about 10 km far from the power plant on the south: research on three oil-gas fields is ongoing: Maljurevac-Babusinac, Bradarac-Maljurevac and Ostrovo.

TPP Kostolac B has a very good communication links with other places in Serbia by road, river and railway traffic (Figure 2.17-1). Several asphalt roads pass through this area, among which the most important are Pozarevac - Veliko Gradiste, by which it connects with Djerdap road, Pozarevac - Petrovac - Bor, which connects the area to the east of Serbia and direction Vranovo - Pozarevac which links this area with the highway Belgrade – Nis.

Figure 2.17-1: A network of roads on the territory around TPP Kostolac B

A standard railway, Pozarevac - Kostolac, passes through the central part of this territory, and this railway connects this territory with the whole country.

This territory is connected to the Danube and every of its port by the channel.

2.18 Environmental conditions at the location of TPP Kostolac B accepted for design

Environmental conditions at the location of TPP Kostolac B include average and extreme (maximum / minimum) parameters which are basis, i.e. input data for design process.

Mean annual air temperature:

Mean temperature	11.52°C
Mean maximum temperature	17.23°C
Mean minimum temperature	6.44°C
Extreme maximum temperature	43.6°C
The extreme minimum temperature	-20°C

Mean monthly values of atmospheric pressure:

Maximum	1 024 mbar
Minimum	998 mbar
Medium	1 007 mbar

Annual precipitation:

Mean monthly precipitation	58 l/m^2
Mean annual precipitation	696 l/m^2
Maximum daily precipitation	113 l/m^2
Average number of days with snow	41 l/m^2

Wind:

Maximum wind speed	26 m/s

Hydrological data:

Typical levels of the Danube in the profile of the hydrological station Veliko Gradiste:

Minimum elevation level	Zmin = 66.37m (a.s.l.)
Average elevation level	Zav = 69.35m (a.s.l.)
Maximum elevation level	Zmax = 71.77m (a.s.l.)

3. PROJECT DESCRIPTION

3.1 Project Scope and Boundaries

In the previous period, up to 1992, the first phase of construction of thermal power capacities on the location Drmno, near Kostolac, was realized by the construction of two power units with the total capacity of 2 x 348.5 MW, which constitute the existing TPP Kostolac B.

By the project and technical documentation, which was prepared in this period, the construction of two more power units with the same capacity was envisaged on this location, which would use the lignite from Kostolac coal basin as the main fuel. In this sense, during the realization of the first phase of construction of TPP Kostolac B (power units B1 and B2), certain plants and facilities were also designed and partially built for the needs of the second phase of construction.

With the aim of further developing and building the electric power system within PE Electric Power Industry of Serbia, there has been a need for analysing the possibilities and justifiability of capacity expansion on the existing location of TPP Kostolac B, by building a power unit of modern design, with the most favourable parameters for the available conditions and limitations of the location.

According to current plans, the construction of thermal power capacities on the location of TPP Kostolac B would be rounded off by the construction of power unit B3.

The considered project includes the construction of a new power unit B3 with all related systems, including the expansion of the coal stockyard with the third stockyard line, as well as the disposal of solid waste within the area of OPM Drmno. The technical solution, which has been the basis for the analyses of environmental impact of the new power unit, implemented within this Study, is based on the technical specifications of the company CMEC, as the chief Project designer and contractor.

3.2. Description of Thermal Power Plant Kostolac B

3.2.1. Technical characteristics of TPP Kostolac B

TPP Kostolac B is located near the town of Kostolac and it consists of two power units, B1 and B2, each with the capacity of 348.5 MW. Power unit B1 was put in operation in 1987, and power unit B2 in 1991. The total planned capacity of the power plant is 4 x 350 MW.

The power units use lignite as the main fuel, and they use heavy fuel oil as the auxiliary fuel, for starting and/or keeping fire. The auxiliary steam for starting is supplied from TPP Kostolac A through a steam line with the approximate length of 6 km.

Coal is supplied from the open pit mine Drmno, located near the thermal power plant. The quality of coal from OPM Drmno is within the following limits:

- lower heat value 6,500 kJ/kg – 8,400 kJ/kg
- ash content 18.4 – 25.0 %
- moisture content 43.4 – 44.1 %
- volatile content 34.0 – 36.1 %
- sulphur content 1.1 – 1.2 %

Using a conveyor belt system, coal is delivered from the mine to the distribution bunker and the reserve bunker which are located in front of the coal stockyard of TPP Kostolac B, whereat the following operations are carried out:

- one portion of delivered coal is directed towards the thermal power plant Kostolac A;
- one portion of coal is allocated as consumer goods;
- the remaining portion of coal is directed towards the crushing plant where it is crushed down to the size of -40+0 mm, and from there it is transported towards the coal stockyard within the location of TPP Kostolac B.

The role of the reserve bunker is to separate the technological process of excavation and transport from crushing and storage.

Crushed coal with the size of -40+0 mm is transported to the stockyard by conveyor belts TR10 and TR11. The stockyard is of linear type with two conveyor lines and it enables the creation of the crushed coal reserve necessary for multi-day supply of TPP Kostolac B, regardless of the current level of production of the mine. The homogenization of coal quality is not performed at the stockyard.

Each of the two stockyard lines is equipped with a combined machine for the stacking and reclaiming of coal. The stacking capacity is 2,700 t/h, and the reclaiming capacity is 1,600 t/h. The capacity of coal stockyard is 700,000 t.

Coal is transported from the stockyard towards the output transfer building IV, and from it further towards the boiler bunkers of power units 1 and 2 of TPP Kostolac B.

The power plant is supplied with cooling water from the river Danube through a canal along which water flows to the pumping station. The cooling system is flow-type, so that return cooling water is discharged into the Danube using the old river bed of the Mlava, Figure 2.5-4.

The original thermal power plant design did not envisage measures for reducing the emission of sulphur oxides. For this reason, in accordance with the stated characteristics of coal, the existing emissions of sulphur dioxide in flue gases exceed multiple times the maximum allowed values defined both in the domestic and the EU regulations. Measured values of sulphur dioxide emissions range within 5,000-8,000 mg/Nm^3, with the mean value of specific emission of around 30 kg/MWh.

The contribution of TPP Kostolac B to the total electricity generation amounts to around 15%. The contribution of uncontrolled SO_2 emissions from power units B1 and B2 to the total emission of sulphur oxides from all coal-fired thermal power plants amounts to around 25%.

Table 3.2.1-1 presents the technical characteristics of the main equipment of the thermal power plant.

The boilers in TPP Kostolac B are one-pipe, membrane-welded, with forced circulation and mixed flow, designed to operate with both fixed and sliding pressure. Each of the boilers of TPP Kostolac B power units is manufactured as a single-duct boiler with one reheating and dry discharge of slag. Vertically, each of the boilers can be divided in two parts – lower and upper. The lower part up to the elevation of 49.5 m, is the boiler fire-box, in which a part of the evaporator and the wall superheater are located, and the upper, convective part of the boiler (streaming tract), consists of heating surfaces, in particular the superheater P3 (output), reheater MP2, superheater P2, reheater MP1 and the feed water heater EKO, respectively in the flue gas streaming direction.

Each of the boilers has its own system for preparing fuel for combustion, which includes 7+1 (seven plus one) mills, with the unit capacity of 76 t/h. The mills are fan-type, dimensioned so that, during the operation with coal of designed parameters, the operation of seven mills is required and sufficient for a maxiumum continuous production of the boiler.

Table 3.2.1-1: Technical characteristics of TPP Kostolac B main equipment

Boiler plant		
Equipment supplier		SES Tlmače (design Sulzer–Wintertur); coal combustion system MINEL – Belgrade
Designed parameters of boiler		
Maximum continuous production of steam		1,000 t/h
Live steam parameters	• pressure	186 bar
	• temperature	540°C
Reheated steam flow		896 t/h
Reheated steam temperature		540°C
Feed water temperature		255°C
Designed lower heat value of coal (Hd):	• for boiler	7,315 kJ/kg
	• for mills	6,061 kJ/kg
Coal mills (7+1), designed capacity		68 t/h
Steam turbine		
Supplier:		Zamech – Poljska (licence BBC)
Designed power (at generator terminals)		348.5 MW
Designed live stream flow		277.78 kg/s
Nominal number of revolutions		3,000 min^{-1}
Condenser		
Cooling surface		8,363 m^2
Cooling water flow		13 m^3/s
Feed pumps (3x50%)		
Manufacturer		Sigma – Lutin
Main pump	• type	Sigma 300 KHS
	• capacity	500 t/h
	• head	209.7 bar
Cooling water system		
Equipment supplier	• cooling water pumps	Jastrebac – Niš
	• hydromechanical equipment	Goša / Metalna
Cooling water pumps (2x50% per power unit)		
	• type	SEZ 1500–1420 VR
	• designed capacity	7.02 m^3/s
	• head	12 m
	• electromotor power	1,330 kW
	• number of revolutions	370 min^{-1}

Fuel (crushed pit coal) is conducted from bunkers to dropping chutes using a system of eight plate feeders and ten rubber belt feeders. The fuel is conducted from the dropping chute into the recirculation duct in which the fuel is dried. Ground fuel is conducted from the mill, through the separators and air mixture ducts, to the coal dust burner.

For igniting and stabilizing the combustion at lower loads, the design envisages eight heavy oil burners. The fuel is sprayed using compressed air. Capacity is regulated by changing the pressure in the return line within the range of 50-100%.

The main concept of construction of TPP Kostolac B envisages a centralized plant for chemical preparation of additional demineralized water for compensating the losses in the water-steam circular flow, which would satisfy the needs of four power plant units of 350 MW.

In the first phase of power plant construction, a CWT facility was built and two demineralization lines were installed with the capacity of 50 m^3/h each, as well as one line for external regeneration of ion exchange resins from the CWT plant, and, for the needs of phase II, space was left for two more demineralization lines of 50 m^3/h, as well as the space for another external regeneration line. Additionally, due to large consumption of demi water for the needs of power units B1 and B2, as well as due to the delivery of significant quantities of demi water to TPP Kostolac A, another demineralization line of 100 m^3/h was installed. Thereby, the space envisaged for additional demineralization lines for phase II was taken.

In addition to demineralization lines, the existing CWT plant also includes four demi water tanks with the capacity of 1,000 m^3 each.

The CWT plant is supplied with raw water from four welds located along the bank of the river Mlava. The procedure of preparing demi water includes: iron removal (aeration), filtration, ionic decarbonisation, CO_2 degassing and demineralization of water.

For the needs of all four power units, in addition to the CWT facility, the following buildings were also constructed in the first phase of power plant construction:

- two raw water pools with the capacity of 240 m^3,
- drinking water pool with the capacity of 240 m^3,
- two pits for waste waters neutralization from the ion changing resins regeneration with the capacity of 190 m^3 each.

The main chemicals used for water preparation are hydrochloric acid (HCl) and sodium hydroxide (NaOH), stored in metal rubberized (anticorrosion protection) tanks 4x50 m^3 for HCl and 2x50 m^3 for NaOH. The tanks are located outdoors, provided with a tub (protected with epoven) that can receive the entire quantity of chemicals in case of tank leakage or rupture. The tub is connected with the neutralization pit through a channel, and dilution with water in the neutralization pit is envisaged in case of accident on the tanks. Decantation point is coated with epoven, resistant to chemical and mechanical action. Decantation is performed using pumps.

In the water-steam system, hydrazine hydrate (levoxine) and ammonium hydroxide are used for removing oxygen and adjusting pH value. These chemicals are stored in a covered warehouse in which oils and lubricants are also stored.

The said chemicals are stored in PVC barrels of 50, 200 and 250 litres.

The average annual consumption of main chemicals used for the operation of power units B1 and B2 is shown in Table 3.2.1-2.

Table 3.2.1-2: Average annual consumption of chemicals (tons)

It. no.	Name	Maximum daily	Average monthly	Average annual
1.	HCl	7.561	78.765	945.18
2.	NaOH	3.645	37.97	455.6
3.	NH_4OH	0.0856	0.892	10.7
4.	N_2H_4OH	0.127	1.325	15.9
5.	Heavy fuel oil	39.888	415.5	4986
6.	Oils and lubricants	0.263	2.736	32.84
7.	Na_3PO_4	0.007	0.725	8.7

In addition to the demineralization and external regeneration equipment, a drinking water production plant with the capacity of 90 m^3/h is also located in CWP facility, as well as tanks for the preparation of diluted solutions of hydrazine and ammonium hydroxide for conditioning the condensate and feed water with accompanying pumps. Storage and preparation of N_2H_4 and NH_4OH solutions are performed in a separate room, whereas the line for producing drinking water is located in the production hall of CWP facility.

With the aim of assessing the possibility of using the existing CWP facility and equipment for the needs of the new power unit, the following has been considered: the available capacity of production lines, the quality of produced demi water, the state of the equipment and available space.

After examining the consumption of demi water in the previous five years, it has been concluded that monthly consumption ranged from 36,000 to 60,000 m^3, reaching the maximum during winter months, considering that demi water from TPP Kostolac B is also used for compensating the losses in the heating system of TPP Kostolac A. The production capacity of existing demineralization lines enables, with the appropriate number of regenerations within a month, a production of ~ 65,000 m^3, on the basis of which it may be concluded that the current capacity of CWP plant would not be able to satisfy the needs of the new power unit throughout the year.

The current quality of produced demi water satisfies the requirements of the existing power units, but taking into account stricter requirements with respect to the quality of feed water for boilers with supercritical parameters, as well as the possibility of degrading the quality of demi water in the future operation of lines, due to the ageing of equipment, providing the required quality of boiler water for the needs of the new power unit is brought into question.

Considering everything above said, as well as the fact that, in the existing CWP facility, there is no available space for installing a new demineralization line and a new external regeneration line, and there is no space for expanding the facility on this location either, the construction of a new CWP facility is proposed, with all related systems and buildings on the location in the extension of the new power unit, with the system for preparing limestone for the FGD plant.

Within TPP Kostolac B, there is also a plant for turbine condensate treatment, the aim of which is to maintain the prescribed quality of the working fluid in the water-steam cycle and, thereby, to reduce the formation of corrosion and deposits in the boiler and turbine plant of the existing power units.

Within TPP Kostolac B, various kinds of technological waste waters are produced, as well as sanitary and storm waters. Waste waters have not been treated so far, but some have been used for preparing the hydro mixture of ash and slag (waste waters from CWP plant, from slag cooling, muddy waters from the boiler plant), whereas some have been discharged in the recipient through the return cooling water channel.

With the aim of harmonizing TPP operation with the Regulation on emission limit values of pollutants in water, the process of designing and constructing the plant for the treatment of all kinds of waste waters is underway. So far, the documentation necessary for the preparation of tender for plant contractor has been done and the Location permit has been obtained. Further project implementation is expected in the near future.

In the previous period, the thermal power plant carried out a series of measures aimed at the revitalization of its facilities. Within the period 2008-2014, power units B1 and B2 were reconstructed (from preparing project documentation to puting the reconstructed power units in operation), with the aim of ensuring reliable and efficient operation of both power units of the thermal power plant in the next 15 years, i.e. around 100,000 operating hours.

The main result of carried out works is the provision of reliable operation of power units at the designed capacity of 348.5 MW, as well as harmonization with the required limitations for emissions into air. After the reconstruction, gross specific heat consumption of power units amounts to 10,000 kJ/kWh.

The main features of the electrical equipment installed in TPP Kostolac B are the following:

- generators with the power of 348.5 MW, three-phase, rated voltage 22 kV, power factor 0.85, number of revolutions 3.000°/min. The first generator (1988) was delivered by PR Poland, and the second generator (1992) by "Rade Končar", both acc. to BBC licence. The generators are cooled with hydrogen and water;
- generator terminals and connections with the set-transformer, power unit auxiliary transformer and excitation transformer are made from single-phase shrouded busbars 22 kV in which current and voltage measuring transformers are installed, as well as the generator switch produced by BBC;
- generator excitation system is static-type with thyristor rectifiers, produced by "Rade Končar";
- set-transformer 1AT (2AT) with the power of 410 MVA, three-phase, double-winding, transmission ratio 410/22 kV, connection YNd5, equipped with all necessary equipment for cooling, protection and signalization;
- power unit auxiliary transformer 1BT(2BT) with the power of 50/25/25 MVA, three-phase, three-winding, transmission ratio 22/6,6/6,6 kV, connection Dd0d0, produced by "Minel";
- general group transformer with the power of 50/25/25 MVA three-phase, three-winding, transmission ratio 110/6,6/6,6 kV, connection YNd5d5, production "Minel". Low-voltage consumers are supplied through dry-type transformers 6,3/0,4 kV with the power of 1,600 kVA, 1,000 kVA, 630 kVA, 400 kVA, transmission ratio 6.3/0.4/0.231, connection Dyn5;
- switchgears 6.3 kV are intended for supplying the motor of 6 kV and low voltage consumes through the transformer of 6.3/0.4 kV. Switchgears of 6.3 kV are metal-clad, produced by "Minel", with pull-out switches, In = 2,500 A, Ik = 44 kA, Iud = 100 kA. The connections between the switch gears of 6 kV and the corresponding transformers are carried out through shrouded bus bars of 6 kV;
- switchgears 0.4 kV are used for supplying all low-voltage consumers. Distribution systems are made of tin, they are free-standing, coffered free-standing with pull-out cassettes. Rechargeable batteries, rectifiers, inverters, diesel aggregates and appropriate switch gears are installed for supplying direct current voltage and safety voltage (220 V jss, 24 V jss, 48 V jss 220 V, 50 Hz.

Management and supervision of operation of power unit plants are carried out from the thermal control of power units I and II that are located at the elevation +12,00 in the bunker part. In the space between the thermal control of power units I and II, there is an integral electrical control (for two power units) so the state of the power unit electric power system can be monitored in one place.

Each power unit thermal control is divided into the operational and the non-operational part. The control panel and dashboard are located in the operational part of the thermal control, both in mozaik technique, delivered by "BBC". The panel and the boards are equipped with all necessary command and signalling elements installed in a simplified technological plant scheme.

The characteristics of the architectural buildings within TPP Kostolac B are described below.

Within the main plant facility, there is a mechanical room (base dimensions 32x120 m, height 33.5 m), bunker tract (base dimensions 12 x 125 m, height 52.3 m), boiler room (base dimensions 65x120 m, height 50.5 m), two lift towers (a/b structure, base dimensions 6.75x7.2 m, height 84 m), chimney (a/b structure with the height of 250 m, the outlet external diameter of 9.8 m, base external diameter of 23 m) and buildings located in front of the line A (transformer foundations, devices supports, oil pits, transformer fire protection facility, firewalls, shut-off chambers, diesel aggregate foundations, track and junction foundations).

The mechanical room and the bunker tract have an a/b basement at the elevation –4.2 m and an a/b plate at the elevation ±0.00, whereas the boiler room has no basement, and the plate at the elevation ±0.00 is resting on the ground. The aboveground support structure is frame-type made of steel hollow sections connected by longitudinal and transversal braces (13,480 t of steel).

When it comes to large foundations, the turbine table foundation and the feed pumps foundations are located in the mechanical room. In the boiler room, there are eight a/b mill foundations and two a/b foundations of fresh air fans around each boiler foundation, all block-type.

In the chemical water treatment system, the main building is the chemical water treatment facility with base dimensions of 40.9x41.4 m, height of 9 m, 4 m in the annex.

Cooling water system consists of the following structures: feed canal from the Danube to the pumping station (earthen channel) including a siphon beneath the river bed of the Mlava (a/b channel containing four pass-through boxes), the relocated river bed of the Mlava with developed new embankments of the river Mlava, the cooling water pumping station, the shut-off chambers (a/b structure) and the return water channels (a/b channel from one, two and four pass-through boxes).

Within the raw water system, there are four wells with technical water, with the depth of 90 m and pipe diameter of ∅ 200 mm.

Coal supply system consists of the coal stockyard (for 700,000 t of coal), conveyor belts and facilities. The buildings in the coal stockyard are steel structures. Bridge conveyors are steel structures (width around 5 m and height 3 m, a trapezoidal sheet cladding for two conveyor belts) that connect the transfer buildings via conveyor belts delivering coal into the MPF.

Technical gases system consists of the facilities of electrolysis station (basis dimension 12x24 m height 6 m), CO_2 storage (basis dimension 9x13 m and height 4 m), hydrogen storage (basis dimension 13x27 m and height 6 m) and argon, acetylene and oxygen storage (basis dimension 8x20 m and height 4 m).

Liquid fuel system consists of the external heavy fuel oil facility (basis dimension 9,3x40 m height 6 m) and steel heavy fuel oil tank with a tub.

3.2.2. Review of Measures for Protecting the Environment from the Operation of TPP Kostolac B

In addition to the measures aimed at extending the power units operation, with increasing the energy efficiency and reliability of their operation, revitalization programs also included the improvement of environmental protection measures, in accordance with the requirements of current regulations within this field in Serbia and the EU. The carried out measures primarily included the reconstruction of electrostatic precipitator plants in both power units, thereby enabling the reduction of powdery matter concentration at the FGD plant inlet to the values of 50 mg/m^3 (under referential conditions).

In the power unit B1, boiler plant reconstruction works included the introduction of primary measures for reducing nitrogen oxides emission (phase combustion, adding air over the flame zone – OFA), aimed at keeping the concentrations of nitrogen oxides in flue gas ≤ 200 mg/m^3. In the power unit B2, these measures were not carried out during boiler reconstruction in 2010. However, emission measurements in power unit B1 did not verify the fulfilment of the stated goal, so the technical documentation is being prepared by which the achievement of the set LVE will be ensured for both power units using additional measures. According to current agreed deadlines, (The Law on Agreement on Common Electricity Market for Eastern European Countries) the set LVE must be achieved by the end of NERP validity period, i.e. by the end of 2027, according to the planned time schedule for other thermal power units.

Moreover, the system for transporting and dumping ash and slag has been reconstructed at which the thin slurry technology and dumping of ash and slag has been replaced with the thick slurry technology (ratio of solid and liquid phases ≈ 1:1).

The transport of ash and slag with a reduced amount of water, as well as the dumping of dense mixture on a new location within OPM Ćirikovac, started in August 2010. The designing and construction of the new dump site were carried out in accordance with the Regulation on Landfill Disposal of Waste, which means that ground waters pollution has been eliminated and the recirculation of free water has been enabled, as well as its reuse in the system for transporting the dense hydro mixture. This manner of ash and slag dumping has also reduced significantly the scattering of ash from the dump site surface, which was one of the biggest problems in the previous period of power plant operation.

The new ash collecting system also enables the possibility of loading the ash directly from the silo into truck cisterns, with the aim of selling the ash to third parties.

The construction of a FGD plant for power units B1 and B2 is underway, this plant being based on the application of wet limestone-gypsum process, with the preparation of limestone suspension on the power plant location through the wet grinding of grained limestone and the process of obtaining dry gypsum in the vacuum filter.

A new wet chimney, with the height of 180m and with two flue pipes (one for each power unit), will be built for the emission of treated flue gas.

Other planned environmental protection measures primarily include the construction of an integral plant for treating the waste waters resulting from the thermal power plant operation, also including the FGD plant, as well as the waste waters from the new power unit B3.

Within TPP Kostolac B, the planned scope of environmental monitoring is carried out, the results of which are presented in Annual Reports prepared for the entire Branch TE-KO Kostolac.

3.2.3. Emission of Pollutants from Power Units B1 and B2 into Environment

Summary values of emissions from power units B1 and B2 TEKO B are given below, these values being forecasted for the period after putting the new power unit B3 in operation.

The main characteristics of power units B1 and B2 after reconstruction are shown in Table 3.2.3-1.

Table 3.2.3-1: Parameters of power units B1 and B2 operation after reconstruction

Parameter	Value
Maximum continuous steam production (100% boiler load)	1,000 t/h
Power at the generator	348.5 MW
Boiler efficiency rate	87%
Coal consumption (medium quality)	445 t/h
Temperature of flue gases at the boiler outlet	160ºC
Concentration of nitrogen oxides in the flue gas	280-500 mg/m^3
Concentration of carbon–monoxide in flue gas	$<$100 mg/m^3
Concentration of sulphur oxides in the flue gas	200 mg/m^3
Concentration of powdery matter in the flue gas	20 mg/m^3

Emissions into air from the plants and systems of the existing power units of TPP Kostolac B are shown in Table 3.2.3-2. The presented values imply that all measures for reducing emissions into air have been implemented, except for nitrogen oxides.

Table 3.2.3-2: Review of all emitters into air from power units B1 and B2 of TPP Kostolac B

Source of emission	Flow, Nm^3/h	Emission kg/h
1. Wet chimney	2,009,022 (wet gas) 1,485,418 (dry gas)	
– Sulphur dioxide	86	259
– Nitrogen oxides	180-300	360-650
– Carbon dioxide	171,724	337,875
– Chlorides	3.9	6.44
– Fluorides	4.3	3.84
– Powdery matter		32
2. Bag filter at limestone transfer point (2 pcs) – Limestone particles	20.000	400
3. Bag filter on daily limestone silo – Limestone particles	3,000	150
4. Delivery and storage of limestone – Limestone particles		Up to 150 g per one unloading*
5. Coal stockyard		0.2-0.4 kg/h/ha**
6. Gypsum dump site within OPM Drmno		Emission of gypsum particles from the dump site is prevented by wetting the dump site surface
7. Ash and slag dump site within OPM Ćirikovac		Emission of ash and slag particles from the dump site is prevented by wetting the dump site surface

* Environmental Impact Assessment Study for FGD Plant of Power Units B1 and B2 of TPP Kostolac B, Energoprojekt Entel, Belgrade, 2015

** Environmental Impact Assessment Study for Expanding the Capacity of OPM Drmno, The Faculty of Mining and Geology, Belgrade, 2013 (assessment acc. to U.S. EPA AP-42 Emission Factors Compilation)

The balance of water consumption and waste waters generation for TPP Kostolac B in 2014 is shown in Table 3.2.3-3.

Table 3.2.3-3: Balance of waters for TPP Kostolac B in 2014 and 2015

Parameter	Quantity 1,000 x m^3/year	
	year 2014	**year 2015**
Affected waters		
- surface	361,644	728,357
- ground	851,340	919
Discharged waste waters		
- return cooling water	354,090	718,236
- overflow and drainage waters from ash dump site	7,177	7,803
- sanitary waste water	321,540	332

During 2014, around 650,000 t of ash and slag were generated, and around 1,251,500 tons during 2015.

3.2.4 Environmental Protection Management and Monitoring

TPP Kostolac B has established and has been implementing three quality standards: ISO 9001, ISO 14001 and OHSAS 18001. During the implementation of activities/processes described by appropriate procedures, the management and the employees apply the same environmental management system (EMS) in accordance with the standard ISO 14001 and the occupational health and safety management system (OH&S management system) in accordance with the standard OHSAS 18001, within the limits referring to the described process. Furthermore, TE-KO Kostolac is starting the introduction of cleaner production methodology in its plants.

The waste resulting from the retirement of capital assets, i.e. tools and small inventory, is managed in accordance with the procedure EHSP 06 – Hazardous and non-hazardous waste management. Municipal waste, as well as PET packaging, is disposed in containers set up particularly for this purpose. Removal of municipal waste or discarded products, i.e. PET packaging, is regulated through the agreement with organizations authorized to remove these kinds of waste and through other appropriate documents.

Chemicals handling is prescribed by the procedure EHSP 08 – Using and storing hazardous substances.

Environmental pollution monitoring consists of several systems. Measurement of pollutants emission is carried out in accordance with the Regulation on emission limit values of pollutants in the air. The said regulation includes periodic, control, garantee, continuous and special measurements of emission. The activities of systematic inspections are carried out in the company Thermal Power Plants and Mines Kostolac, and they refer to the emissions of harmful and hazardous substances in the air and the quality of air within the area of the company TE-KO in accordance with the procedure EHSP-05. Periodic emission measurements are performed by authorized institutions on the basis of the Program for measuring flue gases and powdery matter emissions in the company TE-KO Kostolac. The periodic measurement program includes:

- measurement of emission of total powdery matter, SO_2, NO_x, S, CO, HCl and HF, in particular: monthly concentrations of harmful substances, reduced to normal conditions, dry gas and 6% O_2, (mg/m^3), mass flows of harmful substances (kg/h) and determining the harmful substances emission factor (kg/MWh);
- determining the physical and chemical parameters of coal, slag and electrostatic precipitator ash.

Having finished the measuring, the authorized institution submits a Report on testing – periodic measurement of harmful and hazardous substances emissions into air, for each power unit separately (form defined by the authorized institution). Comparative (control) measurements of emission into air are performed on the power units of TPP Kostolac B, on which there is a continuous measurement of mass concentrations of harmful substances.

Guarantee measurements of output mass concentrations of harmful substances are aimed at checking the guaranteed output mass concentrations of harmful substances at the outlet from the flue gases treatment plant. The measurements are performed by authorized institutions on the basis of the Program of guarantee testing of electrostatic precipitators (ESP), with the aim of checking the guaranteed output mass concentrations given by the ESP equipment supplier. The requirements of the company TE-KO is that mass concentrations of powdery matter in flue gases in the plane behind ESP should be < 50 mg/m^3. The institutions performing the mentioned measurements are authorised by the competent authority, and they submit The Report on Guarantee Testing (ESP) (form defined by the supplier) to the company TE-KO, within 30 days after the performed measurement. The company TE-KO is obliged to submit these reports to The Ministry of Environmental Protection.

In accordance with the legislation, continuous measurements of harmful substances emissions into air are carried out on the power units of TPP Kostolac B, in particular the measurement of mass concentrations emission (mg/m^3, reduced to normal conditions, dry gas and O_2 6%) for pollutants: total powdery matter, SO_2, NO_x (reduced to NO_2), CO and O_2. The reports on measurement results specify the number of measurements that deviate from the limit values of emission (ELV), the calculated values of harmful substances emissions, expressed in the form of mass flows (kg/h, t/year) and the emission factors (kg/MWh).

The report on continuous measurements of emission in flue gas (recorded in electronic form, on the portal) for TPP Kostolac B is made daily by the responsible persons from the Production Sector and the Maintenance Sector. The operation of power units EF is monitored in accordance with the instructions – General plant instructions for electrostatic precipitators.

In addition to the continuous measurement of emission, the operation of equipment on EF (high voltage devices, heaters and rapper drive motors etc.) is monitored, considering he possibility of parameterizing the rapping time and cycle on the controller itself, adjusting to the operating conditions of electrostatic precipitators. The setting of the operating cycle of these motors is directly linked with the immediate experience of the power plant staff, which enables an increase in the efficiency of EF operation. The monitoring includes:

- voltage and current values,
- detection of the level of ash in hoppers: minimum and maximum allowed level,
- rapper motors,
- emission electrodes: operation detection, revolutions detection, and detection of defect on the axle with hammers,
- collection electrodes: operation and defect detection.

All analogue values, electrical and nonelectrical, as well as the alarm lists of defects are stored on the hard disk. All defects and interventions are recorded by the assistant of shift manager for electrical installations, the power unit manager or the power unit operator in the Logbook of defects and damage on power unit equipment (defined by the procedure QP 22). Every morning, engineers from the Maintenance Sector are introduced with the Work requirements and they take appropriate measures in accordance with the procedure QP 12, Maintenance process management in TPP Kostolac B. Continuous measurements of powdery matter emission enable the monitoring of the conformity of EF operation with respect to LVE (50 mg/m^3) during the calendar year. In case of failure of a large number of sections, the emission of powdery matter into air increases, and according to the agreement with dispatcher, the power unit (boiler) is stopped. If the power unit (boiler) stoppage jeopardizes the operation of the electric power system, the power unit (boiler) remains in operation until the threat of jeopardizing the operation of the electric power system has been overcome.

Air quality control is performed on the basis of the Program for controlling the quality of air within the area of the company TE-KO Kostolac, drawn up on the basis of the wind rose and the statistical data on air pollution. Measuring points are arranged on the basis of recommendations of corresponding inspection bodies and local self-government. The Program for controlling the quality of air within the area of the company TE-KO Kostolac includes the control of emission:

- of sulphur dioxide,
- of soot,
- of total particulate matter - TPM.

Authorised institutions submit monthly and annual Reports on air quality testing (imission measurement) in the close vicinity of the company TE-KO Kostolac (form defined by the supplier), and the Environmental Protection Management Department keeps the Record of carried out sampling of SO_2, TPM, soot and the measuring results in the form of a protocol, i.e. tables in free form.

The monitoring results are shown in Annual reports prepared for the entire Branch TE-KO Kostolac.

3.3. Description of Project for Power Unit B3 of TPP Kostolac B

3.3.1. Description of Previous Project Implementation Activities

The activities on the project of construction of the second phase of the thermal power plant Kostolac B began in the period 2009–2010 by the preparation of pre-project documentation titled ”Previous works on the construction of new thermal power plant using coal from OPM Drmno, Kostolac coal-bearing basin” (Energoprojekt ENTEL, Mining Institute). The aim of preparing this documentation was to define the characteristics of the reference power unit that was to be built on the location of TPP Kostolac B.

Within this documentation, extensive analyses were carried out that included the following aspects:

- location analysis;
- analysis of the possibility of cooling water supply;
- analysis of raw material basis and provision of required coal quantities;
- possibility of solid waste disposal;
- analysis of ecological capacity of the location;
- analysis of requirements and possibility of providing heat energy from a new source;
- electric power analysis (the possibility of fitting the new power unit into the electric power system and the possibility of power transmission from the new source to consumers).

Comprehensive analyses of all aspects stated within the preliminary works resulted in the conclusion that a power unit with the capacity of up to 600 MW can be built within the phase II of TPP Kostolac B.
On the basis of this, within the period 2011–2012, the ”Preliminary Feasibility Study with General Design for Constructing New Power Unit B3 on the Location of TPP Kostolac B” (Energoprojekt ENTEL, Mining Institute) was prepared, in which two variants of capacity for the new power unit B3 were considered, 350 MW and 600 MW.

On the other hand, on the basis of the Interstate Agreement on Economic and Technical Cooperation in the Area of Infrastructure concluded between PR China and the Republic of Serbia, a Framework Contract Agreement was concluded in 2010 with the Chinese company CMEC (China Machinery Engineering Corporation) on the implementation of a package of projects in the Thermal Power Plant and Mines Kostolac.

The first phase of this package included the revitalization of power units B1 and B2, the construction of desulphurization plants for these power units, the construction of port, road and railway. A separate contract was drawn up for the first phase and its implementation is underway, and after this, the representatives of the Purchaser (PE EPS and the company TPP Kostolac) started the activities on the preparation of contract for the Second phase.

The second phase of the Package of projects of TPP Kostolac includes the construction of a new power unit B3 (it has been decided that the final capacity of the new power unit B3 should be 350 MW) and the expansion of capacity of OPM Drmno from 9 to 12 million tons annually. In this manner, the construction of power unit B3 will round up the construction of thermal power capacities on the location of TPP Kostolac B.

The financing of project Kostolac B3 should be carried out under preferential conditions from the financial package of the Government of PR China intended for sixteen Central and Eastern European countries.

3.3.2. Technical and Technological Concept of Power Unit

The thermal power unit TPP Kostolac B3 fired by lignite from the open pit mine OPM Drmno will have the electrical power of 350 MW at the generator, whereas the expected power output on the grid is around 308 MW. The power unit will be connected to the electric power system of Serbia (EES) on the voltage level of 400 kV, through the transmission line and switchgear located next to the power plant.

The envisaged power unit is of modern design, with supercritical steam parameters and high efficiency. Heat is conducted from the condenser by streaming, using river water. The power unit will be engaged for the needs of EES in the basic part of the load diagram. The expected average annual engagement time for the power unit, reduced to full capacity, amounts to 7,500 h/year. The assumed availability of the power unit is 90%.

The boiler has been designed for operation with supercritical parameters of live steam of 254 bars and 571^{o}C. The boiler is tower-type, for the combustion of pulverized flying coal, with variable (sliding) operating pressure and with one reheating of steam, with the parameters of 37.46 bars and 569^{o}C at the boiler outlet.

The condensing steam turbine for operation with supercritical parameters of live steam and one additional heating of steam has three cylinders with single-flow turbines of high and medium pressure (HPT and MPT), placed into a common external casing, and one double-flow turbine of low pressure (LPT). Parameters of live steam at the HPT inlet are 242 bars; 566^{o}C, and at the MPT inlet 36.05 bars, 566^{o}C.

It is envisaged that the turbine regulation should be with sliding pressure, and the envisaged scope of power unit operation under these operating conditions is from 45% to 100%.

The regenerative heating of condensate and feed water is carried out in multiple stages in four low-pressure heaters (LPH), by one direct heating in the mixing heater - deaerator (DA) and three high-pressure heaters (HPH) by conducting steam from adequate unregulated turbine reductions.

The condensation of output steam is carried out in a surface-type condenser with two passes in one layer.

The turbine unit is also equipped with all other auxiliary systems: feed pumps with appropriate pre-pumps (buster pumps) with a common electromotor drive with the capacity of 3 x 50%, pumps for the main condensate 2 x100%, auxiliary and sealing steam systems, a system for achieving and maintaining vacuum in the condenser, a technical cooling system, an oil turbine system, condenser pipes cleaning system and other systems.

A three-phase synchronous generator with the following features is envisaged:

- Active power 350 MW
- Power factor (cosφ) 0,85
- Apparent power 412 MVA
- Rated voltage 22 kV
- Number of revolutions 3.000 min^{-1}
- Frequency 50 Hz

The excitation system of the generator will be static. It has been envisaged that generator cooling will be combined, in particular: stator winding with water, and the magnetic circuit and rotor winding with hydrogen. Generator insulation grade will be F, and temperature increase will be grade B.

The power generated in the power unit B3 will be rendered to the electric power grid of Serbia through the existing switchgear SG 400 kV located in the close vicinity of the new power unit.

For the needs of own consumption of the new power unit, an energy transformer 110/6,6/6,6kV is envisaged, which will also be connected to the existing SG 110 kV.

Open Pit Mine Drmno, which represents the raw material base for power unit B3, belongs to the eastern part of Kostolac coal basin. Power units 1 and 2 of TPP Kostolac B and power units on the location of TPP Kostolac A are supplied with coal from this mine, and one portion of coal is allocated as consumer goods. Current designed capacity of OPM Drmno amounts to 9 x 10^6 t/year, provided that, as stated, an increase in coal production capacity of OPM Drmno from 9 to 12 million t/year is implemented within the project of TPP Kostolac B3.

The designed coal quality, as well as the envisaged scope of coal quality are shown in Table 3.3.2-1.

Coal is transported from the Mine using conveyor belt systems and it is delivered to the distribution bunker and reserve bunker that are located in front of the coal stockyard of TPP Kostolac. The following operations are carried out here:

- a portion of delivered coal is directed towards the thermal power plant Kostolac A,
- a portion of coal is allocated as consumer goods,
- the remaining portion of coal is directed towards the crushing plant where it is crushed down to the size of -40+0 mm, and from there it is transported towards the coal stockyard.

Table 3.3.2-1: Project characteristics of coal from OPM Drmno for the Unit B3

Characteristics	Guarantee coal	Coal of lower limit quality	Coal of higher limit quality
Lower heating value Hd, kJ/kg	8.000	7.200	8.800
Ash content A, %	21,5	22,8	19,9
Moisture content W,%	43,38	43,5	43,20
Total sulphur Su, %	1,22	1,13	0,99
Sulphur in ash Sp, %	0,52	0,46	0,51
Combustible sulphur Sg, %	0,70	0,67	0,48
Carbon, C, %	23,0	22,49	25,35
Hydrogen, H, %	2,15	2,26	1,90
Oxygen, O_2, %	8,40	8,6	8,3
Nitrogen, N, %	0,35	0,32	0,36

Coal stockpile was initially designed to be used by the power units B1 and B2 (2 x 348,5 MW), so that two more identical units of the second phase of construction of the power plant (as it was planned at the time). So that in the transfer structure IV there was an outlet left for the connection of the conveyor of the second phase, which is actually the subject of this project. Besides, it was planned to expand the coal storage when second phase construction starts by building the third line, which is within the project TE Kostolac B3.

The third line will be equipped with a crusher (-30 mm) and a stacker/reclaimer machine for stacking and reclaiming coal from the stockpile. Detailed view of solutions and technical parameters of the third line will be given in the following chapters of the Study (3.3.4.).

Cooling of the Unit B3 is to be done by the open flow-through system with water from the Danube. Considering the fact that in the existing pumping station of cooling water (for Units B1 / B2) there has not been intended the space for storing additional equipment for the new unit, the construction of the new (separate) structure of the pump station for the Unit B3 was designed, parallel to the existing structure, using the existing supply channel of cooling water from the Danube.

In order to cover losses in the water - steam circular movement of the unit B3, there will be built a new plant for the chemical treatment of demineralized water, with two lines with capacity 2x50 t / h. The plant will be supplied with water from the Danube.

Emission of flue gas in the air will be carried out through a new, wet chimney. Before emission, flue gas cleaning is done in the devices implementing the necessary measures to protect the air. These measures are related to the control of emissions of sulphur and nitrogen oxides and powdery matter.

The control of emissions of sulphur oxides is achieved through the installation of flue gas desulphurisation (FGD) with the applied wet method, using limestone as a sorbent and having gypsum as a by-product.

Reducing emissions of powdery matter is achieved in three stages: first, in the dry electrostatic precipitator, and then in contact with the recirculation suspension in an absorber for desulphurization and finally extracting the remaining particles and aerosols in a wet electrostatic precipitator.

Reducing emissions of nitrogen oxides is achieved by applying primary measures within the boiler plant (installation of low NOx burners in order to control the temperature of combustion in the boiler combustion chamber and multiple-stage fuel combustion by introducing additional ("over-fire") air. If necessary, it is possible to upgrade the secondary measures to further reduce emissions of nitrogen oxides.

The implementation of the mentioned measures for the purification of flue gases, produced emissions complied with European standards are achieved, which are expected during the commissioning of Unit B3 (according to the current obligations of the Republic of Serbia relating to the new power units).

The limestone will be transported to the site by rail in a granular form. Within the power plant there will be built the unloading station for wagons and roofed storage of limestone. Preparation of limestone suspension will be done at the plant for wet grinding.

Deposition of solid combustion residues will be performed in OPM Drmno excavation area. It is envisaged to have a unified system of mechanical transport and disposal of ash, slag and gypsum suspension from FDG facilities.

The ash is collected in two collection silos, by use of the system of pneumatic transport and slag is collected in two separate silos by the system of internal mechanical transport. From these silos, ash and slag are dosed into the conveyors where the suspension of gypsum and additional water for moistening the mass is delivered and transported to the appropriate depositing cassettes within the area of OPM PK Drmno.

Apart from the described system for mechanical transport to the landfill, there is also envisaged the system for producing dry gypsum with a temporary storage at TE site, where the gypsum can be sold to third parties or transported to the gypsum stockpile by belt conveyor system that is being built within the FDG project of Units B1 and B2 .

The system of mechanical transport of ash, slag and gypsum from the Unit B3 is designed so that at a later stage it can accept the suspension of gypsum from Units B1 and B2.

Designed values of the most important output parameters of the Unit B3 TE Kostolac B are shown in the Table 3.3.2-2.

Table 3.3.2-2: Designed output parameters of Unit B3 TE Kostolac B

Parameter	Unit	Value
Gross power at the generator clamps	MW	350
Net power on the threshold of power plant	MW	308
Efficiency rate of Unit - net	%	37,317*)
Gross specific consumption of power unit heat	kJ/kWh	8.491*)
Air emissions		
- NO_x (dry gas, 6% O_2)	mg/Nm^3	200
- SO_2 (dry gas, 6% O_2)	mg/Nm^3	150
- Powder substance	mg/Nm^3	10

* for the designed value of coal of 8.000 kJ/kWh

Specific heat consumption of the turbine unit for nominal operation mode, at a condensation pressure of 0,042 bar and the temperature of the cooling water 19,5^{o}C amounts to 7,465 kJ / kWh, which corresponds to the turbine unit efficiency level of 48,226%.

As the guaranteed boiler efficiency rate is 0,888, and a coefficient that takes into account the heat losses in the steam line 0.99, gross efficiency level of the unit is 0,424, i.e. 42,397%, while the specific consumption of the unit is gross 8,491 kJ / kWh.

When burning project coal of lower calorific value 8,000 kJ / kWh, at rated load and under the designed conditions of the unit operation, the coal consumption will amount to 1.0391 tons / MWh, i.e. 363.7 tons per hour.

Net efficiency rate of the unit, in its own consumption of 11.98% and/or 41.93 MW, is 37.3%, which corresponds to net specific heat consumption of 9,651 kJ / kWh.

The unit will have optimum specific consumption of heat at a nominal gross electrical power of 350 MW. These parameters will be achieved with the electrical feed-pumps, with all regenerative heaters in operation and at designed temperature of cooling water of 19,5°C and the corresponding pressure in the condenser of 0,042 bar.

3.3.3. General layout solution of the unit B3 TE Kostolac B

The structures of the unit B3 will be located at the free space of the area of Power plant, southeast of the existing units B1 and B2, and to the south of the coal stockpile. The area envisaged for the construction of the Unit B3 is shown in the Figure 3.3.3-1.

Layout of the structures of the unit B3 is shown in the layout drawing of the structures, Annex 3.

New structures necessary for the unit B3, are fitted in the layout drawing of the existing structures, in accordance with the available space on the site, taking care of the existing infrastructure and the structures built in the first phase of the construction. Their position is complied with the orientation of the existing main technological systems of units B1 and B2.

Figure 3.3.3-1: TE Kostolac B incl. site for construction of Unit B3

During the construction of units in the first phase, some civil structures were designed and built, partially or completely, which by their capacity fulfil the needs of both phases of construction of TE Kostolac B. These are mainly common auxiliary plant, and/or parts of common auxiliary facilities and infrastructure facilities. With respect to the previous period and the changes that have occurred in the meantime, some of the structures which were then built and can still be used fully, some can be used with certain adaptations, and some cannot be used at all for the needs of the new Unit.

Common auxiliary plants, i.e. the common parts of auxiliary plants and infrastructure, built for the needs of Phase I and II, which can be used in full or with certain adaptations and / or upgrading are the following:

- Coal stockpile (with new line);
- Operation units for maintenance (incl. construction of the new workshop for the mills along the unit B3);
- Storage of hydrogen and station of CO_2;
- Discharging point of fuel oil and the pump station for liquid fueld and the construction of the new fuel oil tank. For the needs of placing second level pumps, a new pump station will be built near the unit B3. i;
- Cooling water system in the part of the water collecting point, water discharge with the embankment, with the construction of the new coolinf water pump station for the unit B3;
- Buildings, with envisaged adaptation/upgrading of existing management building;
- Roads, platforms, fences, parking lots;
- Oil and fuel oil storage;
- Bulldozer depot on the coal stockpile;
- Infrastructure installation on the site.

When fitting the structures of the unit B3 into the space provided at the site, next to the space occupancy by already built structures, special attention was paid to the planned upgrading and reconstruction of railway infrastructure within the power plant. It was provided for the heavy equipment from existing units to be pulled out by railway track running through GPO of unit B3.
Location of the new silos for ash will be close to the existing silos, while the silo for slag will be located near the GPO building, and a conveyor route for shipping the ash, slag and gypsum towards the landfill was planned to go along the route for gypsum transport from Units B1 and B2.

The plan envisages dismantling auxiliary facilities and parts of two warehouses with the existing units and on that site the chimney and a system for limestone will be located.

Also within the area for construction of unit B3 of TE Kostolac B, the room was left for possible future construction of CO_2 separation.

For the design of the new unit B3, special conditions from the relevant competent institutions were obtained, which are given in Annexes 4-15 of this Study.

Technological scheme of the Unit is shown in the figure, Annex 16 of this Study.

3.3.4. Overview of technical-technological solution for the Unit B3

A. Technological – mechanical section

<u>Boiler plant</u>

Boiler plant of the unit B3 includes:

- boiler;
- coal powder preparation system;

- air combustion system;
- hot flue gases system;
- boiler starting fuel system;
- afterburning gratings;
- slag discharge system;
- other auxiliary equipment and devices.

Steam boiler is instantaneous, tower type, fired by pulverized lignite and with reheated steam. It belongs to the group of boilers with supercritical parameters. Maximum production of fresh steam in continuous operation (BMCRE) is 1,032 t / h, which is 8.6% higher value of steam production required for guaranteed capacity of the turbine (350 MW) in continuous operation (for working conditions at TMCR, steam production is 950 t / h). The temperature of the fresh steam leaving the boiler is 571°C and of reheated steam 569°C.

Boiler is designed so that the parameters guarantee for the guarantee coal. The main design parameters of the boiler are shown in the Table 3.3.4-1.

Table 3.3.4-1 General design boiler parameters

Parameter	Description		
Boiler type	Tower, with supercritical parameters		
Main fuel	Lignite (quality as per table 3.3.2-1)		
Boiler working conditions	Unit	BMCR	TMCR
Calculated boiler efficiency	%	89,4	89,2
Guaranteed boiler efficiency	%		88,8
Fresh steam circulation	t/h	1.032	950,138
Temperature of fresh steam on the outlet of the boiler	℃	571	571
Fresh steam pressure at the outlet of the boiler	MPa	25,5	25,3
Temperature of flue gas behind the air heater	℃	165,6	168,9
Mass flow of flue gas behind air heater	t/h	198,44	190,96
Number of mills in operation	set	6	6
Coal consumption at 100% load	t/h	388.6	363.7
Technical minimum of the boiler operation (only for coal)	%	40	

The boiler is equipped with a three-stage fresh steam superheater, water heater, impermeable membrane screens, additional two-stage steam reheater and two rotary air heaters. All heating surfaces are horizontally built and are placed at the overhead of cold steam pipes.

From the top of the boiler, combustion products go via ascending channel lead in front of two rotary air heaters which is why at this point they are divided into two separate channels. After passing through the two air heaters, combustion products are introduced into the treatment devices and after treatment in a dry electrostatic precipitator, a system for flue gas desulphurisation (FGD) and wet electrostatic precipitator, they are taken into the chimney.

Boiler starting system is designed in such a way to provide a quick start of the boiler, as well as shutting down while ensuring optimal conditions in the evaporator. The starting system consists of separators, expansion vessel, starting tank, starting pumps, connecting pipes and collectors with appropriate reinforcement.

Temperature control of fresh steam and subsequently superheated steam is achieved through the radiator with injector. For controlling the temperature of fresh steam two steam injectors were installed behind the superheater P1 and P2. Water for injection is taken from the feed water line in front of the boiler. For controlling the temperature of superheated steam the injection is installed on the connecting pipelines of reheaters MP1 and MP2. Water for the injection is taken from the boiler feed pump.
One-pipe, membrane-welded boiler is designed to work with sliding pressure. The pressure at the outlet of the boiler follows the turbine load.

The boiler is once-through type. The design of the boiler is adapted to burning pulverized coal with the applied primary measures for the reduction of nitrogen oxide by installing low NOx burners and the introduction of tertiary air in the zone above the burner of coal dust - OFA procedure. Firing is done with coal dust by eight tangentially positioned pulverized coal burner. Two burners are mounted on each side of the combustion chamber. For movement and stabilization of boiler operation fuel oil burners are built.

From daily bunkers the coal is delivered over the respective dispensers to the plant for preparation of pulverized coal, by means of chain conveyors. Coal is delivered to the respective recirculation ducts, where it is mixed with the transport fluid (primary air and cold flue gases being recirculated from the duct behind the electrostatic precipitator) and entered into the mill.
The plant is equipped with eight fan mills. They are sized so that at maximum boiler production in continuous operation, 6 mills work, one is a backup, and one is under repair. In the very mill, in which grinding and drying processes run simultaneously, the coal is further intensively dried until a suitable humidity and the fineness of grinding of the coal powder is reached. Thus prepared coal powder together with the transport fluid is taken through the air mixture duct to the burner.
Below the boiler chute there are also two afterburning gratings with the possibility of regulating the speed of movement. Gratings are movable with chain-drive, longitudinally mounted with discharge towards the center of the combustion chamber.

Below the gratings, there is situated slag remover with scrapers and electric motor drive for continuous removal of slag from the furnaces.

The necessary amount of combustion air is provided with two pressure fans of fresh air and related ducts and flaps that allow the control of flow.

Combustion air is heated in two rotary air heaters. Air heaters are equipped with installation for washing heating surfaces with water, steam soot blower on the upper and lower sides and fire protection installation.

To preheat the fresh air before it is heated in rotary heaters, at low external temperatures, start-up of the unit and reduced boiler loads, two steam air reheaters were installed.

For preheating the fresh air before it is heated in rotary heaters, at external temperatures, the start-up of the unit and reduced loads of the boiler, two steam air reheaters were installed.

For flue gases extraction from the boiler and their suppression to the chimney, two flue gas fans were installed with flow control.

In order to clean the heating surfaces boiler is provided with water soot blower in the furnace and steam soot blowers in the convection part of the boiler.

In addition to the named equipment and systems, the boiler is equipped with all auxiliary equipment necessary for the proper functioning of the boiler plant, as well as for economical and reliable operation. Auxiliary equipment includes all the necessary boiler fine fittings, heavy duty fittings, and sampling system. The boiler is also equipped with all the necessary stairways and platforms for servicing the equipment.

Turbine unit

The characteristics of turbine unit are shown on the basis of technical specifications submitted by the company, CMEC. The condensation steam turbine was envisaged (of supercritical parameters), with the set of regeneration heaters of the condensate and feed water and condenser cooled by flow cooling system. Supply of cooling water is done from the Danube river.

Turbine unit includes the following main (technological and mechanical) equipment:

- high pressure turbine (HPT) and low pressure turbine (MPT) in common external housing,
- low pressure turbine (LPT),
- combined stop and control valve at the inlet of HPT,
- combined stop and control valve at the inlet of MPT,
- condenser and devices for vacuum sustaining,
- high and low pressure devices,
- feed tank with deaerator,
- main condenser pumps (2x100%),
- feed pumps with electric motor drive (3x50%),
- by-pass of high and low pressure,
- oil system of turbine,
- electric-hydraulic system of turbine control,
- turbine sealing system,
- turbine drainage system,
- technological and mechanical part of the equipment of the generator and auxiliary systems of generators,
- other auxiliary systems (machine for low rpm of turbine etc.).

Within turbine unit it is envisaged to have the unit for chemical treatment of the condenser during the operation of the unit.

The Unit B3 is envisaged as highly efficient unit for the operation under basic load, nominal power 350 MW, supercritical parameters. Scope of work of the unit under conditions of work with sliding pressure is from 45% to 100%, thus securing the appropriate flexibility of turbine unit operation.

General technical parameters of turbine unit, at the nominal load is given in Table 3.3.4-2.

Table 3.3.4-2: Technical parameters of the turbine unit

Turbine type	Extraction condensing turbines - with one steam reheating	
Power on the generator, nominal	350	MW
Turbine number of rotation	3.000	min^{-1}
Turbine cylinder number	3	
Number of superheaters	1	
Number of turbine extractions	8	
Efficiency level of turbine unit	48,273	%
Specific consumption of heat of turbine unit	7457.5	kJ/kWh
Fresh steam flow (nominal and maximum permanent)	950,14/1032	t/h
Temperature of steam at the outlet of superheater and reheater of the boiler	571/569	°C
Pressure of fresh / reheated steam at the boiler outlet	254/38,67	bar
Reheated steam flow	824.047	t/h
Temperature of cold reheated steam- outlet HPT	316,3	°C
Pressure of cold reheated steam at the outlet of HPT	42,96	bar
Temperature fresh/hot reheated steam	566/566	°C
Steam pressure at the inlet of MPT	38,67	bar
Temperature of feed water at the inlet of the boiler	276,5	°C
Nominal pressure of condensation	0,042	bar
Nominal temperature of cooling water	19,5	°C

General balance scheme, for the nominal unit operation mode, is shown in the figure 3.3.4-2.

Maximum power of the unit, related to the unit having the primary control, is 377 MW (at fully open control valves of the turbine), at a flow of fresh steam of 1,032 t / h, or about 7.7% more than the nominal power of the unit. In both cases, fresh steam parameters were the same (242 bar / 566°C) and the temperature of reheated steam (566°C).

The steam turbine is a condensing type turbine, with one interheating of steam in the boiler, and eight non-regulated extraction of steam for the needs of regenerative heating of the main condensate and feed water. It is anticipated to have the regulation of sliding pressure.

In the constructive sense the turbine is made of many housings and basically it consists of:

- turbine of high and medium pressure, HPT and MPT,
- two current turbines of low pressure, LPT.

HPT and MPT have common external housing, separate internal housing with control circuits, common shaft – rotor, with working circuit of the turbines HPT and MPT, sealings, fast closing stop and control valves with drives.

Common external housing, is made of steel alloy for casting, from two parts, upper and lower, which are connected by horizontal flange and special bolts. Internal housing of HPT is vertically divided, and the connection of the two parts is secured by the rings that are heated and mounted on the external side. The internal housing of MPT is horizontally divided.

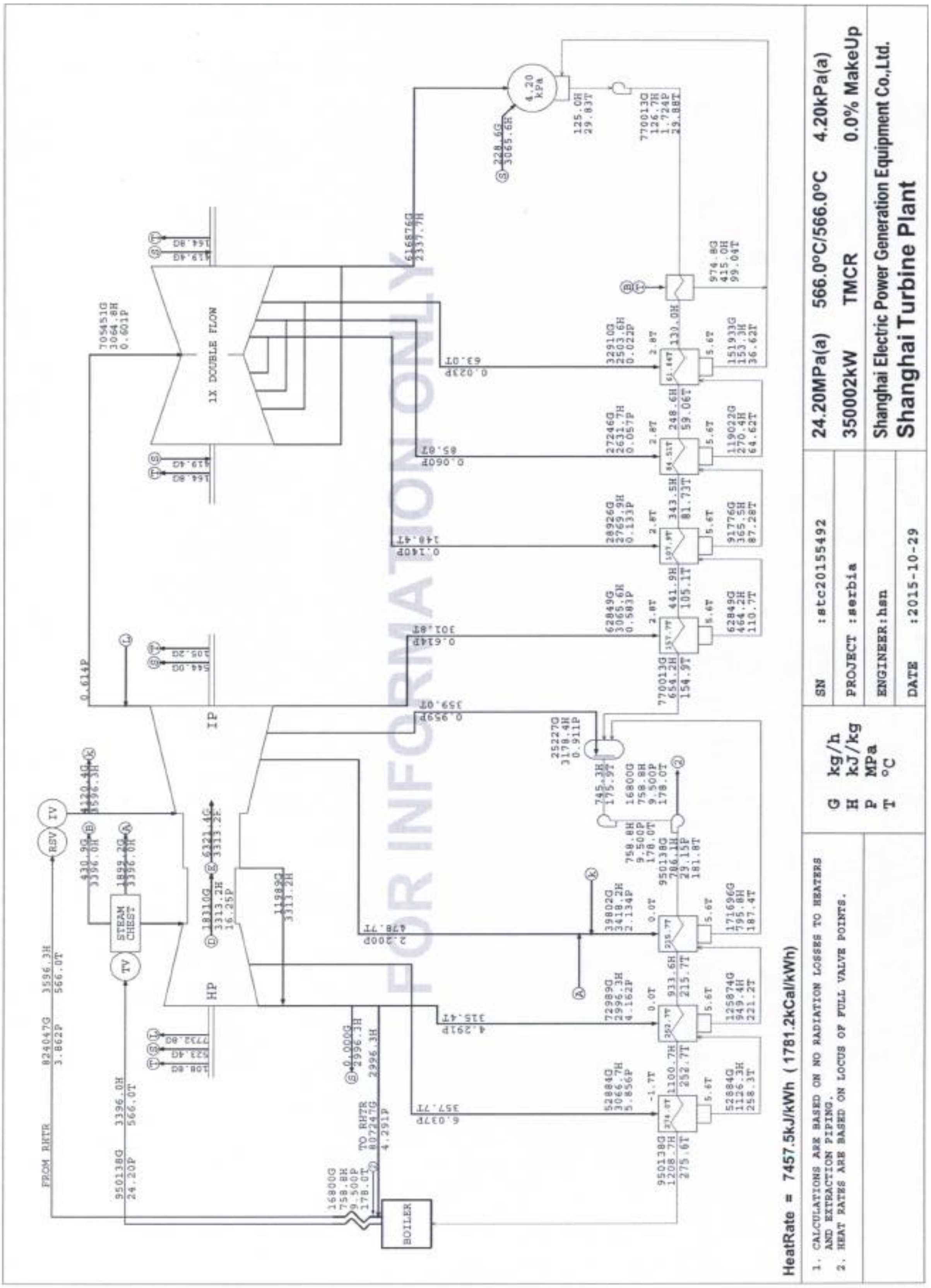


Figure 3.3.4-2: Balance scheme of 350MW supercritical power unit, $p_k = 0{,}042$bar, $t_{RV} = 19{,}5^oC$

From the outlet of MPT, the steam is taken by ducts directly to the cylinder of LPT where it expands until the condensation pressure and goes further on to the condenser.

The parts of the turbine are connected in a row, together with electric generator make one-shaft turbine unit. The connection of the turbine rotor and generator, as well as the interconnection of particular turbine rotors are coupled together. The shaft bearings are via bearing units linked to the turbine foundation.

The planned control system (electro-hydraulic with microprocessors) should provide a reliable and efficient operation of the steam turbine. The system provides automatic starting, synchronization, lifting loads, maintaining parameters, as well as the protection of turbine and generator.

The turbine control system is associated with the system of integrated control of the unit, through the DCS as part of the unit thermal control room.

The control system includes the feature of analysis of thermal stress of the turbine components in order to limit the length of the start-up and turbine-generator load changes. The system provides monitoring the turbine operation, i.e. measurement of rpm, vibration, thermal expansion of the casing, the relative elongation of the inner casing and rotor, as well as the turbine-generator bearings temperature.

As part of the control system, separate parts (functional groups) are planned for monitoring the work of auxiliary turbine systems (system of turbine oil, sealing system, a system for vacuum sustaining, condensate circulation system and drainage system).

Steam pipelines and pipelines of the main technological system

The pipeline of fresh steam - RA, connects to the P3 outlet superheater chambers. The steam is led over two lines leading to the machine room where over the Y line it is entered into a horizontal pipe that is the main collector of fresh steam duct. In both lines, on the horizontal sections, in front of Y pieces from which the collector starts, there are offshoots for connection to the by-pass station of high-pressure connecting the steam line with the cold steam line RC. From the collector, steam goes towards the stop valves of the high pressure turbine.

The pipeline of reheated steam - RB connects to 2 horizontal output collectors of reheater MP2 at the elevation of +67.72 m, on the back side of the boiler. Reheated steam pipeline system consists of two pipelines, which are combined into a single pipeline directly after the boiler, and then again split into two pipelines by Y- connection before the turbine.

The cold steam pipeline - RC, consists of two lines going from output connections of high pressure turbine to the boiler collectors that are at the elevation of + 82,64m, on the back side of the boiler. These two lines are merged into a single pipeline after the turbine, and then divided into two lines directly in front of the boiler. From the collector, the steam is taken into the primary steam reheater MP1. In the bunker, using T pieces, lines are connected to the high pressure by-pass.

The feedwater pipeline - RL represents the main pipeline from feed pumps to the inlet collectors of water heaters ECO. The system of feed pumps consists of a total of three electrical feed pumps (two working and one spare) located at a height of + 0,0m. From feed pumps the feed water is introduced into the high pressure regenerative heaters where the water is heated in 3 stages, and subsequently by this pipeline, led to the boiler.

Feed water pipeline – RL, is connected to 2 water heater collectors, located at the front side of the boiler, elevation +82,64 m.

Systems for flue gases treatment

After leaving the boiler purification of sulphur oxides and powdery matter flue gas is done, as described below.

Dry electrostatic precipitator

Dry electrostatic precipitator will be placed at the point where the flue gas leaves the boiler room (after regenerative air heater). It is envisaged for the dry electrostatic precipitator facility is made of two identical units, each with two chambers separated by a wall and six zones in a row.

Dry electrostatic precipitator facility ensures that the output concentration of powdery matter is below 30 mg/Nm3. Technical characteristics of the facility are summarized below in section 3.2.6. of this Study.

The casing of the electrostatic precipitator is made of sheet steel and consists of floor, wall and ceiling girders, panelling and braces for stiffening. Complete casing is supported on a supporting steel structure. The supporting steel structure rests on concrete foundations. Casing is on the upper side closed by roof where insulators and transformer units are placed. Below each unit of the electrostatic precipitator there are chutes for collecting ash.

Flue gases desulphurization facility (FGD)

Technological solution and the concept of the flue gas desulphurization facility for the new unit B3 are selected on the basis of the necessary efficiency of reducing SO2emissions, in accordance with the adopted criterion to comply the output emissions with the requirements of the EU legislation (Directive 2010/75 / EC - Directive on Industrial Emissions) in terms of limit values of emission (LVE) for the new plants put into operation after January 1st ,2018.

Defined solution for the FGD facilities of the 350 MW unit B3, has the following features:

1. Desulphurization procedure is wet limestone/gypsum procedure;
2. For the treatment of flue gases from the Unit B3 one absorber is envisaged;
3. The type of absorber is tower counterflow absorber;
4. Emission of the treated flue gases will be done by wet standalone chimney;
5. Clean water supply is to be done from the Danube river, by using special pumps for service water supply of the system for FGD and HPV;
6. The delivery of the limestone to the TPP is done by railway. Within TPP it is envisaged to have partly closed limestone storage for the needs of all power units. Potential limestone supplier is the mine Kovilovača;
7. Preparation of the limestone suspension is done in the procedure of wet grinding in horizontal mill with balls (two mills foreseen, each of enough capacity for the operation of the unit at projected parameters for the FGD system);
8. Disposal of the suspension of gypsum is planned to be done in the area of the OPM “Drmno”, on the common landfill of gypsum, ash and slag.

Technological and mechanical part of the system for flue gases desulphurization from the B3 Unit implies the following technological units:

- Flue gas system from the electrostatic precipitator exit point until getting into the absorber and from the absorber until entering the wet electrostatic precipitator located behind the absorber and further on until the entrance into the chimney,
- System for absorption and oxidation (apsorber),
- System for limestone handling, implying receiving the granular limestone in the unloading station for railway wagons, transport and storage of limestone,
- Daily silos with the milling systems and the system for the transport of the limestone suspension to the absorber,
- System for gypsum suspension treatment and producing dry gypsum (for sale) with temporary storage. It is possible to load the gypsum from this storage onto the belt conveyor system for the gypsum from the units B1 and B2.
- The tank of thickened gypsum suspension from where the slurry will be transported by pipeline to the system for preparation of mixture with ash and slag, and from there the entire hydraulic transport of ash, slag and gypsum from Unit B3 will be carried out to the common landfill,
- Technological water supply system.

The main part of the FGD system is the system for the absorption and oxidation, which comprises the absorber reaction tank and the drop eliminator. By the flue gas passing through the absorber its treatment is performed in contact with the reaction suspension. Then clean gas passes through the drop eliminator, which is located in the upper part of the absorber, where excess moisture is eliminated prior to entering the chimney.
The construction of the standing concrete chimneys is planned, from the inside coated with material that provides the necessary protection against corrosion, as well as operation under the flue gas by-pass conditions, when the FGD system is not in operation: it is planned to do the lining with titanium alloy layer, which, in addition to being corrosion resistant, is also resistant to high temperatures. Condensate, which is collected by a special drainage system, set up in the chimney, is returned back into the FGD process. The dimensions of the chimney are 180 m, in height, and internal diameter is 6.6 m at the outlet.
Project of FGD system in some parts is similar to or has common systems with FGD system of Units B1 and B2 (i.e. First phase), whose implementation is in progress. These include:

- Discharge station for the railway wagons with granular limestone and limestone storage: this discharge station and transport system to the storage will be built within the project of the unit B3. The very storage with shelter should be built within the first phase. Until the discharge station is constructed, the limestone for the units B1 and B2 will be transported by trucks, and when the system of railway delivery is built the storage will be equipped with moveable spreaders on rails, which is also being built within the project scope of Unit B3.
- Pipe bridges for the transport of various kinds of fluids, connecting the structures for limestone milling and structures for gypsum drying, are common to all phases and will be built in the I phase. In the II phase required relevant pipelines will be installed.
- System for gypsum production with temporary storage will be, in accordance with the project I phase and technical specification of CMEC for the second phase, placed in the special structure belonging to the Unit B3, and which will be located at the point where the gypsum from the storage of the unit B3 can be loaded by moveable machinery onto the system of belt conveyors transporting the gypsum from the units B1 and B2 towards the mechanical stockpile of gypsum. This possibility would be used as a back up, in case of having issues with the delivery of gypsum suspension from the Unit B3 over the system of unified mechanical transport with ash and slag.

Layout of structures within the FGD system is shown in the Layout drawing of structures, Annex No.3.

FGD system of the unit B3 is located right after the GPO system, behind the dry electrostatic precipitator (and the flue gas fan, where the absorber is). Behind the absorber the flue gases are taken into the wet electrostatic precipitator, and then to the wet chimney.

Along with the absorber there is located a building of circulation pumps and oxidation compressors, as well as the pump station for removing the sludge from the absorber, while the absorber emergency tank with pump station will be located near the chimney of the new unit.
The wet limestone milling system with the daily silo and the storage with the station for unloading the limestone from the wagons will be located in the southern part of the site.

The building of vacuum filter for drying the gypsum will be built within the Main (process) building of FGD of the unit B3 and will be located in the part of the lot where the FGD system for units B1 and B2 is situated, across the same building for these two units. In the gypsum structure facility there will be gypsum thickened suspension tank, filtered water tank and waste water tank and sanitary water tank.

The pipelines for connecting the absorber and the system for limestone and gypsum will be placed on the pipe bridge by the same rout as for the units B1 and B2. The dimensioning and the construction of the pipe bridge is within the scope of the FGD project for the units B1 and B2.
Additional technical characteristics of the FDG system are shown in the Chapter 3.3.6 of this Study.

Wet electrostatic precipitator

Wet electrostatic precipitator will be included in the process after the equipment for flue gas desulfurization (i.e. behind the absorber), and before the chimney. It is envisaged for the wet electrostatic precipitator to be consisted of one unit, with two chambers and two zones (electric fields).

The housing of the wet electrostatic precipitator represents the welded streel structure with appropriate anti-corrosion protection. Complete housing is supported on the steel structure. The supporting steel structure is on the concrete foundations. The housing is from the upper side closed by rook where the insulators and transformer units are placed. Below every unit of the wet electrostatic precipitator there are chutes for the flow of suspension of powdery matter.

Wet electrostatic precipitator provides the output concentration of the powdery matter to be below 10 mg/Nm^3. Technical characteristics of wet electrostatic precipitator are shown in the Chapter 3.3.6 of this Study.

The Layout of the general equipment of the main technological system of the unit B3 is shown in the drawing in Annex No. 17.

Water supply system

Water supply system of the unit B3 provides the cooling water necessary for cooling od the turbine condenser and technical cooling of the unit, as well as technical water for other consumers within the unit (system for chemical water treatment, FGD system, wet electrostatic precipitator, firefighting system and etc.).
Within the existing pump station of the cooling water (for the units B1 and B2) it is not planned to have the area for storing additional equipment for the new unit. Taking into

account that by the time the new unit starts operation (in 2020), the existing structure/system will have been in operation over 30 years, it is planned to construct the new (separate) structure of the pump station for the unit B3, parallel to the existing structure, with the usage of existing feeding channel of the cooling water from the river. The location of the pump station of cooling water is shown in the layout drawing of the power plant structures.

TPP Kostolac B (Units B1 and B2) is supplied by cooling water from the Danube. In technological terms, the cooling water system is consisted of the following parts:

- open feeding channel from the Danube to the pump station;
- Cooling water pump station;
- Discharge steel pipeline from the cooling water pumps to the condenser;
- Steel pipeline from the condenser to shut-off chamber;
- shut-off chamber;
- Discharge close channel from shut-off chamber to new river – bed of Mlava River (and water return to the Danube River).

Cooling water feeding is performed from deepen river bed of the Mlava River, through siphon and channel to pump station. Cooling water channel (river bed of the Mlava River) has the following properties:

- Channel is sized to minimum level of the Danube River of 68,10 m (under condition that minimum level of water before pump station is 67,25 m)
- Level of channel bottom is 64,55 m
- Channel length is 3600 m
- Width of channel is 30 m (slope of 1:3)
- Designed capacity of channel is 56 m^3/s (201600 m^3/h), i.e. it is anticipated for feeding of thermal power plant four units (4x350MW).

The intersection of feeding channel with new designed channel of the Mlava River is performed by siphon. Siphon is also installed for planned construction within second phase, i.e. with four a/b tunnels of 2,6x2,6 m size. Total length of siphon is 190 m. For siphon maintenance, plate flanges are provided at inlet/outlet. The feeding channel going from the syphon to the pump station is opened. In front of the pump station a pool has been built, dimensions 60x40m, with elevation of the bottom 63,50 m.

The cooling water system of the unit B3 (350 MW, supercritical parameters) is conceived in accordance with the technical solution made during the construction of the first two units of the power plant. That is, the construction of two new water intake channels with hydromechanical equipment for the water purification. Hydromechanical equipment includes (as seen in the direction of water flow) a coarse grid and fine grid with a mechanism for cleaning and strip-shaped sieve (clean aperture dimensions 2.5 x 2.5 mm) with a device for flushing. Hydromechanical equipment is placed in the channels.

In the structure of the pumping station it is planned to set up two cooling water pumps (2x50%), which, through a steel pipeline (DN2500), which is being laid in the earth to the entrance into the turbine hall, supply the appropriate amount of cooling water to consumers of the new unit. Return cooling water is then transported to the shut-off chamber, where the by return channel of hot water, by gravity flow, it gets back into the river.

Required quantities of cooling water for the unit are shown in the Table 3.3.4-3.

Table 3.3.4-3: Necessary amount of power unit cooling water

Consumer	Amount (m^3/h)
Turbine condenser	48.610
System of Power Unit technical cooling	2.400
Total for cooling	51.010 (14,2 m^3/s)
Washing of grid and strip-like sieve and pump sealing	350
Total:	**51.360 m^3/h (14,26 m^3/s)**

Designed capacity of water intake is about 51.700 m^3/h and includes necessary amount of cooling water for the operation of Power Unit B3, as well as supply of other plants with raw water: Chemical water treatment plant (CWT), flue gasses desulphurization (FDG) and other smaller consumers. The total required amount of raw water is about 330 m^3/h. Besides, this water intake supplies also fire water by special pumps of the capacity 540 m^3/h.

Cooling water pumps (2x50%) are vertical, with helical impeller, control blades of precircuit and directly connected electromotor. Pumps with possibility of pulling out shaft with impeller are envisaged without dismantling of the entire pump. At the pump discharge port, electro-hydraulic plates are designed (with counter weight) with possibility of adjusting opening and closing time.
Technical characteristics of cooling water pump are as follows:

- nominal flow 7,20 m^3/s;
- head 0,176 MPa;
- power of el. motor 1.700 kW.

Adjustment of head of cooling water pumps. Due to change in river water level, is to be performed by pump regulation pre-circuit.

Inside of the cooling water pump station, there are also raw water pumps (2x100%), of the capacity 350 m^3/s each, as well as the pumps for FP system supply (2 x 100%, one electric and one diesel).
As part of the cooling water pump station, in the separate room, installation of diesel aggregate is envisaged, with the aim to be reserve supply of the electricity for the pumps of priority consumers.
The cooling water is discharged by the newly designed riverbed of the river Mlava, of the total designed capacity of 674 m^3/s. From breaking chambers to the closing point of warm water is being directed trough the closed a/b collector of the length 850 m. One collector per power unit is envisaged. closing point is derived for the II phase of construction i.e. totally four collectors. The length from collector to closing point to the river Mlava inflow is 120 m.

Systems for chemical preparation of water and the treatment of turbine condenser

The system for chemical water treatment (CWT) for the needs of power unit B3 should provide additional demineralised water to cover losses in the circuit flow of water-steam in the closed cooling system and heating system, ventilation and air conditioning. Having in mind the limits of the existing CWT that supplies the power units B1 and B2 with demineralised water, for the power unit B3, the new CWT system is envisaged and located in separate new buildings.

The two lines are envisaged for water treatment, net capacity is 50 m^3/h each, that are supplied with raw water from the river Danube. One line is operative, another one is reserve or in regeneration. The plant is configured in such a way that in some situation when the consumption of demineralised water is increased, parallel operation of both lines is possible in shorter time frame (between the two regenerations). Produced demineralized water is to be used in the main drive plant to cover losses in the cycle water-steam (40 m^3/h) and for the cover of the losses in the closed cooling system and the heating system of ventilation and air conditioning (10 m^3/h).

As starting point for designing of the system, the analysis of raw Danube water is used, shown in the Table 3.3.5-7 of this Study.

According to the requirements of the supplier of the boiler with above critical parameters, demineralised water was produced and it should fulfill the following quality parameters:

- total hardness 0 ^{o}dH;
- conductivity 0,1 μS/cm;
- SiO_2 0,005 mg/l;
- total Fe 0,010 mg/l;
- total copper 0,001 mg/l;
- sodium 0,002 mg/l.

Modern technical solutions for the preparation of feeding water for boilers increasingly include reverse osmosis (RO), in order to avoid or minimize usage of chemicals for regeneration of ion exchange resins, as well as formation of chemically loaded wastewaters. Having in mind that with reverse osmosis complete demineralisation of water cannot be reached (minimum content of sult in RO permeate is ~10 - 20 mg/l), This technology can be used independently in case of low pressure boilers, where just softened water is needed. When it comes to high pressure boilers, and especially those with super critical parameters, after reverse osmosis additional demineralisation is needed by ion exchange, or electro-deionisation. It should be mentioned that the technology of ion exchange is still prevalent in thermal power plants.

Having in mind the sensitivity of RO membranes on the presence of bacteria, mechanical impurities, organic matter, high hardness of iron in raw water, that leads to formation of deposits on the membranes, as well as on the presence of chlorine, which could lead to damage of membranes, the usage of reverse osmosis requires complex pre-treatment of infeed water for RO, especially in using surface water with high turbidity and suspended matter content.

Technological scheme of the proposed water treatment process is shown in the technological scheme of the power unit.

- Phase I includes raw water treatment in the filtration unit, which includes water sedimentation and three stage filtration: mechanical, in double-layer filters, in activated carbon filters and fine sand filters,
- Phase II includes the first stage of desalination in the RO system, including also system for chemical dosing for the protection of RO membranes and the system for membranes cleaning,
- Phase III includes the final desalinisation of water in the system for the ion exchange, that includes cation and anion exchangers, acid-alkali systems for regeneration of ion resins, compressed air system and neutralization system

Two lines for preparation of water are envisaged, of the net capacity 50 m^3/h each. One line is operative, and the other is reserve or in regeneration. The plant is so configured that in the certain situations, when the consumption of demineralized water is slightly increased, the possible parallel operation of both is possible in the shorter period of time (between the two regenerations). Produced demineralized water is to be used in the main drive plant to cover losses in the cycle water-steam (($40\ m^3/h$) and to cover losses in the closed cooling system and heating system of ventilation and air conditioning ($10\ m^3/h$).

Raw water is taken from the river Danube by using the pumps installed in the pump station (PS) of the cooling water by the buried pipeline. The first step in the raw water treatment is the clarification process, performed in clarification basin. Formerly, the raw water is warmed up to temperature of about 25 °C in the steam heat exchanger (steam is available for heating, 250ºC, 0,4 MPa, from the system of the auxiliary steam of the power unit), then it passes trough the device for gas separation (gas separator). The amount of water that is being supplied for the clarification, besides the needs of the CWT device, is going to be used also for the needs for the FGD system. Before entering the gas separator, the dosing of hypochlorite is envisaged for the disinfection of raw water, coagulant and auxiliary flocculant, using the static mixers, installed in the inlet pipeline, ensuring proper mixing of chemicals with water.10-15% NaOCl is delivered in barrels and by using transfer pump, it is transferred to the two reservoirs for the preparation of 1% solution, and each barrel is supplied with stirrer and dosing pump. Coagulant (ferric chloride) is delivered, transhipped by two pumps, stored and dosed as 40% solution. Two reservoirs and two dosing pumps are envisaged. Auxiliary flocculant (polyelectrolyte) is delivered in bags. It is possible to perform additional dosing of $FeCl_3$ and PE at the entrance of the filtration plant. Automatic dosing of chemicals is envisaged, based on the measured raw water flow, with additional adjustment based on measured pH value and raw water turbidity. Besides turbidity, it is necessary to monitor also silt density index (SDI – Silt density index), that is one of the key parameters of water quality for reverse osmosis feeding. SDI in feed water for RO should be <3.

Clarified water is stored in two reservoirs of $100\ m^3$ each in which based on the water level, as indicators, the filtration system is monitored.

Part of the water envisaged for further treatment at the plant for CWT is directed to the aforementioned filtration lines. Two lines for the filtration of clarified water are planned, with capacity of $\approx 80\ m^3$ comprising (each line), of one operating and one reserve two-layer filter, 2x100% based on anthracite and sand, two operating and one reserve filter with activated charcoal (3x50%) and two operating and one reserve (3x50%) sand filter, filled with fine sand. The filtered water released from the sand fine filter is discharged into two basins of filtered water, of a volume of $200\ m^3$ each. The filtration plant should remove mechanical impurities> 10-20 µm.
For backwashing of the filters two common pumps of filtered water 2 x 100% and two blowers, 2 x 100% capacity, the loosening of the filter sand are provided. The aforementioned blowers are designed for mixing ion exchange resin in the mixed filters during regeneration and for mixing the resins in the plant for external resin regeneration of COD. Wastewater from the filters washing is returned to the entrance of the clarification basin, through used water basin ($300\ m^3$), which in addition to solving the evacuation of the wastewater, cost savings in the consumption of raw water and chemicals are achieved. The plant is designed to operate automatically, with the exclusion of the spare filter based on the differential pressure, by the involvement and activation of a spare filter backwashing.

Filtered water from the basin is further directed to the suction of feeding pumps for reserve osmosis, by two pumps of the capacity 2 x 100%. Before entering into the RO plant, water is additionally filtered trough security micron filter with replaceable cartridge, with the pores opening of up to 5 µm and it is treated with chemicals for prevention of lime deposits formation and for residual chlorine removal. To prevent deposits, pH value is adjusted by dosing 30% hydrochloric acid from the shared storage, using two dosing pumps, as well as

10% descaling solution (antiscalant). Antiscalant is shipped in barrels as 10% solution and outpoured by transfer pumps, into dosing tanks (2 x 100%), equipped with dosing pumps. To remove the chlorine sodium bisulphite is used, which is delivered in bags and dissolved to a concentration of ~ 3% in two dosing reservoirs, equipped with mixers and dosing pumps. Equipment for chemical dosing is common for both RO lines.
For supply of RO plant, two high pressure pumps are envisaged (2x100%).

Two lines for reverse osmosis, with the capacity of 52 m3 / h each (flow of water at the entrance is 70 m3 / h), each consisting of a packet RO unit, which includes eleven pressure vessels with membrane elements, mounted on a steel construction), with collectors for feed water, clarified water (RO permeate) and the waste concentrate. The flow through the membrane is adjusted by control valve at the entrance to the system, while the pressure on the membranes is adjusted by the frequency converter on the high-pressure pumps. The lines are equipped with a conductivity meters at the output and pH-meters and gauges for residual chlorine meters at the entrance to the system. RO permeate is discharged into the buffer tank of the permeate, of the volume 2x15 m3, while the concentrate, loaded with salts and unreacted chemicals is discharged into the neutralization tank (with two chambers, 2x250 m3). In case of exceeding the limits, entrance and exit water is evacuated by means of the drainage system in the neutralization tank, from where, after adjusting pH value it is directed into a common facility for wastewater treatment from the system for CWT and FGD for all three blocks.

Since the RO membranes do not remove CO_2, its presence reduces the pH value. In order to reduce the load of very alkali anion mass in a plant for ion exchange, it is suitable to previously remove CO_2, present in the RO permeate, as well as its additional amount to be recovered in the cation filter using CO_2, separator (degassers). Before entering the reservoirs, the permeate is passed through the apparatus for removing carbon dioxide.

In case of stoppage of the line, it is necessary to perform the water membrane washing by demineralised water (demineralised water from the reservoir), in order to prevent the formation of plaque on the side of the concentrate. For this purpose, specific pumps of demineralised water, 2 x 100% are envisaged.

Since during the operation of the plant, despite preventive measures, the formation of deposits on the membranes cannot be completely avoided (inorganic, organic, biofilm), which leads to a reduction in their performance, RO plant must include equipment for chemical flushing of the membranes. Chemical flushing is performed by the circulation of the solution of the appropriate chemicals through the system. The choice of chemicals varies depending on the type of created deposits. For the removal of inorganic deposits, solution of hydrochloric acid is used, and for the deposits of organic origin, an alkaline solution with added surfactant active substance (sodium hydroxide with the sodium dodecyl sulphate - sodium dodecyl sulphate) is used. In the case of quality pre-treatment and adequately guided processes, chemical flush should be conducted once every 4 - 6 months. For chemical flush, reservoir is designed for dry wash, of the volume 5 m^3, recirculation pumps for solution (2 x 100%), micron filter pore size of 5 mm, at the delivery of the pumps, steam heat exchanger for solution heating, as well as tanks and pumps for chemical dosing. Wastewater from chemical flushing is discharged into the neutralization pit.

Bearing in mind that for the RO of the membrane it is necessary for the membranes to be permanently submerged and that the membranes that are out of use, exposed to formation of a biofilm, it is necessary in the event of outages longer than 48 hours to implement membrane conservation, by their immersion into the bisulphite solution, which should be changed once a month. In accordance with the required capacity for water lines, one line of RO will be constantly out of order. This problem could be overcome by installing a membrane only in one line, while the second line membranes could be kept in storage until the first use and then immersed in a solution for conservation. In case of failure on the operative RO line, feed water for the RO can be directed by bypass to the plant for ion exchange, which could be used on its own for some time, with much more frequent regeneration than projected (the envisaged working period of lines is 10 days).

It is envisaged that the RO plant operates automatically with dosing chemicals based on feedwater flow, with further adjustment based on relevant parameters of the feed water quality (pH and chlorine content).

The permeate obtained by reverse osmosis is transferred from the reservoir by two pumps, 2 x 100% through the plant for complete water demineralization by ion exchange, which has the net capacity of 2 x 50 m3 / h.

Each line for ion exchange consists of strongly acidic cation filter, with resin trap, middle pump for water transport in a very alkali anion filter and mixed filter, filled with strongly acidic and strongly alkali ion exchange resin, with the resin trap. Produced demineralised water is stored in two reservoirs for demineralised water of the volume of 1,500 m^3, common for both lines. Demineralised water is transported from the reservoir to MOF by the pumps for additional demineralised water, of the capacity 2 x 100%, and an additional pump of higher capacity is also provided, for the purposes of charging system in the MOF. In addition to the needs of the MOF, demineralised water is used for dry cleaning of the RO unit, in systems for dispensing chemicals, for the reservoir washing of cation and anionic resins, laboratory and the system for the regeneration of resin, as well as flushing of RO membranes.

For regeneration of ion exchange resins from the plants CWT and COD two pumps are envisaged (2x100%). Additional two demineralised water pumps are designed for the transport of ion exchange resins from plants COD and stations for external regeneration CWT facility in.

Regeneration of saturated ion exchange resins is carried out with dilute hydrochloric acid solutions (~ 3 to 5%) and sodium hydroxide (~ 2 and 4%). To prepare the regeneration solution ejectors acid, or alkali are used. Acid and alkali from storage tanks are transferred to the measuring vessels and from them through the ejector are diluted and introduced into the vessel of ion exchanger.

Storage for regeneration of chemicals consists of two horizontal reservoirs of 30% HCl and two horizontal reservoirs of 40% NaOH, of the volume of 20 m^3 each. Reservoirs and dosing vessels for HCl are equipped with the device for capturing and absorption of acid vapours. NaOH reservoirs are supplied with electric heater for heating the alkali in order to prevent crystallization (which occurs at temperatures below 16 ° C). Reservoirs are filled by transfer pumps from the tank. Heating of demineralised water for the regeneration of the anionic resins is done in a steam heat exchanger.

It is envisaged that the facility for water demineralization operates automatically, based on the level of demineralised water in reservoirs. The introduction in the regeneration is carried out upon reaching of the conductivity limit value. Also provided is monitoring of the following parameters: flow, pressure, temperature of water and content of SiO2 and Na.

Wastewaters from regeneration of ion exchange resins are discharged into the neutralization tank with two chambers of the volume 250 m^3 each. The project envisages transport of wastewater by rubber pipelines instead of ducts, as it was in the existing power units. This mode of transport aims to prevent fumes in the production hall of CWT, as well as damage of the concrete channels.

Neutralization pit is equipped with pumps for discharge, (2x100%) and blowers (2x100%), for water mixing to ensure consistency of the content. The project foresees the automatic dosing of acid or alkali based on measurements of pH by dosing pumps. Wastewater after neutralization is transported to a common water treatment plant from CWT and FGD of all three power units.

The required amount of raw water for the production of demineralized water is conditioned by the degree of utilization of system components (ratio of produced water and raw water) and its own water consumption in the process. The lowest efficiency in the system is present in the line of reverse osmosis, which is due to limitations of RO membranes regarding permeability to water and salt retention. In the case of the fresh water, it can be achieved by utilization of the feed water more than 90%, but with a treatment of the concentrate through multiple stages of membrane elements. For the purpose of this project it was adopted the use of water to be 75%, with two-stage treatment of RO concentrate. Power consumption of RO lines does not exceed 1% -2 of the produced permeate for preparation of chemicals solution and for membranes periodic flushing.

The degree of utilization of the clarification facility is about 96.7% (to 3.3% of sewage sludge), while the efficiency of the system for the filtration is about 86%.
The consumption of demineralised water of the ion exchange line will be significantly reduced in comparison to the existing plant, due to reduced loads of ion masses after reverse osmosis. With the additional consumption of demineralised water for external regeneration of resins from COD, respective demineralised water consumption should not exceed 2%.
In accordance with the above mentioned, the amount of raw water at the entrance to the facility should be 82 m^3 / h. In case of simultaneous operation of both lines, which can happen very rarely, the maximum required amount of raw water would be 163 m^3.

Figure 3.3.4-3 shows the flow and balance of water plants CWT in regular operation.

.
The layout of the equipment in the facility CWT is shown in a situation of facilities, Annex 3.

Location of the CWT facility is shown in a situation of power plant facilities, Appendix 3. In the main, production building, filter accommodation is designed, with equipment for washing and pumps for filtered water, RO plant, with a system for membranes chemical wash and flush the system for separation of CO_2 with intermediate tank, complete facility for water demineralization by ion exchange, with the equipment for regeneration and flushing of resins, lines for external regeneration of resins from plants COD of the power unit B3, filter washing return water basin , as well as other equipment. In a separate building warehouse chemicals (acids, alkalis, hypochlorite and coagulant) and neutralization pit with associated pumps and blowers will be located. Special building is intended for housing and electricity control equipment, laboratory for water and flue gas, office and utility rooms. Control building is a three-floor building, while the main production building and chemicals storage are storied buildings.

Sedimentation tank, reservoirs for clarified water, filtered water tanks, tanks of demineralized water and storage tanks for compressed air are designed to be out of the buildings.

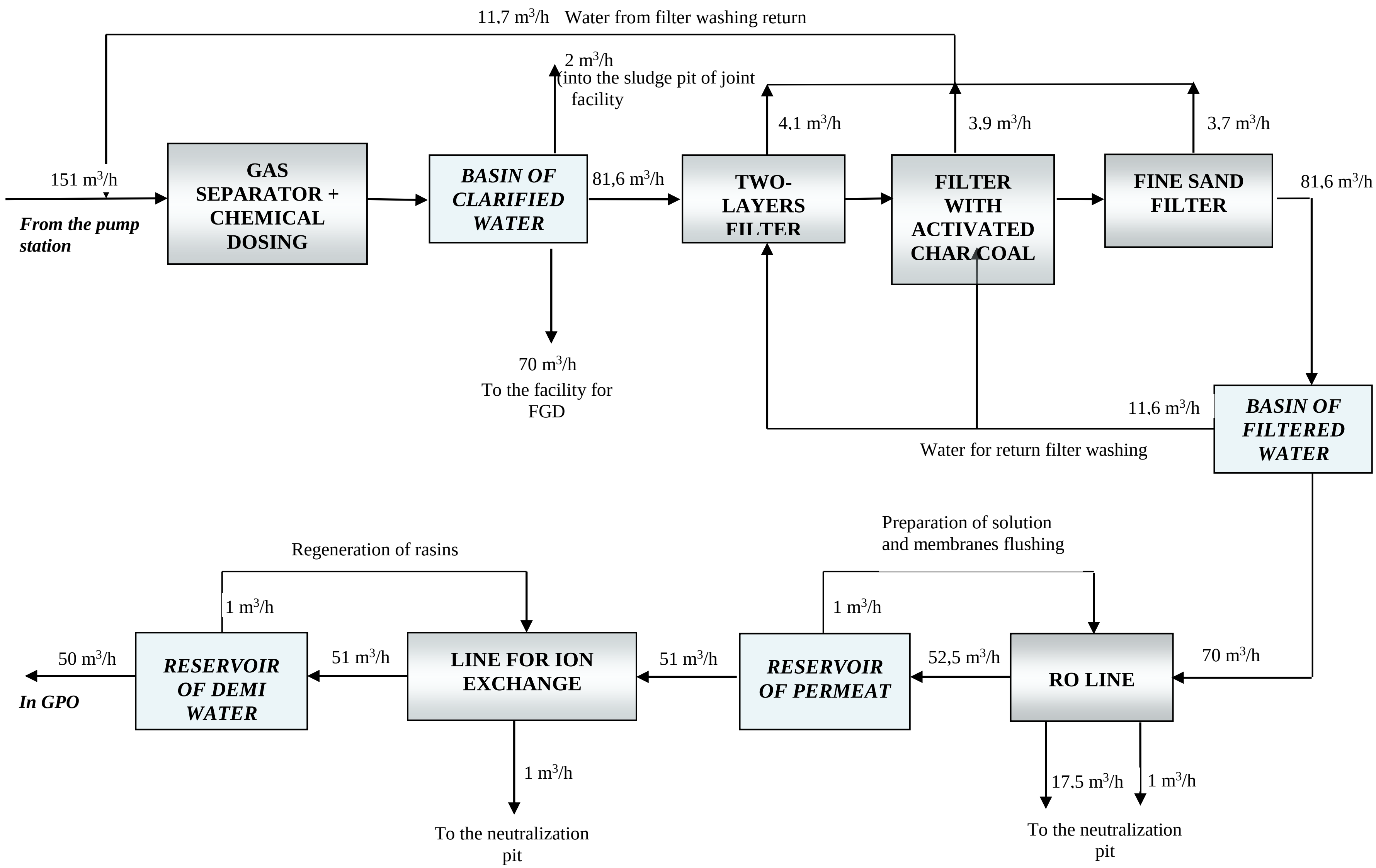


Figure 3.3.4-3: Balance scheme of the facility for chemical water treatment (one line in operation)

System for chemical water treatment and conditioning of the condensate and feed water

Bearing in mind the impact of the quality of the working medium to the condition of the boiler and turbine plant equipment and therefore the reliability of their operation, it is necessary to ensure the maintenance of chemical parameters in the cycle of water - steam within the prescribed limits.

In this regard, it is necessary to provide the adequate quality control of water and steam in the cycle. This includes the introduction of continuous chemical measurements in key parts of the cycle water - steam, condensate and dry-cleaning automatic dosing of chemicals for conditioning condensate and feed water.

Chemical treatment of condensate aims to maintain the required quality of the working fluid in the cycle of water - steam and thus reduce corrosion and deposits in the boiler and turbine facility.
Bearing in mind the technical solution of the Power Unit B3, the following impurities can be expected in the condensate:

- Ions and oxides of iron and copper resulting from corrosion of pipes in the roundabout water-steam,
- Traces of suspended solids, dissolved salts and gases (oxygen and carbon dioxide) in the case of penetration of cooling water in the condensate.

Feed water for boilers with supercritical parameters must meet high standards in terms of quality. According to the standards and recommendations in this area, the quality of the feed water should be within the limits shown in the Table 3.3.4-4.

Table 3.3.4-4: Quality necessary for purified turbine condensate

Parameter	Value	
	Alkali regimen	Combined regimen
Conductivity	< 0,1 µS/cm on 25 ^oC	
pH value	> 9	8.5 – 9
Oxygen content	< 7 ppb	30 – 150 ppb
The content of sodium and potassium	< 3 ppb	
Iron content	< 5 ppb	
Copper content	< 2 ppb	
Silicon content (as SiO_2)	< 10 ppb	

In order to ensure the required quality of water, in addition to appropriate quality of additional demineralized water, it is necessary to envisage clarification of the total amount of condensate.

The purified condensate from the plant for COD was freed of insoluble impurities and dissolved salts, neutral and contains dissolved gases (oxygen and carbon dioxide). In order to achieve the appropriate quality parameters of the feed water at the entrance to the boiler, it is necessary to perform additional conditioning condensate and feed water.

In order to remove dissolved gases, condensate is subjected to a thermal deaeration in the deaerator installed on the feed tank by introducing steam. Oxygen cannot be removed completely in the deaerator from the feed water (residual O_2 content can reach 20 ppb).
The presence of oxygen in the feed water in such a concentration causes corrosion of boiler pipes, so it is necessary to conduct additional treatment. Modern technical solutions for

conditioning the feedwater for supercritical boilers, instead of removing additional oxygen by hydrazine or similar chemicals dosing with reducing properties, as is the case in alkaline operation modes, apply combined treatment of feedwater regimen, which includes alkalization of condensate and feedwater by dosing of ammonium hydroxide and dosing of oxygen in concentrations 20 - 200 at mg / litre. This concentration range of oxygen enables formation of a protective layer of hematite (Fe_2O_3) on the surface of the boiler tubes with a finer particle, smoothness of the layer and a low degree of solubility with respect to magnetite (Fe_3O_4) formed in a alkaline operative mode.

pH value of condensate and feed water in the combined regimen should be in moderately alkaline range (8.5 - 9).

Based on the expected contamination of condensate, the following characteristics of raw condensate at the entrance to the plant COD for the purposes of dimensioning equipment were adopted, Table 3.3.4-5.

Table 3.3.4-5: Characteristics of raw condensate

Parameter	Value	
	mg/l	mval/l
Na	0,10	0,004
NH_3	0,25	0,015
Fe	0,10	0,000
Cu	0,05	0,002
SiO_2	0,10	0,003

Plant for chemical treatment of condensate

Condensate for treatment is taken from the discharge of the first stage of condensate pumps, and refined condensate using a second-degree condensate pump is transported to the low-pressure heaters.

The amount of condensate that should be treated is ~620 t/h.

Condensate clarification should include mechanical filtration, in order to remove iron oxide and other insoluble substances and ion exchange to remove dissolved salts.

Plant for COD is located in the mechanical room of the Power Unit B3, and includes three lines of condensate clarification of the capacity of 400 m3 / h (3x50%) each.

For mechanical filtration and removal of dissolved iron three mechanical filter cartridges are envisaged with the capacity of 400 m3 / h (two working and one spare), with the possibility of backwashing. After reaching the limit values of the pressure difference, the filter is saturated by mechanical impurities is automatically cancelled and it backwashes with condensate, onsite, and includes a spare filter.

Removing of the dissolved salts is carried out in a mixed ion exchange filters, filled with strongly acidic cation and strong base anion mass. The projected capacity of the mixed exchanger is 3 x 400 m3 / h, so that the two ion exchangers are operative, while the third is in reserve, or is regenerated.

It is envisaged that the regeneration of ion exchange resins is saturated externally, in the building of chemical water treatment, and the condensate washing (purified condensate from the line) and the air, in the case of mechanical dirt of the resins, is performed on site. For this purpose, two blowers are provided. Transport of saturated resins to plants for external regeneration is done by the specified pipelines, by hydraulics and by using special demineralised water pumps located in the facility of CWT.

It is designed that the plant operates automatically, with the possibility of manual operation. On the basis of the measured values of the pressure difference, washing of mixed dirty filters with water and air is performed, while the process of regeneration is carried out in case of exceeding the value of conductivity or sodium silicate.

For protection of the plants for COD and condensate pumps of high pressure differences, with a bypass duct with drive valve is provided. In case of exceeding the maximum value of the pressure difference, as in the case of exceeding the maximum allowable temperature, condensate is automatically directed through the bypass duct.
For regeneration of ion exchange resins from the condensate clarification plant of the Power Unit B3, external regeneration facility of the chemical water treatment facility is provided.

Line for external regeneration consists of: the container for the separation of cationic and anionic mass and for the regeneration of the cation mass, with the resin trap, the vessel for the regeneration of the anion mass, columns for residual of cation resins, containers for storage of the regenerated resins, an ejector for diluting the solution of the acid and sodium hydroxide and the pump for recirculation of sodium hydroxide solution.

Regeneration of the resins is carried out with diluted HCl and NaOH solutions, and then the resin is washed with demineralised water. Preparation of diluted HCl solution is carried out by ejector, or NaOH with a pump, used also for recirculation of the NaOH solution in order to get more efficient regeneration of anion resin. The regenerated resins are transferred to a storage vessel, from which, if necessary, they transported by means of a hydraulic mixed in appropriate filter for the HVAC installation.
The acid / alkaline wastewaters from regeneration resins is evacuated by pipes in the neutralization pit of the plant CWT.

System for condensation and feed water

Conditioning of the condensate and feed water is conducted by dosing of diluted solution of ammonium-hydroxide (NH_4OH), for alkalization and oxygen for passivation of the steel surface.
Preparation and storage of NH_4OH solution is carried out in the new CWT object, in a separate room. The storage includes: a storage reservoir for the concentrated solution (25%), of the volume 1 m^3, two pumps for loading chemicals in barrels in a storage tank, the tank to prepare dilution, of the volume 1 m^3, two pumps for transferring chemicals into the reservoir for preparation of diluted solvents and two pumps to transport of the diluted solution to the dosing tank in a MOF. The room is provided for placing of several barrels with a concentrated solution.
The system for dispensing of ammonium hydroxide in condensate and feed water (tanks and dosing pumps) are stored in the MOF, on the elevation $\pm$0,00 m mechanical rooms. Installation of two dosing tanks is envisaged, each with a corresponding dosing pump. It is envisaged that the ammonium hydroxide is primarily fed into the main stream of the condensate (second degree of suppression of condensate pumps) for alkalizing the condensate, and that, if necessary it is dosed into the intake of feed pumps, if further correction of pH value of feed water is required.

Dosing pumps should be equipped with the regulator of the piston strope length, or with frequent regulator. Adjustment of the amount of chemicals dosage is performed by adjusting the length of the piston stroke, based on the measured flow of feed water with a correction based on the measurement of pH values.

Oxygen is dosed at discharge condensate pump and the feed water after the deaerator, bottled under pressure. Dosing is automatic, includes the flow of condensate and feed water and measured oxygen content. Dosing system includes a battery bottle with a pressure reducing valve, which is located in a fenced area, devices for measuring oxygen in the condensate and feed water pipelines and dispensing pipelines with control valves. Bottles of oxygen under pressure will be stored in the existing stock of technical gases.

Management of the systems for dosing of ammonium hydroxide and oxygen is carried out from thermocontrol of the power unit.

Delivery of coal

The existing system for coal delivery is shown in Section 3.2, in the part of the Study relating to the description of already built power units B1 and B2.

Power Unit B3 TPP Kostolac B will use the pre-crushed coal to size class -30 + 0 mm. As with the existing coal stockpile crushed coal of particle size -40 + 0 mm is disposed, and often larger, for the new power unit, special stockpile line will be formed. In this sense, as an extension of the existing system for coal, for the needs of construction of power unit TEKO the following is planned:

- construction of a third storage line, from distribution bunker to transfer building IV;
- construction of a system of internal transport of coal to the power unit B3, which is made of the belt conveyor system from the exit of the transfer building IV to the boiler bunkers, with transfer chutes and supporting safety and measuring equipment.

Technological scheme of the transportation process crushing and storage of coal to the fine coal stockpile, as well as the reclaiming of coal from the stockpile and transport to the power unit B3 is shown on the technological scheme of the power unit, Annex 16.

The system for delivery of coal consists of the following parts:

- equipment for primary and secondary coal crushing,
- coal deposits with equipment for the disposal and reclaiming of coal,
- system for the transportation of coal from transfer building to the boiler bunkers,
- equipment for the supply of coal to the bunkers, auxiliary equipment (magnetic separators of metal parts, dedusters, etc.).

Basic characteristics of the conveyor and stacker- reclaimer and their capacities are as follows:

- particle size of the coal stored at the stockpile is -30+0 mm,
- bulk density of fine coal is 0,8 t/m^3,
- internal friction angle of coal is 36^o,
- apply the equipment for disposal and reclaiming of coal, i.e. stacker-reclaimer, of the stacking capacity 2.400 t/h reclaiming capacity of 1.900 t/h, and reach on the reclaiming of 35 m,
- disposal and reclaiming of coal is performed on both sides of the stockyard,
- towards the power unit B3 only coal that was crushed in two stages to the particle size of -30+0 mm can be reclaimed.

The third stockyard line

In accordance with the above mentioned, it is envisaged to expand the coal stockyard by taking the area east of the existing storage, located between the stockyard and “Topoljar” formed along the bypass. Complete third stockyard line is located within the complex of TPP (cadastral plot no. 303, KO Kostolac-village), and is shown in buildings layout drawing, Attachment no.3

Upgraded part should create space for storing additional 300,000 t of coal (for about a month for power unit B3 operation). Length of the storage will be identical to the existing one, while the maximum height of the pile of coal will be up to 15 m.

Third stockyard line of coal supply shall be made from these reserve bunkers through the already installed raker feeder of the capacity of 1,200 t / h. Arrived coal of the input size -400 + 0 mm should first pass through the two-stage crushing system (primary and secondary) in order to get crushed product of particle size -30 + 0 mm, which is then transported to the storage.

For disposal and reclaiming of coal, a device with combined functions of disposal, reclaiming and passing of coal with the following characteristics is going to be used :

- hourly disposal capacity: 2.400 t/h;
- hourly reclaiming capacity: 1.900 t/h;
- hourly rate on coal passing : 1.900 t/h;
- boom reach length: 35 m.

Crushed coal from the storage is then transported to the existing command transfer building IV building from where the coal is directed towards the new power unit B3.

Scheme of the new coal transportation crushing and storage system, is shown in the principled technological scheme of the power unit, Annex 16.

The reserve bunker consists of three bunker cells, each of which is emptied with two raker feeders. Coal from these feeders is directed to the crushing plant or TPP KO B1 / B2 or to TPP-KO A.

It is envisaged that with the last feeder, GD-6, coal can be directed to the newly designed conveyor belt C-1, that is delivering it to the building of primary crushing, which will be equipped with two crushing lines, each crushing line with a primary screen and with one primary crusher .

Primary crushed coal is beneath the crushing load on the conveyor belt C-2, which takes it to the building of the secondary crushing. In the building of the secondary crushing one line of crushing will be installed with a secondary screen and a secondary crusher.

In the building of the secondary crushing, crushed coal is loaded on the longitudinal storage conveyor C -3. Transporter will be equipped with a combined machine for stacking and reclaiming. Disposal and reclaiming of coal will be carried out on the third stockyard line of coal. Power station and the conveyor transfer points will be located in the new transfer building T-1.

The third stockyard line should enable the following functions:

- flow operation (permeability of the crushed coal directly to the boiler bunkers of the Power Unit B3),
- disposal of crushed coal to the stockyard,

- reclaiming and transport of the crushed coal from the stockyard.

Selected capacities of crushing system as well as the capacities of combined machines at the disposal of coal of 2,400 t / h, leaving the possibility that is in the future, double the capacity of the third storage lines for disposal of coal to the stockyard, as required by the Investor.

The transport system of the third storage line (transfer building T-1) to the existing penitentiary IV consists of the following conveyors:

- new C-4 conveyor from the new transfer building T-1 to the existing transfer building PZ3,
- the existing conveyor T5-1 i T5-2 from the existing transfer building -PZ3 to KPZ IV.

System for the inside transport of coal

System of the coal delivery from KPZ-IV to the boiler bunkers TPP KO B3 is so designed that it is made of the system of double belt conveyors (one operative, one reserve), that provides 100%-reserve.

The capacity of the transport system of 1,600 t / h is adopted, as defined in the design of the first phase of power plant, which corresponds to the maximum capacity of conveyor belts coming from the storage. Effective operative time of the system in lower quality coal burning is 6.7 h.

The system consists of a stable belt conveyors with associated auxiliary and safety equipment. Coal is accepted from the reversible moveable conveyor T-6.1 and T-6.2 of the existing transfer building KPZ IV to new conveyors C5 and C5-A-B, which start from the elevation point ± 0.00 in the same building will be placed perpendicular to the conveyors T - 6.1 and T-6.2.

The choice of left or right transport line towards the power unit B3 is going to be performed by overcoming of the conveyor T-6.1 andT-6.2 above the chosen line C5-A or C5-B.

New conveyor belts C5 and C5-A-B which are used for accepting coal in the building KPZ IV connect this transfer building with a new transfer building T-2, which starts with the most pieces of conveyors 6-A and 6-B, where the coal is transported to the transfer tower MOF-T - 3. This building is redirected to the coal conveyors C7-A and C7-B, which is responsible for filling the boiler bunkers.

Conveyors C7-A and C7-B will be equipped with a plow remover for two sided lateral unload which would help the coal to be unloaded into the boiler bunkers. These removers will be equipped with a mechanism for lifting and lowering of the belt with pneumatic drive. Scrapers are normally raised from the belt, and a choice of bunkers that are filled will be done by lowering the corresponding scraper above the selected bunkers. Coal is unloaded from the belt will be loaded to the bunker through a side mounted rods on each side of the conveyor.

Protection of the belts from damage caused by pieces of metal that can get to the conveyors will be conducted by electromagnetic separator of metal pieces. The magnetic separator will be located at the beginning of an inclined bridge in the building of the separator of metal pieces, above the belt conveyor C6-A and C6-B. Magnet of the separator will be activated to signal detector magnetic items that will be placed above the belts at the appropriate distance in front of the magnetic separator.

In addition to building separator of metal shavings building for sampling will be located in which the sample will be installed, which will enable monitoring of the quality trend of the input fuel.

Boiler bunkers

It is envisaged that eight (8) bunkers of steel structure that will be supplied with continuous replenishment level gauges. In this way the control and management of bunkers filling will be enabled.

The volume of each bunker is 670 m^3, which provides a reserve of more than six hours of coal consumption.

Geometric shape of the bunker is such that they have steep slopes of the transitional part walls. The conical part of the bunker will be coated by stainless steel. Emptying of each bunker into the corresponding mill feeder system will be carried out by using the central bunker buster feeder with a rotating arm. Overall technical solution should enable uniform highlight of coal from the bunker without sticking of coal to the walls bunker.

Within the system for the coal supply, accompanying dedusting installations are planned. That includes:

- centralized systems of dry dedusting of boiler bunkers and crushing plants and
- local dedusters at the conveyor transfer points.

In order to remove dust from the coal for transport of coal (conveyor belts and transfer towers) water washing is provided (foreseen amount of water is 0.01 m^3 / m^2, three times a day). This amount of wastewater in this way is ≈11 m3 / h.

As part of fire protection systems, the stable installation of automatic fire-extinguishing bridge at the inclined bridge of coal will be envisaged.

<u>The system for the collection, transport and disposal of ash, slag and gypsum</u>

Before the combustion of coal in the firebox of the boiler of TPP Kostolac B3 the solid residues of combustion are going to be separated aside, as follows:

- slag under the boiler;
- boiler ash under the channel of flue gas in the boiler room;
- fly ash under the electrostatic precipitator facility.

Those solid residues of coal combustion will be by internal transport systems collected in separate collection silos for ash and slag, from where they should be disposed to the dumpsite (external transport and disposal).

Given that the power unit B3 will be equipped with a system for desulphurisation of the flue gas wet limestone procedure, whereby the by-products obtained as synthetic gypsum, the same, if it is not used as a by-product, must be safely deposited as waste material.

The dumpsite location of the mentioned solid waste is an area of the open pit mine Drmno, thus avoiding the taking of the new areas for disposal and for it is going to be used already reserved space dedicated to industrial activities. Transportation corridor of TPP Kostolac B3 to the dumpsite in OPM Drmno and reservation of the areas for the purposes of disposal of solid waste from the TPP Kostolac B3 are defined in the Spatial Plan as special purpose area of Kostolac coal basin (Official Gazette of RS, no. 1/13), part II Rules of construction and the rules of organization of spatial areas and corridors specific purposes, section 1-complex open pit mine Drmno and Chapter 7 Corridor for transport of gypsum emulsion from TPP Kostolac B to the stockyard into the OPM Drmno, transport corridor in the part of the complex TPP Kostolac B, in the space between the complex TPP Kostolac B and OPM

Drmno and partly in the complex OPM Drmno, which is shown on the map in the Appendix 19th

In accordance with the recommendations for the use of the best available techniques (BAT) applicable to large combustion plants (LCP BREF - Reference Document on Best Available Techniques for Large Combustion Plants, European Commission, 2006) priority is given to the unified disposal of ash, slag and gypsum suspension due to the properties that such mixture has in relation to the features of each of the components separately disposed. With the addition of binding component in an amount up to 3%, this mixture is often referred to as "stabilizator" because it can be transported and disposed safely, without environment dusting.

Conceptual design for the power unit B3 TPP Kostolac B has just applied this technical solution, according to which the ash and slag dispensed from the silo with the addition of binding material (if necessary) and are mixed with the participation of the suspension of gypsum. Thus obtained homogenized mixture with a moisture content of 25-30% is dosed to the system of belt conveyors and so delivered to the stockyard.

In accordance with the above mentioned, the entire system for ash, slag and gypsum of the power unit B3 TE Kostolac B will include the following technological unit.

- collection of dry ash and pneumatic transport to the silo and the facility for preparation and moistening of the mixture,
- Collection and mechanical transport to a silo for slag and then transport by belt conveyor system to the external transport of the moist mixture to the stockyard;
- Collection and transport of gypsum to the facility for preparation of wet mixture of ash. Slag and gypsum;
- storage and dosing of additives in wet mixture of ash slag and gypsum, preparation plant,
- preparation of wet mixture of ash slag and gypsum and external mechanical transport to the stockyard,
- micro dedusting of the mixer,
- supply and distribution of technologically clean water,
- drainage of the equipment and pipeline,
- disposal of the mixture of ash, slag and gypsum,
- loading of ash and slag into the trucks.

The scheme of technological process of preparing a mixture of wet ash, slag and gypsum and mechanical transport to the border of the open pit is shown in the Figure 3.3.4-4, and we will give a description of the following parts of the process.

The internal system for ash includes:

- system of pneumatic collection of boiler and fly ash from the exhaust of the exhausting points into collecting silo,
- equipment of collecting silos for the ash including systems for dedusting, fluidising the bottom of the silo, dosing ash into the system for mixing and loading dry ash in tanks.

Compressed air (transport and instrumental) will be provided from the central compressor plant of the power unit B3.

The internal system for slag includes:

- the acceptance of slag under the boiler and cooling of slag,
- the mechanical slag transport to silos,
- silo for slag, which is located next to the boiler room and equipped with a crusher for grinding large pieces of slag,
- system for cooling water and drainage of deslagger.

Transport of gypsum suspension to the plant for the slurry preparation

The suspension of gypsum from the FGD plant delivers the suspensions to the tank, located in the facility for the gypsum production within the system of FGD of B3 power unit. The tank has a capacity that allows the acceptance of daily production of gypsum suspension.

Preparation of a wet mixture and external mechanical transport to the dumpsite

Slag that is extracted below the boiler and falls into the deslagger, where it is being cooled and further mechanically transported to th collecting silos for slag, which will be located directly near the boiler room. Slag silo will be of steel structure and equipped with two outlets: one outlet will be used for loading the slag onto the belt conveyor, in order to transport it to the dump site, and the other outlet will be used for loading onto the trucks.

The preparation of the wet mix of ash and gypsum is done in the working mixer receiving dry ash from the silo, gypsum suspension (50%Č), over pipeline from the tank of suspension and technological water from the raw water system.

After mixing all the dosed components in the working mixer, the mixer is emptied gravitationally onto the rubber belt conveyor (TR-1). The belt conveyor takes the wet mix (the amount of moisture is 25-30%) from the silo to the first loading structure PK-1, where merging with the slag takes place which is delivered by the belt conveyor, from the slag silo. By unloading and final mixing of ash, slag and gypsum on the belt conveyor (TR-2), placed beside the stockpile of coal from the units B1 and B2, side products are delivered to the second loading building PK-2 where the load of the wet material takes place onto the closed belt conveyor (TR-3). This conveyor takes the wet material to the loading structure PK-3 on the mine border.

Dedusting

In the process of preparing wet mixture of ash, slag and gypsum, the wet dedusting mixer venturi scrubber with a fan is envisaged for the air intake. The dust set down by the water mist refers gravitationally as a slurry into a suitable mixer.

At the transfer points of the belt conveyor (TR-1, TR-2 i TR-3), the dedusting will be performed locally with directing the lowered dust to the next conveyor in a row.

Supply and distribution of technical and clean water

The supply of the plant with water is performed mainly by using the technical water and less using the clean water, that is only where the envisaged equipment requires that or as an addition to the missing water in the process.

Technical water is used for wetting of mixture of ash, slag and gypsum as well as for sealing of the deslagger. Technical water is purified water from the cooling of slag, which is collected in a tank of purified water.

Clean water is used to supply the scrubber for the dedusting process. Water is lead from the thermal power plant with a pipeline which branches off to the facilities where the consumers of clean water are provided. One branch goes into the tank in the facility of silo, which is connected to supply pump dedusting system, as well as for sealing the pumps under the thickener.

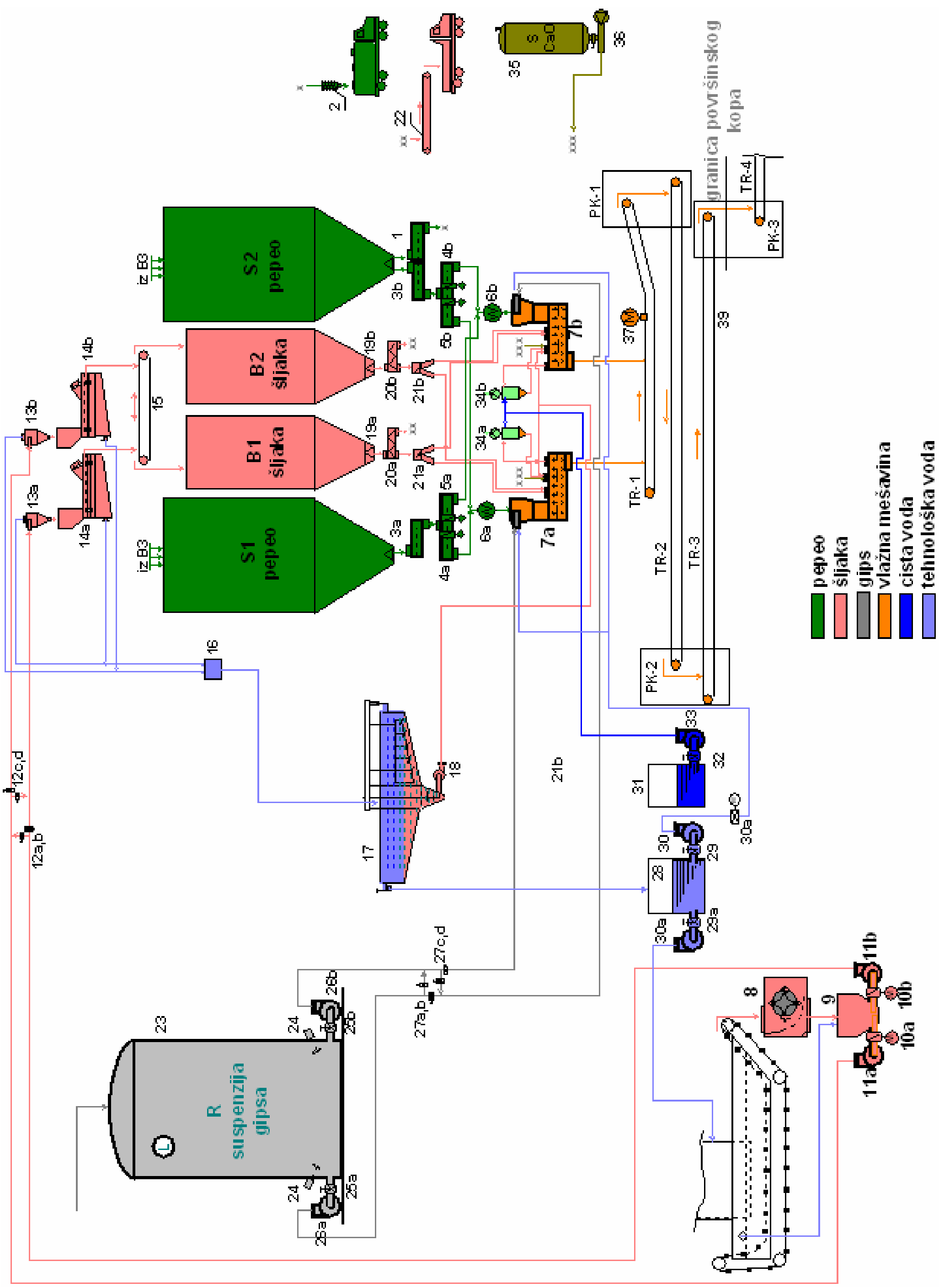


Figure 3.3.4-4: Scheme of technical process of preparation of wet mixture of ash, slag and gypsum and mechanical transport to the dumpsite

The system for the external transport of wet mixture includes the system of belt conveyors from the collecting silo to the dumpsite.

The entire transport system for ash, slag and gypsum silos at the plant to the dumpsite includes 5 (five) belt conveyors with total length of approximately 4.27 km, as it is shown schematically in Figure 3.3.4-5.

As it has been already described, the mechanical transport within the plant to the OPM is conducted by closed conveyor belts TR-1, TR-2 and TR-3, with a width of 1,000 mm, on the grating structure at high supports. At the transfer tower on OPM-3 PK-3, the transfer is performed of the wet material which is transported from the conveyor TR-3 on the high structure to the conveyor TR-4 positioned on the prepared ground. On this transfer tower, the transfer point is planned for connecting conveyor TRV, by which the gypsum of power units B1 and B2 can be included in the present transport system. Within the open pit mine, up to the top of hydro-technically prepared dumpsite, the waste material is transported by covered conveyor belts pos. TR-4 and TR-5, with a width of 1,400 mm, mounted on pontoons on the site.

In addition to the cassette 1 and 2 of the dumpsite of ash, slag and gypsum dimensioned according to a five-year disposal period, the main conveyor TR-6 is placed in the east site. The conveyor TR-6 with a rubber band width of 1,400 mm is set by connecting the sections of supporting structure mounted on the pontoons, on which the rails for movement of transfer carts S1 are set. The transfer carts S1, which move along the conveyor TR-6 in accordance with the position of the disposal conveyor OTR-8 and place of the disposal, have a rod at the side of the conveyor towards the dumpsite and direct the transported material on the short binding belt VTR-7. Connecting conveyor connects the transfer carts S1 on the main conveyor with the disposal conveyor OTR-8 located at the dumpsite on the main conveyor TR-6. The disposal conveyor is mounted on the crawlers with the electric motor that can move in both directions during the disposal. The crawlers can negotiate an inclne of up to 10^{o} during the disposal, or 20^{o} when the disposal of the materials is not performed. On the construction of the disposal conveyor, the rails are set for moving of the unloading carts S-2 along the conveyor in both directions. An integral part of the transfer carts S2 is disposal belt OTR-9.

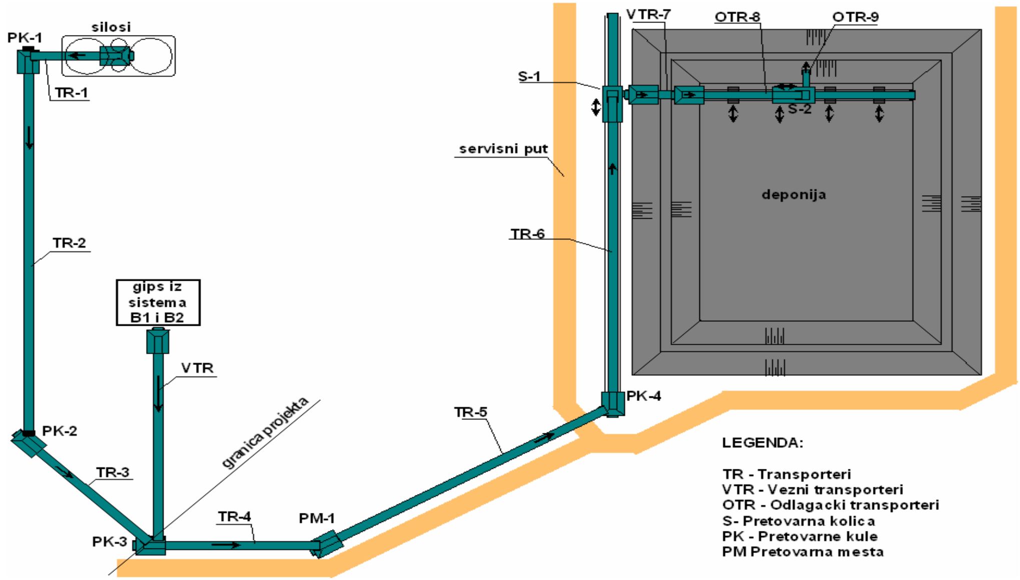


Figure 3.3.4-5: Scheme of transport and disposal of the mixture of ash, slag and gypsum

In order to protect both the material transported from the atmospheric agents and the environment from possible dusting or spillage of materials, the conveyor belts will be covered with hoods of corrugated sheet metal, which is easy to open and provides the access to the belt, which is illustrated in Figures 3.3.4-6 and 3.3.4-7.

Figure3.3.4-6:FEECO system for covering the conveyor

Figure 3.3.4-7: An example of the system developed for covering the conveyor (conveyor for crushed coal in TPP Stanari)

The envisaged working hours of mechanical transport of wet mixture will take place within two shifts with effective working time on transportation and mixture disposal of 12 h. The remaining time is envisaged for the maintenance of the drive, slewing parts and conveyor belts themselves, as well as for the necessary preparation work on the dumpsite.

The transport system will only have 1 line, and a reserve of the system is achieved through working hours of the system, because we believe that during 12 hours any necessary repair can be made.

The situation of the route of the external transport of ash, slag and gypsum from TPP Kostolac B to the dumpsite in OPM Drmno is shown on the map, Appendix No. 20.

Loading of ash and slag on the trucks

Excluding the ash and slag for mass consumption is provided from ash silo, out of which the ash is being excluded by pneumatic sink through a tanker loading device.

Slag from the silo is being transported and loaded on the trucks by screw conveyors and belt conveyors.

Dosing of additives

The need for possible dosing of additives will be determined later, by its type and amount, after the tests that need to be carried out after obtaining the first quantity of gypsum from the FGD process of power units B1 and B2.

The practice in the world is different, but generally the additives are not used. Where they are used, CaO is generally dosed, somewhere as dry powder pneumatically, and somewhere in the form of lime milk hydraulically. Because of this, the typical technological scheme is provided in this project for the envisaged system for storing and dosing of the additives (Figure 3.3.4-8), as well as the space for the possible installation. Regarding that the choice of dosing manner and equipment for this purpose may occur only after defining the types and amounts of additives, if it turns out that the same is needed, this project does not specify the equipment and necessary papers for this subsystem.

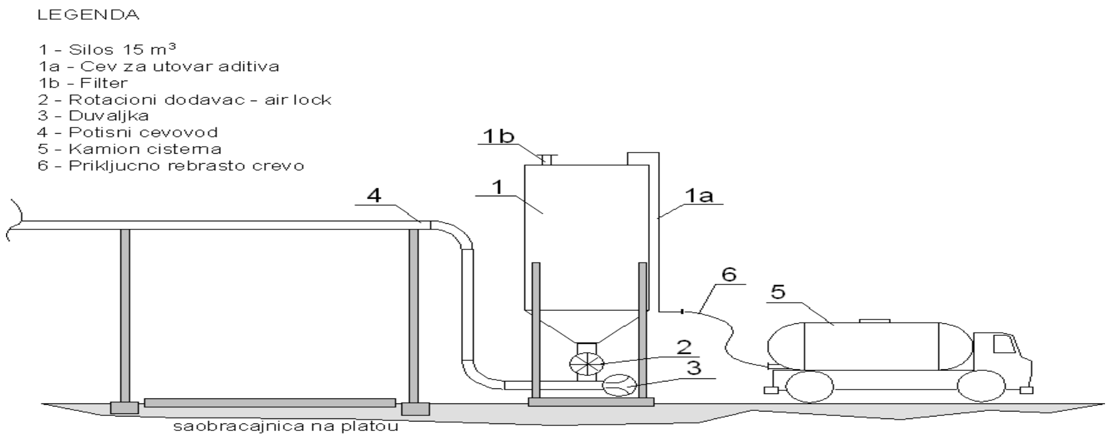


Figure 3.3.4-8: Scheme of silo for additive

The space for the disposal of solid waste and dumpsite description

For disposal of ash, slag and gypsum, the space for disposal of solid waste will be established by mining operations, in such a way that during the disposal of the overburden by peak system the initial space will be left for the phase I of the disposal or cassette for the first 10 years of operation. After that it is continued with the successive movement of the excavation front by leaving the adequate space for the next phases of the dumpsite formation. Cassettes will be prepared with construction works in accordance with the dynamics of progression of mining activities in the exploitation of open pit mine which are defined in the relevant technical documentation of the overburden disposal at the inside of the dump site of OPM Drmno.

The corridor in the disposed overburden for the dump site will be formed by the spreaders III ECS and V ECS system during the technological process of selective disposal of excavated overburden. Upon completed mining operations, the corridor will be formed with following dimensions:

- width of the bottom at the elevation of 85.0 mnm 450.0 m
- width on the final disposal elevation of 105.0 mnm 580.0 m
- general slopes inclination 1:3.2
- depth 20.0 m.

In the previously given area, at the disposed overburden, on the inner slopes of the cassette, two benches will be formed with the height of 10.0 m, slope inclination of 1:3 with the berm width of 3.0 m at the elevation 95.0 m above sea level. After planning and development of the slopes, the works on ground compaction of both cassettes will be performed\, as well as the levelling of the terrain at the elevation of 85.0 m above the sea level with a layer of sand of ~10 cm. In the so-prepared area two cassettes are envisaged with the base of 450 x 480 m, and depth of 20.0 m for receiving the decade long production of ash, slag and gypsum. Between the two cassettes the barrier embankment is designed with the height of 3.0 m, with crown elevation of 88.0 m above sea level. Crown width is 3.0 m, and slopes inclination is 1:3. The role of the partition embankment is to prevent the uncontrolled leakage of the drain atmospheric waters from the disposed materials into the surrounding area. The embankment will be made of mining overburden by construction mechanization. After the earthworks, the bottom and the slopes of the cassette are coated with two-layer waterproof barrier in accordance with the provisions of the Regulation on the disposal of waste at the dumpsite (Official Gazette of RS, No. 92/10). For collecting the drain waters at the bottom of the dumpsite, the water collector is planned. For collecting the drain water from the atmospheric precipitation in the dump site, the drainage mat was designed with the thickness of 0.5 m at the bottom of the cassette with the line drainage system to evacuate the collected water to the water collector WC with the surface 25 x 25 and evaluation of the bottom 84.0 m above sea level, available volume of 625 m^3 out of which, when necessary, the tank will be supplied for wetting the dry surface of the dump site, as well as for wetting the material during the compaction by construction mechanization.

Accumulation space of the Cassette 1 and Cassette 2 is dimensioned to accommodate the ash, slag and gypsum for a period of 10 years and totally amounts to about 9,200,000 m^3, while the total area of both cassettes is about 65.0 ha. The necessary space is determined according to the projected annual production of ash and slag and gypsum suspension from power unit TEKO B3, calculated on equivalent working time of 7,500 h/year with a maximum load and consumption of guaranteed quality coal.

The position of the newly projected dump site in the internal dump site OPM Drmno with the position of embankment and drainage system is shown in Appendix No. 20.

The cross section of the deposit cassettes are shown in Annex 21.

Description of the technology of deposing a mixture of ash, slag and gypsum

The material is brought to the dump site of ash, slag and gypsum according to the previously described mechanical transport. The spreader is in the start position at the end and the bottom of the hydro technically prepared hydro insulation dump site on the gravel layer with the thickness of 0.5 m. A layer of gravel has two roles. Technologically, the gravel layer functions as a drainage body. It is also a protective layer of hydro insulation foil of HDPE for movement of a discharge conveyor through the dump site.

Depositing a mixture of ash, slag and gypsum is performed from the spreader belt OTR-9 which will be moving along this conveyor at a constant rate, forming a layer of material with a triangular cross-section. When the disposal is completed along the total length of disposition (full width of the cassette), the discharge conveyor moves (varies) for the formation of the next cross layer.

Disposed material is planned by the construction machinery (bulldozer) and compacts (by vibrating roller) up to the necessary geotechnical parameters that allow the following acess of the spreading conveyor on it. Dispositioned is performed in the layers of 2-3 m thick after planning and compacting. When the spreader exceeds the total length of the dump site, the spreading conveyor OTR-8 turns on the other side and the second layer is being formed in the other direction.

The technology of disposition is based on the spillage of the material from the removable spreading conveyor with the „S“ cart. The spreading conveyor takes the material from the main transport system and moves progressively toward the dump site filling. The additional spreading and compacting materials will be performed by construction machinery. The waste disposed on such a way (with binding agent), properly planned and compacted material should be resistant to scattering.

Tripper car consist of two drums and unloading hopper attached to the cart. The belt wraps both drums in the form of letter S. When hitting the discharge drum, the material is being directed into the receiving hopper from which it is being discharged through the rod at the side of the conveyor. The tripper cars are shown illustratively in Figure 3.3.4-9.

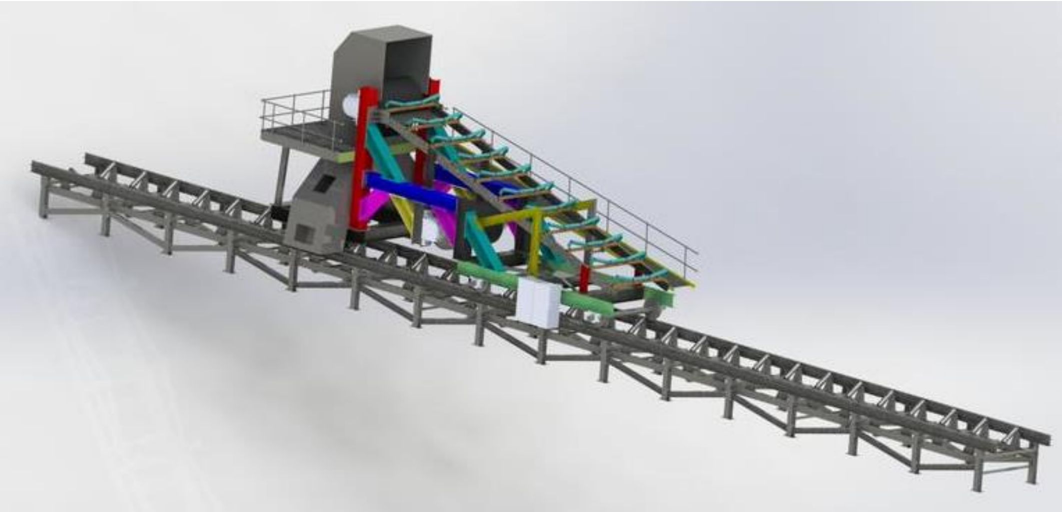


Figure 3.3.4-9: Illustration of tripper car S1

Spreading conveyor is delivered together with the support structure, tripper car by discharge belt, as well as crawlers for transverse movement of the conveyor through the dump site. Total weight of the spreading conveyor is about 320 t. Total length of the conveyor is 450 m. For running the conveyor, 10 crawlers are envisaged at the distance of 45 m. Spreading conveyor is illustrated in Figure 3.3.4-10.

Mobile spreading conveyor (MSC) receives the material from the connecting conveyor and transfer it to the tripper cars that move along the mobile bridge. MSC discharges in advance, which meant that it moves on the previously disposed material. The layer thickness of the disposed material on which MSC is moving must have adequate geotechnical properties.

Figure 3.3.4-10: Spreading conveyor belt with tripper car

MSC consists of a series of supporting sections that rely on the tracks. The inclination of the side rolls on the supporting part is 35°, and on the returning part 10°. Transitional rolls and rolls for alignment of the belt are set in all the places where it is necessary, depending on the load and vibration.

The supporting sections are connected by a ball joint that provides a diversion between the support and has a conveyor's path on the cables over which the tripper cars are moving. Telescopic bridges between sections support the rails so that the tripper car can travel over the joints.

On each supporting section the sensor measures the deflection of the joint and automatically maintains the alignment of the machine. The levelling sensor controls the cross level of each section. GPS system controls the MSC orientation with respect to the connected conveyor that feeds him.

The bridge has a total of ten sections: one at the beginning and end of the discharge belt and eight central sections. Each section has its own electric drive of 15 kW, coupling and gearbox. The crawlers are designed and constructed for the heavy load of the support sections and tripper cars. MSC is moving only when the tripper cars are at the beginning or end of the discharge belt where the crawlers are adjusted to the increased load. The speed of MSC varies from 0 to 0,025 m/s.

The electric cabinet and transformer are located at the end section of MSC, and the operator's cabinet is at the tripper car from which the disposal of the material is monitored. The walkways and platforms provide the access and possibility of maintenance for all the components of the MSC.

MSC uses RAHCO system for centering the belt, provides a permanent alignment of the belt and prevents side-slipping of the belt, even under the heavy and uneven load. The spreading conveyor has the ability to automatically maintain the level in relation to the surface which ensures the proper movement of the belt. The elements for the alignment are the level sensors of the support structure, hydraulic aggregates and cylinders and mobile construction.

The tripper car with the discharge belt is moving on the rails along the spreading conveyor. The tripper car directs the material from the spreading conveyor on the discharge belt with the length of 10 m, from which the material is being disposed on the dump site.

Figure 3.3.4-11 shows the tripper car with the discharge belt.

Figure 3.3.4-11: Tripper car with discharge belt

After disposal of wet mixture of ash, slag and gypsum into the cassette up to the height of 2.5 m, the spreading and planning of the materials will be performed by the bulldozer, as it is shown in Figure 3.3.4-12.

Figure 3.3.4-12: Bulldozers working on spreading and planning

The planned mixture will be compacted by vibrating roller to achieve the required geotechnical parameters that allow the next passage of the spreader on it and disposal od the new layer of the material, as shown in Figure 3.3.4-13.

Figure 3.3.4-13: Vibrating roller working on compacting

Service roads

Service roads follows the route of the closed belt conveyor, mounted on the pontoon construction, from the edge of OPM Drmno to the dumpsite of ash, slag and gypsum in the western part of the internal dumpsite of mining overburden. In addition to this, the service roads is designed around the edge of the dumpsite for the needs of construction machinery during the construction of the cassette and its maintenance.

Horizontal and vertical route elements are adapted to the needs of maintenance and exploitation of the belt conveyor. The road je made of unbound material – crushed stone.

Protection of soil and groundwater from dumpsite impacts

Since the dump site of ash, slag and gypsum is potentially in contact with the groundwater, and the surface with its geo-mechanical characteristics does not meet the recommendations of the Council Directive on waste, after the construction of the embankment out of the compacted overburden, the bottom and inner side of the dump site are coated with the waterproof foil over the bentonite geomembrane. Installation of two-layer waterproof geomembranes must be carried out according to the recommendations of the Regulation on the disposal of waste on dump site (Official Gazette of RS, No. 92/10) and Directive 75/442/EEC and EU 1999/31/EC.

1) Conditions regarding the dump site bottom of the Regulation on waste disposal on dump site

The bottom and sides of the dump site body should consist of natural geological barrier that meets the requirements regarding permeability and thickness with a combined effect in terms of protection of soil, groundwater and surface water, at least equivalent to the effect that is the result of the following requirements:

- Dumpsite for hazardous waste: K≤ 1,0 x 10^{-9} m/s; thickness ≥ 5 m;
- Dumpsite for non-hazardous waste: K ≤ 1,0 x 10^{-9} m/s; thickness ≥1 m;
- Dumpsite for inert waste: K ≤ 1,0 x 10^{-7} m/s; thickness ≥1 m.

2) Conditions in terms of drain waters

When the natural geological barrier does not meet the prescribed value, they are provided by a coating of the dumpsite bottom with synthetic materials or natural mineral buffer which must be consolidated in order to obtain the equivalent value of the bottom in terms of its water permeable properties. Natural mineral buffer should not be smaller than 0.5 meters.

It is necessary to provide the additional protection of the dumpsite bottom in order to prevent the migration of the drain water into the dumpsite subsoil, as it is shown in Table 3.3.4-6.

Table 3.3.4-6: Applied measures of protection of the dumpsite bottom from the drain waters

Applied measures in terms of forming a layer to protect the dumpsite bottom	Dumpsite class	
	For non-hazardous waste	For hazardous waste
Artificial sealing coating- foil	required	required
Impermeable mineral layer ≥ 0,5 m	required	required

For sealing the dumpsite bottom and sides of the dumpsite, the other methods and techniques can be used, which provide the conditions from the table.

First layer of protection is designed from the geotextile composite with the bentonite powder connected by sewing. The thickness of the bentonite ranges, depending in the purpose and classification of waste, from 4.5 – 7.0 mm, and the condition is that the coefficient of water resistance is less than 3x10^{-11} m/s, in order to replace the natural clay layer of minimum thickness of 5 m, coefficient of water resistance 10^{-9} m/s.
The required characteristics of geosynthetic clay (bentonite mat) are:

- Coefficient of water resistance: k< 3×10^{-11} m/s (ASTM D 5887-04)
- Unit flow rate: 4,5×10^{-9} $m^3/m^2/s$ (ASTM D 5887-04)
- Layer thickness: 7^{-10} mm (ISO 964-1:2001)
- Area weight of: 5 - 5,5 kg/m^2 (ISO965:2001)
- Tensile strength (longitudinal/transverse): 25 - 28/16 - 18 kN/m
- Elongation at break: 17 - 18/15 - 17%
- Breakthrough force: 4 kN (ISO 12236-2001).

The second layer of protection is designed from a smooth high density polyethylene film (HDPE). The adopted thickness of the film is 2 mm.

The sealing layer consists of the elements that are described and specified below. The manufacturer of the specified geosynthetic must have the certificate of ISO 9001. the Contractor shall obtain all the details related to these proposed materials, including the specification of the product by the manufacturer, technical and derived data, methods of quality control on the site by the manufacturer, as the manufacturer's ISO certification, the samples of the proposed materials.

Basic characteristics of HDPE film are:

- thickness: 2.0 mm (EN 964-1),
- raw materials: HDPE,
- endurance: practically indestructible,
- chemical stability: the largest of geomembranes (±PP),
- thermal stability (environmental conditions): the largest of geomembranes (±OC),
- density / specific weight: 94 g/m^2 (ISO 1183, ASTM D 1505),
- tensile strength (long./vert.): 30 N/mm^2 ISO 527-3,
- elongation at break: 800% (EN ISO 527-3),
- disruptive strength: >5.7 kn (EN ISO 12 236),
- breaking point in weld test on tearing: the break outside the weld,
- jam behaviour at 20°C: without interruption or rupture,
- water absorption: < 0.04%(ISO 1269),
- water permeability: ≤ n x 10^{-14} l/sec.

The manufacturer of HDPE film submits the technology and installation of the water resistance film, details of installation, anchor, details of protection of pipe penetration through the film and the method of binding the film to the construction.

Installation of HDPE membrane will be performed in phases in accordance with the dynamics of dumpsite progression.

For the collection of the atmospheric waters inflow into the dumpsite of ash, slag and gypsum, the drainage mat is designed on the bottom of both cassettes with the thickness of 0.5 m, after installation of HDPE film, over which the geotextile is laid for separation of layers, as well as a protection against congestion of the drainage layer.

For draining gravel drainage body, the horizontal drainage line was designed with 4 lines with the length of L= 370 m and a diameter of DN 150 mm declining to ~ 2 ‰ for both cassettes. The drainage pipes flow into the collectors with the length of L=405.0 m, which lead to the water collector located at the base of each of the cassette.

Water collector volume V=625 m^3 is of trapezoidal cross-section at the base with dimensions of 25.0 x 25.0 m, the available depth of 1.0 m with an inclination of slopes of 1:3 excavated on the site and coated with double-layer water resistant geomembrane. Water from the water collector is used for dumpsite spraying in order to prevent the scattering of the fine particles of disposed material.

The position of the water collector and the cross-sections of the dumpsite cassette are shown in the Appendix No. 20.

Closing and reclamation of dumpsite

After filling the cassettes 1 and 2 up to the final deposition level, the cassettes are closed and reclaimed by forming the upper cover layer that isolates the source of contamination, in order to prevent the direct contact with waste, the generation of dust and atmospheric water penetration into the dumpsite. The final surface of the cassette is levelled in the bilateral declining with the material disposed by the conveyor in order to ensure the runoff od the atmospheric waters from the reclaimed layer.

Covered construction was designed with geotextile composite with bentonite powder over which the layer for reclamation is applied (Figure 3.3.4-14).

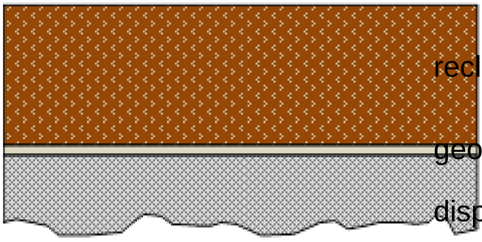


Figure 3.3.4.-14 Covered construction for closing and reclamation of dumpsite of ash, slag and gypsum in the OPM Drmno

<u>Auxiliary systems</u>

A. The system of compressed air

Compressed air system provides the necessary amount of service and instrument air of required pressure and quality for the operation of power unit B3 and the system of pneumatic transport of ash. This system includes compressors, tanks, equipment for obtaining the required air quality, as well as distribution pipelines to air consumers.

Compressor station consists of six rotary screw compressors with oil injection with capacity of Q=40 m^3/min, two absorption air dryers, three refrigerating air dryers, fiv fine oil separators, three fine water separators, two fine dust separators and one collector of compressed air. In addition to the compressor stations, three tanks of compressed air were installed:

- tank of compressed service air of unit with volume of 30 m^3,
- tank of compressed instrument air with volume of 50 m^3,
- tank of compressed air for pneumatic transport of ash with volume of 30 m^3.

For the purpose of equipment maintenance within the compressor station, the monorail is planned with the capacity of 5 t.

Four compressors will meet the need for compressed air of the unit and pneumatic transport, while the two compressors will be in reserve. Screw compressors are connected in such a way that each of them can supply any group of consumers. The compressors and compressed air coolers are air-cooled.

Within the compressor, there is a two-stage air purification system with suction regulator, the lubrication system with the oil coolers, multi-stage system for oil separation, cooler of compressed air output and water separator.

B. The system of technical gases

For the purposes of power unit B3 it has been envisaged the existing warehouse of technical gases of power units B1 and B2. For the purposes of cooling the coil of the generator, the hydrogen will be used and the displacement of hydrogen from the installation will be performed by carbon dioxide. Technological system of technical gases consists of:

- Hydrogen storage with the installation for discharge and gas pressure reduction,
- Carbon dioxide stations,
- Distribution pipeline of hydrogen and carbon dioxide from the hydrogen storage and carbon dioxide cells to the gas panel power unit,
- Internal gas installations – gas panel power unit for controlling of operating parameters.

Hydrogen station

Hydrogen storage that has been installed for the needs of the power units B1 and B2 will be used for the purposes of the power unit. The existing storage of hydrogen in bottles was built in the open space and covered with porch that protects the bottles from sunlight and atmospheric precipitation. In the storage the bottles are arranged along the pallets (batteries of bottles) within which the bottles are tightly linked but in such a way that it is prevented the mutual contact of the bottles by placing the rubber or similar belts.

The hydrogen storage capacity for the needs of the new unit has been designed to allow generator charging and reimbursement of seven days generator losses. It has been calculated that 36 hydrogen bottles and one palette are needed. Each bottle has a capacity of 40 litters and a pressure of 150 bar. It has been anticipated that the 2 pallets of hydrogen has to be installed. During the reimbursement of hydrogen losses one pallet would be used, while the other pallet would be included during charging the generator with the hydrogen.

Each bottle in pallet is supplied with a valve. From the pallet, the hydrogen is led to the installation for discharge of hydrogen and pressure reduction located within the warehouse. After pressure reduction, the hydrogen goes to the tank with the capacity of V=13.9 m^3 each. The tanks are connected in such a way that the hydrogen from the tank goes back to the collector from where it goes further to the gas panel unit. There are the tanks of hydrogen in the power plant near the hydrogen warehouse that are not in use and it is necessary to check if they can be used for the new power unit.

In the installation, the pressure of hydrogen is being reduced from 150 bar, which prevails in the bottles, to the pressure of 5 bar, which prevails in the distribution pipeline to the gas panel. The installation leans against the protective wall, so it is protected from the atmospheric precipitation and consists of:

- Hydrogen reducer with safety valve,
- Block valve in front of and behind the reducing valve;

Installed on the main and by pass duct as well as

- Manometer for hydrogen,
- Safety valve,
- Flame catcher.

Separation of hydrogen from the warehouse to the generator is performed by pipeline DN 32. In order to ensure 100% reserve in the inlet pipeline, it is necessary to connect the gas panel of the generator B3 with the inlet hydrogen pipeline of power unit B2. In doing so, one line should be used for charging and one for recharging the generator.

The route of the new pipeline distribution of hydrogen should follow the route of the existing pipeline for supply of the power units B1 and B2. From the hydrogen storage, the hydrogen pressure of 5 bar is being led at T columns to the bridge for ash pipeline, and then to the underground channel with which these pipeline lead to the MPF of power unit B1. From the channel at the pillar I in row 1, the pipeline is raised to level +7.00 m and leads though the boiler room to the column C where it passes through the hole at the elevation + 6.50 m. Further, the pipeline goes along the rows of columns 1 up to the columns Ag where the existing hydrogen pipelines of power unit B1 are being separated towards the gas panel of power unit B1. Hydrogen pipelines of power units B2 and B3 are being led further on the route along the wall of the generator's hall from the row of columns 2 to the row of columns 7 where the hydrogen pipelines of the power unit B2 are being separated toward the gas panel of power unit

B2. Hydrogen pipelines of the new power units are being led further on the wall of the mechanical room on the elevation of +7.00 m following the column row A to the exit from the mechanical room. Further, the hydrogen route goes along the channel under the road up to the intersection with the cable channel, where the hydrogen pipelines go up to the surface and are led to the new power unit by the pipe bridge.

Station of carbon dioxide

Station of carbon dioxide that was installed for the purpose of the power unit B1 and B2, which is not in use, will be used for the purpose of power unit B3. With the basic concept of technological system of carbon dioxide, the acceptance of full containers of liquid carbon dioxide, shipping the empty containers, degassing the liquid carbon dioxide, storing the gaseous carbon dioxide in the tanks and the use of gaseous carbon dioxide from the tanks have been envisaged, whereby the reduction of the CO_2 pressure is being performed up to the desired value during washing of the generator.

Supply of carbon dioxide is carried out in the liquid state under pressed into the steel containers. The pressure of the filling depends on the outdoor temperature and ranges from 70 to 100 bar. The steel containers are filled with carbon dioxide so that on each kilogram of gas goes 1.34 l of container volume. Under these conditions, there is a balance between the liquid and vapour phase in the container. Since there is a vapour phase in the container apart from the liquid, the content of CO_2 in the container is determined by not only the pressure, but also by weight.

Discharging containers are placed in the provided space at the station CO_2. In order to prevent the shifting of the containers, the ramp is planned, which will be closed by chain on the front. On the other side of the main door, the same space is envisaged for the empty containers. Near containers the scale is placed for weighing the mass up to 150 kg.

The containers are placed on the ramp for discharging. The containers on the ramp are connected to a common collector on which there is a manometer and device for alarming when the lines with the containers are discharged. The block valves on the containers and on the collector pipes enable the simultaneous discharge of a desired number of containers. The collector pipes are connected to the line for degassing of liquid carbon dioxide. The line consists of the inlet of liquid carbon dioxide, an electromagnetic valve, evaporator-expander with reducing valve, thermometer, manometer, safety valve and drain of gaseous carbon dioxide.

The electromagnetic valve interrupts the supply of liquid carbon dioxide when the a pressure of 10 bar is reached in the tank of gaseous carbon dioxide. The evaporator of carbon dioxide with degassing valve uses the electricity. The gas temperature at the outlet of the evaporator is 20^{o}C, and the pressure corresponds to the pressure in the tank of gaseous carbon dioxide. When the pressure of 10 bar is reached in the tank, the closing of the electromagnetic valve should be performed in front of the evaporator.

The electric heater has been installed in the evaporator, which turns on and off by the built-in thermostat in order to maintain the outlet temperature of carbon dioxide. Before the opening of the inlet valve of the liquid carbon dioxide, it is necessary to heat the evaporator to 150^{o}C in order to avoid freezing of the gas in the evaporator. On the duct of the carbon dioxide behind the evaporator, there is a thermometer and contact manometer. On the manometer, the contact has been envisaged for closing the electromagnetic valve on the inlet of the liquid carbon dioxide and turning off the evaporator when the gas pressure in the installation rises to 10 bar.

The gaseous carbon dioxide is led from the degassing line into the collector from which the suppling of the main plant facility is being performed. Similar, the two tank with the volume of V=4 m^3 each are connected to the collector. The tanks are equipped with manometers, safety valve and venting valve. At the lower part of the tank, the pipe with the valve for drainage of the tank was taken out.

Consumption of carbon dioxide from the tank leads to a reduction of pressure in the tank as well as in the installation, so it is necessary to turn on the evaporator and perform the refilling of the tank.

It has been anticipated the natural and forced ventilation of the building CO_2 station as well as heating with 2 space heaters. The storage and the area around the storage is lit by artificial lighting. The storage is fenced.

The supply of carbon dioxide gas panel of the new power unit has been planned by pipeline DN 50. The pipeline of carbon dioxide will take the same route as the hydrogen pipeline. Within the existing units the pipe was installed for drain of the carbon dioxide from the station of the carbon dioxide to the gaseous panel units B1 and B2, which it is out of use.

C. The system of liquid fuels

The basic concept of the technological process envisages the liquid fuel oil is used for fire lighter and fire maintenance at low loads of the new boiler.

Fuel oil is being delivered to the power plant by tank trucks. From the pumping station, the heated fuel oil is being lead into the storage tank of fuel oil by the existing transfer pumps.

For the purposes of the new unit, the installation of a new fuel oil tank with capacity of 3.000 m^3 is planned, which would be connected to the existing tank. For heating the fuel oil in the new tank, the installation of flow and floor heater has been envisaged. The tank will be set in a concrete pool that is able to accept the entire amount of fuel oil from the tank in case of its breakdown.

The supply of fuel to the burner of the main boilers has two degrees. The fuel oil, heated with the flow heaters to a temperature of 80˚C, is being surprises with the distribution pumps of the first degree to the fuel oil pumping station of the second degree. Within the fuel oil station, the fuel oil is being heated to a final temperature of about 150˚C, and then is being led with the high pressure pumps of second degree to the fuel oil burners in the boiler. The surplus of fuel oil goes back into the storage tank by recirculation duct.

New fuel oil pipelines (distribution and return) with associated water heating are being lead along the route of the existing fuel oil pipelines from the pumping stations of the distribution pumps of I degree to the fuel oil pump station of II degree of unit B2, next, the new pipelines is being led by the channel to the new pump station of II degree of unit B3.

The flow of fuel oil to the burners is regulated by a control valve with the electric actuator. Each burner is separated in relation to the fuel oil supply system, without affecting the rest of the burners and has its own local control station. It is mounted near the burner at which the two fast closing valves are being set, controlled by electro-pneumatic actuators. The first is three-way valve and allows the recirculation of fuel oil, when the burner is out of operation. The second valve prevents the flow of fuel oil when the burner is not working.

The fuel oil ignition is achieved by fire-lighter gas – propane-butane (50-70 kPa) electrical spark.

D. System for reception and discharge of the turbine oil

A system for reception and discharge of turbine oil should enable the reception of the total amount of fresh turbine oil delivered to the power plant for the needs of oil system turbo generator of unit B3, as well as for its discharge in case of need. This system consists of several tanks, pumps, fittings and pipeline.

The basic concept of the system for reception and discharge of turbine oil envisages:

- reloading of turbine oil into the receiving tank,
- drainage of fresh turbine oil into the main turbine tank,
- treatment of the used turbine oil by its circulation between the tanks of clean and used oil,
- transportation of the used turbine oil to the car tank and its removal.

System for the reception and discharge of turbine oil consists of:

- pump for discharging of oil barrels,
- pump for discharging of central tanks,
- pump for drainage of oil into central tank,
- centrifuge,
- turbine tank with the volume of v = 40 m^3,
- tank for adding the oil with the volume of v = 2 m^3;
- tank for the clean oil reception with the volume of v = 50 m^3;
- tank for the used oil reception with the volume of v = 40 m^3.

The supply of clean turbine oil into the tank is carried out from the concrete plateau from barrels or from cistern. The electrical connection for the pump used for discharging of oil barrels is envisaged on the plateau.

Tanks for clean and used oil are buried between the row AC and row AD of the mechanical hall and are protected against corrosion on the outer side.

From these tanks, turbine oil is taken via pump to the tank for adding the oil with the volume of V = 2 m^3 located at the level of +13.00 m. Next, turbine oil by free fall while passing through the centrifuge, goes into the turbine tank located at the level of 6,3 m in the main mechanical hall.

The used oil from the turbine tank returns via the oil drain pump into the central tank for the used oil reception. Treatment of the used turbine oil is carried out through centrifuge by oil circulating from the central tank of used oil to the central tank of pure oil.

System for the reception of turbine oil is used only occasionally. The whole technological process is carried out by using the appropriate manual valves.

E. The system of auxiliary steam

The supply of auxiliary systems of unit by steam is provided from the common collector of unit auxiliary consumption, which is supplied by steam from the cold inter-superheated steam pipeline. During unit start-up and all in all other conditions when there is no main steam production in the unit, provided is the supply of collector of unit steam auxiliary consumption from the steam busbar of 10 bar, common for all thermal power plant units.

From the auxiliary steam system, steam is provided for the following consumers:

In the boiler room:

- fuel oil heaters of the internal fuel oil plant,
- supporting heating of the internal fuel oil plant,
- steam air heaters for start-up,
- thermal treatment of water for washing the regenerative air heater.

In the mechanical hall:

- power supply of generator while unit start-up,
- installation for heating and deaeration of water in the feed tank while unit start-up.

Besides the specified consumers within the unit from the auxiliary steam system through the common collector, steam is also provided for general consumers within thermal power plant, such as:

- heating of facility and premises of thermal power plant,
- supply of 6 bar collector (for fuel oil tank heaters, installations for fuel oil unloading, supporting heating, chemical water treatment, etc.).

Except from the substation for treatment of water for facility and premises heating, exchanger of station for railway cars defrosting and installation for thermal water treatment, for washing of regenerative air heaters, condensate of auxiliary steam from the system with surface heaters does not return again to the main thermodynamic cycle, but after treatment, i.e. purification it is discharged.

F. Raw water system

For the purposes of supply of consumers with raw water in Power plant, it is necessary to install new pumps and pipelines of raw water with the appropriate valves. The installation of raw water pumps is envisaged in the cooling water pumping station.

Within the Power plant, raw water consumers are: CWT plant, FGD plant, wet electrostatic precipitator, fire protection system, devices for wet dedusting in systems for de-ashing and coal transportation etc.

Total estimated quantity of raw water necessary for supplying of all consumers in the Power plant is ≈320 m^3/h. On the basis of the hydraulic calculation made, selected are 3 raw water pumps (2 x 100%), with the capacity of Q= 350 m^3/h.

G. Thermo-technical installations

Within facilities and premises of the new unit B3, envisaged are the installations for heating, ventilation and air conditioning in accordance with technical requirements of the installed equipment, as well as with conditions appropriate for people's stay, and for defined external and internal design parameters.

Facilities, i.e. systems of the new unit B3 with the power of 350 MW at the location of TPP Kostolac B in which thermo-technical installations are envisaged, are the following:

- Main Plant Facility (MPF): boiler room, mechanical hall, unit control room, E-rooms,
- ash and slag disposal: silos for ash and slag, hydro-transport pumping station, room below the condenser,

- flue gases desulphurization system (FGD): FGD facility, drainage station, limestone grinding facility, gypsum drying facility, discharge station for railway cars,
- technological and technical preparation (upgrading the existing facility)
- compressor station,
- cooling water pumping station,
- chemical water treatment (CWT),
- mills service,
- E-building for electrostatic precipitator,
- fuel oil station.

B. Electrical facilities

Electric power facilities

Envisaged is the installation of a three-phase synchronous generator with the following properties:

- active power 350 MW
- power factor (cosφ) 0,85
- apparent power 412 MVA
- nominal voltage 22 kV
- rpm 3.000 rev/min
- frequency 50 Hz

The excitation system is a static one and consists of the excitation transformer with the power of Sn=3,6 MVA, cabinet with thyristor rectifiers and excitation voltage regulators, resistors for rapid de-excitation and other equipment, and it is supplied from tapping of generator busbars, 3 x 22 kV, 50Hz.

Generator cooling is combined, with water-cooled stator winding and hydrogen-cooled rotor winding and magnetic circuit. The final solution for cooling will depend on the manufacturer and its applied system. Insulation class of the generator will be F, and the temperature rise class will be B.

The generator will be placed in the mechanical hall at the level of +12,6 m, and the excitation system below the generator at the level of ±0,00 m, except for the excitation transformer, which will be placed from the outside, in front of the rows of "A" columns of the mechanical hall.

Generator switch will be mounted in shielded busbars. It is placed at the level of +6,30 m, and the busbars are supported at the same level. Expansion pieces, openings for control and other auxiliary equipment will be mounted in busbars.

Large power transformers are:

- main unit power transformer,
- unit auxiliary power transformer,
- station service power transformer.

Envisaged are oil transformers, for the outdoor installation.

Large transformers will be placed in the open area in front of the rows of "A" columns of the mechanical hall. The unit auxiliary power transformer and the main unit power transformer, will be placed under generator busbars in axis with them. Generator busbars will be connected by vertical lines to the connection taps of the transformer.

Placement of the generated power of the new unit B3 in Power Grids of Serbia will be provided through 400 kV switchgear, located in the immediate vicinity of the new Main Plant Facility. On the high-voltage side, the main unit power transformer connects via the air connection (about 200m) to the existing plant RP 400 kV. This is the existing plant for outdoor installation with completed systems of busbars and portals, in which, for the purposes of connecting the main unit power transformer B3, new 400 kV high-voltage equipment (switch, busbar and output disconnector with earthing blades, measuring transformers) will be installed. The equipment for control, protection, measuring and signalling of the newly-equipped field is designed for placement into the existing control building.

For the purposes of general group consumers of the new block B3, envisaged is a new power transformer 110/6,6/6,6 kV, with the power of 60/35/35 MVA which will be connected to the existing switchgear RP 110 kV in TPP Kostolac B, also by air connection (about 200 m) since this plant is also located in the immediate vicinity of the new operating facility. Also, envisaged is the new equipment for control, protection, measurement and signalization for the new field in RP 110 kV which will be equipped for the needs of the new unit B3.

Envisaged is the microprocessor system of generator’s electrical protection. The equipment will be installed in three free-standing cabinets, located in the mechanical hall’s annex in the Main Plant Facility (MPF), at the level of +8,9 m, in E-room below the control room of unit B3.

Along with transformers, envisaged is the delivery of the following protections:

- transformer’s Buchholz,
- Buchholz of transformer's voltage regulator,
- transformer oil's temperature,
- thermal image.

6,3 kV switchgear of the unit will be divided into two sections. Each unit section will be connected, via feeding switches, with one of the secondary windings of transformer of unit auxiliary power.

All electric motors with powers greater than 200 kW will be supplied from RP 6,3 kV.

For the supply of consumers of low voltage 0,4 kV, envisaged are three-phase dry-type transformers 6,3/0,4 kV.

For the supply of 0,4 kV unit consumers and general group, envisaged are two transformers, with the power of 1.600 kVA and one transformer with the power of 1.600 kVA for lighting, heating, ventilation and air conditioning of MPF. In normal operation, they are all in operation, and in case of fault, spare transformer is automatically switched on, depending on the fault location. The envisaged power of spare transformers is 1.600 kVA. Diesel aggregate of 700 kW is connected to the diesel section of the unit.

For the supply of 0,4 kV flue gases desulphurization consumers, envisaged are two transformers with the power of 1.600 kVA, as the operating and spare one, and the same is also envisaged for the supply of 0,4 kV consumers: slag and ash transportation system. For the supply of dry electrical precipitator, envisaged are transformers with the power of 2.500 kVA, 400 kVA for wet electrostatic precipitator, cooling water pumping station and CWT, transformers with the power of 630 kVA.

Envisaged transformers are with voltage regulation in voltage-free condition on the higher voltage side. Transformers are adapted for the direct connection to distributions 0,4 kV, by busbar connections 0,4 kV, except for transformer with the power of 2.500 kVA and are equipped with auxiliary equipment (thermal protection etc.).

With the implementation of dry-type transformers, avoided are all inconveniences which accompany oil transformers, and the additional space is obtained as well.

Transformers 6,3/0,4 kV of the unit and general group will be placed at the level of +4,2 m in the mechanical hall's annex, for dry and wet electrostatic precipitators they will be placed at the level of ±0,00 m in E-building of electric precipitators, for desulphurization they will be placed at the level of ±0,00 m in the desulphurization facility, for slag and ash transportation system they will be placed at the level of ±0,00 m, in the silo and the cooling water pumping station at the level of ±0,00 m.

For unit B3, provided are the following auxiliary power sources:

- diesel aggregate with the power of 700 kW, with 0,4 kV distribution of unit diesel. Diesel aggregate will be placed at the level of ±0,00 m in a separate building which is located in the immediate vicinity of the mechanical hall's annex.
- diesel aggregate with the power of 500 kVA, with 0,4 kV distribution of cooling water pumping station diesel. Diesel aggregate will be placed at the level of ±0,00m in the cooling water pumping station.
- diesel aggregate with the power of 250 kVA with 0,4 kV distribution of gypsum drying facility diesel. Diesel aggregate will be placed at the level of ±0,00 m in the facility for gypsum drying in a separate room.
- rechargeable battery 220 V JSS, with the capacity of 1.500 Ah, with the possibility of supplying of emergency consumers of 60 min, with the associated rectifier (two sets as the operating and spare one) and 220 V JSS distribution.
- converter (inverter) (two sets as the operating and spare one) with 0,4 kV distribution of safety voltage.

Measurement, regulation and control system (MRC)

Control and monitoring of operation of plant and system of unit B3 complex, for the purpose of ensuring safe and efficient operation and the fulfilment of the required properties, will be implemented by means of the control system.

Functions of control and monitoring of operation which are necessary for the provision of resources (coal, fuel oil, water, electricity...), start, operation and stopping the plant, electricity supply, will be provided from the central control room of the complex located at the level of +12,60 m of the Central control building. Central control room, which is at the same time the control room of the unit and electrical command, will be normally occupied.

For the provision of resources, responsible are the operators in constantly occupied control centres: coal transport command, fuel oil external distribution command, water treatment command, FGD command, slag and ash disposal command. For normally unmanned facilities and systems, local control centres will be formed. The main technological system as well as all auxiliary systems will be subjected to automatic control.

Situation of facilities with the arrangement of control rooms is shown in Appendix 22.

Technical solution of the system of measurement, regulation and control includes:

- control and monitoring of the unit’s operation,
- control and monitoring of the operation of electric power facilities,
- control and monitoring of the operation of auxiliary systems and the new unit’s plant.

Distributed Control System (DCS) with operator stations (OS) and redundant process stations, connected through the redundant communications network, will enable operators in command the control of the unit's plant with the presentation of the necessary signals of state and disturbances.

Normal control of auxiliary facilities and systems will be carried out from local control rooms, through the associated control systems with operator stations (OS). Local control systems will, via the redundant communications network of auxiliary facilities, be connected to the equipment in the central control room. Operator stations of auxiliary facilities will enable to the operator in the central control room the insight into operation and problems in operation of auxiliary facilities and systems.

In accordance with technological requirements on the unit's plant and auxiliary systems and facilities, envisaged are extensive analogue and binary measurements of all necessary technological values: pressure, level, flow, temperature, vibrations, measurement of conductivity and other chemical analyses, flue gas analyses, etc.

Block diagram of control and monitoring system is shown in the Appendix no. 23.

The system of continuous monitoring of flue gas emission will be provided at the new wet chimney, and it will provide Reports for the Ministry of Environmental Protection. The organization of CEMS is presented in the Appendix no. 24.

The control of electric power facilities will be carried out remotely from the central control room, which is also the electrical command, and locally from the front of the distribution cabinet. Functions of control and monitoring of electric power facilities will be implemented within DCS control system of the unit.

For the purposes of automatic remote monitoring of processes in the new unit, from EMS remote control centres, envisaged is the transmission of necessary signals, which will be realized via the existing network information system (NIS) of the power plant.

The control of unit B3 plant will be independent in relation to the existing control systems of units B1 and B2.

External and internal electrical installations

The design of external and internal electrical installations envisages the following:

- installation of lighting and sockets of unit B3 facilities,
- installation of grounding and lightning rod of unit B3 facilities,
- installation of external lighting of access roads of the second phase of construction,
- external grounding grid of unit B3, which is connected to the existing grounding grid from the first phase of construction.

The installation of lighting and sockets in facilities includes:

- general lighting,
- emergency lighting which consists of safety lighting of exit routes (anti-panic) and auxiliary lighting,
- portable lighting,
- sockets for general use.

For the supply of general lighting installation and socket outlets in the Main Plant Facility (MPF), provided are two separate distributions 400/230 V, OCN31 and OCN32 which are supplied from the transformer for lighting OCT35 with the power of 1.600 kVA.

The main distribution and transformer 6/0,4 kV for the supply of lighting installation and socket outlets will be placed in the mechanical hall's annex, at the level of ±4,20 m.

From 0,4 kV OCN31 distribution, provided will be the supply of lighting installations and socket outlets for general use for MPF of the third unit, and from OCN32 distribution, provided will be the diesel power supply of auxiliary lighting and so-called emergency consumers, i.e. around 30 - 50% of general lighting and part of sockets, so as to ensure the minimum of operation process. OCN32 distribution is supplied from the diesel aggregate 3EY of 700 kW located in the diesel house in the vicinity of MPF.

Safety lighting of exit routes will be provided by power supply from rechargeable batteries 220V JSS, i.e. from 3EA distribution, located in the room for rechargeable batteries and inverter at the level of ±8,40 m.

For portable lighting, envisaged are portable luminaires for 24 V which may be used only in MPF, where the socket outlet installation 24 V will be located.

Power supply of lighting installations and socket outlets for general use will be provided from distribution cabinets for lighting and sockets RO-S. Part of these distribution cabinets is three-piece, with three groups of busbars, for mains, diesel and supply from the distribution of direct current 220 V JSS. In case of mains power supply failure, busbars of diesel and DC power supply in these distribution cabinets remain under voltage. Automatic switching is done on the main distributions.

Protection against dangerous touch voltage in 400/230 V installation will be provided by protection in TN-C-S system. Separation of neutral and protective conductor will be executed in 0,4 kV sub-distributions or in distribution cabinets of lighting RO-S, and from there, they will be separately guided to end consumers. Protective conductor will be connected to PE busbar in distribution cabinets, which is connected to the main ground electrode of power plant.

Grounding and lightning rod installations of unit B3 facilities

The ground electrode for MPF of unit 350 MW and individual ground electrodes of auxiliary facilities which are added in the second phase, will be connected with the ground electrode of the first phase of construction, and will represent a unique protective, operating and lightning protection within the power plant and in the distribution switchgear.

Grounding of each facility consists of a foundation ground electrode and a ring ground electrode around the facility.

Lightning protection system of MPF and auxiliary facilities of unit B3 in the power plant will be in accordance with SRPS IEC 62305 and designed as a classic lightning rod installation. The reception system of lightning rod installation on the facilities' roofs will be a grid of galvanized steel strip Fe/Zn 30 x 4 mm, 25 x 4 mm and 20 x 3 mm. Grid eyelets width will depend on the calculated level of protection for individual facilities.

The unit's external grounding grid and lightning protection system

The external grounding grid of the unit B3 will include the grounding grid of the switchgear 400/110 kV (part which is being additionally built) with connections to devices, as well as connections between the ring ground electrodes of facilities, connections with the existing ground electrode of the first phase of construction, and ground electrodes of all metallic masses on the unit A3 (light poles, steel structures etc.) Ground electrode in the ground is realized by a tinned copper wire with the cross-section of 95 mm^2, and the connections to devices with 2 x 95 mm^2 wire.

Lightning protection system RP 400/110 kV is realized via additional protective wires, mounted on portals and the outer wall of MPF, which will protect a part of RP which is being additionally built.

Outdoor lighting

Outdoor lighting installation continues after the existing outdoor lighting installation and includes:

- lighting of new roads,
- lighting of transformer plateaus near MPF,
- a new part of RP 400 kV and 110 kV.

C. Architectural and structural facilities

Architectural and structural facilities are new facilities necessary for functioning of all technological systems and sub-systems of the new unit B3 of the second phase of construction of TPP Kostolac B.

When designing, respected were: urban – spatial conditions from the initial project of TPP Kostolac B complex from 1984, the available area at the location, the existing infrastructure and utility networks and disposition of the existing facilities implemented in the first phase of construction, as well as designed facilities for desulphurization of units B1 and B2.

Technological structure and new FGD technological systems of unit B3 caused the displacement of some primary traffic corridors for railway traffic.

Main Plant Facility (MPF)

Main Plant Facility is located southeast of the existing unit B2 at the location provided for in the project from 1984. The location is equipped with the project envisaged by primary utility infrastructure or connectors in the zone between the existing unit B2 and the new unit B3.

Main Plant Facility consists of: mechanical hall, hopper system with transfer tower, boiler room with mills, boiler and installations for fresh air and evacuation of ash, slag and flue gases from the combustion process. The facility is connected via warm pedestrian passageway with the existing unit B2. Coal transportation is carried out by a slope conveyor bridge from the coal deposit to the transfer tower of the hopper system, left from the row 1.

Coal transportation is carried out by a slope conveyor bridge from the coal deposit to the transfer tower at the level of +66,7 mm of the hopper system, left from the row 1.

MPF is connected via flue gas ducts with the electric precipitators facility.

Main Plant Facility of unit B3 350 MW consists of four interconnected facilities:

- boiler room building with stairway-and-elevator tower,
- hopper system building with receiving tower with hoppers for coal and conveyor belts,
- mechanical hall,
- annex and stairway-and-elevator tower.

The gross area of MPF is approximately 29.800,0.m^2. Within the area of MPF, turbine-generator in the mechanical hall is set up along the longitudinal axis in parallel with the longitudinal axis of the mechanical hall, and perpendicular to the longitudinal axis of the boiler room.

Boiler room with elevator tower

The above-ground part of the boiler room building consists of a lower, basically wider part and a higher, basically narrower part. Dimensions of this part of the building are 75 x 80m, 57m in height, and columns of the boiler support ('gerist') are located at a distance of 24 x 24m, height of the roof above the boiler is 117,0m.

The facility functionally consists of:

- the main boiler body which includes: the boiler with the associated equipment and coal transportation systems, mills, fresh air pipelines, flue gas ducts and “Pipeline inspection gauge” at the level of -3,00 m whose dimensions are 14,40 x 16,40 x 3,0 m with the equipment for slag transportation;
- smoke and ash exhaust channel with complete associated equipment;
- eight mills for coal at the level of 0,00m, radially arranged, fresh air fans and other electrical and mechanical equipment;
- a series of primary and secondary levels and galleries located inside the boiler room next to the boiler body. All levels inside the boiler room building are connected by two primary stairway-and-elevator communications.

Within the boiler room, located is also the equipment for fresh air distribution as well as the equipment for the collection and transportation of smoke from the boiler to the electrostatic precipitators.

Hopper system with receiving tower

The hopper system facility occupies the space between the boiler room and the mechanical hall. Dimensions of the hopper system are 11,0mx81,0m, and the height is 59,0m.

The facility functionally consists of:

- transfer tower,
- horizontal coal conveyors above the silo,
- silo for coal.

Coal is transported from the deposit to the receiving tower by the slope conveyor bridge and then by horizontal conveyors inside the hopper system, to the hopper system's silo.

Mechanical hall

The mechanical hall facility is a part of MPF. Dimensions are 33,0mx81,0m, with the height of 33,5m to the roof slope. The mechanical hall's area is organized at the following levels □0,00m, +6,20m, +12,6m. The main operating level is +12,6m, i.e. the level of turbine and generator.

In the building of the Main Plant Facility , envisaged are the following hydro-technical installations:

- sanitary water,
- sanitary sewage,
- stormwater sewage,
- hydrant network,
- industrial sewage.

The main horizontal connections with other parts of MPF are:

- with the boiler room at the level of ±0,00 m, at the level of +12,6 m through the hopper system,
- with the external area via main, big doors on the route of the railway track, with the dimensions of 5.000 x 7.000 mm,
- with the main pedestrian corridor toward the annex at levels ±0,00 m and 12,6 m.

Electrical control building of the unit contains: the control hall of the unit B3 with all associated rooms, E-distribution rooms and offices of heads of operational services by professions.

The building is of rectangular shape in the basis, with the dimensions of 26,0 x 37,5m, 28,0m in height. The number of floors in the building is P+3. Gross area of the building is cca. 3.695,0 m^2.

In this building, envisaged are the following hydro-technical installations:

- sanitary water,
- sanitary sewage,
- hydrant network,
- stormwater sewage.

Diesel aggregate building is located on the area below the Electrical control building of the unit, and next to the existing internal vehicular road.

The building has a ground level, with the dimensions of 8,0 x14,0m, 8,5m in height, with the gross area of 123,0 m^2.

Dry electrostatic precipitator control building is located east of the dry electrostatic precipitator next to the main vehicular communication.

The building has a ground level, with the dimensions of 11,5 x 26,0m, 6,5m in height. Gross area of the building is cca. 320,0 m^2.

Workshop for the maintenance of mills is located next to the boiler room on the east side and internal vehicular roads.

The facility has a ground level with the dimensions of 21,0 x 36,0m, 18,50m in height, with the gross area of cca. 827,0 m^2.

Workshop for the maintenance of mills is functionally organized for a series of successive operations: washing and disassembly of millwheels, repair and adjustment to transport towards the boiler room. The crane is used for the internal transportation of millwheels in the repair process.

The compressor station is located on the plateau in the vicinity of MPF and below the bridge for coal transportation.

The facility's dimensions are 12,0 x 38,0m, cca. 8.0m in height. The facility has a ground level, its gross area is approximately 500 m^2. The compressor station is connected through a pipe bridge with the boiler room.

The compressor station contains the following water supply and sewage installations:

- stormwater sewage,
- industrial sewage,
- hydrant network.

External system of fuel oil

Fuel oil substation is located on the area immediately adjacent to the MPF facility, on the northwest side of MPF, between the main and service vehicular communication.

The facility has a ground level, with the dimensions of 14,0 x15,0m, 4,0-5,0m in height. Gross area of the facility is cca. 210,0m^2.

Facility for flue gases desulphurization

It is envisaged that facilities of flue gases desulphurization system should be located between facilities of MPF system and facilities of the system for the internal transportation of ash. They include mechanical, electrical and technological equipment required for technological process of flue gas treatment. Envisaged are the following facilities:

1. Building with recirculation pumps and oxidation compressors: the building's dimensions are 26.0m x 21.0m, and its height is cca. 16.0m. Gross area of the building is approximately 1.400 m^2.
2. FGD facility, intended for the placement of technological and mechanical, electric power and control equipment. The facility's dimensions are 65.0 x 11.6m (20,0m), 13.5-30.0m in height. The number of facility's floors is P+4, with the gross area of cca. 2.250.0 m^2.
   In this facility, envisaged are the following hydro-technical installations:
   - sanitary water,
   - sanitary sewage,
   - hydrant network,
   - stormwater sewage,
   - industrial sewage.
3. Pumping station for sludge removal from the absorber,
4. Reservoir for incidental discharge with pumping station,
5. Absorber: Absorber is a steel structure of cylindrical shape. The inner diameter of the cylindrical sheath of the absorber is 14,2 m, and the height is 40,9 m. In the absorber's sheath between levels +16 m and +20 m, located is the rectangular opening for the entry of flue gas duct into the absorber, while the outlet of the flue gas duct is at the height of 39,3 m. The absorber is coated with stainless steel in the top part on the inner side, while in the lower part (the reaction sump) it is coated with a non-metallic material (rubber).
   At levels +21,2 m, +23,3 m, +25,4 m, +27,5 m and +29,6 m, installed are sprinkler systems, while the two-stage drops eliminator is above them, at the level of 36-38 m. At each level for spraying, installed are 880 nozzles for suspension spraying, with a total flow of 10.000 m^3/h. Above the steel sheath, located is the roof steel structure of conical shape. This cone consists of a steel plate enforced by steel profiles in the direction of cone's generating lines. The suspension is retained in the absorber as a liquid. The level of liquid in the bottom of the absorber can reach 13 m, which means that the absorber's structure contains the reaction sump as well.

The system for limestone

Facilities of the system for limestone are in function of the flue gases desulphurization system (FGD) of unit B3 of TPP Kostolac.

Main facilities of the system are:

- station for unloading of limestone from railway cars,
- building for the preparation of limestone suspension, which includes the facility for the preparation of limestone suspension, and it is designed as the building divided into three

functional zones: the zone with mill for limestone, the zone of day silo and day hopper for limestone with E-building.
Dimensions of this building are 12-22,0 x 47.0m. The number of building's floors is P+3, and the height is 31.0m. Gross area of the building is cca. 1.200,0 m^2.

- limestone storage facility, located between the building for the preparation of suspension and the station for unloading of limestone from railway cars, it is used for temporary storage of limestone. Dimensions of the facility are 40,0 x35,0m, and its height is 16,0 m. Gross area of the facility is cca. 1.400.0 m^2.
- station for unloading of limestone from railway cars is used for the receipt of limestone from railway cars and the start of its transportation by conveyor bridges. Discharging station consists of the underground reinforced concrete hoppers and steel canopy on the part where limestone is unloaded from railway cars.
- transfer buildings T-1 and T- 2 are located at points of change of direction of limestone conveyor, between the discharging station and the limestone storage facility. In transfer building, performed is the vertical transfer of material from one to the other orthogonal conveyor.
  Transfer building T – 1 is an underground one and its dimensions are 8,0 x 10,0m, 13.5m in height. The building has two floors at levels -9,40 and -14,90. Gross area of the building is 160,0 m^2.
  Transfer building T – 2 is also an underground one, and its dimensions are 10,0 x 8,0m, 13.0m in height.
  The facility has two floors, at -5.0m and -10,5 m.
  Gross area of the facility is 160,0 m^2.

Water supply

Cooling water pumping station of unit B3 is within the supply system of MPF with water for cooling the unit B3 and it is located at the water intake immediately next to the existing pumping station of units B1 and B2. The facility consists of the underground and the above-ground part.

The underground reinforced concrete part consists of two water lines and coarse screen at the entry necks of the pumping station. Dimension of the underground part of the building is 29,65 x 10,20m, with the height determined by the water intake depth H = -11,6m.

The above-ground part of the building is a two-nave hall with the approximate dimension of 30,0 x 34,0m, 15,0m in height.

The number of building’s floors is P+1, and the gross area is cca. 1.130.0 m^2.

Chimney has a height of 180,0m, and a variable shape by height. The inner diameter varies from 15,7m at the level of $\pm$0,00m to 9,7m at the level of +90,00m from where the chimney has a constant inner diameter up to the top, i.e. the level of +180,00m. The chimney is a reinforced concrete structure in the form of a vertical console with variable circular cross section, leaning via the capping plate onto piles.

Flue gas duct in the chimney is made of steel with the diameter of 6,7 m, coated with titanium alloy from the inner side, which is resistant to high temperatures and chemical agents.

Chemical water treatment plant

Facilities of the chemical water treatment plant (CWT) consist of three buildings, connected by a warm passageway:

- CWT building, which has a ground floor, with the dimensions of 22,50 x 70,0m, cca. 14,0m in height. Gross area of this part of the facility is cca. 1.600.0 m^2.
- laboratory and control building, where the number of floors is P+2, with the dimensions of 15,0 x 22,5m, cca. 14,0m in height. Gross area of this part of the facility is 1.075 m^2.

- chemicals warehouse, which also has a ground floor, with the dimensions of 15,0 x 18,0m, cca. 10,0m in height and the gross area of cca. 300 m^2.

CWT plant of the unit B3 is located on the south side of the Main Plant Facility of the unit B3 complex. Vehicular and pedestrian access to the facilities of CWT complex is enabled via main and service communications from all sides.

Facilities of CWT system are designed for the chemical preparation and treatment of water for technological systems of unit B3. The biggest part of the equipment and technological units is located in the main facility. Next to the facility, located are tanks of filtered, clarified and demi water and the sedimentation sump.

In the hall of the facility's ground floor, organized are the main inner vehicular and pedestrian communication and all primary technological units of CWT process, the associated technological and service units (e-power supply, chemicals warehouse, pumps and sub-system's compressors), control room and sanitary block.

In the facility, envisaged are the following hydro-technical installations:

- sanitary water,
- sanitary sewage,
- stormwater sewage,
- hydrant network,
- industrial sewage.

System for coal transportation

Facilities of the system for coal transportation are:

- E-control building for coal transportation, intended for the placement of electric power and control equipment of the system for coal transportation of the unit B3.
- garage for bulldozers: dimensions of the facility are 34,5 x 12,0m; the facility's height is 9,5 m, and the gross area is cca. 360 m^2.
- crushing plant for primary crushing,
- crushing plant for secondary crushing,
- facility for the treatment of waters contaminated by coal,
- conveyor bridges,
- building for coal sampling,
- transfer buildings.

System for the internal transportation of ash and slag

Facilities of the system for the internal transportation of ash and slag include:

- silo for slag, which is a day reservoir for slag with the possibility of discharging to the conveyor system towards the stockyard or to loading into the truck,
- conveyor bridge CA-1,
- silo for ash: The facility consists of two reinforced concrete cylindrical silos for ash collection, with the diameter of 13,6 m and the height of this part of the facility is cca. 31,0,m,
- conveyor bridges CA-2 and CA-3,
- transfer buildings TA-1 and TA-2, with the dimensions of 8,0 x 8,0m i.e. 9,0 x 9,0m. The height of transfer building TA-1 is 19,0m.

External hydro-technical installations

For the uninterrupted operation of the new unit B3, envisaged are the following external hydro-technical installations inside TPP Kostolac B:

- stormwater sewage,
- sanitary sewage,
- sanitary water,
- hydrant network,
- industrial sewage.

Stormwater sewage collects precipitation from roads, roofs and plateaus and leads them to the local light liquid separator, with the capacity in which the treatment of this water will be performed before discharging into the recipient. Street drainage is resolved through the drains as recipients which are connected to the sewage network via drain connections.

Waste waters from the road are collected by a special network placed under the road. These waste waters are treated on the separator with the capacity of 408 l/s before discharging into the stormwater sewage network. Local separator is part of the joint plant for treatment of waste waters for all three units. The design includes only channelling of stormwater within the unit B3 location and the connector to the separator.

Sanitary sewage of all facilities of the new unit B3 is connected to the existing sanitary sewage network. Sanitary waters are now, before discharging into the recipient, treated in the plant of Biodisk type. The design of joint plant envisages the construction of new treatment plants for all three units, with the capacity of 1500 ES, which will be based on the implementation of technology of biological treatment with the activated sludge.

The entire sanitary sewage network is provided from PVC sewer pipes.

Treated sanitary waters will be discharged into the recipient (the river Mlava).

Sanitary water is provided by connecting to the existing sanitary water network of thermal power plant. Pressures in the existing network range from 4,5 - 5 bar and are sufficient for the uninterrupted operation of sanitary consumers of the new unit.

Upon the completed installation of water supply network, pressure testing and disinfection of the entire water supply network is to be carried out. After the completed installation, water supply network is to be examined at a test pressure of 12 bar.

Hydrant network for the new unit B3 is a ring with the diameter of Ø 200 mm designed to meet the water supply of a total of 30 l/s. Hydrant network is supplied with water from the newly designed CS cooling water. Envisaged are the submersible pumps for pressure boosting with characteristics Q=30 l/s and H=80 m. Envisaged are two pumps, the operating and the spare one. Both pumps are connected to the diesel aggregate. Hydrant network's pipes are cast iron pipes.

The diameter of the hydrant network ring is Ø 200 mm, and the diameter of sections from the ring to the above-ground hydrant is Ø 100 mm. Pressures in the external hydrant network are around 7,0 bar.

Upon the completed installation of hydrant network, pressure testing and disinfection of the entire network is to be carried out.

Technological sewage collects waste waters that need special treatment before being discharged into the recipient.

The following waste water treatments are envisaged:

- oily and fuel oil polluted water treatment,
- saltwater and turbid waste waters (from the FGD, CWT plant , wet EF, etc.) and ash and slug systems,
- coaly water treatment.

The concerned project includes coaly water treatment, as well as treatment of waste waters from the ash and slug systems, while for other waste waters only their collection and drainage is envisaged to the point in the common plant, where their final treatment.
Sources of oily and fuel oil polluted waters which should be treated are: boiler room, mechanical room, liquid fuel system and storage of oil and lubricants. Oily and fuel oil polluted waters are collected and channeled by special sewage.
Coaly waste waters which are generated from the washing of the sloping bridge and transfer points, as well as in the case of drencher system activation on the slope transport bridge. They are collected in the manhole, from where they are pumped to the plant for coaly waste water treatment.

During the precipitation, waste waters from the area of coal stockpile are collected and drained from the stockpile, in the form of polluted storm water. These waters are also treated in the coaly water treatment plant.

D. Compliance of technical solutions with the best available techniques (BAT)

The entire power unit plant TPP Kostolac B3 and all its systems were constructed fin accordance with the recommendations of the BAT reference documents, as follows:

- IPPC, Reference Document on Best Available Techniques for Large combustion plants, July 2006, Draft Final, July 2013. and July 2016. (working material),
- IPPC, Reference Document on Best Available Techniques for energy efficiency, February 2009.
- IPPC, Reference Document on the application of Best Available Techniques to Industrial Cooling Systems, December, 2001.
- IPPC, Reference Document on General principles of monitoring, July 2003.

In relation to the best available techniques (BAT) which are listed in the reference BREF documents, in the considered project the following solutions are implemented

1. Combustion technology. For the power unit B3, the boiler with supercritical steam parameters is envisaged, thus achieving fuel consumption efficiency. Also, the boiler contains three stage preheater of live steam, water heater, membrane impermeable screens, two stage additional steam preheater and two rotational air heaters. For the production of the boiler unit, materials providing safe work at the projected parameters are used. The applied combustion technology is in accordance with all BAT techniques listed in the table 4.57 LCP of BREF, except for cogeneration of electrical and heat energy. The power unit B3 will work only in condensation mode, as the heat supply is secured from the existing power units of TPP Kostolac A.

2. Thermal efficiency of the power unit B3. Thermal efficiency of the power unit is defined in LCP BREF as no name number representing the relation of the useful net mechanical power of the turbine and heat power transferred to the process medium (Chapter 2.7.2). In technological process envisaged for the power unit TEKO, B3 the mentioned values are determined in the following manner:
   - Heat power, transferred to the water (which is an operating medium), is determined based on the heat entered with fuel (i.e. coal consumption and coal heating capacity) and designed value of the boiler efficiency, which amount to:
     - coal consumption is 375,4 t/h for the heating capacity of 8.000 kJ/kg
     - boiler efficiency is 88,8%
   - feed pump power is 2 x 7 MW,
   - other electricity consumers within turbine unit are 2,7 MW,
   - total electricity consumption of the turbine unit is 16,7 MW,
   - efficiency level of the power unit amounts to 0,424, i.e. 42,396%, while specific consumption of the unit is the gross amount of 8.491 kJ/kWh.

   Based on the afore mentioned values, thermal efficiency of the power unit TEKO B3 amounts to 44,99%.
   Reference values for thermal efficiency of the thermal unit are defined in the table 4.66 LCP of BREF, according to which the required scope for thermal efficiency of the new LCP lignite fired plants with boilers using pulverized coal amount to 42 - 45%.
   Based on shown values, it can be concluded that the power unit B3 meets the requirements of the LCP BREF relating to the plant thermal efficiency.

3. Technologies of powdery matters emissions reduction: application of the dry and wet electrostatic precipitator plant for powdery matter emissions reduction is one of the recommended BAT techniques (Table 3.2 and 4.59 in LCP BREF). By applied measures it is accomplished that the concentration of the powdery matters in the output gas amounts to ≤10 mg/m^3. By applied measures the reduction of the heavy metals emission, which are contained in powdery matters, contained in the flue gas, is also accomplished (flying ash and unburned fuel particles).

4. Technology of sulphur dioxide emission reduction. Wet limestone procedure is shown as the most frequent FGD technology for lignite fired boilers of power greater than 300 MW_{th} (Table 3.5 and 4.68 in LCP BREF). By applied technology, the required efficiency of sulphur oxides reduction is achieved, so that concentration of SO_2 in the output gas is ≤150 mg/m^3.

5. Technology of reduction of the nitrogen oxide emission. For the boiler plant of the power unit B3, the following measures are applied to prevent the generation of nitrogen oxides in the combustion process:
   - reduction of the air coefficient surplus,
   - phase combustion (OFA),
   - flue gas recirculation,
   - installation of the burner with low NO_x (low NO_x burners).

   By applied measures, it is expected to reach required efficiency of nitrogen oxides reduction, so that the concentration of NO_x in the output gas amounts to ≤200 mg/m^3. Applied measures are in accordance with the LCP BREF (Tables 3.19, 4.62 and 4.69).
   If it is ascertained that the primary measures cannot meet the mentioned conditions, there is a space left behind the boiler for possible installation of the plant for selective catalytic reduction of the emission of NO_x, with the application of ammonia as a reagent, according to the Table 4.63 LCP BREF-a.

6. Technology of limestone suspension preparation. Preparation of limestone suspension by using the technology of wet grinding is the proposed technology in case that crushed limestone is delivered to the thermal power plant. The optimal solution is that the delivery of limestone is done in granules that are directly delivered in the ball mill for wet grinding, in order to avoid additional grinding at the location that is the source of dust. By using the technology of wet grinding air is not polluted by limestone particles emissions, which would be the case with dry grinding.
   Limestone grinding techniques are not included in LCP BREF.
7. Delivery and storage of limestone. Limestone storage is envisaged for the needs of all three power units at the location of the TPP Kostolac B. In the first phase of the project (including the construction of the FGD plant for the power units B1 and B2) it is envisaged to deliver the limestone by trucks and unload into partly closed storage. After the construction of the power unit B3, it is foreseen to deliver the limestone by railway, with the system for unloading into underground bunkers.
   In the system for loading and storage of limestone, dedusters for air filtering are used, according to the table 4.65 LCP BREF-a.
8. Delivery and storage of coal. Described way of coal delivery by closed conveyor belts with installed systems for dedusting at the transfer points and in the bunker tract, as well as the way of coal crushing with installed dedusters, is in accordance with the BAT techniques named in the Tables 4.55 i 4.65.
9. Technology of chemical water treatment. The project envisages that the required quality of water for the needs of the water-steam system (boiler water) should be ensured by the application of the process of reverse osmosis and demineralization. This way of chemical water treatment allows the achievement of chemicals consumption reduction and waste water generation. Techniques of chemical water treatment are not covered by LCP BREF.
10. Technology for turbine condensate treatment. In previous practice, for the final removal of oxygen and conditioning of condensate, which will be used as feed water, a solution of hydrazine was used, which is classified as a carcinogen (according to the regulation relating to the management of chemical accidents, plants using hydrazine in solutions greater than 5% and amounts greater than 0.5 t are classified as Seveso facilities[1]). Modern technical solutions for conditioning the feed water for supercritical boilers, instead of additional removing of oxygen by dosing hydrazine or similar chemicals with the reducing properties, apply a combined treatment of feed water, which includes alkalizing of the condensate and feed water by dosing of ammonium hydroxide and dosage of oxygen at concentrations of 20-200 µg/l. This oxygen concentration range enables formation of a protective layer of hematite (Fe_2O_3) on the surface of the boiler pipes with a larger particle fineness, smoothness of the layer and a low degree of solubility with respect to magnetite (Fe_3O_4) formed in alkaline operation mode.
    By applying the above mentioned mode of condensate conditioning, the use of hydrazine is avoided.
11. Waste water treatment. The project envisages the treatment of waste waters in the common plant for waste water treatment of all three power units of TPP Kostolac B until the quality for the release into the recipient is reached. The waste waters from the FGD plant will be used, through the gypsum suspension, for the preparation of wet mixture of resistive waste from the power unit B3, which is one of the ways to use the water from the FGD plant according to the BREF (Table 4.70 in LCP BREF).

[1] Rulebook on harmful substances list and their quantities and criteria for determination of types of documents, developed by the operator of Seveso plants, i.e. complexes. Official Gazette of the Republic of Serbia, No. 41/2010.

12. Ash and slug treatment. In order to provide the sale of electrostatic precipitator ash from the power unit B3, pneumatic transport and storage in silos is envisaged, from which it is possible to load the ash directly into trucks. For dedusting of transport air, bag filters are planned to be installed at the inlet of the silos.
    Disposal of ash and slag mixed with the gypsum suspension is BAT for the process of the final treatment of coal combustion product waste, if the further commercial use is not provided (Table 4.70 in LCP BREF).
    The project envisages the possibility of commercial sale of ash and/or slag, which is formed in a mixture for depositing, temporarily stored in silos from which the direct loading into trucks for further use can be done, (as listed the BAT for the treatment of thermogenic waste).

13. Gypsum treatment. LCP BREF as BAT proposes the gypsum usage. The project envisages the possibility of gypsum production of quality for further commercial use. If gypsum is deposited on the stockpile, it is envisaged to mix the gypsum suspension with ash and slag and disposal on the joint stockpile. This way of waste disposal is BAT according to the LCP BREF, and the stockpile is designed according to the regulation.

14. Cleaned gas emission. Cleaned flue gas emission via moist chimney is given as preferable when compared to the option of heating up the flue gas as economically and technically more favourable, Tables 3.5 and 4.58 in LCP BREF.

Based on the afore mentioned, it is concluded that the project of the power unit B3 TPP Kostolac B contains technical solutions which are in accordance with the recommendations of modern techniques, for both main plant and ancillary systems. Applied technologies ensure that the work of the power unit is compliant with the regulation relating to the new combustion plants in terms of environmental protection, which will reduce potential impacts on the environment to the minimum and make them within acceptable limits.

3.3.5. Raw materials and products

Main raw materials necessary for thermal power plant operation are the following: (1) fuel: coal as the main fuel and fuel oil as auxiliary fuel), (2) combustion air, (3) process and cooling water, (4) limestone as raw material for FGD process, (5) chemicals, used for different needs in the auxiliary systems of the power unit B3.

Main products of technological process are the following: (1) solid products of combustion - ash, slug, (2) gaseous products of combustion – flue gas, (3) by-product of FGD process – gypsum suspension, (4) waste waters from different parts of the system, (5) other solid waste, generated in the regular drive and during the plant maintenance.

Raw materials

Main fuel- coal

Power unit 3 TPP Kostolac B will be supplied with coal from OPM Drmno, which is at the same time the source of the raw material base for the existing power units of TPP Kostolac A and B, partially for TPP Morava and as consumer use. Possibility of providing the coal supply for the new power unit B3, as well as other mentioned consumers, in the following period, till the end of their operating life, was analysed on the basis of the studies and projects relating to coal deposits and quality and coal production capacity in Kostolac basin. Information required for the consideration of this raw material base are given below.

Main characteristics of the Kostolac coal basin

Kostolac coal basin, in the widest sense, covers the area between the River Morava in the West, Golubac Mountains in the east, the river Danube in the North and the river Resava and Svilajnac in the South. Characteristics of coal of Kostolac coal basin have been geologically identified and tested over a long period of coal exploitation for different needs and purposes of geological, mining and exploitation and technological reasons. According to chemical and petrographic characteristics, coal of the Kostolac coal basin belongs to lignites of carbonization of lower degree.
Potentiality of Kostolac coal basin reflects through the level of knowledge of coal reserves state - degree of geological exploration and coal quality, balance of geological reserves in the function of technical, technological and economic criteria and limitations.

Kostolac basin is divided, according to the exploration degree and morphological, geological and other characteristics, into two regions: East and West, which are, according to the relation of geological exploration between them, in disproportion in favour of the eastern part.

Eastern part of the Kostolac basin, where the first coal exploitation started, is divided into several exploration-exploitation fields, which are defined as separate deposits within the Kostolac coal basin. It can be concluded from this fact that this part of the coal basin is relatively well and thoroughly explored from the point of the current needs and production requirements, compared to the western part of the basin.

Figure 3.3.5-1 shows the location of the eastern and western part of Kostolac coal basin, and the Figure 3.3.5-2 gives a spatial overview of the active and future open pit mines and thermal capacities position.

The current coal exploitation in the Kostolac coal basin is focused primarily on supply needs of the existing thermal power plants and it is based on coal exploitation practically only from OPM Drmno, while other deposits (OPM Ćirikovac and OPM Klenovnik) are depleted or are in the closing phase.

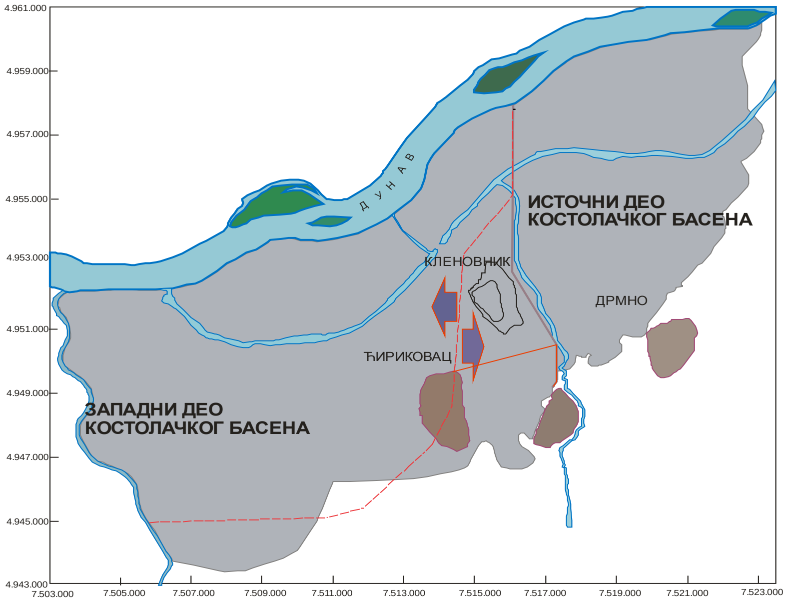


Figure 3.3.5-1: Kostolac coal basin

It should be noted here that the open pit mining on OPM Ćirikovac is finished, but that there are remaining geological reserves in that deposit which are not economical for open pit mining.

However, part of those reserves (about 64 x 10^6 t) from the first and second part of the third coal seam can be used by underground exploitation of the capacity from 1,8 ÷ 2,0 x 10^6 t/year.
As part of providing the required coal amounts for the next period, the geological exploration project of the western part of the Kostolac basin has started, which is necessary to define the balance, quality, reserves and other deposit conditions.
According to the realized geological exploration works by now (Study on coal and gravel reserves and resources in the western part of the Kostolac coal basin, as of 31.12.2013), the area of western part of the Kostolac basin has a a great potential in terms of coal bearing capacity. The Study confirms the balance reserves of B + C1 categories in the amount of 408.211.206 tons.

Figure 3.3.5-2: Spatial overview of the active and future open pit mines and thermal capacities position.

<u>Basic characteristics of the Open Pit Mine Drmno</u>

Coal reserves
The starting point for defining the raw material base potential from OPM Drmno for coal supply of TPP Kostolac A and B is the Study on Drmno deposit reserves (as of 31.03.2013.), for which the certificate on coal reserves was obtained from the Republic Commission for certification of reserves of solid mineral resources, based on which the state of balance geological reserves of coal of Drmno deposit is as shown in the Table 3.3.5-1. Potential reserves of C2 category are estimated to~164 million t.

Table 3.3.5-1: State of balance geological coal reserves of the Drmno deposit

Category	Seam		
	II seam	III seam	Interseam II-III
B	4.949.302,00	233.725.780,82	
C_1	21.372.732,43	134.642.755,73	3.294.974,73
B+C_1	26.322.034,43	368.368.536,55	3.294.974,73
TotalB	238.675.082,82		
TotalC_1	159.310.462,89		
TotalB+C_1	397.985.545,71		

Exploitation coal reserves calculation has been done in the designed contour of the open pit mine, in accordance with the updated Conceptual Design with the Feasibility Study for upgrading the OPM Drmno for the capacity of 9x10^6 t/year (Faculty of Mining and Geology, University of Belgrade, 2010.), whereby the geological reserves were reduced by the designed exploitation losses of 4,11% and they amount to ~293 ×10^6 t.

According to the Feasibility Study with the Conceptual Design on providing the necessary quantities for the operation of the existing thermal power plants in TE KO Kostolac and the new power unit B3 (FMG, Belgrade, 2013), taking into account the necessary amounts for the supply of thermal power capacities in the designed contour OPM Drmno with the state of reserves at the end of 2013, the exploitation reserves amount to 290 x 10^6 t. Table 3.3.5-2 shows planned coal mining by the end of exploitation life of OPM Drmno.

Table 3.3.5-2: The dynamics of coal mining by the end of the exploitation on the OPM Drmno

Period	2014-2018.	2018.	2019-2024.	2025-2036.	2037-2038.	2039-2050.	2051.	2052.	Total
Overburden	4x47,5 190	1x41,5 41,5	6x56,5,0 339	12x47,5 570	2x32,5 65	12x17,5 210	1x16,5 16,5	1x15,5 15,5	**1.447,5**
Coal (10^6t)	4x9,2 38	1x8,3 8,3	6x11,3 67,8	12x9,5 114	2x6,5 13	12x3,5 42	1x3,5 3,5	1x3,5 3,5	**290**

Based on the coal production data in 2014, obtained from the Purchaser, the production in OPM Drmno amounted to 5.7 million tons, which would mean, with the estimation that in 2015 will be mined out the designed amount of 9.2 million tons of coal, that the state of exploitation reserves at the and of 2015 amounted to about 275 million tons.

Coal quality

Total exploitation amounts of coal appear in two coal seams (II and III coal seams), which are not homogeneous geological structures, but they are characterized by the presence of overburden interseams. For that reason, the overview of total exploitation coal reserves is given as the sum of coal interseams which form the mentioned seams. Table 3.3.5-3 shows coal quantities, while the Table 3.3.5-4 shows the basic parameters of coal quality in interseams.

Table 3.3.5-3:Exploitation coal reserves in OPM Drmno

II Coal seam		III Coal seam	
Interseam	**Quantity (t)**	**Interseam**	**Quantity (t)**
1. Interseam U_II_I	11.400.000	1. Interseam U_III_8	37.202.000
2. Interseam U_II_2	10.593.000	2. Interseam U_III_7	38.492.000
Total II coal seam:	21.993.000	3. Interseam U_III_6	37.684.000
		4. Interseam U_III_5	37.523.000
		5. Interseam U_III_4	34.286.000
		6. Interseam U_III_3	34.125.000
		7. Interseam U_III_2	31.530.000
		8. Interseam U_III_1	29.145.000
		Total III coal seam:	279.987.000
Total II+III seam:	301.980.000 t		
Exploitation losses (4%):	12.000.000 t		
Exploitation reserves:	**290.000.000 t**		

Table 3.3.5-4: Parameters of coal quality in OPM Drmno

Interseam	Exploitation quantities (t)	Sulphur total (%)	Moisture (%)	Ash (%)	DTE (kJ/kg)
U22	10.948.000	0.95	38,64	24,69	8.141
U21	10.173.000	1,01	38,69	23,97	8.227
U38	35.726.000	1,22	38,22	20,53	9.510
U37	36.965.000	1,16	38,83	19,40	9.655
U36	36.189.000	1,06	39,53	17,30	10.047
U35	36.034.000	1,08	39,51	17,54	9.982
U34	32.926.000	1,10	39,51	16,84	10.182
U33	32.771.000	1,13	39,53	17,53	10.003
U32	30.279.000	1,17	38,81	18,71	9.898
U31	27.989.000	1,16	38,83	19,62	9.632
Average :	**290.000.000**	1,12	39,07	18,85	**9.743**

When it comes to the quality of coal that will be supplied to the thermal power plants, EPS submitted an actualized data that it is the coal with the average quality of about 8.000 kJ/kg, ash content of 21,5%, moisture 48% and sulphur 1,1%. EPS also provided the information that the homogenization of coal quality in the range of ± 5% will be provided within the development of OPM Drmno in the following period. These data were used as a basis for the assessment of the required amount of coal to supply the customers in the future, as it is shown further in this chapter.

Forecast of consumption of coal from the Kostolac coal basin

The forecasted consumption of coal in the next period included the following:

- Supply of the existing power units 1 and 2 TPP Kostolac B (2x350 MW), until the planned end of their operating life (until 2036.) Forecasted coal consumption of these power units is 2x3x10^6t/year.
- Supply of the new power unit 3 TPP Kostolac B (350 MW) for the operating life of 40 years. Forecasted coal consumption of this power unit is 2,8 x 10^6 t/year.
- Coal delivery for consumer use in the amount of 0,15 x 10^6 t/ year.
- Coal delivery for TPP Morava since 2016. in the amount of 0,5 x 10^6 t/ year.
- Supply of the existing power units 1 and 2 TPP Kostolac A (100 + 210 MW) until the planned end of their operating life in case of realizing the extension of both power units' operating life of 15 years after the reconstruction, which means by 2038 (with one year of reconstruction). Forecasted coal consumption of these units is 0,9 x 10^6 t/ year. For the unit A1 1,8 x 10^6 t/ year and for the unit A2.

Based on the above input data, the dynamics of production and consumption of coal from OPM Drmno for the period to the end of operating life of all planned power units of TPP Kostolac A and B, including the coal supply of TPP Morava and delivery for consumer use, is shown in Table 3.3.5-5. Total required amount of coal for considered consumers is ≈300 x 10^6 tons, calculated with average quality of coal, heat value of 8.000 kJ/kg.

Table 3.3.5-5:Overview of consumers and needs of coal from OPM Drmno

Consumer	Annual coal consumption* ($x10^6$t/year.)	Total coal consumption since 2016. till the end of exploitation ($x10^6$t)
TEKO B1	3,0	60
TEKO B2	3,0	60
TEKO B3	**2,8**	**112**
TEKO A1	0,9	19,1
TEKO A2	1,8	35,5
TPP Morava	0,5	10
Consumer use	0,15	3
Annual needs	12,2	299,6

* Exploitation quality is 8.000 kJ/kg

Bearing in mind that the available reserves at the end of 2014 were estimated at around 275 x 10^6 tons (equal to 2,680 MJ), and that it is necessary to provide around 2,400 MJ for the needs of the consumers aforementioned in Table 3.3.5-5, it can be noticed that there are sufficient coal reserves to fulfil all anticipated needs for coal from this mine. It should be noted that in order to meet the anticipated consumers, it is necessary to increase the annual coal production to 12 million tons, with dynamics which will depend on the final plans of power Kostolac A and B engagement in the following period.

Liquid fuel

By main concept of technological process it is provided to use fuel oil for firing and fire keeping at low boiler load, with low content of sulphur, if possible

Data on characteristics of firing liquid fuel (fuel oil) are given in the Table 3.3.5-6.

Table 3.3.5-6: Characteristics of firing liquid fuel (fuel oil)

Description	Unit	Value
Water content	% (V/V)	<0,1
Ash content	% (m/m)	<0,20
Sulphur content	% (m/m)	2.102
Mechanical impurities	%	<0,1
Flash point	°C	85
Pour point	°C	3
Kinematic viscosity	mm^2/s	34,47 (at 100°C) and 49,03 (at 90°C)
Acidity	mgKOH/100ml	
Density at 20 °C	kg/m^3	0,9656 at 15°C u g/cm^3

System of liquid fuel in TPP Kostolac B includes external and internal system of fuel oil. External fuel oil system includes receiving, storage, preparation and delivery of liquid fuel to main plant facility.(MPF)

It is anticipated to install internal fuel oil system in new pump station next to the boiler plant of new power unit. The system comprises of pump power unit of second stage which includes three high pressure pumps (3x50%), two filters, set of stop valves and control valve for pressure control at pump outlet.

Fuel oil is delivered to thermal power plant by railway and tank vehicles and then loaded into fuel oil storage reservoirs using appropriate devices within thermal power plant area, and from there they are distributed to burners of main boilers. Fuel oil supply line to the main boiler burners is performed at two stages. Fuel oil, heated by flow heater up to the temperature of 80ºC, is discharged from storage reservoirs by distribution pumps to the main plant facility. Within MPF, fuel oil is heated to the final temperature cca 150ºC and then using second stage high pressure pumps it is repressed into fuel oil burners on the boiler. For purpose of new unit it is provided to install new fuel oil tank of 1200m³ which would be connected to existing tank of 5000m³. This solution provides independent supply of the existing units and new unit by fuel oil, as well as easier maintenance of existing and future fuel oil tank. For fuel gas heating in the new reservoir, the installation of the new steam heater up to the temperature of 50º is envisaged.
Fuel oil firing is performed by firing gas – propane – butane (50 – 70 kPa) using electric spark. System of gas fuel, propane butane, comprises of propane butane station, distribution grid of gas fuel propane butane and propane butane burner. Construction of new butane propane station is provided for the purpose of new unit.

Process and cooling water

Water supply for all consumers within the power unit B3 is envisaged from the river Danube.

For the needs of the consumers for the process water supply in the power unit B3, new pumps and new pipelines for process water with accompanying armature will be installed in the pumping station of cooling water.

Within the power unit B3 consumers of raw water are: (i) CWT plant , (ii) FGD plant, (iii) dry electrostatic precipitator, (iv) de-ashing system, (v) fire protection system, etc. Total estimated quantity of raw water necessary for the supply of mentioned consumers is up to 330 m^3/h. Based on performed hydraulic calculation 2 pumps of raw water (2 x 100%), with the capacity Q= 350 m^3/h each has been chosen.

Supply of the power unit B3 with cooling water is envisaged by means of two pumps (2x50%) with the capacity Q= 7,2 m^3/s.

Designed quality of raw cooling water is given in the Table 3.3.5-7.

Table 3.3.5-7: Designed quality of raw water

Parameter	Unit		
	mg/l	o dH	mval/l
Cations			
Ca	84,04	11,8	4,2
Mg	20,05	4,6	1,6
Na	9,2	1,1	0,4
K	5,85	0,4	0,15
NH4	0,3	0,0	0,0
Fe	0,6	0,0	0,0
Total cations	**120,04**	**17,8**	**6,35**
Anions			
HCO_3	260	11,9	4,3
CO_3	0	0,0	0,0
Cl	27,68	2,2	0,78
SO_4	53,76	3,14	1,12
NO_3	9,3	0,42	0,15
Total anions	**350,74**	**17,66**	**6,35**
TDS	**470,78**		
SiO_2	10	0,9	0,3
UT		16,4	5,8
KT		11,9	4,3
m-alk			4,3
p-alk			0,0
pH	**8**		
t, °C	**3**		
Suspended particles, mg/l	**64**		
Turbidity	**100**		

Limestone

Limestone (calcium carbonate) belongs to sedimentary rocks with calcite and aragonite minerals admixtures. It is grey of white, without smell. It is not flammable, nor toxic and it has low solubility in water.

Possible limestone supplier is Kovilovača mine. Designed limestone quality, shown in Table 3.3.5-9, represents minimum requested quality necessary for achieving of anticipated efficiency of FGD process and quality of produced by-product. Limestone quality from the mine anticipated as raw material base for supplying of TPP Kostolac is also shown in Table.

Table 3.3.5-9: Limestone quality

Parameter	Unit	Required limestone quality	Quality of limestone from "Kovilovača" mine
Free moisture	% weight	<5,0	0,51
Calcium carbonate, total $CaC0_3$	% weight	>94,0	98,5
Magnesium carbonate, total $MgC0_3$	% weight	<3,0	0,50
Silicon dioxide, $Si0_2$	% weight.	<3,0	0,51
Iron oxides as Fe_20_3	% weight	<0,8	0,19
Total inert matter	% weight	<6,0	0,97
Granulation	mm	≤19,0	

Limestone consumption is about 360.000 tons a year for all three power units (out of which for the power unit B3 the consumption is about 120.000 tons).

For the needs of the FGD plant for the power unit B3 granular limestone will be used, of -20 mm granular size. Limestone supply to thermal power plant will be provided by railway . Partially closed facility is provided for limestone storage. Storage capacity is 8.700 t, which is enough for 7 days of operation of all three power units at nominal power.

Chemicals

Chemicals for chemical water treatment

Part of the plant for raw water treatment is designed for storage of chemicals necessary for conducting of chemical and technological processes of chemical water treatment. Storage of chemicals used in the process of demineralization of raw water is located within the building of the chemical water treatment plant (CWT), at the level ± 00:00 m.

For the purposes of technological process of chemical water treatment (pre-treatment of raw water, water treatment by reverse osmosis and demineralization of permeate by the process of ion exchange), as well as for the regeneration of ion exchange resins chemicals listed below are used.

Filtered water is used to prepare the chemical solution.

Sodium hypochlorite, NaOCl is an inorganic chemical that is used as a disinfectant based on hypochlorite**.** It is used for drinking water treatment in water supply systems and water in the swimming pool systems. Disinfectant for surfaces, materials and equipment that are not in the direct contact with food for humans or animals, for walls and floors in health institutions.

Not recommended ways of chemical use are not known, but during the use pay particular attention to safety recommendations and comply with them.

It is used within the concerned project to disinfect raw water and it is dosed before raw water enter the pre-treatment systems 10–15% NaOCl is supplied in barrels of 200 liters from which the loading pump transfers it in two reservoirs for preparation of a 1% solution.

Na-hypochlorite is yellow-green liquid, with the smell of chlorine. It is completely soluble in water, with the solubility of 1 kg / l (at 20^{o}C). In contact with acids it liberates the toxic gas.

It is stable at normal conditions. The substance is very oxidizing and reacts violently with combustible and reducing substances. Solution in water a strong base (pH $>$ 12), it reacts violently with acids abd it is corrosive. It corrodes many metals.

Chemical stability decreases in time and decay is accelerated under the influence of heat, light and the presence of impurities (traces of iron, nickel, copper, cobalt, aluminum, magnesium). It slowly decomposes in the presence of carbon dioxide from the air. It decomposes in hot water. During degradation hazardous substances chlorine, hypochlorous acid and sodium chlorate are formed.

The substance is not flammable, but in case of fire, taking into account the above facts, a person should not remain in danger area without breathing apparatus and protective clothing. It is necessary to provide maximum space ventilation.

The product should be stored in tightly closed containers, in a dry and cold room, away from heat sources. Avoid contact with air to avoid moisture absorption.

Persons using Na-hypochlorite should use personal protective equipment, i.e. respiratory protection, protection for hands, eyes and skin.

Basic physical and chemical properties of hypochlorous acid are given in the Table 3.3.5-10.

Ferric chloride, $FeCl_3$ is used as a coagulant in the process of raw water pre-treatment in a clarification plant. Solution of 40% concentration is delivered at the location. The above mentioned solution is a liquid which varies from orange to brown, of sour smell, completely soluble in water, with the boiling point of 230 ° C. The solution is stable, not prone to polymerization under normal conditions of use and storage. It reacts negatively with metals, sodium and potassium, and therefore the conditions that lead to the direct contact of the mentioned substances with FeCl3 solution should be avoided.
$FeCl_3$ solution as toxic and corrosive substance is kept at the location in closed containers in a cool, dry, ventilated area, separated from incompatible substances. Empty containers in which the solution was stored also must be properly treated because they represent potential danger due to the fact that they contain residues of $FeCl_3$.

In contact with human skin, $FeCl_3$ solution causes redness, pain and severe burns. Contact with the eyes can cause blurred vision, redness, pain and burns. In case of inhalation, the solution has a very aggressive effect on human tissue and respiratory system, causing their destruction. Symptoms that may indicate to the presence of dangerous effect of $FeCl_3$ solution include burning sensation, coughing, sneezing, shortness of breath, headaches and nausea. If swallowed, the solution leads to severe burns of the mouth, throat and stomach tissue, with accompanying nausea and vomiting. Long-term exposure to small amounts of the solution causes chronic effects that lead to permanent liver damage, and in extreme cases they can lead to coma and even death. Prolonged exposure of the eyes can cause their discoloration.

First aid procedures that must be applied on the personnel who have been exposed to inhalation of the solution $FeCl_3$ relate to their immediate transfer to the ambiance of fresh air, giving artificial respiration or oxygen and the provision of emergency medical assistance. If the solution has been swallowed, the injured person should be given the biggest possible amount of water and the help of medical staff should be provided. Parts of the body exposed to the direct effects of the solution should be washed with water immediately at the latest 15 minutes after exposure and clothes and shoes should be thoroughly washed. Eyes of the injured person should be washed immediately with clean water.

If there is a risk situation that includes spills or leaks of $FeCl_3$ solution, the contaminated area should be ventilated and isolated and access should be allowed only to qualified personnel who are properly protected from the harmful effects of the considered solution. Protective equipment includes protective clothing, shoes, gloves and goggles or special shield that hides the whole face. Spilled liquid should be collected, as much as possible, and dispose it in the designated containers. Collection of liquid can be carried out by using an inert material that absorbs the solution, such as dry sand or earth and dispose such contaminated material in containers for chemical waste disposal. Containers are then treated in accordance with national, state or local regulations relating to the handling of waste material.

Ferric chloride, $FeCl_3$, is transported to the location with special tank trucks intended for transport of aggressive substances. From the tank trucks the solution is further transported and stored in two reservoirs with the volume of 1.5 m^3 each through the inlet hose i.e. rubber and plastic pipeline. Reservoir filling is performed by using two pumps (one active, one spare) with the capacity of 5 m^3 / h each.

Polyelectrolyte, which is used as an auxiliary flocculant in the process of raw water pre-treatment in the clarification plant, is stored in the solid state, in plastic bags. Preparation of 0.2% solution for dosage is provided in a vessel with the volume of 200 l. Flocculant dosing is automatic, proportional to the flow of raw water.
In the process of demineralization for regeneration of cationic weights, hydrochloric acid is used, while sodium hydroxide is used for the regeneration of the anionic weight.

Sodium hydroxide, NaOH, is used fo chemical cleaning of membranes, as well as for the regeneration of ion exchange resins. It is delivered as a concentrated, 40% solution, in special tank trucks intended for the transport of aggressive substances. Aqueous sodium hydroxide solution with 45% of NaOH boils at 105°C and has a density in the range of 1,2-1,5 kg/dm^3. 50% solution boils at 142-148°C, 73%- solution at 188-198°C, while dehydrated NaOH boils at 1390°C. It is soluble in water and when dissolving it releases heat, and it may happen that a solution boils. Sodium hydroxide does not burn and will not contribute to combustion. It can react very violently, even explosively with many organic substances. As the solution has a feature of crystallization that for a solution of 40% NaOH is 15 ° C, pipelines which transport the mentioned solution must be isolated and reservoirs must be additionally equipped with steam heaters to ensure the smooth manipulation during the winter months. Iron is used as a structural material for pipelines and reservoirs of NaOH, although it should be noted that hot alkali, in the long retention periods, partially dissolve iron. At normal temperature, NaOH causes slight corrosive phenomena on iron and copper, and NaOH becomes unusable if the stated metals appear in the solution as impurities. NaOH is aggressive towards the skin and the wool and to metals such as aluminium, zinc and their alloys. It does not affect rubber.

Basic physical and chemical properties of sodium hydroxide are given in the Table 3.3.5-10 which shows a summary approach to the physical and chemical properties of concentrated chemicals that will be stored at the location of the power unit 3 TE Kostolac B.

Dissolved NaOH can cause carbonization or ignition of the containers and other objects, particularly if there is a large amount of dissolved NaOH and the cooling is comparatively slow.
If the handling is performed according to the foreseen instructions, which include proper protection of workers and the established work procedure, NaOH does not represent a serious industrial hazard. However, the solution is considered a strong base and very dangerous if the handling is not done in the proper way. In contact with the tissue it causes burns, often deep blisters with permanent scars. Serious burns are not the result of contact only with solid sodium hydroxide, but also with a very mild solution over a long period of time. Numerous minor burns occur in contact with dust or mist of NaOH. In contact with eyes, NaOH, regardless of its form, causes vision impairment very quickly. If a solid or liquid sodium hydroxide is ingested, it leads to damage of the mucus or even deeper tissue, which can lead to serious scars which can require a surgical intervention. In extreme cases, it can even cause death. Inhalation of dusts or droplets of a NaOH solution leads to the damage of the airways and lungs, depending on the amount of inhaled substance.

In the case of frequent contact with diluted solution, chronic local effects occur, manifested by numerous surface damages of the skin, and the inhalation of dust causes damage to the respiratory tract in various degrees. For this reason, in the rooms where there is the dust of NaOH, regular ventilation is necessary. The threshold limit value of allowable amounts of dust or mist in the industrial area is 2 mg per m^3. Maximum allowable concentration for the workspace amounts to 0.5 mg / m3.

NaOH solution is delivered at the location of the thermal power plant with tank trucks and then through the rubber and plastic pipeline is transported to the two storage reservoirs with the capacity of 20 m^3 each. Reservoirs are equipped with all required connections and equipment. Transfer of NaOH from the tank trucks into the storage reservoirs is performed by pumps with the capacity of 2 x 15 m^3/h, out of which one is operational, while the other is spare.

Sodium bisulphite, $NaHSO_3$, is an inorganic chemical which is used as an inorganic reducing agent, and as a raw material for the production in the chemical synthesis. It is used in different industry sectors. In the concerned project it will be used for conservation of RO membranes, in such manner that the membranes which are not used are put into the sodium bisulphite solution.

Sodium bisulphite is a liquid with no colour or it can be pale yellow, with the smell of sulphur. It is soluble in water, with the solubility of 515 g / l (at 20^{o}C). Toxic gas is released in contact with acids. It is chemically stable and non-reactive under normal prescribed storage conditions. In case of heating toxic sulphur compounds, that evaporate, are released.
The substance is not flammable, or in case of fire, taking into account the above facts, a person should not remain in the danger area without breathing apparatus and protective clothing. It is necessary to provide maximum space ventilation.

Product should be stored in well closed packaging, in dry and cold room, away from the source of heat. Avoid the contact with air in order to avoid moisture absorption.
People using sodium bisulphite should use means of personal protection, for the protection of the respiratory organs, hands, eyes and skin.

Basic physical and chemical properties of sodium bisulphite are given in the Table 3.3.5-10.

Sodium bisulphite is delivered to thermal power plant in bottles, and solution is made in the reservoir with the volume of 1 m^3, by dosing pumps.

Antiscalants are complex chemicals (usually organic polymers) which are added into the water before the process of reverse osmosis in order to increase the solubility of the salts present in the water and thereby prevent the formation of deposits on the membranes.
The most common deposits are made of $CaCO_3$, $CaSO_4$, $SrSO_4$, $BaSO_4$ and CaF.

They are delivered to the thermal power plant in bottles, with the purity of 100% and they are used in solutions of 10%.
Antiscalants are chemicals which are not classified as hazardous to human health.

Citric acid, $C_6H_8O_7$, is a tribasic organic acid. It is a white crystal substance which has a sour taste (pH of the solution 50g/l H_2O amount to 1,85) and without smell, easily soluble in water. It is produced industrially from lemon or sugar by fermentation by means of Aspergillus niger. Is used in the production of non-alcoholic beverages, in medicine and in industry.

If it is released into the environment, biodegradation of 98% in 2 days occurs. Detrimental impact on the environment is reflected in the change of pH value.

In the concerned project it can be used for membrane cleaning. It is delivered in bags, with 99% purity, and the solution of 1-2%. Is used.

Basic physical and chemical properties of citric acid are given in the Table 3.3.5-10.

Hydrochloric acid, HCl is used for the chemical cleaning of the membranes as well as for the regeneration of ion exchange resins. It can be delivered to a location as a concentrated, extremely aggressive, 30% solution, and is therefore transported using adequate tankers. Hydrochloric acid is an aqueous hydrogen chloride solution. Hydrogen chloride is a very hygroscopic gas, which uses the absorption of moisture from the air to build up a whitish fog consisting of very small drops of hydrochloric acid. Hydrochloric acid itself is a clear, bright-yellow liquid, non-flammable and does not burn. Boiling temperature of HCl is maximum 108°C, while the density is in the range from 1.01 to 1.21 kg/dm3. During heating of concentrated hydrochloride only acid is evaporated and a slight amount of water, until a 20% solution is obtained, followed by further heating, i.e. distillation at 110°C, leading to the evaporation of the mixture (20% HCl and 80% H_2O) without any change of the boiling point. In the reverse procedure, when a very diluted solution of HCl is distilled, water first evaporates until it reaches a concentration of 20% solution of HCl. At an elevated temperature, hydrochloric acid is stable up to 1,500°C, after which it dissolves to hydrogen and chlorine.

Basic physical and chemical characteristics of hydrochloric acid are given in Table 3.3.5-10.

Hydrochloric acid is among the strongest mineral acids. Is reacted with oxides and hydroxides of metals building salts, chlorides, and also displaces the weaker acids from the salts thereof. It dissolves many metals even in the absence of oxygen, at the same time giving corresponding chlorides. According to its action in this case only copper, mercury, lead, gold, silver, bismuth and platinum are quite resistant. In the presence of oxygen, ie. air, hydrochloric acid corrodes all metals, including precious. Its effect is particularly strong in a mixture with water, ie. in the case of the solution known as "imperial water". Oxidizing effect of HCl can be removed if the substances are added impurities in the form of colloidal substances. In case of iron, the resistance to the effects of HCl and rusting is achieved by addition of glues. As structural metals we use enamelled cast iron and steel, graphite, carbon, cement, quartz, porcelain, glass, hard and soft rubber, polyethylene, polypropylene, polyvinyl chloride, polyisobutylene, polymethacrylate. Pipelines and apparatus for operation with hydrochloric acid are made of steel, with coating of rubber.

Hydrochloric acid is classified in the group of very dangerous materials, toxicity class 3. As it is very toxic to the plant and animal world, it is necessary to be very careful when handling the above mentioned solution. Smell sensitivity, which is defined as the lowest concentration of certain substances in the air that can be recognized by 50% of the surveyed people, is 0.14 mg/m3.

The maximum allowable concentration for short periods (MAC) of hydrogen chloride (which is released as a gaseous component from the solution during acid propagation) in the atmosphere of the settlement is 0.05 mg/m^3, and midday is 0.015 mg/m^3. In the workspace air MAC is 5 ppm. As hydrogen chloride is a highly toxic gas, any longer stay in the area that is contaminated is not recommended, and any part of the skin of staff to be found in this area should not be unprotected.

From the standpoint of environmental impact, it should be noted that the greatest danger of hydrochloric acid comes from the fact that it is an easily volatile liquid.

After transport to the location of thermal power plant, a solution of HCl will be transported from the cisterns into two storage tanks with volume of 20 m^3 equipped with all the necessary connections and equipment. Reloading of HCl from the tank in storage tanks is performed using pump with capacity of 2 x 15 m^3/h, one of which is working and the other reserve.

Table 3.3.5-10: Physical-chemical properties of chemicals used

Characteristic	Chemical						
	Ferric chloride	**Hydrochloric acid**	**Sodium dioxide**	**Sodium bisulphite**	**Citric acid**	**Sodium hypochlorite**	**Ammonium hydroxide**
Chemical formula	$FeCl_3$	$HCl + H_2O$	$NaOH + H_2O$	$NaHSO_3$	$C_6H_8O_7$	$NaOClx5H_2O$	NH_4OH+H_2O
Molecular weight	162,21	36,46 (HCl)	40,01 (NaOH)	104,06	192.124 g/mol (anhydrate)	164,53	35,05
Density (at 0°C), kg/m^3	2,9	1,02-1,21	1,2 – 1,5	1,48	1.665 g/cm^3		0,8-0,92
Vapour density (with respect to air)	-	1,26	-				1,295
Vapour pressure, kPa	0,133	4.620 (30%)		24 mbar		2,5 (at 20°C)	58 (at 20°C)
Toxicity degree	2	3	3	2	0	3	3
Flammability degree	0	0	0 (does not burn)	0	1	0	0
Reactivity degree	0	0	1	0	0	2	1
Lethal dose (LD_{50}/LC_{50})	LD50: 316 mg/kg	LC_{50}: 45,6 mg/m^3 30 min	-	LD_{50}: 2.610 mg/kg	LD_{50}: 3.000 mg/kg	LD_{50}: 9 g/kg	LD_{50} = 350 mg/kg LC_{50} = 1,4 mg/l, 4h (anhydrous comp.)
MAC of working area, mg/m^3		5	0,5	TWA=5 mg/m3			35 (50 ppm)
MAC in settlement atmosphere, short-term, mg/m^3	-	0,05	-				
MAC in settlement atmosphere, mid-day, mg/m^3	-	0,015	-				
Ecotoxicity: Acutely harmful to aquatic organisms Toxicity to fish Toxicity to aquatic invertebrates Toxicity to aquatic plants		Yes LC_{50}: 20,5 mg/l 96 h EC_{50}: 0,45 mg/l 48 h	Yes LC_{50}: 45,4 mg/l 96 h EC_{50}: 76 mg/l 48 h	Yes LC_{50}: 316 mg/l 96 h LC_{50}: 89 mg/l 48 h 43,8 mg/l 72 h	Yes LC_{50}: 440-760 mg/l 96 h LC_{50}: 120 mg/l 72 h 640 mg/l 7 d	Yes Fresh water LC_{50}=0.06 mg/l 96 h Sea species LC_{50}=0.032 mg/l	Yes Fresh water LC_{50}=0.53 mg/l 96 h

* LD_{50}: lethal dose for rats orally
LC_{50}: lethal dose for rats by inhalation
TWA: Expositiom in 8h (Time weighted average)

<u>Chemicals for the chemical treatment of condensates and external regeneration of ion exchange resins</u>

The system for chemical treatment of condensates is block type, located in the main operating facility and is intended for treatment of 100% of turbine condensate (≈620 t/h). Purification system consists of a debris filters plant for removal of mechanical impurities from the crude condensate and mixed filter plant for removal of salts. In the debris filters plant with capacity of 2x310 m^3/h, a mechanical treatment of turbine condensate will be performed. Condensate purified in debris filters will be further transported through the mixed filter plant with capacity of 3x310 m^3/h (two filters working and one spare) in order to remove present salts.

Control of the filter soiling is done by measuring the differential pressure and flow through the filter (soiling by mechanical impurities), and measuring the conductivity of the purified condensate and SiO_2 content (saturation of salt). In case of contamination by only mechanical impurities internally backwashing using condensate and air is performed. After saturation of ion exchange resins with salts, external regeneration facility situated in a building of CWT, mutual for both blocks, will be implemented. Cation resin is regenerated with hydrochloric acid, while the anionic mass is regenerated with sodium hydroxide. Chemicals for regeneration shall be delivered from the above-mentioned storage tanks which are located in the CWT building.

<u>Chemicals for the conditioning of feed water and condensates</u>

For conditioning of feed water and condensate ammonium hydroxide and oxygen are used.

Ammonium hydroxide NH_4OH, is a colourless liquid, sharp, suffocating odour and sour taste. It is characterized by severe alkali reactivity. Boiling point of the compound under consideration is about 36 °C, and pH value of 11.6. If the ammonia water is found near the volatile acid, it leads to the formation of smoke. In contact with the sulfuric acid it causes an exothermic reaction. In normal conditions of use and storage, ammonium hydroxide is a stable compound. It is stored in closed containers in a well-ventilated room and at temperatures lower than 25°C, and always far from flammable substances. As part of the thermal power plant it is used as an additive to boiler water to neutralize carbon acids in the condensate and thereby prevent corrosion of boiler equipment.

It is common to store ammonium hydroxide as a 25% solution, and it is used as a diluted 2% solution.

It should be noted that ammonium hydroxide has a corrosive effect on copper and zinc. In systems where there is a high pH value, the presence of ammonia will cause an increase in the presence of copper and zinc in the boiler water subsystems over the levels that would not require preventive measures. That phenomenon is of importance in places where the copper or zinc is used in surface coatings or as primary materials for manufacturing of boiler walls. In addition to copper and zinc, NH_4OH is also not compatible with oxidizing agents (such as peroxides, permanganates, chlorates, nitrates, bromine or fluor), strong acids (e.g., sulfuric or nitric), galvanized iron, aluminium, lead and silver nitrate.

Ammonium hydroxide is irritating and toxic to human beings, regardless of how it gets into the organism (inhalation, ingestion, or skin exposure to its effects). Exposure to an environment that is contaminated with this compound causes effects in humans such as irritation of the eyes, throat and skin, whereas swallowing can cause burning pains in this organs. Short-term exposure to concentrations of 5,000 ppm can be fatal. Long-term exposure to low concentrations result in chronic irritation of the eyes and respiratory tract and may lead to bronchitis. For these reasons handling this compound must be careful, with the use of protective equipment designed to protect the skin, eyes and respiratory tract. All places where the compound can be found should be appropriately marked and warning signs should be set. Maximum allowable medium concentration during the 8-hour period according is 50 ppm (some experiences across the world).

In case of skin contact with NH4OH, it is necessary to take measures that are similar to measures being implemented in the case of contact with the previously discussed materials. It is urgent to remove the victim from the contaminated area, take off his contaminated clothing and replace it with clean one, wash the whole area with plenty of water. After that, they should immediately seek medical assistance. Similar considerations apply in the case of inhalation of the studied compounds.

Although it is among the toxic substances, around the world it is considered that ammonium hydroxide is safe to use, provided the use is made in accordance with the recommendations, based primarily on cases of good practice.

Raw materials for the production of demi water

The raw materials used in the production process demi water are:

- substances used for filtering and pre-treatment of raw water: quartz sand, anthracite and activated carbon,
- substances used for demineralization of permeate from the reverse osmosis process: ion exchange resin for cationic, anionic and mixed filters.

Products

The main product of the technological process that takes place in the power plant is electricity. For the purpose of this process in the context of TPP Kostolac B3 feed (boiler) water of required quality shall be produced, as described in Chapter 3.3.2 of the Study.

In addition to these useful products, waste products also occur as a result of technological processes, and they need to be adequately treated before final disposal/emissions into the environment.

A. *Electricity*

Electricity production

Electricity is produced by a generator with the nominal power of 350 MW steam turbine driven by the specific consumption of heat 7457.5 kJ/kWh. The generator will be located in the engine room at the elevation of +12.6 m, and excitation system below the generator at ±0,00 m angles, except the excitation transformer, which will be located outside, in front of rows of columns "A" of the machine hall. Unit B3 generator is connected via block transformer of 410 kVA nominal power and the transfer ratio of the voltage 22/410 kV. The placement of the unit B3 power into Serbia's power grid shall be made through the existing substation RP 400 kV located in the immediate vicinity of the new unit.

Produced electricity is intended to meet the needs of the electric power system of Serbia, as well as for the plant’s own consumption. It is anticipated that the unit B3 works in base mode, with nominal operation of 7,500 hours per year, while the gross electricity production would be approximately 2,600 GWh per year.

Unit's own consumption

For the purpose of the new unit's own consumption power transformer 110/6,6/6,6 kV is designed, and it shall also be connected to the existing 110 kV.

Power consumption is divided into unit consumption and general consumption (general group). Therefore, the consumers of less technological significance are connected to the general group's distribution. Overall consumption, such as: transport of coal, CWT, delivery of liquid fuel and the like, is powered by electricity from the existing distribution of the first stage of building TPP Kostolac B general group. Self-consumption, i.e. electricity consumption for the purposes of the unit amounts to 11.98% of the gross production of the unit, i.e. 41.93 MW.

B. Feed water

Production method, quantity and characteristics of the feed water (demineralized water) used in the context of TPP are described in Section 3.3.4 of this Study, in part related to the plant CWT.

C. Waste matter formed as a result of TPP Kostolac B3 operation

During normal operation of the unit B3, waste materials are generated during the following processes:

- coal combustion in the boiler, resulting in waste flue gases as combustion products, non-combusted coal residue in the form of ash and slag, and waste heat,
- chemical water treatment and turbine condensate treatment,
- transportation and depositing of coal,
- flue gases desulphurization, including transportation and storage of limestone as well,
- flue gases dedusting in wet electrostatic precipitator,
- collection, transportation and disposal of ash, slag and gypsum,
- auxiliary activities which occur during the operation of units, such as cooling of slag, various washing and rinsing within MPF, workshops and other facilities and the like.

In addition to these matters, commonly referred to as industrial waste materials, in the course of the unit B3 operation sanitary and storm wastewater as well as municipal waste are also formed.

Each group of waste materials is to be analyzed in more detail, including a description of their main physical and chemical properties, types and quantities, as well as the place of occurrence.

Gaseous waste matters

Gaseous waste products occurr as a product of the coal combustion process and are contained in the flue gases leaving the boiler. Characteristics of the flue gases largely depend on the characteristics of the coal being burned, but also on the conditions of combustion in the boiler. The characteristics of coal to be used for the purposes of the unit B3 are shown in Section 3.3.2 of this Study, Table 3.3.2-1. Taking into account the adopted characteristics of the unit,Table 3.3.5-11 shows the characteristics of the flue gases at the entrance to electrostatic precipitator system for the boiler operation at full load (TMCR mode). Reducing emissions of nitrogen oxides is performed in boiler plant by using primary measures.

Table 3.3.5-11: Characteristics of the unit flue gases (behind the air heaters)

Parameter	Unit	Medium calorific value coal	Low calorific value coal
Calorific value of coal	kJ/kg	8.000	7.200
The temperature of the flue gas	°C	168	170
The flue gas flow (real)	m^3/h	2.510.914	2.656.550
The moisture content in the flue gas	%	20,5	21,5
The flue gas flow (dry, 0°C, 1013 mbar, 6 % O_2)	m^3/h	1.236.170	1.291.800
Concentration of powdery substances in flue gas before dry EP (dry, 0°C, 1013 mbar, 6 % O_2)	g/m^3	60	67,1
Concentration of SO_2 in flue gas (dry, 0°C, 1013 mbar, 6 % O_2)	mg/m^3	6.700	6.830
Concentration of NO_x in flue gas (dry, 0°C, 1013 mbar, 6 % O_2)	mg/m^3	200	200
Concentration of chlorides in flue gas (dry, 0°C, 1013 mbar, 6 % O_2)*	mg/m^3	5-15	
Concentration of fluorides in flue gas (dry, 0°C, 1013 mbar, 6 % O_2)*	mg/m^3	8-26	

* assessed values on the basis of measurements on TPP Kostolac units A and B, which use coal from OPM Drmno

The composition of the flue gases are gaseous pollutants: sulfur and nitrogen oxides, powdery substances, carbon oxides, organic matters, trace elements and heavy metals, halides. Below are the characteristics of these pollutants on the basis of which their possible impact on the environment can be seen.

Sulfur dioxide is a dangerous substance that occurs in the flue gas from the thermal power plant chimney, primarily due to its harmful effects on humans, flora and fauna, as well as the corrosive effects on different materials. Emissions of sulfur oxides occur as a result of oxidation of sulfur from coal during the combustion process. SO_x emissions from conventional coal plants are mainly in the form of SO_2, with over 95% of the sulfur emitted as SO_2, while 1-5% of SO_2 further oxidizes into sulfur trioxide, SO_3, whereas about 1-3% is being emitted as elemental sulfur. Uncontrolled emissions of SO_x is almost completely dependent on the sulfur content of coal, but also on the general characteristics of coal (primarily calorific value and concentration of alkaline compounds). The emission of SO_x, generally speaking, is not affected by the size and type of boiler or burner type and design. Sulfur conversion from the coal is inversely proportional to the concentration of the alkaline compound, since these compounds represent a natural sorbent for the removal of SO_x.

Main features of sulfur dioxide are shown in Table 3.3.5-12.

Table 3.3.5-12: Basic physical and chemical SO_2 characteristics

Waste material name	Sulphur-dioxide
Chemical formula	SO_2
Physical characteristics	
Appearance	gas without colour, sharp suffocating odour
Molecular weight	64,054 g mol^{-1}
Density (1,013 bar at boiling point)	3.049 kg/m^3
Melting point	-75,51°C
Boiling point	-10,06°C
Solubility in water	228,04 g/l (0°C)
Relative density with respect to air	2,2
Chemical characteristics	
Flammability	neither flammable nor supports combustion
Toxicity	toxic
Oxidation susceptibility	can be oxidized to sulphur trioxide which is dissolved in water forming a sulfuric acid which has an extremely corrosive impact on metallic surfaces
Reaction with other elements	reacts violently with ammonia, acetylene, alkali metals, chlorine, ethylene oxide, butadiene; aggressively reacts with many metals, including aluminium, iron, steel, brass, copper and nickel in the presence of water
Incompatibility with other chemical substances	not compatible with halogen elements
Aggressive effect	aggressively reacts with plastics, rubber and coatings in liquid form
Occurrence in nature	geothermal activity, including mineral springs and volcanic activity; a natural result of rotting of vegetation on the ground.
Industrial sources	combustion of fossil fuels, primarily coal-fired thermal power plants, industrial processes, such as wood processing, paper production, petrochemistry, processing and melting of metals, especially ores containing sulphides such as lead, silver and zinc ores, traffic (exhaust fumes).
Short-term exposure effects on human health	Strong irritation of eyes and respiratory tract, direct inhalation of gas may cause the occurrence of lung oedema; causes damage to respiratory tract which leads to asthmatic reactions, reflex spasms of the larynx and respiratory failure; in extreme cases it may lead to death; the occurrence of a delayed effect of a short-term exposure is also possible, thus a medical supervision is recommended.
Long-term or chronic exposure effects on human health	chronic or a long-term exposure may lead to asthmatic diseases; a value of 0,38 mg/m^3 is considered a limit long-term concentration for the appearance of symptoms, while the sensitivity limit is already at 0,1 mg/m^3.
Effects on vegetation	damage to vegetation depends on the type and synergistic reactions with other pollutants in the air; chronic damages occur already at concentrations of 0,1-0,4 mg/m^3.

It should be noted that sulphur dioxide in the air, in the presence of hydrogen peroxide and hydroxyl radicals, forms acidic compounds and returns to the soil as a sulfate in the form of dry and wet deposition. Its impact on human health refers primarily to its direct introduction into the body by inhalation. Since it is soluble in water, it is absorbed in the upper part of the respiratory tract (nasal mucosa, trachea) in the form of acid that acts damaging. Health effects depend on the concentration of sulphur dioxide in the air and they shall be analysed in more detail in Section 6.3.5.

Nitrogen oxides are formed by combustion of coal at high temperatures. Although at the ambient temperatures nitrogen and oxygen in the air do not enter into a reaction, at elevated temperatures that develop during the combustion, nitrogen ceases to act as an inert gas, but instead reacts with oxygen to form the various oxides of nitrogen.

The above mentioned nitrogen oxides, NO_x, are a result of unwinding of two mechanisms: thermal fixing of the atmospheric nitrogen in the combustion air (so-called. thermal NO_x) or the conversion of nitrogen from the fuel (ie. NO_x from fuel). In coal burning systems, 80% of total nitrogen oxides emissions originate from the nitrogen in the fuel. Conversion degree of nitrogen in the fuel into the NO_x varies in a wide range from 5 to 60%. The term NO_x refers to a mixture of nitric oxide NO and nitrogen dioxide NO_2. Numerous studies have shown that in most systems of fossil fuels combustion, over 95% of NO_x is emitted in the form of NO. Nitrous oxide N_2O is not covered by the formula NO_x, but has recently become very interesting as one of the greenhouse gases.

The amount of NO_x formed by mentioned mechanisms depends on a number of factors. One of the most important factors is the configuration of the combustion chamber, where the tangential furnaces organization generally results in lower NO_x emissions. An important factor is the organization of the combustion process in the boiler. Low coefficient of excess air, flue gases, combustion in several stages, reduced air preheating, burners with low NO_x emissions, or a combination of these solutions can lead to lower emissions of NO_x, from 5 to 60%. NO_x emissions can also be reduced from 0.5 to 1% for each decrease percent of the boiler load in relation to the full load.

The formation of NO_x in large combustion plants is conditioned by the type and characteristics of the boiler combustion process.

Unit B3 steam boiler is a flow boiler, tower type, with pulverized lignite firing and inter-superheating of steam. It belongs to the group of boilers with supercritical parameters. The boiler is once-through. The design of the boiler is adapted to burning pulverized coal with the applied primary measures for the reduction of nitrogen oxide by installing low NO_x burners and the introduction of tertiary air in the zone above the burner of coal dust - OFA procedure. Firing is done with coal dust by eight tangentially positioned pulverized coal burners.

Features of nitrogen oxides are shown in Table 3.3.5-13. As shown in the foregoing table, nitrogen oxides are also hazardous air pollutants, which also, in addition to the primary (direct), have a secondary effect (by means of the photochemical effects). The primary effect of nitrogen oxides is toxic: they irritate the respiratory system, penetrate into the pulmonary alveoli and damage the tissue. Damages may also occur during short exposures to relatively small concentrations of NO_2 (acute above 0,025 mg/m^3, and chronic already at 0,005 mg/m^3). Lower concentrations of nitrogen dioxide have an irritating effect on the eyes and the nasal mucosa. The secondary effect of nitrogen oxides occurs in a combination with aerosols and non-combustible hydrocarbons and reaction under the influence of solar energy. Described photometric reaction takes place at higher air temperatures (above 25°C) and the nice weather, resulting in the formation of ozone, aldehydes and various organic radicals, each of which works for itself (at least as irritant) on the respiratory system. Thus formed "photochemical smog" is red-green, occurring at concentrations of nitrogen oxides from 0,015 mg/m^3 to 0,1 mg/m^3. Smog which is formed has a strong oxidizing property and leads to direct damage to the lung tissue.

Table 3.3.5-13: Basic physical and chemical characteristics of the gases NO and NO2

Waste material name	Nitrogen-monoxide	Nitrogen-dioxide
Chemical formula	NO	NO_2
Physical characteristics		
Appearance	colourless gas sharp, sweet smell, which at higher concentrations in the air turns into brown	reddish-brown gas, pungent odor
Molecular weight	30,0061 g mol^{-1}	46,05 g mol^{-1}
Density (1,013 bar at boiling point)	3,027 kg/m^3	3.4 kg/m^3
Melting point	− 163,6°C	-11.2°C
Boiling point	− 151,7°C	21.2°C
Solubility in water	slightly soluble in water, forms a weak acid	very soluble in water, forms a strong, nitric acid
Relative density with respect to air	1,04	1,59
Chemical characteristics		
Flammability	not flammable but it is a strong oxidizing agent	not flammable or strong oxidizing agents, can cause burning in contact with clothing and other combustible materials
Toxicity	toxic, corrosive	Highly toxic
Reactivity	free radical, extremely reactive	extremely reactive
Oxidation susceptibility	unstable, contacted with oxygen quickly turns into nitrogen dioxide	strong oxidizing agents, forms nitric acid with oxygen
Reaction with other elements	in the presence of water, affects many metals corrosively	strong reaction with combustible and reducing substances; react with water forming nitric acid and nitric oxide; in the presence of water aggressively affects many metals
Incompatibility with other chemical substances	reacts violently with Cl, B, CS2, Cr, Fr, chlorinated hydrocarbons, ammonia, O3, N2O and P with the occurrence of fire and explosion	contact with certain types of plastics, elastomers and lubricants can lead to ignition
Occurrence in nature	part of the organisms of mammals	atmospheric electrical discharge (lightning), aerobic bacteria activity in the land
Industrial sources	the primary product of the plant for the combustion of fossil fuels, transportation, chemical industry,	fossil fuels combustion plants, transport
Short-term exposure effects on human health	corrosive to the skin and respiratory tract; inhalation of gas or vapor may cause pulmonary oedema; Exposure to concentrations far higher than the maximum permitted could lead to death; Effects of exposure may be delayed, monitoring by the medical experts.is recommended	
Long-term or chronic exposure effects on human health	may cause the changes of the immune system and functions of the lungs, resulting in a reduced resistance to infection; Experiments conducted on animals suggest toxic effects on reproductive organs.	
Effects on vegetation	the occurrence of acid rain which is a harmful effect on vegetation	

Nitrogen oxides are subject to oxidation, forming a nitric acid which is in the form of nitrate salts deposited on the surface. The presence of nitrogen oxides is important in the reaction of ozone or "photochemical smog" formation which exhibits strong oxidizing property and leads to the direct damage of the lung tissue. Lower concentrations of nitrogen dioxide have an irritating effect on the eye and nasal mucosa.

Carbon oxides, carbon monoxide (CO) and carbon dioxide (CO2) are formed as a product of the oxidation of carbon during fuel combustion (carbon content in Kolubara lignite basin of guaranteed quality is 20.8%), whereby the amount of CO is incomparably less than the amount of CO_2. The formation of carbon monoxide depends on the efficiency of fuel oxidation. The presence of carbon monoxide in the exhaust flue gases is the result of incomplete combustion of fossil fuels, which occurs due to insufficient oxygen available for combustion, poor mixing of fuel and air, low combustion temperature, extinguishing of flame on cold walls of the boiler, the reduced time of combustion, lower plant load (reduced intensity of combustion). Since the above mentioned occurrences may happen due to various modifications which are introduced in order to reduce NO_x emissions, the risk of CO emissions increase represents a serious problem which must be taken into account for reasons of environmental protection, energy efficiency and operability of the plant. Emissions of CO can be reduced to the lowest possible value by careful control of parameters of the combustion process, with regular maintenance of all elements of the plant. CO is generally a very widespread pollutant which comes much more from other sources of pollution than from power plants, primarily from transportation sector. However, in contact with air, it rapidly oxidizes into carbon dioxide, so that CO concentrations in the atmosphere are short-lived.

However, almost all carbon from the coal (99%) is converted to CO_2 during the combustion process, wherein the said conversion does not depend on the organization of combustion in the combustion chamber. Although the formation of CO impacts on the reduction of CO_2 emissions, the amount of CO produced is negligible compared to the amount of CO_2 formed. The main part of the carbon from the fuel which due to incomplete combustion did not convert to CO_2, leaves the combustion chamber tied up in slag. Although it is not on the list of substances whose emissions and imissions are limited by the existing legislation, the presence of carbon dioxide in the atmosphere affect the process of global warming and as such must be analyzed as the cause of adverse effects caused by the combustion process. This is especially important if we bear in mind the obligations arising from the International Convention on global warming and the Kyoto Protocol on reducing CO_2 emissions into the atmosphere.

Properties of CO and CO_2 are listed in Table 3.3.5-14.

Table 3.3.5-14: Basic physical and chemical characteristics of the gases NO and NO_2

Waste material name	Carbon monoxide	Carbon dioxide
Chemical formula	CO	CO_2
Physical characteristics		
Appearance	gas without colour, smell and taste	gas without colour, smell and taste
Molecular weight	28,0101 g/mol	44,0095(14) g/mol
Density (normal conditions)	0.96716 kg/m³	1,98 kg/m³
Melting point	-205°C	−57°C
Boiling point	-192°C	−78°C

Waste material name	Carbon monoxide	Carbon dioxide
Solubility	limited solubility in water (23 ml/l at 20°C), soluble in ethyl acetate, glacial acid, allyl acetate and other organic solvents,	soluble in water, forms carbonic acid
Relative density with respect to air	0,968	1,521
Chemical characteristics		
Flammability	Highly flammable	Not flammable, but supports burning metals
Toxicity	highly toxic	toxic at concentrations above permissible
Oxidation susceptibility	rapidly oxidizes to CO_2	-
Incompatibility with other substances	reacts violently with strong oxidizing agents or halogen components	compatible with most materials
Occurrence in nature	volcanic activity, unsolicited fires low vegetation (bushes, shrubs)	Earth's atmosphere, water (as part of the carbon cycle), volcanic activity, geothermal activity (hot springs, geysers)
Industrial sources	Traffic, combustion of fossil fuels	Traffic, combustion of fossil fuels
Short-term exposure effects on human health	Changes in body temperature, blood pressure, nausea, chest pain, shortness of breath, headache, drowsiness, fatigue, dizziness, disorientation, hallucinations, pain in extremities, loss of hearing, coordination, impaired vision, blueness of the skin, shortness of breath, circulatory diseases, cramps, coma	Exposure to concentrations below 2% (20,000 ppm), has no adverse effects; Higher concentrations can affect the respiratory system and cause damage to the central nervous system; High concentrations can "squeeze out" oxygen from the air, with consequent lower concentration of oxygen necessary for respiration; thus the effects of a reduced amount of oxygen are associated with toxic properties CO_2
Long-term or chronic exposure effects on human health	nausea, vomiting, loss of appetite, headache, dizziness, impaired vision, diseases of the circulatory system, heart, nerve damage, damage to the reproductive organs, brain damage	Exposure to concentrations of 1-1.5% in the long run leads to reversible chemical imbalances in the blood and increases the amount of air inhaled. Indirect impact through the greenhouse effect.
Effects on vegetation	Carbon monoxide does not adversely affect vegetation as it rapidly oxidizes into carbon dioxide, which is used in the process of photosynthesis	Increased concentrations are positively affecting the plants, because they improve the photosynthesis process; negative influence is seen through the result of the greenhouse effect.

CO is binding in blood due to a higher affinity than of oxygen and prevents the normal intake of oxygen into the organism, causing dizziness, poisoning, and the like, in accordance with the symptoms listed above. People with heart disease are especially sensitive to the effects of exposure to CO emissions. Exposure to high concentrations is associated with visual impairment, working ability, learning ability, and execution of complex tasks.

CO_2 affect the environment indirectly, by changing climate. The discharge of CO_2 into the atmosphere changes the equilibrium of gases content in the air, and the physical properties of mixtures of CO_2 and aerosols change the atmosphere and heat accumulation. Constant increase of the CO_2 content in the atmosphere does not reduce the transmittance of solar radiation, but does not allow the radiation reflected from the earth's surface out (which has a greater wavelength), and the heat is retained in the lower atmosphere.

All the most important *greenhouse gases*, carbon dioxide (CO_2), methane (CH_4) and nitrous suboxide (N_2O), are also emitted during coal combustion. Carbon dioxide, which was previously discussed more, is the most common representative of this group, participating in total emissions of greenhouse gases of the energy sector with 96,4%. Methane emissions of 2,1% and nitrogen sub-oxide of 1,5%, represent only a small fraction of total emissions of the considered gases.

Out of the total methane emissions, over 80% occurs as a result of emissions during the excavation of coal in the mine, treatment and transportation of fossil fuels. Methane emissions resulting from the coal combustion heavily depend on the type of coal which is combusted and the combustion chamber organization, but they are the highest during periods of start-up and shutdown of the boiler.

As previously mentioned, nitrous sub-oxide emissions occur as a result of the combustion process in the boiler's combustion chamber. The amount of generated N_2O depends much on the combustion temperature, thus it is the highest at a temperature of about 730^oC, whereas for temperatures lower than 530^oC and higher than 730^oC it is almost negligible. In addition to temperature, N_2O emission also depends on the pressure in the combustion chamber and the oxygen content (whose increase directly affects the emission), as well as on other chemical processes in the combustion chamber related to binding of nitrogen in other forms of oxide. Practice has shown that in case of boilers with conventional combustion mode, in which temperatures in the combustion chamber are above 1.000°C, amounts of N_2O formed are very low. The exceptions are chambers with combustion in a fluidized layer where localized areas of low temperature within the layer contribute to the occurrence of a significantly higher N_2O emissions.

Pursuant to the above said, and based on the presented description of the boiler's combustion chamber, N_2O emission from the unit B3 boiler can be considered negligible and will not be further considered.

In addition to these substances, in the exhaust flue gases powdery substances also occur, which, although they represent only a small part of the total amount of solid residues of coal combustion, including unburned particles as well, considering the manner and range of their transportation, they can have a significant role in the environmental pollution in the area of thermal power plant location.

Behaviour of particulate matter depends on their size:

- dust with granulation over 10 μm in still air settles down spontaneously under the influence of gravity; in case of inhalation, particles mostly stop in the mucous membrane of the nose or pharynx and cause irritation which has no significant adverse effect, excluding high-risk parts of the population;
- particles whose size ranges from 1 μm to 10 μm, are deposited according to Stokes law, and are retained longer in the air; In case of inhaling, they are retained in the bronchial tree,
- particles smaller than 1 μm behave similarly to gases; in case of inhaling, they are deposited in the lungs.

Figure 4.8-5 shows the probability of deposition of inhaled particles in some parts of the respiratory tract. It can be seen that the larger particles with a higher probability are being kept at the entrance of the respiratory tract, while smaller ones get to the bronchi.

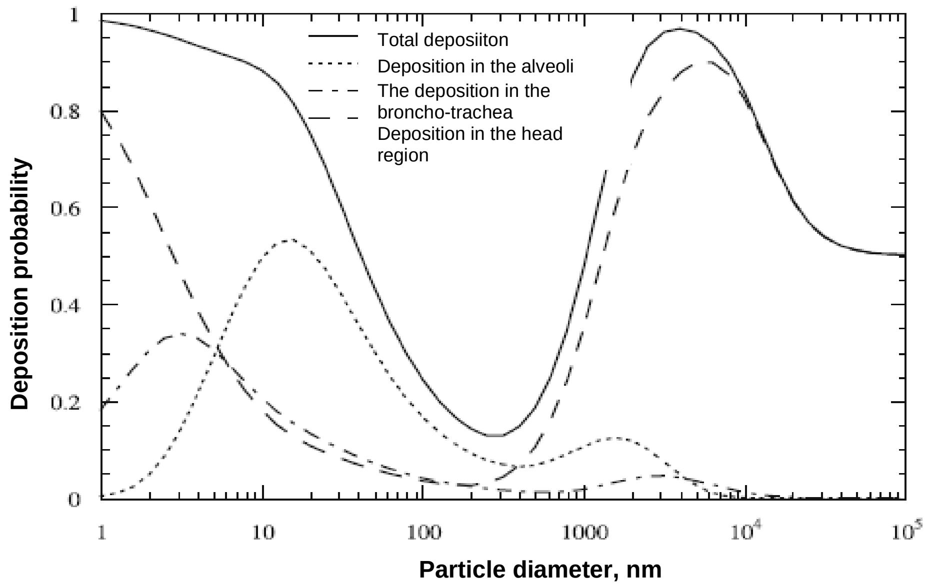


Figure 4.8-5 Probability model of the particles deposition in the respiratory tract (ICRP, 1994)

The deposition of fly ash particles has a negative impact on the vegetation, slowing its growth, and can also lead to the discharge of high voltage electrical installations during adverse weather conditions, as a result of increased deposited ash conductivity in the presence of moisture.

The particles in the air have a significant impact on the weather conditions near the ground, because they affect the intensity of solar radiation that reaches up to it. The particles scatter the sun rays into different wavelengths, depending on the size of the particles, their concentration, their nature and the like, and a part of the solar radiation is often absorbed. Visibility is, generally speaking, reduced due to the presence of particles in the air. Reducing the intensity of light radiation that passes through the air to land is caused by two optical effects related to air molecules and particles in the air: sorption of light energy and light scattering.

Solid particles together with the presence of the components (molecules) in the air, create a large volume of particles or solid particles, which serve as cores around which crystals or droplets (e.g., fogging due to saturation of water vapour, in the presence of solid particles in the air). This is especially true in urban areas, where frequent fogs direct consequence of this effect.

Due to the low calorific value of coal in the TPP Kostolac B3 boiler, large amounts of coal shall be burned (about 9,000 t/day), which will result in large amounts of generated ash (about 1,600 t/day). The transport of coal to the power plant by closed belt conveyors, expects minimum wastage of coal dust particles only along transportation corridors. Manipulation of coal in the boiler room to the firebox entrance, shall be monitored, with the of workspace dedusting devices installation (see the description of the coal transportation system, (Section 3.3.4), so that the emissions from the ventilation outlets is in accordance with the Regulation on air emission limit values.

Organic substances that are emitted from coal-powered plants include fuel volatiles remaining in the gaseous state in the ambient air, semi-volatile organic matter and condensable organic matter. Nevertheless, the total organic matter emitted during the combustion of coal, primarily lignite, are present only in trace amounts. Their quantity, as in the case of CO emissions depend on the efficiency of coal combustion in the boiler. For this reason, modifications made in the boiler, affecting the change of combustion duration, temperature or flow turbulence in the combustion chamber, can lead to an increase in the concentration of organic substances in the exhaust flue gases.

The emission of *trace elements* generated during coal combustion depend on the combustion temperature, furnaces firing manner and the composition of coal and is mainly contained in the particles of ash that are transmitted via flue gas.

In addition to emissions of SO_x and NO_x, combustion of coal also causes emission of compounds of chlorine (Cl) and fluorine (F) are primarily in the form of *hydrogen chloride*, HCL and *hydrogen fluoride* HF. Part Cl and F from the fuel can be absorbed by the ash and slag in the furnace, albeit the type at lignite coal it is expected that the majority of fluor and fluorine form the said gaseous compounds.

In addition to the above mentioned pollutants that occur as a result of coal combustion, it is necessary to mention that unit startup uses liquid fuel, ie. heavy fuel oil. Heavy fuel oil represents a heavy fraction of crude oil remaining after the removal of lighter fractions (gasoline, kerosene and distilled liquid fuels) and as such contains a certain amount of ash and sulfur. Since they fall into the category of fossil fuels, combustion of liquid fuels forms the same pollutants as does the combustion of coal, in proportion to the content of the fuel and the combustion conditions.

<u>Solid waste material</u>

Ash and slag

Planned unit TPP Kostolac B3 shall burn coal from OPM Drmno, which is already used in the existing units of TPP Kostolac B1 and B2 and TPP Kostolac A1 and A2, therefore the basic characteristics of the ash and slag will not significantly be changed compared to those defined by previous studies. Granulometric composition of ash and slag may be slightly modified depending on the future process of coal grinding for the new unit.

Figure 3.3.5-4 shows the summary results of the analysis of particle size distribution of samples of ash from previous tests ashes from TE Kostolac B.

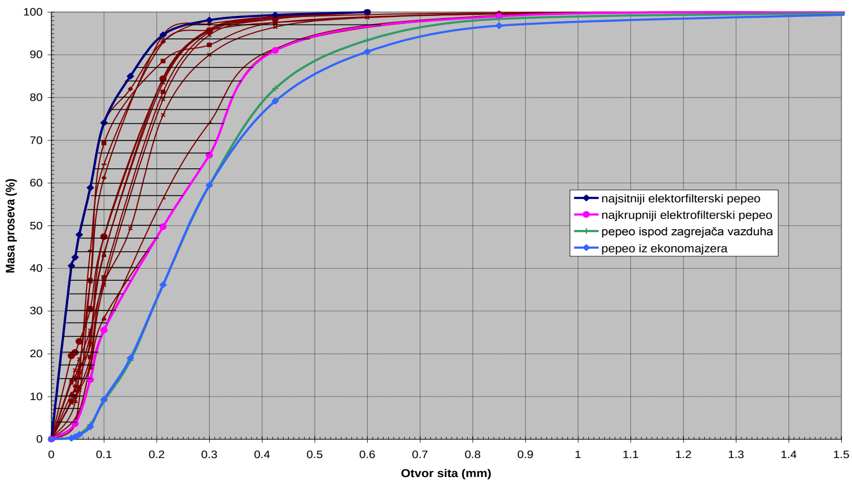


Figure 3.3.5-4: Curves of sifts of slag samples from TPP Kostolac B

From the shown results of granulometric compositions it can be seen that the ash grit varies, upper grit limit varies between 0.22 and 0.7 mm, and the mean grain diameter varies from 0.07 to 0.22 mm.

Fig. 3.3.5-5 shows particle size of slag obtained by analysis of previous test results in range between curve of smaller and larger slag particles.

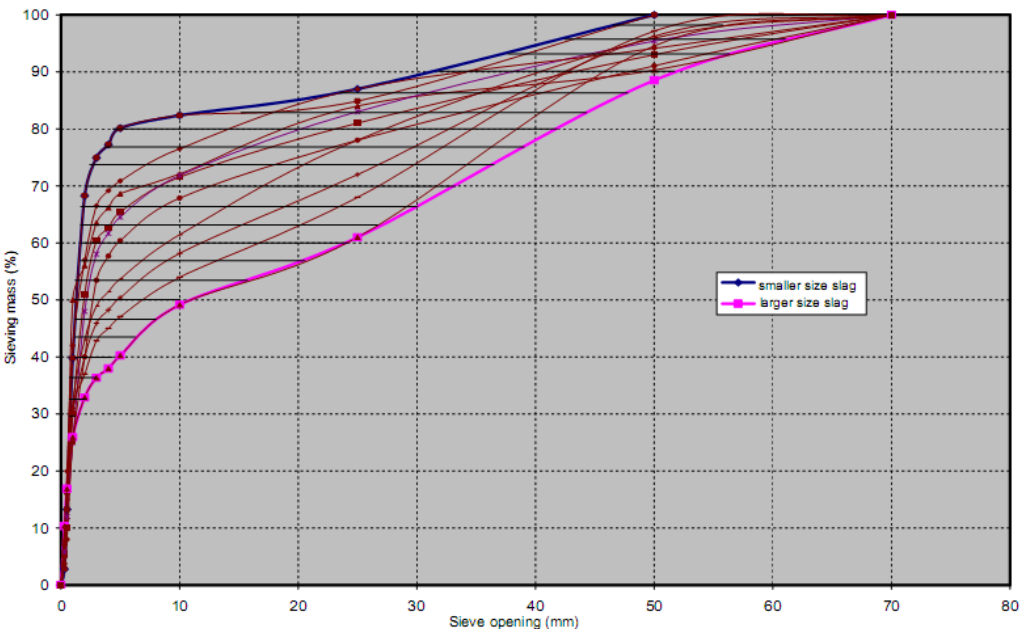


Fig. 3.3.5-5: Curve of slag samples from TPP Kostolac B

Provided results show that upper limit of slag particle size is in range from 50 to 70 mm, while mean grain diameter is from 1 to 10 mm, i.e. below 5 mm average.

For the purpose of the subject Project preparation, the following values of ash and slag properties are adopted:

- ash and slag density (ratio of 90:10) 2,110 t/m^3
- ash and slag bulk mass 0,644 t/m^3
- ash and slag volume mass 0,755 t/m^3

Chemical and mineral composition is important parameter for ash and slag transport and disposal because of components which are chemically aggressive and abrasive for material which is used for the equipment. Table 3.3.5-15 shows chemical composition of ash and slag produced by combustion of coal from OCM Drmno.

Table 3.3.5-15: Chemical composition of ash and slag

Component	Ash	Slag
	Content, %	
SiO_2	48,5	51,5
Fe_2O_3	9,0	8,6
Al_2O_3	26,0	26,3
TiO_2	0,85	
P_2O_5	0,25	
CaO	6,5	7,8
MgO	3,5	2,4
Na_2O	0,3	1,4
K_2O	0,5	
SO_3	4,6	2,0

Prevailing components of ash and slag are SiO_2 and Al_2O_3, which are defined as inert substances. According to chemical composition, ash is classified as aluminosilicate ash with low content of binding components, i.e. without significant impact to ash chemical binding.

In amorphous phase, prevailing are aggregates of thermally modified minerals of clay and glass particles. Aggregates, of 0,030 - 0,500 mm size, are round with coal content which is the reason why they are opaque to slightly transparent. Glass particles are colourless or slightly coloured, size of less than 0,030 mm. Coal, in cases when it is free, usually occurs in the largest particles in sample.

Mineral cristobalite is most present in crystal phase, as well as thermally degraded feldspar and carbonates. Other minerals occur in traces.

Ash and slag produced as by-product of Kostolac lignite combustion, are classified as non-hazardous waste by their nature, with index number 10 01 01 (Catalogue of waste, Annex 1 of Rulebook on categories, testing and classification of waste, Official Gazette of RS 56/2010).

FGD gypsum

Primary product of FGD process is thin slurry of gypsum (with 15% ratio of solids), which is, for the purpose of water consumption reduction in process, primarily dewatered in hydrocyclones up to thickness of 50% solids. Properties of thick gypsum slurry and dry gypsum are provided in Table 3.3.5-16.

Table 3.3.5-16: Properties of thick gypsum slurry and dry gypsum

Parameter	Unit	Value	
		Gypsum slurry	Dry gypsum
Flow	kg/h	39.750	21.760
Content of water with dissolved salts	kg/h	19.875	2.178
Content of solids	kg/h	19.875	19.581
Content of gypsum	kg/h	18.932	18.670
Ca-sulphite content	kg/h	43	41
$CaCO_3$ content	kg/h	429	423
$MgCO_3$ content	kg/h	71	71
Ash content	kg/h	18	18
Content of inert substances and other solids	kg/h	382	350
Content of soluble substances	kg/h	766	10
Chloride content	ppm	7.000	100
Density	kg/m^3	1.414	1.000*

* volume mass

Main physical properties of gypsum from FGD process are provided in Table 3.3.5-17.

Table 3.3.5-17: Main physical properties of gypsum from FGD process

Property/Parameter	$CaSO_4$ x $2H_2O$ (FGD gypsum)
d_{50}	35-55 μm
d_{95}	100-185 μm
d_{85}	60-90 μm
Specific density	2,3-2,6 t/m³
Bulk mass	0,7-1,0 t/m³
Volume mass	0,9-1,2 t/m³

Gypsum particle size composition, shown in Fig. 3.3.5-6, is also taken from available data.

For the purpose of the subject Project preparation, the following values are adopted:

- d_{85}' 90 μm
- specific density 2,45 t/m³
- bulk mass 0,85 t/m³
- volume mass 1,0 t/m³

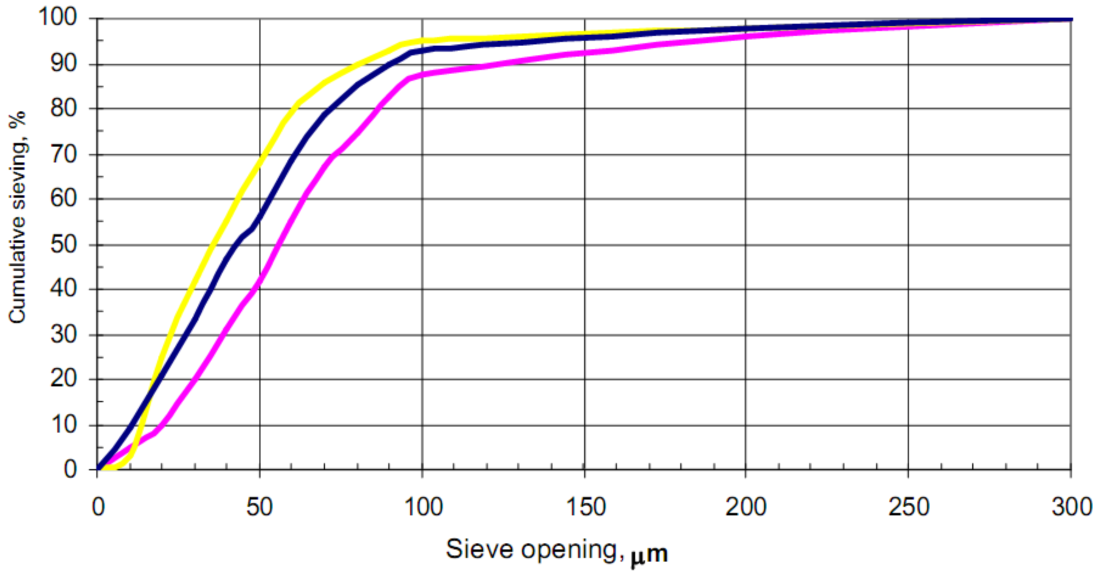


Fig. 3.3.5-6: Particle size composition of FGD gypsum

Chemical analysis implies predominant content of CaO and SO_3 which is from 28 to 36% of CaO and from 42 to 48% of SO_3 in samples from different tests, depending of purity degree, i.e. gypsum content.

FGD gypsum predominantly contains gypsum ($CaSO_4$ x $2H_2O$), bassanite ($CaSO_4$ x $1/2H_2O$), anhydrite ($CaSO_4$) and calcite ($CaCO_3$), fly ash particles and unburnt coal can be found in traces. Predominant content of sulphur and calcium is clearly seen at spectroscope X-ray recording of sample, shown in Fig. 3.3.5-7. Since FGD gypsum has prevailing crystal structure, grains themselves are mostly in shape of extended rhomboid crystals, as seen at microscopic recording shown in Fig. 3.3.5-8.

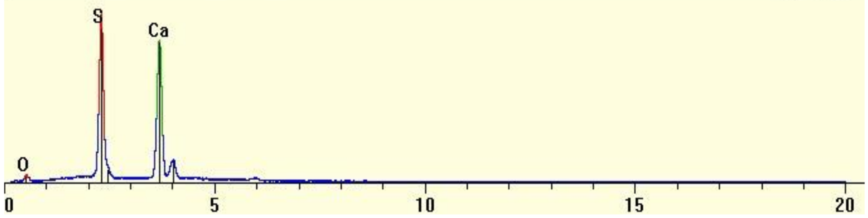
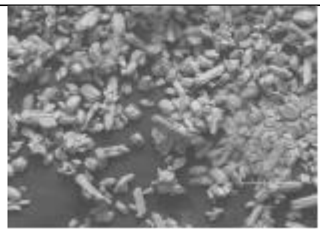
	

Fig. 3.3.5-7: spectroscope X-ray analysis of FGD gypsum	**Fig. 3.3.5-8: Crystals of FGD gypsum**

By its nature, gypsum slurry is classified as non-hazardous waste with index number 10 01 07, while index number for FGD gypsum is 10 01 05 (Catalogue of waste, Annex 1 to Rulebook on categories, testing and classification of waste, Official Gazette of RS, No. 56/2010).

Mixture of ash, slag and gypsum

Compaction of wet ash, slag and gypsum is provided by planning and compacting using machinery, to dry volume mass of 0.85 t/m^3. For disposal of 1 ton of ash, slag and gypsum, area of around 1,176 m^3/t is necessary.

On the basis of mixture integral parts classification, it can be concluded that by its nature it is classified as non-hazardous waste, on which basis criteria for ash disposal site shall be defined.

<u>Liquid waste material</u>

In facilities of thermal power plant, such as Unit B3, waste waters of different physical and chemical properties are generated. Most of these waters contain pollutants above permitted limits, thus they require appropriate treatment prior to discharge into recipient. Some of these waste waters are continuously produces, while others are produces periodically.

Waste waters of Unit B3 will be produces in following systems/facilities:

- Boiler Plant,
- Mechanical Hall,
- External Heavy Fuel Oil System,
- Chemical Water Treatment facility,
- FGD System,
- Coal Supply System,
- Ash and Slag System,
- Cooling Water System.

Besides the stated waters which are produced in technological process or during preparation and maintenance of main and auxiliary systems of power plant (process waste waters), the following are also present at power plant:

- atmospheric water and
- sewage waste water.

Occurrence of waste water in boiler plant is expected within internal heavy fuel oil system (from condenser expander of heavy fuel oil heating station). These waters are probably polluted by heavy fuel oil. Expected amount of waste water from internal system of heavy fuel oil is ~43 m^3/day.

Occurrence of oil containing water is expected at mechanical hall, at places where it cannot be completely prevented by preventive measures (area around supply pumps, oil cooler etc.). These waters shall be collected in drainage pits in mechanical hall basement and shall be discharged by drainage pumps to connection of all three units joint system. Oil containing atmospheric water from transformer sump will occur at transformer bay which is located near mechanical hall. This water can be drained together with water from mechanical hall. It is possible that this water contains petroleum products, and its expected amount is ~120 m^3/day.

In external heavy fuel oil system of new Unit, waste water will occur in heavy fuel oil tank during rainfall. Due to possible leakage at terminals and valves, this water may contain heavy fuel oil. Water from heavy fuel oil system (internal and external) shall be connected to joint treatment system for all three Units. Expected amount of waste water from external heavy fuel oil system is ~9 m^3/day.

Expected total amount of heavy fuel oil containing and oil containing water is ~220 m^3/day including oil containing atmospheric water. With application of preventive measures, expected content of oil/heavy fuel oil in this water is < 10 mg/l.

Waster water from cooling system. Condenser cooling system and technical cooling of the Unit are of flow type, while cooling water is taken from the Danube River and after cooling process it is returned to the river through terminal chamber, return collectors of cooling water and water discharge into new riverbed of the Mlava River, by which cooling water is returned into the Danube River downstream from water intake.

Return cooling water is of the same quality as raw cooling water, but its temperature is increased. Part of return cooling water can be used, as necessary, for preparation of wet mixture of ash, slag and gypsum slurry.

The following types of waste water are produced *in chemical water treatment facilities*:

- Silted waste water which is generated by cleaning of sump and filter. Silt from the sump is periodically separated and transported to joint plant for treatment of waste water from chemical water treatment system and FGD system. Expected amount of separated silt is 2 m^3 within period of 12 h. Water for filter cleaning is provided for reuse within system for chemical water treatment, i.e. returned to start of previous treatment process. Content of suspended particles in this water is ≈ 2% in silt, while content of particles is significantly lower in water from filter cleaning.
- Water containing acid/alkaline substances/salt, generated from regeneration of ion exchange resin and concentrate from reverse osmosis plant. RO concentrate is generated continuously, in the amount of 17,5 m^3/h (420 m^3/day). Expected maximum daily amount of waste water during regeneration of ion exchange resin of chemical water treatment system is ~80 m^3, while expected maximum amount of waste water in case of external regeneration of resin from Chemical Condensate Treatment system is ~30 m^3. In terms of quality, RO concentrate contains ~ 2.000 mg/l of salt, and pH value is within mild alkali area. pH value of water generated by resin regeneration prior to neutralization varies from 2 to 12, while content of salt is within range 4.000 – 10.000 mg/l. This water can have high concentration of suspended particles.
- Waste water generated by cleaning of ion exchange resin and pre-filter of chemical condensate treatment, is polluted by suspended particles and iron, and its maximum daily amount is ~150 m^3.
- Waste water generated by chemical cleaning of RO diaphragms, which is generated several times a year, is in the amount of ~ 30 m^3 per one cleaning. This water is

acid/alkaline and contains removed deposits from diaphragms and inactivated chemicals. Its discharge is provided by neutralization sump.

- Waste water generated by floor cleaning in facilities and waste water from discharge of chemicals. Discharge of these waters is performed through technological sewage into neutralization sump.

Waste water from FGD system. Removal of sulphur oxides from flue gas is performed in flue gas desulphurization plant (FGD), using limestone slurry as absorbent. During the stated process other gases (HCl, HF), as well as ash particles, which are contained in recirculation slurry are removed.

Gypsum slurry is produced as by-product of FGD process, which besides calcium sulphate (gypsum) as main product, also contains calcium sulphite, inactivated limestone, magnesium carbonate, inert substances from limestone, ash particles and dissolved material generated in chemical reactions of flue gas components and recirculation slurry.

Produced gypsum slurry, with around 15% of solids, is discharged from absorber. Content of around 50% of solids is obtained by preparing thick slurry in hydrocyclones, while overflow of hydrocyclones is discharged into filtered water tank, and separated silt is transported to drying until reaching of around 10% humidity of gypsum or it is permanently disposed. Water separated from drying process is also collected into filtered water tank. Filtered water is returned to absorber reaction sump.

By permanent return of water from gypsum slurry dewatering into system, there is occurrence of concentrated dissolved salts and other substances, which has adverse effect to desulphurization efficiency. Thus, it is necessary to discharge certain amount of water from the system, in order to maintain content of recirculation filtered water (primarily concentration of chloride and particles), at acceptable, designed level.

On the basis of estimated water balance in FGD system for Unit B3, average amount of water which should be removed from the process in case of gypsum drying to 10% of humidity content, is around 13 m^3/h. If gypsum slurry of 50% is discharged to disposal site, sufficient amount of water is discharged with the slurry, thus there is no additional waste water from the process.

Regarding waste water quality, there is increased content of chloride ($\approx$ 8.000 ppm) and particles ($\approx$ 3%$_{tež}$.), which is the reason why such water must not be discharged into natural recipient. Its treatment is provided in accordance with requirements of Regulation of RS regarding GVE into water.

In *wet ESP,* spraying of process water which recirculates in system increases efficiency of removal of smallest particles and dust from flue gas. For the purpose of providing necessary quality of recirculating water (content of suspended particles), it is necessary to permanently discharge certain part of it from the system. Evaluated amount of water which is discharged is 10 m^3/h. In order to maintain pH value, HaOH solution is dosed into recirculating water. Regarding quality, this waste water contains increased amount of suspended substances and dissolved salts.

The following waste waters are generated in *coal supply system*:

- during floor cleaning in transfer buildings and cleaning of conveying bridges, waste water with high content of suspended substances is generated and that water may contain increased concentration of heavy metal. Expected amount of coal containing waste water is ~11 m^3/h.

- waste water from fire extinguishing, which contains products of coal combustion and conveyor belt. Expected amount of this water is ~ 100 m^3. Drainage sump below conveyor is provided for discharge of this water.
- atmospheric water at coal stockyard and coal supply system platform: expected amount of atmospheric water is ~ 330 m^3, based on one hour lasting rain. Collecting of surface water around stockyard is provided by concrete trench which is located along stockyard border, and it is conveyed from the trench to sedimentation sump. Partly cleaned atmospheric water shall be conveyed to coal containing water treatment plant for further cleaning with other coal containing waters.

Waste water from *ash and slag system occurs as overflow of deslagger* and as waste water from air heater cleaning.

Waste water from deslagger overflow contains high level of suspended substances and may contain increased concentration of heavy metal. Expected amount of this waste water is ~70 m^3/h.

Expected amount of waste water generated by air heater cleaning, which may contain high level of suspended substances (ash), in operating mode is ~40 m^3/h, while expected amount of this waste water during overhaul is ~350 m^3/h.

Waste water from *workshops, garages, storage of oil and grease:* Workshops, garages, storage of oil and grease, warehouses of equipment and spare parts are constructed during the First Phase also for the purpose of the Second Phase of Power Plant construction.

Waste water generated in these facilities is generated during floor cleaning and it contains petroleum products, suspended particles and washing powder used for cleaning. Solution of collecting, treatment and discharge of waste water from the stated facilities shall be considered within joint plant for treatment of waste water from all TPP Kostolac B Units.

All other clean waters may be discharged through return duct of cooling water or atmospheric sewage into the Danube River.

Atmospheric waste water is water which occures at surface of Power Plant Site in form of atmospheric precipitation, rain, snow and ice. This water is classified as neutral waste water which, after collecting, may be discharged into natural recipient without any special treatment.

However, atmospheric water from surfaces containing heavy fuel oil or oil, such as heavy fuel oil loading station, oil and grease storage, platforms in front of workshops, may be the subject of continuous or temporary contamination, and it cannot be discharged into sewage network. It must be treated as process waste water, i.e. treatment of this water must be provided.

Sewage waste water from Unit B3 facilities shall be treated at joint plant for entire power plant, and it shall be conveyed to the stated plant by connecting to the existing sewage network.

<u>Other waste</u>

Besides waste which is generated as product of technological process, other types of waste are generated during operating life of power plant, such as:

- waste from regular maintenance and overhaul of power plant,

- municipal waste.

Waste which is generated during regular maintenance and overhaul of power plant, mostly is solid and liquid waste.

The following types of waste are generated as solid waste:
- construction waste, such as wood, debris, waste metal parts,
- packing material waste, which may be plastic, paper, metal – depending on package purpose, it should pay attention whether packing material waste is hazardous or non-hazardous,
- waste tyres,
- waste devices of different purpose (power units, batteries, engines etc.),
- electronic and electrical waste,
- waste neon lamps,
- used chemicals from technological process (active coal, ion exchange resins),
- waste paper and glass,
- municipal waste.

The following types of waste are generated as liquid waste within power plant:
- waste oil,
- waste chemicals,
- different waste waters: oil containing, silt containing and chemicals containing waters.

Rulebook on categories, testing and waste classification (Official Gazette of RS, No. 56/2010), defines Waste Catalogue, which provides list of non-hazardous and hazardous waste which is used for waste classification depending on place of occurrence and origin. Hazardous waste is designated by * sign within the stated Catalogue. Main classification of the waste is performed according to activities which cause the waste, and Table 3.3.5-18 shows the stated activities which are important for the stated waste.

Table 3.3.5-18: Classification of waste according to activities which cause its occurrence

Designation	Type of waste
10	Waste from thermal process
13	Waste from oil and liquid fuel remaining (except edible oil and oil stated in chapters 05, 12 and 19[2])
15	Waste from packing material, absorbents, cleaning cloth, filter material and protective fabrics, if not otherwise specified
16	Waste which is not otherwise specified within Catalogue
17	Construction waste and demolishing waste (including excavated soil from contaminated locations)
19	Waste from waste treatment plants, plants for waste water treatment away from generation site and preparation of water for human consumption and use in industry
20	Municipal waste (household waste and similar commercial and industrial waste), including separate collecting of fractions

[2] *The stated chapters include: 05 – Waste from oil refining, natural gas treatment pyrolytic treatment of coal,12 – Waste from shaping and physical and mechanical surface processing of metal and plastics and 19 – Waste from waste treatment plant, plant for waste water treatment away from generation site and preparation of water for human consumption and use in industry.*

Tables 3.3.5-19 and 3.5-20 show detailed specification of waste.

Table 3.3.5-19: Category and classification of waste generated during maintenance and overhaul of Unit (according to Rulebook from Official Gazette of RS, No. 56/2010)

Designation	Type of waste
10	**Waste from thermal process**
10 01 22*	silts based on water from boiler cleaning, which contain hazardous substances
10 01 23	silts based on water from boiler cleaning, different from those stated within 10 01 22
13	**Waste from oil and liquid fuel remains (**except edible oil and oil stated in chapters **05, 12 and 19)**
13 01*	waste hydraulic oil
13 02*	waste engine oil, oil for gearbox and lubrication
13 03*	waste oil for insulation and heat transmission
13 05*	content of oil / water separator
13 07*	liquid fuel waste
15	**Waste from packing material, absorbents, cleaning cloth, filter material and protective fabrics, if not otherwise specified**
15 01	***packing material (including separately collected packing material in municipal waste)***
15 01 01	paper and cardboard packing material
15 01 02	plastic packing material
15 01 03	wood packing material
15 01 04	metal packing material
15 01 05	composite packing material
15 01 06	mixed packing material
15 01 07	glass packing material
15 01 09	textile packing material
15 01 10*	packing material which contains remains of hazardous substances or which is contaminated by hazardous substances
15 01 11*	metal packing material which contains hazardous solid porous matrix (e.g. asbestos), including empty bottles under pressure
15 02	***absorbents, filter material, cleaning cloth and protective clothes***
15 02 02*	absorbents, filter material (including oil filters which are not otherwise specified), cleaning cloth, protective clothes, which are contaminated by hazardous substances
15 02 03	absorbents, filter material, cleaning cloth and protective clothes different from those specified under 15 02 02
16	**Waste which is not otherwise specified in Catalogue**
16 02	electrical and electronic equipment waste
16 05	gas in bottles under pressure and waste chemicals
16 06	batteries and power units
16 11	waste lining and fireproof material

Designation	Type of waste
17	**Construction waste and waste from demolition (including contaminated waste and excavation from contaminated locations)**
17 01**	concrete, bricks, roof tiles and ceramics
17 02**	wood, glass and plastic
17 04**	metal (including its alloys)
17 05**	soil (including soil excavated at contaminated locations), rock and excavated material
17 09**	other construction and demolition waste
19	**Waste from waste treatment plants, plants for waste water treatment away from generation site and preparation of water for human consumption and use in industry**
19 09	***waste from water preparation for human consumption or use in industry***
19 09 04	used active coal
19 09 05	saturated or used ion exchange resin
20	**Municipal waste (household waste and similar commercial and industrial waste), including separately collected fractions**
20 01	***separately collected fractions (except 15 01)***
20 01 01	paper and cardboard
20 01 02	glass
20 01 21*	fluorescent tubes and other waste containing mercury
20 01 29*	detergents containing hazardous substances
20 01 30	detergents different from those stated in 20 01 29
20 01 33*	batteries and power units included in 16 06 01, 16 06 02 or 16 06 03 and unclassified batteries and power units which contain these batteries
20 01 34	batteries and power units different from those stated in 20 01 33
20 01 35*	waste electrical and electronic equipment different from the equipment stated in 20 01 21 and 20 01 23 which contains hazardous components 20 01 36 waste electrical and electronic equipment different from the equipment stated in 20 01 21, 20 01 23 and 20 01 35
20 03	***other municipal waste***
20 03 01	mixed municipal waste
20 03 03	waste from road cleaning
20 03 06	waste from sewage cleaning
20 03 07	bulk waste
20 03 99	municipal waste which is not otherwise specified

***** hazardous waste
** may be hazardous waste if contains hazardous substances

Table 3.3.5-20 shows summary of waste which is generated at TPP Kostolac B during year 2014.

Table 3.3.5-20: List of waste which is generated at TPP Kostolac B in year 2014 and year 2015

No.	Name according to nomenclature of Rulebook on categories, testing and classification of waste Official Gazette of RS, No. 56/10	Index No.	Unit	Quantity		Note
				2014	2015	
1.	Waste paint and varnish different from those stated in 08 01 11	08 01 12	t			Waste varnish
2.	Waste toner cartridge for printing different from the one stated in 08 03 17	08 03 18	t	0,065	0,084	Waste toner cartridge
3.	Fly ash from coal	10 01 02	t	646.312	1.251,470	Fly ash from coal
4.	Waste wax and grease	12 01 12				Waste grease
5.	Mineral non- chlorinated hydraulic oil	13 01 10	t	41.260	8,380	Hydraulic mineral oil*
6.	Mineral non-chlorinated engine oil. oil for gearboxes and lubrication	13 02 05	t			Engine mineral oil*
7.	Oil filters Other engine oils. oil for gearboxes and lubrication	13 02 08 16 01 07	t			Oil filter
8.	Oil for insulation and heat transmission which is included in PCB transformers and condensers	13 03 01 16 02 09	t	1.340		Transformer oil which contains PCB
9.	Mineral non-chlorinated oil for insulation and heat transmission - transformer	13 03 07	t	56.600		Transformer oil
10.	Other fuels (including mixtures)	13 07 03	t			Fuel mixture
11.	Other emulsion – water oil	13 08 02 19 03 03	t	19.320	1,200	Emulsion of oil water soil sand
12.	Packing material which contains remains of hazardous substances or which is contaminated by hazardous substances - chemicals	15 01 10	t	0,737		Packing material of chemicals
13.	Metal packing material, barrels of oil*	15 01 10	t			Barrels of oil
14.	Absorbents. Filter material (including oil filters which are not otherwise specified). cleaning cloth. protective clothes. which are contaminated by hazardous substances	15 02 02	t			Cotton for cleaning*
15.	Absorbents. filter material. cleaning cloth and protective clothes different from those stated in 15 02 02	15 02 03	t			Air filters
16.	Waste tyres	16 01 03	t			Car tyres
17.	Waste vehicles which do not contain liquid or other hazardous components	160106	t			Waste vehicles
18.	Antifreeze solution different from the one stated in 16 01 14	16 01 15	t			Waste antifreeze solution
19.	Transformers and condensers which contain PCB	16 02 09				Condensers

No.	Name according to nomenclature of Rulebook on categories, testing and classification of waste Official Gazette of RS, No. 56/10	Index number	Unit	Quantity		Note
				2014	2015	
20.	Waste equipment which is different from the equipment stated in 16 02 09 to 16 02 13	16 02 14	t			Waste equipment
21.	Lead batteries	16 06 01	t	12.400		Power unit batteries
22.	Nickel-cadmium batteries	16 06 02	t			Power unit batteries Ni-Cd
23.	Other batteries and power units	16 06 05	t			Other batteries
24.	Glass	17 02 02 20 01 02	t			Glass
25.	Plastics	17 02 03	t			Plastic helmets
26.	Aluminium	17 04 02	t	88.848		Aluminium
27.	Iron and steel	17 04 05	t		2.589,582	Iron up to 5 mm
			t	241.845	133,700	Iron of more than 5 mm
			t	1.920.302		Different thickness
			t	197.000		Impact plates and beams
28.	Soil sand containing oil	17 05 03 15 02 02	t			Soil and sand containing oil
29.	Insulation material different from the material stated in 17 06 01 and 17 06 03	17 06 04	t	758.020		Mineral wool
30.	Plastics and rubber	19 12 04	t	4.040		Rubber belts
31.	fluorescent tubes and other waste containing mercury	20 01 21	t		0,300	Fluorescent tubes which contain mercury
31.	Waste electrical and electronic equipment which is different from the equipment stated in 20 01 21 and 20 01 23, which contains hazardous components	20 01 35	t	25,720	1,540	Electronic and electrical waste
32.	Waste electrical and electronic equipment which is different from the equipment stated in 20 01 21 and 20 01 23, which contains hazardous components	20 01 36	t			Fluorescent tubes

Waste heat

Total amount of waste heat for average annual Unit operation is ≈ 370 MW_t. Waste heat is discharged by cooling water, using flow cooling system. Cooling water balance is provided within previous text of this chapter, Table 3.3.4-2.

Noise, vibration and electromagnetic radiation

Noise emission

Due to specific production process and large size equipment, thermal power plants are considerable sources of noise and vibration. For the purpose of predominant noise source analysis, within referred power plant complex, the following functional units have been separated, which contain sources that have significant contribution to acoustic properties of observed Site:

- Main Plant Facility,
- Related technical facilities,
- Switchgear Plant and Electrical Grids,
- Secondary operation,
- Roads,
- Pipelines for water transportation.

Within Main Plant Facility the most important noise emitters are boiler plant, mechanical hall with turbine and generator, turbines and related equipment, elevator towers, bunker tract, slurry pumping station, ESP plant, chimney and FGD plant. Safety valves for superheated and reheated steam are the strongest source of noise at Boiler Plant, which generate noise up to level of 110 dB with maximum in most unfavourable frequency range i.e. around 1.000 Hz. However, these valves are not in continuous operation, but they are rarely in operation which lasts only few minutes, thus they do not contribute to continuous plant noise emission. In Boiler Plant there are also coal mills, FD fans and ID fans, pumps and other equipment which generate noise in range from 80 to 100 dB. Noise which is generated during combustion is of low frequency, especially at impact and passing of gas and air through pipe system, and although it has no significant environmental impact, it is unfavourable from the point of boiler structure. The greater source of noise in mechanical hall is turbine generator plant with noise level in range 85-105 dB, and in frequency range 20-2.500 Hz; at part of high pressure turbine noise level is highest in the area of high frequency, and at part of low pressure turbine and generator, due to large area, in range of low frequency. Chimney is source of 95-100 dB noise level (only fans generate noise of around 85 dB), and this noise is of low frequency, with maximum of nearly 200 Hz.

Table 3.3.5-21 shows main equipment noise level, according to data from CMEC Technical Specification.

The following possible noise sources within auxiliary plants should be stated: supply pumps, which shall generate noise level of 95-105 dB in high frequency area (1000-5000 Hz), which is the reason why special housings of these pumps are provided, which shall reduce noise level to required level.

Table 3.3.5-21: Main equipment noise level

No.	Noise Source	Value, dB (A)	Mode of operation
1.	Turbine	85	Continuous
2.	ID fans	85	Continuous
3.	Mill fans	90	Continuous
4.	Water pumps	85	Continuous
5.	Boiler safety valves	110	Temporary

Evaluating reference level of external noise for TPP Kostolac B related technical facilities, the following values were obtained:

- raw cooling water pumping station 72 dB(A),
- chemical water treatment plant 68 dB(A),

- liquid fuel system 70 dB(A),
- compressor station 85 dB(A),
- auxiliary boiler room 64 dB(A).

Secondary operation within thermal power complex means construction of maintenance plant, storage, mechanical workshop, garage, head office building, ambulance station, service. It is estimated, considering their purpose and operation, that these facilities will not be the source of significant level of noise.

On the other hand, roads within power plant site may be significant source of noise during operation of road network and industrial railway inside and around the complex. Noise generated by road network which is used for the purpose of power plant, is determined by properties of roads, primarily by traffic load, speed, percentage share of trucks, as well as properties of roads and conditions of sound spreading. Noise generated by industrial railway inside and around Complex, is caused by trains passing along industrial railway, transit through station, entry and exit of trains through station, sound signals for notification and other sources which may occur within discussed activities.

Vibration emission

The same elements which generate noise in thermal power plant, also generate vibration. Generated vibrations are transferred to steel structure and by foundation and soil they have impact to other elements which provide occurrence of vibrations.

Mechanical oscillations which occur during operation of Units, cause fatigue of human body, similar like noise. Since noise and vibrations usually occur together, their mutual impact increases occurrence of occupational diseases.

There is occurrence of vibrations in almost all parts of power plant. The strongest vibrations are from largest parts of equipment in boiler plant and mechanical hall. The highest level of vibrations in boiler plant is cause by mills, then fans, pipelines and boiler itself. Turbine with generator and auxiliary equipment also cause large scope of vibrations in mechanical hall. Besides turbine, sources of vibrations are pumps, reducer station and pipelines, crane and various vessels, especially expanders. Regarding auxiliary facilities outside boiler plant and mechanical hall, the largest scope of vibrations is caused by stacker-reclaimer (excavator) at coal stockyard, cooling tower, Unit transformer etc. However, all the stated vibrations can be significantly reduced by special supports. These supports are flexible and they have installed springs, rubber elements and vibration absorbers. Such foundation supports of certain rotating machines significantly reduce foundation size and vibration transmission. The same applies for supports of pipeline and boiler itself, and for the purpose of supporting structure vibration reduction.

Nevertheless, in terms of adverse impact to environment, vibrations are minor issue since transmission ratio is lower and they are absorbed through the ground. Considering their impact is important for analysis of operating condition impact within power plant site, which is in scope of protection at work analysis. Within analysis of environmental impact, vibration impact is of less importance.

Radiation emission

Radioactivity

Analysis of coal, ash and slag radioactivity of Kostolac coal is shown within overview of the existing state of environment prior to construction of new Unit B3 (Preliminary works for construction of new Unit at TPP Kostolac B Site, Energoprojekt Entel, Belgrade, 2009).

Table 3.3.5-22 shows results of gamma spectrometric measurements of coal, ash and slag samples from TPP Kostolac A and B in year 2008.

Table 3.3.5-22: Results of gamma spectrometric measurements of coal, ash and slag samples from TPP Kostolac A and B

Measuring point	^{226}Ra	^{232}Th	^{40}K	^{238}U	^{235}U	^{137}Cs
Unit A coal	28 ± 3	20 ± 3	97 ±13	37 ± 7	1,6 ± 0,3	< 0,7
Unit A slag	19 ± 2	22 ± 3	153 ± 15	30 ± 12	2,5 ±0,4	< 1,0
Unit A ESP ash	58 ± 6	49 ± 5	231 ± 23	56 ± 17	3,9 ± 0,5	< 0,8
Unit B coal	8 ± 1	14 ± 2	95 ± 9	15 ± 6	1,0 ±0,2	< 0,5
Unit B slag	27 ± 3	32 ± 4	218 ± 26	22 ± 9	1,0 ± 0,3	< 1,0
Unit B ESP ash	47 ± 9	32 ± 5	215 ± 26	68 ± 18	2,0 ± 0,3	< 0,8
Ash/active cassettes	36 ± 4	41 ± 4	193 ± 19	79 ± 17	3,4 ± 0,3	< 0,8
Ash/passive cassettes	59 ± 10	29 ± 5	188 ± 25	51 ±12	1,5 ± 0,3	< 0,9

On the basis of shown Table, it can be seen that natural radio nuclides ^{226}Ra, ^{232}Th, ^{40}K, ^{235}U, ^{238}U are detected in the stated samples, as well as artificially generated radio nuclide ^{137}Cs. Obtained values of their content are usual for this type of coal. Difference in concentration for samples of ash from active and passive cassette, as well as for samples of ESP ash, is not significant, i.e. it varies within error limit.

The lowest values are measured in coal samples (in relation to ash and slag), which is expected. Ratio of activity ^{235}U/^{238}U in all analysed samples corresponds to natural uranium.

Electromagnetic radiation

Electrical and magnetic fields are generated due to presence and movement of charged particles. Regarding thermal power facility, electromagnetic fields are generated during generation, transmission and distribution and use of electric power, thus it can be stated that man is constantly exposed to effect of these fields. Field intensity is inversely proportional to distance from the source.

Fig. 3.2-25 shows diagram of system parts from generation capacity to End User of electric power, while each part of the system is source of electromagnetic field. Within TPP electrical and magnetic fields of highest intensity are generated in vicinity of switchgears which include Unit Transformers and output high voltage transmission lines.

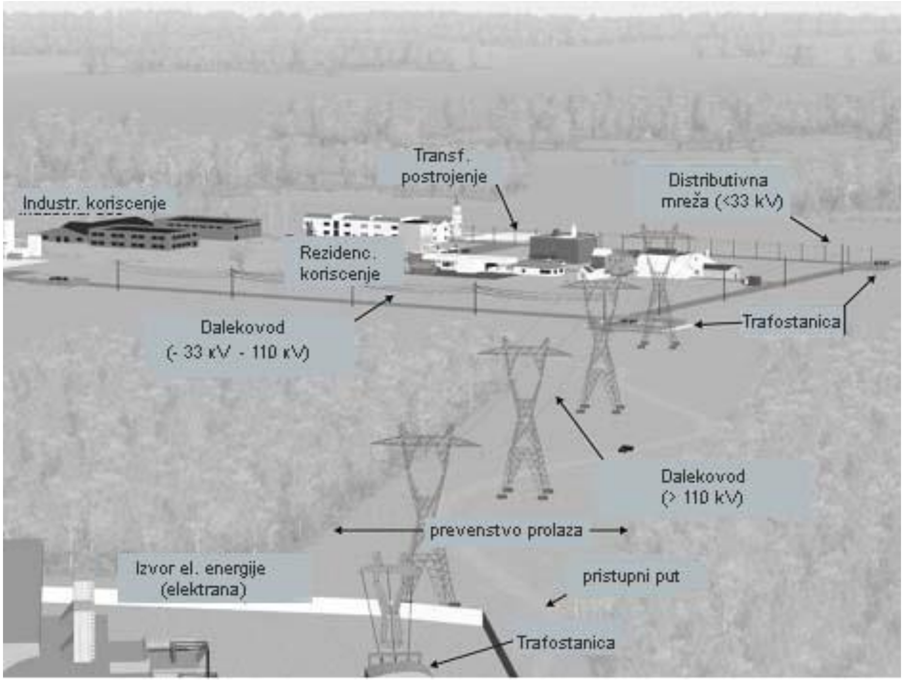


Fig. 3.3.5-9: Diagram of electric power transport from generation capacity to users

Time-variable electrical and magnetic fields which are generated during electric power generation of 50 Hz frequency, can be classified as fields of extreme low frequency and large wavelength (for 50 Hz wavelength is 6.000 km).

Electromagnetic field of low frequency (such as industrial frequency of 50 Hz) is classified as slow variable field and it can be analysed as two uncoupled fields: slow time-variable (quasi static) electrical field and slow time variable (quasi static) magnetic field.

High voltage overhead electric power lines (transmission lines), when under voltage, are source of electrical field which is equal to voltage, and when electric power runs through them, they are source of magnetic field which is equal to electric power. Value which describes electrical field is E, vector of electric power strength (unit V/m). Value which describes magnetic field is vector of magnetic field intensity-H, (unit A/m), although standards and recommendations usually use other value, vector of magnetic induction B (unit T).

Fig. 3.2-26 and 3.2-27 show that electrical and magnetic field intensity depend on distance for different sources, while provided dependence apply for field spreading in the air. In case of obstacle, intensity of electrical field reduces, while intensity of magnetic field remains unchanged.

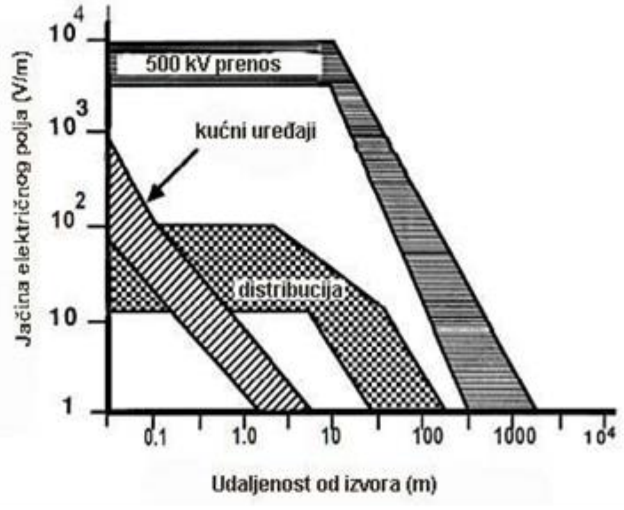


Fig. 3.3.5-10: Electrical field depending on distance for transmission and distribution systems and at consumers

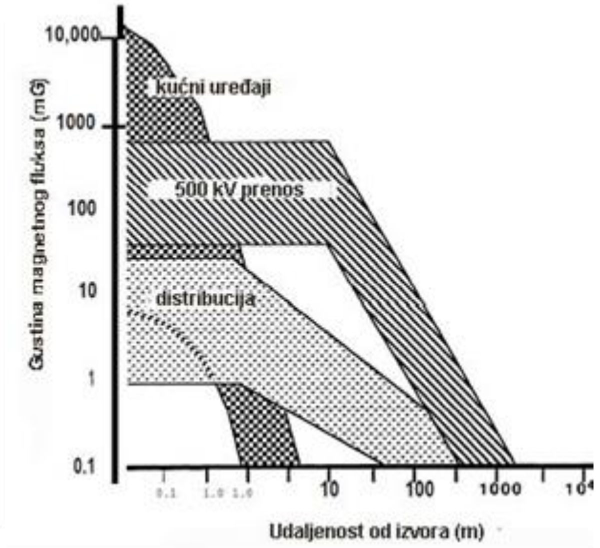


Fig. 3.3.5-11: Magnetic field depending on distance for transmission and distribution systems and at consumers

Measuring of electric field strength and magnetic flux density, is performed at direction below overhead high voltage lines of 400 kV and 110 kV, at height of 1,7 m from the ground with simultaneous measuring of field frequency, while several measurement at each direction were performed with small distance between measuring points. Measurement results are shown in Table 3.3.5-23, which shows maximum measured values of electrical and magnetic field at selected direction below each of the stated overhead lines, as well as height of the lowest conductor ("phase") of the stated overhead line.

Table 3.3.5-23: Measurement results of electrical and magnetic field below overhead lines

No.	Column type	Voltage level, kV	Conductor height, m	Electrical field strength, kV/m	Magnetic field intensity, kV/m
1	barrel	400	14,0	4,003	12,12
2	portal	400	17,2	2,750	3,2
3	portal	400	13,6	4,77	5,64
4	portal	400	14,2	3,72	8,69
5	barrel	110	17,4	0,338	1,23
6	barrel	110	15,2	1,625	2,20
7	portal	110	10,5	0,745	5,43
8	fir	110	8,5	0,923	6,00

3.3.6. Review of system for waste material treatment and emission into environment

A. Review of criteria for defining methods of waste material treatment

Requirements regarding limits of pollutants emission into environment which are also criteria on which basis terms are defined for designing of technical solutions for waste material treatment, are the subject discussed within the following part of the Study.

Limits of emission into the air

Limit values of emission into the air from new combustion plants (such as TPP Kostolac B Unit B3) are defined by Directive EU 2010/75/EC – Industrial Emission Directive (IED), as well as by Decision reached in October 2013, regarding obligations of Serbia according to Contract on joint electric power market of Southeast European countries (D/2Ol3/O6/MC-EnC) regarding implementation of IED. Local regulation transfers the stated EU requirements by Regulation on measurement of pollutant emission into air from stationary sources (Official Gazette of RS, No. 5/16) and Regulation on limit values of pollutant emission into air from combustion plants (Official Gazette of RS, No. 6/16).

According to classification of combustion plants, Unit B3 belongs to large plants which use solid fuel (coal), > 300 MWth power, and the stated Directive and Regulation stipulate the following limit values of emission for such plants:

- for sulphur dioxide 150 mg/m^{3*};
- for nitrogen oxides, such as NO_2 200 mg/m^{3*};
- particles 10 mg/m^{3*}.

* reference terms of flue gas: dry gas at temperature of 0°C (273,15 K), pressure of 101,3 kPa and volume fraction of 6% oxygen.

Compliance with GVE, which is controlled based on results of continuous measurements for calendar year, is defined by Regulation on measurement of pollutant emission into air from stationary sources of pollution (Official Gazette of RS, No. 5/16). According to the stated Regulation, it is considered that GVE values are fulfilled if the following conditions are fulfilled, considering measurement results for operating hours for time period of one calendar year:

- annual average of mean daily values does not exceed limit values of emission,
- 95% of all half hour values does not exceed 120% GVE,
- none of half hour mean value does not exceed 200% GVE.

Emissions into air from other systems within FGD plant, which generate emissions into air, are defined by the above stated Regulation, Annex IV – General limit values of emission, which are the following:

Limit values for total amount of particles:

- 20 mg/m^3 if mass flow is higher than 200 g/h,
- 150 mg/m^3 if mass flow is higher than 200 g/h.

Limit value for inorganic gas substances:

- 30 mg/m^3 for chlorine compounds if mass flow is higher than 150 g/h,
- 3 mg/m^3 for fluorine and its compounds if mass flow is higher than 15 g/h.

Limit of emission into water

According to applicable legislation of the Republic of Serbia, maximum permitted emission of pollutants into water is defined within appropriate Regulation on limit values of pollutant emission into water and time for their reaching (Official Gazette of RS, No. 67/2011 and 1/2016). Annex 2 of the stated Regulation includes, among other stipulations, limit values of emission of certain groups and categories of pollutants for process and other waste water directly discharged into recipient. Within the stated Annex of mentioned Regulation, limit values of pollutant emission from certain types of industrial plants are separately defined, including thermal power plants of more than 50 MW power, where combustion of solid fuel is performed in furnaces with grid or combustion of coal dust, as well as combustion in fluidized bed.

Quality of surface water is defined in requirements stated in Tables from 3.3.6-1 to 3.3.6-4, which show limit values of emission stipulated by the stated Regulation, at point of waste water discharge into surface water, as well as limit values of emission after FGD plant and for thermal power plants which use coal as fuel. The stated Regulation also defines that reaching stipulated limit values of pollutants for waste water cannot be performed by dilution i.e. mixing of polluted and unpolluted waste water (e.g. using cooling water or atmospheric water).

It should also be stated that Regulation provides that competent authority for process and other waste water may determine even more severe limit values of emission than values stated in tables below, all in accordance with Law which is applied for water and environmental protection management.

Table 3.3.6-1: Limit values of emission at point of discharge into surface water

Parameter	Unit	Limit value of emission(I)
Temperature	°C	(II)
pH value		6 - 9
Suspended substances	mg/l	35
Biochemical oxygen consumption (BPK_5)	mgO_2/l	30
Chemical oxygen consumption (HPK)	mgO_2/l	120(III)
Ammonia (as NH_4-N)	mg/l	10
Total inorganic nitrogen (NH_4-N, NO_3-N, NO_2-N)	mg/l	5(IV)
Total phosphorus	mg/l	2
Mineral oil	mg/l	10
Metals		(V)
Organohalides		(V)
Cyanides		(V)
Toxicity		5(VI)

(I) All values refer to mean daily average based on 24 hour composite sample of proportional flow, except where otherwise stated and for pH value, referring to continuous values. The stated levels refer to effluent prior to dissolving using unpolluted stream such as atmospheric water, cooling water etc.

(II) Temperature measured downstream from the point of thermal discharge must not exceed initial temperature for more than 1,5°C for salmonid water and 3°C for cyprinid water.

(III) HPK value may even reach 250 mgO_2/l, but removing efficiency must not be less than 75%.

(IV) Value of total nitrogen may reach value of 25 mgO_2/l, provided that removing efficiency is not less than 80% and it is permitted by sensitivity of water recipient.

(V) Limit values of emission depend on production process, properties of waste water and treatment, as well as on ecological and chemical potential of recipient. For each case, competent authorities shall determine limit values for discharge on the basis of values in tables shown below.
(VI) number of units of toxicity TU = 100/LC50 (hours of test lasting) i.e. TU = 100/EC50 (hours of test lasting), thus higher TU values show higher toxicity level. For tests where mortality of species cannot be easily determined, immobilization is considered equivalent to mortality rate.

Table 3.3.6-2: Limit value of emission for waste water after FGD, prior to mixing with other waste waters

Parameter	Unit	Limit value of emission(I)
Substances removed by filtration	mg/l	30
	g/MWh	1,5
Chemical consumption of oxygen (HPK)	mgO_2/l	100
	g/MWh	4
AOH (absorbing organic halogen)	mg/l	0,04
	g/MWh	0,002
Zinc	mg/l	1
	g/MWh	0,05
Total inorganic nitrogen (NH_4-N, NO_3-N, NO_2-N)	mg/l	10
	g/MWh	0,5
Chrome	mg/l	0,01
Cadmium	mg/l	0,01
Copper	mg/l	0,01
Lead	mg/l	0,1
	g/MWh	0,005
Nickel	mg/l	0,02
Sulphates	mg/l	2000
	g/MWh	110
Sulphites	mg/l	20
	g/MWh	1
Fluorides	mg/l	30
	g/MWh	1,5
Mercury	mg/l	0,001
Sulphides	mg/l	0,2
	g/MWh	0,1

(I) Values refer to 2-hour sample

Table 3.3.6-3: Limit values of emission for waste water of thermal power plants which use coal as fuel, prior to mixing with other waste waters

Parameter	Unit	Limit value of emission(I)
pH value		6-9
Conductivity	µS/cm	6.500
Suspended substances	mg/l	35
Biochemical oxygen consumption (BPK_5)	mgO_2/l	30
Chemical oxygen consumption (HPK)	mgO_2/l	120
Ammonia (as NH_4-N)	mg/l	10
Total inorganic nitrogen (NH_4-N, NO_3-N, NO_2-N)	mg/l	70
Total phosphorus	mg/l	2
Arsenic	mg/l	0,01
Lead	mg/l	0,05
Total chrome	mg/l	0,05
Cadmium	mg/l	0,05
Copper	mg/l	0,05
Nickel	mg/l	0,05
Mercury	mg/l	0,001
Zinc	mg/l	1
Fluorides	mg/l	2
Sulphates	mg/l	2.000
Sulphites	mg/l	20
Sulphides	mg/l	0,2
Chlorides	mg/l	800

(I) Values refer to 2-hour sample

Table 3.3.6-4: Limit values of emission for waste water from cooling systems of thermal power plants

Parameter	Unit	Limit value of emission(I)
Chemical consumption of oxygen (HPK)	mgO_2/l	120
Total phosphorus	mg/l	1,5(II)

(I) Values refer to random (current) sample
(II) If only inorganic phosphorus compounds apply, value of 3 mg/l may be applied

Ground water quality is defined by the following requirements:

- Inlet of pollutants into ground water is forbidden if such activity may cause deterioration i.e. deterioration of the existing chemical status of ground water, which is evaluated based on data obtained by monitoring, in accordance with regulations which refer to water and environmental protection management.
- It is forbidden to perform direct or indirect discharge of pollutants from List I in Table 3.3.6-5 into ground water.
- It is forbidden to perform direct or indirect discharge of pollutants from List II, provided in Table 3.3.6-4 into ground water, until determining basic (zero) level of pollutants in ground water.

Table 3.3.6-5: List of pollutants which must not be discharged into ground water (Official Gazette of RS, No. 50/2012)

Hazardous substances of List I	Hazardous substances of List II
Organic halogen compounds and substances which may form the stated compounds in water environment	metalloids and metals
Organic phosphorus compounds	biocides and their derivatives which are not stated in List I
Organic tin compounds	substance which have adverse effect to taste and/or smell of ground water, as well as compounds which can cause forming of the stated substances in ground water and to make it unsuitable for human consumption
Substances which have cancer, mutagen or teratogen properties and express them through or by water	toxic or stable organic compounds of silicone, as well as substances which can cause forming of the stated compounds in water, except those which are biologically harmless or quickly transform into harmless substances in water
Mercury and its compounds	inorganic compounds of phosphorus and elemental phosphorus
Cadmium and its compounds	fluorides
Mineral oil and hydrocarbons	ammonia and nitrites
Cyanides	

Industrial Waste Treatment

During the TPP operation different types of waste to be generated and treated as industrial waste. This mostly refers to the solid waste resulted from the combustion process (ash and slag), waste created during waste water treatment process as well as the other types of solid waste.

Valid local legislation regulating this topic consists of the following documents:

- Law on waste management (Official Gazette of RS, no. 36/09 and 88/10),
- Rules on categories, testing and classification of waste (Official Gazette of RS, no. 56/10),
- Rules on conditions and the manner of collecting, transportation, storage and treatment of waste used as secondary raw material or for energy (Official Gazette of RS, no. 98/10),
- Regulation on the waste oils management (Official Gazette of RS, no. 60/08),
- Regulation on waste disposal (Official Gazette of RS, no. 92/10).

The Law on waste management regulates handling the waste materials that can be used as secondary raw materials, collecting method, terms of processing and storing, as well as treating the waste materials with no utility value and cannot be used as a secondary raw material.
The following terms referring to waste management are abstracted:

- Waste is to be treated in the manner that ensures the protection of the environment from their adverse effects,
- Incineration of certain types of waste is to be carried out according to previously obtained approval issued by the Ministry responsible for environmental protection,

- Together with the request for issuing the approval for the incineration of waste, a Study Report with the analysis of the impact of the incineration object, i.e. unit to the environment, must be enclosed,
- The approval for the incineration of waste must provide the measures to be taken for environmental protection,
- Secondary raw materials are to be disposed on the dump in the manner prescribed for certain types of waste.

According to the Rules on categories, testing and classification of waste (Official Gazette of RS, no. 56/10), by-products from the gypsum-based FGD process, as well as ash and slag, are classified as hazardous waste, as specified in the section 3.3.5 of this Study.

Regulation on Waste Disposal defines the technical and technological conditions for designing, construction and commissioning of the landfill, including the requirements for landfill bottom and sides impermeability, management of the filter waters and control of the landfill stability. More precisely, keeping in mind that a joint landfill foe ash, slag and gypsum (classified as non-hazardous waste) will be constructed for the needs of the TPP Kostolac B new Unit, compliance with the requirements provided in the mentioned Regulation means complying with the following conditions:

1) Conditions in terms of the landfill bottom – landfill bottom and sides must consist of the natural geological barrier meeting the terms of permeance and thickness with combined impact on the protection of the ground and underground and surface waters, equal to the impact of the protective layer with filtration coefficient $k \leq 1{,}0 \times 10^{-9}$ m/s, when the layer thickness is ≥1 m;
2) Conditions in terms of filter water – when the natural geological barrier does not meet the defined values, it is secured by coating the landfill bottom with synthetic materials or natural mineral buffer which must be consolidated so that the equivalent value of bottom is reached in terms of its water tight features.

   The natural mineral buffer must not be shorter than 0,5m.

   It is necessary to also provide the landfill bottom protection in order to prevent the migration of filter water in the landfill sub-layer in the following manner:

   - artificial protective coat – foil and
   - drainage layer ≥ 0,5 m thick.

   On non-hazardous waste landfill it is necessary to provide the separate system for collecting and directing the filter water through the drainage layer where the drainage pipes are laid for its directing to the system designed for its treatment.
3) Conditions in terms of surface, underground and atmospheric waters – The landfill must meet the technical conditions providing the surface, underground and atmospheric waters from the surrounding surfaces of from the areas outside the landfill which have no contact with the landfill body.

   It is necessary to install the adequate collection manhole for temporary withholding the filter water gathered from the landfill body.

   The filter water from the landfill, technological waste waters and atmospheric waters are separately collected and directed to the waste waters treatment unit or to the relevant designed recipient.

Noise level limit

The allowed level of equivalent noise in the work area for the distance of 1m from the device/equipment is 85dB(A) for the exposure of 8 hours per day. Maximum noise level for a short-term exposure (not over 7,5min during the day) is 115 dB(A).

B. Treatment of waste gas materials

Based on the presented characteristics of waste gas materials created during the Unit B3 operation, the following measures are provided for the reduction of the emission of polluting matters into air:

- reduction of the polluting matters emission via flue gasses,
- reduction of dust matters emission from the scattered matters transport and storage system (limestone and coal),
- reduction of dust matters emission from the solid matters transport and storage system (ash, slag and gypsum).

Measures for waste gas materials treatment designed within the general design for the TPP Kostolac B Unit B3 are in compliance with the requirements of the described relevant regulation and are shown in further text.

Measures for NO_x emission reduction

NO_x emission reduction to 200 mg/m^3 (for dry gas, 0°C, 6% O_2) will be accomplished by applying the following measures:

- by installing the low NO_x emission burner (low-NO_x burner),
- by introducing the additional combustion air in the zone above the coal dust burner in two levels (OFA procedure).

In case the primary measures do not accomplish the satisfactory level of NO_x emission reduction, applying the secondary measure for emission reduction by selective catalytic reduction with ammonia compound-based reagent, is provided.

The technology is based on an interaction of nitric oxide with the products of the thermal decomposition of ammonia at a temperature of 300-400°C in the presence of a catalyst. Multiple substances can be used as a catalyst, and the best results are achieved by using the following elements: titanium, vanadium, molybdenum or tungsten.

Since NO is a dominant component of NO_x the main reduction reaction is:

$$4NH_3 + 4NO + O_2 = 4N_2 + 6H_2O$$

Reaction between NO_2 and ammonia also produces nitrogen and water:

$$4NH_3 + 2NO_2 + O_2 = 3N_2 + 6H_2O$$

Urea can be used instead of ammonia, which makes more acceptable agent, from the environmental standpoint. NO urea reduction reaction is expressed by the following equation:

$$2CO(NH_2)_2 + 4NO + O_2 = 4N_2 + 2CO_2 + 4H_2O$$

Selective catalytic reduction can result in removing up to 90% of NOx. Using pure ammonia or ammonia hydroxide is related to the necessity of meeting the strict demands in terms of safety measures against fire and explosion, which requires additional area for this plant, as well as security zones, special permits for ammonia transportation and highly qualified personnel for servicing the system.

The basic elements of the proposed $DeNO_x$ system are:

- ammonia/ammonium hydroxide warehouse and its delivery,
- ammonia/ammonium hydroxide injection and mixer (mixing ammonia and air),
- $DeNO_x$ reactor with soot blowers and the router,
- catalyst.

The ammonia is transported in the liquid state by auto-tanker and reloaded in the storage tank. There is an area provided for placement of the ammonia tank on the site on the right side of the boiler room next to HPV. After the evaporation it is transported via pipeline into the vessel (mixer) where it is mixed with air. After that it get injected into $DeNO_x$ reactors (2 pcs) which are placed in the flue gas channels.

If needed, SR would be installed in the flue gas channels according to the gas flow behind the economizer and before the air heaters.

Measures for SO_2 emission reduction

Display of the FGD plant design parameters

Considering the valid legislation for the limitation of emissions into the air from large combustion plants, and based on the expected levels of SO_2 concentration in flue gasses from the new Unit B3 boiler, during the Unit construction it is necessary to provide the measures for SO_2 reduction. Providing the required reduction of the emissions of sulphur dioxide will be achieved by constructing the flue gas desulphurization plant. The proposed flue gas desulphurization procedure is wet limestone gypsum process, using the limestone as an absorber and gypsum as the end-product.

Technological solution and the flue gas desulphurization plant concept for the new Unit B3 have been selected based on the needed efficiency of SO_2 emission reduction in accordance with the adopted criteria defining that the output emission must be comply with the EU Directive requirements (Directive 2010/75/EC -Directive on Industrial Emissions) in terms emission limit values (ELVs) for new plants.

The wet limestone gypsum process was selected and the design parameters for the FGD plant dimensioning were determined based on the following:

He was elected wet limestone / gypsum process and design parameters for sizing facilities for EDC are determined on the basis of:

- technical and technological characteristics of the Unit B3,
- characteristics of coal to be used for the Unit B3 and the flue gases at the FGD Plant input,
- requirements of the mentioned EU Directive, defining the 150mg/m^3 to be the adopted ELV for this project.

FGD Plant was designed for the combustion for the lower quality coal, Table 3.3.2-1, for the boiler operating at maximum permanent steam production (BMCR). For this scenario of Unit operation, the input parameters for designing the FGD Plant are provided in the Table 3.3.3-6. Besides the flue gas characteristics, the data on the input raw materials (limestone and water) quality are also used, as well as the required quality of by-products (commercial gypsum).

Table 3.3.6-6: Unit B3 design parameters for ODG Plant

Parameter	Unit	Value
Coal characteristics		
Coal calorific value	kJ/kg	7.200
Total sulphur content	%	1,13
Unit B3 parameters		
Fresh steam production	t/h	1.032
Coal consumption	t/h	438.2
Flue gas characteristics at FGD Plant input		
Flue gas temperature behind ESP	°C	178
Flue gas flow (real)	m^3/h	2.705.641
Flue gas flow (dry, 0°C, 1013 mbar)	Nm^3/h	1.284.391
Flue gas moisture content	%	23,0
Particles concentration in flue gas (dry, 0°C, 6% O_2)	mg/m^3	30
SO_2 concentration in flue gas (dry, 0°C, 6% O_2)	mg/m^3	6.760
HCl concentration in flue gas (dry, 0°C, 6% O_2)	mg/m^3	18-55 (35)

In order to consider the market potential requirements and the marketing possibility of FGD gypsum for the needs of gypsum products manufacturers (plasterboards, etc.), the obtained gypsum must comply with the certain level of quality. Typical FGD gypsum quality required in Europe is provided in the Table 3.3.6-7.

Table 3.3.6-7: Required quality for EURO-gypsum

Parameter	Unit	Value
Moisture, H_2O	% of weight	< 10
Calcium sulphate dehydrate, $CaSO_4$ x $2H_2O$	% of weight	> 95
Calcium sulphite hemihydrate, $CaSO_4$ x ½H_2O	% of weight	< 0,50
Magnesium salts, water-soluble, MgO	% of weight	< 0,10
Sodium salt, the water-soluble, Na_2O	% of weight	< 0,06
Chlorides, Cl	% of weight.	< 0,01
pH		5 – 9
Colour		white
Smell		neutral
Toxicity		non-toxic

Scheme of the FGD Plant technical solution

Basic FGD Plant systems are shown in the block diagram on the figure 3.3.6-1.

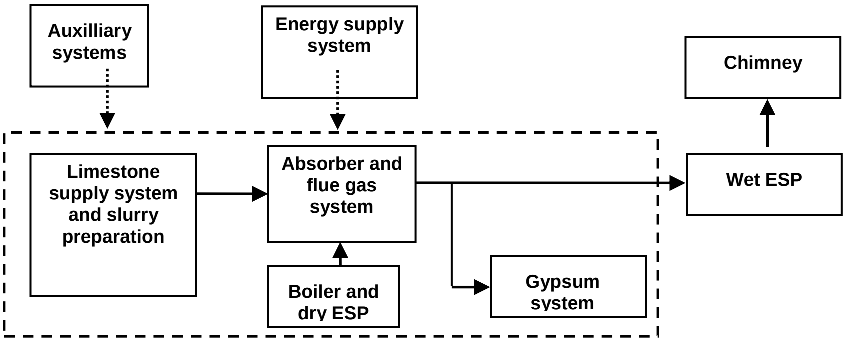


Fig. 3.3.6-1: FGD Plant scheme

Limestone supply and slurry preparation system is used for receiving and storing the limestone as well as the preparation of 30% limestone slurry and its transport to the absorber where it is used as the active substance for removing the SO_2 from the flue gas. Possible variations of the technical solutions for the mentioned system are: preparation of powdered limestone at TPP or at the coal mine, as well as the slurry preparation facility.

Absorber system includes the absorber with the pumps for recirculation of the reaction suspension and the absorber auxiliary systems (tank for the right-side absorber emptying with accompanying pump, drainage system, air supply system) while the flue gas system comprises of the flue gas channels to the absorber and from the absorber to the wat ESP and chimney, input and output stopples and the chimney.

Modern technical solutions for this part of the plant offer different variants for the following parts of the system:

- absorber technical solution,
- technical solution for flue gas emission in the environment after the desulphurization, which includes optional technical solutions for the chimney, as well as the necessity for pre-reheating of the flue gas by adding a regenerative air heater.

Gypsum system. The desulphurization process product is gypsum slurry. Ca-sulphite and Ca-sulphate oxidation reaction and gypsum molecules crystallization occur in the tank (reaction pool) located in the bottom part of the absorber. By constant measuring of slurry density ≈15% m/m of concentration of produced gypsum is maintained ($CaSO_4 x 2H_2O$), supplied from the reaction pool using the slurry draining pump and it is transported to the hydrocyclone where it get thickened up to 50% m/m. Concentrated slurry is then transported to the gypsum slurry tank. Hydrocyclone overflow (with approx.3% of solid) is then returned to the filtrate tank and from there to the absorber.

Concentrated suspension may be further treated to obtain dry gypsum, with about 10% of moisture, which is suitable for placement on the market, or to be transported to the mixer, where it is mixed with ash and slag and transported to landfill for final disposal.

Gypsum landfill. Final disposal of gypsum slurry is provided in the cast mine Drmno excavated area, as the wet mixture with ash and slag from the Unit B3. The disposal is carried out mechanically disposing the mixture via disposal conveyor belt on caterpillar tracks with unloading cart. After the disposal of wet mixture of ash, slag and gypsum into the 2,5m height cassette, depredation and planning of material with the bulldozer is done. The detailed description of waste mixture transportation and disposal technology is provided in the section 3.3.4 of this Study.

Landfill design is in all terms pursuant to the Regulation on Waste Disposal (Official Gazette of RS no. 92/2010). Air and water protection measures are indicated in the sections 3.3.4 and 8.2 of this Study.

Electric power supply system provides the necessary power supply of the consumers within the FGD Plant. Supply mode is created so that it provides the necessary reliability of the plant power supply, which will, among other, meet the requirements in terms of the 98% plant availability.

Auxiliary systems include the process water supply system, drainage systems, mobile fire protection systems as well as the atmospheric and sanitary sewage within the Plant..

Considering the defined terms and the available area on the Unit B3 location, the solution for the FGD Plant for the Unit B3 with the power of 350 MW was defined and contains the following characteristics:

- for flue gas from the Unit B3 purification one absorber is provided,
- absorber type is tower absorber, countercurrent,
- treated flue gas emissions will be carried out via wet self-standing chimney,
- clean water supply is provided from the river Danube by construction of the new raw water pumping station,
- limestone supply to TPP will be done by rail. Within the TPP a roofed limestone warehouse is planned. Potential limestone suppliers are mine Kovilovača or Jelen Do, preparation of the limestone slurry will be done by wet ball mills in mills facility with two wet ball mills (on in operation and one on stand-by),
- disposal of gypsum slurry is foreseen in the area of the open cast mine Drmno, on the gypsum, ash and slag joint landfill.

Technological scheme of the plant is shown in Annex No. 16.

The layout of objects within the FGD system is shown in the layout scheme of the objects, Annex 3.

Unit B3 FGD Plan is located below the GPO behind the dry ESP and flue gas fan, where the absorber is located. Flue gases are carried from the absorber to the wet ESP and then into the wet chimney.

Next to the absorber, the REC pumps and oxidation air compressors object is located, as well as the pumping station for de-slagging the absorber, while the absorber emergency drainage tank with the pumping station will be located near the new Unit chimney.

Limestone wet grinding facility with day-silos and the warehouse with the station for unloading the limestone from the train wagons will be located in the southern part of the lot.

Building for the vacuum filter for gypsum drying with gypsum warehouse will be constructed in the area of the Main (process) building of FGD Plant of the Unit B3 and will be located on the part of the lot where the FGD Plant for the Units B1 and B2 is located, across the same building for these two Units.

Dislocation od the Unit B3 gypsum system in relevance with the absorber location was done for the purpose of merging this system with the same plants for the Units B1 and B2, in order to facilitate the dispatch of the total produced gypsum (for all three Units), either to the landfill or to the external users.

Pipelines for the connection of the absorber and Plants for limestone and gypsum will be placed on the pipe bridge that will be constructed for the same needs of the Units B1 and B2, with the route parallel to the coal storage, to the location of the FGD Plant for the Units B1 and B2, where one arm is separated towards the absorbers for the Units B1 and B2 and the other goes to the mentioned objects for the gypsum system for the Units B1, B2 and B3. Dimensioning and construction of the pipe bridge is a part of the project for Units B1 and b2 FGD.

Display of the SO_2 emission reduction technology

The applied technology is based on the absorption of sulphur dioxide from the flue gas by the active substance, in this case the limestone slurry in the process of passing the flue gas through the slurry flow. The basic reactions occur in the absorber, which is the most important component of the plant. Absorber type is countercurrent. This implies that the flue gas enters the absorber at the lower end of the column for gas flushing. After it enters the absorber, the gas moves upward and passes through the process slurry flow which is continuously brought into the absorber by slurry spraying system, consisting of several levels of sprayer with nozzles (5 level at a distance of approx.2.1m are provided). Each level s linked to a recirculation pump and a pipe that carries the slurry to the spraying zone. The construction and arrangement of the nozzles are such that provide even dispersion throughout the cross-section of the absorber, thus creating the optimal contact of gas and liquid. The required quantity of slurry that is recirculated is determined based on the design values of the gas and liquid phase ration (L/G) and the amount of flue gas entering the absorber.

Process slurry is recirculated from the reaction basin making the bottom part of the absorber. Basic components of the slurry are Ca-sulphate, Ca-sulphite, particles of reagent (limestone), the fly ash particles and the dissolved substances from the process water and the flue gas, in a concentration of about 15%. The fresh reagent is added to the reaction basin, in a quantity which ensures the maintenance of the pH value on the designed level.

Dimensioning of the reaction basin is done so that it provides sufficient time for the realisation of all necessary chemical reactions. Also the additional oxidation of Ca-sulphite to sulphate (CaSO4), which is later crystallized in gypsum plaster (CaSO4 x 2H2O) is done in this basin. The oxidation is realized by blowing the air in, providing a 99% transition of sulphite to sulphate. The amount of air that is required for the formation of gypsum crystals in the absorber tank is provided by the blowers.

In order to maintain the required slurry state and prevent sedimentation of solid particles in the absorber tank, 4 mixer were installed arranged in two levels around the tank brim.

Removing the droplets from flue gas is performed in the drop eliminator. Droplets separation is done in two stages (coarse and fine). Besides the drop eliminator, this system also includes the flushing system together with the pipes, valves and nozzles. For optimal functioning of the droplets separation process it is necessary to provide the required frequency and parameters for device flushing. Flushing is done with water from the process water tank via pumps provided for this purpose. Waste flushing water is used in the process.

The required SO_2 removal process efficiency is achieved by the following:

- determining the required value of the recirculation slurry flow, i.e. the value of the liquid and gas phase (L/G) ratio, as well as the number of slurry spraying levels, the designed value of L/G is ≈23 l/m^3, and the number of spraying working levels is 5;
- proper selection of the characteristics, positioning and number of nozzles used for limestone slurry spraying and the required number and the size of slurry droplets; estimated number of nozzles per one level is 176;
- selecting the appropriate speed of the flue gas through the absorber, as well as uniform distribution of speed over the cross section of the absorber; gas speed through the absorber for the design parameters is about 3,8 m/s;
- controlling the pH value for the recirculation slurry: optimal value is in the range 5-6);
- providing sufficient retention time of the solids in the absorber tank: volume of the tank is ≈2.850 m^3, so that the residence time of the solid phase in the reaction basin is ≈3,6 min.

In case of a significant variation of the input SO_2 concentrations, the process efficiency can be improved by adding the chemical reactions catalyst (e.g. organic acid).

The absorber cross section is shown on the Figure 3.3.6-2. Basic dimensions of the absorber are: height 40,9 m, tower diameter 14,2 m, reaction basin diameter 17 m.

During the process of removing the sulphur from the flue gas, besides the sulphur dioxide, the reaction suspension reacts with other pollutants from the flue gas as well, such are the ash particles, flushed by the liquid phase flow, and the compounds of chlorine and fluorine atoms which in the reaction with limestone create easily soluble salts. As the main product of the process the calcium sulphite is created, and after the further oxidation in the absorber tank, it turns into sulphate gypsum. As a heavily soluble compound in water, it sediments on the absorber tank bottom, and is removed via slurry drainage process. Quantity of gypsum slurry being removed is defined based on the control of the process physical and chemical parameters. Quality of the recirculated water, in terms of maintaining the content of harmful substances (primarily chloride and particulate impurities) is held constant by continuous slurry drainage of one part of the filtrate, which is the waste water.

In terms of the requirements for the desulfurization degree, based on the characteristics of the untreated flue gas and the adopted ELVs being 150 mg/m³, it is necessary for the desulphurization degree to be 97,8%. It is estimated that the efficiency of the removal of HCl and HF is about 90%, while the reduction of particulate matter emission is min. 50%. However, the purified gas contains droplets of recirculated slurry, remained after the drops eliminator.

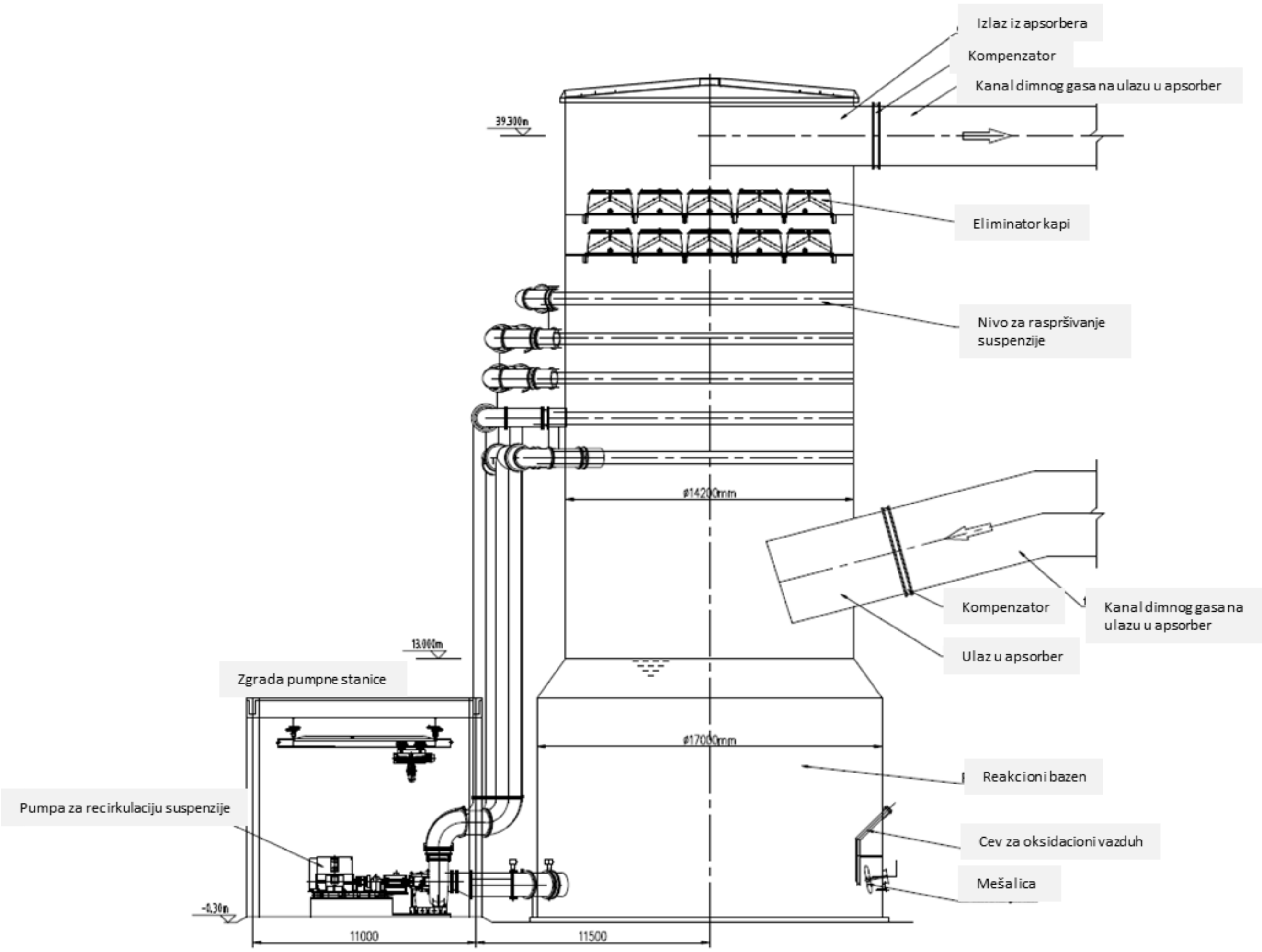


Figure 3.3.6-2: Absorber cross section

FGD process uses a significant quantity of water brought in the process via limestone slurry as the water for flushing the drops eliminator, for flushing the limestone in the drying process and in small amount as sealing water. Most of the water in this process comes out as water steam in the in the saturated flue gas outlet. The amount of water evaporated in this manner and emitted in the environment depends on the quality of coal, the moisture content and temperature of the flue gas entering the absorber. The loss of water is compensated by fresh water brought into the absorber by drops eliminator flushing, as well as fresh limestone slurry. Filtered water from the primary and secondary gypsum slurry drainage, drainage process water and the water used for gypsum flushing is also recirculated into the absorber.

Limestone handling system

This system serves for the reception and storage of limestone. For the purposes of FGD Plant for the Unit B3 with the power of 350 MW, granular limestorne sized 19mm will be used. Limestone supply to the Power Plant will be done by rail, in which case the limestone will be transported in wagons with side discharge.

Limestone consumption at design conditions is 16 t/h (384 t/day i.e. 120.000 t/year, considering the average time for Unit B3 operation at full power of 7.500 h/year).

Limestone system consists of:

- granular limestone unloading station from the railway wagons,
- limestone transportation system from the unloading station to the roofed warehouse with the retarder on the moveable rails.

Taking over the limestone from the warehouse and the transportation to the grinding plant will be done by the movable equipment (wheel loaders).

Limestone unloading station will be located on a separate unloading track and will consist of the underground unloading bunkers for receiving the material from the wagon and the object on the ground above the unloading position. Unloading bunkers will be emptied by two strip feeders installed above the bunkers on the conveyor with the ribbed belt, used to draw the material above the ground level to the tripper building. At this location the material is poured in the longitudinal storage conveyor with the movable retarder with the arrow used to deposit all the material together below the eaves. .

Capacity of the wagons discharge and the system for charging the warehouse is 360 m^3/h, which makes the effective unloading capacity. However, the actual unloading capacity will be smaller since it involves the extended time for emptying the compositions due to the time required for handling the wagons and other unloading activities. Wagons unloading station will be equipped with the wagons defrosting system.

An object under the eaves is provided for storing the limestone and it is designed for the operation of all three Units of TPP Kostolac B. The existing warehouse intended for the Units B1 and B2 will be extended so that the overall dimensions for storage will be: length 90m, width 25m, and height 10m, which provides a storage capacity of 8,700t of limestone, which is enough for seven (7) days of FGD plant operation with the maximum consumption of limestone for all three Units.

Limestone grinding system

Grinding system must ensure the continuous operation of the absorber, where the fineness of grinding and the quantity of grinded limestone can be adjusted depending on the system requirements.

Technical data for the grinding system are as follows:

- limestone granulation supplied into the mills is 0-20mm, with the humidity 5%;
- limestone particles output fineness is P80 < 32μ (P90 < 44 μ),
- grinding process and the process of limestone slurry formation is uses fresh process water from the process water tank,
- mill capacity is 16,1 t/h; two mills are provided, one in operation and one on stand-by.

The loaders taking the limestone from the pile pour the limestone in the receiving hopper in the grinding object under which the vibration feeder is located used for dozing the material in the elevator installed next to the mill facility bunker.

Limestone unloading location will be equipped with the local dedusting system with bag filter with the suction fan. The collected dust is gravitationally inserted into the elevator that lifts the material in the limestone bunker. Scheme display of the dedusting system is shown on the Figure 3.3.6-3.

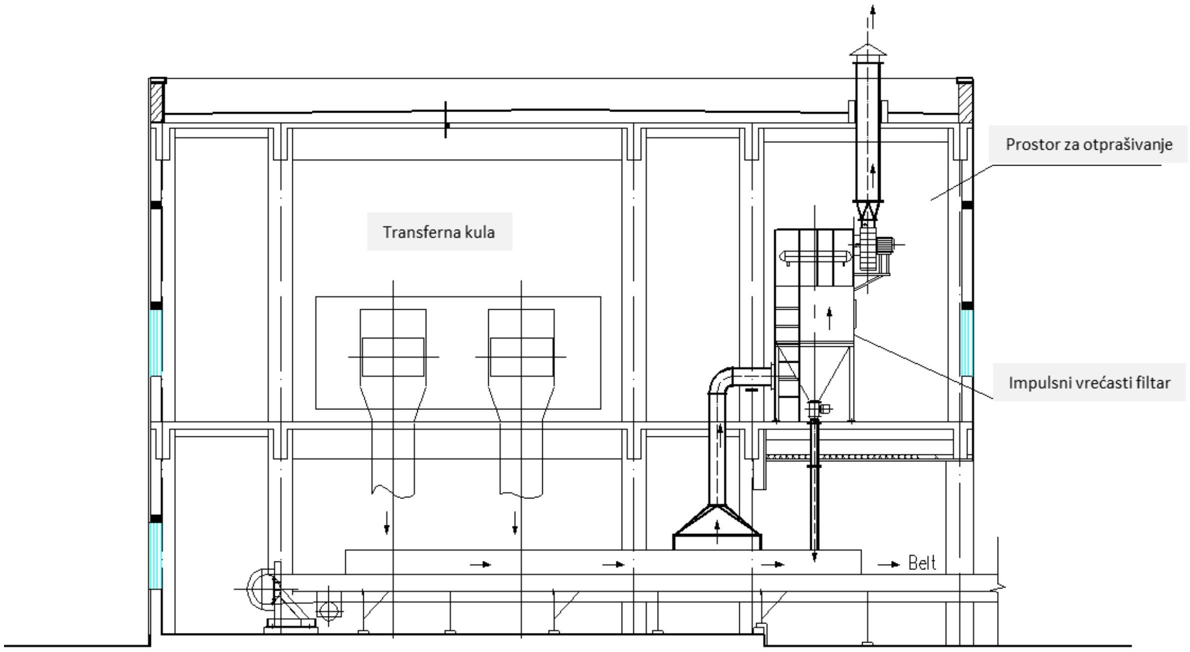


Figure 3.3.6-3: Scheme of the dedusting system in the limestone supply system

The bunker has a pyramidal shape and is made of concrete, with the volume of 1.100 m^3 (useful ≈850 m^3) which provides a three-day reserve for limestone consumption. A bag dedusted with a suction fan will be installed at the top of the bunker.

Principal technological scheme of limestone grinding is shown in Figure 3.3.6-4.

The limestone is extracted from the bunker via belt feeder and brought into the mills input hopper and into the mills drum feeder. also, water is supplied in the input hopper needed for the wet grinding via process water pipeline, together with the blow-down sand from the hydrocyclone from the hydrocyclone battery. Hydrocyclone sand represents a circular charge in the grinding process.

Ball mill is filled with steel balls taking 30-40% of the mill's cylindrical part volume, depending on the necessary grinding capacity. Grinding will be done in the dense area with 60-65% of a solid phase content.

Mill output represents the overflow which is discharged via output sleeve and the drum sieve-tormel into the receiving case of the hydrocyclone centrifugal slurry pump which transports the diluted limestone slurry via DN 200 pipeline to the hydrocyclone battery. Hydrocyclones classify the grinded limestone into two following products:

- hydrocyclone overflow of size class 80% - 35 μm, with 30% participation of solid phase in the slurry being a finished product of the grinding and classification process, and is gravitationally transported from the cylindrical vessel into the slurry tank, and

- sand hydrocyclone, i.e. bigger product that represents the circular charge for grinding and which is poured into the mill's input hopper from the batch.

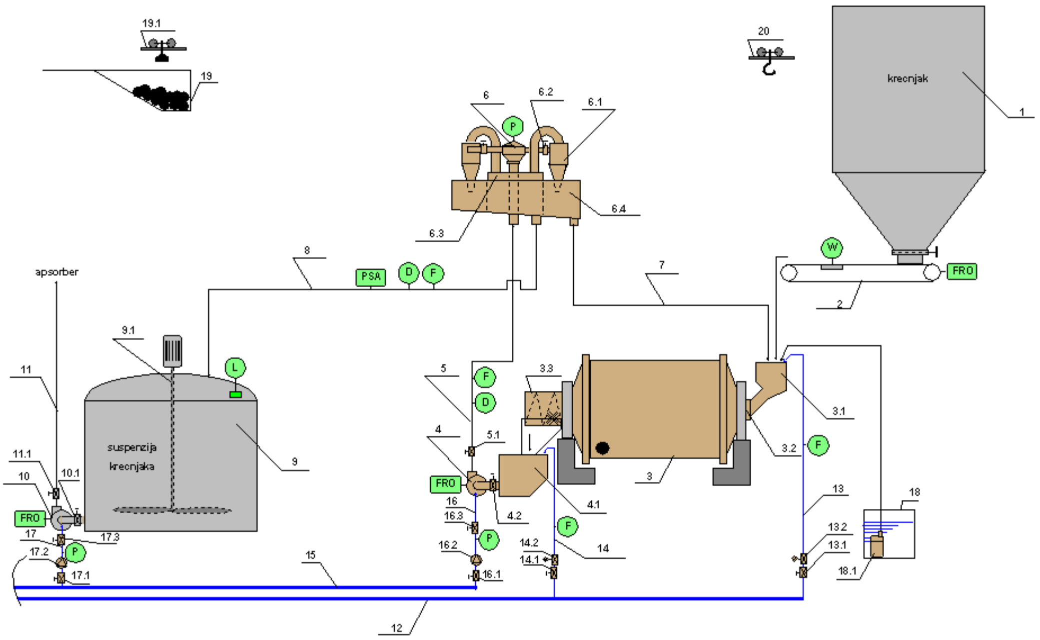


Figure 3.3.6-4: Principal technological scheme of limestone grinding

The limestone slurry is transported from the tank via centrifugal slurry pump and the pipeline to the accumulation tank with the value of 200 m^3, located near the absorber, next to the chimney. Operational pump is equipped with the rotation number frequency regulator.

Water supply of the limestone slurry preparation facility is done from the process water tank.

Gypsum slurry treatment and gypsum production system

In the bottom part of the absorber by constant measuring of the slurry density the gypsum concentration of 12-16% (weighted) is maintained. From the absorber, the gypsum slurry is via slurry transport pump is brought to the hydrocyclone battery where the primary gypsum slurry concentration is done: hydrocyclone overflow is gravitationally brought into the return water (filtrate) tank. One part of the filtrate is via hydrocyclone supply tank for the waste water separated from the system as waste water.

Primary hydrocyclone sand with approx.50% of gypsum (weighted) is gravitationally directed either to the concentrated gypsum slurry tank or to the vacuum filter. Dry gypsum production (with 10% of moisture) is ≈24 t/h, during the Unit's rated operation (Table 3.3.6-9).

All the equipment for gypsum slurry treatment will be placed in the gypsum drying facility.

Slurry is directed to the concentrated slurry tank in order to be transported towards the ash and slag silos object, where it is mixed with the ash and slag and via thick slurry system delivered to the dump.

Gypsum slurry tank is sized to the capacity able to receive the quantity of slurry required for the twelve hours plant operation (for design conditions of plant operation), being 600 m^3.

In case that for any reason the gypsum slurry cannot be delivered to the dump or in case there is an entity buying the gypsum, the concentrated slurry is gravitationally directed to the vacuum belt filter, used for the additional thickening and possible flushing the gypsum, in order to receive the required quality for further placement of the commercial market. Vacuum belt filter capacity is 41 t/h of dry gypsum.

At the end of the filtration process, powdered gypsum with approximately 10% of moisture is received on the reversible belt conveyor directed towards the conveyor with plough removers used to unload the gypsum into the closed gypsum warehouse (belt vacuum filter is installed above the warehouse).

For the needs of the external consumers, the gypsum will the transported from the warehouse by trucks. The warehouse capacity is provided for one day production of the gypsum during the combustion of the designed coal and is about 650 m^3.

In order to maintain the quantity of the unwanted particles in the slurry recirculating in the absorber (chloride concentration and impurities content) below the highest designed value, it is necessary to discharge (purge) a certain amount of water as waste water.

It is estimated that the average quantity of water to be removed is about 13 m^3/h in case of the gypsum slurry treatment to the dry gypsum production (with 10% of moisture). Further treatment of these water is provided in the waste water treatment plant for all three Units. Approximate content of these water is provided in the Table 3.3.6-8.

In case the gypsum slurry is delivered directly to the disposal area, it is not necessary to additionally separate waste water from the system, since the sufficient amount of water from in the process is drained together with the gypsum suspension.

Table 3.3.6-8: Estimated content of waste waters from the FGD Plant

Component	Unit	Value
Quantity	t/h	13
Flow	m^3/h	12,5
Particles content, total	%	3
Gypsum content	kg/h	337
$CaCO_3$ content	kg/h	12,6
Ash content	kg/h	5,15
Heavy metal content	kg/h	-
Inert matter content	kg/h	23,16
Diluted particles content	kg/h	581
Chloride content	ppm	8.000
pH value		5 - 6
Temperature	^oC	67

Water supply system

Within the FGD Plan both process and clean (purged) water is used.

Process water in FGD Plant is used for the following purposes:

- flushing the drops eliminator in the absorber,
- forming the limestone slurry,
- regulation of the liquid level in the process tank,
- flushing the process equipment and the pipeline,

Purged water is used for the following:

- saturation of oxidation air
- cooling the lubrication system and gear reducer,
- pumps sealing,
- flushing the chloride from the gypsum in the vacuum filter.

It is provided for the FGD system to be supplied with water from the river Danube via special pumps located in the new raw water pumping station for the Unit B3.

Process water will be transported to the process water tank where it will delivered via adequate pumps to all the consumers within the FGD system, wet ESP system and ash, slag and gypsum transportation system.

Process water tank is sized so it provides the amount of water sufficient for two hours of shut down T_r, under the maximum operating conditions. maximum flow towards the system is Q = 150 m^3/h. Necessary useful volume of the tank is 300 m^3.

Purged water supply is provided from the tank for the closed cooling system within the Unit B3, where the purged water is delivered via pipeline from the plant for water pre-treatment within the HPV facility. Purged water consumption is approx. 40 m^3/h.

Material and energy balance

Based on the provided flue gas characteristics at the absorber input, necessary quantities of raw materials and energy are defined as well as the gypsum slurry production. Table 3.3.6-9 shows the basic units for the material and energy balance for the adopted design operating conditions for the Unit B3 (TMCR terms).

Table 3.3.6-9: Main units for the material and energy balance (H_d = 8.000 kJ/kg)

Parameter	Unit	Value
Flue gas input parameters (FGD Plant input)		
Flue gas quantity (real)	m³/h	2.559.300
SO_x concentration (dry, 1013 mbar, 0°C)	mg/m³	6.700
HCl concentration (wet, 1013 mbar, 0°C)	mg/m³	30
Flue gas temperature	°C	169
Flue gas moisture content	%	20,4
Flue gas output parameters (absorber output)		
Flue gas quantity (real)	Nm³/h	2.115.500
Flue gas temperature	°C	67.6
Flue gas moisture content	%	27,7
SO_x concentration (dry, 1013 mbar, 0°C)	mg/m³	≤ 150
Particles concentration (dry, 1013 mbar, 0°C)	mg/m³	<20
HCl concentration (dry, 1013 mbar, 0°C)	mg/m³	4
CO_2 emission increase	% vol	1,6
Process parameters		
Necessary desulphurization efficiency	%	min. 97,8
Electric power consumption	kWh/h	~ 7.000
Removed sulphur dioxide	t/h	7,64
Water consumption - process water - purged water	 m³/h m³/h	 100 40
Limestone consumption	t/h	~ 13,5
Production of gypsum with 10% of moisture	t/h	24
Gypsum slurry flow at absorber output (~ 15% of solid matter concentration)	m³/h	163
Gypsum slurry production (~ 50% of solid matter concentration)	t/h	43
Chloride concentration in the gypsum slurry	ppm	~ 8.000
Waste waters	t/h	13

Measures for the dust particles emission reduction

Reduction of the dust particles in the flue gas will be done in three stages:

- I stage is the installation of dry ESP with 99,96% efficiency in dust particles emission reduction, making the emissions of 30 mg/m^3;
- II stage is flushing the particles from the flue gas in contact with the recirculation slurry in the absorber with 50% efficiency, making the emissions of 20 mg/m^3, with the presence of the remaining slurry drops creating aerosols, thus estimating that the total content of the suspended particles in the flue gas behind the absorber is ≈ 30 mg/m^3 (with two-stage drops eliminator);
- III stage is the separation of the remaining particles < 2,5 µm and the aerosol in the wet ESP with 70% efficiency, making the final emission < 10 mg/m^3.

Dry ESP facility operation principle is based on the interaction between the charged particles and the electric field. High voltage electric field is formed between the emission and sediment electrodes. Sediment electrodes are grounded, and emission electrodes are connected to the negative pole of the single-current supply.

Corona appearance lead to the electrons emission. Electrons perform the ionization of flue gas molecules in the corona zone. Flue gas anions move towards the sediment electrodes which get in contact with the dust particles from the flue gas current, which makes them charged. Negatively charged ash particles move towards the sediment electrodes. After the contact with the sediment electrodes or previously formed dust layer, electric discharge of the particles occur and they stay on the sediment electrodes forming a layer on them. Settled particles are removed from the sediment electrodes surface by shaking and are collected in the hoppers, and from there are further transported via internal ash transportation system to the ash silos. Cations formed near the corona travel short distance to the emission electrodes therefore they charge a small quantity of ash particles causing the sedimentation of small amount of ash on the emission electrodes. Sediment particles are removed from the emission electrodes by shaking.

Efficiency of particles separation from the flue gas current depends on the intensity and the characteristics of the electric field, mutual distance between the electrodes, flue gas speed through the ESP and gas flow characteristics, period of gas being in the electric field, flue gas characteristics (temperature, moisture), particles characteristics (granulation content, electric resistance), etc.

Wet ESP facility operation principle is based on the interaction between the charged particles and the electric field. High voltage electric field is formed between the emission and sediment electrodes. Sediment electrodes are grounded, and emission electrodes are connected to the negative pole of the single-current supply

Wet ESP outlook is shown in the Figure 3.3.6-5.

Corona appearance lead to the electrons emission. Electrons perform the ionization of flue gas molecules in the corona zone. Flue gas anions move towards the sediment electrodes which get in contact with the dust particles from the flue gas current, and then they, negatively charged, move towards the semimetal electrodes.

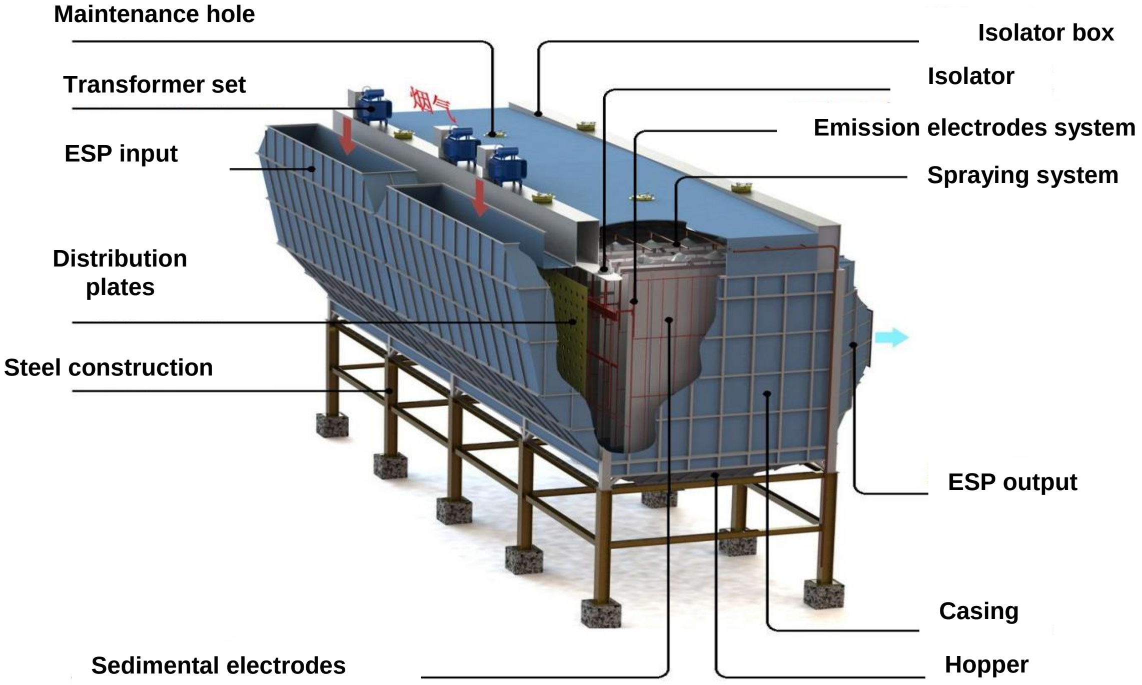


Figure 3.3.6-5: Wet ESP outlook

At the same time, through the nozzles system located above the electrodes across the entire ESP surface, water is continuously sprayed in the form of small drops falling between the emission and sediment electrodes. Water drops form a water film on the sediment electrodes thus flushing the separate powdered materials. Together with the suspended particles, water falls in hoppers out of which gets via pipeline system delivered to the circulated water tank. From the tank via circulation pumps, water is returned to nozzles system and the process repeats. In order for the suspended particles concentration in recirculating water to remain in requested limits, there is an automatic separator for circulation water on the pressure pipeline after the circulation pumps. The waste water separated in the separator (approx. 9,4 t/h) is via pumps delivered to the joint plant for waste water treatment for all three Units. Waste water characteristics are provided in the Table 3.3.6-10. Since the suspended particles also contain a certain amount recirculated slurry drops from the FGD Plant absorber, and that the flue gas contain the remaining part of sulphur trioxide (SO_3), which reduce the pH value of water and have a corrosive effect, pH value of the circulating water is controlled and maintained in the defined range by dozing the sodium hydroxide (NaOH).

In order to prevent the removal of water drops which are not isolated from the electrodes, a drops eliminator was installed before the ESP output bonnet. The drops eliminator is occasionally (with previously set time interval) rinsed with fresh water brought above the eliminator via pipeline system and there sprayed via nozzles and poured down the eliminator and though the hoppers supplied to the circulation tank.

Principal scheme of the wet ESP operation is shown in the Figure 3.3.6-6.

Table 3.3.6-10: Content of the waste waters from the wet ESP

Component	mg/l
Insoluble	
SiO_2	230
α-Al_2O_3	123
α-Fe_2O_3	43
$CaSO_4 \cdot 2H_2O$	287
TiO_2	4
other	2
Suspended matter, total	689
Soluble	
Mg^{2+}	160
K^+	8
Na^+	4501
SO_4^{2-}	8808
Cl^-	155
F^-	58
Soluble matter, total	13.690
Solid matter, total	14379
PH value	6-7

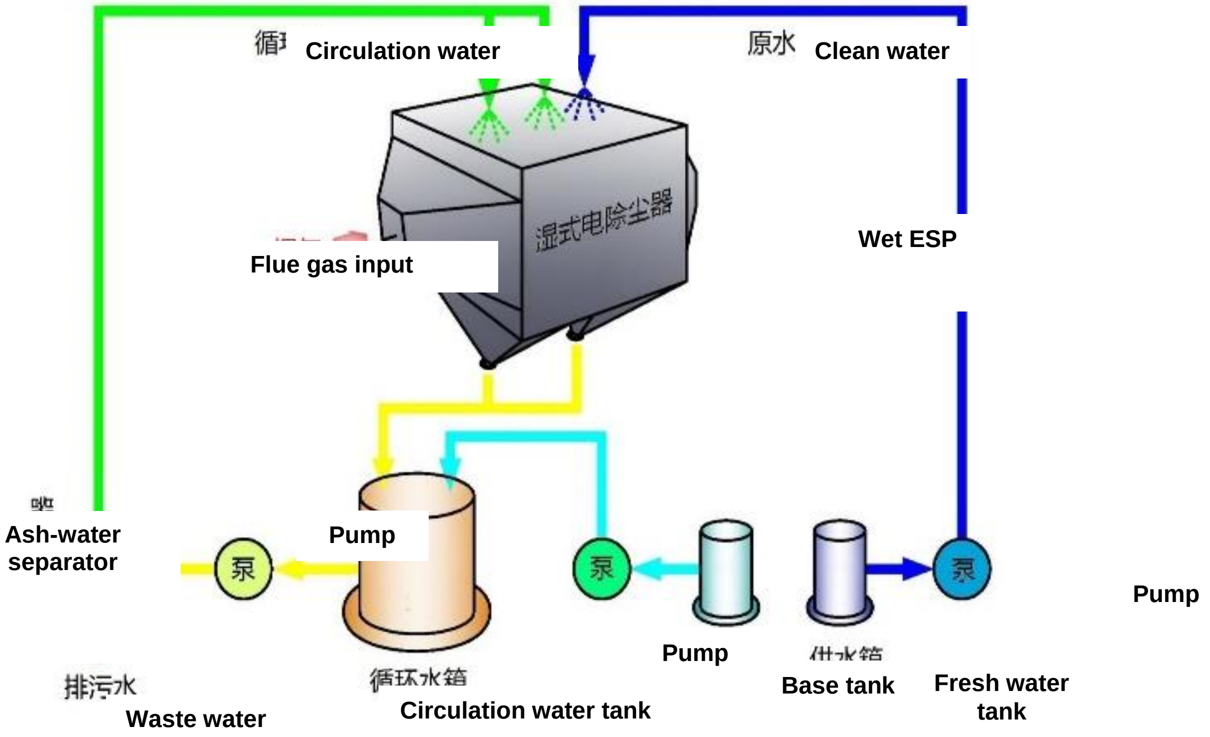


Figure 3.3.6-6: Principal scheme of wet ESP operation

Total water quantity for the needs of the wet ESP (filling and re-filling the installations) will be provided from the flue gas desulphurization fresh water tank.

Main characteristics of the dry and wet ESP facilities are shown in the Table 3.3.6-11.

Table 3.3.6-11: Main design characteristics of dry and wet ESP

Parameter	Dry ESP	Wet ESP
Input parameters		
Flue gas flow at ESP input, real, m^3/h	2.768.569	2.465.551 (10% reserve)
Flue gas temperature, °C	174	66,6
Dust particles content, mg/Nm^3 (dry gas, 6% O_2)	66.955	20
ESP characteristics		
Number of ESP units	2	2
Number of electric fields	6	2
Field length, m	4,275	11,7 (width)
Total field length, m	25,65	23,4 (width)
Field height, m	15,5	7,3
Total effective surface of collector electrodes, m^2	106.704	9.547
ESP facility unit dimensions:		
– length, without input and output bonnet, m	~ 29,1	~ 8,33
– one ESP unit width, without staircase tower, m	~ 54,68	~ 24.6
– ESP height, m	~ 30	~ 14
Dust particles content, mg/Nm^3 (dry gas, 6% O_2)	<30	<10
Raw material consumption		
Electric power consumption, kW	2.209	580
Chemicals consumption (32% NaOH), kg/h		225

Layout schemes for the dry and wet ESP are shown in the layout scheme of the Unit B3 equipment (Annex 3) and in more detail in the Annex 17

Measures for reduction of emission of CO_2

Design of Unit B3 guarantees high efficiency of the unit components (efficiency of the Unit for TMCR working conditions during combustion of guarantee coal is 89.2%, while the turbine plant efficiency is 48.22%), so that total gross efficiency of the unit is 42.39%, and net 37.3%. With such parameters, gross specific emission of CO_2 is 0.87 kg/kWh of produced electric power.

Developed technical documentation did not predict measures to reduce emission of CO_2, but the layout of the unit is made such that it is possible to place all the required equipment of such plant in future.

Also, within the General design for erection of unit B3 all necessary activities for realization of the status 'carbon capture and storage ready' for unit B3 were analysed. These activities depend on CO_2 extraction technology applied and it can include additional treatment of the flue gas until the required quality is reached (very low content of SO2 and dust matters).

In case that the mentioned plant is not performed, and there are certain limitations with regards of CO_2 emission from Unit B3, with precondition that there is possible trade of CO_2 emission for Serbia, it is necessary to achieve rights to emissions in such way.

Emissions into air via flue gases

After cleaning, emissions of pollutants into air via flue gases during combustion of guaranteed quality coal and unit load under TMCR conditions, it will be as given in table 3.3.6-11. It is assumed that effective unit engagement is 7,500h a year.

Table 3.3.6-11: Emissions of pollutants into air via flue gases from unit B3

Pollutant	Emission	
	Hourly , kg/h	Yearly, t/year
Sulphur-dioxide	176	1.320
Nitrate oxides	235	1.762,5
Fly ash particles	5	37,5
Carbon-dioxide	297.500	2.231.250

Measures for reduction of dust matters emission from the feeding and storage of disperse matters system (limestone and coal).

1. Within the system for feeding and storage of coal the following devices for preventing dispersing fo coal dust into environment were installed:

   - Coal transport is performed by closed belt conveyors. The subject design includes coal transport from distribution bunker to entrance into the boiler.
   - In the plants for primary and secondary coal crushing there is air dedusting provided. Dedusting will be performed via autonomous bag filters with 'pulse-jet' system for bag shaking off.
   - Air dedusting is provided at all bridge locations. Dedusting will be performed via autonomous bag filters with 'pulse-jet' system for bag shaking off.

It is anticipated to install the device on the following spots:.

- Dedusting in the primary crushing building (PD) 1 pcs
- Dedusting in new bridge tower (NPM) 1 pcs
- Dedusting in the secondary crushing building (SD) 1 pcs
- Dedusting in the transfer building PZ III 2 pcs
- Dedusting in the transfer building PZ IV 2 pcs

Basic characteristics of the dedusting device are given in the Table 3.3.6-12.

- During the process of bunker filling with coal in the bunker bay and transferring the coal from slide belt conveyors to the transfer chute there comes to dispersing coal dust. In order to prevent this it is anticipated to install dedusting consisting of filter devices (8 pcs, one for each bunker), with the system of round steel ducts for air suction from the upper bunker area.
- Reduction of the coal dust emission from the coal disposal surface can be reduced by wetting the disposal during dry weather and with high wind velocity (higher than 8 m/s).

2. Within the *system for unloading, storage and transport of the limestone* the following devices are predicted to prevent disperse of the small fractions into environment:

- Supply of the grain limestone is performed by rail wagons with side unloading, during which the underground covered bunkers are provided.
- Limestone storage is covered and fenced up to 2m high, by which direct wind impact is prevented. The storage is mutual for all three units of TPP Kostolac B.
- Local dedusting of the bunkers for limestone intake from the storage is performed by suction bonnet, bag deduster, exhaust fan and vertical pipeline for gravitation return of the dust into the basic material flow (elevator for lifting the material into silo). Basic features of the device are given in Table 3.3.6-12.
- At the silo filling place for limestone there are bag dedusters with fans, features given in Table 3.3.6-12.

Table 3.3.6-12: Characteristics of the dedusting device in the systems for coal and limestone supply

No.	Installation place	Device type	Device no.	Air flow m^3/h	El.power consumption kW/Set	Dedusting efficiency %	Guaranteed concentration of particles at the outlet mg/Nm^3	Particle emission g/h
	Coal supply system							
1	Crusher for primary coal crushing	Impulse bag filter	1	10.500	15	>99	20	200
2	Crusher for secondary coal crushing	Impulse bag filter	1	11.000	16	>99	20	210
3	Transfer tower T-1	Impulse bag filter	1	11.000	16	>99	20	210
4	Transfer tower T-2	Impulse bag filter	2	10.000	15	>99	20	190x2
5	Transfer tower T-3	Impulse bag filter	2	9.500	13	>99	20	180x2
6	Boiler bunker	Impulse bag filter	8	8.500	10	>99	20	162x8
	Limestone supply system							
1	Transfer tower TI-1	Impulse bag filter	1	5.000	7.5	>99	20	95
2	Transfer tower TI-2	Impulse bag filter	1	5.000	7.5	>99	20	95

Measures for dust matters emission reduction from the system of collection, transport and disposal of hard waste (ash, bottom ash and gypsum)

Within the system for collection, transport and disposal of ash, bottom ash and gypsum the following devices for reduction of dust matters are anticipated:

- Ash transport from ESP hoppers to silos is performed in closed system, pneumatically,
- Bottom ash transport from de-slagger to silos is performed mechanically, in closed conveyor,
- For the dedusting of transport air, ash silo will have completely automatized bag dedusters with impulse rapping of bags by compressed air. Cleaning level of these filters will provide outlet concentration of the cleaned air under 20 mg/m^3.
- At the plant for wet ash and slag mixture and gypsum suspension there is a scrubber for dedusting of 5.400 m^3, with air suction fan, with capacity of 5.400 m$^{3.}$
- Transport of wet ash and slag mixture and gypsum suspension is performed by belt conveyors,
- At the cassettes disposal of wet ash, slag and gypsum is made by planning and compact civil machinery to dry volume of 0,85 t/m^3. The design anticipates possibility to dose the active substance (lime) in amount of 3%, which would promote the process of hardening the deposited mass.
- For prevention of dust emission from active operating surface it is anticipated to apply water flushing technical solution (to optimal humidity of about 6%) with car-cisterns at the places where such approach is possible on the dust emission sources. Three cisterns are anticipated and its filling is made with drainage water from water collection VS1 for Cassette 1 and VS2 for Cassette 2.
- After filling the cassettes 1 and 2 up to final deposition level of 104,5 mnm cassettes are closed and recultivated by formation of upper covering layer by which the contamination source is insulated, in order to prevent direct contact with waste, dust occurrence and atmospheric rainfall at disposal. Final surface of the cassette is levelled in two-side fall by material deposited by disposal conveyor in order to provide atmospheric water flow from recultivation layer. Covering construction is designed from composite geotextile with bentonite particles over which the recultivation layer is being put (figure 3.3.4-15).

C. Fluid waste matter treatment

Technical solution for unit B3 is based on temporary solutions which include prevention, in order to reduce amount of waste water amount, which is achieved by the following activities:

- Prevention of waste water occurrence (occurrence of chemical and oil leakage, collection baths at potential leakage places with special ducts),
- Controlled usage of water and
- Separated ducts for clean and polluted water, as well as ducts of waste water toward pollution type.

Unit B3 erection design anticipated collection of waste water which occur within the facilities of the unit acc.to pollution (clogged, oiled, chemically polluted and salted waste water etc.) and its streaming to mutual treatment plants which are designed for all three units at the location of TPP Kostolac B3. Waste water treatment which are not comprised by mutual plants will be within the design of Unit B3 erection.

The design for mutual plant anticipated collection and treatment of waste water in four plants:

1. Oiled waste water treatment plant with pre-treatment of heavy oil polluted water (WWTP-U)
2. Waste water treatment plant from the CWTP and cleaning of turbine condensate and FGD plant (WWTP-ODG&HPV)
3. Atmospheric water treatment plant (local separators at four locations within the TPP Kostolac Separator no.1-4)
4. Sanitary waste water treatment plant (WWTP-S).

Proposed situation of the mentioned plants within TEKO B is shown in the Attachment no.18.

Streaming of the waste water occurred within unit B3 to certain systems in mutual plant, as well as to the treatment system within unit B3 shown in Attachment no.25.

With regards to the mutual plants, waste water from Unit B3 will be treated in the following manner:

1. Within the plant for oiled water treatment (WWTP-U) the oiled water from the following systems of B3 will be treated:

   - Internal heavy oil plant of unit B3 Q ~ 43 m^3/day;
   - External heavy oil plant of unit B3 Q ~ 9 m^3/day
   - Drainage pits of mechanical room of unit B3 Q ~ 120 m^3/day;

   Atmospheric water from tank of the future heavy oil tank of unit B3 were not taken into consideration during sizing of the plant, having in mind that this water can be kept in tank and later drain into the collection pit in controlled manner.

   Unit B3 design includes connection of oiled water from Unit B3 to collection pit of oiled water of the existing units.

   Central plant for oiled water treatment is anticipated for cleaning of pre-treated oiled water and oiled water from all three units. According to anticipated amounts of this wast water the plant is sized to capacity of 2x30 m^3/h.

   Wastewater from the current drainage pits of mechanical room of units B1 and B2 will be transported to equalization pools, volume 260 m^3, over new designed pump station. The capacity of pump station (2x40 m^3/h) is designed on the base of water quantity from the existing units, while for the unit B3 needs it is necessary to provide additional pump.

   Unit B3 design anticipated connection of the waste water from mechanical room to new designed pump station of the oiled water.

Cleaning of the oiled water comprises of: rough extraction of the heavy oil from heavy oiled water, using gravitation API separator (pre-treatment of heavy oiled water), equalization of oiled and pre-treated heavy oiled water, cleaning in DAF unit (Dissolved Air Flotation) and in case of worsening of the quality there is a space left for filter facility for additional oil and suspended matters extraction. Anticipated quality of cleaned water is allowed quality for exhausting into recipient. Cleaned water will be let via return cooling water collector and evacuated from power plant in accordance with the regulations related to waste treatment, after the waste character is determined (hazardous/non-hazardous). Extracted oil and heavy oil is also collected and evacuated in accordance with the regulation.

Treatment of the waste from central plant is a part of the mentioned special design of the mutual system for waste water treatments of units B1-B3.

2. In the plant for waste water treatment from the chemical water treatment and turbine condensate and FGD plant (WWTP ODG&HPV) waste water from the following systems of Unit B3 will be treated:

- Waste water from FGD unit B3 — Q = 13 m^3/h (312 m^3/day)
- Concentrate from the plant for RO — Q = 17,5 m^3/h (420 m^3/day)
- Waste water from regeneration of ion exchanging resin From the CWT plant — Q = 80 m^3/ day
- Waste water from regeneration of ion exchanging resin From the external regeneration plant — Q = 30 m^3/ day
- Waste water from return column washing for turbine condensate treatment — Q = 150 m^3/ day

Waste water after chemical cleaning of RO membranes were not taken into account, having in mind small quantity and dynamics of occurrence (once in several months).

Process of cleaning this water is based on equalization, neutralization, removal of heavy metal, coagulation and flocculation with further deposition, while the extracted waste is further sent to the sludge line. Sludge line includes thickening with conditioning and centrifuging as the final process until the sludge cake is formed. Water above the sludge returns to the beginning of the processes. The recipient of cleaned water will be the return duct of the cooling water.

In the mentioned plant (WWTP ODG&HPV) waste water from the chemical boiler cleaning , occurred during the overhaul (once in period of 4-6 years) will be treated too, in amount of ~2500 m^3. Pre-treatment of this water is anticipated within the chemical cleaning of the boiler after which this partially cleaned water is sent to treatment of the water from FGD and CWTP.

3. Atmospheric waste water from the roads and platforms are collected via atmospheric sewage and sent to new designed local Separator no.3 and then to the exhaust place into Mlava river.
Dewatering of the street is solved via cesspool as recipients which are connected to sewage network. Cesspools are made of concrete tubes with inner bright opening 450mm, with the precipitator of min.400mm high and concrete base at the bottom. At the top of the precipitator there is a horizontal one part cesspool grate with the frame.

Waste water from the roads are collected with the special network set under the road.

4. Sanitary waste water from the facilities of unit B3 will be treated in newly designed mutual plant for the whole power plant, and it will be connected to the existing sewage network. New plant will be designed on the base of technology of active sludge biological treatment in SBR (Sequenced Batch Reactor) reactors. The capacity anticipated is 1500 ES (Total waste water volume is 210 m^3/d, and load factor is 0.7).

   The anticipated technology comprises of three basic levels of cleaning: primary (physical), secondary (biological) process in SBR reactors and sludge treatment. Thick slurry will be deposited in compliance with the regulation and according to the defined waste category.

Waste water from unit B3 which will not be treated in the mutual plant is:

1. Waste water from the coal supply system

Treatment of the waste water from the coal supply system from new, third line, is not solved within the mentioned Basic design of the waste water treatment so it is necessary to include this issue in the project of new unit B3.

The expected amount of coaly waste water included in the design of Unit B3 and which will be treated within the designed plant is:

- Fire extinguishing water Q~100 m^3/day;
- Atmospheric water from the coal disposal and coal supply platform Q~330 m^3/day.

For collection of waste atmospheric water from the coal supply system, a duct around coal storage shall be anticipated in order to stream the water gravitationally to the plant pool.

The plant for cleaning the coaly water, capacity 2x20 t/h, includes collection of coaly waste water and partially cleaned atmospheric water in precipitator, where from the overflow from the precipitator is directed to the treatment in cleaning device. In the cleaning device, there is a three-level sedimentation of the suspended substances from waste water with addition of coagulant. The designed quality of the cleaned water means the suspended substances content of ≤ 30 mg/l (pH 6-9).

Design of this system for unit B3 anticipated recirculation of the cleaned water for repeated washing in the system and for coal disposal wetting, while the extracted sludge from the precipitator is collected with crane and put at the coal disposal.

2. Sludge waste water from the ash and slag system:

- Waste water from the washing of the air heater and boiler room floor ,
- Waste water from slag cooling.

It is anticipated to treat the waste water from the ash and slag system in a special line within the specified system for coaly water treatment. Cleaning technology is the same as in the system for waste water occurred from the coal supply system. The adopted capacity of the plant is 2x70 t/h.
Cleaned water shall be recirculated within the system of ash and slag, while the extracted sludge from the precipitator will be collected by crane and sent to mixer for ash and slag. The designed quality of cleaned water means the suspended substance content of ≤ 30 mg/l (pH 6-9).

3. Waste water from the ash, slag and gypsum disposal

Waste water from ash, slag and gypsum disposal occur as a consequence of atmospheric rainfall at the disposal. Having in mind that this inflow is unequal in time and amount, the drainage system is designed to solve the dewatering of the disposal.

For collection of atmospheric water inflow in ash, slag and gypsum disposal a drainage carpet is designed at the bottom of both cassettes in thickness of 0.5m, after the installation of HDPE foil, over which geotextile is being set to separate layers and as a protection against drainage layer

For gravel drainage body there is a line horizontal drainage is designed with 4 lines long L=370m and with diameter DN 150mm with fall ~ 2 ‰ for both cassettes. Drainage pipes inflow in collectors which have length of L=405,0m which lead to water collector located at the bottom of each cassette.

Water collector, volume V=625 m^3,has trapezoid cross section in base with size 25,0x25,0 m, available length 1,0m with slope 1:3, excavated terrain and covered with two-layer water-impermeable geo-membrane. Water from water collector is used for spraying of the disposal in order to prevent spreading of the waste matter particles.

In final phase of deposition before going to Cassette 2, the pump from water collector VS1 is dismantled and moved to VS2, water collector VS 1 will be backfilled.

It is not anticipated to make any waste water discharge into underground water during normal operation of unit B3.

D. Solid waste substances treatment

Solid waste substance treatment means collection of ash, slag and gypsum with internal systems (in the power plant range), outer transport to disposal and final deposition at the anticipated area. Each mentioned phase of solid waste treatment includes in its design environmental protection measures, determined by the technological process itself and in accordance with the conditions imposed by the appropriate environmental protection regulation.
Ash and slag as a by-product from the combustion process of the Kostolac lignite are classified as non-hazardous waste in its character with index number 10 01 01 (Catalogue of waste, Attachment 1 of the Rulebook on categories, inspection and classification of waste, Official Gazette RS, no.56/2010). Gypsum suspension is also classified as non-hazardous waste, with index number 10 01 07 (acc.to above mentioned Catalogue)
Ash, slag and gypsum characteristics are shown in the Chapter 3.3.5 (part Products) in the Study.

Description of the ash, slag and gypsum deposition technology is shown in Chapter 3.3.4 of this study.

Basic feature of the solid waste treatment system from unit B3 is that ash, slag and gypsum suspension from unit B3 are mixed and transported as a wet mixture by mechanical transport to OCM Drmno, where the phased deposition will be performed on a specified internal overburden disposal area with all required systems for underground protection (protection layers, drainage system, recirculation of the return water, monitoring, recultivation)

System for further treatment of gypsum suspension, until the dry gypsum, will also be installed and it will be used in case when the gypsum selling is provided to external users or when it is not possible to deposit the gypsum suspension for some reason.

Summary review of the protection measures against possible harmful effects to environment which can occur in treatment processes and final taking care of the solid waste from the power production process from unit B3 described in Chapter 8.3 of this Study.

E. Other waste type treatment

Beside basic types of waste characteristic for technological process itself, some other types of waste substances will appear (packing, oiled cotton waste, and other oiled small waste, waste oil, etc.)
This type of waste will appear in usual (small) quantities and the procedure of its collection and deposition shall be put together with the existing practice for waste management in TPP Kostolac B (Chapter 3.2 of the Study)

F. Noise and vibration protection

Protection of the environment against noise depends on the place of its occurrence i.e. noise source location. For the range of power plant there are special regulations relating to the working environment where the allowed noise level depends on duration of noise during a working day (maximum 8 hours).

General requirement for equipment producers is to guarantee that the noise level at the distance of 1.5m from equipment will be less than 85dB, which is the allowed noise level in the working area during the 8-hour stay.

Regarding environment around the facility, it is necessary before commissioning of unit B3 to measure the noise at the border of the power plant range. In order to comply with the regulation requirements, it is necessary to make zones of the space around power plant to determine the allowable noise level on the borders with nearby zones, and based on this to define the need for eventual additional protection measures in relation to those already specified for the working environment.

It should be highlighted that in period up to the completion of erection and commissioning of unit B3 at the location of TPP Kostolac B, the FGD plant for units B1 and B2 will be commissioned as well as the waste water treatment plant. In these terms, the existing measuring results can be just indicative for recording of possible exceeding.

3.3.7. Cumulative effects with the existing or planned activities on location

When analysed the cumulative influence of the new unit with the existing or planned activities on the observed location, the pollution sources effects of the same or similar type are monitored, but also the sources which appear as result of other activities, whose emitter parameters are different. That means within the influence analysis of the new B3, the cumulative effect shall be observed together with the existing power units at locations of TPP Kostolac A and B, as well as mining activities at OCM Drmno. The characteristics of other pollution sources at the area, which are dispersed sources of small capacity and local character, will be deemed as phon of pollution.

A. Cumulative effect with existing units

New unit B3 is designed so that it dos not produce negative cumulative effects with existing activities at location of TPP Kostolac B and in its environment which would result in overly environment pollution. As mentioned in Chapter 3.1 of this Study, as a starting activity on unit B3 erection project Preliminary works were performed, with the basic aim to analyse and determine possibility of new unit erection at the given location, taking into consideration all factors. One of the important parts of the preliminary works is determination of the ecological capacity of the location, which means analysis of the environmental quality status before unit B3 starts, based on which the protection measurements will provide complying of the B3 operation influence within the remaining capacity and legal norms.
Within the Chapter 6 of this Study the influence of unit B3 is analysed but also cumulative influences on existing units B1 and B2 and TPP Kostolac A. As said, the future operation of the existing units was taken into consideration during determination of the chimney size for new unit B3.

B. Cumulative influence with OCM Drmno

As mentioned in Chapter 3.3.3 of this Study, for the supply of coal to the new unit B3 it is planned to increase the capacity of the coal production at OCM Drmno to 12 mil. tones a year, as well as to install the third disposal line, where from the coal will be sent to B3. In this sense, the following is a brief review of the influence of OCM Drmno operation to environment, developed according to completed design documents for open cut mine development,[3,4], based on which conclusions can be made on importance and intensity of future cumulative influence of the OCM operation and unit B3.

Figure 3.3.7-1 shows the area around OCM Drmno. Operation of the mine can mainly jeopardize villages Drmno and Klicevac, placed at the distance less than 1km from the mine border.

Figure 3.3.7-1 Area around OCM Drmno

---

3 Updated BD with Feasibility study of OCM Drmno upgrade to capacity 9x106 tones per year, Volume II – Influence analysis of OCM Drmno to environment, MGF University in Belgrade, 2010.

4 Feasibility study with Basic design for provision of required coal quantities for operation of the existing power plants in TE-KO Kostolac and new unit B3 (350 MW), MGF University in Belgrade, 2013.

Identification of the pollution source to OCM Drmno

Exploitation of coal from OCM Drmno is potential source of pollution of environment, while the most important pollutants emitted during excavation of overburden and coal, suspended particles occurred during mining equipment operation (excavator, spreader, loader as point pollution source) and belt conveyors (line pollution source). Spreading of particles is possible from the mine roads as well as active surface on which the coal exploitation is performed. In all mentioned cases there are ground or low sources of pollution with small starting energy, which dominantly influences the distribution and range of pollution.

Table 3.3.7-1 shows the characteristics of the mentioned pollution source.

Table 3.3.7-1: Characteristics of the suspended matter at OCM Drmno

Activity/Equipment	Emission factor	Source type
Dragline	0,026 kg/m^3	Point
Excavator	0,014 kg/t	Point
Bulldozer	4,0 kg/h	Point
Truck	0,004 kg/t	Point
Truck movement	0,4 kg/km	Line
Belt conveyors	0,002 kg/t	Line
Loading the belt	0,013 kg/t	Point
Wind erosion	0,2 kg/ha/h	Surface

* Source: influence analysis of OCM Drmno to environment, Mining-geological faculty, Belgrade 2010.

Beside the mentioned, the small pollution sources are also motors with internal combustion which start mining equipment and machinery. Exhaust gases occurred by motor operation emit combustion products: carbon, nitrate and sulphur oxide, unburned hydrocarbons and other harmful organic matters. Table 3.3.7-2 shows recommended values of emission of the most important pollutants which occur from mining motors diesel fuel combustion.

Table 3.3.7-2: Mining equipment motor pollutant emission

Equipment	Emission, kg/1000 l fuel			
	CO	NO_x	SO_2	VOCs
Bulldozer	14,73	34,29	3,74	1,58
Truck	14,73	34,29	3,73	1,58
Dragline	11,79	38,5	3,74	5,17
Scraper	10,16	30,99	3,74	2,28
Guider	6,55	30,41	3,73	1,53

* Source: influence analysis of OCM Drmno to environment, Mining-geological faculty, Belgrade 2010

As a special influence to the environment noise should be mentioned which occurs during mining machinery operation and transport equipment movement. Table 3.3.7-3 gives the levels of noise during operation of certain types of equipment and according to measurement data by Department for ventilation and technical protection of MGF Belgrade.

Table 3.3.7-3: Noise levels during operation of equipment on open cut mines

equipment	excavator	excavator cabin	dragline	spreader	belt conveyors	bulldozer	vehicles
Noise level (dB)	92-94	78	82	85-89	96-102	115	110

Assessment of OCM Drmno influence to environment

Brief summary of the estimation of OCM Drmno influence to environment is given based on detailed analysis in the mentioned documents, on the base of designed mining works and adopted emission characteristics of equipment and devices. Using the computer model AERMOD, calculations were made for spreading suspended particles and gas pollutants around the mine. The calculations were made for case without implementation of measures for reduction of dust matter and with implementation of emission reduction measures. Based on the results the following conclusions were made:

- Calculations for distribution of pollution for cases with and without implemented measures for emission reduction, it is shown that by implementation of measures can make great reduction of pollution level nearby mine, even to 50%.
- In period of exploitation and development of mine, mining works go toward north, so that influences previously dominant in the area of Drmno are now moved toward Klicevac village.
- For mining works condition in 2024 it is concluded that in the area of closes recipients, in Klicevac village, imission of suspended particles will not exceed imission limit values 120 $\mu g/m^3$, under condition that the measures for emission reduction are implemented (estimated values of imission are 80-116 $\mu g/m^3$).
- In the area where devices and crushing equipment work, classify and deposit coal the estimated imission value on the north edge of the Drmno village is 120 $\mu g/m^3$, under condition to implement measures for emission reduction.
- Concentration of gas pollutants, which result from motor fuel combustion have local character and have no influence to area beyond mine borders.

Regarding noise influence occurring during mining equipment operation, it is concluded that the noise level at the distance of 1km from the source at the border or above permitted level in the area affected by equipment for transport, crushing and classifying of coal. This jeopardizes the north part of the village Drmno so it is required to predict measures for noise reduction in this part. In the part of mine where the overburden and coal are excavated, the equivalent noise level beyond the mine borders is 55 dB (A).

Anticipated protection measures

According to the mentioned, the Analysis of the influence of OCM Drmno to environment (MGF, Belgrade, 2010.) the following protection measures against coal mine influence were anticipated:

- For prevention of dust emission from the active working area the technical solution anticipated is dewing via special vehicles, car-cisterns, with the dewing equipment; necessary number of cisterns is determined by individual vehicle characteristics and area to be showered.
- For prevention of dust emission at the transfer spots in the conveyor system the wet and dry procedure is anticipated. The wet procedure anticipated wetting at the place of load and unload, using nozzles which make water cloud. Dry procedure anticipated caption of the transfer place from conveyor to another by setting the metal cover fastend to

conveyor's construction and rubber sealing.

- For prevention of dust emission from moving belts for coal and overburden transport it is anticipated:
  - Belt conveyor moving in optimum speed, especially in period of unfavourable weather (dry weather and/or strong wind)
  - Reduction of height distance between conveyors and height of unloading
  - Subsequent covering of belt conveyor (if the technical-economic analysis determines the justifiability of such measure).
- For prevention of the unfavourable influence of excessive noise the following measures are anticipated:
  - Noise reduction at individual devices and machines by implementing: installation of noise damper in mining machinery motors, maintenance of good condition of equipment, implementation of adjustment and modification of exhaust branches and exhaust pipes of machine motors and acoustic insulation of metal and other assemblies of noisy machinery parts.
  - Application of acoustic protection, by setting the greenbelt or other barriers or fences.
- During exploitation of open cut mine, with development of coal excavation, outer and inner disposal of overburden are formed. Outer disposal is partly recultivated with forest vegetation at the slopes. Currently the inner disposal area is being formed, for which the technical and biological reclamation is planned. As preconditions for reclamation humus soil layer is being excavated and deposited for future agrotechnical reclamation needs.

<u>Cumulative influence of work of OCM Drmno and TPP Kostolac</u>

Based on analysis for certain influence of TPP Kostolac and OCM Drmno operation, the following conclusions can be made regarding their possible cumulative influence:

- Cumulative influence of suspended particle emission is possible in case of active mine area and from dry solid waste disposal (ash, slag and gypsum), within the mine. With the described deposition technology as wet ash mixture, and with implementation of anticipated procedure for mixture deposition it is expected to achieve the hardening of material, which would maximum reduce the spreading from disposal. In case of need, it is anticipated to add lime in order to create appropriate environment for compact deposited mass.
- Influence of emitted pollutants which make waste gases from internal combustion machines in the mine is not added to the influence of these pollutants which are integral part of flue gases from the chimney, because of significantly different pollution source nature and spreading. Cumulative influence in this case does not exist in the area outside the mine.
- Cumulative influence of noise can be subject of influence on village Drmno. However, having in mind that a part of mining complex for classifying and crushing of coal is at the smaller distance from the units of TPP Kostolac, the influence of this equipment is prevalent, while the TPP's effect is less (the village is over 1km far from the TPP facilities). Also, it should be underlined that the TPP and mine noise influence come from different sides, so that putting the protection barrier between TPP and village Drmno the reduction of noise from the mine will not be reduced.

Beside the influence on air quality, there is also a cumulative influence of the mine and TPP Kostolac on the quality of water having in mind that drainage water from the mine inflows into the feed water lake. The quality analysis stated occasional overstepping of MDK for dissolved oxygen (reduced concentration), HPK, BPK_5 and suspended matters.

Cooling water with its good quality and significantly higher amount affect the polluting of drainage water from the mine. Based on results of the performed analysis at the inlet of TPP (The Danube upstream from the cooling water take off) and at the outlet of the cooling system it is stated that cooling water does not change its starting quality.

3.3.8. Direct influence of the Project to the human health

Influence of the facility operation to the health of people is estimated through the level of ris for undesired effects to population affected. The risk estimation means estimation of the quantity and quality of changes which can appear in physical, biological and humane environment, as well as how these changes will affect environmental resources and in which level it will contribute to appearance of risk factor on people's health. Determination of the risk for people should provide information on nature and greatness of the influence expected in the area during the operation of the plant.

Estimation of the influence of the environmental factors to the health means estimation of influence of the factors which are very special or most significant for the health, or as called 'health factors of environment'. Although the most of risks (risk factors) present in the environment to which the population is exposed at the low level in relation to norms, there has to be taken into account that frequent exposure refers to the whole life time. Besides, when we know or assume that event the low-level exposure is harmful, it is not to prove clinical or physiological effects of such exposure to the population level. Due to frequent incubation time of the first exposure and clinical effects, there is a low rate of incidence on the exposed, especially if the small part of population was exposed to certain agent in early years, so that health disorder can be unrevealed for several years.

Chemical pollutant substances that cause harmful health effects are divide into five wide groups, depending on the effects that can cause:

1. Toxic matter (acute and chronical effects)
2. allergens
3. teratogens
4. mutagenic matter
5. cancerous matter.

Classification of certain chemical matter in some group is made according to its physical-chemical characteristics and dominant health effect. In this way it is possible to anticipate the effect to health and quantitatively estimate (calculate) risk for organism.

Also, there should be underlined that there is a basic difference between mentioned groups, which should be considered, i.e. for cancerous or teratogenic effects there is no dose-response relation. In case of acute and chronic toxic effects there is a system of standards, that is MDK (Maximum Allowed Concentration), below this value there is no health problems of the exposed population. For certain matters which have no MDK, it is considered that certain measurable risk exists for exposure to any value above zero.

It means that in such cases some protection measures should be taken to put the risk of exposure to minimum, or to the level which would contribute to negligible increase of individual risk.

It is hard to determine the latent period from the start of exposure to the moment of illness occurred under the influence of environment factor. For the most solidary cancers the latent period is 20-30 years, for leukaemia 5-10 years and for the most of chronic diseases it is uncertain. Also, the complex problem is determination of factors which are responsible for pathogenesis as well as its ranging in relation to the total risk.

In procedure of estimation of the risk to people's health in case of exposure to harmful substances, it is necessary to follow a certain procedure which can have qualitative or quantitative result or combined.

Danger identification means the first phase of the risk estimation where the data are collected about identified significant matters. First, the classification is made in terms of harmful effects to health (cancerous, non-cancerous effects). Data collected from epidemiological researches, controlled human experiments, toxicological studies, in vitro and in vivo tests and physical and chemical features of agents.

Relation dose-effect and relation time-effect. It is very important to define the term dose, as well as the quantity of available substance at the aimed place and the time duration of its staying in the organism. Only the small part from the total amount to which the body was exposed is absorbed and only a small part of this absorbed dose goes to the aimed place, the rest can be tied or at some other way bio-accumulated. After absorption the concertation of the matter in organism raises, and then is indigested, distributed, transformed and excretion. When the body is removed from the exposure, the absorption stops. Retention time for the matter in a body determines its half-life. The important question is: how much time is required to reduce the concentration below specified, safe level?

Exposure estimation is the third phase in the process of risk estimation, which means imission characterization, emitted matter destiny, transport toward outer space, features of the exposed population in the area and calculation of the exposure (quantitative).

Exposure is the contact of a man via one or more entries with harmful matter of certain concentration in certain time, present in the certain space.

Risk categorization is final phase which has to integrate information from previous three phases and provides definition whether it will come to occurrence of different toxicity related to the substance. EPA and NAS define the risk as a summation of nature and volume (size) of humane risk.

External exposure in general sense does not have to mean internal exposure too. Internal exposure is the relationship between entries and taking of agents. The absorption level of certain substance greatly varies (sulphur dioxide is hard to absorb in upper respiratory tract but with catalyser is faster and better) or methyl mercury is almost completely absorbed in gastrointestinal tract, while the metal mercury is hard to absorb.

Local and system effects that appear after absorption. System agent (toxon) reaches the aimed body organ tissues, certain systems or whole organism where the effects appear.

Some agents (toxons) act typically causing irritation or neurosis. They can cause lesions and have local effect. Some matters can produce systematic and local effects.

Starting base during quantification of risk is a data whether for a certain substance there is a concentration value below which the unfavourable health effects are not expected. According to the recommendation of World Health Organization (WHO) and EPA for cancerous substances from the first group of cancerogens acc.to IARC (International agency for cancer researches) there is no safe limit value. For non-cancerous substances there are defined so called allowed values due to homeostatic, compensatory, geo-chemical, physiological and metabolic processes in the exposed organism.

The dose-response curve shows probability for unwanted effects occurrence is proportional to dose increase, but the proportion factor is increased after exceeding the allowed value.

Based on toxicological experiments of four level EPA has differentiated four levels of responses for systematic non-cancerous toxicants which are used in evaluation of dose-response relation:

1) NOEL (No-observed-effect-level): The highest experimental dose with no statistically or biologically significant increases in frequency or weight of toxic effects observed in the exposed in comparison with unexposed population.
2) NOAEL (No-observed-adverse-effect-level): The highest experimental dose with no statistically or biologically significant increases in frequency or weight of observed non-desirable effects in the exposed and unexposed population. Effects can be produced but they are not considered side effects (harmful).
3) LOAEL (Lowest-observed-adverse-effect-level): The lowest dose or level of exposure to chemical substance during research when there is a statistic or biological significant increase in frequency or strength of side effects in the exposed referring to unexposed population.
4) FEL (Frank-effect-level): Certain biological response to chemical substance exposure is defined as irreversible damage or death.

Two most important factors for calculation of the possible effects of pollutant substance included in risk analysis are its concentration on the observed area and toxicity.

It means that in screening procedure for each chemical substance evaluation shall be done in each medium based on concentration of that matter and toxicity, which provides getting the risk factor for each medium separately.

Harmful effects of agents from polluted environment, i.e. the changes that occur in environment can lead to the increase of negative influences to health of people in several ways

- Intensive exposure to toxic matters can cause acute health effects,
- Exposure to low concentration of harmful substances in long period can lead to chronic diseases,
- Exposure to harmful substances which can cause genetic changes,
- Reduction of immunological capability of organism,
- Provoking subclinical irritation and unpleasant feeling and
- Influence to worsening of the existing illness.

Intensity of the organism exposure depends on:

- Agent quantity (concentration of the pollutant in air, water, soil),
- Toxicity of pollutant (acc.to classification),
- Number of take-ins (breathing, food, skin),
- Exposure time,
- Health condition

Harmful effects of polluted air are manifested as functional disorders or pathological lesions that can affect the function of organism as a whole, or which contribute to reduction of ability to successfully react to this effort.

Figure 3.3.8-1 schematically shows the range of biological responses of organism to the pollutants' exposure.

Scheme 3.3.8-1 Review of biological responses to pollutant

The base makes total stress of the body with pollution, i.e. to all that a man is exposed to (by breathing, food, etc.). Having in mind that most of the pollutants often cause effects to health, this influence is shown as a part of invisible effects, i.e. physiological and other changes with unproved significance. The other part of the pyramid make visible health effects, when there comes to side effects in terms of illness, even mortality.

Some groups within population can be extremely sensible to negative environment factors. These are marked as vulnerable groups: children, elderly people, chronical patients and those who are exposed to toxic substances or stress for a long time.

As a base for people health protection, having in mind total exposure, there are NORM/STANDARD /LIMIT VALUE/ MAXIMUM ALLOWED VALUE/ MAXIMUM ALLOWED DAILY ENTRY, which depends on the kind of source, kind of limit value that can be breathed without consequences, or taken orally or via skin passively.

Norm is a value which occurs after careful researching and collection of information, executed tests (dose-response, reaction) including the lowest level at which the visible changes are noticed. Every person has been exposed to air, water and food pollutants during his life (in external environment, home or working place)

As instruments for measuring of health condition, i.e. indicators of certain situation or reflection of such situation the indicators are used as variables which assist to measure changes directly or indirectly. In practice, the most frequent indirect and/or partial measures of complex situations which are too complex to be directly measured.

The short summary of all pollutants (Chapter 3.3.4 of this Study) which occur during B3 operation, as well as physical-chemical features that indicate that it is about the **non-cancerous group** of substances..

The operation of plant presents the conventional technological procedure which in its nature belongs to closed type of technological processes with modern automatic management and control processes. Plant operation does not make direct influence to human health of the employees. The work procedure with chemicals in certain processes belong to the level of usual activities controlled in existing procedures, where the quality level of work in the existing TPP Kostolac B is very high. During the operation of B3 it is necessary to apply prescribed measures for safety at work, which depends on the activity and certain unit systems (work with chemicals, and dangerous substances, work at high temperatures, work at height etc.) the special measures of protection at work are prescribed for activities during the overhaul of unit.

The health condition of the population in area affected by B3 unit is described in Chapter 5.8 of this Study, while the expected effects of the B3 operation to health are given in Chapter 6.8.

4. PRESENTATION OF THE MAIN ALTERNATIVES CONSIDERED BY THE PROJECT DEVELOPER

Within previous project phases for the new unit B3, different technical solutions have considered for its construction. Thereby, as factors of influence, potentials of raw material base and limited locations have taken into account, as well as contemporary technical and technological solutions, which are relevant for thermal units, which use lignite for combustion. On the other hand, it has been also raised the question of the financial resources of the project carrier.

4.1 Version for the power and technical solution of the unit

In accordance with previously said, within previous works, unit power and technical solution have considered as primary parameter. Unit power option depends mostly from raw material base, i.e. coal supplying possibility within calculated working unit lifetime (25+15 years). Option for Unit technical solution has determined by contemporary world practice, which refers to units in observed power range and coal characteristics.

Defining technical characteristics of reference thermal unit has been performed on the basis of conducted analyses of following main conditions for construction the new thermal capacity on the existing location TPP Kostolac, i.e.:

- exploitation coal reserves from OCM Drmno,
- planned maximal mine capacity,
- coal transport system from the mine to the power plant,
- spacious possibilities of existing location,
- usage possibility of existing auxiliary systems,
- conditions for environmental protection,
- integration the new unit into electric power system of Serbia,
- costs for new unit construction.

Taking into account available space for new capacity construction at the location TPP Kostolac B, the possibility of construction of one unit has been analysed, from the perspective of power and technical solution, following versions have considered:

- Version 1: unit with the power of 400 MW, conventional parameters,
- Version 2: unit with the power of 500 MW, overcritical parameters.

Solutions for both versions include built-in systems for emission reduction into air, i.e. boiler facility with systems for emission reduction for nitrogen oxides till 200 mg/m^3, electrostatic precipitator with limited values of solid particles separation till 30 mg/m^3 (dry gas, with 6% O_2), flue gas desulphurisation system and possibility of building the system for CO_2 separation (space is reserved for building the facility).

Base technical characteristics are following:

- Version 1
  - unit power (generator/outlet): 400/351 MW
  - live steam parameters: 185 bar/538°C
  - live steam flow: 1.256 t/h
  - condensate pressure: 0,048 bar

- specific heat unit consumption: 9.948 kJ/kWh
- fuel consumption: 3.102 mil.t/year

- Version 2
  - unit power (generator/outlet): 500/453 MW
  - live steam parameters: 284 bar/582°C
  - live steam flow: 1.459 t/h
  - condensate pressure: 0,048 bar
  - specific heat unit consumption: 9.477 kJ/kWh
  - fuel consumption: 3,82 mil.t/year

Basic technical-economical comparison of different technical solutions for the new unit shows that version 1 requests lower investments, some shorter construction time and lower dependence from foreign high technologies, while advantage of the version 2 is in higher value of energy efficiency, which achieves with the units with overcritical parameters.

Constructing these types of units (with overcritical parameters), primarily from the aspect of higher energy efficiency (unit efficiency is higher than 45%) relative to units with conventional parameters of similar power becomes more and more attractive. In the whole world (in Germany, Russia, USA, Japan, China) it has been built dozens unit of this type and it can be expected positive trend in following period.

Related to technical characteristics of reference thermal unit, as the results of previous works, it has been suggested construction of the unit with 500 MW with overcritical parameters (according to contemporary trends), based on:

- spacious possibilities of the location,
- rational exploitation of raw material base at OCM Drmno,
- lower specific investments per installed MW,
- possibility of integration into ecological capacity of the location.

Based on further activities which were connected to final decision about realisation the project of construction the new unit, and according to the possibilities to finance the project, it has been decided that the power of the unit is going to be 350 MW, with technical solution of the unit with overcritical parameters, as it was described in chapters 3.3 and 3.4 of this Study.

4.2 Solution version for disposal of solid waste

The analyses of following options for by-products disposal have been covered in general project:

- mechanical disposal of dry gypsum (with 10% of moisture) of commercial quality into open mine pit, with possibility of its later selling on mutual disposal site with the gypsum from the units B1 and B2,
- mixing gypsum slurry with thick hydro mixture ash and slag and its disposal onto ash and slag disposal site of the power plant,
- mechanical disposal of gypsum slurry (with 50% of moisture) into open mine pit, in moistened mixture with ash and slag.

Having in mind recommendations by LCP BREF, where it is stated and emphasised advantages of mutual disposal of gypsum slurry with ash and slag, in order to minimise possibility of particle scattering from the disposal site by forming „stable“ disposed material, as well as protection of necessary disposal site stability within open cast mine in the conditions of higher rainfalls and its undisturbed exploitation at the same time with disposal site operation, it has been adopted the solution of mutual disposal of solid waste from the unit B3 mechanically.

Having in mind foreseen technical solution for collecting ash, slag and gypsum by internal transport system within the unit B3 location, conditions for usage each of formed materials as secondary raw material and selling to the third party have been provided. By this act, one of the basic “3R” criteria (Reduce-Reuse-Recycle) for waste management has fulfilled.

4.3 Possibility of engaging the new Unit as combine source of electrical and heating energy

According to analyses, which were carried out, it can be concluded that solution for new facility as combine source of electrical and heating energy, even it is needed and possible, is not valid. The reasons why is that are following:

- lack of sufficiently large heating consumer, respectively impossibility to place significant heating power from the new Unit with electrical power over 300 MWe,
- due to insufficient engaging of heating power from the Unit, increasing its total thermodynamic efficiency from 35-36% to 38-39% on an annual basis is marginally. That does not provide status of privileged produce of that source,
- there is not reserve heating capacity, so in the case of the Unit shut down, beside peak capacities, reserve basic capacities has to be also provided,
- relief and geological characteristics along the potential connection route TPP KO B with TPP KO A are very unfavourable for performing and installing the main heating pipeline,
- possibility to ensure supplying consume area with hearing energy without unit B3, and after units A1 and A2 are going to be shut down, by construction the alternative heating source at existing location of TPP Kostolac A.

Based on displayed facts, the Unit B3 has designed as condensing unit.

5. PRESENTATION OF THE ENVIRONMENT CONDITION AT THE SITE AND NEARBY SURROUNDINGS

At the environment quality, which is under the influence of the unit B3 affects more different industrial complexes located nearby the unit. Among the others, these are TPP Kostolac A (two units with the power of 110, in total 210 MW), TPP Kostolac B (two units with the power of 348.5 MW each), open cast mine of lignite Drmno, ash and slag disposal sites at the location of Srednje Kostolacko Ostrvo and Cirikovac, as well as local sources of pollution within settlements Stari and Novi Kostolac, Petka, Bradarac, Klenovnik, Klicevac, Drmno.

5.1. Display of criteria for environment evaluation

Air quality

Requests for environmental air quality given in Table 5.1-1 are defined by Regulation of conditions for monitoring and requests for air quality (“Official Gazette of RS”, No 11/10, 75/10 and 63/13).

Table 5.1-1: Parameters for air quality evaluation

Averaging period	Limit value	Tolerance limit	Tolerance value	Deadline for achieving the limit value(1)
Sulphur dioxide				
One hour	350 µg/m^3, must not exceed more than 24 times during a calendar year	On January 1st, 2010, it is 150 µg/m^3. From January 1st, 2012, each year it minimises in every 12 months for 20% of starting tolerance limit so it could reach 0% on January 1st, 2016.	500 µg/m^3	January 1st, 2016.
One day	125 µg/m^3, must not exceed more than 3 times during a calendar year	-	125 µg/m^3	January 1st, 2016.
Calendar year	50 µg/m^3	-	50 µg/m^3	January 1st, 2016.
Nitrogen dioxide				
One hour	150 µg/m^3, must not exceed more than 18 times during a calendar year	On January 1st, 2010, it is 75 µg/m^3. From January 1st, 2012, each year it minimises in every 12 months for 10% of starting tolerance limit so it could reach 0% on January 1st, 2021.	225 µg/m^3	January 1st, 2021.
One year	85 µg/m^3	On January 1st, 2010, it is 40 µg/m^3. From January 1st, 2012, each year it minimises in every 12 months for 10% of starting tolerance limit so it could reach 0% on January 1st, 2021.	125 µg/m^3	January 1st, 2021.

Averaging period	Limit value	Tolerance limit	Tolerance value	Deadline for achieving the limit value(1)
Calendar year	40 µg/m³	On January 1st, 2010, it is 20 µg/m³. From January 1st, 2012, each year it minimises in every 12 months for 10% of starting tolerance limit so it could reach 0% on January 1st, 2021.	60 µg/m³	January 1st, 2021.
Suspended particles PM10				
One day	50 µg/m³, must not exceed more than 24 times during a calendar year	On January 1st, 2010, it is 25 µg/m³. From January 1st, 2012, each year it minimises in every 12 months for 20% of starting tolerance limit so it could reach 0% on January 1st, 2016.	75 µg/m³	January 1st, 2016.
Calendar year	40 µg/m³	On January 1st, 2010, it is 8 µg/m³. From January 1st, 2012, each year it minimises in every 12 months for 20% of starting tolerance limit so it could reach 0% on January 1st, 2016.	48 µg/m³	January 1st, 2016.
Suspended particles PM2.5 STADIUM 1				
Calendar year	25 µg/m³	On December 31st, 2011, it is 5 µg/m³. From January 1st, 2013, it minimises in every 12 months for 0.7143 µg/m³ to reach the value 0 on January 1st, 2019.	30 µg/m³	January 1st, 2019.
Suspended particles PM2.5 STADIUM 2(2)				
Calendar year	20 µg/m³	-	20 µg/m³	January 1st, 2024.
Lead				
One day	1 µg/m³	-	1 µg/m³	January 1st, 2016.
Calendar year	0,5 µg/m³(3)	On January 1st, 2010, it is 0.5 µg/m³. From January 1st, 2012, each year it minimises in every 12 months for 20% of starting tolerance limit so it could reach 0% on January 1st, 2016.	1 µg/m³	January 1st, 2016.(3)

Averaging period	Limit value	Tolerance limit	Tolerance value	Deadline for achieving the limit value(1)
Carbon monoxide				
Maximal daily eight hours mean value (4)	10 mg/m^3	On January 1st, 2010, it is 6 mg/m^3. From January 1st, 2012, each year it minimises in every 12 months for 20% of starting tolerance limit so it could reach 0% on January 1st, 2016.	16 mg/m^3	January 1st, 2016.
One day	5 mg/m^3	On January 1st, 2010, it is 5 mg/m^3. From January 1st, 2012, each year it minimises in every 12 months for 20% of starting tolerance limit so it could reach 0% on January 1st, 2016.	10 mg/m^3	January 1st, 2016.
Calendar year	3 mg/m^3	-	3 mg/m^3	January 1st, 2016.

1) *Time limit for reaching limit values starts from January 1st, 2010.*

(2) *Stadium 2 – indicative limit value.*

(3) *Limit value that should reach until January 1st, 2016, nearby certain industrial sources positioned at the locations that have been polluted by industrial activities for decades. In those cases, limit value, which should reach until January 1st, 2015, will be 1.0 µg/m^3. Area where higher limit values is applied should not be nearer than 1000 m far away from those sources.*

(4) *Source of maximal daily eight hours mean value is based on studying eight hours consecutive mean values, calculated on the basis of hourly updated data in every hour. Each calculated eight hours mean value has been attributed to the day in which determine the mean value finishes. The first calculation period for each single day is the period between 17:00h from the previous day until 01:00h of that day; the last calculation period for each single day is the period between 16:00h until 24:00h of that day.*

In the Table 5.1-2 are given maximal permitted concentrations of certain pollutants in order to protect human health, which apply in case of dedicated measuring (from the Annexes XII and XV at the Regulation).

Table 5.1-2: Maximal permitted concentration of the pollutants into air (aim values for human health protection and in case of dedicated measuring)

Substance	Averaging period	Maximal allowed concentration
Arsenic	Calendar year	6 ng/m^3
Hexavalent chromium	Calendar year	0,3 ng/m^3
Nickel	Calendar year	20 ng/m^3
Cadmium	Calendar year	5 ng/m3
Total sedimentary substances	One month	450 mg/m^2/day
	Calendar year	200 mg/m^2/day
Soot	One month	50 µg/m^3
	Calendar year	50 µg/m^3

Water quality

Maximal allowed concentrations (MAC) of pollutants for surface water are defined by Regulation about limit values of pollutants at surface and underground water and sediments and deadline for their reaching (“Official Gazette of RS”, No 50/12). Surface water quality is defined based on water classes, as it is stated in the Table 5.1-3.

Table 5.1-3: Water characteristics by quality classes (“Official Gazette of RS”, No 50/12)*

Item No	Indicator	Class I	Class II	Class III	Class IV	Class V
General						
1.	pH value	6,8-8,5	6,8-8,5	6,8-8,5	6,5-8,5	<6,5 or <8,5
2.	Suspended substances in dry water in mg/l, up to	25	25	-	-	-
Oxygen regime						
1.	Dissolved oxygen in mg O_2/l	8,5 or NL*	7	5	4	< 4
2.	Oxygen saturation, %	70-90	50-70	30-50	10-30	< 10
3.	Five days biochemical oxygen consumption in mg O_2/l, up to	1,5	5,0	7,0	25,0	> 25
4.	HPK (permanganate method), mg O_2/l	5 or NL	10	20	50	> 50
5.	Total organic carbon (TOC), mg/l	2,0 or NL	6,0	15	50	> 50
Nutrients						
1.	Total nitrogen, mg N/l	1 or NL	2	8	15	> 15
2.	Nitrates, mg N/l	1,5	3	6	15	> 15
3.	Nitrites, mg N/l					
4.	Ammonium Ion, mg N/l	0,05	0,1	0,6	1,5	> 1,5
5.	Phosphorus, mg P/l	0,05	0,2	0,4	1	> 1
Salinity						
1.	Chlorides, mg/l	50	100	150	250	> 250
2.	Sulphates, mg/l	50 or NL	100	200	300	> 300
3.	Total mineralisation, mg/l	< 1.000 or NL	1.000	1.300	1.500	> 1.500
4.	Electrical conductivity at 20°C, µS/cm	< 1.000 or NL	1.000	1.500	3.000	> 3.000
Metals						
1.	Arsenic, µg/l	< 5 or NL	10	50	100	> 100
2.	Boron, µg/l	300 or NL	1.000	1.500	2.500	> 2.500
3.	Copper, µg/l	5 - 112	5 - 112	500	1.000	> 1.000
4.	Zink, µg/l	30-500	300-2.000	2.000	5.000	> 5.000
5.	Chromium, µg/l	25 or NL	50	100	250	> 250
6.	Iron, µg/l	200	500	1.000	2.000	> 2.000
7.	Manganese, µg/l	50	100	300	1.000	> 1.000
Organic substances						
1.	Phenolic compounds	< 1	1	20	50	> 50
2.	Petroleum hydrocarbons	**	**	-	-	-

Item No	Indicator	Class I	Class II	Class III	Class IV	Class V
Microbiological parameters						
1.	Faecal coliforms, cfu/100 ml	100	1.000	10.000	100.000	> 100.000
2.	Total coliforms, cfu/100 ml	500	10.000	100.000	1.000.000	> 1.000.000
3.	Intensive enterococcuses, cfu/100 ml	200	400	4.000	40.000	> 40.000
4.	Number of aerobic heterotrophs, cfu/100 ml	500	10.000	100.000	750.000	> 750.000

NL natural level
** for small and middle watercourses, meter above mean sea level till 500 m*
*** petroleum products should not be in water in those quantities that:*
- *form visible film onto water surface or coating at watercourses banks and lakes,*
- *give recognisable taste of "hydrocarbon" to the fish,*
- *cause damaging effects in fish*

Underground water quality is defined by following demands:

- it is forbidden to enter pollutants into underground water if that kind of activity could lead to deterioration, i.e. deterioration of existing chemical status of underground water. That evaluates based on data got from monitoring implementation, in accordance with the regulations governing the field of water and environment protection;
- it is forbidden, directly or indirectly, to realise pollutants from the List I stated in the Table 5.1-4 into underground water;
- it is forbidden, directly or indirectly, to realise pollutants from the List II stated in the Table 5.1-4 into underground water till determine basic (zero) level of pollutants in the underground water body.

Table 5.1-4: List of pollutants which should not release into underground water ("Official Gazette od RS", No 50/12)

Hazardous materials list I	Hazardous materials list II
Organohalogen compounds and substances which could form mentioned compounds into water environment	metalloids and metals
Organophosphorus compounds	biocides and its derivatives which does not show in the List I
Organotin compounds	substances which have detrimental effects on underground water taste and/or smell, as well as substances which could create that kind of substances into underground water and make it useless for human use
Substances which have carcinogen, mutagen and teratogen properties and manifest them through or by water	toxic or steady compounds of silicone, as well as substances which could create above mentioned compounds, except those which are not noxious biologically or they transform into innocuous substances
Mercury and its compounds	phosphorus inorganic compounds and elementary phosphorus
Cadmium and its components	fluoride
Mineral oil and hydrocarbon	ammonia and nitrite
Cyanides	

Remediation values of concentration of hazardous and noxious substances and values, which could show significant contamination of underground water are defined in Regulation on systematic monitoring of soil quality, indicators for risk evaluation of soil degradation and methodology for remediation programme development ("Official Gazette of RS", No 88/10) and they are shown in the Table 5.1-5.

Table 5.1-5: Remediation values of concentration of hazardous and noxious substances which could show significant contamination of underground water (“Official Gazette od RS”, No 88/2010)

Metals	Remediation values (μg/l in solution)
Cadmium (Cd)	6
Chromium (Cr)	30
Copper (Cu)	75
Nickel (Ni)	75
Lead (Pb)	75
Zink (Zn)	800
Mercury (Hg)	0,3
Arsenic (As)	60

Soil quality

Regulation about systematic monitoring of soil quality, indicators for risk evaluation of soil degradation and methodology for remediation programme development (“Official Gazette of RS”, No 88/10) defines remediation values of pollutants in soil.

Noise

Noise measuring is defined by the Law on the Protection of Environmental Noise (“Official Gazette of RS”, No 36/09 and “official Gazette of RS”, No 88/10), Code on Noise Measuring Methodology, Content and Form of the Report of Noise Measuring (“Official Gazette of RS”, 72/10) and Decree on Noise Indicators, Limit Values, Methods for Indicator Measuring Noise, Disturbance and Adverse Effects of Environmental Noise (“Official Gazette of RS”, No 75/10).

In Table 5.1-6 are given limit values of noise in open space.

Table 5.1-6: Limit values of noise indicators in open space (“Official Gazette of RS”, No 75/2010)

Zone	Use of the space	Noise level, dB(A)	
		day and evening	night
1.	Areas for rest and recreation, hospital zones and nursing homes, cultural and historical sites, huge parks	50	40
2.	Touristic areas, camp areas and school zones	50	45
3.	Only residential areas	55	45
4.	Commercial and residential areas, trade and residential areas and playgrounds	60	50
5.	City centre, trade, administrative zone with houses, area along highways, motorways and local roads	65	55
6.	Industrial, storage and service areas and transport terminals without residential buildings	On the boundary of this zone, noise could not reach limit value in the zone with it is bounded*	

** Area zoning with respect to allowed noise level aspect has not finished yet. It may be assumed that zone which is bounded with TPP Kostolac, zone 1 or zone 2.*

5.2 Air quality

Emissions in the air – existing condition[5]

The most significant emitters of pollutants into the air at this location are TPP Kostolac A and B. in order to monitor and control emission of the pollutants, TPP Kostolac A and B have developed the systems for continual monitoring of the emission into the air for pollutants which are regulated by appropriate regulative, i.e. for sulphur dioxide, nitrogen dioxide and powdery substance.

During designing and construction period of the Units at TPP Kostolac A and B, measures for emission reduction into the air have not undertaken. Only electrostatic precipitator has been built, giving that, at that time, emission limit values (ELV) were not regulated, but the influence on air quality was evaluated according to emission values of some pollutants in the area of TPP.

In previous period, after enactment of regulation about ELV into the air, the first measure in order to comply with set emission limits was the reconstruction at electrostatic precipitators at those power plants. Those reconstructions have contributed in significant reduction of emission the powdery substance via flue gases.

The new deadline for compliant with ELV which are the part of LCP Directive for the operation of existing Units is end of 2023., while the deadline for compliant with ELV which are the part of Directive of industrial emission is end of 2017.

Until now, the reconstruction of electrostatic precipitators has done at all units in TPP Kostolac: at the Units A1 and A2 in TPP Kostolac A and at the Units B1 and B2 in TPP Kostolac B. The guarantee of the equipment supplier for mass concentration of powdery substances at the electrostatic precipitator outlet is ≤ 50mg/Nm^3, which is in accordance with EU regulative and regulative of Republic of Serbia.

By single measurements of pollutant emission into the air measured in 2015, it has been confirmed deviation mass concentration of powdery substances on the electrostatic precipitator outlet in relation to supplier guarantee at both Units in TPP Kostolac A, whereby increased flue gas temperature at the electrostatic precipitator inlet has been measured as well, and it was higher in relation to supplier guarantee. We have undertaken obligations to test all parameters, which have influence on the EP operation so we could undertake necessary measures in order to improve EP efficiency at TPP Kostolac A.

During 2015, we did guarantee measurements on EP at the Unit B1 in TPP Kostolac B, while at the Unit B2 in TPP Kostolac B we postponed again guarantee measurements which were foreseen to be done in December 2015, due to technical reasons (according to the contract, again guarantee measurements perform after one year of unit operation).

Mass concentrations of SO_2 in flue gas are significantly above ELV regulated by RS and EU regulatives. In order to decrease sulphur oxide emission under 200 mg/Nm^3, in accordance with EU regulatives, which must apply for those units which will operate after 2023, we plan to upgrade facilities for flue gas desulphurization according to agreed dynamic, defined with the European Commission. Until now we did technical documentation for desulphurization facility at TPP Kostolac B, as well as, the Study of assessment the influence of flue gas

[5] Report on environment condition in PE EPS in 2015, PE EPS, Belgrade, April 2016.

facility at TPP Kostolac B on the environment (the Ministry of Environment gave consent in August, 2015). Chinese government approved a credit for erecting the flue gas desulphurization facilities and their start of operation is planned for the end of 2016.

We are planning to do technical documentation for FGD facility at the units in TPP Kostolac A in second part of 2016, after making a final decision about further status of these units.

In 2012, we did the Study of directions for nitrogen oxides emission reduction from thermal power plants, which use coal in PE EPS. According to overview of the current situation of units regarding to nitrogen oxide emission into the air and defined by ELV, we have done the selection of optimal technical solution, which will ensure decrease of emission the mass concentration of nitrogen oxides up to 200 mg/Nm^3.

During 2013, in partnership with the Ministry of Energy, Development and Environment Protection and PE EPS together with the European Integration Office we started the activities for preparing the request for using funds from IPA fund donations for period 2014-2020. Those funds are necessary for implementation above mention measurements at the Unit A1 in TPP KO A and at the Unit B2 in TPP KO B.

We plan to implement mentioned measurements at the Units A1 and A2 in TPP KO A, as well as at the Unit B2, while during revitalisation the Unit B1 in TPP KO B we installed new burners with low NOx emission. Measurement results show significant decrease of nitrogen oxide emission. Before reconstruction, emissions were from 450 to 600 mg/Nm^3, and after burner reconstruction, results of the emission are in range of 218 - 230 mg/Nm^3, which is still above ELV. Deadline for reaching ELV of 200 mg/m^3 for all units in EPS is 2027 (according to the dynamic, which is defined in national emission reduction plan – NERP).

In accordance with all stated, in Table 5.2-1 are shown values of measuring concentrations of pollutants into the air from the stacks in TPP Kostolac A and B, as well as total annual emission in period of 2013-2015.

Table 5.2-1: Emission overview in the air from TPP Kostolac A and B

Pollutant	TPP Kostolac A		TPP Kostolac B	
	Unit A1	**Unit A2**	**Unit B1**	**Unit B2**
1. Sulphur dioxide				
- Concentration, mg/m^3	5.800-7.100	6.800-7.700	4.000-7.200	4.000-7.200
- Emission, t/year				
Year 2013.	9.017	37.898	35.498	49.425
Year 2014	8.657	31.306	6.222	34.508
Year 2015.	12.817	19.389	60.179	53.283
2. Nitrogen oxides, mg/m^3				
- Concentration, mg/m^3	250-440	300-430	280-460-	510-550
- Emission, t/year				
Year 2013.	519	2.335	2.431	4.382
Year 2014	453	1.879	426	3.390
Year 2015.	726	1.944	2.849	4.982
3. Powdery substances, mg/m^3				
- Concentration, mg/m^3	50-250	70-200	≤ 50	≤ 50-120
- Emission, t/year				
Year 2013.	280	1.273	3.945	477
Year 2014	87	438	691	355
Year 2015.	108	934	365	755

Emissions in the air – predicted condition

Based on current development plans in EPS, the new unit B3 should start operation in 2021. According to needs of electro energy system in Serbia and predicted increase of electric energy consumption after 2020, as well as EPS plans related to engaging certain electro energy units, it is expected that the Units in TPP Kostolac A, we are talking about the Unit A1 (reconstructed, if we make the decision about its continuation of operation after 2023, or based on “opt-out” regime, for operation until 2023) and the Unit A2 (reconstructed for operation in following 100 000 hours) and TPP Kostolac B (both units reconstructed for operation in following 100 000 hours).

In accordance with commitments regarding to obey the emission limits into the air, reconstructed units will have installed measures for emission reduction into the air according to IED demands. It means that concentrations of sulphur dioxide and nitrogen oxides will be ≤ 200 mg/m^3, and powdery substances ≤ 20 mg/m^3. In case of “opt-out” regime of operation for the Unit 1 in TPP Kostolac A, we do not foreseen emission harmonisation with ELV. In that case, predicted annual emissions are as stated in Table 5.2-2.

Table 5.2-2: Emission overview in the air form TPP Kostolac A and B after 2020.

Pollutant	TPP Kostolac A		TPP Kostolac B	
	Unit A1	Unit A2	Unit B1	Unit B2
1. Sulphur dioxide				
- Concentration, mg/m^3	5.800-7.100* 200**	200	200	200
- Emission, t/year	8.440* 270**	864	1610	1610
2. Nitrogen oxides, mg/m^3				
- Concentration, mg/m^3	300* 200**	200	200	200
- Emission, t/year	405* 270**	864	1610	1610
3. Powdery substances, mg/m^3				
- Concentration, mg/m^3	100* 20**	20	20	20
- Emission, t/year	135* 27**	86,4	161	161

Predicted annual unit engagement: TPP KO A1: 3.000 h, TPP KO A2: 5.000 h, TPP KO B1/B2: 6.000 h
* *The Unit A1 operates according to “opt-out” regime*
** *The Unit A1 has been reconstructed*

Beside above-mentioned measurements for emission, reduction via flue gases, in following period we expect totally to eliminate emission of the particles from disposal site “Staro kostolačko ostrvo”, having in mind that in TPP Kostolac A started to operate new system for thickened hydro transport of ash and slag toward disposal site in PK Ćirikovac. That will enable closing the existing disposal site “Staro kostolačko ostrvo” and recultivation before the start of operation of the Unit B3.

Air quality (imission) – existing condition

By control quality programme at the location of Kostolac basin, at following measuring points we measure quality parameters of the ambient air:

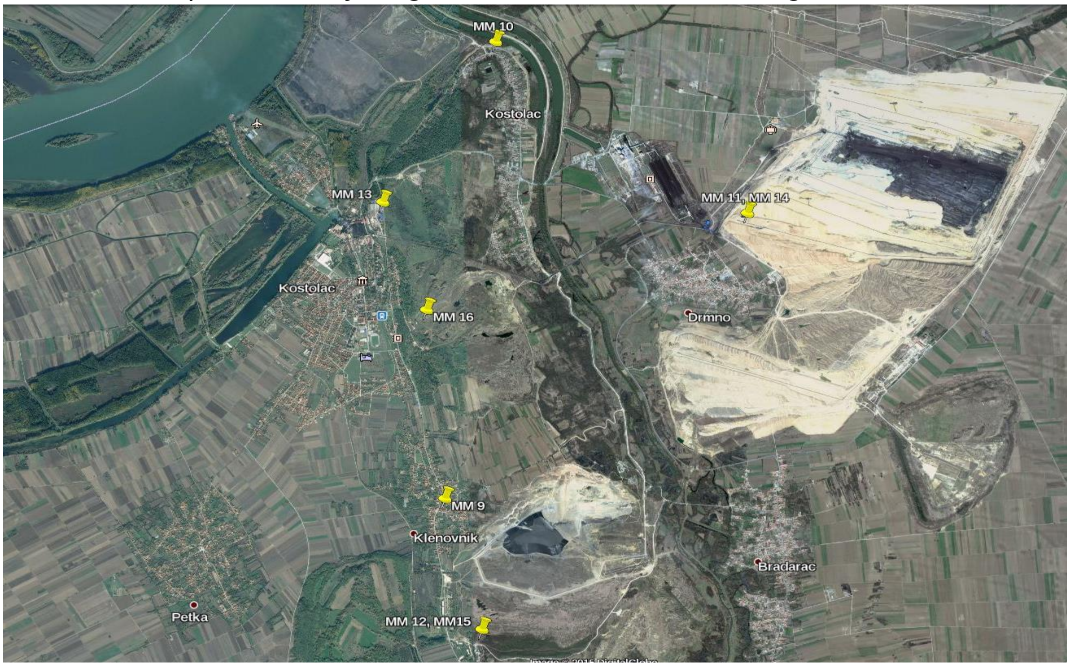
- Klenovnik (MM9),
- Stari Kostolac (MM10),

- Drmno (MM11),
- Ćirikovac (MM12).

Accredited labs conduct measuring programme (Institute for Public Health Požarevac etc.). Within the programme, we measure sulphur dioxide, soot, sedimentary substances and heavy metals (Pb, Cd, Zn, As, Ni). In the picture 5.2-1 is shown a location map with marked measuring points.

Pollutant transport into atmosphere carries out via airflow, and basic cause of spreading the cloud with those impurities is turbulent diffusion. Turbulent diffusion measure is variability of wind direction, so it is possible that even in the areas with light breeze; there are conditions for spreading air pollution. It is only necessary for wind; even it could be light breeze to change direction significantly.

Vertical temperature distribution, actually, vertical stratification presents measure of atmosphere stability, and this is one of main elements, which dictate dispenser impurity. Another significant element is wind. At the locations, which are poorly ventilated, which is not the case in Drmno, particles stay longer and concentrations are higher.



Picture 5.2-1: Measuring points of ambient air quality at the location of TPP Kostolac

In Table 5.2-3 are given annual mean value of total sedimentary substances (immission limit value ILV = 200 mg/m^2/day, Regulation of conditions for monitoring and requests for air quality ("Official Gazette of RS", No 11/10, 75/10 and 63/13) for 2013 and 2014, based on report on ambient air quality around TPP or 2013 and 2014.

Table 5.2-3: Annual mean value of total sedimentary substances for the period of 2013-2015.

Place of taking samples	Unit	Total sedimentary substances			ILV
		2013.	2014.	2015.	
MM9: Klenovnik	mg/ m^{2}day	163,7	164,0	148,9	200 (for the period of 1 year) 450 (for the period of one month)
MM10: Stari Kostolac	mg/ m^{2}day	164,4	207,8	167,9	
MM11: Drmno	mg/ m^{2}day	458,7	306,4	163,2	
MM12: Ćirikovac	mg/ m^{2}day	157,7	171,6	141,4	

Based on mentioned data it can ascertain that in 2014, at measuring points Stari Kostolac and Drmno ILV has exceeded for total sedimentary substances on annual level, while the imission in Klenovnik and Ćirikovac above determined limit value. During 2013, all ILV has exceeded at the measuring point Drmno. In 2015, we did not register increasing on monthly or annual level of ILV at any measuring point.

Mean monthly value of total sedimentary substance (TSS) in most cases do not increase ILV (monthly ILV=450 mg/m^2/day) at measuring point Drmno, while at other measuring points it is mostly under ILV.

The cause for these high TSS concentrations is, primarily the way of ash and slag disposal by technology of thin hydro mixture (ash : water = 1 : 10/15) onto Srednje Kostolacko Ostrvo disposal site, whereby it comes to segregation and sedimentation of large ash particles in deposal site, while the smallest fractions stay on the surface. When winds blow (otherwise, this area is very windy and dominant direction of the wind blowing is southeast-northwest),it comes to the erosion of the disposal site surface and lifting and spreading small ash fractures.

For increased TSS concentration also affects particle emission from the power plant stack, but in a smaller degree the height of the stack. That dominant influence on air quality (increased TSS concentration) has disposal site, we could see from the fact that the highest increased imission limit values for TSS are in places Stari Kostolac and Drmno.

Measured annual mean values of SO_2 concentration during 2013 and 2014 are shown in Table 5.2-4. Analysing the data, we can ascertain that in period from 2013 till 2014, there was not increasing of ILV even for 24 hours concentration (ILV for 24 hours concentration is 150 μg/m^3), and also not for mean annual value (50 μg/m^3, “Official Gazette of RS”, No 04/08). Mean annual values are under ILV at all measuring points.

Table 5.2-4: Mean annual value of SO_2 concentration into the air for period 2013-2015.

Place of taking samples	Unit	SO_2 concentration, μg/m^3			ILV for annual mean value
		2013.	2014.	2015.	
MM9: Klenovnik	μg/m^3	28,46	35,38	10,63	50
MM10: Stari Kostolac	μg/m^3	21,89	29,30	11,98	
MM11: Drmno	μg/m^3	21,66	30,65	12,78	
MM12: Ćirikovac	μg/m^3	23,81	32,86	10,63	

In Table 5.2-5 are shown annual mean values of sooth for 2013 and 2014, which show that emissions are under limit values allowed by the law.

Table 5.2-5: Mean annual values of sooth concentration into the air for period 2013-2015.

Place of taking samples	Unit	Sooth concentration, μg/m^3			ILV for annual mean value
		2013.	2014.	2015.	
MM9: Klenovnik	μg/m^3	7,16	6,92	13,13	50
MM10: Stari Kostolac	μg/m^3	6,14	6,79	11,59	
M11: Drmno M	μg/m^3	6,74	6,98	12,25	
MM12: Ćirikovac	μg/m^3	7,38	6,73	12,88	

Mechanism of spreading the particles entered in atmosphere depends of spacious distribution of series of meteorological element, and mostly it depends of spacious distribution of temperature and wind.

In case of TPP Kostolac, there are high pointed, continual sources (stack at TPP) and surface sources (open dumps for tailing and ash disposal site). Stacks could be significant source of powdery substances emission, having in mid that emitted particles have very fine granulation, with significant part under 10 microns. Particles emitted in this way have far greater range related to those lifted from ash holes and open dumps, which mostly pollute nearby area.

Immissions PM10 are measured at following measuring points:

- Prim (MM13),
- Georad (MM14),
- Main office of ash and slag disposal site PK Ćirikovac (MM15),
- Klenovnik Kostolac services (MM16).

Measuring results of the imission PM10 in nearby TPP Kostolac B from the period 2013-2015 are shown in the Tables from 5.2-6 to 5.2-8. In red are marked values of concentrations PM10, which are above ILV on daily basis (50 μg/m^3). It can be noticed that the greatest number of increasing happens during winter, at the measuring point MM13, which is nearby disposal site Srednje kostolačko ostrvo, and MM14, which is nearby open cast mine Drmno. The smallest number of exceeding was recorded in 2015, which is probably resulted by lack of data for period January-March, when, otherwise, is the most frequent period of recorded exceeded pollution levels PM10.

During measuring period PM10 from 2014, it was also analysed content of heavy metals (nickel, lead, arsenic and cadmium) in suspended particles. Results show of exceeding limit values for arsenic during periods when increased concentrations of PM10 were recorded.

Table 5.2-6: Maximal and mean monthly daily values of PM10 concentration into the air in 2013

μg/m^3

Month	Measuring point							
	MM13		MM14		MM15		MM16	
	Maximal value	Mean value	Maximal value	Mean value	Maximal value	Mean value	Maximal value	Mean value
January	71,0	35,7	91,0	66,1	59,0	33,7	40,0	30,6
February	39,0	30,4	69,0	24,0	97,0	61,0	69,0	37,9
March	84,0	45,0	34,0	23,7	59,0	27,9	42,0	21,9
April	52,0	38,2	69,0	50,7	43,0	30,4	29,0	25,3
May	48,0	32,1	49,0	19,6	65,0	40,7	33,0	24,3
June	39,0	23,7	54,0	27,1	36,0	26,1	23,0	18,9
July	56,0	38,2	99,0	51,0	38,0	25,3	47,0	28,0
August	65,0	36,7	119,0	46,3	41,0	29,9	39,0	34,0
September								
October								
November								
December								
Mean annual value	**56,8**	**35,0**	**73,0**	**38,6**	**54,8**	**34,4**	**40,3**	**27,6**

Table 5.2-7: Maximal and mean monthly daily values of PM10 concentration into the air in 2014

μg/m³

Month	Measuring point							
	MM13		MM14		MM15		MM16	
	Maximal value	Mean value	Maximal value	Mean value	Maximal value	Mean value	Maximal value	Mean value
January	82,0	32,7	53,0	36,9	75,0	59,0	94,0	50,1
February	61,0	32,4	56,0	32,9	38,0	24,3	72,0	45,4
March	991,0	198,9	48,0	33,7	58,0	28,4	62,0	29,7
April	60,0	36,7	96,0	46,3	25,0	20,3	21,0	14,4
May	31,0	23,7	34,0	22,2	30,0	23,6	19,0	13,0
June	43,0	33,7	24,0	19,1	42,0	25,3	39,0	28,9
July	43,0	26,6	34,0	28,4	33,0	28,7	35,0	24,3
August	47,0	32,1	36,0	23,1	38,0	19,1	47,0	31,4
September	34,0	27,6	44,0	30,6	36,0	29,1	37,0	27,8
October	46,0	20,1	70,0	38,3	56,0	29,3	68,0	47,4
November	82,0	40,4	16,0	10,8	69,0	42,8	64,0	31,3
December	64,0	48,1	63,0	43,6	144,0	35,3	116,0	53,9
Mean annual value	132,0	46,1	47,8	30,5	53,7	30,4	56,2	33,1

Table 5.2-8: Maximal and mean monthly daily values of PM10 concentration into the air in 2015

μg/m³

Month	Measuring point							
	MM13		MM14		MM15		MM16	
	Maximal value	Mean value	Maximal value	Mean value	Maximal value	Mean value	Maximal value	Mean value
January								
February								
March								
April	47,7	31,5	47,1	32,8	40,6	27,8	38,2	22,3
May	34,8	29,9	39,1	29,4	34,6	21,1	28,1	21,2
June	32,6	21,7	64,5	39,5	30,8	26,1	23,7	17,3
July	62,7	32,8	78,5	38,4	22,1	20,0	37,9	27,9
August	24,8	12,3	44,0	29,8	34,6	29,1		
September	47,7	25,9	36,6	19,6	30,3	22,3		
October	57,6	34,8	52,7	27,8	21,6	15,4		
November	72,7	57,6	84,6	28,9	148,5	72,9		
December								
Mean annual value	47,6	30,8	55,9	30,8	45,4	29,3	32,0	22,2

By continual monitoring, the ambient air quality it was not identified ILV increasing of heavy metals, only in case of arsenic, which in 2013 exceed ILV.

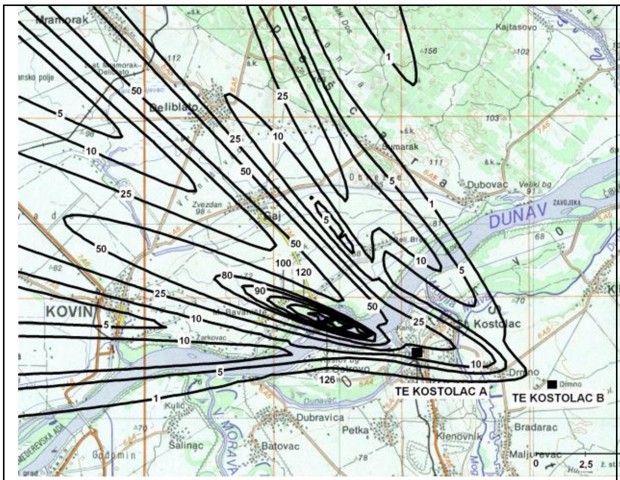
Air quality (imission) – predicted condition

Having in mind the dynamic of Unit B3 construction, as well as predicted operation of existing units at TPP Kostolac A and B, air quality condition, before starting the operation of the new unit, will be different comparing to shown existing condition. Firstly, changings will be conditioned by construction FGD facility at the Units B1 and B2 in TPP Kostolac B, (start the construction is planned for the end 2016). Besides that, in case of making the decision to continue with operation of the Units A1 and/or A2 in TPP Kostolac A after 2023, it is necessary their reconstruction, and also building all necessary environment protection measures.

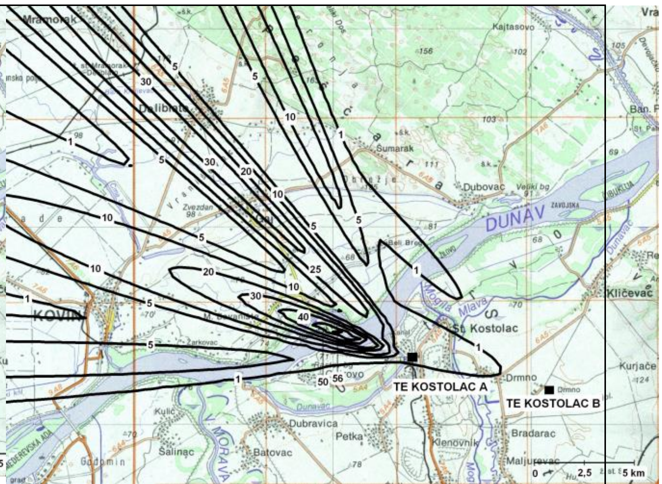
According to the said, it is also real to predict significant increase of air quality related to existing condition, which will reflect into decreasing pollutant concentration emitted into the air by flue gases, and thereby decreasing their content into ambient air.

In case of sulphur dioxide, for which will realise the most significant emission decrease, comparison of existing and planned condition for characteristic weather conditions are shown in the pictures 5.2-2 and 5.2-3. (It shows the wind from southeast direction, which is the most probably for this are and in that period, it comes to the superimposition of emission influences from the units at the location of TPP Kostolac A and B).

When we are talking about nitrogen oxides, concentration changes will be less expressed before and after units' reconstruction, having in mind that by predicted measures, emission decreasing for 50-70% will achieve, but flue gases parameters are also changed (lower temperature and less flue gas outlet velocity). Having in mind that ELV for sulphur and nitrogen oxides for revitalised units with the power of 300 MW the same, predicted imission levels of nitrogen oxides are the same as the one shown for sulphur oxides.



Picture 5.2-2: Distribution of mean daily concentrations of sulphur dioxides in the area under the influence of TPP Kostolac A and B – existing condition, μg/m^3



Picture 5.2-3: Distribution of mean daily concentrations of sulphur dioxide in the area under the influence of TPP Kostolac A and B – condition after implementation FGD facilities, μg/m^3

5.3 Soil quality

In previous period, branch TPP Kostolac did monitoring of soil quality in each two years, and from 2015, it did each year. During 2012, we did measuring at the wide area of the company, which cover around 450 km^2. Results from those testing show that average value of heavy metal total content in the soil of tested are common for agricultural land. The total content of the most heavy metals, as they are zinc (Zn), mercury (Hg), lead (Pb), cadmium (Cd), copper (Cu) none of the samples exceed maximal allowed concentration (MAC). The total content of arsenic (As) and chromium (Cr) in two samples is above MAC, while nickel (Ni) in 40% of the samples is above MAC.

In 2015, the Institute of Soil Science, Belgrade did sample taking and soil quality testing. On taken samples, following analyses are done: physical characteristic of the soil, chemical characteristic of the soil, soil reaction, humus content, content of the total nitrogen and organic carbon in soil, content of nitrate and nitrite ion, content of easily accessible phosphor and potassium, content of heavy months and other toxic elements.

Soil control programme includes: on site or in laboratory measuring at representative measuring points, which are market in topographic maps (places are determined by GPS). This will enable monitoring the changes of tested parameters, at same measuring points in following period. Testing is done two times a year. Measuring points are defined depending on the distance from disposal site:

- from the disposal site (ash)
- in impacted zone as follows: zone 1 – to 1 km from the disposal site, zone 2 – from 1 km to 3 km from the disposal site and zone 3 – from 3 km to 5 km from the disposal site
- outside the impacted zone of disposal site (control measuring).

Data evaluation has carried out in accordance with the Regulation on systematic monitoring of soil quality, indicators for risk evaluation of soil degradation and methodology for remediation programme development (“Official Gazette of RS”, No 88/2010), the Code on allowed quantities of dangerous and harmful substances into the soil and water for irrigation and methods for their testing (“Official Gazette of RS”, No 23/94).

We analysed total of 58 soil samples in the area of each disposal site (SKO and Ćirikovac). With regard to heavy metal content, it was recorded exceeding nickel content regarding to MDK in 25 soil samples in the area of each disposal site, as well as exceeding lead content in two samples from almost each disposal site. For other analysed materials, we did not record exceeding in any sample. Content of heavy metal and other toxic elements in ash and soil was around common concentration values and below remediation values for: chromium (Cr), cadmium (Cd), mercury (Hg), arsenic (As) and iron (Fe).

Measured values are far below remediation, when remedial measures are needed. Taking all soil testing results into consideration, we can conclude that testing area is not contaminated by most heavy metals. As more expressed pollutant is nickel (Ni), which high content is conditioned by geochemical content of mother substrate. In addition, differences in mean values of metal by zones do not clearly indicate at influence on distance of pollutants to pollutant content, especially due to large variation of values within the same zone.

5.4 Surface water quality

Surface water and wastewater quality control programme in the area under the influence TPP Kostolac include measures of physic-chemical, bacteriological and radiological parameters: air and water temperature, turbidity, pH, electrical conductivity, dissolvable O_2, % of O_2 saturation, chemical treatment of condensate (CTC), biochemical oxygen demand (BCD_5), evaporation residue of unfiltered water, evaporation residue of filtered water, suspended substances, sediment substances, total surfactants, mineral oils, phenols, alkalinity, F, Cl, NO_2, NO_3, SO_4, PO_4, NH_4, Ca, Mg, hardness, Al, Fe, Mn, Cd, Cr^{6+}, total Cr, Cu, Ni, Zn, Pb, Hg, As, B, α and β activity, microbiological analysis.

These controls include:

- waste water in the area of its appearance and/or drainage into warm water canal,
- river water – water recipient at the profiles upstream and downstream from the place of wastewater drainage.

We carry out wastewater quality control in the branch TPP Kostolac and its influence to water recipient and underground water 12 times per year for water recipient and 4 times per year for underground water, atmospheric and sanitary water.

In the Table 5.4-1 are shown summed up results for wastewater quality measure and water recipient for the period 2013-2015.

By analysing these data from the table, we can conclude that the Mlava River does not suffer significant negative influences from TPP Kostolac B, because the concentrations of pollutants are below maximal allowed concentrations.

The most significant harmful impacts of the ash and slag disposal site come from arsenic and sulphates, which migrate from disposed mass into underground and surface water. Sulphate ion migrates the quickest and it is considered as excellent indicator of underground water contamination due to disposal site operation. Measuring of the pollutants into underground water performed in piezometers at disposal site area.

We control the river Mlava water quality once in a month at the profile Petrovac, according to the same parameters as on the river Danube, and it should, according to above mention regulation to correspond to the second class quality. For this Study, these results are not reference having in mind that measuring point is upstream form TPP at about 50 km, and that between measuring point and TPP exist significant sources of contamination of utility type. It is estimated that it could affect deterioration quality of water in the river Mlava regarding to quantity of dissolvable oxygen, biochemical and chemical oxygen consumption and intensity of microbiological contamination.

Water temperature in the river Mlava downstream from the cooling wastewater flow from TPP Kostolac B, on average increases for 1^oC, and after the Mlava river's entrance to the Danube, water temperature in the Danube has not changed.

Table 5.4-1: Wastewater quality and water recipient during 2013 and 2014.

Water	Wastewater quality and water recipient		
	Year 2013.	**Year 2014.**	**Year 2015.**
Water recipient	There are not significant changes in water quality of the Mlava river downstream/upstream from the TPP Kostolac B for reference parameters: Arsenic: upstream and downstream: 5 µg/l (MAC= 50 µg/l) Sulphates: upstream: 33,78-97,42 mg/l, downstream: 29,93 - 56,63 mg/l Mineral oils: upstream <50 µg/l, downstream <50 µg/l (MDK = 50 µg/l) Temperature: Increasing the river temperature downstream up to 3°C (according to EU regulations)	There are not significant changes in water quality of the Mlava river downstream/upstream from the TPP Kostolac B for reference parameters: Arsenic: upstream and downstream: 20 µg/l (MAC = 50 µg/l) Sulphates: upstream: 34-45 mg/l, downstream: 24,62 - 53,2mg/l Mineral oils: upstream: <50 µg/l, downstream: <50 µg/l (MDK = 50 µg/l) Temperature: Increasing the river temperature downstream up to 3°C (according to EU regulations)	There are not significant changes in water quality of the Mlava river downstream/upstream from the TPP Kostolac B for reference parameters: Arsenic: upstream and downstream: 20 µg/l (MAC = 50 µg/l) Sulphates: upstream: 28-62 mg/l, downstream: 26-69 mg/l Mineral oils: upstream: <50 µg/l, downstream: <50 µg/l (MDK = 50 µg/l) Temperature: Increasing the river temperature downstream up to 3°C (according to EU regulations)
Drainage wastewater	Electrical conductivity: 580 - 1.240 µs/cm Arsenic: 0,005 - 0,033 µg/ Sulphates: 235,16 - 839,2 mg/l	Electrical conductivity: 766 - 1.319 µs/cm Arsenic: 20,8 - 300 µg/ Sulphates: 437,2 - 667,6 mg/l	Recirculation of drainage and overflow water from the disposal site has been carried out
Overflow wastewater from the disposal site	Electrical conductivity: 570 - 940 µs/cm Arsenic: 0,04 - 0,13 µg/ Sulphates: 57,66 - 538,59 mg/l	Electrical conductivity: 692 - 1.416 µs/cm Arsenic: 20 - 20,9 µg/ Sulphates: 375,7 - 976,3 mg/l	Recirculation of drainage and overflow water from the disposal site has been carried out

5.5 Groundwater quality

Many years of research have shown that the sulphate and arsenic concentrations are the most important parameters of monitoring ash disposal site impact on groundwater. The quickest to migrate, sulphate ion from disposal site is deemed to be an excellent tracer in monitoring the disposal site impact on the groundwater. On the other hand, arsenic is very slow to enter the groundwater, as it is previously absorbed on the aluminosilicate base (ash from the disposal site and/or clays making an integral part of the soil).

For the purpose of groundwater quality review, existing data on groundwater quality were analysed and shown, which are monitored on regular basis by water quality analysis using piezometers installed:

- in vicinity of ash disposal site (piezometers EP-1, EP-2, PSK-30 and PSK-31),
- at old disposal site (C1, V1 – near cassette C, NK4, NK6 near cassette A),
- in vicinity of coal stockyard (D4 and D5),
- from drainage well lines at open cast mine Drmno.

Quality of groundwater in vicinity of ash disposal site

For the needs of TPP Kostolac B, as-is, i.e. “zero state” of the groundwater quality in the ash internal disposal site OCM Ćirikovac is recorded, enabling monitoring the changes in quality level as well as assessment of the impact of the ash disposal site operation on the groundwater quality.

Environmental monitoring program implemented by TPP Kostolac B encompasses measurements of the quality of groundwater in piezometers located near cassette B, cassette C of the disposal site "Central Kostolac Island" and ash disposal site OCM Ćirikovac (seven sites in total). Measured values of quality parameters in the period 2013-2015 show increased concentration of sulphates, arsenic, ammonia and nitrites comparing to MAC for drinking water.

Quality of groundwater in vicinity of coal stockyard

Design anticipated for water containing oil to be discharged from thermal power plant to coal stockyard and then to be combusted together with coal. In order to monitor impact of this operation, piezometers are installed in vicinity of coal stockyard. Analysis of mineral oil content, in this water, showed that enormous pollution of this water occurs and discharge of water containing oil to coal stockyard was stopped. Since then, concentration of mineral oil decreases in these piezometers. However, certain measurements show significant increase of mineral oil concentration, which implies possibility of uncontrolled leakage of water containing oil to coal stockyard.

Content of mineral oil in all piezometers is very often above MAC, which is caused by inadequate treatment of water containing oil, i.e. the fact that there is no plant for this water purification. It is anticipated to construct this plant (funds provided from EAR donation), and design and technical documentation is currently being prepared.

Quality of groundwater in the area of open cast mine Drmno

It is groundwater of mild alkali type (average pH value is 7.72), with moderate mineral content (dry remaining of around 400 mg/l) and hardness which is almost of carbonate type (around 18º dH). Sulphates content is up to 70 mg/l, at average of around 40 mg/l. Calcium content is up to 110 mg/l, at average of 80 mg/l. Magnesium content is up to 50 mg/l, at average of around 25 mg/l.

Iron content at average is around 0.2 mg/l. Arsenic, mercury, chrome and cadmium are in concentration of up to 1 µg/l. Lead is with average concentration of 15 µg/l, copper content is at average of 130 µg/l and zinc of 230 µg/l.

Comparison of data from 1991-1992, with test results of groundwater taken from "Drmno" source during last years, it can be concluded that there are no significant changes regarding groundwater quality.

Latest measurements show the following:

1. **Arsenic concentration** in groundwater (piezometers) was occasionally slightly above MAC, 10 µg/l, of drinking water, in surrounding of ash disposal site "Central Kostolac Island". Arsenic concentration was in range from 0.005 to 0.015 mg/l. At ash and slag internal disposal site OCM Ćirikovac, concentration of arsenic did not exceed MAC:
2. **Calcium and magnesium concentration** in groundwater exceeded MAC of drinking water, 200 mg/l i.e. 50 mg/l. Calcium concentration was in range from 161 - 350 mg/l and manganese from 5 – 123 mg/l. At ash and slag internal disposal site OCM Ćirikovac, concentration of calcium did not exceed MAC, while one value of magnesium was above MAC (70.9 mg/l).
3. **Concentration of sulphates** in groundwater is variable and it was above MAC of drinking water, of 250 mg/l, at all measuring points and it was in range from 407 to 1.056 mg/l. At ash and slag internal disposal site of OCM Ćirikovac, concentration of sulphates exceeded value of MDK of 485 mg/l in one sample.
4. **Concentration of manganese** often varies and it is often higher or lower than MAC and it is in range of 0.02-0.77 mg/l. At ash and slag internal disposal site OCM Ćirikovac, concentration of manganese was in range of 0.02 – 2.85 mg/l.
5. **Concentration of nitrites** in all tested water was less than 0.005 mg/l, while concentration of ammonia was in range of 0.02 to 41. At ash and slag internal disposal site OCM Ćirikovac, concentration of nitrites did not exceed MAC, and for ammonia it was in range of 0.09 to 1.045.

5.6 Ionizing radiation

During coal combustion, combustion of organic substances occurs while radionuclides are deposited on ash and slag which causes increase of ash and slag activity related to coal.

Control of radioactivity in environment and in work environment has been performed on regular basis since 1990. In 2012, control of radioactivity was performed in work environment of the company TPPs-OCMs Kostolac d.o.o. by Institute of radar medicine of Serbia dr Dragomir Karajović. Control included gamma-spectrometric analysis of samples:

- coal,
- ESP ash,
- slag below afterburning grate,
- ash from active and passive cassettes,
- plants from ash disposal site,
- soil which is in range and out of range of disposal site impact,
- plants from this soil.

Also control of total alpha and beta activity of wastewater and absorbed dose of gamma radiation was performed. Based on obtained results, the following was determined:

- Results of spectrometry of coal, slag, ash and soil gamma emitters point out that obtained values of natural radionuclides concentration are of the same value as recorded in thermal power plants in other countries;
- Concentration of natural and produced radionuclides in plants, soil and water, is not different in relation to same samples which are in other areas of our country or in the world;
- Since there are no special legal regulations on concentration of natural and produced radionuclides in samples from work environment of thermal power plant, performing comparison with recorded data from the world is one possibility of getting overall view regarding environmental impact of thermal power plant operation;
- Intensity of absorbed dose of gamma radiation in lower layer of atmosphere varies within limits of basic radiation level;
- All water tested is in compliance with valid Rulebook on hygienic quality of drinking water.

General conclusion, based on all analyses performed, within project of "Control of radioactivity of work environment of the company TPPs-OCMs Kostolac d.o.o." implies that implemented protective measures have effect in prevention of increased contamination of natural radionuclides.

5.7 Noise

Occurrence of noise which is registered away from TPP Kostolac B main facility, is caused by regular operation of units, especially during units start-up as well as in special situations during regular operation (safety valves activation).

Noise measurement was performed in 2014 at six measuring points in accordance with Law on protection against noise in environment (Official Gazette of RS No. 36/2009 and Official Gazette of RS No 88/2010), Rulebook on methodology of noise measurement, content and form of reporting on noise measurement (Official Gazette No. 72/2010) and Regulation on noise indicators, limit values, methods for noise indicators evaluation, disturbance and harmful effects of noise in the environment (Official Gazette No. 75/2010). Measurements were performed during summer period, during day and night at the following measuring points.

Noise measurement results are given in the Table 5.7-1.

Local self-government (Kostolac city) did not perform acoustic zoning of area in accordance with Law on protection against noise in environment ("Official Gazette of RS", No. 36/09 and 88/10). Since there are no clearly limited acoustic zones, neither measuring points can be accurately determined nor limit values at these measuring points. This is the reason for not being able to evaluate compliance with legal requests for the branch TPPs-OCMs Kostolac.

Results obtained by measurement show that the reference noise level exceeds the values of 50 dB(A) at all measuring points except “FIO Minel” and “put ka Klićevcu” measuring points, while the highest values are registered at Viminacium measuring point.

Table 5.7-1: Noise level measurement results in 2014 and 2015 in Kostolac Basin

Measuring points	TEKO A		TEKO B		OCM Drmno	
	River police	FIO Minel	Viminacium	Mlava lock chamber	Vidikovac	Klicevac road
2014						
Day and evening	54; 52; 54	46; 46; 45	63; 63; 63	55; 55; 55	56; 56; 56	42; 42; 42
Night	54; 53	44; 44	62; 62	55; 54	55; 55	41; 41
2015						
Day and evening summer period	56; 58; 57	20; 48; 49	57; 54;;57	48; 48; 48	61; 59; 61	61; 61; 60
Night summer period	58; 57	47; 47	57; 57	48; 49	56; 57	60; 60
Day and evening night period	53; 54; 54	44; 43; 45;	63; 64; 63	53; 53; 54	55; 62; 64	51; 46; 51
Night night period	52; 52	43; 42	58; 59	56; 55	64; 62	57; 56

5.8 Health status of population

Review of health status of population was prepared on the basis of regular annual Report of the Institute of Public Health, Pozarevac, named "Analysis of health status of population in Branicevo region, for the period 2011-2014". Performed analysis of health status of population of Branicevo region is based on regular data of demographic and health statistics and it is cross section of population health status in the analysed period.

According to demographic assessments of 30.06.2014, population of 177,217 inhabitants in total lives on the territory of Branicevo region, with an average population density of 46 people per 1 km^2. The city of Pozarevac is the most populated with 74,328 inhabitants, and the least populated is Golubac municipality with 7,940 inhabitants. Compared to 2012, population decline of around 2.5% was recorded.

Population living on the territory of the observed region belongs to older population, with an average age of 44.6 years. Share of adults aged 65 and over in total number of population is 21.40%.

According to the latest official data of the Statistical Office of the Republic of Serbia from 2012, vital characteristics of Branicevo region, viewed through natural population changes (livebirths and deaths), show slightly better situation compared to the previous two years. Birth rate in 2012 is still low and amounts to 7.5/1000, while the overall mortality rate is high and amounts to 18.6‰.

Natural population growth rate in 2014 on the mentioned territory is very low (- 11.1% compared to -11.20‰ in 2012), with negative values in all municipalities, but with regard to the previous two years it is slightly better. It is -5.3‰ (compared to -6.38‰ in 2012) in Pozarevac, and even -12.0‰ in Veliko Gradiste.

The overall morbidity, as indicator of health status of population on the territory of Branicevo region, is monitored through reports on diseases, conditions and injuries on the level of community health centres in the subject region. In 2013, 412,657 diseases were registered within primary health care, while in 2014, the relevant figure was 336,861 which shows that, according to the number of healthcare users on the territory of the region, there are 2.3 diseases per capita in 2013, i.e. 1.9 diseases per capita in 2014.

Most common registered diseases, conditions and injuries according to International Classification of Diseases and Related Health Problems 10th Revision (ICD – 10) for persons treated at the primary healthcare level, in 2014, were respiratory system diseases (29.64%), diseases of circulatory system (12.34%), diseases of urinary and genital system (8.69%) and pathological clinical and laboratory findings (8.1%). The situation was similar in the previous years.

According to number of reported infective and parasitic diseases in 2014, on the territory of this region, 10,402 ill persons were registered (compared to 16,548 ill persons in 2013). The most common of reported infective diseases are, as in the previous two years, the following: influenza, varicella, diarrhoea and gastroenteritis.

Chronic non-infective diseases as modern-age diseases are constantly growing and are legally subject to mandatory registration and deregistration in accordance with the Rulebook on registering form and its maintenance, application form and the procedure of registration and deregistration related to certain diseases (Official Gazette of the Republic of Serbia, No. 2/80 and 42/86). According to data of the Institute of Public Health Pozarevac for 2013, number of registered chronical non-infective diseases shown as sum of received notices of beginning/ending of these diseases and registered diagnosis with confirmation of death of persons who suffered from these diseases, the most common chronical non-infective diseases were: malignant diseases, acute coronary syndrome and diabetes.

Hospital treatment was mostly used by persons aged 65 and over, in the period 2011 – 2014. In 2013, hospital treatment is used by 8,014 persons aged 65 and over, which makes 37.4% of total number of persons treated in hospitals. The main reason for hospital treatment in of Branicevo region hospitals, were circulatory system diseases (16.9%), digestive system diseases (12.2%) and tumours (11%).

Absenteeism, i.e. temporary absence from work, as well as disability, i.e. any restriction or inability to perform due to disability an activity in the manner which is deemed normal for human being, are very important indicators of health status of population. According to Report on temporary disability – inability to work during 2014, 15,009 cases of absenteeism in total is registered on the territory of Branicevo region, with 374,813 days of absence from work. Compared to the previous year, number of absenteeism cases is lower by 6.4%; and number of days of absence from work is by 0.04% higher compared to the previous year.

Results of analysis related to temporary inability to work in Branicevo region show that the most of the cases mentioned, as well as the most of the days of absence from work in 2014 were due to illnesses and injuries unrelated to work (79.64% cases and 51.17% days). In 2014, rate of cases of disability/inability to work is 44 out of 100 employed workers. (estimated number of workers for Branicevo region according to the Statistical Office of the Republic of Serbia is 34,260 workers).

On the basis of specified results, it may be concluded that disability and absenteeism are problems that all Branicevo region municipalities are facing and which has a significant impact on results of analysis related to health status of population.

In 2013, a total number of 50,252 diseases of preschool children (0 - 6 years old) was registered, with the rate of 4,870.8/1,000, i.e. 4.87 diseases per child, which is by 0.07 diseases more than in the previous year. In 2014, a total number of 45,966 diseases was registered with the rate of 5,742.9/1000, i.e. 5.74 diseases per child, which is by 0.87 diseases more than in the previous year. The most common groups of diseases and conditions per ICD – 10, as in the previous years, were diseases of respiratory system and ear (66%, i.e. 58.14%), as well as symptoms, signs and pathological clinical and laboratory findings (8.79%, i.e. 10.64%).

According to results of analysis, it may be concluded that the first place, regarding preschool children on the territory of Branicevo region, as well as in the previous years, belongs by far to diseases of respiratory system with the share of 58.14%. Morbidity rate related to respiratory system diseases was 3,338.8/1,000.

In 2013, total number of 22,591 school children and adolescents from 7 to 18 years old used healthcare, while in 2014 the relevant figure was 18,706. In 2013, total number of 61,803 diseases with the rate of 2,735.74/1,000 was registered, i.e. 2.7 diseases per school child, which is by 0.2 diseases less than in the previous year. In 2014, total number of 54,515 diseases with the rate of 2,914.3/1000 was registered, i.e. 2.9 diseases per school child, which is by 0.2 disease more than in the previous years.

According to ICD – 10, the most common groups of diseases and conditions were as follows: respiratory system diseases (54%, i.e. 57.12%), symptoms, signs and pathological clinical and laboratory findings (10.5%, i.e. 11.08%) and injuries, poisonings and external causes implications (8%, i.e. 5.5%). Physical examinations which represent a very good indicator of health status of school children and adolescents, determined foot deformation (around 22%), poor physical condition (16.8%, i.e. 14.8%) and poor nourishment (14.4%, i.e. 12.73%) as most frequently diagnosed problems related to the primary school children. As far as the secondary school children are concerned, most frequently diagnosed problems are as follows: poor physical condition (20.5%, i.e. 14.6%), foot deformation (15.2%, i.e. 13.6%) and poor nourishment (12%).

On the territory of Branicevo region, healthcare services within general practice are used by 115,449 patients. Health status analysis of adults within the general practice on the territory of the region in 2013, shows that 190,099 diseases were registered with the rate of 1,564/1,000, i.e. 1.6 diseases per adult, which is by 0.3 diseases more than in the previous year. In 2014, a total number of 178,578 diseases was registered with the rate of 1,546.8/1.000, i.e. 1.5 diseases per adult which is by 0.1 diseases less than in the previous year.

The major groups of diseases and conditions according to ICD – 10 regarding this population group were circulatory system diseases (around 20%), then respiratory system diseases (around 19%) and diseases of musculoskeletal system and connective tissue (around 11%). The above mentioned groups of diseases were also the most frequent health problems of adults, in general practice, in the subject region during the previous two years as well.

Similar situation is with medical data received within the occupational medical service. Analysis show that digestive system diseases, circulatory system diseases and musculoskeletal system and connective tissue diseases prevailed regarding the working population on the territory of this region, as during the previous years.

In 2013, women health care medical services were used by 81,379 women in total aged over 15. Total number of 12,746 diseases were registered with the rate of 156.6/1,000. In 2014, total number of 12,192 diseases were registered with the rate of 161.5/1,000. The most frequent diseases were related to genital-urinary system (78%), then infective diseases and parasitic diseases (around 8%) and tumours (around 6%). Situation was similar in the previous years.

The most frequent diagnoses within dental health care of Braničevo region in 2013, as well as in the previous years, were the following: dental caries as the greatest problem of all age groups, diseases of pulp and tissue around the tip of the tooth and other, non-defined diseases of teeth and supporting tissue.

Mortality as a very important indicator of health status of population shows, according to ICD – 10, that in 2012, the major number of persons died of circulatory system diseases (around 55%) and tumours (around 17%). Average duration of life within the observed period was around 75 years.

Primary prevention measures (vaccination, disinfection, disinfection and sanitation) are implemented in Branicevo region every year for the purpose of health protection and disease prevention and control. In 2013, foreseen volume of immunization against certain infective diseases (TBC, polio, diphtheria, tetanus, pertussis, measles, rubella, and hepatitis B) is implemented in total in Branicevo region, except vaccination against hepatitis B at the age of 12, which is realized in total volume of 62.7% compared to the scheduled values.

Tetanus revaccination for persons aged 30 – 60 were carried out on a small scale compared to the scheduled values in the period from 2011 to 2013. This is reasoned by the practice of carrying out tetanus revaccination after exposition.

On the basis of the above mentioned analysis of health status of population in Branicevo region, conclusion can be made that the population belongs to older population with low birth rate, high general mortality rate and negative natural growth in all municipalities. According to the data of the Institute of Public Health Pozarevac, diseases of circulatory system, tumors and diabetes, etc. were registered. These are diseases belonging to category of social and ecological diseases, which means that they are mainly conditioned by organization of social life, fears and life style. The major number of diseases of preschool and school children refers to respiratory system diseases.

6. DESCRIPTION OF POSSIBLE IMPORTANT ENVIRONMENTAL AND HEALTH IMPACTS OF THE PROJECT OF CONSTRUCTION OF TPP KOSTOLAC B UNIT B3

6.1. Review, classification and evaluation of possible impacts

Construction of TE Kostolac B Unit B3 is a project of significant industrial capacity and it will be implemented on already existing industrial location created with the purpose, within TPP Kostolac B. According to detailed analysis performed in the previous chapters of the present Study, different types of waste materials are generated during operation of Unit B3, which enables various environmental and health impacts.

Bearing in mind the unit operation concept and the solutions presented, this part of the Study covers the following:

- Analysis of impact of the system for supply and storage of main raw materials,
- Analysis of impact of new chimney releasing emissions of treated flue gases into atmosphere,
- Analysis of impact of the system for treatment and disposal of waste and by-products generated in technological processes within unit B3,
- Analysis of other impacts due to the unit B3 operation (noise, terrain surface impact, etc.).

Impact classification and evaluation methodology prepared for the purpose of this Study is based on multiparametric analysis according to which, impact review is carried out in relation to the following parameters:

- spacial aspect, providing classification of impacts as local, regional and global,
- time aspect, providing classification of impacts as periodical or permanent, short-term or long-term,
- intensity, providing five-gradation impact classification (from severe to negligible),
- type i.e. character, providing classification of impacts as direct and indirect, i.e. cumulative and synergistic.

Review of possible significant impacts that FGD plant may have related to the environment (in accordance with the Article 7 of the Rulebook on content of Study on evaluation of environmental impact (Official Gazette of RS, No. 69/05) will include quality and, where possible, quantitative view of possible environmental changes during the project implementation, regular operation and case of accident, referring to:

- air, water and soil quality,
- noise, vibration, heat and radiation levels,
- ecosystem status,
- meteorological parameters and climate characteristics,
- area population parameters and infrastructure,
- population health,
- existing natural resources,
- natural and cultural goods,
- terrain surface.

Impact evaluation is carried out on the basis of the results of impact analysis, per classification as previously quoted, taking into account probability of observed impact realization.

Importance of certain impacts is ranked on the basis of total analysis of consequences and impact realization probability, and it is used for making decisions on necessary measures to be taken in order to diminish estimated importance. Impact importance is commonly quantified through the following categories:

- irrelevant impact: the observed impact is negligible and does not affect the decision on project implementation,
- very low: observed impact is very small and it should not affect the project implementation;
- low: observed impact will not affect project implementation,
- medium: observed impact may affect project implementation,
- high: observed impact will affect project implementation,
- very high: contemplated project may be implemented only under certain conditions.

Consequences of certain impacts are analysed on the basis of impact range, intensity and duration, as specified in Tables 6.1-1 and 6.1-2.

Table 6.1-1: Ranking of consequences

Impact level	Impact description	Evaluation
A Impact range		
Local	Limited to the location of facility	1
Reginal	Limited to the region	2
International	Transboundary	3
B Impact intensity		
No impact		0
Low	Natural and created functions of the area are not changed	1
Medium	Natural and created functions of the area are modified	2
High	Natural and created functions of the area are significantly changed	3
C Impact duration		
Short-term	Up to 2 years	1
Mid-term	2-15 years	2
Long-term	Over 15 years	3

Table 6.1-2: Impact total ranking

Total evaluation (A+B+C)	0-2	3-4	5	6	7	8-9
Impact level	Irrelevant	Very low	Low	Medium	High	Very high

With regard to impact probability, usual impact classification is as specified in the Table 6.1-3.

Table 6.1-3: Classification related to impact probability

Probability	Impact evaluation
Low probability	1
Possible	2
Probable	3
Certain	4

Defining total importance of certain impacts is shown in the Table 6.1-4.

Table 6.1-4: Impact total importance

Impact level	Consequences	Probability
Irrelevant	Very low	Low probability
	Very low	Possible
Very low	Very low	Probable
	Very low	Certain
	Low	Low probability
	Low	Possible
Low	Low	Probable
	Low	Positive
	Medium	Low probability
	Medium	Possible
Medium	Medium	Probable
	Medium	Certain
	High	Low probability
	High	Possible
High	High	Probable
	High	Certain
	Very high	Low probability
	Very high	Possible
Very high	Very high	Probable
	Very high	Certain

Results of performed analysis will be shown in the form of summary tables, as per the recommendations.

6.2. Description of possible environmental impacts of the Unit B3 during the construction phase

Construction of new unit on location of the existing thermal power plant is accompanied by a series of activities with possible positive and negative environmental impacts. These activities comprises:

- Performance of works related to location preparation for new unit,
- Supply of materials and equipment to TPP site,
- Performance of construction works on the new unit location,
- Performance of mechanical and electrical works on the new unit location,
- Collection and removal of generated waste from TPP location,
- Landscaping of the area around the new block upon construction completion,
- Provision of conditions for stay and work of employees on the location.

Generally, possible impacts for all specified activities are caused by:

- Additional traffic and transport,
- Waste generation (inert, hazardous, municipal and sanitary),
- Work of construction and other machinery on the site,
- Occupation of the space and temporary change of its purpose,
- Change in social structure of the area.

6.2.1. Traffic and transport

During construction of the new unit, increased road and rail traffic flows are expected on the routes towards TPP Kostolac B location, which is result of the need to supply all necessary equipment and material to the site and to perform regularly other related activities necessary for site functioning.

Power plant location is connected by the local road with the highway Belgrade – Nis – Skopje, and by industrial railway track with the railway Belgrade – Bar. Equipment supply by river, via Danube to the port in Kostolac, is also possible.

Increased traffic flows on these road routes may have the following additional environmental adverse impacts:

- Traffic deceleration and obstruction, primarily on local road directions, due to the circulation of trucks transporting large equipment. Therefore, these activities have to be planned in detail and notified in advance to the competent traffic police, and it is recommended to perform such special transport in time periods of reduced traffic intensity (after 21 h, or similarly)
- Increased intensity of the high load traffic may additionally affect road damages and requires additional, increased maintenance of loaded sections,
- Increased traffic intensity causes higher emission of fuel combustion products (mainly diesel fuel), which will affect the air quality along the roads. Major harmful ingredients of diesel fuel combustion products are carbon-monoxide, nitrogen oxides, hydrocarbons, sulphur dioxide, soot and abrasive particles from car tyres, as well as carbon dioxide, the most important representative of the gases with the greenhouse effect. Table 6.2.1-1 shows EU standards related to emissions of some pollutants from heavy trucks on diesel fuel.
- In addition to emissions of combustion products, transport of bulk cargo causes scattering of transported material along the road, which causes additional pollution of the soil in surroundings of the roads,
- Increased traffic intensity causes higher noise level along the roads, which is particularly unfavourable for parts of the road through the settlements,
- Increased traffic intensity causes higher probability of traffic accidents, particularly in the parts through the populated places.

Table 6.2.1-1: EU standards for emissions of some pollutants from diesel heavy trucks[6]

Heavy trucks	NO_x (g/kWh)	CO (g/kWh)	HC (g/kWh)	PM (mg/kWh)
Euro I (1992-95)	9,0	4,9	1,23	400
Euro II (1995-99)	7,0	4,0	1,1	150
Euro III (1999-2005)	5,0	2,1	0,66	100/160
Euro IV (2005-2008)	3,5	1,5	0,46	20/30
Euro V (2008-2012)	2,0	1,5	0,46	20/30
Euro VI (2013)	0,4	1,5	0,13	10

6.2.2. Waste generation

During mentioned activities on the site, different types of waste are generated:

- During construction of facilities within the TPP location area, significant quantities of different types of construction waste are generated which should be sorted and from time to time transported from the site in prescribed manner. The same goes for the waste generated upon installation of mechanical and electrical equipment,
- In some auxiliary buildings built for the purpose of construction of thermal power plant, such as workshops, laboratories, health station, certain quantities of hazardous waste may be generated, which requires special treatment,
- Construction of settlement with restaurant for accommodation and nourishment of workers within location of thermal power plant is foreseen. Within this settlement, as well as in barracks with offices for the team working on construction monitoring, municipal waste will be continuously generated. Waste generated on the very site should be collected and transported from the plant location with other communal waste.
- Sanitary waste is generated in all points where a longer sojourn of people is foreseen. For the purpose of collection of this kind of waste, mobile sanitary cabins should be provided. Workers' settlement has sewage network connection.

6.2.3. Construction and other site machinery operation

Site machinery performance causes local adverse impacts resulting from emissions of engine fuel combustion products (mainly diesel engines), noise incitement and soil pollution in case of spillage of oils and/or fuels during maintenance of machines.

From the aspect of possible environmental impacts, i.e. impacts on the space outside the power plant area, the most important impact is the one of the noise.

At the moment, it is difficult to anticipate the noise level in the surroundings, since it depends on volume of the works carried out simultaneously. Bearing in mind that the closest houses are at around 500 m from the fence of the thermal power plant location (barracks along the west frontier of TEKO B location), noise fading related to the mentioned distance is around 50%.

---

[6] *EU AIR POLLUTION LEGISLATION, Emission standards for light and heavy road vehicles, Environmental Factsheet No. 17, September 2004*

6.2.4. Space occupation and its intent conversion

New unit location is within TPP Kostolac B location, on the space intended for construction of the II phase of the Power plant, so that the implementation of this project does not require additional space. Erection yard is also within TPP Kostolac B location.

Location of stockyard of technological solid waste generated during unit operation is within OCM Drmno area, thus no need to occupy new space for this purpose neither. Time life and extension of the stockyard are in line with the time life and exploitation of the cast mine.

Stockyard site location is adopted by Spatial Plan for the area of special purpose of Kostolac coal basin (Official Gazette of the Republic of Serbia, No. 1/2013).

6.2.5. Changes in social structure of the area

Considering the size and complexity of the site, presence of a larger number of contractors and large number of workers is expected from time to time on the site. Bearing in mind that the TPP location is in predominantly rural area, with most of villages with 5,000 inhabitants, a longer sojourn of season workers will have impact on established lifestyle habits of local population in this area.

Sojourn of temporary employed workers on construction of power plant will cause development of certain activities in vicinity of the location, which are related to service activities in the field of trade, hospitality and culture, which altogether may have a positive effect to income of surrounding municipalities, as well as employment possibilities in the mentioned fields.

6.2.6. Summary evaluation of environmental impact during construction phase

Through application of specified impact evaluation methodology, evaluation of environmental impact during construction phase of TPP Kostolac B unit B3 is summarized in the Table 6.2.6-1.

Table 6.2.6-1: Summary evaluation of environmental impact during the TPP Kostolac B3 construction phase

Impact description	Impact evaluation						Measures required
	Range	Intensity	Duration	Consequences Total	Probability	Importance Total	
Traffic and transport	2	2	2	6 Medium	Definitively	Medium	Yes
Waste generation	1	2	2	5 Low	Definitively	Low	Yes, within the site
Performance of construction and other machinery on the site	1	2	2	5 Low	Definitively	Low	Yes, within the site
Space occupation and its intent conversion	2	1	2	5 Low	Probably	Low	No
Changes in social structure of the area	2	2	2	6 Medium	Probably	Medium	Yes

6.3. Description of possible environmental impacts of unit B3 operation

6.3.1. Air quality impact

Potential air quality impacts of unit B3 TE Kostolac B are caused by the following sources of pollution:

- Emissions of air pollutants through flue gases released through the plant chimney;
- Emissions of limestone particulates during unloading and pressing on the limestone stockyard and limestone supply to daily silos;
- Emissions of coal particulates during coal supply, crushing and disposal;
- Emissions of particulates from the solid waste transport and disposal system (ash, slug and gypsum).

Bearing in mind characteristics of pollution sources defined in such manner, detailed in the Chapter 3.3.4-3.3.6 of this Study, analysis of air quality changes shall be carried out on the basis of assessment of spreading of mentioned pollutants in the air surrounding TPP.

A. <u>Flue gases impact</u>

Harmful ingredients of flue gases belong to the essential pollutants emitted in thermal power plants affecting the air quality. Upon emission into atmosphere through the chimney, due to their own kinetic and thermal energy, dispersion of flue gases in atmosphere and their further transportation conditioned by current meteorological parameters, i.e. air flows, occur. As described in the Chapter 3.3.5, presence of sulphur and nitrogen oxides, as well as of particulates in the air, has adverse impact on human health, flora and fauna, and in case of precipitations, acid rainfalls occur. Additionally, adverse effects upon human health due to joint action of sulphur oxides and other pollutants, especially of suspended matter in the air, are also recorded. Therefore, concentrations of this matter in the air are legally regulated, as well as their emission from the source of pollution.

Unit B3 technical solutions described within the chapter 3.3.4 of this Study, encompass all necessary measures for harmonization of air emissions with legally prescribed values. Table 6.3.1-1 summarizes projected levels of decline in flue gas pollutant concentration achieved by application of projected measures.

Task of this part of the Study is to estimate impact of flue gas emissions through TPP Kostolac B unit B3 chimney on change of air pollution quality, as well as to forecast air pollution level in the area of interest in the period of operation of the unit B3. This estimate is based on calculation of spatial distribution of concentration of mentioned harmful substances in atmosphere and comparison of resulting values with legally prescribed emission limit values (ILV), applying dispersion models for modelling of flue gas behaviour in the atmosphere.

Table 6.3.1-1: Summary assessment of reduction of Unit B3 flue gas pollutants emission

SO_x	NO_x	Particulate matter	HCl and HF	CO_2	CO
In combustion process					
No change	Reduction of min. 50%	No change	No change	Provision of boiler performance parameters	Provision of boiler performance parameters
In dry electrostatic precipitator					
No change	No change	Reduction of 99,95%	No change	No change	No change
In desulphurization process					
SO_2: reduction of ≈98% SO_3: reduction of ≈40%	No change	Up to 70% (min. 50%) reduction	Reduction of min. 90%	Increase of around 2%vol.	No change
In wet electrostatic precipitator					
No change	No change	Up to 70% reduction	No change	No change	No change

Dispersion models

In order to enable adequate preventive, space – planning air protection measures to be taken against excessive pollution, it is necessary to ensure possibility for forecasting of air pollution distribution in the area of interest for the relevant scenarios.

If there are not enough data on air quality measurement available (in phase of designing of new industrial facilities as potential air pollutants), mathematical modelling is applied, i.e. process simulation in atmosphere using mathematical model, so-called dispersion models. Dispersion model includes calculations of smoke plume movement, as well as chemical and physical transformations of emitted pollutants on their way to atmosphere.

Modelling process result is evaluation of spatial distribution of concentrations of pollutants in defined area, averaged at different periods of time.

Different models are used in environmental quality analysis depending on purpose of achieved results. In effect, model represents an instrument by means of which connection between environment and anticipated project is realized, thus one of the basis characteristics of the model is its ability to describe specific processes in environment for given conditions in the manner as realistic as possible.

Problem of air pollution is mostly related to increased concentration of pollutants at limited area. For the purpose of overcoming possible problems which could arise due to pollution allowed levels exceeding, forecasting of pollutants' concentration is made, based on which, necessary protective measures are defined and applied related to defined acceptable levels of pollution. Models have very important role since they may simulate different facility operation scenarios (thus different emissions of pollutants), as well as variations of weather conditions. Using the model, necessary information can be obtained regarding holding and distribution of pollutants and warning can be issued to pollutants in order to keep emission within acceptable (permitted) limits. Preparation of models defining and/or verifying air quality level is difficult due to complexity of conditions in the atmosphere, emission of different pollutants, as well as complexity of pollution source locations.

When testing distribution of pollutants, model is based on assumption of one main air stream which is "transporter" for the whole process. Model is based on diffusion process equations and they provide as result concentration values in the given points in space. Model must be adjusted to the data available and used for quantitative image of diffusion process. On the other hand, in order to obtain as real as possible results, complexity of diffusion process must be taken into consideration.

After emission, pollutants enter atmosphere, air layer directly near emitter, and then they are included into various processes which occur in air layer where they are and whereby their transformation may occur. Thus, pollutants after emission:

- diffuse into wider air layer, by dispersion in expanded area, and at the same time, dilution of their concentrations,
- under influence of gravity forces and vertical air flow, they are subject to dry or wet deposition on the ground (in case of precipitations),
- they are subject to sorption on particles in the air,
- they are subject to chemical reactions and transformations in the atmosphere.

Models are more reliable for evaluation of average concentrations for longer time periods than for shorter. Their reliability is acceptable for evaluation of highest concentration value which is expected within observed area under defined conditions. Usual accuracy of results obtained by modelling is in range of 10 - 40 percent for evaluation of maximum concentration.

Generally, three types of information are necessary for modelling: information about emission source, about weather conditions of the area and about receptors, i.e. locations for which the pollution level is determined. Additionally, it is necessary to have data on characteristics of objects nearby the source which may disturb plume movement through the air (building downwash), as well as terrain characteristics of the area affected by calculations.

Methodological researches and practice usually include Gaussian diffusion models. Although Gaussian model uses some parameters defined in an empirical manner, main reasons in favour of application of these models are, above all, their simple usage and relatively good agreeing with the physical experiments. Gaussian models assume that the distribution of the concentration of passive substances in the plume has a certain mathematical form, and they include the Gaussian diffusion equation, which, in fact, is the solution of Fick's diffusion equation with constant coefficients. The base for Gaussian smoke plume model is the following equation:

$$C(x,y,z)=\frac{Q}{2\pi u\sigma_y\sigma_z}\exp\left(-\frac{y^2}{2\sigma_y^2}\right)\left\{\exp\left(-\frac{\left(z-H^2\right)}{2\sigma_z^2}\right)+\exp\left(-\frac{\left(z+H^2\right)}{2\sigma_z^2}\right)\right\}$$

where:

C(x,y,z)	emission value in the point (x,y,z), g/m^3
Q	mass flow of pollutant, g/s
u	wind speed, m/s
σ_y, σ_z	plume deviation in y and z direction, m
H	effective chimney height, m
x	source distance in wind direction, m
y	horizontal distance from plume centre, m
z	distance above the ground, m

For easier understanding of the basic principles of Gaussian models, i.e. their coordinate system, Figure 6.3.1-1 displays its scheme. These models usually take the emitter as a starting point of coordinate system (as is given in the figure), while calculating the concentration and spreading of smoke plume is represented in x, *y* and *z* direction. Depending on the area observed, emitter may also be in some other coordinate.

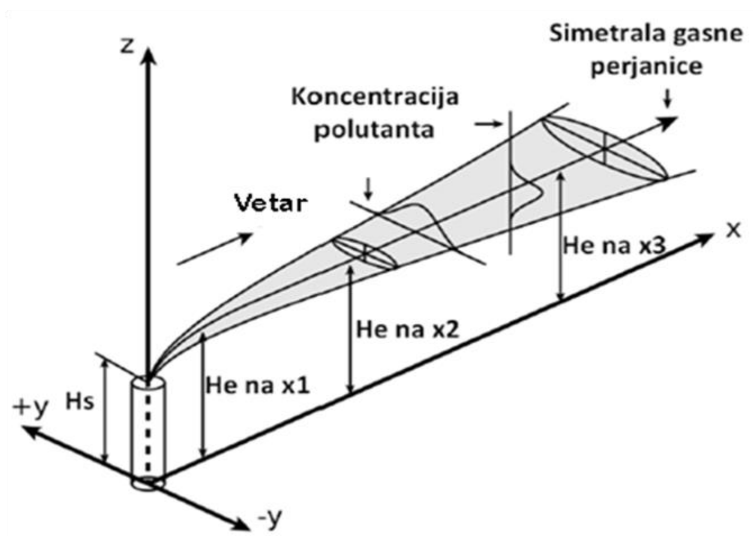


Figure 6.3.1-1: Display of coordinate system of Gaussian distribution horizontally and vertically

Gaseous substances that reached the atmosphere are spreaded via diffusion and turbulent mixing. Two basic types of turbulent motions are observed, thermal turbulence resulting from the different local heating of some parts of the air and mechanical turbulence caused by air movement over rough terrain and obstacles.

Atmospheric diffusion leads to the movement of emitted pollutants horizontally and vertically. The speed of diffusion depends on various factors, the most important of which are: wind speed, solar radiation intensity, effective height of the chimney, emission intensivity at pollutant source, speed of mixing and cooling the emitted gases and other meteorological factors that lead to turbulence of gases.

Description of parameters and their effect on pollutants spreading

Meteorological factors significantly affect the spatial distribution of emitted pollutants. Meteorological elements that must be included in the model, and the spreading of pollutants widely depends them, are: wind direction and velocity, atmospheric temperature, the state of cloudiness, atmospheric stability, inversion layer and the amount of solar radiation. It is safe to say that there is no meteorological element that does not affect the air pollution to a greater or less extent.

Wind

Direction of transport of air masses which is determined by direction and speed of the wind is of the utmost importance for spreading clouds of pollutants. Wind characteristics depend on the area where the pollution source is located, on topographic and general climate conditions of the atmosphere. Wind speed generally increases with altitude, and direction at a height above 50m is often different than close to the ground at a height of 10 meters, which is why it is necessary to consider all the characteristics affecting the direction and speed of the wind. Frequency of silence has special significance related to the spatial distribution of air pollution since in the situation without wind, emission is spread exclusively by diffusion. In this case the transport of particles is decelerated and it may be exacerbated by the atmosphere being stratified in such situations, so the transport to the upper layers which would make effluents travel vertically upwards, is very poor.

Air temperature

Temperature conditions in the atmosphere, i.e. temperature changes with altitude, significantly affect the dispersion of emitted pollutants.

Atmosphere temperature profiles are conditioned by many influences, such as earth surface heating and cooling, air mass movement, presence of clouds and topographic obstacles. In order to show temperature profiles, and considering that the air is bad heat conductor, we use reference, adiabatic change (expansion of ideal gas without exchange of heat with surroundings). Adiabatic change of condition is characterized by linear atmospheric temperature change by altitude. Ray temperature reduces on average approximately 1K for each 100 m of height.

In reality, vertical atmosphere profile often diverges from adiabatic. Case of temperature reduction with height is faster compared to adiatabic is called superdiabatic. Such atmospheric condition is characterised as instable. If temperature reduction is however slower (with height) than adiabatic, condition is stable. Stable condition is featured by two special cases: isotherm with temperature constant with height, as well as inversion with temperature increase with height. Adiabatic atmospheric condition is characterized as neutral.

Figure 6.3.1-2 shows characteristic atmospheric temperature distribution in the function of altitude.

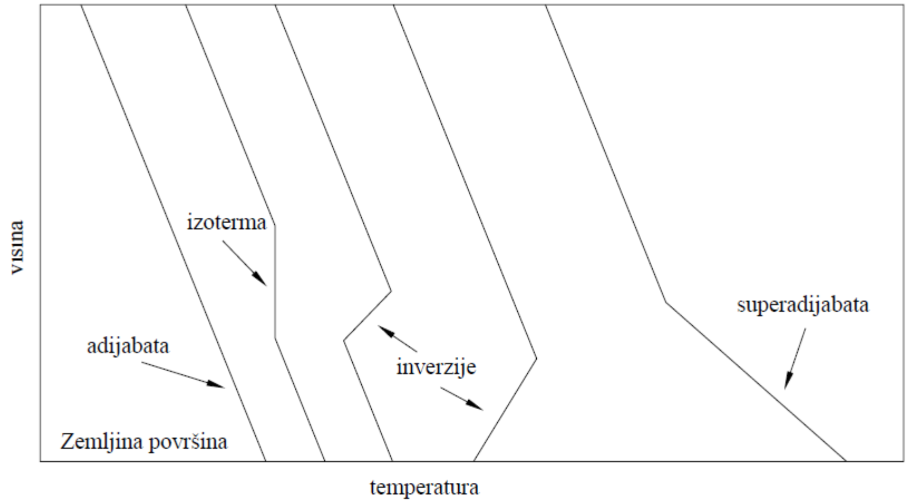


Figure 6.3.1-2: Characteristic atmosphere temperature distribution in the function of altitude

Depending on temperature gradient changes with height, it is possible to determine several different ways of smoke plume behaviour, Figure 6.3.1-3.

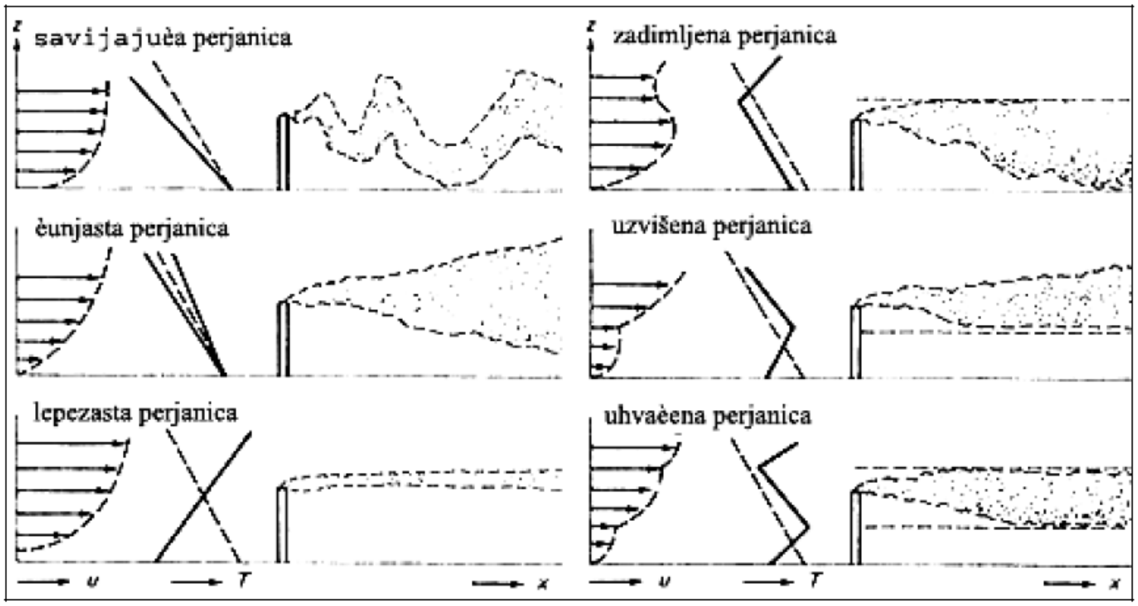


Figure 6.3.1-3: Temperature profiles impact on smoke plume trajectory

Coning Plume – Basic form of smoke trajectory under neutral and slightly instable conditions. Spreading smoke forms cones with the top in the top of the chimney. Under such conditions, concentrations in any point slightly vary.

Looping Plume – This kind of phenomenon appears under strong convective conditions when the effluent is caught in curving up and down due to vertical air movement caused by lifting of hot particles and falling of cold particles in the air. Such plume looks like shaken rope tied on the top of the chimney. This case of diffusion is deemed the best.

Fanning Plume – At stable atmosphere conditions, i.e. at inversion, the plume takes the form of fan. Observed from aside, it looks very thin, with barely noticeable conical expansion, while observed from the top it is in the form of fan spreading from the top of the chimney. This smoke spreading is very slow, and in case of high altitude of the chimney, it may not touch the surface even for a few kilometres.

Lofting Plume – Plume elevation occurs at releasing smoke in the atmosphere whose lower part is in stable layer, inversion, and above it there is unstable layer. Presence of the inversion at air movement upwards causes the change in moving downwards, but smoke lifting through unstable layer is significantly stronger.

Fumigating Plume – In this case, inverse layer is above the smoke cloud axis, and unstable layer is underneath. Smoke dispersion occurs vertically, but dispersing downwards and thus causing increased effluent ground concentrations. Fumigating plume appears every day when night inversion along the surface starts to disappear with the morning sun heating. Sun heating relatively quickly destroys inversion, transforming stable lower layer of the atmosphere into very unstable within the time less than one hour. However, if sun heating is disabled, by cloudy weather for example, transition from stable into unstable may last for hours and cause high concentrations of pollutants on the earth surface.

Trapped Plume – This is similar case compared to fumigating plume where unstable layer is slightly weaker and therefore the diffusion downwards is slower. Thus concentrations close to the surface, unlike those in case of fumigating plumes, are significantly lower. This case may last much longer due to weaker surface radiation. This happens in urban areas where slow heating of atmospheric layer close to the surface is caused by town emissions of heat. Inversion layer is formed above such slightly unstable layer.

Topographic conditions are one of the important factors that modify the local climate, have an impact on some meteorological parameters and thus the spatial distribution of pollutants. Air flow in the atmosphere is determined by the height processes, while at low altitudes the local influences have important part. Surface friction causes the wind at lower altitudes to have lower speed, so the pollutants are transported more slowly. The change of wind speed with height depends on surface roughness and atmospheric stability. Relationship between the wind near the ground and at a height enables creation of the model by means of which one can get a three-dimensional flow field at any selected cote.

Plant cover greatly affects the air flows and the concentration of pollutants near the ground. The movement of air in urban areas can be controlled by selecting and proper setting of vegetation. Dispersed vegetation creates an obstacle in the air flow path and can speed up or slow down the flow around buildings. The role of vegetation in the air flows depends on its form, density, height, and other characteristics that affect the speed, direction and quality of the air flow.

Objects influence aerodynamically the movement of air layers and thus the dispersion of pollutants. Unequal heights of objects lead to mechanical turbulence and specific dispersion of pollutants. If an object separates, i.e. splits the air stream with pollutants, it can result in increased concentrations of pollutants at the foot of the object.

As a result of air turbulence upon repealing the wind from the objects, the dynamic vortices (whirlwinds) appear. Depending on the shape and position of the object as well as the wind speed, vortices can vary in size, scale and structure. The vortices with horizontal axis are of great importance, which are formed upon the side impact of wind on the particular objects, as well as those formed behind the objects of greater size, in downwind direction, so that they bring down smoke plume towards the earth in the area behind the object (building wake).

Chimney effects on pollutants spreading: When analysing emissions from industrial facilities, the most important regarding possible impacts on air quality and pollution range are high sources, i.e. chimneies. Spreading of pollutants from these sources in the close area around the source of pollution is primarily influenced by turbulence that occurs as a result of air flow around the pollutant outlets, while atmospheric condition is of importance at large distances.

Chimney height can affect the spatial distribution of air pollution. Relative importance of chimney height decreases with distance from the source of pollution. At the foot of the chimney, the concentration is very low, whereas it is extremely high at chimney opening. In the process of smoke plume spreading, dilution by air occurs, so that the concentrations of pollutants in ambiance air are significantly lower compared to those in flue gas. Moving away from the chimney, the concentration rises up to a certain distance when it reaches its maximum value and then decreases moving away and approaching zero. Maximum concentration near the ground is proportional to the intensity of the source, and inversely proportional to the wind speed and the square height of the chimney. This last fact is very important and is taken into account in the design of the chimney.

In the models, due to the rise of the smoke plume the *effective height of the chimney,* which represents sum of physical height of the chimney and the height of smoke plume elevation caused by its kinetic and heat energy, figures instead of the physical height of the chimney.

For calculation of concentration distribution, model verified by US Environmental Protection Agency – EPA is used as reference model for application at preparation of this type of project documentation. Calculations of short-term and average daily concentrations of SO_2, NO_X and flying ash particles are made by using computer ISCST (Industrial Source Complex-Short Term) packages SCREEN3 and AERMOD.

Calculations' input parameters

Basic input data necessary for calculation are: reference meteorological parameters, emission characteristics of sources and geometry of the area on which the calculation is made.

Reference meteorological parameters are defined on the basis of data related to general meteorological data from meteorological station Veliko Gradište, which serve is reference meteorological station for the area around TPP Kostolac B location (based on opinion of RHMSS as reference institution). Meteorological sequence of 5 consecutive years is used (2010-2014), whereby input data used in mentioned models represent hourly values of the following meteorological parameters: wind direction and speed, ambiance air temperature, relative humidity of the air, atmospheric pressure and cloudiness coverage level. Figure 6.3.1-4 shows mid wind resistance rose (distribution by directions and speeds) for the mentioned period, as one of the basic indicators of meteorological parameters determining atmospheric distribution of pollutants.

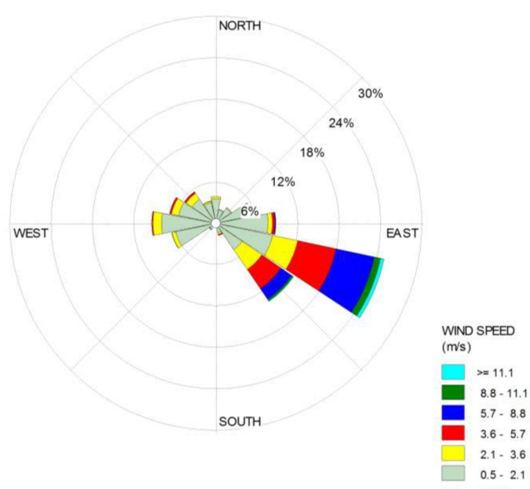


Figure 6.3.1-4: Mid wind resistance rose for the period 2010-2014

Flue gas emission characteristics are determined on the basis of reference scenarios for operation of the existing units TPP Kostolac A and B in the period after commissioning of the unit B3, as follows:

- units TPP Kostolac A will be revitalized with application of measures for reduction of air emissions of pollutants, whereby the emission parameters are presented in the Table 6.3.1-2.
- units TPP Kostolac B will be revitalized with application of measures for reduction of air emissions of pollutants, where the emission parameters are presented in the Table 6.3.1-2.
- Content of pollutants in treated flue gases is: 200 mg/m^3 for sulphur dioxide, 200 mg/m^3 for nitrogen oxides and 20 mg/m^3 for particulate matter.

Emission parameters of the units considered in analysis of the air quality impacts, on the basis of represented observations of their operation in the forthcoming period (at nominal cpacity and combustion of the warranty quality coal), are summerized in the Table 6.3.1-2.

Table 6.3.1-2: Characteristics of emissions in the air from the units of TPP Kostolac A and B

Parameter	TPP Kostolac A		TPP Kostolac B		
	Unit A1	Unit A2	Unit B1	Unit B2	Unit B3
Chimney height, m	105	110	180	180	180
Chimney diameter, m	4.4	6.0	6.7	6.7	6.6
Flue gas temperature at chimney output, °C	90	65	66	66	67
Flue gas flow, real, at chimney output, m^3/h	806,400	1,562,400	2,509,640	2,509,640	2,115,500
SO_2 mass flow, kg/h	31.2	48.0	71	71	49
NO_2 mass flow, kg/h	25.0	48.0	71	71	65
Particulate matter mass flow, kg/h	3.0	5.0	10	10	1,6

Observed *calculation area* includes surroundings of the location within the radius of 50 km from pollution source. Calculations are carried out for measurement network in steps of 400 m.

Topographic data related to the terrain are taken from digital maps of the areas of interest (SRTM1 - Shuttle Radar Topography Mission, with resolution of ~ 30 m), Figure 6.3.1-5. It is evident that the area is predominantly of lowland type, with mild elevations at distances of around 10 km (200-300 m) and 15-20 km (300-500 m), in the northeast direction of TPP Kostolac.

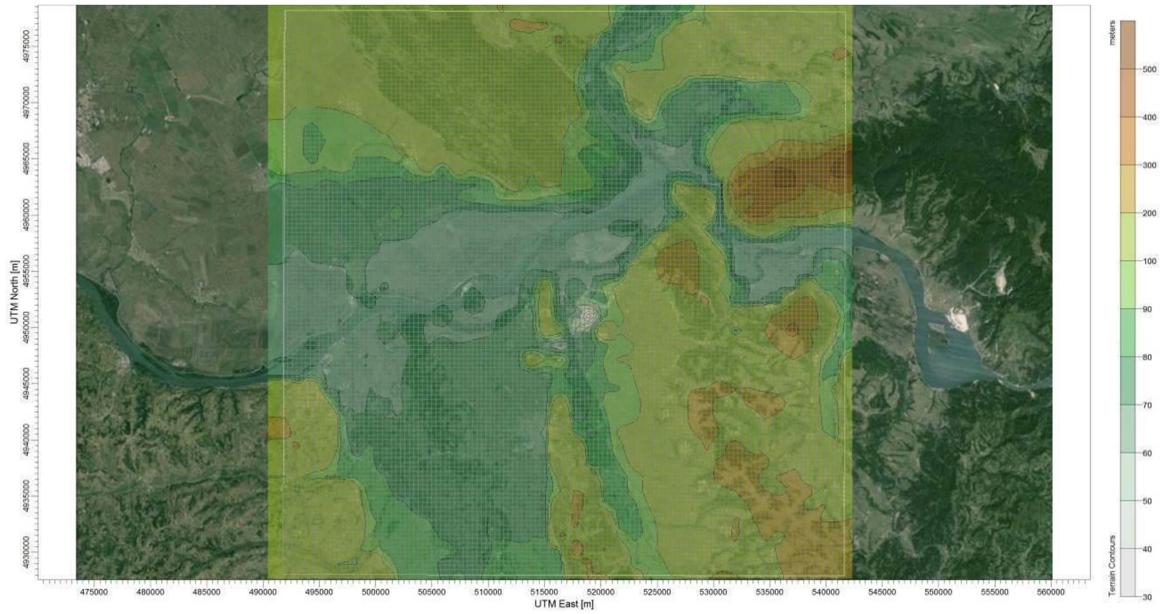


Figure 6.3.1-5: Area to which the calculations apply, with terrain topography

Facilities on locations of thermal power plants are also modelled on the basis of data on their size and disposition within the area of each power plant, as illustrated in the Figure 6.3.1-6 a and b.

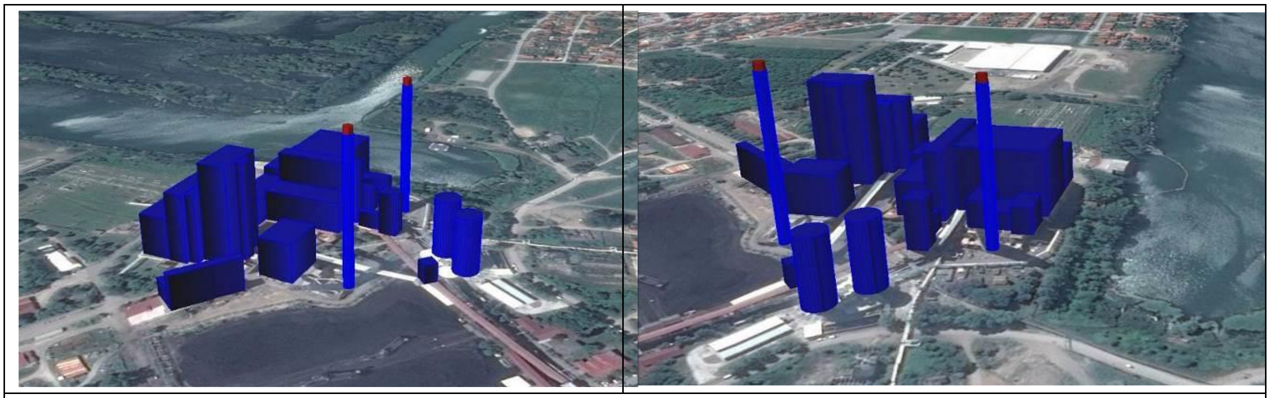


Figure 6.3.1-6: a) 3D model TPP Kostolac A location

Figure 6.3.1-6: b) 3D model TPP Kostolac B location

B. Presentation of calculation results

1. Unit B3 operation impact

Flue gas impact on air quality is analysed on the basis of calculations of sulphur dioxide, nitrogen oxides and particulate matter concentrations emitted from the mentioned pollutants. Calculations of hourly and 24-hourly concentrations of observed pollutants in ambiance air within the close field around the unit B3 chimney are made and compared to requirements of the Regulation on monitoring conditions and air quality requirements with the aim of estimation of unit B3 operation share from the aspect of use of ecological capacity of location.

Unit B3 share in air pollution in vicinity of the unit B3 is estimated on the basis of the following calculation results and their analysis:

- maximum values of hourly concentrations of pollutants, as well as the distance at which they appear, mostly depend on the following meteorological parameters: wind speed, temperature gradient and cloudiness level determining altogether atmospheric stability. The highest concentrations may be expected in very unstable atmospheric conditions, particularly in vicinity of pollution source. The more stable atmosphere, the wider plume spreading, thus the maximum concentrations are lower and their distance from the source larger. Increased concentrations may also occur in cases of the terrain being obstacle for smoke plume spreading.

- maximum values of hourly concentrations of sulphur and nitrogen oxides emitted from the unit B3, amounting up to 15% of threshold values for sulphur and up to 40% of threshold values for nitrogen oxides,
- maximum values of mean daily concentrations of sulphur and nitrogen oxides emitted from the unit B3, amounting up to 6% of threshold values for sulphur and up to 10% of threshold values for nitrogen oxides,
- air pollution by particulate matters emitted with flue gases of the unit B3 is negligible considering their very low concentration and mass flow in flue gas output,
- forecasted values of deposition of particulate matter emitted from the chimney of the unit B3, on the soil in surroundings of the chimney are significantly lower than the allowed values, whereby daily levels of the matter deposited from flue gases do not exceed 20 mg/m^2day.

2. Summarized impact of flue gases emitted from TPP Kostolac A and TPP Kostolac B

In addition to presented analysis and the impact of the unit B3, coinciding with the fact that the air quality is the result of contribution of all sources of pollution in the affected area, in order to obtain clear view on pollution during operation of unit B3, calculations are also completed related to predicted distributions of concentrations for the probable scenario for operation of units TPP Kostolac A and B, that is less favourable from the aspect of the overall impact on air quality, as follows:

- Operation of the units B1 and B2 TPP Kostolac B for the next 100,000 hours after 2021, with implemented measures for reduction of emissions in accordance with IED (Directive 2010/75 / EC) and national Regulation,
- Operation of the units A1 and A2 TPP Kostolac A for the next 100,000 hours after 2021, with implemented measures for reduction emissions in accordance with IED (Directive 2010/75 / EC).

The results of calculation are presented in the form of hourly values and daily averages and annual averages of observed concentrations of air pollutants, as follows:

- Figures 6.3.1-7 to 6.3.1-9 for sulfur dioxide,
- Figures 6.3.1-10 to 6.3.1-12 for nitrogen oxides,
- Figures 6.3.1-13 and 6.3.1-14 for particulate matter PM10.

Figure 6.3.1-15 represents the spatial distribution of average daily values of sedimentation of particulate matter from the flue gases in the environment HPP Kostolac A and B in occasion of the blowing wind from the southeast (the direction of the wind is characteristic of the observed area, Figure 6.3.1-4) .

Distribution of concentrations (in $\mu g/m^3$) are represented in the corresponding percentile maps, in accordance with the Regulation, for each pollutant and time averaging, as follows:

- 99,73 percentile of hourly values for SO_2,
- 99,18 percentile of mean daily values for SO_2,

- maximum mean annual values for SO_2,
- 99.79 percentile of hourly values for NO_2,
- maximum mean daily values for NO_2,
- maximum mean annual values for NO_2,
- 90.40 percentile of mean daily values for PM10,
- maximum mean annual values for PM10.

On the basis of their result output, the following may be concluded:

Sulphur dioxide:

- predicted values 99.73 percentile of hourly concentrations amount to around 117 μg/m^3 and appear at the distance of around 10 km at northeast from TPP Kostolac B, which means that they are significantly under the legal maximum of 350 μg/m^3,
- predicted values 99.18 percentile of daily concentrations amount to around 22 μg/m^3 and appear at the distance of around 10 km at northeast from TPP Kostolac B, which means that they are significantly under the legal maximum 125 μg/m^3,
- predicted values of mean annual concentrations amount to around 4 μg/m^3 and appear at the distance of around 1 km at northwest from TPP Kostolac B, which means that they are significantly under the legal maximum 50 μg/m^3.

Nitrogen oxides:

- predicted values 99.79 percentile of hourly concentrations amount to around 112 μg/m^3 and appear at the distance of around 10 km at northeast from TPP Kostolac B, which means that they are significantly under the legal maximum 150 μg/m^3,
- predicted maximum values of daily concentration amount to around 44 μg/m^3 and appear at the distance of around 10 km at northeast from TPP Kostolac B, which means that they are significantly under the legal maximum 85 μg/m^3,
- predicted values of mean annual concentrations amount to around 4 μg/m^3 and appear at the distance of around 2 km at northwest from TPP Kostolac B, which means that they are significantly under the legal maximum 40 μg/m^3.

Particulate matter PM10:

- predicted values 90.4 percentile of daily concentrations amount to around 1 μg/m^3 and appear at the distance of around 10 km at northeast from TPP Kostolac B, which means that they are significantly under the legal maximum 50 μg/m^3,
- predicted values of average annual concentrations amount to around 0,45 μg/m^3 and appear at the distance of around 2.5 km at northwest from TPP Kostolac B, which means that they are significantly under the legal maximum 40 μg/m^3,
- bearing in mind that the emissions of particulate matter in flue gas will be significantly reduced (to concentrations of 20 mg/m^3 for the existing units) and 10 mg/m^3 for the new unit, predicted share of particulate matter in total sediment material on the soil will be up to the maximum of 20 mg/m^{2}day, which is around 5% of allowed value.

Summarized, we may say that on the entire observed area, forecasted air quality level for the observed reference scenario of operation of thermal capacity, is within the limits of allowed, with concentrations of pollutants under the legally prescribed values. Thus, it is ensured that on the entire observed area, total level of air pollution with the existing background which is from other types of pollution (traffic, agriculture, other industry) is within allowed limits. There is also a part of remaining, unused, ecological capacity enabling possible involving of new pollution sources the contribution of which could be summarized with the existing emitters.

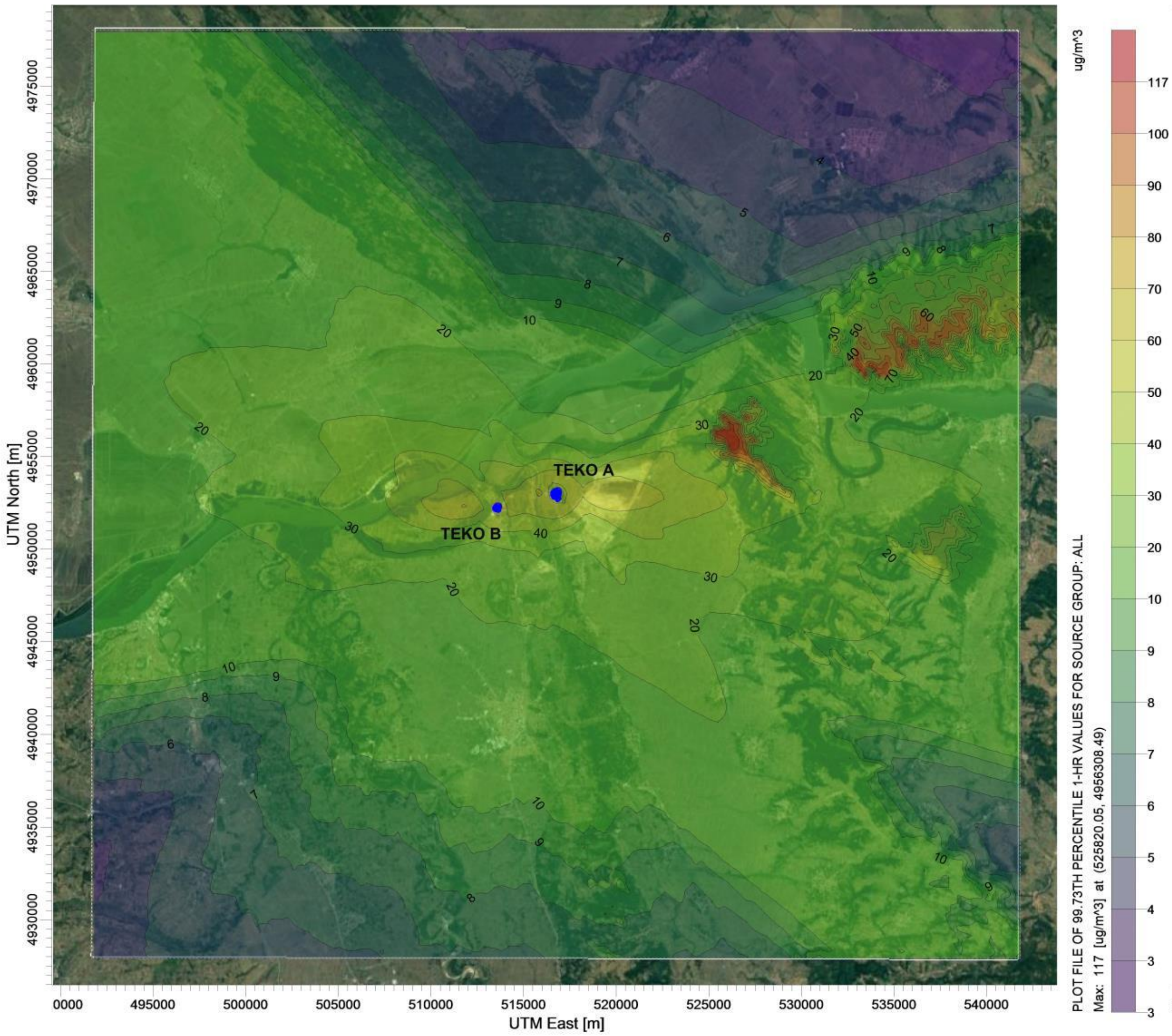


Figure 6.3.1-7: Spatial distribution of 99.73 percentille of SO_2 hourly concentrations in the vicinity of TPP Kostolac A and B, μg/m³

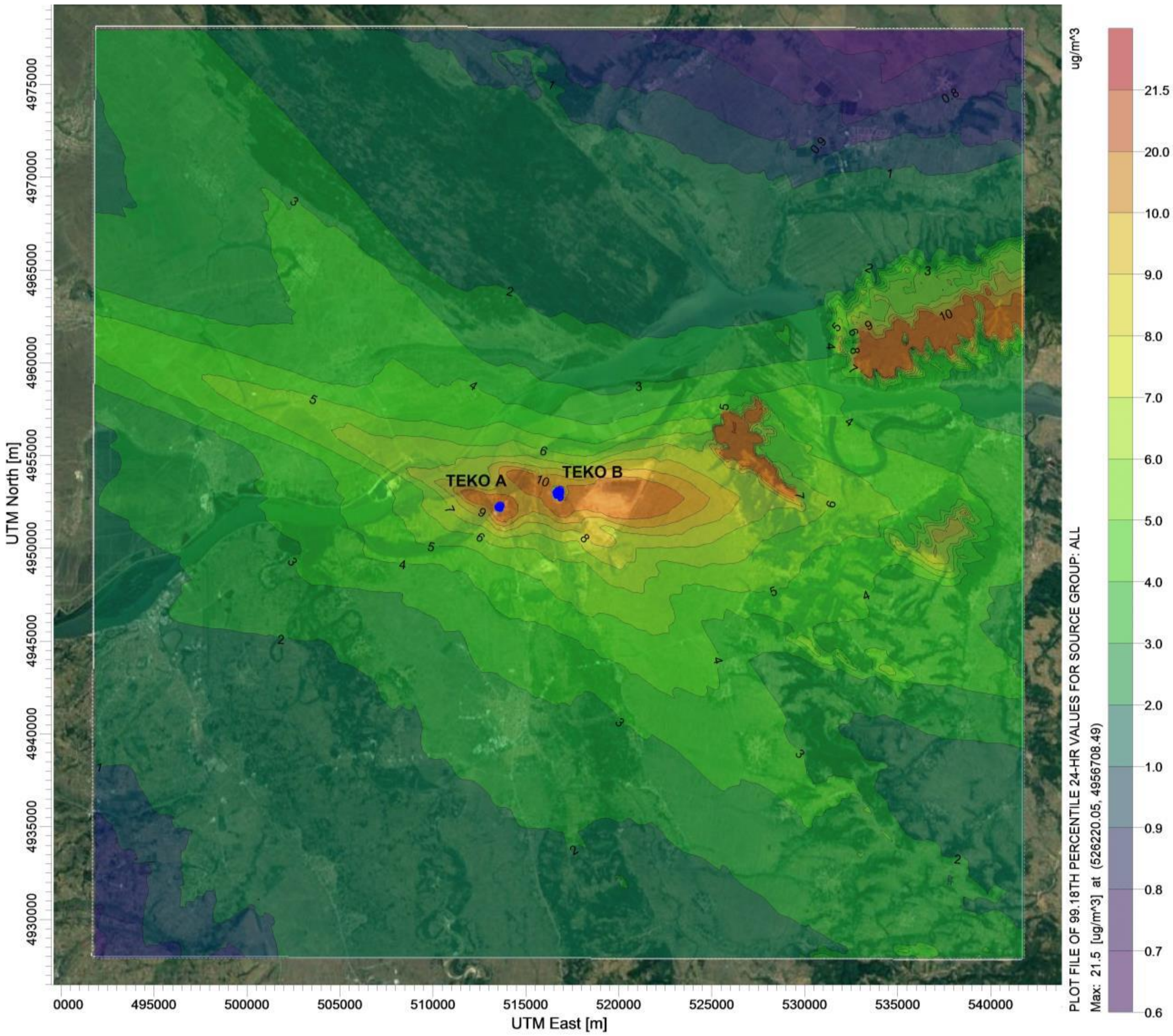


Figure 6.3.1-8: Spatial distribution of 99.18 percentille of SO2 average daily concentrations in the vicinity of TPP Kostolac A and B, µg/m3

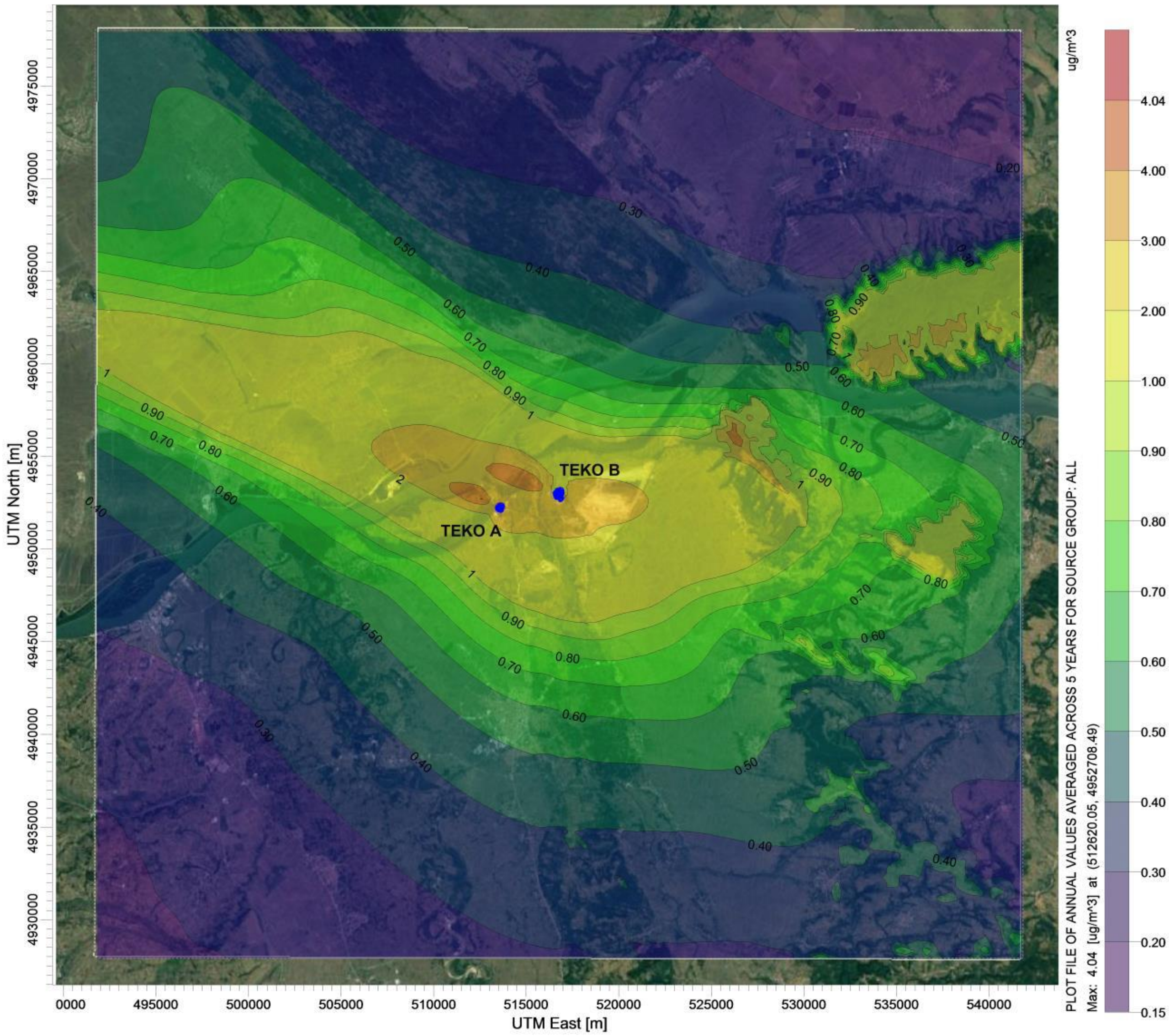


Figure 6.3.1-9: Spatial distribution of average annual SO2 concentrations in the vicinity of TPP Kostolac A and B, µg/m3

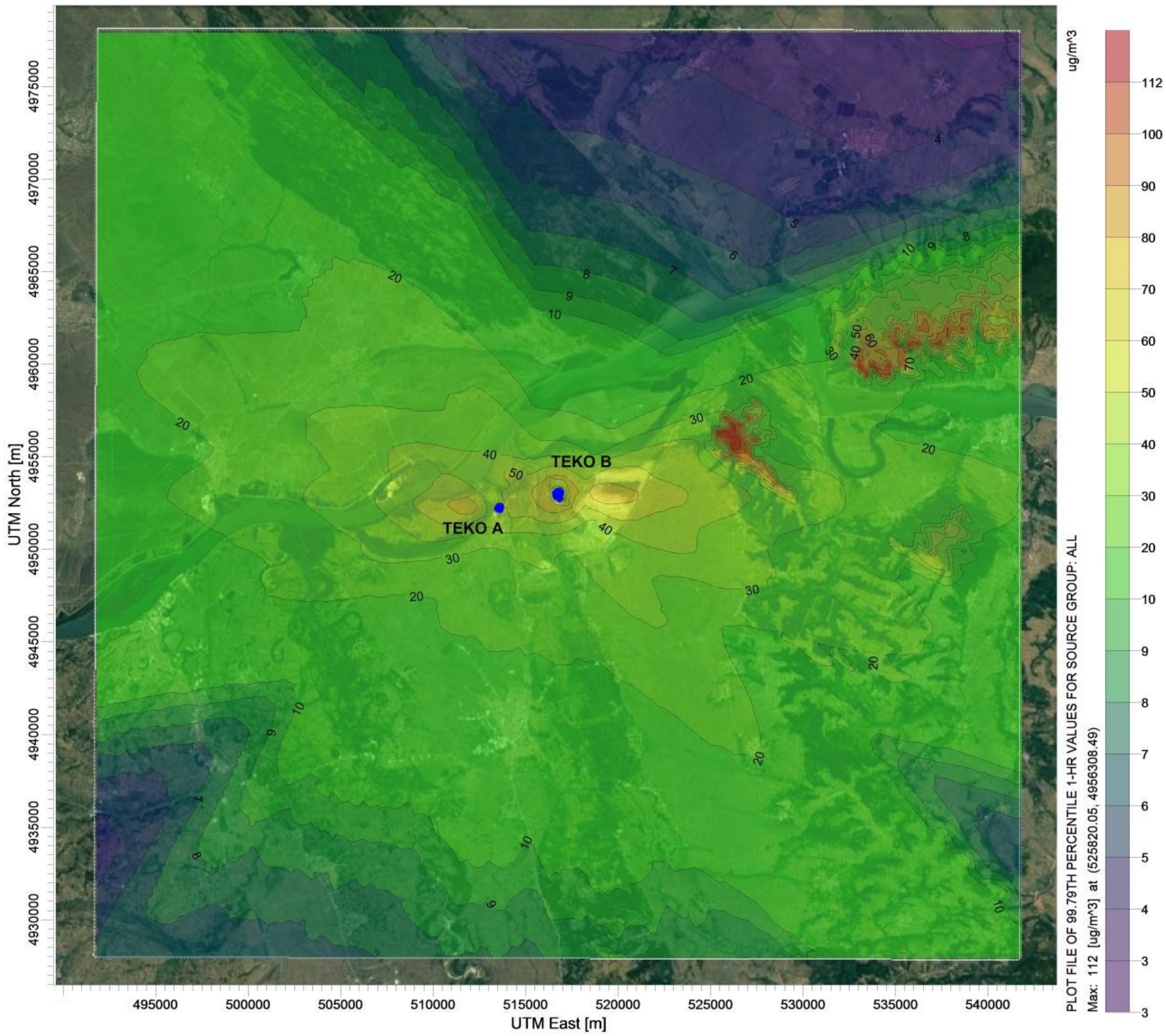


Figure 6.3.1-10: Spatial distribution of 99.73 percentille of NO_2 hourly concentrations in the vicinity of TPP Kostolac A and B, μg/m^3

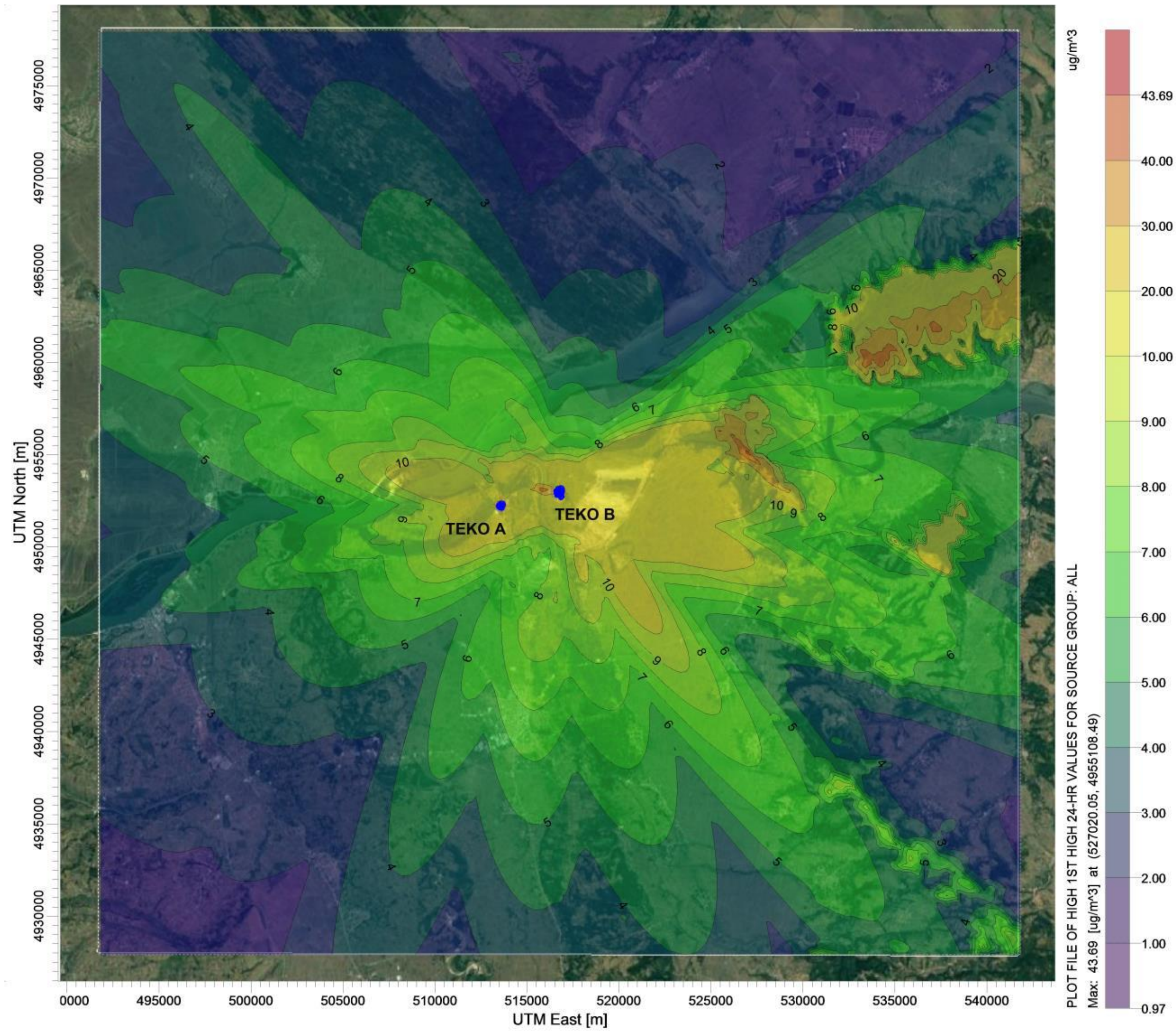


Figure 6.3.1-11: Spatial distribution of maximum daily NO_2 concentrations in the vicinity of TPP Kostolac A and B, μg/m^3

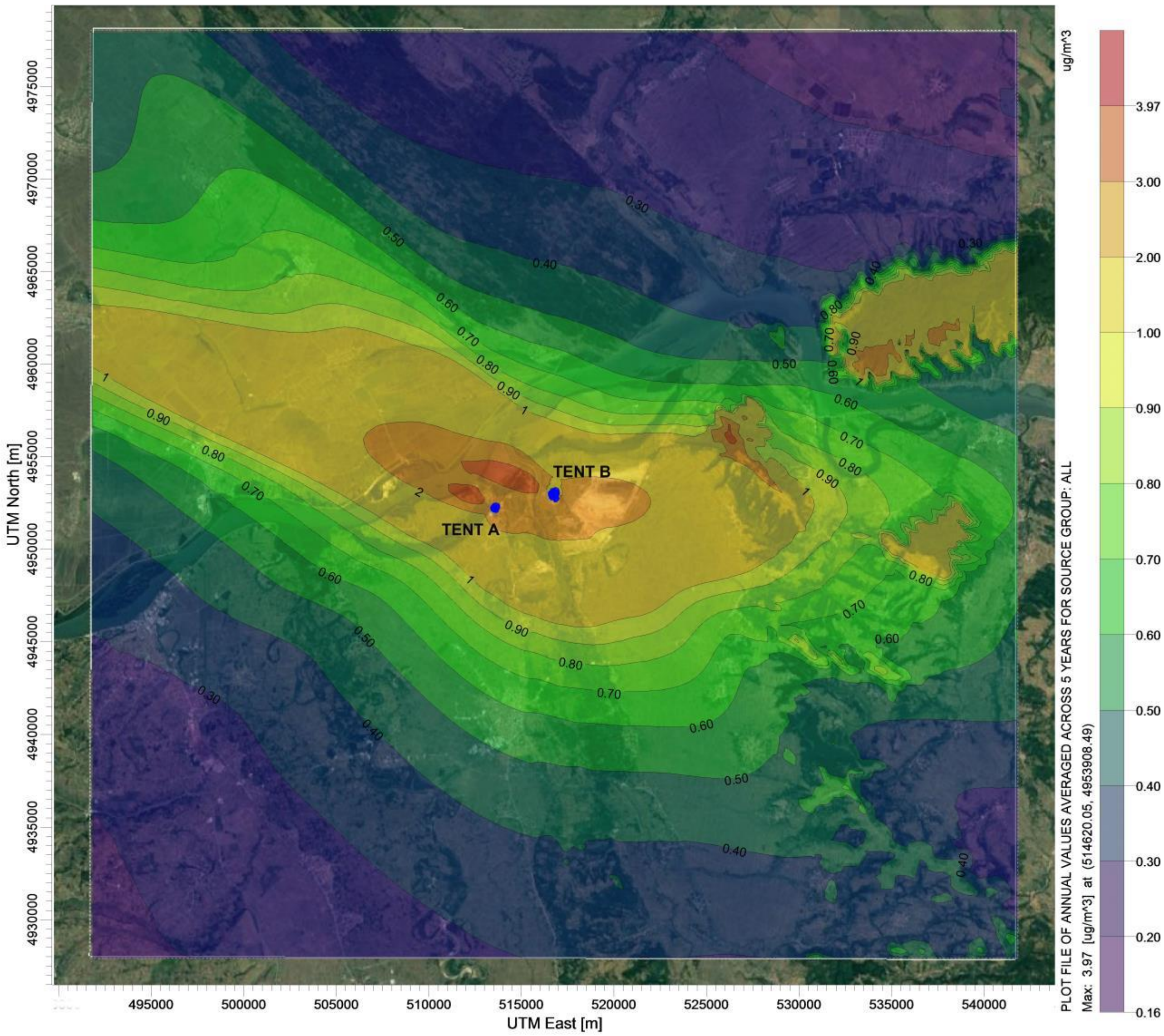


Figure 6.3.1-12: Spatial distribution average annual NO_2 concentrations in the vicinity of TPP Kostolac A and B, μg/m^3

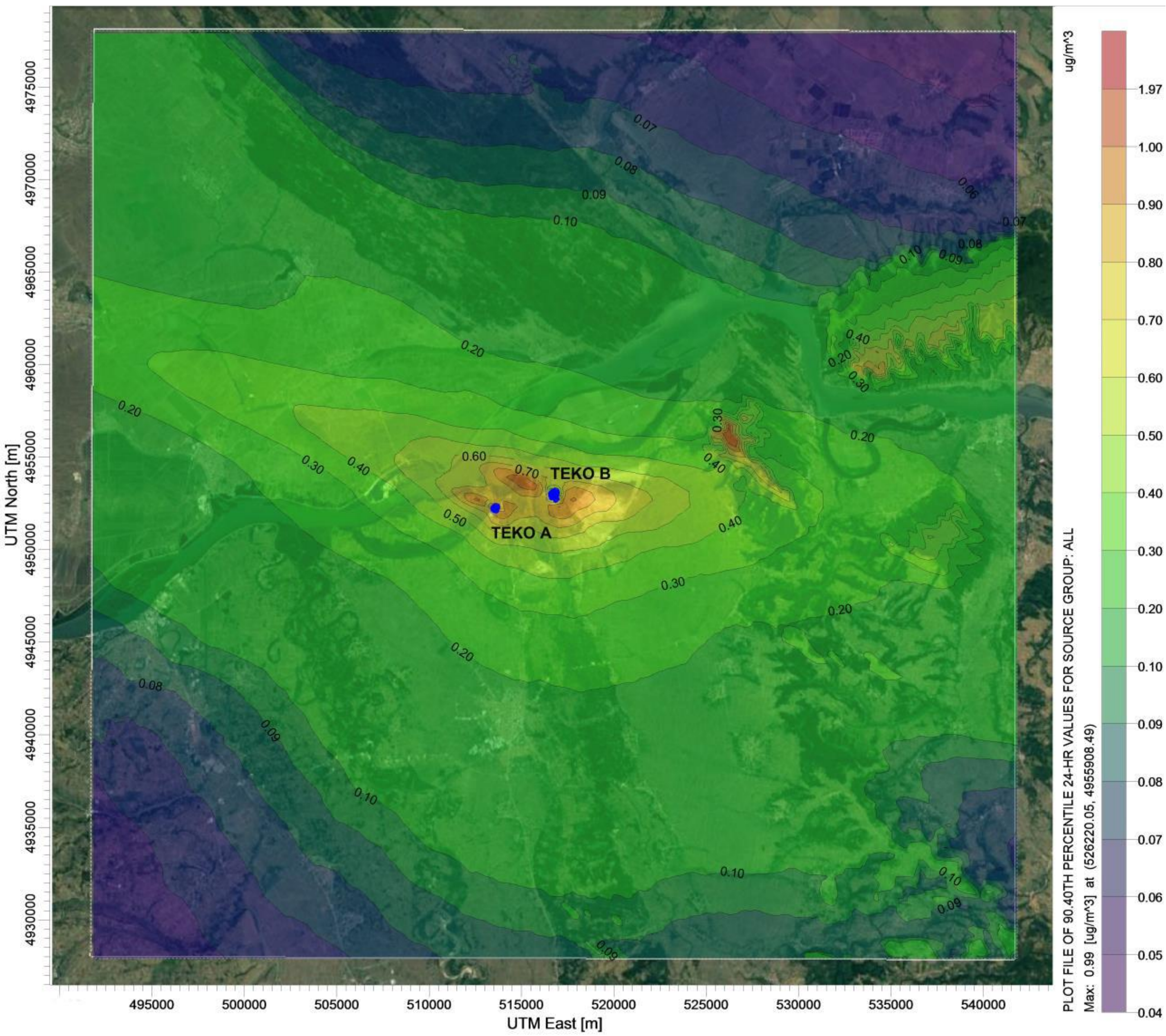


Figure 6.3.1-13: Spatial distribution of 90.4 percentille of daily PM10 concentrations in the vicinity of TPP Kostolac B3, g/m²/day

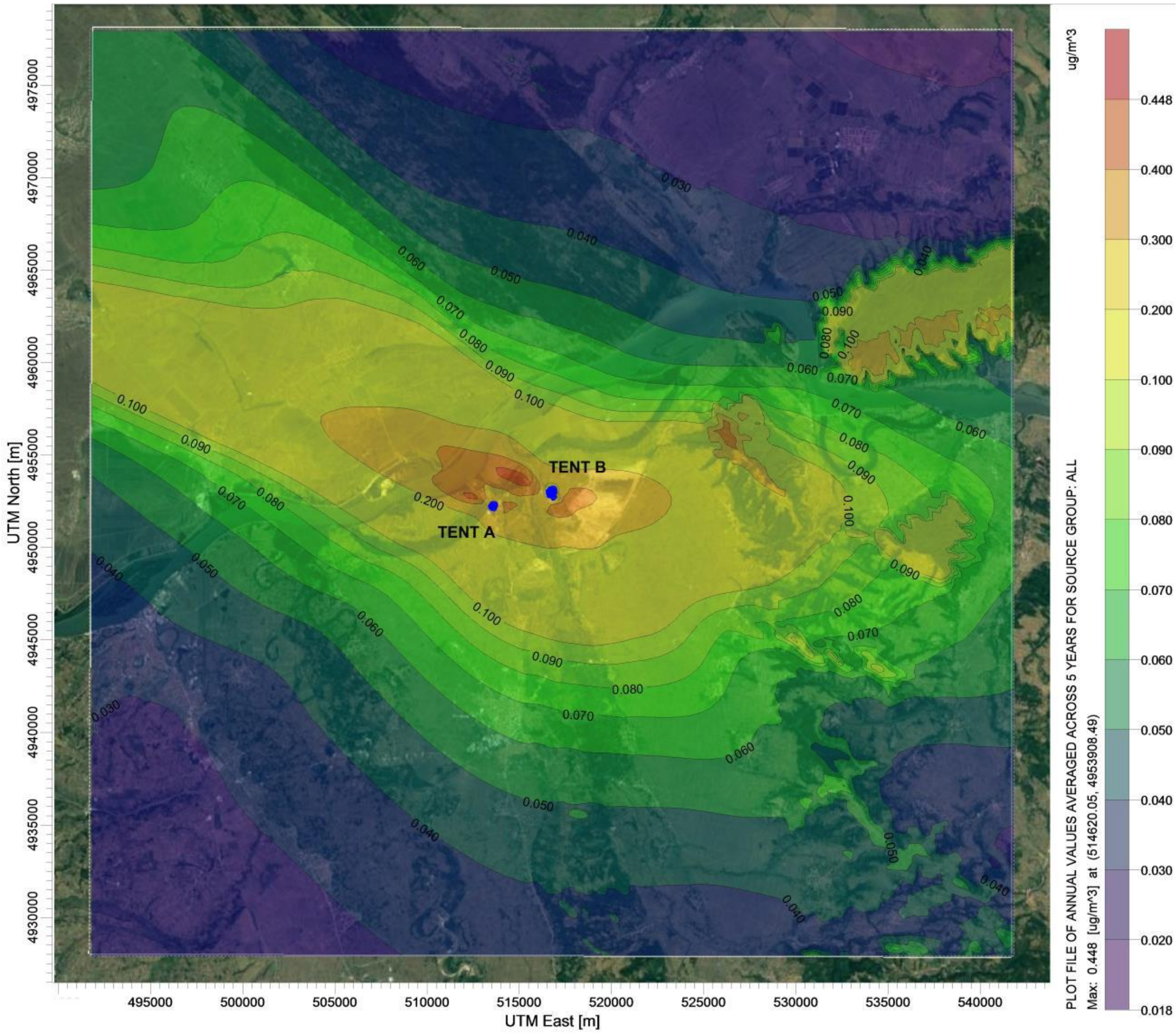


Figure 6.3.1-14: Spatial distribution average annual PM10 concentrations in the vicinity of TPP Kostolac A and B, μg/m^3

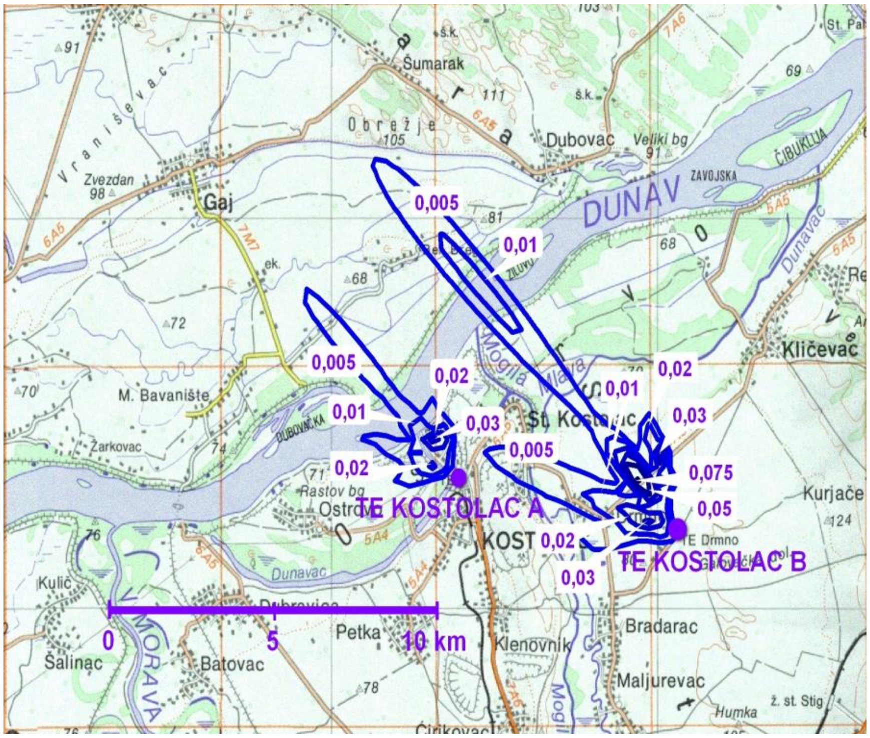


Figure 6.3.1-15: Spatial distribution average daily deposition particulate matters from flue gases in the vicinity of TPP Kostolac A and B, μg/m³

Besides the above mentioned pollutants, flue gases also contain acidic components of halogens, chlorine and fluorine (which contain the elements representing a coal component), as well as carbon dioxide, that is a greenhouse gas.

Flue gas desulphurization process also efficiently reduce the emission of acidic gases HCl and HF. Following chemical reaction represent the mechanism for the removal of these components from flue gases:

$2HCl + CaCO_3 \rightarrow CaCl_2 + CO_2 + H_2O$

$2HF + CaCO_3 \rightarrow CaF_2 + CO_2 + H_2O$

HCl and HF are highly reactive, therefore the level of removal of these gases from flue gases is very high, similarly as with SO_2 removal (Table 6.3.1-3).

Table 6.3.1-3: HCl and HF concentration in flue gases before and after the absorber

Parameter (for medium quality coal)	Unit	Value
HCl concentration in flue gas at the absorber inlet (wet, 1.013 mbar, 0°C, 6% O_2)	mg/m^3	50
HCl concentration in flue gas at the absorber outlet (dry, 1.013 mbar, 0°C, 6% O_2)	mg/m^3	5
HF concentration in flue gas at the absorber inlet (wet, 1.013 mbar, 0°C, 6% O_2)	mg/m^3	30
HCl concentration in flue gas at the absorber outlet (dry, 1.013 mbar, 0°C, 6% O_2)	mg/m^3	3

In regards to the emissions that are produced during the coal combustion, additional CO_2 emission, after FGD plant installation, occurs as the result of the formation of this gas after the reaction of limestone and SO_2, HCl and HF from flue gas. Total emission increase (volume flow rate) is around 2%.

B. Impact of coal and limestone supply and storage system

Dispersed material, supplied coal of up to -400+0 mm grain size is prepared in the coal supply and storage system, whereby the grain size of the coal is up to -100+0 mm after the primary grinding and up to -30+0 mm after the secondary grinding, during the transportation towards the storage.

In the coal supply and crushing system the measures for the coal particles reduction are foreseen by the installation of de-ashing system at all load points and key points (as described in the Section 3.3.6 hereby).

Scattering of coal particles from the landfill occurs in dry weather conditions, if the wind speed is faster than 8 m/s. Taking into account that the number of very small particles that can be transported to the distant locations is very small at the coal landfill, the reach of the pollution will be limited to the area close to the landfill, where the deposition of large coal particles is expected. Detailed analysis of pollution by the coal particles from the landfill are given Section 6.3.3 analysing the impact on land quality.

Study foresees the measures for the reduction of emission of the particles of the coal from landfill, Chapter 8.3.

In the limestone supply and disposal system, the dispersed matter of up to 19 mm has been prepared, which includes the risk from air pollution in the event of scattering of tiny limestone particles during the process. The following sources can produce emission of particles during limestone supply and disposal:

- Unloading of the batches of grinded limestone from the carriages to the storage,
- Scattering of the particles from the storage by wind,
- Loading of limestone over the transfer rod on belt conveyor to day silos.

Taking into account that the storage is covered, the possibility for the wind dispersion of limestone particles is minimum, while the reach of dispersed particles would be local.

Projected measures for the protection from limestone particles emission during limestone unloading and preparation are given in Section 8 hereof.

C. Impact of particulate matters from ash, slag and gypsum handling system

Technical solution foresees that ash, slag and gypsum suspension mix is transported in the closed transport systems (as shown in Figures 3.3.4-7 and 3.3.4.-8) that disables mix distribution and spillage along the route. Also, when the mix is wet it is more compact and this is very important when the mix is poured from the conveyor to disposal trolleys and landfill.

D. Impact of particulate matter from ash, slag and gypsum landfill

Previous experience from existing ash and slag landfills from thermal power plants in Kostolac Basin indicate that during the landfill operation serious problems frequently occurred regarding the particulate matters distribution from landfill surface, if the active cassettes surfaces were not adequately wetted, i.e. reclamation of the surfaces of passive cassettes. Therefore one of the main goals for the change of ash disposal technology was reduction of this adverse impact. Additionally, introduction of flue gas desulfurization also caused the necessity to solve the issue of the disposal of waste generated during this process.

Proposed technology of joint disposal of ash, slag and gypsum suspension in the area of open cast mine has obvious advantages, when compared to the previously used technology, y and they are reflected in the following:

- locating the landfill in the area of open cast mine Drmno does not occupy an extra space for waste disposal,
- mixing ash and slug with gypsum suspension with additional wetting (up to 25-30%) produces the mix that has more favourable characteristics regarding the mechanical strength, permeability coefficient and leak intensity in relation to single components. This mix is also called s*tabilizer* because it combines pozzolanic characteristics of ash, which result in the increase of affinity for the connection of heavy metals in deposited mass with gypsum characteristic, thus reducing the mobility of heavy metals but also the scattering of particles form landfill surface.

In addition to given advantages, by mixing ash and slag with gypsum suspension, the generation of waste waters from the desulphurization process is avoided (since sufficient amount of water is irreversibly taken out from the process with the gypsum suspension) that reduces the total amount of wastewater that need further treatment.

In accordance with above mentioned, there is an estimation that the proposed solution for the disposal of solid technological waste generated during the operation of B3 Unit will have significantly lower adverse environmental impact compared to the previously used solutions (technology for disposal in the form of slurry, particularly the disposal of ash and slag and gypsum).

This is also confirmed by already implemented solutions at some thermal power plants in the EU countries, as given in Table 6.3.1-4.

Table 6.3.1-4: Examples for shared disposal of ash, slag and gypsum in the area of open cast mine

Thermal power plant	Waste amount
TPP Janschwalde, Germany Capacity: 3000 MW	Ash and slag amount: 2.4-3.0 million tons per annum Gypsum amount: 0.3 million tons per annum Landfill location: Janschwalde Distance from the landfill: 18 km
TPP Schwarze Pumpe, Germany Capacity: 1600 MW	Ash and slag amount: 2,1 million ton per annum Gypsum amount: 0.2 million tons Landfill location: Spreyer Hohe Distance from the landfill: 25 km

Thermal power plant	Waste amount
TPP Boxberg, Germany Capacity: 1800+675 MWe	Ash and slag amount: 2.1 million ton per annum Gypsum amount: 0,2 million tons Landfill location: Spreyer Hohe Distance from the landfill: 4 km

Figure 6.3.1-16 shows the manner for the mixing of disposed mass at the landfill of TPP Janschwalde, as well as the system for wetting the landfill that additionally prevent distribution of particles from landfill surface.

a) Mass compaction **b) Landfill surface wetting**

Figure 6.3.1-16: Measures for the prevention of particulate dispersion from the landfill Janschwalde

6.3.2. Impact on water quality

A. <u>Ground waters intake</u>

Water from the Danube river will be used in new B3 Unit. For the needs of B3 unit, the construction of new (separate) pumping station plant is planned simultaneously with the existing plant, by using the existing intake channel with cooling water from river.

Planned capacity of water intake amounts to ≈52.000 m^3/h (≈ 14, 5 m^3/s), and includes, in addition to the amounts of cooling water the needs for supply of other consumers within B3 unit, such as the plants for chemical water treatment (CWT), flue gas desulphurization (FGD), fire protection system (FPS), as for the purpose of supply of cooling water for future plant for separation of CO_2 from flue gases. Total necessary amount of raw water (from the river) for CWT, FGD, FPS is up to 500 m^3/h.

Involvement of given water amounts will represent an increase in the total balance of surface water exploitation (for the needs of existing units TPP Kostolac A and B). Considering that medium annual discharge of the Danube river is about 5500m^3/sec and the minimum is around 1400 m^3/sec, water involvement in the amount of 14.5m^3/s can be assessed as the impact of minor significance.

Total water involvement from TPP Kostolac A and B is around 65 m^3/s for nominal operation of all units.

B. Waste waters discharge

Potential adverse impacts of the operation of B3 unit on water quality may be the result of:

- Discharge of treated wastewaters directly into the recipient,
- Discharge of waste heat through return cooling water.

Design solutions do not foresee direct or indirect wastewater discharge into the groundwater.

Wastewater treatment will be performed in the shared plant for all three units of TPP Kostolac B. Technological wastewaters from Unit B3 will be channelled into the shared plant. Recipient of treated wastewaters is the Danube (by direct discharge or by the discharge in the Mlava River). Having in mind that wastewater treatment in the plant foreseen for wastewater treatment will be performed in accordance with the requirements of the regulation defining ELVs (emission limit values) of pollutants into the waters from thermal power plants (criteria are given Section 3.3.6 hereof), the discharge of such wastewater will not have an impact on the quality change of the Danube river.

Based on the scheme of thermal unit, cooling water flow is around 14 m^3/s and project value of the increase of the temperature of return cooling water is around 9 °C (temperature of the water from the river is 15°C).

According to the project solution, return channel of cooling water flows into the regulated riverbed of the Mlava River, at the distance of around 3km from the confluence into the Danube, Figure 6.3.2.-1. Flow of the Mlava River is highly variable and often less than the flow of cooling water return channel (average flow of the river Mlava is 13.5 m^3/s). In such situation it can be deemed that the river Mlava flows into the cooling water return channel that flows into the Danube, which means that the course of the river Mlava is now shortened for the part that is transformed into the cooling water return channel, i.e. that return cooling water flows into the Danube. By flowing through the return channel the return cooling water is being cooled before it flows into the Danube.

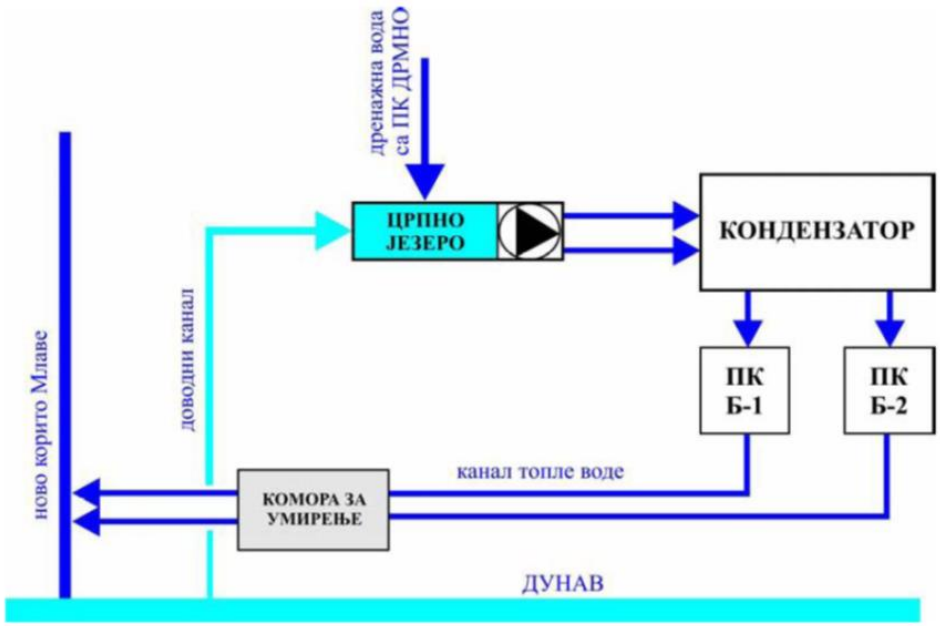


Figure 6.3.2-1: Cooling water flow scheme

Thermal pollution of the water potentially causes the watercourse eco-system changes since the number of species that need cooler water reduces and the number of species that need warmer water grows. Besides, microorganisms develop faster and this adversely affects the water quality. Due to the above, the functioning of eco-system changes and the health of people who use this water is potentially affected.

In accordance with the conditions determined by the Institute for Nature Conservation of Serbia, "cooling waters may be evacuated through the return channel into the Danube river under the condition that the temperature measured downstream from the point of thermal discharge does not exceed the initial temperature by more than 3 °C for cyprinid waters as is the water of the Danube". Position of metering point downstream from the discharge is not defined. According to BREF document for cooling systems in industrial plants (BREF for Industrial Cooling Systems, December 2001), the allowed increase of temperature of 3 °C is measured at the line of mixing zone.

Amount of waste heat that river can accept depends on its flow. If we start from the relation describing the balance of thermal load that reads as follows:

$$\Sigma Q_t = \Delta T \times C_p \times \rho \times Q_s$$

Where the following symbols are:

ΣQ_t – total waste heat that is emitted into the river, MW_t
ΔT – change of the Danube water temperature, °C,
C_p – specific water heat at average temperature in the amount of 4,18 kJ/kg °K,
ρ – water density, kg/m^3,
Q_s – the Danube flow, m^3/s

The following relation is obtained for the maximum allowed value $\Delta T = 3\ ^\circ C$

$$Q_t\ (MW) = 12{,}51 \times Q_s\ (m^3/s)$$

If it is known that the total wastewater from the existing units at TPP Kostolac A and B and new unit B3 is around 1450 MW_t, minimum water flow that can accept this heat amount with temperature change (at full mixing) not higher than 3 °C is around 116 m^3/s. This water amount is considerably smaller than the minimum Danube flow (1.400 m^3/s measured at MP Smederevo) and it represents around 8% of this flow. According to the criteria for the assessment of the location benefits in relation to the cooling water needs (Table 1.5 of BREF document for cooling systems in industrial plants), location of TPP Kostolac is assessed as “very favourable” (Grade 1- Good suitability).

Due to the above, it may be concluded that, under the given conditions, the impact of the operation of B3 unit on the surface water quality will be within the limits defined by the law. Possible changes of water quality are within limited zone around the discharge into the Danube river.

C. **Impact on underground waters**

Taking into account the given solution for ash, slag and gypsum landfill which does not foresee underground waste waters discharge, adverse impacts on underground waters may occur only in the event of unplanned circumstances. Due to the fact that the landfill is located on the open cast mine, unplanned circumstances may occur as the result of the impact of the waters generated during the mine exploitation. Thus, measures for adequate open cast mine dewatering and protection from the surface waters are important, since they also maintain the landfill stability level.

The basic concept of open cast mine protection from the surface (atmospheric) waters is as follows:

- accepting the atmospheric waters gravitating to the mine work area, before they jeopardize it and taking them to the nearest existing permanent or temporary water flows outside the mine;
- directing the atmospheric waters which directly fall into the work area of the mine to the location provided for their collection (water collectors);
- removing the collected water from the water collectors outside the work area of the open cast mine,
- accordingly, and based on the conducted hydrologic analysis and determination of the direction of further development of mining and disposal of excavated mass, creating the solution for protection of the open cast mine from the flow of surface and ground waters that will resolve the issue of protection from the flow into the mine contour and the issue of protection from the flow of the internal disposal site.

Protection of the mine Drmno from surface water and ground water from tier slopes is done in standard facilities: channels, water collectors, pump stations and pressure pipelines. Pumped waters are drained from the main area of the open cast mine drainage pipes to the Mlava river.

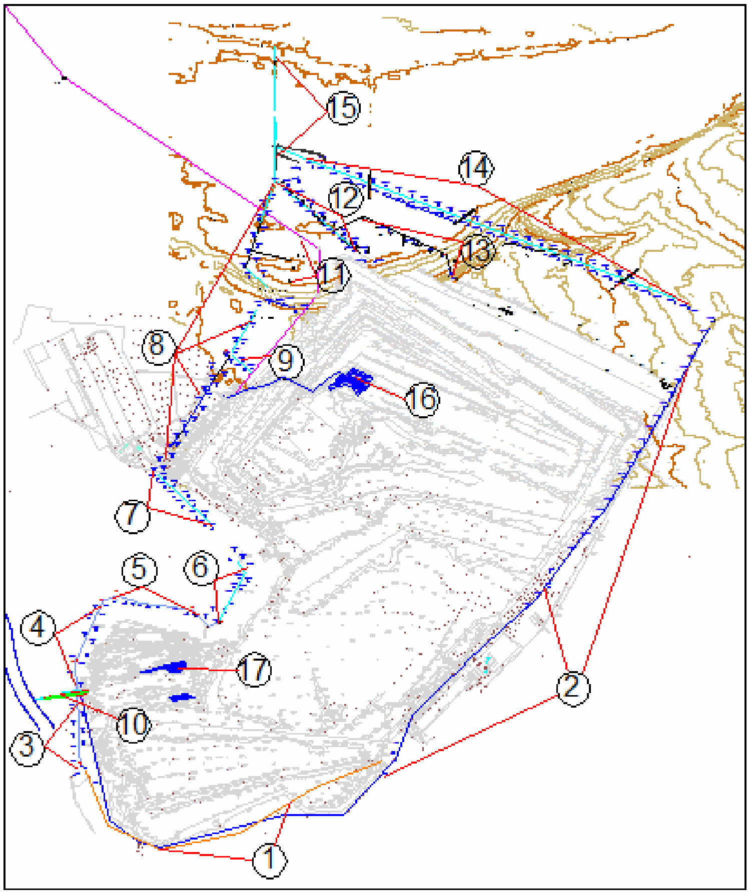
Open cast mine Drmno, for exploitation of coal deposits overlying drainage and protection from the flow of groundwater in the work mine area, uses the drainage wells and water-proof screen. The wells are located in linear barrages around the borderline of the open cast mine and in front of the excavation front in XII barrages.

Schematic display of the surface drainage facilities position is given in Figure 6.3.2-2.

To prevent filtration of ground water from the alluvial sediments of the Mlava river inside the open cast mine contour alongside the southern and south-eastern borders of the exploitation field, the screen about 2200m long and 12-30m deep was made during 1984.

Drainage wells are located in linear barrages over the open cast mine border lines and in front of excavation border line. The distance between the wells barrages is from 450 to 650m. Each well barrage consists of two lines of wells that are at the distance of 50m, except the ŠLA barrage which contains one line of wells. Distance between the wells in lines is from 75 to 150m. Taking into account the designed measures to protect ground water at the gypsum landfill and the fact that the receptor potential (underground area in OCM Drmno zone) is in the mode of strict drainage (pumping), when large quantities of ground water are mixed and transported to Mlava, the potential impact on quality and groundwater regime may be classified as the impact of minor significance.

Taking into account the designed measures to protect ground water at the gypsum landfill and the fact that the receptor potential (underground area in OCM Drmno zone) is in the mode of strict drainage (pumping), when large quantities of ground water are mixed and transported to Mlava, the potential impact on quality and groundwater regime may be classified as the impact of minor significance.



1 - waterproof screen
3 - LB-II well barrage with drainage line OLB-II
5 - LC-4 well barrage with drainage line OLC-4
7 - LC-V well barrage with drainage line OLC-V
9 - LC-VII well barrage with drainage line OLC-VII
13 – Substitute wells
15 – main drainage line GOL-2
17 – water collector at inner disposal site with pump station

2 - ŠLA well barrage with drainage line OLŠLA
4 - LB-III well barrage with drainage line OLB-III
6 - LB-IV well barrage with drainage line OLB-IV
8 - LB-V well barrage with drainage line OLB-V
10 – drainage line influx in Mlava river
12 - LC-IX' well barrage with drainage line OLC-IX'
14 - LC-XI well barrage with drainage line OLC-XI
16 – main water collector with pump station

Figure 6.3.2-2: System for protection from water at OCM Drmno

6.3.3. Impact on land quality

Unit operation has an impact on land quality in the form of pollutant emission from flue gases and from other sources of emission into the air and their (wet and dry) deposition on the ground. Besides, land pollution may occur as the result of the pollution of waters related to the land (it's a reversible process) and, it may also occur as the result of waste disposal.

Land is very sensitive to long-term presence of SO_2 and NO_x, therefore it is considered that all land containing higher concentrations, in the amount of 50 $\mu g/m^3$ (annually), should be regarded as the area where protection from adverse gas impacts has to be provided. If necessary biological measures are not undertaken, adverse effects will be transferred to living organisms over the impact on soil fertility.

Taking into account foreseen air protection measures as well as the forecasts regarding the impact of new unit on air quality and total impact of all relevant units, it may be concluded that estimated levels of concentrations of acidic oxides will be significantly lower than the given values. Therefore, there are no expectations that gas pollutants will have adverse impact on land quality in this area. Having in mind that the implementation of the measures for reduction of gas pollutant emissions into the air at the existing units is ongoing or it will be performed during the period until the completion of construction of B3 unit, impacts on land quality will be significantly more favourable compared to the current status.

Regarding the pollution by powder matters form flue gases, estimated pollution levels are significantly lower than allowed levels (Figure 6.3.1-14). Also, foreseen disposal technology will also reduce spreading of particulates from the landfill area, which reflects in the reduction of the deposition of particles on the ground and in the concentrations of suspended matters in the air as well.

Spreading of silt particles from the coal landfill is caused by the wind impact (wind erosion) under the conditions when the wind speed is faster than limit speed value; the characteristics of the surface from which the particulates are spread and the characteristics of particles determine the limit speed value. Studies show that limit wind speed value that causes significant dust spreading from coal storages is 6 m/s. Besides, significant influential factor that contributes to the level of particles spreading is precipitation frequency.

Applying empirical formulae and taking into account that the content of silt particles is (diameter of silt particles is up to 75 µ) 1-5 %, and also that the number of days with rainfall is around 100 days per annum, it is estimated that the average emission of particles from the surface of landfill is 5-23 kg/day/ha.

Taking into account all given influential factors the wetting of the landfill surface when there is no rainfall is the most efficient measure for the reduction of particles spreading.

6.3.4. *Impact on the noise level, vibrations, heat and radiation*

Noise impact

In accordance with the regulation requirements defining allowed noise level in work area, overall plant noise at a distance of 1 m can be approximately up to 85 dB (A). Taking into account that the intensity of the sound decreases with the expansion of wave front (increasing the distance between the source and receptor) and the passage of sound waves through a medium (air), we can estimate the volume that will occur in receptors that are closest to the location of thermal power plant, during the regular plant operation.

The nearest receptor on the location of the future of the project represent about twenty structures (sheds) at the distance of about 500m from the area of the future plant, near the western border of the location of TPP Kostolac B. The other two receptors are Drmno village located about 1.5 km southeast of the thermal power plant site and the village of Old Kostolac, located about 1.3 km west of the thermal power plant building. Because of the sound waves in free space outside the thermal power plant, the noise level decreases with distance from the source. The weakening of the sound waves occurs due to the absorption in the air.

As the noise level at the boundary circle of thermal power plant does not exceed 70 dB (based on the results of measuring), it can be concluded that the zone where noise level is within the limits allowed for settlements is at the distances of <500 m (Figure 6.3.4-1). Taking into account the requirements regarding the noise protection in the work area (85 dB(A) at the distance of 1m from the equipment) there are no expectations that the noise level at the boundary circle will be significantly changed after the construction of B3 unit.

Besides, allowed noise level at the boundary circle of thermal power plant will be defined in the following period pursuant to the requirements of the Rulebook that request the categorization of the space bordering with each industrial complex; and according to this the allowed noise level at the boundary circle of that space is defined (according to Table 5.1-6).

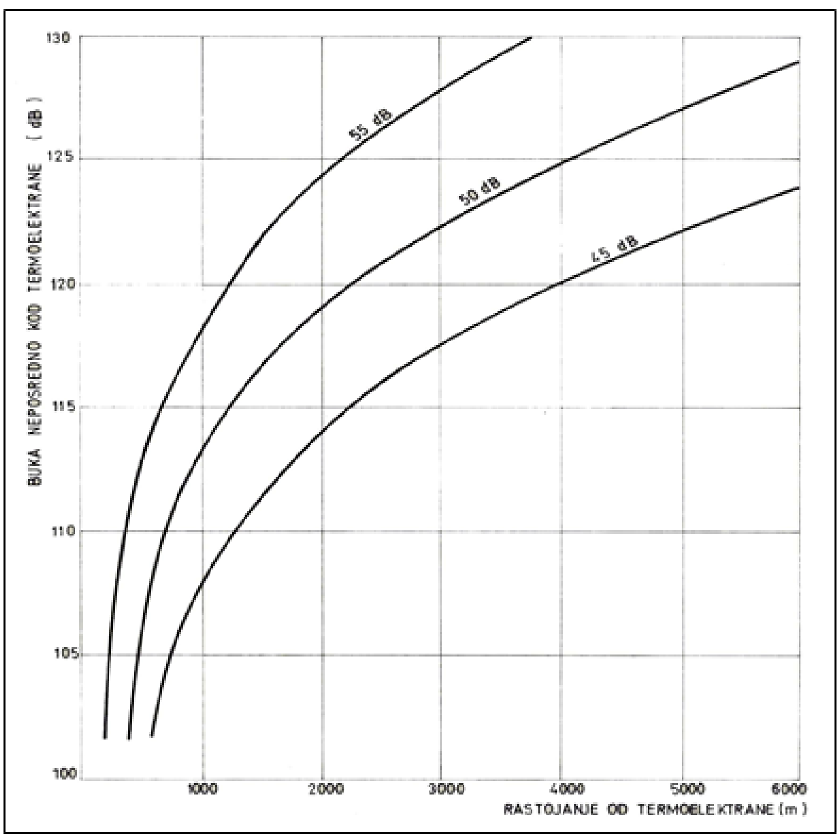


Figure 6.3.4-1: Reduction of noise levels depending on the distance from the source

In terms of adverse environmental impact, the vibrations represent smaller issue, since their transfer is much smaller and they are faster absorbed in the soil. Review of their impact is significant in the analysis of working conditions within thermal power plant and this analysis is within the field of safety at work. The analysis of environmental impact, the importance of vibration is negligible.

Electromagnetic radiation

Within the construction of B3 unit two high voltage lines are foreseen:

- air connection from the bay of switch gear room of 400 kV to the main facility of the unit for new B3 unit, around 175m long,
- new transformer 110/6,6/6,6 kV, capacity 60/35/35 MVA for own consumption of new unit that should be located near the new main facility of the unit B3 will be connected by air connection to 110kV plant. Air connection at 110 kV voltage level is realized by the line around 96m long.

Field of non-ionizing radiation protection is defined by relevant regulation of the RS, by adopting the Law on Protection from Non-Ionizing Radiation and supporting rulebooks, where the Rulebook on The Limits of Exposure to Non-Ionizing Radiation and Rulebook on Non-Ionizing Radiation Sources are particularly significant and they are adopted during 2009. Given regulation defines the limits of exposure and it prescribes the application of measures for reduction of the impact in the events when measured levels of non-ionizing radiations in the so-called increased sensitivity zones exceed the proposed reference levels given in Table 6.3.4-1.

Table 6.3.4-1: Referent limit levels of electromagnetic radiation

Limit types	Value	Reference limit level	
		According to the Rulebook	**According to the international recommendations**
Reference level	Electric field strength	2 kV/m	5 kV/m
	Magnetic induction strength	40 µT	100 µT

Based on the results of measuring the reference units (given in Table 3.3.5-23) it can be concluded that none of the analysed over ground lines has the maximum measured value of electric field strength above the limit of exposure for the public safety sector of 5 kV/m, that is defined by international recommendations. Also, it can be concluded that measured values of electric field strength on 110 kV over ground lines do not exceed the strict limit of exposure for public safety sector of 2 kV/m, proposed by the Rulebook. But, regarding the 400 kV overhead lines the measured values of electric field strength exceed this limit of exposure only directly beneath the phases of 400 kV over ground lines, i.e. that already at the distance longer than 25m from the axis of over ground line (at both sides) the values of electric field strength are less than 2 kV/m.

Based on the results of measuring the magnetic induction (Given in Table 3.3.5-23) it may be concluded that none of the analysed over ground lines, at given loads, maximum measured value of magnetic induction does not exceed the limit of exposure for the public safety sector of 100 µT, defined by international recommendations, as well as the strict limit of the exposure for the public safety sector of 40 µT, recommended by the national Rulebook. Recalculated values of maximum magnetic induction in the event when the projected current would flow through the analysed over ground line indicate that the values recalculated in such manner represent maximum magnetic induction values, at all analysed over ground lines, which are lower than the limit of exposure for the public safety sector (100 µT), that is defined by international recommendations. Also, recalculated values of magnetic induction at 110 kV overhead lines do not exceed the limit of exposure to for public safety sector of 40 µT, proposed by national Rulebook. Higher values of magnetic induction from more strict limit of exposure could be expected at 400 kV overhead lines, but it has to be taken into account that the calculations of possible magnetic induction are done according to the projected load currents (for analysed type of overhead line), and not according to the actual load currents of analysed overhead line (regular and maximum for given overhead line).

6.3.5. *Impact on people's health*

Unit operation has a dominant impact through flue gases emitted from the stacks, then indirectly, through water use (surface and underground water), if the water is polluted by the excessive emissions generated during unit operation, as well through the food chain.
Matters contained in flue gases and that adversely affect people's health are sulphur and nitrogen oxides, fly ash particles and carbon oxides.

Sulphur dioxide is a gas from the group of irritant gases *that* under usual circumstances is successfully removed by the mucous membranes of the nose. But, while performing moderate intensity physical activity, i.e. during faster walks which provokes mouth breathing, most people can feel health problems.

In these situations while performing the activities outdoor, patients with asthma will feel health problems. Main problem, even in the events of short exposure (exposure that lasted for few minutes) is the constriction of airways (bronchoconstriction), that might be followed by wheezing, tightness in the chest and breath shortening, which may result in the use of bronchodilators and other medicines. Symptoms get worse with the increase of sulphur dioxide level or with rapid breathing. When sulphur dioxide exposure is finished, lungs function usually returns to the usual level within an hour, even without the used f medicines. Very high levels of sulphur dioxide may cause that even adults who do not suffer from asthma may experience wheezing, tightness in chest and shortage of breath. Long-term sulphur dioxide exposure may cause respiratory symptoms and diseases and it may also make asthma symptoms worse. People with asthma as well as the people suffering from chronic respiratory and cardiovascular diseases represent the most sensitive group to the sulphur dioxide. Table 6.3.5-1 show the interval of daily sulphur dioxide concentrations with respective intervals of daily quality index and recommendations for population.

Table 6.3.5-1: Actions to protect your health under specific DAQI* values for SO_2 (respective interval of daily concentrations is specified for every air quality class)

Interval of DAQI classes (interval of daily concentrations in µg/m^3)	Actions to protect your health from sulphur dioxide

Excellent (0-29)	No specific recommendations
Good (30-62)	No specific recommendations
Acceptable (63-125)	People with asthma should reduce outdoor physical exertion.
Polluted (126-250)	Children, people with asthma and people suffering from heart or lung diseases should reduce outdoor physical exertion.
Very polluted (>250)	Children, people with asthma and people suffering from heart or lung diseases should avoid outdoor physical exertion. Everyone else should limit outdoor physical exertion.

***** DAQI: Daily Air Quality Index

Nitrogen oxides (NO_x) are the sum of volume concentrations of nitrogen monoxide and nitrogen dioxide (ppb_V), expressed in the units of mass concentration of NO_2 in (μg/m^3). Thus, NO_2 is an indicator of NO_x nitrogen oxides group.

Short-term exposure to nitrogen dioxide lasting from 30 minutes to 24 hours, causes adverse effects on respiratory airways, i.e. inflammation of respiratory airways with healthy people and aggravating respiratory symptoms with people with asthma. Researches also show the connection between short-term exposure to nitrogen dioxide and increased number of emergency service calls and hospital admission due to respiratory ailments.

People living or working in the vicinity of huge roads or industrial plants are exposed to higher NO_2 concentrations compared to the people who are located at some distance from the source of pollution. This exposure is specifically important for sensitive groups, i.e. the people with asthma, children and older people.

Actions to protect your health under specific DAQI values for under specific DAQI values for NO_2 (respective interval of daily concentrations is specified for every air quality class) are given in Table 6.3.5-2.

Table 6.3.5-2: Actions to protect your health under specific DAQI values for under particular values of DAQI* for nitrogen oxides

Interval of DAQI classes (interval of daily concentrations in µg/m3)	Actions to protect your health from NO_2
Excellent (0-19)	No specific recommendation since health problems are not expected
Good (20-42)	Extremely sensitive people should reduce prolonged outdoor physical exertion
Acceptable (43-85)	Following groups should reduce prolonged physical outdoor exertion: • People suffering from lung diseases, such as asthma • Children and older people

Polluted (86-170)	Following groups should reduce prolonged outdoor physical exertion: • People suffering from lung diseases, such as asthma • Children and older people Everyone else should limit prolonged outdoor activities
Very polluted (>170)	Following groups should not have outdoor physical exertion: • People suffering from lung diseases, such as asthma • Children and older people Everyone else should limit prolonged outdoor physical exertion.

* DAQI: Daily Air Quality Index

Suspended particles: Behaviour of ash particles is conditioned by their size: (i) gravity causes that dust with granulation of over 10 μm will spontaneously deposit if the air is still; if those particles are inhaled they will mostly be stopped in the mucus membrane of the nose or pharynx and they will cause irritation that does not have significant adverse effects, except on critical population groups (ii) particles with the size from 1 to 10 will deposit according to the Stokes' law and they will remain longer in the air; if inhaled they will remain in bronchial tree, (iii) particles smaller than 1 μm will behave similarly as the gases; if inhaled they will be deposited in the lungs.
New Ambient Air Quality Directive defines the limit values of concentration of particles, up to 10 mm (PM10) in diameter, as well as the particles up to 2.5 mm (PM2.5) in diameter, in form of daily and average annual values, which imposes the necessity to provide measuring of granulometric composition of emitted particulate matters through flue gases as well as the metering of concentrations PM_{10} i $PM_{2,5}$ in the air during the period after 2016.

Particles 10 µm in diameter or less may cause or aggravate large number of health problems and they have been associated with both short-term exposures (usually over 24 hours, but possibly as short as one hour) and long-term exposures (years).
Sensitive groups for particle pollution include people with heart or lung disease (including heart failure and coronary artery disease, or asthma and chronic obstructive pulmonary disease), and children. The risk of heart attacks, and thus the risk from particle pollution, may begin as early as the mid-40s for men and mid-50s for women. Exposure to particle pollution may cause people with heart disease to experience chest pain, palpitations, shortness of breath, and fatigue. Particle pollution has also been associated with cardiac arrhythmia and heart attacks. When exposed to high levels of particle pollution, people with existing lung disease may experience additional breathing problems. They may experience symptoms such as coughing and shortness of breath. Healthy people also may experience these effects, although they will not be difficult as the problems of sick people. Particle pollution also can increase susceptibility to respiratory infections and can aggravate existing respiratory diseases, such as asthma and chronic bronchitis, causing more use of medication and more doctor visits.

Actions to protect your health under specific DAQI values for PM_{10} and soot (respective interval of daily concentrations is specified for every air quality class) are given in Table 6.3.5-3.

Table 6.3.5-3: Actions to protect your health under specific DAQI values for PM10 and soot

Interval of DAQI classes (interval of daily concentrations in µg/m3)	Actions to Protect Your Health From PM_{10} and soot
Excellent (0-12)	No specific recommendation

Good (13-25)	Extremely sensitive people should reduce prolonged or excessive outdoor physical exertion
Acceptable (26-50)	Following groups should reduce prolonged or excessive physical outdoor exertion: • People suffering from lung diseases, such as asthma • Children and older people • People having outdoor activities
Polluted (51-100)	Following groups should avoid all physical outdoor exertion outdoor: • People suffering from lung diseases, such as asthma • Children and older people • People having outdoor activities Everyone else should avoid prolonged or excessive outdoor physical exertion
Very polluted (>100)	Following groups should avoid the presence in outdoor space and to reduce the level of their activities: • People suffering from lung diseases, such as asthma • Children and older people • People having outdoor activities Everyone else should avoid all outdoor physical exertion

***** DAQI: Daily Air Quality Index

Carbon oxides: Coal burning produces large amounts of carbon dioxide as combustion product, whereby it is assumed that the amounts of carbon monoxide will be negligible (if the parameters of combustion in boiler are adequately recorded and monitored).

Although, carbon dioxide is on the list of matters whose emissions and immissions in the air are limited by the regulation, the presence of carbon dioxide in the atmosphere has an impact on the global heating process and thus, indirectly, it can have adverse effects within the impacts that this process brings.

Summary assessment of impact on people's health

B3 Unit operation will be completely in accordance with the applicable limitations that refer to the emissions of pollutants into the environment. Contribution of B3 Unit to the air pollution is given in Section 6.3.1 hereof, and this bring to the conclusion that it makes a small part of total level defined by the legal limitations that refer to the ambient air quality requirements.

Furthermore, commissioning of new unit will create the conditions that will enable cold reserve status of some old units or their reduced engagement. This also has indirect positive impacts on people's health, taking into account that these units, according to their project and operation characteristics, have more significant impact on aggravating environment quality when compared with modern thermal units.

Also, during B3 Unit operation, in accordance with the undertaken obligations of EPS and in respect to the compliance with the requirements of regulation in the field of environmental protection, the existing units will be reconstructed, including the adoption of all necessary measures for the reduction of emissions into the air. Therefore, new positive changes are expected regarding the people's health status in the neighbouring settlements, that will be seen through reduced number of currently registered respiratory and cardiovascular system diseases, particularly diseases registered within sensitive population groups (Section 5.8 hereof).

6.3.6. Impact on eco-system

By Regulation of Waterways, the Danube river (Official Gazette of RS 5/68) in its whole course through Serbia is classified into the river whose waters should correspond to quality class II according to the Regulation on Water Classification (Official Gazette of RS 5/68).

Republic Hydro meteorological Institute monitors the water quality of the Danube also, among others, on the profiles of Smederevska Palanka and Banatska Palanka, which are the closest to the subject site. As the profile of Smederevo is located upstream from the same village, steel-processing plant and the mouth of the Morava, the test results are not relevant to the water quality of the sector TPP Drmno. Profile Banatska Palanka is located about 11 km downstream of the TPP Drmno and since there is no other source of pollution in between, it completely corresponds to water quality of the sector TPP Drmno as well.

The tests include the determination of the parameters defined by the above mentioned Rules and the Regulation on Hazardous Substances in Water (Official Gazette of RS 31/82), which includes: basic physics and chemical parameters, indicators, oxygen regime, mineralization, nutrients, toxic and heavy metals, organochlorine insecticides, triazine herbicides, pesticide based chlorophenoxy carboxylic acids, polycyclic aromatic hydrocarbons and polychlorinated biphenyls. Also provided radiological, microbiological and hydro biological tests are being done, which include determining the saprobic index by Pantle-Buck.

According to the results of systematic studies on the water quality of the Danube around OCM Drmno the following conclusions can be reached:
Danube water quality is generally slightly lower than required and it ranges from II-III class to III river water class. The most common variations are recorded in the microbiological content and suspended matter content, as a result of erosion in the basin. Oxygen regime gets disturbed occasionally, causing the detection of decreasing the level of oxygen saturation or increasing of the five-day biochemical oxygen demand. Less frequently, slight increase of phenol and nitrites is registered.

The favourable fact is that the water of the Danube does not records elevated concentrations of detergents, mineral oils, cyanide, pesticides, polycyclic aromatic hydrocarbons, polychlorinated biphenyls, which are hazardous substances, some of which are toxic, carcinogenic and teratogenic. Performed tests on heavy and toxic metals (Pb, Cd, Cu, Zn, As, Ni, Cr, Hg) recorded that only Zn, Cu, As are in in measurable concentrations, but they are several tens of times lower than the MRL for II river water class.

Water of the river Mlava is checked once a month at Petrovac, according to the same parameters as the Danube river, and it should correspond to the II-a quality class, according to the above-mentioned Regulation. The results of these tests are not applicable to the given sector as profile Petrovac is located about 50 km upstream, and after passing the control profile, the river Mlava passes through several villages and it flows into a number of smaller tributaries.

Bearing in mind that the settlements through which the river Mlava passes do not have sewage not waste waters treatment facility, are therefore the river receives a significant amount of organic matters and nutrients, leading to the decrease in dissolved oxygen and the increase of biochemical and chemical oxygen demand and intense microbial contamination.

After being treated in central plant, waste waters that will be discharged into the recipient, practically they will flow into the cooling water return channel and then into the Danube. Taking into account the required quality of treated water that is in accordance with legal limitations, discharged waste waters will not have an impact on the change of the Danube water quality.

At the sector TPP Drmno, the river Mlava flows through the regulated channel and accepts the cooling water from TPP. Considering the flow of the river Mlava and amount of hot water that is discharged into it, there is certainly a significant thermal degradation which disrupts oxygen regime, the solubility of salt, the process of self-purification and reproductive cycles of hydro-bionics in the recipient.

So far, there have been no studies about the impact of the TPP Drmno on the Special Nature Reserve Deliblatska Pescara, Ramsar Swan pane area and IBA Dubovac – Ram area.

General conclusion regarding the effects that the operation of new unit has on eco-system is that additional adverse changes are not expected taking into account the analysed area has for many years been under the impact of mining and power complex Kostolac. In the previous few years the complex Kostolac initiated the activities on the improvement of environmental protection measures that in addition to the air protection measures include the most significant measures related in connection with waste treatment and deposition. Ash and slag handling technology has been changed by changing the density of hydro mix from thin to dense hydro mix, as well as by changing the location of the landfill from Middle Kostolac Island site to OCM Cirikovac site.

6.3.7. Impact on living organisms (flora and fauna)

Impacts on vegetation may be divided into the following categories: (i) acute damages, (ii) chronical damages and (iii) physiological damages. Reference pollution levels that result in these damages are the following:

- Acute damages occur due to the fast absorption of SO_2 with the concentrations over 1.250 $\mu g/m^3$ in short-time period,
- Critical concentrations of NO_x that cause acute damages on the leaves and tissue of the plants depend on the exposure conditions (sensitivity is much higher when the light is low) and amount to 3.000-7.000 $\mu g/m^3$,
- Chronic damages occur by longer exposure of plants to the concentrations of around 250 $\mu g/m^3$, or 250-1.250 $\mu g/m^3$ during several days or weeks,
- Chronic damages on leaves and yields occur due to long-term effects of NO_x with the concentration around 300-500 $\mu g/m^3$.

According to the global standards, the area where mid-day concentrations of sulfur-dioxide are higher than 50 $\mu g/m^3$ during the spring and summer period is defined as the area for protection with biological measures in order to eliminate the effects and reduce TPP impact.

It should be noted that the area Dubovac-Ram is proclaimed as separate IBA area-YU 34 SE as one of the most significant habitats, rest areas and wintering areas of migratory swamp birds in the Europe. Furthermore, the Special Nature Reserve Deliblatska Pescara, Ramsar Swan pane area and IBA Dubovac – Ram area are under special protection regime and many protected plant and animal species that live there were affected in the past by the particulate matter and flu gas emissions from the area of TPP Drmno, but the assessment of the adverse impacts was not conducted.

Detail analysis of the habitats and overall characteristics of bird and bat fauna at the area of Kostolac Basin was conducted within earlier works for the needs of Kostolac Wind Farm Construction Project[7].

Methodological items, scope and dynamics for bird and bat monitoring are created based on the EU relevant regulation, practice and recommendations within this field. Figure 6.3.7-1 shows the monitoring area with the observation locations for monitoring.

Conducted monitoring showed that 120 bird species and 19 bat species live at the monitored area, but many of those were registered in a very small number and only marginally at the marked locations. Dominant species who live within the narrower area are the species that prefer open ruderal habitats, thickets and very dense brushwood; the species that prefer water and wet habitats live in some parts as well. It should be emphasized that important bird (and bat) habitats known before live within broader area, i.e. protected Sawn pane area and valleys of Mogila and Mlava and internationally significant ecological corridors (the Danube and Velika Morava) as well, that already have ecological resources necessary for the fulfilment of all life needs of bird and bat species who live there.

Figure 6.3.7-1: Layout of the observation locations for bird monitoring at the researched area

[7] Monitoring of birds and bats for the needs of Kostolac Wind Farm Construction Project, Netinvest, Belgrade, Fauna C&M, Belgrade, 2015

Bird Fauna

Most sensitive subjects of the monitoring are prey birds that are classified as endangered species group and therefore they are extremely protected. 12 species out of 17 belong to the day prey birds. During the monitoring and at the location, larger prey bird species such as eastern imperial eagle (Aquila Heliaca), as well as the booted eagle (Aquila Pennata) or saker falcon (Falco Cherrug) were not recorded and White-tailed Eagle (Haliaeetus Albicilla) was observed only once around OL 7 within the control area.

Nevertheless, the presence of a large number of small rodents (Rodentia) and insectivores (Lipotyphla) in the agrocoenosis of the location attracts a large number of day prey bird species such as Common Buzzard, Common Kestrel and Hen Harrier, therefore their number is high and it is confirmed by the fact that they are observed in much greater number than other species. Common buzzard (Buteo Buteo) and Common Kestrel, Falco Tinnunculus are the most common day prey bird species and individual overflights of Marsh Harrier (Circus Aeruginosus) are quite usual. Northern Goshawk (Accipiter Gentilis) and Eurasian Hobby (Falco Subbuteo) is always present as well, but its number gets reduced only during the hottest season of the year.

Bat fauna

Monitoring clearly showed that the bats are, in small number, always present at contemplated locations, especially outside the urban zones and at longer distances from them. Low to moderate activity was registered within the larger part of the location surfaces, with the exception of only few ecologically specific zones where the recorded activity was high or extremely high. Even more than 83% of all overflights/contacts registered on transects are performed by 3 species: Pipistrellus Kuhlii, Pipistrellus Nathusii and Nyctalus Noctula. All other species are recorded in a far smaller number mostly from time to time, and this small number does not indicate that the location has great significance on their population.

The analysis of ecological functions of the area that are obtained based on the bat monitoring data determined the manner how bats use the contemplated area, present habitats and how significant are they for present bats.

Based on the assessment of ecological function of contemplated locations it was assessed that the area in the vicinity of location TPP Kostolac B has the low cryptic and trophic potential for birds and bats, which means that it does not represent suitable area for the formation of their habitats. Area around the settlement Petka has the greatest potential for formation of habitats, which is located beyond the direct impact of TPP Kostolac B, in terms of the impact of analysed aspect.

Construction of B3 Unit has small contribution to the already existing impacts on the living organisms in the vicinity of TPP Kostolac B location, due to the following reasons: :

- Construction of B3 unit is planned within the location of TPP Kostolac B where two units of equal capacity have already been constructed and they are in operation form more than 20 years,
- Dimensions of the facilities that will make B3 Unit are similar to the existing facilities at the location of TPP Kostolac B,
- Coal supply will be conducted from the existing open cast mine Drmno that has been exploited for more than 20 years.

All this indicated that the construction of new unit will not cause additional changes in ecosystem in the vicinity of TPP Kostolac B that could contribute to further endangerment of the living organisms habitats, since the existing species during the previous long-term period have adopted to the new conditions caused by the operation of the mining and power complex Kostolac.

Regarding the impact on birds and bats that are regarded as potentially endangered and protected species, it has been concluded that the area around TPP Kostolac does not represent suitable location for the formation of the habitat of these species, probably due to its purpose for industrial activities. Therefore, adverse contribution of B3 Unit is negligible.

On the other hand, assessments regarding the positive impact of the construction and functioning of power plant and auxiliary infrastructure on some bird species has to be emphasized. Thus, construction of power lines in terms of obligatory auxiliary infrastructure can have significant impact on nesting populations of those bird species that find these power lines suitable for their nests. As already defined, many species like to nest on power lines, i.e. the sparrows (Passer spp.), common starling (Sturnus vulgaris), raven (Corvus Corax), corvus (Corvus Cornix), common magpie (Pica Pica). Raven nests are often used by prey birds such as Falco Tinnunculus, common buzzard (Buteo Buteo), falco subbuteo, and also saker falcon (Falco Cherrug) and very rarely eastern imperial eagle (Aquila Heliaca).

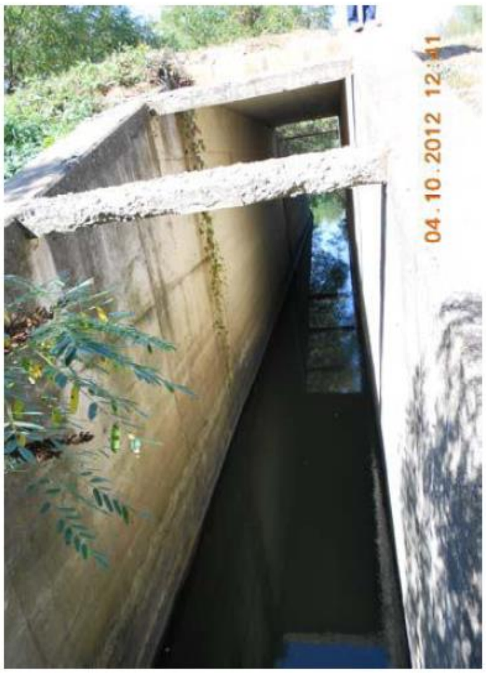
Based on the potential levels of pollution after the construction of B3 Unit, with the assumption that the modernization projects on B1 and B2 units as well as on the units of TPP Kostolac A are being implemented, it can be concluded that the impacts on living organisms will significantly become lower compared to the current state, in terms of both intensity and reach.

Water supply system is constructed for both planned phases of the construction of TPP Kostolac B capacity. Impact of this water system is seen in the change of the Mlava river course, i.e.

diversion of the river course for the needs of construction of feed and return cooling water channel.

In order to preserve the conditions for the survival of living organisms, fish path has been built, i.e. overflowing hole on middle (separation) embankment, with the capacity of 2,0 m^3/s, that provide for the hydraulic-biological relation between old riverbed (feed cooling water channel) and new riverbed of the Mlava river.

Facility consists of three parts: trapezoid channel, concrete rectangular channel 2m wide through renovated middle embankment and waterfall cascades in feed channel, Figure 6.3.7-2.



Fish path **Middle feed channel embankment**

Figure 6.3.7-2: Fish path on the Mlava River

6.3.8. Impact on climate

The influence on climate of B3 unit is viewed through carbon dioxide emission. Although the Basic design does not provide the measures for reduction of CO2 emissions, taking into account that commercial activities in these purposes are not being reached, based on the available results of previous studies and development, space for subsequent installation of the plant is foreseen, when some of the technology is commercially available and as EPS starts the implementation of these measures at its plants.

Looking from the point of view of technical solution for B3 unit, it can be concluded that the design values of the efficiency of boiler and turbine plants result in significantly lower values of specific CO2 emissions compared to the existing thermal capacities of EPS (for revitalized units, specific emissions of CO2 are in the range of 0.96 to 1t/MWh, while the value for B3 unit is

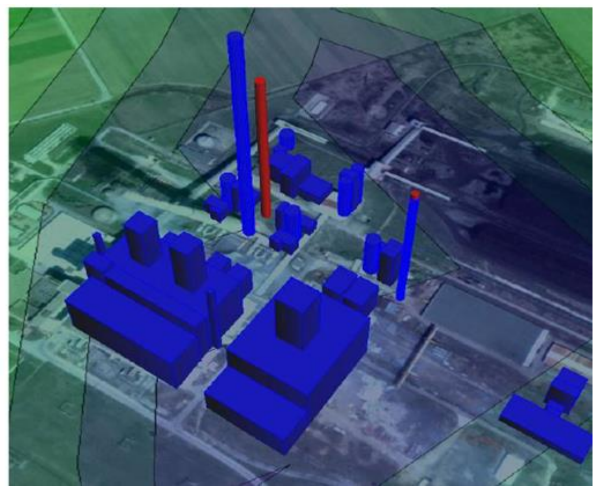
0.88t/MWh, which represents a contribution to the reduction of total CO2 emission from EPS facilities through the increase of energy efficiency of its facilities.

6.3.9. Impact on landscape

Area in the vicinity of TPP Kostolac B is rural landscape type with small settlements. Vegetation elements of agricultural land are dominant among the landscape features, with the buildings for mining and industrial purposes, Figure 6.3.9-1.

Since two thermal power units with all auxiliary building and 250m high stack as well coal landfill and open cast mine at 2km distance have already been located on this location, the construction of new B3 Unit will not significantly impact the landscape. However, given the proximity of the archeological finding Viminacium that borders the location of power plant and that in future will have a growing tourist and cultural and historical importance, attention has to be paid on entire area within power plant regarding biodiversity protection measures and construction of protective green belt around TPP location.

TPP Kostolac B



Model of the existing and future facilities at TPP Kostolac B location

Figure 6.3.9-1: TPP Kostolac B location

6.3.10. Impact on the objects of cultural heritage

Only protected monument that could be affected by the construction and operation of the plant is an archaeological site Viminacium (cultural monument of great importance). The impact of this archaeological site was originally made in the late seventies of the 20th century during the construction of TE-KO B, which is located on the southern tombs of Viminacium. Construction works on the construction of power plants initiated and archaeological research during which they discovered and preserved memory, now exposed within the building thermal power plants.
Space for the future plant is flat land, mostly covered with vegetation, all zoning and the planning documents and approved for that purpose. The investor is required to provide constant monitoring of one archaeologist who will carry out continuous monitoring of soil and preparatory works for the construction of the facility. In the event that during the archaeological monitoring

immovable property is recorded requiring extended works, relocation or presentation, the investor should undertake protective measures under special conditions issued by the Republic Institute for Protection of Cultural Heritage. For the construction of unit 3 at TPP Kostolac B the competent institution, i.e. the Institute for Protection of Cultural Heritage gave its consent which defines the conditions in terms of protective measures that should be undertaken and which are included in the measures given in Section 8 hereof.
During the process of ground clearing and earthworks for the preparation for construction site, can new archaeological findings that belong to Viminacium may be found. The works of construction machinery could destroy or damage archaeological objects and it is essential that Electric Power Industry of Serbia, Institute for Protection of Cultural Heritage in Smederevo and archaeological institutions coordinate their construction works and archaeological research.

Implementation of plant project will not have an impact on the existing preserved facilities of Viminacium – memorabilia since they are about 600 m far in the northwest from the site and they are adequately protected.

6.3.11. Impact on social and economic elements

Construction and operation of the plant will have positive impact on social and economic elements, primarily on the increase of employment and revenues of local community.

According to the plan, the construction will last five years. During the period of most intensive construction a large number of workers will be engaged. Equipment suppliers will mostly buy goods and services from local suppliers and this will have a positive impact on local community development.

More than 50 workers will be employed for the needs of plant operation and maintenance. Plant operation and maintenance will require the procurement of additional required raw and processed material (e.g. chemicals for various purposes, crude oil, limestone and others), which may have a positive impact on local industry development.

Gypsum created as a by-product of desulphurization process may have commercial application (production of gypsum and cardboard panels or cement production) and its placement may have an impact on future development of gypsum market that is quite undeveloped in Serbia.

6.3.12. Transboundary pollution transport

Transboundary long range transport of pollutants is a result of the transport of smoke plume under the influence of altitude flows of air mass. Thus, the pollutants are transported to the distances of several hundred kms long. Regulation on the obligation for the reduction of pollutant emissions at the pollution source was adopted in previous decades, with the aim to reduce the level of the impact of long range pollution sources.

In accordance with international treaties, Serbia adopted the laws regulating this field as follows:

- Law on Ratification of the Convention on Environmental Impact Assessment in a Transboundary Context (Official Gazette of RS, no. 102/97),
- Law on Ratification the protocol on strategic environmental assessment with the Convention on Environmental Impact Assessment in a Transboundary Context.

Furthermore, Convention on Long Range Transboundary Air Pollution, adopted in 1979 at the European Conference on the Environment defines the obligations of the European countries regarding the air protection from pollution at international level. In that sense, within harmonized program of the cooperation for monitoring and assessment of spreading of long range air pollution in the Europe (EMEP), transboundary transport of specific pollutants among the European countries has been analysed every year.

EMEP includes two basic groups of activities: (i) measurements of air quality on determined network of metering points within the European territory (overall 169 stations in 36 countries) where the measurements of the concentrations of SO_2 , sulphate particles, NO_x, total nitrates, ammonia+NH_4, sulphate, nitrate and ammonia in rainfall; and (ii) calculations of transboundary transport of matters that are measured as well as sulphur and nitrogen deposits in the analysed territory for particular country.

Calculations of transboundary transport (concentrations and deposits) are conducted based on the data on emissions of analysed pollutants for particular country (all countries annually submit the reports) and meteorological parameters for which the data base from meteorological stations is used. Then, they are processed in numerical weather forecast model (Numerical Weather Prediction). Calculations are made for the area given in Figure 6.3.12-1, per square network of 50 x 50 km^2.

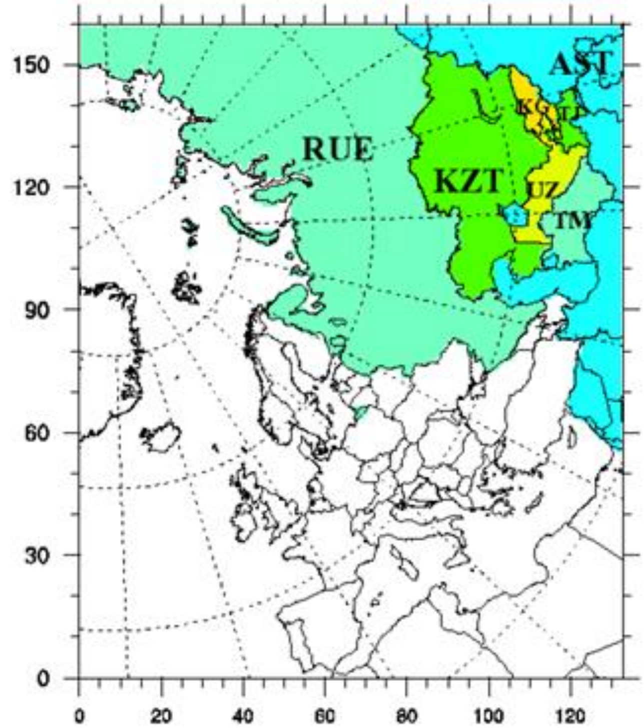


Figure 6.3.12-1: Area covered by the calculations of EMEP and EMEP network

Analysis of submitted emission values for each country in the period 2000-2013 show various trends for eastern and western part of EMEP area: emissions in western part constantly tend to decline, while in the eastern part they fluctuate around the same level or they even show growing trend. Total emission at the overall area are: NO_x (-28%), NMVOCs (-29%), SO_2 (-46%), NH3 (+5%), $PM_{2.5}$ (-1%), PM_{uk} (+7%), CO (-29%).

Tables 6.3.12-1 and 6.3.12-2 show the emission trend for each country that has been used in the calculations (ref.: EMEP Status Report for 2015).

Table 6.3.12-1: Total national sulphur emissions for each country for the period 2007-2013,

Gg SO_2 per annum

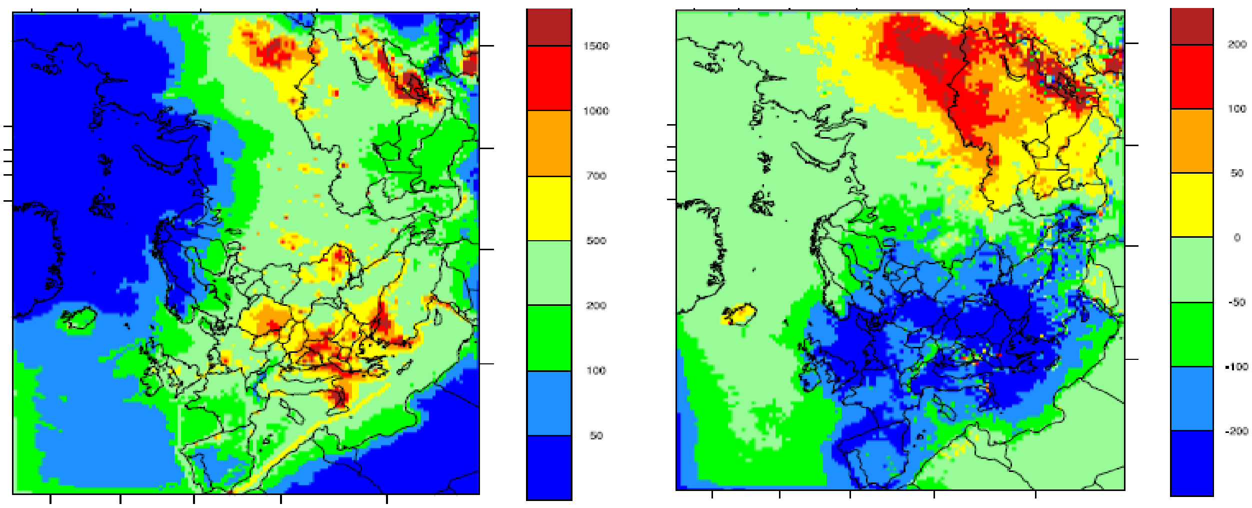
Area/Year	2007	2008	2009	2010	2011	2012	2013
Albania	18	17	16	16	15	14	13
Armenia	2	2	2	2	2	2	2
Austria	25	22	17	19	18	17	17
Azerbaijan	79	63	47	31	18	5	5
Belarus	83	82	82	81	83	86	89
Belgium	125	97	76	61	53	47	46
Bosnia and Herzegovina	224	224	224	224	221	219	217
Bulgaria	819	569	440	387	515	329	194
Croatia	59	53	56	35	29	25	16
Cyprus	29	22	18	22	21	16	14
Czech Republic	196	189	182	174	162	150	138
Denmark	28	21	15	15	15	13	14
Estonia	88	69	55	83	73	41	36
Finland	83	70	59	67	61	51	47
France	422	357	305	285	249	235	219
Georgia	6	6	6	6	7	7	7
Germany	461	462	412	434	431	417	416
Greece	424	371	319	266	236	205	174
Hungary	35	35	30	31	34	31	29
Iceland	58	74	69	73	80	84	86
Ireland	57	47	34	28	27	25	25
Italy	341	286	233	215	194	175	145
Kazakhstan (KZT)	2083	2210	2338	2466	2593	2721	2849
Kyrgyzstan	30	33	35	38	40	42	44
Latvia	5	4	4	3	2	2	2
Lithuania	26	22	21	21	23	20	19
Luxembourg	2	2	2	2	1	1	2
Malta	9	7	6	5	5	5	5
Montenegro	12	15	8	28	40	40	40
Netherlands	61	51	38	34	34	34	30
Norway	20	20	15	20	19	17	17
Poland	1229	1007	868	937	885	859	847
Portugal	145	96	61	53	48	43	42
Republic of Moldova	6	6	5	4	4	4	4
Romania	531	475	420	364	329	294	259
Russian Federation (RUE)	3711	3736	3497	3504	3588	3658	3685
Serbia	463	479	435	422	470	433	429
Serbia and Montenegro	0	0	0	0	0	0	0
Slovakia	71	69	64	69	68	58	53
Slovenia	15	13	11	10	12	11	11
Spain	1096	477	427	401	436	385	272
Sweden	32	30	30	32	29	28	27
Switzerland	13	13	12	12	10	10	10
Tajikistan	36	39	41	43	47	50	54
TFYR of Macedonia	109	112	114	117	113	109	105
Turkey	2648	2561	2665	2561	2641	2716	1939
Turkmenistan	160	183	195	213	244	271	298
Ukraine	1093	1103	1113	1123	1132	1142	1151
United Kingdom	589	492	399	428	391	440	393
Uzbekistan	775	845	913	991	1073	1161	1254
North Africa	413	443	463	487	496	507	517
Asian areas (AST)	1470	1488	1535	1595	1642	1695	1680
Baltic Sea	106	105	100	95	69	61 (69)	54 (69)
Black Sea	55	51	50	50	53	52 (53)	52 (53)
Mediterranean Sea	1027	951	938	920	976	966 (976)	956 (976)
North Sea	367	254	247	223	163	122 (163)	81 (163)
Remaining N-E Atlantic Ocean	478	443	437	426	452	447 (452)	442 (452)
Natural marine emissions	743	743	743	743	743	743	743
Volcanic emissions	2500	2500	2500	2500	2500	2500	2500
TOTAL	25791	24219	23446	23493	23914	23843 (23907)	22818 (22946)

Table 6.3.12-2: Total national nitrogen emissions for each country for the period 2007-2013

Gg NO_2 per annum)

Area/Year	2007	2008	2009	2010	2011	2012	2013
Albania	19	19	18	18	18	18	18
Armenia	16	17	18	19	20	21	22
Austria	212	195	179	180	170	165	162
Azerbaijan	100	100	101	101	101	101	101
Belarus	172	169	166	164	163	162	161
Belgium	267	236	210	252	235	216	208
Bosnia and Herzegovina	33	33	33	32	32	32	32
Bulgaria	166	161	139	139	154	140	123
Croatia	83	80	73	64	60	56	56
Cyprus	22	20	20	19	21	21	16
Czech Republic	244	232	220	208	199	190	181
Denmark	187	170	150	145	138	128	124
Estonia	38	36	30	36	36	32	30
Finland	187	168	155	167	154	147	145
France	1297	1198	1116	1096	1036	1008	990
Georgia	27	29	30	31	32	33	34
Germany	1484	1411	1310	1334	1311	1270	1269
Greece	357	335	312	290	278	266	254
Hungary	167	164	157	154	140	124	121
Iceland	27	25	25	23	21	21	20
Ireland	129	116	93	85	76	78	79
Italy	1129	1056	982	969	950	863	821
Kazakhstan (KZT)	532	561	591	620	649	679	708
Kyrgyzstan	33	36	39	43	45	48	51
Latvia	45	40	38	38	33	34	34
Lithuania	54	55	48	50	46	48	46
Luxembourg	49	45	39	39	39	35	31
Malta	9	9	9	9	9	8	8
Montenegro	8	9	7	10	13	13	14
Netherlands	310	299	275	274	258	248	240
Norway	196	185	175	177	170	163	154
Poland	861	829	809	861	843	819	798
Portugal	229	203	191	177	169	162	161
Republic of Moldova	24	22	21	19	19	18	18
Romania	277	262	246	230	224	217	210
Russian Federation (RUE)	3595	3522	3334	3253	3231	3204	3158
Serbia	183	180	171	172	184	188	137
Serbia and Montenegro	0	0	0	0	0	0	0
Slovakia	96	94	84	89	85	81	80
Slovenia	51	56	48	47	47	46	43
Spain	1265	1077	949	891	885	854	743
Sweden	166	157	148	150	139	131	126
Switzerland	87	85	80	78	73	73	72
Tajikistan	57	62	64	68	73	79	84
TFYR of Macedonia	36	36	37	37	36	35	34
Turkey	1031	984	961	945	1120	1090	1047
Turkmenistan	65	75	79	87	99	110	121
Ukraine	801	764	727	690	684	678	673
United Kingdom	1471	1325	1149	1123	1051	1073	1020
Uzbekistan	227	248	268	290	314	340	367
North Africa	96	103	108	113	115	118	120
Asian areas (AST)	430	437	449	463	477	493	497
Baltic Sea	281	273	267	267	271	269 (271)	267 (271)
Black Sea	91	82	80	78	79	77 (79)	75 (79)
Mediterranean Sea	1713	1556	1511	1476	1497	1453 (1497)	1410 (1497)
North Sea	733	668	650	635	644	626 (644)	608 (644)
Remaining N-E Atlantic Ocean	796	723	702	686	695	675 (695)	655 (695)
Natural marine emissions	0	0	0	0	0	0	0
Volcanic emissions	0	0	0	0	0	0	0
TOTAL	22260	21032	19889	19711	19662	19276 (19362)	18776 (18948)

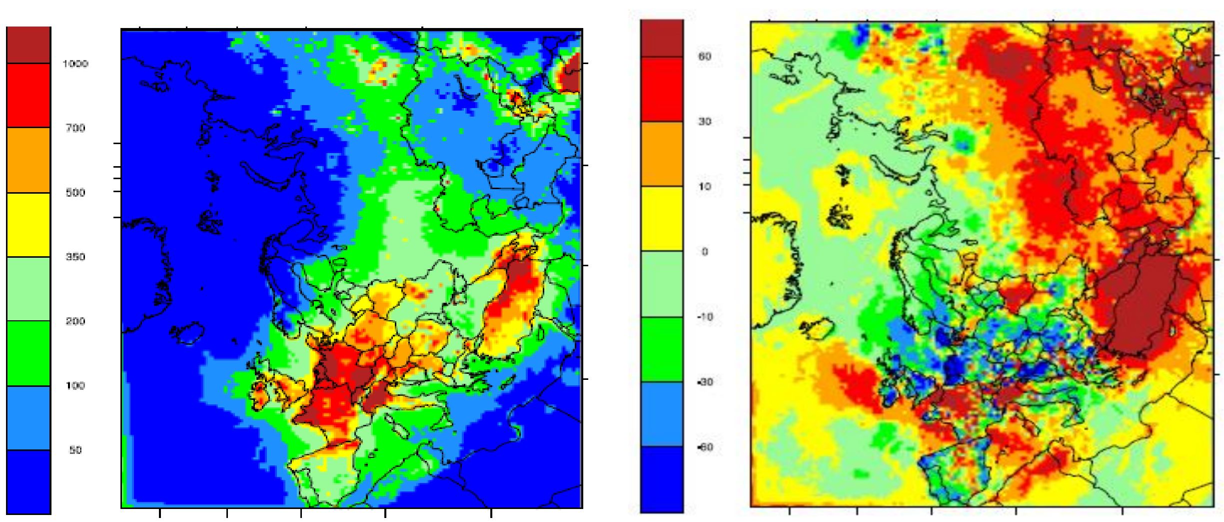
The calculation results of the deposition of sulphur and nitrogen for 2013, as well as the differences compared to the average values for the period of 2000-2007 are given in Figures 6.3.12-2 6.3.12-3 respectively. Significant reduction in sulphur deposition is noticeable on the entire territory of the Europe, as well as the reduction of nitrogen deposition to a certain extent in central Europe, while in Eastern Europe stagnation or increase of nitrogen deposition has been recorded.



a) Sulfur deposits

b) Differences compared to the period 2000-2007

Figure 6.3.12-2: Sulphur deposition in the EMEP network



a) Nitrogen deposits

b) Differences compared to the period 2000-2007

Figure 6.3.12-3: Nitrogen deposition in the EMEP network

The emitted and received emissions balanced for sulphur and nitrogen between Serbia and neighbouring countries in 2013 are given in Tables 6.3.12-3 and 6.3.12-4.The following conclusions could be made based on given results:

- around 24.5% of sulphur out of total emission is deposited on the territory of Serbia

• around 93% out of total emissions is deposited on the analysed EMEP area

•:The deposits of following amounts of sulphur are deposited on the territories of the neighbouring countries, compared to the total emissions, Romania 8.6%, Bulgaria 3.7%, Greece 1.8%, Albania 1.5%, Montenegro 0.8%, Macedonia 1.5%, Bosnia and Herzegovina 3.3%, Croatia 2.9% and Hungary 7.3%.

•The following amounts of sulphur are deposited on territory of Serbia from neighbouring countries: Romania 3.3% Bulgaria 2.9%, Greece 1.6%, Macedonia 8.7%, Albania 6%, Montenegro 12.1%, Bosnia and Herzegovina 6%, Croatia 4.9% and Hungary 4.8%.

Table 6.3.12-3: Balances of emitted and received emissions of sulphur oxide in 2013

100 Mg S

Emitter/ Recipient	RS	RO	BG	GR	MK	ME	AL	BA	HR	HU
RS	526	43	28	14	46	24	4	65	4	7
RO	184	514								
BG	79		263							
GR	39			169						
MK	32				96					
ME	17					27				
AL	31						27			
BA	70							264		
HR	62								24	
HU	156									64
Total emission	2.147	1.297	970	871	527	198	67	1.084	82	147

Table 6.3.12-4: Balances of emitted and received emissions of nitrogen oxide in 2013

100 Mg N

Emitter/ Recipient	RS	RO	BG	GR	MK	ME	AL	BA	HR	HU
RS	66	19	12	18	9	4	3	6	4	15
RO	34	164								
BG	18		72							
GR	10			117						
MK	8				12					
ME	4					4				
AL	8						7			
BA	15							15		
HR	12								17	
HU	28									44
Total emission	418	640	373	774	103	44	56	96	170	367

Based on given balances, as perceived through the absolute values of emitted and received sulphur and nitrogen oxides, it could be clearly seen that the most of emissions from Serbia remain on its territory and also they are mostly transported towards Romania and Hungary and mostly received from Romania Bulgaria and Greece.

It is also necessary to emphasize that the given emissions in Serbia, that mostly originate from the energy facilities represent the levels prior to the introduction of measures for reducing emissions, which shall be implemented in the period until 2023, i.e. 2026. Thus, after the construction of desulphurization facilities for flue gas and measures taken in order to reduce emissions of NOx, the amount of transported pollutants will be significantly reduced. In neighbouring countries, which are the EU members, these measures are already applied in most of the large combustion facilities.

The Project foresees the measures to reduce emissions into the air at unit B3 according to the requirements of Serbia's international obligations related to emissions from large combustion plants. Thus, sulphur dioxide emissions have been reduced to 97.5% in comparison to the uncontrolled emissions. Emissions of nitrogen oxides and particulate matters are also reduced according to the requirements IED (Industrial Emissions Directive).

The assessment of transboundary transport from thermal power plants in Serbia was carried out within the Study, Courses of Optimum Sulphur Dioxide Emission Reduction from power plants EPS (Energoprojekt Entel, 2006) for the condition without the implementation of measures for the reduction of emissions and diverse scenarios for implementation of these measures on thermal units of EPS. The calculations were performed with the application of software package MESOPUFF, verified by the USEPA as a reference model for the analysis of air pollutant transport on regional level (radius area up to 1000 km). The calculation results are given in the form of spatial distribution of sulphur deposition on the ground.

The main conclusions of carried out calculations could be summarized as follows:

• In case when the measures are applied for the reduction of sulphur emissions, about 18% of emissions is deposited on the territory of Serbia. 88% out of total annual emission is deposited in radius area of 1,000 km. Such result has been expected given that, in relation to the total emissions covered by EMEP (from different types of pollutant sources) emissions from energy facilities are transported outside the territory of Serbia in a greater quantity, at greater distances, which is due to characteristics of the emitters (high, dotted sources with significant power).

• Based on FGD facility characteristics, the total annual emission of sulphur from the unit B3 is around 680 tS / year. If equal percentages are assumed for transboundary sulphur transport, in the radius area of 1,000 km about 600 tS/year will be deposited or about 0.6 kg / km2 / year on average.

• Similar calculation is for nitrogen as well, transboundary nitrogen transport will be 447 tN / year, while in the radius area of 1,000 km about 480 tN/year, or about 0.48 kg / km2 / year on average.

Regarding the impact of the new unit B3 on pollution on the territory of neighbouring countries, the conclusion has been drown out that potential impact has to be taken into account on the territory of Romania which is the closest to the location to HPP Kostolac B and it is located at a distance of approximately 15 km towards the northeast, on the other side of the Danube river. From the aspect of pollution spreading, operation of unit B3 represents a potential air pollution source on this territory.

Section 6.3.1 hereof includes the analysis of the spatial distribution of air pollution, estimated for the period after commissioning of unit B3, and is given precisely in Chapter 6.3.1 of this Study. According to given calculation results the levels of air pollution for reference pollutants shall be within the allowed limits according to the applicable EU Directives, with sufficient reserve for the contribution of background pollution. In addition, regarding the assessment of the potential risk of unit B3 operation on the consequences regarding changes in the air quality within the analyzed area, it is necessary to emphasize the following:

- impact of thermal units from TPP Kostolac site on Romanian territory is possible the wind blows from southwest direction,

- according to the several years of meteorological data analysis, this wind direction is not likely (frequency is about 6%),
- contribution of unit B3 to overall impact of the units from TPP Kostolac B site is about 26%.

Having in mind that the risk is the product of the intensity of impact and probability for the occurrence of this effect, it can be concluded that all of the above significantly reduces air pollution and overall risk from the new unit B3.

6.3.13. Summarized analysis of environmental impact

According to the methodology that is given in Section 6.1 hereof, Table 6.3.13-1 includes summarized evaluation of the environmental impact during the regular operation of Unit 3 at TPP Kostolac B.

Table 6.3.13-1: Summarized evaluation of the environmental impact during the regular operation of Unit 3 TE Kostolac B

Description of the impact	Impact assessment						Necessary measures
	Range	Intensity	Duration	Consequences	Probability	Overall significance	
Air quality	Regional	Low	Long-term	6 moderate	Certain	Medium	Yes: Regular control of the plant operation efficiency for emission reduction, equipment maintenance, compliance with technological process procedures
Surface water quality	Regional	Low	Long-term	6 moderate	Certain	Medium	Yes: Regular control and equipment maintenance, compliance with procedures of the technological processes; monitoring of the emissions of waste water by their quantity and quality, as well as surface water quality upstream and downstream from the point of discharge into the recipient
Groundwater quality	Local	Low	Long-term	6 moderate	Uncertain	Low	Yes: installation and maintenance of piezometers, water quality monitoring in piezometer
Landscape quality	Local	Low	Long-term	5 (low)	Possible	Very low	Yes: Following the procedures for waste treatment and maintenance of dust collectors
Noise and vibration	Local	Low	Long-term	5 (low)	Probable	Low	Yes: regular inspection and maintenance of equipment, monitoring of noise levels within the TPP circuit
The impact on living organisms	Local	Low	Long-term	5 (low)	Little probability	Low	Yes: regular inspection and maintenance of equipment, compliance with procedures and technological processes; monitoring of the emissions
The impact people's health	Regional	Low	Long-term	6 moderate	Certain	Medium	Monitoring of people's health status
Transboundary pollution	Yes	Low	Long-term	6 moderate	Certain	Low	With envisioned measures for reducing emissions a significant reduction of transboundary pollution is achieved through the dispersion of flue gases from TE KO B3 stack, regarding its intensity and range
The impact on nature	Local	Low	Long-term	5	Possible	Low	During the construction of plant the possibility of

Description of the impact	Impact assessment						Necessary measures
	Range	Intensity	Duration	Consequences	Probability	Overall significance	
and cultural heritage				(low)			finding artefacts belonging to the archaeological site Viminacium should be taken into account
Space occupancy and visual pollution	Local	Low	Long-term	5 (low)	Possible	Very low	The plant is located within TPP Kostolac B and the existing layout of site will be a bit changed little bit
The impact on microclimate factors	Global	Low	Long-term	5 (low)	Certain	low	The impact on climatic factors due to the emission of wet flue gas and CO_2 is low

7. ENVIRONMENTAL IMPACT ASSESSMENT IN CASE OF ACCIDENT

7.1. Subject and Scope of Accident Analysis

Analysis of accidents from the aspect of the impact on the environment represents integral part of mandatory content of Facilities Environmental Impact Assessment Study, as defined by the Law on Environmental Impact Assessment, Article 17 (Official Gazette of RS, no. 135/04 and 36/09) and Rulebook on the Content of Environmental Impact Assessment Study, Article 7 (Official Gazette of RS, no. 69/05).

Analysis of accidents aims at defining real risk for the environment caused by accidents, as well as defining necessary measures that would reduce potential consequences and environmental risk to the socially acceptable level in the event of the accident. Also, it is necessary to primarily define basic terms related to accidents, according to Article 3 of the Law on Environmental Protection (Official Gazette of RS, no. 135/04) and Article 1 of the Law on Amendments to the Law on Environmental Protection (Official Gazette of RS, no. 36/09):

- *accident* is a sudden and uncontrolled event which occurs with release, leakage or dispersion of dangerous substances in the process of production, utilization, processing, storage, disposal or long term inadequate storage*,*
- *risk* is a certain level of probability that certain activity, directly or indirectly, shall cause danger towards the environment, life and human health,
- *dangerous substances* are chemicals or other substances with harmful or hazardous properties,
- *Seveso plant*, i.e. plant where the activities which include presence or potential presence of hazardous substance in equal or larger quantities than prescribed are performed, it is the technical unit inside the complex where hazardous substances are produces, used, stored or handled,
- *complex* means spatial unit controlled by the operator, where hazardous substances are present in one or several plants, including individual or shared infrastructure, i.e. individual or shared activities.

Environmental impact assessment in the event of accident is prepared based on the following:

1. Identification of accident risks, including:
   (i) definition of the projected quantities of harmful and hazardous substances that are present in TPP,
   (ii) identification of TPP systems / plants that represent potential accident points.
2. Analysis of accident consequences for defined reference accidents
3. Accident risk assessment for defined reference accidents, based on the accepted criteria for risk classification and quantification.

7.2. Accident Risk Identification

Baseline in the identification of danger is an overview of types and project planned quantities of hazardous substances that will be used for power plant operation. Chemical substances and other potentially hazardous substances manipulated during power plant operation can be divided into several groups:

- fuel (coal as the main fuel and liquid fuel as an auxiliary fuel),
- chemical substances used in CWT plant,

- chemical substances used for plant operation (turbine and transformer oil, hydrogen),
- chemical substances used for equipment and plant maintenance,
- technical gasses,
- ash and slag as waste material produced during combustion process,
- gypsum suspension as waste material produced during flue gas desulphurization process.

Table 7.2-1 shows overview of types, expected quantities and storage points for hazardous substances that will be present inside the power plant. Columns 6 and 7 of the Table show quantities of specific hazardous substances regulated by the Rulebook on Hazardous Substances List and Their Quantities and Criteria to Define Type of Document Prepared by the Operator of “Seveso“ Plant, i.e. Complex (Official Gazette RS, no. 41/2010., 51/2015.), and based on them the scope of obligations is defined for the plant or complex related to “Seveso“ facilities.

Based on the data shown in Table 7.2-1, during B3 unit life cycle the following substances included in the lists of hazardous substances (Table I and II of Rulebook) will be used:

- hydrogen: listed under number 15 in Table I of Rulebook,
- fuel oil and different types of oil: listed under number 34 in Table I of Rulebook (petroleum products),
- hydrochloric acid, ferric chloride, Sodium hypochlorite and ammonium hydroxide: substances hazardous to aquatic eco-system.

When it comes to identification of potential sites / plants / systems where accidents may occur, the following systems within B3 unit that should be analyzed are identified:

- electrostatic precipitators,
- FGD plant,
- plant for chemical water treatment (CWT),
- transformer facilities,
- ash, slag and gypsum landfill.

Auxiliary facilities that are part of the existing B1 and B2 units, which will be also used for the needs of the new unit (storage of technical gases, storage of oil and lubricants, liquid fuel system) will not be analyzed in this Study, since they are included in the analysis prepared for these units.

The obtained results of the previous Studies regarding the analysis of accidents at the thermal power plant facilities show the characteristics of the particular systems with regard to accidents:

- primary systems with potential large-scale accidents with significant environmental impact are related to the storage of larger quantities of hazardous and harmful substances in TPP, including the following: CWT chemicals storage (base and acid), storage of liquid fuel and ash, slag and gypsum landfill,
- secondary importance when it comes to severity of consequences are accidents in flue gases treatment systems, i.e. particulate matter emission through flue gases in the event of failure of electrostatic precipitators, and emission of sulfur dioxide due to a failure at FGD plant,

- other auxiliary systems may be the accident points with minor environmental impact (oil and lubricants storage, technical gasses etc.).

It is necessary to prepare appropriate documents in accordance with the Rulebook on Hazardous Substances List and Their Quantities and Criteria to Define Type of Document Prepared by the Operator of Seveso Plant, i.e. Complex (Official Gazette RS, no. 41/2010) for the purpose of further preparation of technical and other documents for construction and commissioning of B3 unit, including the documents submitted along with the application for Integrated Permit. Also, it should be taken into consideration that (i) Seveso Plant Safety Report and (ii) Accident Protection Plan (EKO-TOK, Belgrade, 2016) have been prepared for the existing B1 and B2 units. After construction of B3 unit, it is necessary to analyze TPP Kostolac B complex as the whole which includes all three units, according to Article 7 of the Rulebook (“when hazardous substance is located at several places in Seveso plant, i.e. complex, individual quantities of that hazardous substance type add up“).

Table 7.2-1: Overview of Type and Quantity of Hazardous Substances for Unit 3 in TPP Kostolac B

Hazardous substance type	u/m	Storage capacity /Common stock/the resulting quantities	Hazard type (according to the Rulebook[1)])	Stock location	Min. regulated quantity, t (according to Rulebook[1)],Table I and II)	
					Column 1	Column 2
1	2	3	4	5	6	7
Technical gasses						
Hydrogen	bottle	For B3 Unit: 2 x 36 bottles/40 l /150 bar	explosive	technical gasses storage TEKO B	5	50
Carbon dioxide	bottle	Existing storage for B1 and B2 units is being used	S9 and S23	technical gasses storage TEKO B		
Flammable substances						
Fuel oil	m^3	1 x 5.000	Petroleum products flammable [2)]	fuel oil storage TEKO B	2.500-	25.000
Turbine oil	l	Tank 40.000	Petroleum products flammable [2)]	powerhouse	2.500-	25.000
Transformer oil	l	10.000	Petroleum products flammable [2)]	oil and lubricants storage TEKO B	2.500-	25.000
Machine oil	l	Existing storage for B1 and B2 units is being used	Petroleum products	oil and lubricants storage TEKO B	2.500	25.000
Other oils and lubricants (reduction gear, mechanical, engine, hydraulic)	l	Existing storage for B1 and B2 units is being used	Petroleum products flammable [2)]	oil and lubricants storage TEKO B	2.500-	25.000
Toxic substances						
Hydrochloric acid, 30%	m^3	2 x 20	corrosive C; R34-37, hazardous for the environment	CWT plant	100	200
Sodium hydroxide, 40%	m^3	3 x 20	toxic / corrosive C; R35, S26,36/37/39, S45	CWT plant and wet ESP		
Ferric chloride, 40%	m^3	10	Corrosive hazardous for the	CWT plant	100	200

Hazardous substance type	u/m	Storage capacity /Common stock/the resulting quantities	Hazard type (according to the Rulebook[1])	Stock location	Min. regulated quantity, t (according to Rulebook[1],Table I and II)	
					Column 1	Column 2
1	2	3	4	5	6	7
			environment C; R22, R38-41, R50 S26, S28, S36/37/39, S45			
Sodium hypochlorite	m^3	10	ecotoxic to fish Corrosive C; R31, R34, R50	CWT plant	100	200
Antiscalant	l	200		CWT plant	-	-
Ammonium hydroxide, 25%	m^3	1	toxic ecotoxic to fish Corrosive C; R34, R50	CWT plant	100	200
Polyelectrolyte	bags	50 kg bags		CWT plant		
Polyphosphate, solution 0.5-2%	m^3	2 x 5		CWT plant		
Sodium bisulfite	l	200	R22, R31, S25, S46	CWT plant		
Sodium metabisulfite	bags	50 kg bags	R22, R31, R41			
Ecotoxic substances						
Ash and slag	t/p.a.	≈ 520.000	Potentially ecotoxic [3]	Ash, slag and gypsum landfill	-	-
Gypsum suspension (50% solid)	t/p.a.	≈ 345.000	Potentially ecotoxic [3]	Ash, slag and gypsum landfill	-	-

1) *Rulebook on Hazardous Substances List and Their Quantities and Criteria to Define Type of Document Prepared by the Operator of Seveso Plant, i.e. Complex*
2) *Flash point is above 55°C*
3) *Further investigation should define characteristics of these substances.*

Classification of danger according to EU Directive 2001/59/EC

R22 - Harmful if swallowed;
R31 - Contact with acids liberates toxic gas
R34 - Causes burns;
R35 - Causes severe burns;

R36 - Irritating to eyes;
R37 - Irritating to respiratory system
R41 - Risk of serious damage to eyes;
R46 - May cause heritable genetic damage
R50 - Very toxic to aquatic organisms
S9 - Keep container in a well-ventilated place
S23 - Do not breathe gas/fumes/vapor/spray
S26 - In case of contact with eyes, rinse immediately with plenty of water and seek medical advice
S28 - After contact with skin, wash immediately with plenty of ... (to be specified by the manufacturer)
S36 - Wear suitable protective clothing
S37 - Wear suitable gloves
S39 - Wear eye/face protection
S45 - In case of accident or if you feel unwell, seek medical advice immediately (show the label where possible)

7.3. Analysis of Accident Consequences

7.3.1. Identification of Potential and Selection of Reference Accidents

Based on the technological processes overview, potential accidents were identified for B3 unit on the following systems:

- potential accident points within CWT system are storages and chemicals loading system. Based on the data from Table 7.2-1, the following tanks of chemicals are planned: for 30% HCl two tanks each 10 m^3, for 40% NaOH two tanks each 10 m^3, for 40% $FeCl_3$ two tanks each 1.5 m^3, and several smaller tanks (≤ 1 m^3) for other present chemicals (25% ammonium hydroxide, bisulfite, sodium hypochlorite). The first group of accidents could include full tank cracking, where the total amount of liquid would spill into bund, while the second group includes the various leaks in the reinforcement and partial or full cracking of pipeline and/or hose while loading chemicals within the plant;
- potential accident points within the flue gas system are the following: (i) electrostatic precipitators where outage of one or several sections may occur, which leads to reduction of efficiency of separation of particulate matter from flue gas, which results into increased emission of particulate matter into the air; (ii) FGD plant, i.e. its failure to operate, which causes emission of SO_2 into the atmosphere without concentration reduction in the flue gas;
- potential accidents within the liquid fuel system may be uncontrolled spillage of fuel oil due to damage or overfilling of the tank or due to damage of pipeline and their equipment. As the reference accident, the event including spillage of fuel oil on the ground as the result of pipeline cracking or during reloading of liquid fuels from the tanks in the event of reloading hose disconnection is defined. Quantity of spilled fuel oil depends on the accident point and duration of spilling and it goes from one to several and even dozen tons. Discharge of fuel oil from tanks is done with the intensity of about 1.5 t/min, which represents the reference value for the estimation of the quantity of spilled fuel oil in the event f disconnection of this hose.
- accident at ash, slag and gypsum landfill that may occur if dike break on cassette occurs. With applied technology of disposal of wet slurry, dike break is very unlikely, which was one of the reasons to select this technology.

7.3.2. Accident Consequences Assessment

<u>CWT Plant</u>

Based on the presented characteristics of the present chemicals the following can be concluded:

- hydrochloric acid is volatile matter, therefore its spilling creates a cloud of toxic hydrogen chloride gas, which is heavier than air. The intensity of evaporation depends on the concentration of acid and environmental conditions at the site at the time and after spilling,
- hydrochloride in water rapidly dissociates to H^+ and Cl^- ions and causes a change in pH value of the aqueous medium,
- NaOH has a very small vapor pressure ($<10^{-6}$ kPa at 25°C), so the evaporation in the air is negligible and no toxic cloud is created during spill,
- NaOH is a strong base which completely dissociates in water into Sodium and hydroxyl ion, whereby the dissociation process, i.e. dissolution in water is a strong exothermic reaction,
- due to its easy solubility in water and low vapor pressure value, NaOH represents the substance that is a potential pollutant of the aqueous medium, since a change of pH value has an adverse impact on the water ecosystem.

It can be concluded from the above that the accident with spill of concentrated HCl causes air and water pollution, while other analyzed chemicals are mainly potential water pollutants. Therefore the following part will analyze accidents related to HCl spill, having in mind that the potential of water pollution as well as the water pollution protection procedure is the same in all cases.

The Effect of the Toxic Cloud of HCl on Air Pollution

Damage on HCl Tank

HCl tanks are located outdoors, in a concrete bund; dimension ≈ 4 x 8 m. In the event of tank damage the acid would spill into defined limited bund space.

In this case, during spilling of HCl from one tank, based on the physical and chemical characteristics of concentrated HCl and free surface of the bund containing HCl tank, hydrogen chloride would evaporate from the surface of the bund with the intensity of 0.3 kg/min.

Chemicals Spill during Unloading

In the event of direct leakage of chemicals from unloading hose on the plateau in front of the facility, the spilled liquid would spill over the unloading plateau until flowing into the existing manholes. At the same time, the conditions for air pollution would be created as a result of partial evaporation of spilled liquid (in case of hydrochloric acid spillage), whereby cloud of toxic gas is formed and it is being transported into the atmosphere. Extent of this cloud depends on several parameters related to weather conditions at the moment of spillage and immediately after it. Having in mind that all manholes at the unloading plateau are connected with neutralization tank, spilled liquid will be collected in a controlled manner and treated before discharge into the environment.

The range and intensity of the effect of formed toxic cloud should be predefined for the environmental impact assessment. For that purpose computer model ALOHA was used (certified by USEPA for preparation of documents for regulatory institutions).

Calculations were performed for different meteorological parameters that may have the strongest impact on both, evaporation intensity and extent of formed toxic cloud, and they are the following:

- wind speed analyzed within the range 2 – 12 m/s,
- air temperature within the range 10-40°C,
- choice of atmospheric stability classes are in line with variations of meteorological parameters.

In the assumed ranges of meteorological parameters, speed of hydrogen chloride evaporation from the plateau where the acid was spilled is within the interval of 5-30 g/s.

The range of toxic cloud for defined reference values of potential dangers of HCl concentration in air is given in Table 7.3.2-1, whereby:

- ERPG-1 – the maximum concentration of HCl in the air believed to cause only minor transient harm to health at 1 hour exposure, with the occurrence of odor, which is 3 ppm (4 mg/m^3),
- ERPG-2 - the maximum concentration of HCl in the air believed to cause, for the majority of population being exposed for 1 hour, no irreversible damage or other serious adverse health effects that would prevent a person from undertaking protective measures, which is 20 ppm (30 mg/m^3),
- ERPG-3 - the maximum concentration of HCl in the air believed to cause, for the majority of population being exposed for 1 hour, no threat to life, which is 150 ppm (224 mg/m^3).

Table 7.3.2-1: The radii of the danger zones for different danger levels and reference meteorological parameters, m

Level of HCl concentration in air	Description of meteorological parameters				
	D category t=10°C, v=4 m/s	D category t=20°C, v=8 m/s	C category t=30°C, v= 4 m/s	B category t=30°C, v= 3 m/s	F category t=20°C, v=1,5 m/s
Reference values for protection plan and response to accident					
150 ppm – EPRG*-3	< 10	< 10	< 10	< 10	20
20 ppm – EPRG*-2	30	37	40	31	105
3 ppm – EPRG*-1	92	100	110	84	400
Reference values for the work environment					
50 ppm – IDLH**	14	18	23	19	57
5 ppm – MDK_{rp}	70	80	86	65	230
Reference values for the environment					
1 ppm***	163	190	195	160	560

** EPRG – Emergency Response Plan Guideline*
*** IDLH – concentration per criteria of NIOSH Pocker Guide as currently harmful to health concentration*
**** – allowed level of pollution for the population up to 24 hours*

According to the presented results the following can be concluded:

- all reference values of HCl concentration in air are expected in the area smaller than 200 m, i.e. within the power plant area, except for the reference unfavorable meteorological parameters given in the last column of Table 7.3.2-1. Having in mind that these meteorological parameters occur usually at night, there is a requirement to discharge chemicals solely during the day. Delivery and discharge of chemicals at night is prohibited.
- radius of the zone where evacuation of the people must be carried out in 10 minutes is about 15 m from the place of spill, downwind direction,
- radius of the zone where evacuation of the people must be carried out in 30 minutes is about 25 m from the place of spill, downwind direction,
- radius of the zone where the concentrations are ≥ 5 ppm (maximum allowed value for work environment) is up to 90 m from the place of spill, downwind direction,
- distances where 1 ppm concentration level is expected are within thermal power plant except for the most unfavorable conditions when they are up to 560 m from the spill place, downwind direction.

Other Impacts

In case of damage to the tank containing concentrated solutions of chemicals, total amount of chemicals would be found in the tank bund. Also, there is no direct risk of fire since the liquids are not flammable.

The risk of analyzed accident is reflected in the risk of surface waters contamination in case of spillage of chemicals into the watercourse, as well as in potential injuries of staff in the event of contact with a concentrated solution.

Having in mind that the existing technical solution of CWT plant does not allow the possibility of direct spillage of chemical into watercourse, since the bund is connected to neutralization tank, that is larger than the bund and that is being emptied by pumps, conclusion is that it is unlikely that there would be direct spillage of chemicals into watercourse.

The control of watercourses contamination is performed first by neutralizing the content of neutralization tank, and then by discharge of neutralized waste water into the watercourse in portions or by using this water to form a moist mixture of ash and slag.

It is unlikely that the staff would have direct contact with the concentrated solution, since staying in storage space is only possible with the use of protective equipment.

Electrostatic Precipitator

The calculation results are presented in accordance with legally defined limit values, as mid-day values of particulate matter concentration in the air and their deposition on the ground. The selected reference days are the following: (i) mean day and (ii) day with Kosava wind, as less favorable. According to the calculation results, the following conclusions about potential impacts of outage of particular sections to the air quality were made:

- when outage of one i.e. two sections on ESP occurs, mid-day values of particulate matter concentration in air will not be higher than allowed values, while maximum depositions will be around 1-3.5 g/m^{2}day, depending on the wind speed (with maximum values at the distance of about 1 km from the stack); areas with concentrations higher than allowed value (450 mg/m^{2}day) have radius of about 0.8-1 km compared to the position of maximum deposition,
- in the event of outage of three sections of one ESP, higher concentration of particulate matter can be expected (up to 110-360 μg/m^3, at the distance of about 3 km from the stack); depositions of particulate matter would not exceed 7-25 g/m^{2}day at the distance of 2 - 4 km from the stack of unit B3.

Effects of increased concentration of particulate matter PM10 on health are given in Table 6.3.5-3. It should be taken into account that when outage of a section of ESP occurs, there is a significant part of particles bigger than PM10, deposited at the smaller distances from the source of emission, and therefore data given in the table should be analyzed in relation to the estimated total levels of pollution.

The duration of ESP section outage may vary, usually from several hours to several days. Thus it can be assumed that the values of particle deposition, averaged across the entire month (as defined by regulation) could rarely exceed allowed values, except in the case of outage of three sections of ESP (which is an event highly unlikely to happen, according to the data on the level of availability of these devices). In addition, compliance with legal obligations requires the unit to stop operating in these cases.

Flue Gas Desulphurization Plant

Outage of FGD plant would cause increase of SO_2 emission into the atmosphere. According to the existing measurements, it is expected that SO_2 concentration in the untreated flue gas is within 5.000-8.000 mg/m^3. Design foresees the provision of flue gas by-pass for the new stack.

In case of FGD plant outage, during combustion of coal of guaranteed quality (SO_2 concentration in flue gas is about 6.700 mg/m^3) it is estimated that the maximum hourly concentration of SO_2 could be up to 500 μg/m^3, and maximum mean daily up to 200 μg/m^3, which is exceeding allowed values. However, having in mind the limitations of the regulation related to unit operation without measures for emission reduction (no more than 120 hours annually), this type of accident would be of limited duration, as would be the period with exceeded allowed pollution levels. In such conditions, with the limited time of exposure to higher concentrations, long and severe adverse effects to the health of the local population is not expected (Table 6.3.5-1).

Ash, Slag and Gypsum Handling System

Reference accident at ash, slag and gypsum landfill is dike break at the cassette of the landfill.

Applying the technology for ash, slag and gypsum disposal landfill is formed within open cast mine, within the limited space (cassettes) that due to the presence of minimum amount of water has significantly higher stability compared to hydraulic landfills, and also significantly lower probability of dike break and cassette disintegration type of accident. Besides, the space of the landfill itself within the open cast mine prevents impact beyond the borders of the mine.

7.3.3. Risk Assessment

Risk Assessment Criteria

Hazardous activities risk assessment is performed based on the assessment of probability of event for which risk is being assessed and expected consequences of the same event.

The probability of an event occurrence is assessed based on the available information about similar events in the similar type of plants worldwide and in our country (statistical data) or based on a hazard identification (analytical approach). Combined approach is usually used for new facilities since there is no statistical data about the plant operation.

Criteria for accident consequences determination is performed based on the indicators on environmental risk, as given in Table 7.3.3-1[8].

[8] *Rulebook on Accident Prevention Policy Content and Content and Methodology for Preparation of Safety Report and Accident Protection Plan (Official Gazette of RS, no. 41/2010).*

Table 7.3.3-1: Accident Consequences Assessment Criteria

Indicator / Consequence level	Negligible	Significant	Severe	Great	Disastrous
Number of people with fatal outcome	none	none	1-2	3-5	More than 5
Number of severely injured/poisoned	none	1-2	3-6	7-10	More than 10
Number of moderately injured/poisoned	none	1-5	6-15	16-30	More than 30
Dead animals, t	≤ 0.5	0.5-5	5 -10	10 -30	> 30
Contaminated surface, ha	≤ 0.1	0.1-1	1 -10	10-30	> 30
Injury to property, 000 din.	≤ 100	100-1.000	1.000-10.000	10.000 -100.000	> 100.000

Risk Level Acceptability Criteria

The general principle followed in defining the level of acceptable risk is following the principle "As low as Reasonably Practicable (ALARP)", where the final decision should be made by the legislative authority.

Practice is different in EU countries, though it is common to define acceptable risk level for each individual case. General assessment of the significance of certain risk levels can be made on the basis of some known indicators from everyday life. Tables 7.3.3-2 and 7.3.3-3 show death risk levels for different ages, as well as the risks which are expected in some other common human activities[9].

Table 7.3.3-2: Death Risk Depending on the Age

Age	0-4	5-14	15-19	20-24	25-34	35-44	45-54	55-64	65-74	75-84	> 85
Risk 10^{-3}/year.	2,6	0.24	0.55	0.60	0.72	1.5	4.9	14	34	79	190

Table 7.3.3-3: Individual Risk Levels for Specific Activities

Death risk (annually)	Activity / event
10^{-4}	Car accident
10^{-5}	The accident in the safe industry
10^{-6}	Fire or gas explosion at home
10^{-7}	Lightning / Thunder

Risk levels are generally classified as unacceptable, ALARP or acceptable. Risks in industrial plants fall into ALARP category which requires analysis of needs and possibilities of their

[9] *Quantitative Risk Assessment for New Service Berth, AEA Technology, 2000.*

reduction. Also, more attention should be paid to risk analysis with higher probabilities and greater intensity of consequences, although when analyzing collective risk, risks with higher probability and lower consequences level are also significant. Initial assumption is that the risk of the analyzed activity cannot be higher than the existing risk levels in everyday life.

Individual risk – the maximum acceptable level of individual risk is the one that increases total death risk for a person by maximum 1%. As it is accepted that the middle death risk is 10^{-4}, the maximum level of acceptable risk for a person is 10^{-6}. Risk level of 10^{-8} is considered to be negligible.

Collective risk - the maximum acceptable level of collective risk is the risk that with the probability of 10^{-5} causes maximum 10 fatalities. Collective risk acceptability criteria are given in Figure 7.3.3-1.

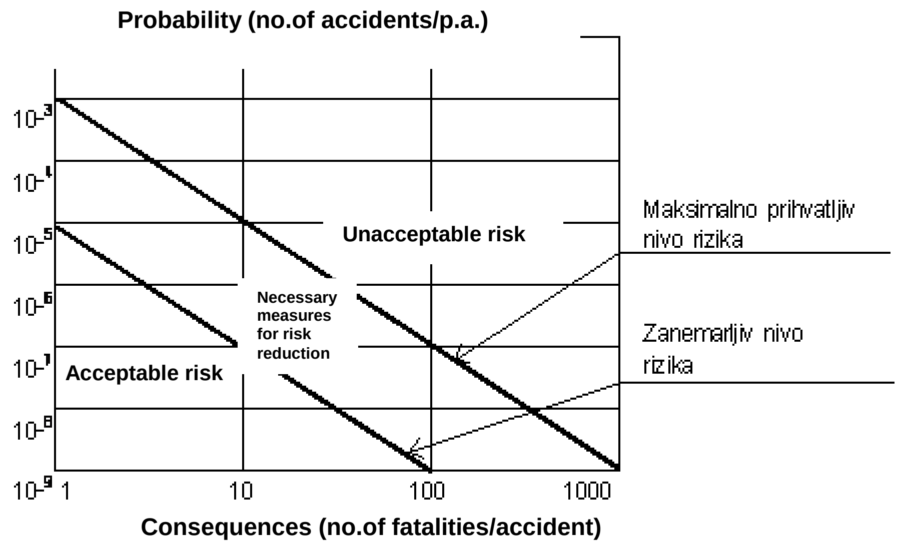


Figure 7.3.3-1: Collective Risk Acceptability Criteria

According to the above mentioned Rulebook, the term acceptable risk means risk assessed as negligible, low, medium and high risk. Risk is not acceptable if assessed as very high risk. Risk quantification based on the above defined terms is given in Table 7.3.3-4.

Table 7.3.3-4: Accident Risk Quantification

Consequence level / Probability	Negligible	Significant	Severe	High	Very high
Low	negligible	low	medium	high	very high
Medium	low	medium	high	very high	very high
High	medium	high	very high	very high	very high

Accident Risk Summary Analysis

Risk summary analysis was performed according to the given criteria based on the given analyses per systems. Analysis results are given in Table 7.3.3-5.

Table 7.3.3-5: Accident Risk Summary Analysis for Unit B3 TPP Kostolac B

TPP system	Reference accident	Accident characteristics			
		accident level	accident probability	environmental consequences	risk assessment
ESP	section outage	third	medium	negligible	low
CWT (chemical storage)	chemicals spillage	second	medium	significant	medium
Ash, slag and gypsum transport	Belt conveyor interruption	first/ second	low	low	low
Ash, slag and gypsum landfill	Dike break	first	low	significant	low

8. DESCRIPTION OF THE MEASURED ENVISAGED TO PREVENT, REDUCE AND, WHERE IS IT POSSIBLE, ELIMINATE ANY SIGNIFICANT ADVERSE IMPACT ON THE ENVIRONMENT

8.1. General requirements and the aim of protection measures

The application of environmental protection measures is set as imperative in design and construction of each thermal power facility. This requirement is, on one hand, a result of the respect of environmental protection related legislation, and on the other hand, compliance with specific conditions those characteristics of area, on which the work of concerned B3 unit may have impact, set.

In the present study, the requirements of regulations relating to the environmental quality are given in Chapter 5.1, while the characteristics of the area are given in Chapter 2.

When defining protection measures from Unit 3, it is necessary to bear in mind the characteristics of site related to other existing pollutant or which is planned in the area of B3 unit location, as well as to present ecosystems and material goods. This primarily refers to existing TPP Kostolac A and B units and OCM Drmno, whose influences can coincide with those from B3 unit (summary impacts of chimney emissions, waste waters, solid waste landfills, total noise level on the site boundary, etc.).

The surrounding area of TPP Kostolac B has an average population density (40-50 people per km^2, except the city of Pozarevac), and in the area there is no large urban settlements. In the immediate vicinity of the location is located archaeological site Viminacium. Around the location, there are, as well, areas settled by rich fauna.

On the other hand, the area of consideration will be, due to nature of activities that take place on it, whereby primarily refers to surface coal mining, shorn for a long time, with reduced possibilities of natural defence against harmful effect of thermal power plant's operation.

Purpose and grouping of protection measures

Globally observed, all protection measures can be divided into the following groups:

- Preventive protection measures,
- Protection measures applied as technical solutions during construction and TPPs' operation,
- Mitigation measures of unit's operation consequences in terms of environmental pollution.

Preventive measures include measures taken during planning and facility construction preparation, such as the selection for optimal location for construction, drafting of spacial plan of area affected by mining-energy-industrial complex, selection of optimal technologies for the transportation and waste disposal, selection of cooling system and selection of appropriate architectural solutions.

Technical solutions applied during construction and power plant's operation are provided within project and are related to its individual systems. The mentioned solutions include:

- Choice of chimney's dimensions that achieve satisfactory conditions for further dispersion of harmful substances in the air and the required quality of ambient air in the chimney's area,
- Purification of flue gases from gaseous and particulate pollutants before being discharged into the atmosphere,
- Construction of facility for waste water treatment,
- Recirculation of leachate from landfill in order to prevent its direct discharge into the surrounding watercourses,
- Designing and ash and slag landfill maintenance in order to prevent particles dispersal and the reach of leachate into underground waters.

Additional measures to mitigate the consequences of possible effects of environmental pollution due to B3 unit and exiting B1 and B2 units operation, are planned, because, besides the predicted technical and technological protection measures in certain areas in the vicinity of the power plant, it can be expected, to a certain extent, altered environmental conditions that can affect human health as well flora and fauna. These measures include the following activities:

- Adequate choice of agricultural crops that will be grown on the affected area,
- The built of protective forest belts and buffer zones in power plant area,
- Maintenance of material goods in the surrounding areas,
- Protection of cultural property in the surrounding areas,
- Better health care for potentially affected population.

Overview of pollutants i.e. products arising from unit's operation is given in the Chapter 3.3.5.

Criteria for technical protection measures determination

Technical protection measures, envisaged by the B3 unit construction Project, are defined in the way that the plant's operation is in accordance with the above-outlined requirements of legislation, as well with Regulation on the criteria for determining the best available techniques, application of quality standards, and for determining emission limit values in integrated permit (Official Gazette of RS, no 84/2005). Basic criteria applied for technical protection measures selection are:

- application of technology that produces minimal waste volume,
- possibility of reuse and recycling of substances that are created and used in process,
- the usage of less hazardous substances,
- accidents prevention and reduction of their consequences on the environment,
- tracking the latest information on the best available techniques,
- analysis of similar and comparable processes whose application has already been successfully implemented in industrial scales,
- Analysis of practical experience on similar plants.

Basis for defining specific techniques applied as protection measures are summarized in BREF document for large combustion plants (LCP BREF - IPPC Reference Document on Best Available Techniques for Large Combustion Plants, European Commission, July 2006.). Compliance of technical solutions applied on B3 unit with LCP BREF document is summarized in Chapter 3.3.4. of this Study.

8.2. Project environmental protection measures

8.2.1. Measures to protect air

Systems for emissions reduction into the air through the flue gases

In order to comply with emissions reduction of pollutants in the air through flue gases, in accordance with ELV according to Directive 2010/75/EU, as well as according to national regulations, the following measures are foreseen:

- Dry electrostatic precipitator for first level particulate matters emission reduction, with characteristics shown in Chart 3.3.6-11 of this Study,
- Facility for FGD for reducing sulphur dioxide, with the basic balance sheet sizes, as shown in Chart 3.3.6-9 of this Study,
- Wet electrostatic precipitator for second level particulate matters emission reduction, whit characteristics shown in Chart 3.3.6-11 of this Study.

System for flue gas discharge - chimney

Emissions of purified flue gas will be carried out through new, wet stack that, besides measures for emissions reduction, regulates the level of air pollution near boiler plants, in accordance with the requirements of the Legislation on ambient air quality. Chimney is designed to provide favourable conditions of flue gases propagation in atmosphere around power plant, both in near area and at greater distances. In connection with that, sizing of the wet stack is an integral part of technological and mechanical part of unit B3 preliminary design, and it is based on application of methodology recommended by the relevant institutions, and based on experiences of established practice on wet stack operation[10] and ambient air quality regulation. The following chimney dimensions were obtained:

- Height of the chimney in the amount of 180 m,
- Light opening diameter of the chimney, in the amount of 6,6 m.

In determining of chimney height, the protection of ambient air quality during the operation of all units A and B of TPP Kostolac was taken into account, whereby exists sufficient reserve for pollution phon which comes from other sources whose influence exists on related area. Detailed overview of predicted air pollution levels is given in Chapter 6.3.1 of this Study.

In order to protect against corrosion, the inner side of the chimney must be coated with a special acid and temperature resistant coating, bearing in mind that the same chimney will be used for unit with by-pass working conditions (transitional regime, FDG plant outage, and similarly). Project envisages chimney's inner lining of titanium alloys.

[10] Revised Wet Stack Design Guide, Electric Power Research Institute (EPRI), Final Technical Report, December 2012

Measures to reduce particulate matter emissions from limestone delivery system and system for preparation of suspensions

Within the system for limestone, the following measures for air protection are provided:

- Limestone warehouse is covered and partially closed on all sided, reducing possibility of limestone's tiny fraction dispersal by the wind,
- In unloading station, which is covered, are provided underground bunkers where the wagons are emptied,
- System for dedusting silo for limestone, for which is provided a dry dedusting system with bag filters, located on silos: efficiency of bag filter is such that is provided an output concentration of particulate matter in the air of max. 20 mg/Nm^3. Air flow is 5.000 m^3/h,
- For limestone grinding is provided so called wet grinding method in ball mills, preventing emission of suspended particles during the milling process.

Measures to reduce particulate matter emissions from coal delivery and storage system

Within the coal delivery and storage system, the following measures for air protection are provided:

- Coal transportation is carried out by closed conveyor belts,
- On all reloading area is provided dedusting through Pulse jet bag filter with self-cleaning dedusting system,
- In overbunker duct, dedusting is provided during the coal outpouring from slant belt conveyors to reloading funnel, which comprise filter devices with a system of round steel channels for air with dust extraction from upper zone of bunker,
- for periodic cleaning of these floor areas of overbunker duct, sloping bridge and boiler room, installation of central cleaning by dust extraction is provided,
- in order to prevent coal particles dispersion from landfill, it is proposed to regularly spray the landfill during a period without rainfall and when the wind speed is higher than 6 m/s.

Measures to reduce particulate matter emissions from system for transport and ash, slag and plaster disposal

Within the system for transport and ash, slag and plaster disposal, the following measures for air protection are provided:

- ash, slag and plaster transport in the complex of TPP Kostolac B, up to open cast mine, and in the open cast mine is carried out by closed conveyor belt,
- Using technology of common disposal of ash, slag and plaster, in the form of mixture which represent stabilized material, it is reduced probability of particles scattering from the landfill surface. The possibility of dosing additives for deposited mass hardening is foreseen (to form a stabilizer),
- For wetting the dry surfaces of the landfill during the dry period, system for sprinkling is provided,
- All reloading towers in system for mixture transportation, T1, T2, T3 i T4 are closed.

8.2.2. Measures of waste water management

Construction of a joint plant for waste water treatment (for all units of TPP Kostolac B) is planned. After a treatment, the treated water will get into the recipient.

Within the unit B3, the following protection measures against the waste water impact:

- Waste water from FGD process: Characteristics of waste waters generated in FGD process are shown in Chapter 3.3.5 of this Study. Project anticipates pre-treatment of these waste waters, which implies correction of ph values by dosing base solution. Further treatment of waste waters will be carried out in central plant for waste water treatment (for whole thermal power plant) up to the quality required for putting into recipient (Mlava River[11]). Other possibility is to use these waters for forming high-density slurry of ash and slag from B1 and B2 unit, which will be transported to the landfill of surface mine Ćirikovac.
- Atmospheric waste waters from the limestone warehouse: limestone warehouse is situated on inclined concrete surfaces, where incurred atmospheric waters are collected under the control, drained and treated with other atmospheric waters within the B3 unit (in local separator No. 3),
- Atmospheric waste waters from coal deposits: Collection and treatment of waste water around third coal yard line, which will be constructed for the purposes of B3 unit, will be treated in the facility described in Section 3.3.6 of this Study. The treated water will be collected in a pool of clean water and be used for moisturizing coal deposit,
- Other atmospheric waste waters from plateau within B3 unit are collected as well and properly channelled towards a common facility,
- Sanitary wastewaters from B3 unit facilities are channelled in a common facility for whole TPP,
- Waste waters from transformer oil well: in order to ensure proper function of transformer oil pit, it is necessary to regularly clean and empty pit from collected atmospheric precipitations,
- Waste waters from ash, slag and plaster dumps: leachates from dump are collected in water collector which is designed so that it can accept water from the rain with the probability of occurrence 1%. Collected water will be used for moisturizing landfill's dry surfaces. By calculation of water balance on landfill (precipitations, evaporation from the surface of the landfill, drained water) it was defined that three tanks of water of volume 6m3 will be necessary for moistening of landfill surface. Water excess, which may occur in the rainy season, will be dispatched in tanks to the system for moistened mixture preparation.

8.2.3. Ground and underground water protection measures

Technology and solution of transportation and disposal of fly ash, slag and gypsum suspension is designed to allow safe operation of their impact on the environment as follows:

1. Transport of a mixture of ash, slag and plaster suspension with max 30% of humidity is applied, wherein :
   a) Using a small amount of water which requires that the landfill does not form a precipitant reservoir, the quantity of drained water is small,

[11] Feasibility study with preliminary design of facility for purification and waste water treatment TPP Kostolac B, for units B1, B2 and future unit B3 with 350 MW power, Energoprojekt Hidroinženjering, Beograd, 2013.

b) Using the limited amounts of water ensures uniform deposition of small and large grains in the landfill which provides better stabilization of the deposited mass and heavier scattering,
c) The use of limited amounts of water allows full use of binding materials present in the waste,
d) The transport system is forced through sealed pipes which impact on the environment is reduced merely to the possible occurrence of an accident.

2. For the location of the selected disposal of overburden PC Drmno thus:
   a) conducting new area of land degradation,
   b) The dump was formed on the mineral layer thickness exceeding 50 m with mineral layer is made of mixed clay and sands that have a significant adsorption capacity of pollutants and water binding that emerged in the case of an accident.
3. Technical planning landfill provides:
   a) double waterproofing (bentonite layer film + HDPE), which is in the dumps, completely isolated from the environment and waste water down the likelihood of an accident
   b) drainage system that collected water from the waste water system feedback returns to the technological process.

8.3. Storing and handling hazardous materials measures

Hazardous materials that will be used for the purposes of B3 unit operation will be transported and stored in the same way as it was for the needs for exiting B1 and B2 units. This, for these activities, the same procedures and protection measures prescribed in the internal documents of power plants, as well as procedures relating to the ISO 14000 and safety at work standards will apply. This, among other, comprises:

- Loading and unloading of dangerous goods (loading, pouring, handling, transferring, loading, unloading, storage and other operations in connection with loading or unloading) performed only at certain places that do not endanger human health, the environment, or material good, or safety,
- Ensure that the place where the loading or unloading of dangerous goods to be equipped with the prescribed equipment and devices, and in a conspicuous place with appropriate sign of danger,
- Storage of hazardous materials carried out in accordance with the manufacturer's instructions, especially in areas designated for that, equipped with a concrete base and a system for the collection and disposal of waste water to the treatment plant,
- Premises for the storage of hazardous materials must be equipped with an adequate system of controlled local / general ventilation,
- Hazardous materials stored on pallets with secondary bottom for receiving liquid spills, taking into account the separation of incompatible chemicals (special acid and base baths, etc.),
- Guidelines for the management of hazardous materials must be placed in a prominent place in all the places that are used for handling hazardous materials,
- At places of storage and use of hazardous substances provide sorbents (eg barrels of sand) for the collection of chemicals in case of spills.

8.4. Measures to be taken in case of accident

In order to reduce the probability to prevent accidents, as well as consequences of accidents, it is necessary to implement the following measures within the thermal power plant:

- Accident prevention measures,
- Preparedness measures and accident response measures,
- Measures taken to eliminate the consequences of the accident.

The main role of accident *prevention measures* is reduction of the probability of accidents. These measures are related to: (i) technical measures domain, (ii) information system and documentation domains and (iii) management domain. Bearing in mind that the above mentioned power plant is still under construction, so, the organizational scheme, qualification structure, operation and maintenance department and the other divisions are still not defined, in the following will be given an overview of necessary technical accident prevention measures system by system, which are mostly included by project requirements.

Electrostatic precipitator plant

The consequences of emergencies (failures) on electrostatic precipitator plants are excessive pollution of the environment (air and soil) by powdered substances.

Technical protection measures are primarily related on reduction the likelihood of the failure or electrostatic precipitator disorder, since the repair, i.e. elimination of consequences is practically impossible to carry out.

Electrostatic precipitator operation largely depends on boiler plant operation, i.e. on the quantity and temperature of the flue gases, so, the efficiency of its operation is determined by the parameters of boiler operation. Thus, one of the first protection measures would be optimal management of boiler plant, which is, otherwise, important and required due to other reasons, primarily in order to achieve the highest possible efficiency of the boiler operation.

Nevertheless, regular maintenance and equipment components validation should be carried out for optimal electrostatic precipitator operation, bearing in mind that the most common causes of reduced efficiency of electrostatic precipitators are related to disturbance in voltage levels and reduced number of electrodes. In accordance with that, it is necessary to continuously conduct systematic electrostatic precipitator monitoring.

Chemicals warehouse

The main role of accident prevention measures is reduction of likelihood that uncontrolled chemical release in workspace and environment occur.

Technical measures for reduction the probability of accident entail:

- Regular condition monitoring of tanks, containers and barrels in which chemicals are stored, as well as associated measuring equipment,
- Regular facility overhaul on the locations of decanting chemicals,
- Only authorized persons which are trained to work hazardous materials can handle with equipment and chemicals,

- Mandatory use of personal protective equipment when staying in a room where chemicals are stored as well when working whit chemicals,
- Setting the alarm in chemicals stock room in order to timely recognize leaking chemicals on the tanks or auxiliary equipment,
- Do not store incompatible chemical in the same storage area,
- Provide appropriate ventilation in the storage area,
- Only allow access in storage area to authorized persons, trained for working with hazardous substances, and equipped with personal protective equipment,
- Delivery and transhipment of chemicals only during a day,
- Compliance with procedures of transhipment,
- Packaging waste should be appropriately treated, marked and put off in temporary storage of hazardous waste within the complex.

In case of emergency, rupture of tank with acid, etc. it is acting in accordance with emergency response plan, according to EHSP 12 procedure, Emergency preparedness and response.

System for transport and ash, slag and gypsum disposal

Accident prevention measures are contained in activities envisaged by the program of landfill monitoring, Chapter 9 of this Study

Fire protection measures

Fire protection preventive measures

Evacuation

The main element determining effective evacuation from the facility is a time in which it can be enforced. Based on maximum time allowed for evacuation and number of people that can be found in facility at a time of outbreak of fire, the width of passages, stairways and doors are determined.

In case of need, horizontal passages, staircases and exterior doors are used for evacuation.

The facility has a sufficient number of exits, which, at ground level, directly lead into a free space.

Doors on the evacuation routes are opened in the exit direction from facility.

The length of the evacuation route from the furthest part of the facility to the exit doors does not exceed 30 meters.

Labelling of evacuation routes is clearly market as a direction of evacuation. All exits from facility as well as access roads to exist are marked with visible signs. Signs indicating the path to an exit are on the emergency lighting, and with EXIT signs are marked exits from facilities.

Security systems

In facilities, the following installations represent security system and should operate in fire conditions:

- Anti-panic lighting – 0 minutes (has its own power supply via accu batteries),
- Fire-resistant flap – 0 minutes (automatically closed upon fire occurrence or short circuit),
- Fire report - 0 minutes (has its own power supply via accu batteries),
- Pumping station of hydrant network – 120 minutes,
- Drencher of installation – 30 minutes,
- Ingeren fire suppression system - 0 minutes (automatically activated upon fire notification).

Continuous secure power supply of these electric consumers is provided, in addition to the substation, from diesel electric generator.

Fire alarm systems

New B3 unit in TPP Kostolac B comprises more technological and construction units: main engine facility (MEF), facilities of flue gas desulfurization system (FDG), facilities of limestone-gypsum FDG system, facilities of cooling water system, facilities of CWP system, facilities of system for internal transport of ash, slag and gypsum. In all indoor construction facilities of stated system is planned preventive fire protection by constructing a stable installation for signalization for fire occurrence.

Taking into account considerable surface of B3 unit facility, more pronounced technological units of facility, as well as larger amount of information to be monitored in alert system, it can be concluded that at TPP Kostolac B3 implementation of decentralized stable fire alarm system with a large number of local fire stations is justified.

It is planned that entire B3 unit facility, in terms of fire occurrence, is monitored from 4 local fire headquarters.

Local fire headquarters will be completely autonomous in operation and will provide complete insight into the state of fire detection system on the area they cover. Local fire headquarters will be equipped with addressable loop modules. Conditions of local fire headquarters will be monitored in local via operating consoles which are integrated with headquarters and via remote system. This system provides redundancy which is, regarding system importance, required.

All local fire headquarters planned for B3 unit will be integrated through main operational console, which will be located in B3 unit master control in MEF. All important information on alarms and local headquarters operation could be monitored on main operational console. At the same time, these information will be transmitted on parallel panel at counter on the entrance in facility TPP Kostolac B, where is a team of firefighters on duty.

In the future, it is planned to establish a central system for monitoring and fire alarm system control, which would integrate exiting local fire headquarters in TPP Kostolac B and new fire headquarters in B3 unit. New central monitoring system and fire report system management should provide full graphical and textual support to entire fire report system.

Locations of local fire headquarters

Local fire headquarters will be located on the following locations:

PPC-B3	the main operation facility – telecommunication room, the main control console in the main command (cote +12,00m),
PPC-HPV	chemical water treatment – command room,
PPC-SIL	ash and slag silos – command room
PPC-DU	inclined bridge of the coal yard – coal delivery command (existing).

Installation in facilities

Bearing in mind the possible causes of fire, the purpose of the facilities, as well as the speed of fire development on the one side, and the possible types of automatic fire detectors on the other side, it can be concluded that the optical smoke detector meets the most of conditions for early fire occurrence detection. For that reason, it was adopted, as a basic detector of fire signalization system, addressable optical smoke detector. Besides this detector type, depending on the application conditions, thermo-differential/thermo-maximal fire detectors are provided.

Manual call points

Increase of fire alarm system efficiency is achieved with adding addressable type manual call points, giving the possibility to manually switch alarm., in case that a fire is detected by man. This type of detectors is placed along the evacuation routes, and near devices for mobile fire extinguishing.

Connection to a fire alarm system is performed via twisted-pair cable.

Alarm sirens

Alarm sirens provide general alarm in the facility, i.e. alarm for evacuation of vulnerable persons in the facility.

Sirens are set to broadcast « howling » tome. They have ability to adjust the intensity of the sound.

Connection to fire central is performed via two-wire installation cable.

Fire extinguishing systems

To extinguish possible fires, external and internal hydrant network is provided.

Total water amount needed for fire extinguishing in the facility, depending on the degree of fire resistance of the largest facility in complex, facility volume and category of technological process according to the risk, is given in Table 8.4-1.

Table 8.4-1: water amount needed for fire extinguishing in the facility

Degree of facility's fire resistance	Category of technological process according to fire risks	Water amount (in litre per second) necessary for one fire, depending of facility volume (in cubic meters) to be protected						
		Up to 3.000	3.001 up to 5.000	5.001 up to 20.000	20.001 up to 50.000	50.001 up to 200.000	200.001 up to 400.000	above 400.000
V i IV	K4, K5	10	10	10	10	15	20	25
V i IV	K1, K2, K3	10	10	15	20	30	35	-
III	K4, K5	10	10	15	25	-	-	-
I i II	K4 i K5	10	15	20	30	-	-	-
I i II	K3	15	20	25	-	-	-	-

Given that the category of technological process in the facility is classified in K3, and the volume of entire facility is from 50.001 and 200.000 m^3, as well as the fact that degree of facility's fire resistance is IV, water amount necessary for efficient firefighting is 30 l/s according Article 13, Rules on technical standards for firefighting hydrant network (Official gazette SFRJ, no. 30/91).

In present case for fire extinguishing, it has to be provided minimum amount of water of 30 l/s, which is required for simultaneous operation of external (17,5 l/s) and internal (12,5 l/s) hydrant network.

Stable extinguishing equipment

Basic protection of inclined conveyor bridge from fire is made with drencher installation.

Stable automatic fire extinguishing installation with inert gas IG-541 is intended for fire extinguishing at the level +12,60 m of main power facility, in central control room and engineering station (E28 and E29).

Mobile extinguishing equipment

Mobile extinguishing equipment represents basic standardized firefighting equipment. That equipment includes hand held and mobile fire extinguishers.

Based on assessment of possible fire classes and the selection of appropriate fire extinguishers for these fire classes, hand held and mobile fire extinguishers are installed:

- Fire extinguishers with dry power, marked with "S",
- Fire extinguishers with carbon monoxide, marked with "CO_2".

Number of fire extinguishers is defined on the basis of fire load. S-9 apparatus is defined as a unit.

Extinguishing of possible fire will be carried out by firefighter unit of TPP Kostolac and gradska firefighter unit from Pozarevac.

It takes about 10 minutes that firefighter unit reaches the scene of fire.

Architectural and civil fire protection measures

To prevent the spread of fire on the entire facility, building should be divided on fir sectors with limited surface. Fire sector should be observed as a part of facility which will possibly be completely destroyed by the fire, but it will not extend out of that area for a certain period of time. Fire sectors are separated by fire walls, whose resistance is determined according to fire sector which has a greater fire load.

Preventive electrical fire prevention measures

Mechanical protection of installation elements is achieved by choice of equipment with required structural characteristics and setting mode of installation lines, cables and installation equipment, according to their location and working conditions.

Electrical protection of installation elements was achieved by protection of installation lines from overloads and short circuits, by constructing of specific elements providing necessary protection – high-quality insulation and contact materials, current load withstand during short circuits, etc.

Preventive fire protection measures on mechanical installations:

- Non-flammable materials will be used for ventilation systems. In case of fire, fan and air conditioning are automatically switched off in order to prevent spread of fire; penetrations of installation for heating or ventilation through firewalls should be insulated with the material of the same fire resistance at the firewall ; appropriate certificates should be provided for a fireproof mass used to seal openings during the pipe penetration on the border of fire sectors,
- Openings for pipes that pass through different fire sectors must be sealed by material of the same fire resistance as a wall, ceiling, and floor on the sector border. Materials for insulation and sealing should possess atests on fire resistance,
- diesel generator facility is separated as a separate fire sector,
- for diesel fuel spillage is planned sedimentary pit; all diesel pipelines have a decline in direction of sediment reservoir, which is located at the lowest point of sedimentation pit,
- To prevent heating of diesel fuel in reservoir below permitted temperature, automatic temperature regulators or thermostats must me installed,
- In diesel generator facility is foreseen forced ventilation.

Other preventive fire prevention measures:

- works with equipment, maintenance of equipment and preventive care during the process of welding, cutting and soldering according to provisions of Regulation on fire prevention measures during the process of welding, cutting and soldering (Official Gazette SRS, no. 50/79),
- Regular accuracy control of all electrical devices and fire equipment.

Technical fire protection measures

Based on reviewed level of fire danger, the following measures are foreseen with the aim to ensure safety and protection of facilities and property from fire within normal functioning:

- support, structural, construction elements are made of non-combustible building material: concrete and steel (which is coated with fireproof coatings where is necessary to achieve the required fire resistance of min F30),
- Anti-panic lighting installation is provided,
- Protection system against atmospheric discharge is provided,
- Setting of mobile devices for initial fire extinguishing is provided,
- Installation for automatic fire detection is provided,
- External hydrant network for fire extinguishing is provided
- Stable system for automatic fire extinguishing of a part of the desulphurization system (the main power source) with a sprayed water (drench system) is provided.

8.5. Protection measures during the construction (civil works)

- The contractor is required to do a special study on the construction site and site work,
- Build construction site fence around building site and properly mark,
- Prior to the commencement of the works necessary to carry out preparatory work, provide the location and perform other work to ensure human health and safe transport,
- When cleaning the land in the area of the works must be observed all the rules on the protection and safety and prevent any negative impacts on the environment and the immediate surrounding locations,
- Prior to the commencement of earthworks to obtain information on the exact location of existing infrastructure (underground electrical cables, pipes, etc.) to avoid damaging them,
- The works carried out according to the technical documentation on the basis of which the approval was granted for the construction and the technical measures , regulations, norms and standards for the construction of this type of object,
- The location of the predicted adequate storage place (dump) of the material used in the construction,
- It is necessary to take all necessary measures for the safety of workers, plant and adjacent buildings and transport, as well as to protect the immediate vicinity of the site,
- The subject site is, during the works, is prohibited pumping and storage of petroleum products, oil and lubricants for machinery. Provide an enclosed space on the site for storage and preparation of materials,
- If the work is stopped for any reason, it is necessary to protect the facility and the environment.

8.6. Protection measures for archaeological site Viminacium

- If during the construction and other works archaeological sites or archaeological objects, the contractor shall immediately stop work immediately and notify the Department for the Protection of Cultural Monuments in Smederevo and take all measures to ensure that the findings do not destroy and damage and to be kept in place and in a position where it is detected,

- If there is an imminent danger of damage to archaeological sites and objects , Institute for the Protection of Cultural Monuments in Smederevo must temporarily suspend the work until it is determined whether the property in question or a cultural thing good or not .,
- The investor is required to provide constant monitoring of one archaeologist will conduct ongoing monitoring of all the earth, and preparatory work for the construction of the building desulphurization,
- The investor is obliged to take measures to protect the special conditions to be issued by the Republic Institute for Protection of Cultural Heritage in the event that, during the archaeological monitoring take note immovable cultural property condition more extensive work , relocation or presentation,
- Also , the developer is required to provide funds for archaeological monitoring, research , protection , preservation , publication and presentation of goods which are under special protection in the event of the exercise of earth , construction and other work in areas where there are archaeological sites and assets given protection

The main preventive measure to reduce the probability of accidents is the respect of project protection measures and establishing accident management system in accordance with the requirements of the current legislation in this area.

- Assess the risk of accidents for solutions that will be provided by the main project within the overall documentation for TPP Kostolac, in accordance with regulations,
- Create protection against chemical accident Plan, as a part of overall documentation for TPP Kostolac, whose content is defined by regulations,
- For all identified accidental situation establish procedure of reacting which will define undertaken actions, external institutions that are informed about the accident, mitigation of accidents' consequences,
- Response in cases of accidental situation should be integrated in existing response procedures in case of other accidents on thermal power plant facility,
- for fire extinguishing proper equipment should be provided, such as mobile extinguishing equipment and fire hydrants,
- in hazardous areas must not be located substances and devices that can cause fire and explosion or facilitate their expansion,
- project carrier is bound to maintain fire-fighting equipment in good condition and to make familiar employees with its use,
- in case of chemical spills, spills is collected using sorbent.

8.7 Noise protection measures

Site preparation and B3 unit construction

Potential noise and vibration influence during thermal power plant construction is not high, but it is necessary to reduce noise into permitted limits. Therefore, some measures are proposed to reduce the noise and vibrations impact during phases of site preparation an B3 unit construction:

- Machines on construction site should be switched off when not in use. Work should be organized so that machines, operating at the same time on site, are not close to each other. Work should not be performed during a night.
- Equipment with effective sound mufflers and noise barriers that are not made of metal should be used.

- For paving, digging the soil, transport of materials and drilling should be used more efficient machines with built-in dampers and enclosed motors,
- Also, compressors and generators with enclosed motors should be used,
- Access road to the site and on the site should be constantly maintained,
- If necessary, noise barrier (wall), which can be movable to receptors, depending on work progress, should be installed,
- All vehicles and machinery must be accompanied by manufacturer's warranty that the noise emitted by machines during the operation complies with permitted limits and in accordance with EU specifications.

B3 unit operation

During preparation of technical documentation, as a project criteria for equipment suppliers is specified obligation of noise protection, under the applicable law, which refers to noise level limits in work space. In order to protect the area outside TPP from noise, it is required to implement the following measures:

- Determine reference zones in the area of B3 unit location, in accordance with Regulations that determine acceptable levels of noise in environment,
- Carrying out the measurement of noise levels on the borders of location prior to start B3 unit operation, in order to determine potential area where is noise phon increased or noise level is on the limit of permitted level,
- Determine conditions under which increased noise levels occur, i.e. noise sources that lead to such situations,
- After B3 unit commissioning, noise level should be measured in order to determine the change in the level of noise compared to defined phon,
- If necessary, for regular B3 unit operation, implementation of additional protection measures in the form of fences, hedges, etc. should be foreseen.

9. PROGRAM OF ENVIRONMENTAL INFLUENCES MONITORING

9.1. Purpose and aim of environmental monitoring

New B3 unit is integral part of TPP Kostolac B, and, hence, environmental monitoring that relates to this facility must be a part of overall monitoring that TPP implements.

Obligations relating to the monitoring of environment quality are defined by the Law on environmental protection, Part IV „Environmental conditions monitoring" (Official Gazette RS, no.135/04), where the obligations of the Republic or the local self-government in terms of environmental monitoring are quoted, as well as obligations of the pollutant.

It is also important to mention that TPP Kostolac B is obliged to comply with the requirements of the Law on integrated pollution prevention (Official Gazette, no. 135/04), which means that it should organize and conduct monitoring in accordance with the plan attached with documentation submitted for the purposes of integrated work permits issuing. In integrated permit should be precisely defined conditions relating to the requirement for emissions monitoring in facility concerned, including defining the adopted methodology, frequency measurement, the rules for measurement results interpretation, as well as obligation to deliver the monitoring results to the competent authority. TPP has begun the process of obtaining the integrated permit.

9.2. Determining the environment status before the functioning of the project

Prior to the commencement of the installation it is necessary to determine the so-called 'Zero state' of the environment. This process includes (1) the collection and systematization of the existing data on measuring the environmental media in zones of influence of future plant and (2) the performance of additional conditional sampling and analysis of environmental media in the zones of influence of newly constructed plants.

In this particular case, "zero state" of the environment represents results of the monitoring program before the beginning of new unit operation. Should be mentioned that on the existing units in previous period was performed revitalization in order to extend lifetime for another 100.000 hours, and compliance with emission norms, as well as reconstruction of system for transport and ash and slag by switching to the depositing technology in the form of thick mixture. Summary results of all measurements relating to the control of environmental situation in the area under the TPP Kostolac influence, for which the program is made and realized by TPPs – CHPs Kostolac branch, is given in annual report for each year separately.

Scope and frequency of monitoring the environmental influences

This chapter contains a proposal regime of monitoring the impact of FGD facility operation on the environment. It should be noted that the impact of this facility may be monitored in an integrated monitoring system, along with other environmental impacts that are realized via TPP operation.

In Table 9.2-1, there are scope and frequency of monitoring, defined according to the requirements of Regulation, which include monitoring of parameters and environmental media which are in relation with FGD facility operation:

- emission of pollutants into the air from the chimney,
- imission (air quality) on measuring stations in the TPP surrounding, used to monitor the effects of units operation,
- waste water quality from FDG facilities on output pipeline from B3 unit's neutralization pit,
- quality of treated waste waters on output of plants for coal water treatment and the treatment of waters from ash and slag system,
- The quality of groundwater in observation wells (piezometers) in the area of ash, slag and gypsum disposal.

In addition to the stated monitoring, Technical mining project of ash, slag and gypsum landfill defines monitoring to be carried out for the purpose of providing landfill stability, and which includes technical monitoring of the landfill facility (landfill auscultation).

Ash, slay and gypsum landfill monitoring is operated by technical service. Each recording and measurement is recorded in special monitoring book i.e. observation diary, in order to timely react if the observation results indicate possibility of damage, facility destruction or endangering the stability and security of adjacent facilities. Observation diary is the most important document which should be dully kept up to date and, after filling, it should be kept in branch's archives. The following data should be entered in diary: date and time of observation, weather conditions, technological activities at the landfill, visual observations related to the landfill and facilities at the landfill. Based on the observation diary, periodic reports are made. Facility user shall be required in emergency cases to immediately provide expert evaluation of observation results and, if necessary, to ensure preparation of technical documentation for repair works on facility and soil, and to inform the competent inspection on newly created situation.

The type and manner of technical surveillance of the landfill facility are defined in accordance with Regulations on design of embankment dams and hydro-technical dams (SRPS U. C5.020). The main goal of surveillance is to permit exploitation of landfill in projected conditions, to prevent possible accidents by timely detection of phenomena and events that adversely affect stability and to bring programs of works for partial remediation and repair of landfill, current maintenance and general repairs.

In accordance with the Rules for ash, slag and gypsum landfill, it is necessary to foresee the following:

- Visual observation,
- Measurements (geodetic, geo-mechanical, hydrometric and meteorological).

Visual observation aims direct observation of phenomena related to the conditions of landfill exploitation and landfill stability and it is necessary to pay attention on appearance of base body and embankments deformation, occurrence of erosion, filling regularity and reached heights of landfill fillings.

The objective of measurements is timely quantitative and qualitative assessment of the reliability and stability of the gypsum landfill, and measurements and test are divided into four groups: geodetic, hydrometric, and meteorological and geo-mechanical.

Table 9.2-1: General elements of the regime for environmental influences monitoring

Medium	Type of measurement	Monitoring parameters	Legal terms/standards	Monitoring frequency
Air	**Emission measuring** This project provides the installation of the continuous emission monitoring system	• particles, • SO_2, • NOx, • Carbon monoxide – CO • CO_2, • O_2, • gaseous inorganic fluorine compounds expressed as HF • gaseous inorganic compounds of chlorine expressed as HCl • temperature, • pressure and flue gas flow	Regulative of ELVs into air ('Off. Gazette of RS', br. 71/10) Directive 2010/75/EC – Industrial Emissions Directive	Continuous monitoring
	Imission measuring Air quality monitoring is necessary to continue and align with existing systematic measurements	• total sediment substances (mg/ m^2/day) • Nitrogen oxides expressed as NO_2 • Sulphur oxides expressed as SO_2 • Powdery substances, PM10	Regulation on conditions for monitoring and requirements for air quality (Official Gazette of the RS, no. 11/10, 75/10 i 63/13)	Continuously on measurement grid in the vicinity of TPP
Waste waters (effluent)	Monitoring waste waters quality (effluent) at the entry of the facility for treatment and before mixing with receptors waters	Based on the two-hours composite sample, it is necessary to analyse parameters according to Tables 3.3.6-1 to 3.3.6-3	Regulations on the manner and conditions for quantity measuring, waste water quality testing and the content of the report on performed measurements (Official Gazette of the SRS no. 33/16) Regulation of ELV of the polluting matters into eaters and the deadlines for their reaching (Official Gazette of RS, no. 67/11, 48/12, 1/16)	4 times a year (once in 3 months)

Medium	Type of measurement	Monitoring parameters	Legal terms/standards	Monitoring frequency
Underground waters	Carry out sampling in observation wells located in the area of ash, slag and gypsum landfill. According to technical mining project was planned location and number of piezometers, which will be set up in order to determine tightness of foil.	a) general physical and chemical parameters: • temperature °C, • colour, smell, turbidity, • pH, • usage KMnO4 mg/l as O_2, • specific conductibility, • pH, • dry remain, • suspended particulate matter, • HPK, • BPK5 b) specific parameters • chlorides	Regulation on limit values of polluting substances in surface and underground waters and sediment and deadlines for their achievements (Official Gazette of RS, no. 50/12) does not define dynamics of underground water quality control	According to requirements of water management permit and integrated permit Dynamics of water quality measurements in observation wells will be defined with the Project of landfill monitoring
Noise	Perform the initial noise measurement before B3 unit operation within TPP and in the area of the first receptors	noise level (dBA)	Regulations on noise indicators, limit values, methods for noise indicators assessment, disturbance and harmful effects of noise in environment i (Official Gazette of the RS, no. 75/10) Regulations on measures and norms of protection at work from noise in work areas (Official Gazette of the SFRJ, no. 21/92)	According to the existing plan and program of noise monitoring

Geodetic benchmarks and piezometers are auscultation devices that will be installed at the gypsum landfill. Geodetic benchmarks on the boundary embankments od landfill: 6 in total (one on the narrow part and 2 on the longer part of the landfill) which are used to determine the absolute or relative displacement of the corresponding benchmarks in horizontal and vertical plane, i.e. relative change in the benchmarks' distance; if by geodetic measurements are registered large horizontal displacements of benchmark points on the slopes of landfill's embankments, inclinometers will be installed.

Hydrometric measurements comprise quality monitoring of installed geomembrane, and are performed via water quality monitoring in piezometers which are placed at a distance of about 10 m from embankment toe of landfill, according to technical mining project.

Meteorological measurements and observations should comprise monitoring of the following parameters: amount and types of precipitation, evaporation rate, air temperature and direction and intensity of the wind. If there is no weather station at landfill, mentioned data will be retrieved from the nearest station (in Veliko Gradište). TPP has an obligation to install its own weather station.

Geo-mechanical testing of disposed material will be held at least one in a year and they are aimed to determine the value of the relevant parameters of importance for the stability of the landfill and the load capacity of the equipment in operation at the landfill. In this regard, humidity, bulk density, compressibility, angle of internal friction and cohesion will be determined. All these provided tests should be performed by specialized and competent institution. After each test, report should be made, as an integral part of annual report of landfill auscultation.

Impacts on the environment are determined according to the following parameters:

- Air quality – periodically is performed measurement of total and respirable dust (particles of gypsum) in the air above and around the landfill by appropriate instruments. Sampling of total dust at different speeds of windfall can be performed by instruments type AERA or similar: for sampling of respirable dust sized below 10 µm, instruments type MPG WAZAN or similar are used.
  Number and schedule of measuring points will be defined by the Project of the landfill monitoring, which will be made with the Main mining project.
  Within the OCM Drmno, there is five permanent measuring points where are measured concentrations of total and respirable dust, which serve to control air pollution from coal mining process. Within the above mentioned Project, the need to expand the existing measurement network will be analysed..
  Measurements will be carried out by authorized institutions for the purposes of the OCM Drmno.
- Water quality – it is necessary to perform occasionally water sampling from piezometers and water quality assessment in order to determine possible cracking or foil punching: also, occasionally will be performed sampling and analysing of water from water collector, which will collect water from the landfill, as a result of precipitations.

Measurement results of all provided parameters must be recorded and archived with results of the technical observations of gypsum landfill.

10. NON-TECHNICAL SUMMARY OF THE ENVIRONMENTAL MPACT ASSESSMENT STUDY

Non-technical summary of Study was prepared as a separate document.

11. DATA ON TECHNICAL DEFECTS

Upon making this Study, no significant technical faults were established, which could influence the effect evaluation process.

The Study clearly defines the output parameters of all water matters and shows treatment contemporary practice. Building the subjected facility represents one of the high-priority projects for the Republic of Serbia and PE EPS, and its realization is in progress.