TE-TO AD SKOPJE

Combined Cycle Co-Generation Power Plant Project Skopje

Environmental Assessment Report

SECTION E
ENVIRONMENTAL IMPACTS

August 2006

Thermal Energy Plants Department

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1 Introduction

The Project, including the construction and operation of the thermal cogeneration power plant of 220-240 MWel will play a very important role in the development of the Macedonian Energy Sector. It will promote the policy of industrialization and modernization of Macedonia in the coming decades and make a big contribution to the overall socio-economic development. In this section of the EA Report the impact of the Combined Cycle Co-Generation Power Plant Project on the environment will be investigated. All relevant types of emissions and influences are considered in the study, particularly those that may have an impact on the physical and biological resources in the vicinity of the project, as well as those that could affect humans and their quality of life.

Beside significant beneficial impacts, and despite the use of a modern, clean technology and the use of natural gas as exclusive fuel, the project may have minor negative effects on the environment. But the design, approach and implementation are intended to minimise such negative effects as much as possible.

Additionally, it has to be taken into consideration that this power plant project will be constructed in the area of the existing heating plant which is located in an already developed industrial area.

In the following sections the impacts during the construction phase and especially during the long lasting operation phase, as well as socio-economic aspects will be investigated and assessed in more detail.

2 Impacts during the Construction Phase

Possible impacts during design and construction phase are

- Impacts of land clearing on local people
- Impact on land used
- Impacts by traffic and transportation
- Impacts caused by labour concentration
- Impacts by civil works and construction of the power plant.

2.1 Impacts of Land Clearing on Local People

The new Combined Cycle Cogeneration Power Plant is located in the industrial area on the site of HPP East. Almost the complete space required for the new power plant project will be used by TE-TO AD. The space which was foreseen for the switchyard (not yet owned by TE-TO AD) is around 0.4 ha (area FIII in Figure E- 1). However, since this property is currently partially occupied by squatters the project development is currently also looking for alternatives.

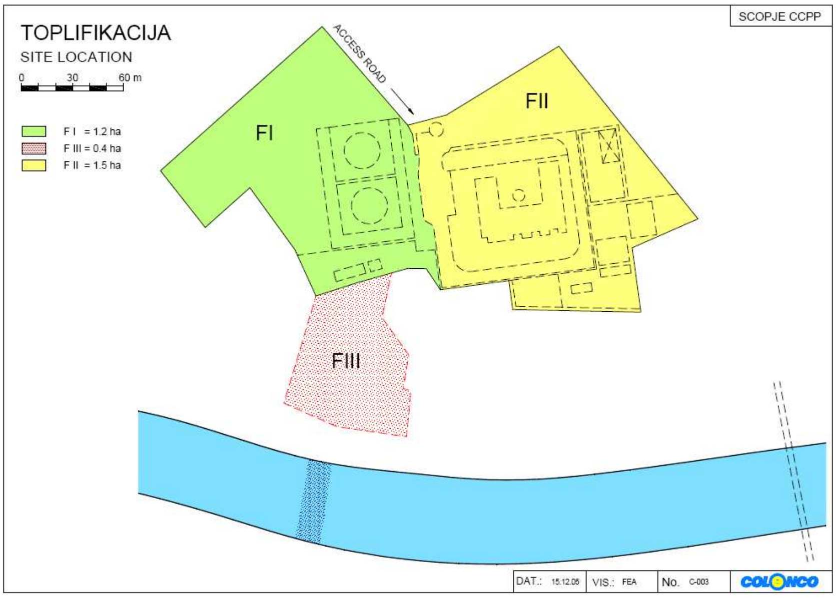


Figure E- 1: Area FIII requiring Land Clearing

If the owner of the property does not intervene and remove those squatters within a short period of time, it will be difficult to remove those buildings without their agreement.

Since the property has not been needed so far, the owner has not taken any further steps to remove the squatters. Therefore most likely a resettlement action plan for the people currently living on this property has to be established.

According World Bank Standard an appropriate compensation for assets, logistical support for moving, and a relocation grant may be the only requirements if the number of affected people are smaller than 200. However, the principles of compensation for larger groups apply.

WB standard (OD 4.30) contains the following points:

- (a) organizational responsibilities
- (b) community participation and integration with host populations
- (c) socioeconomic survey
- (d) legal framework
- (e) alternative sites and selection
- (f) valuation of and compensation for lost assets
- (g) land tenure, acquisition, and transfer
- (h) access to training, employment, and credit
- (i) shelter, infrastructure, and social services
- (j) environmental protection and management

- (k) implementation schedule, monitoring, and evaluation

2.2 Land Used

The CCPP Skopje will be located in an existing area in the Toplifikacija AD directly adjoining the existing district heat plant “ISTOK” of Toplifikacija. The plant site is near the river Vardar and can be reached easily by the existing good road connections.

The total size of ‘ISTOK’ is about 4.3 ha. It is partly used for the existing Heating Plant including 5 VKS Boiler with a common stack, 2 BKW boilers plus one additional stack, a heavy oil reservoir with 2 x 5000 m^3 tanks, an administration complex containing offices, a laboratory, a workshop and mounting/storage areas/shelters. On the property is also a ground water well station owned by “Toplifikacija AD” with forwarding pumps and a holding tank, a gas compressor station and parking places. A public access road (material cobblestones) leads to the entrance.

Figure E- 1 also shows the distribution of the required space for the new power project. On area F I (green, approx. 1.2 ha) the new CCPP shall be erected. The two tanks (belonging to existing heat plant) will be removed to provide enough space for the new plant. The area F II (yellow, approx. 1.5 ha) comprises the existing heat plant. Area F III (red, approx. 0.4 ha) is foreseen for the switchyard and laydown area during construction phase.

2.3 Impacts by Traffic and Transportation

The Site can be reached by both either railway or road connection. The railway connection has a terminal nearby the site. Therefore heavy and huge equipment can be transported also on this way. Since it is a direct line to Thessaloniki which can be considered the closest international harbour heavy and huge equipment can be delivered via ship and moved on that way to the site.

The road connection is in good paved condition without any known restrictions on weight and dimensions. It passes no critical areas such as housing estates or ecological protected areas where specific measures need to be taken into account.

Due to transportation of construction materials, plant equipment and labour, the traffic volume in the area, especially on the roads leading to and from the site and the main ones which are leaving / entering Skopje may increase slightly but only for a temporary period during the construction phase. The emission of dust and exhaust gases of cars and trucks will reach an increased level which will be directly attributable to the civil and construction activities.

The increase of traffic may cause a bigger amount of traffic accidents. It will be a main concern of the local people to maintain the traffic safety i.e. to keep the traffic slow which pass through residential and other populated areas by appropriate measures such as giving a safety education to the drivers or by setting strict speed limits which have to be controlled by the local authorities.

It is expected that the transportation of the main materials and equipment will be as follows:

Material / Equipment	Method of transportation
Civil construction material (stone, cement, brick, rock, etc.)	Truck transport to site
Plants and equipment (gas and steam turbines, heat recovery boiler, steel structure, etc.)	Railway transport where equipment loads and dimensions allows it – otherwise transport by heavy load trucks

2.4 Impacts Caused by Labour Concentration

During the construction phase, this will constitute the highest levels of activity, with about 250-350 construction workers concentrated at the project site. Thus the following impacts may be considered.

Most of the local workers originate from the city of Skopje and the surrounding area and will be accommodated in their own houses. Several other workers will be accommodated in the nearby hotels. A limited number of the workers will stay directly at the construction site. These workers will be accommodated in camps, which the EPC contractor shall provide according to the local regulations.

Sanitary waste:

The average daily amount of sanitary waste produced by a group of 250 workers is estimated to reach 10 to 15 m^3. Standards request a concentration of oxygen higher than 50 % saturated concentration, i.e., higher than 3.8 mg/l. The sanitary effluent is usually treated by a biological method. The appropriate method is selected depending on flow rate, collection method and condition of land surface. In the case where it is not possible to build a wastewater treatment plant to treat all of wastewater from the site, the most effective treatment method would be to use a septic tank system. The function of a septic tank is to settle solid waste, digests in anaerobic process and produces residue with a treatment efficiency of more than 70 - 80 % BOD. The achievable waste water discharge quality will comply with the Macedonian standards.

Domestic solid waste:

With the increase of the construction activities, the amount of the daily domestic solid waste will also increase. Depending on the intensity of the activities, the amount of domestic wastes may reach up to 100 to 250 kg, containing 60-70 % organic matter and 30-40 % others (plastic, papers etc). These wastes will be disposed according to the local regulations by an external authorized disposal company.

Possible Transmission of Infections Diseases from Workers to Local Population and vice-versa:

Effective mitigation and prevention measures shall be taken into consideration to avoid transmission.

2.5 Impacts by Civil Works and Construction of the Power Plant

During construction phase of the Skopje CCPP and associated civil works, the following impacts are to be expected:

- Temporary increase in air pollution from the construction site, from construction materials utilised on site and from the transportation of construction materials
- Temporary noise and vibration pollution produced by construction equipment

Impacts on air quality:

In the construction phase air pollution is predominately produced by dust and exhaust gas from trucks and construction machinery. It is indicated that during site preparation, the following construction equipment will cause adverse impacts on air quality: trucks, compactors, pile drivers, jackhammer and drills, generators, asphalt heating equipment, concrete processing stations. Because most of this equipment uses gasoline or diesel, they will emit particulate matter, SO_2, NO_X, VOC and lead into the air.

This impact on air quality is only local (could only be classed as serious at or nearby the construction sites) and temporary (only during the construction period).

The major air pollutant during the construction phase will be dust produced by earth works (digging, excavation, and filling, levelling). Receptors, which can be affected, are areas surrounding the construction sites with houses and buildings located at a distance of approximately 200 m from the construction site. At this distance at the peak of construction hours, ambient air quality may be degraded.

Noise impact:

According to data monitored and indicated in Section D, chapter 2.5, the present noise levels in populated areas in the City of Skopje and in the project site area are rather high, and sometimes even exceeding the local respective the WB Noise Standards for industrial areas and residential areas. Comparison between WB and local guidelines shows that for the same norm (industrial area) the values are identical (see Section B, Tables B-09 and B-10):

Noise standards for industrial areas:

Macedonian Standard		WB Standard	
6 h to 22 h	22 h to 6 h	7 h to 22 h	22 h to 7 h
70 dB(A)	70 dB(A)	70 dB(A)	70 dB(A)

Noise standards for Residential and Business areas:

Macedonian Standard		WB Standard	
6 h to 22 h	22 h to 6 h	7 h to 22 h	22 h to 7 h
60 dB(A)	50 dB(A)	55 dB(A)	45 dB(A)

During the construction phase temporary noise emissions may be caused by:

- Construction equipment
- Concrete mixing plant
- Pile driving for construction
- Rock blasting and drilling
- Earth moving activity
- Generators
- Vehicles used for material transport.

For most of the above mentioned construction equipment, the noise level in 10 m distance will be within a range of 70 to 90 dB(A). The noise level at further distances can be determined using –6 dB(A) every time distance is doubled and there is no obstacle. Thus, the maximum level will be 84 dB(A) at 20 m, 78 dBA at 40 m, 72 dB(A) at 80 m, 66 dB(A) at 160 m and 60 dB(A) at 320 m.

Since the noise pressure level in the city of Skopje often exceeds the WB standards in both areas, the residential and the industrial independent of operation or construction activities, it can be stated that during construction of the power plant, the average noise level in the residential area will not be significantly increased due to the minimum distance of about 250 m. Attention has to be paid attention that intense noise activities are performed only during daytime (from 07.00 h until 22.00 h) to avoid high noise level peaks and disturbance of population at night.

Vibration Impact:

During construction phase, the major potential vibration sources are pile driving. The main types of construction pile driving are presented below:

- Linked sheet piles of 7.5 to 5 meters length with U-shape cross section are hammered to the desired depth to form a linked steel panel, an 8-ton drop hammer with energy input of 48 KJ can produce vibration of 12.9 mm/s at a distance of 10 m.
- Sheet piling operation silt bed at an energy input of 30 kJ may produce vibration of 4.30 mm/s at a distance of 10 m.
- Diesel hammer on clay bed can produce vibration of 7 mm/s at a distance of 10 m.

Another option to avoid pile driving is boring. With this technique vibrations can be reduced to a minimum.

Concerning the above mentioned environmental impacts that may occur during the construction phase, it can be stated that:

- They are mainly restricted to the Site of the CCPP.
- The impacts can be classed as only local and temporary

3 Impacts during Operation Phase

In general, a thermal power plant may cause the following environmental impacts.

- Emission of carbon dioxide (CO_2), i. e. contribution to the so-called greenhouse effect
- Influence on the air quality by the emission of gaseous pollutants, comprising:
    - nitrogen oxides (NO, NO_2), summarised as NOx
    - carbon monoxide (CO)
    - sulphur dioxide (SO_2)
    - dust, particulates
    - eventually others like heavy metals and organic components
- Water consumption and wastewater production
- water temperature raise by cooling water
- Solid residues production
- Noise.

In the present case of a combined cycle plant with heat and power generation, due to the type of plant, the operation and the kind of fuel a number of environmental impacts will be limited.

The CCPP Skopje will be operated with natural gas as exclusive fuel. Due to this, the emissions of SO_2, dust and heavy metals do not matter.

The cooling concept with hybrid cooling towers will ensure the minimization of environmental impact by cooling water consumption.

In the following, the relevant environmental aspects for the CCPP Skopje are described in more detail.

3.1 Impact on Climate

Each combustion process, burning fossil fuels containing carbon material produces carbon dioxide (CO_2) according to the carbon content in the fuel. Carbon dioxide is the major gaseous combustion product. It is not poisonous, but it contributes to the undesirable greenhouse effect, which may probably lead to an increase in the average temperature and other detrimental disturbances of the global climate. There is no practical way of disposing of large quantities of carbon dioxide other than to release them into the atmosphere. The only measures that can be taken to limit CO_2 emissions is to use fuels with low specific CO_2 values and to increase the plant efficiency in order to keep the carbon dioxide emission per produced electric energy unit as low as possible.

The specific CO_2 emission factor (kg CO_2 per normal cubic meter natural gas firing) is only dependent on the fuel composition. The natural gas used in the present case has the following composition.

Composition of Natural Gas			
Lower Heating value (LHV):		MJ/Nm³	36.0
	% vol		% vol
CH4	98.13	H2	0.00
C2H2	0.00	O2	0.00
C2H4	0.00	N2	0.78
C2H6	0.70	CO	0.00
C3H6	0.00	CO2	0.04
C3H8	0.24	H2S	0.00
C4H8	0.00		
C4H10	0.09		
C5H12	0.02	C6H14	0.006
Specific CO2 factor:		kg CO2/Nm3 gas	1.989

Table E- 1: Composition of Natural Gas

The specific CO_2 emission for this gas amounts to 1.989 kg CO_2 per Nm^3 of gas combustion. Based on this, for the new CCPP Skopje, the following CO_2 emission rates have been calculated:

hourly base	87.5	t/h
annual base (8300 h/a assumed)	726'000	t/a.

In the following section, also a comparison will be made with the carbon dioxide emissions of the existing district heating plant and with possible savings elsewhere, after the new CCPP will be in operation.

3.2 Impacts on the Air

The following sections deal with the evaluation of the emissions of CCPP Skopje as well as with the impacts on ambient air quality.

As a basis for the calculation of the emission rates combustion calculations were performed. The results of these calculations give the required information on flue gas volume flows and flue gas data as well as on main data of flue gas composition. The NOx and CO emission loads can not be calculated exactly. They only depend partly on the fuel composition but strongly on the combustion conditions. But experience is available from operating plants to estimate expected values.

The results of the combustion calculations with the gas composition according the table above are summarised below.

RESULTS of combustion calculation

		Nm^3 / Nm^3 Gas	kg / Nm^3 Gas	Nm^3/h
Min. demand O2		2.006	2.868	88'285
Min. demand air	dry	9.555	12.357	420'404
Act. demand air	dry	29.619	38.308	1'303'253
Act. demand air	wet	29.905		1'315'839
Min. flue gas volume	dry	8.564		376'808
Min. flue gas volume	wet	10.655		468'818
Actual flue gas volume	**dry**	**28.629**		**1'259'657**
Actual flue gas volume	**wet**	**30.913**		**1'360'192**
spec. CO2-value		1.008	1.989	
spec. SO2-value				

Flue gas composition related to wet flue gas			**Flue gas composition** related to dry flue gas		
H2O	7.39	% vol			
N2	75.72	% vol	N2	81.76	% vol
CO2	3.26	% vol	CO2	3.52	% vol
O2	13.63	% vol	O2	14.72	% vol
SO2		ppm	SO2		ppm
SO2		mg / Nm^3	SO2		mg / Nm^3

Flue gas volume flow at fuel throughput of

44'000	Nm^3 Gas / h		1'259'657	Nm^3 / h	dry
			1'360'192	Nm^3 / h	wet
ralated to	15	% Ref.-O2:	1'318'829	Nm^3 / h	dry

Table E-2: Results of Combustion Calculation

The combustion calculations have been based on a full load fuel consumption of 44'000 Nm^3/h (equivalent to approx. 31'680 kg/h) which is corresponding to a total firing heat duty of 440 MW_{th} which has to be expected as yearly average.

For these average conditions, the flue gas volume flow amounts to approximately 1.3 million Nm^3/h (related to dry condition @ 15 % ref. O_2).

3.2.1 Emissions of the new CCPP

In the following the emission concentrations and emission rates are calculated or estimated on a reliable data basis and compared with relevant standards in order to assess the environmental impact caused by the emission of pollutants with flue gas.

Emission Data Existing District Heat Plant and New Combined Cycle Power Plant

		Exist. Heating Plant Heating period: Winter	**Exist. Heating Plant** Heating period: Transition	**New CCPP** normal operation over year
		not in operation during summer		
		ratio mazout/gas: 70% / 30%	ratio mazout/gas: 70% / 30%	only gas in GT
Operation & Fuel Data				
Firing heat duty by natural gas	MW	51	32	440
Firing heat duty by mazout	MW	124	77	
Heat (to DH system)	MW	160	100	160 / 100 / 0
LHV natural gas	MJ/Nm3	36.0	36.0	36.0
LHV mazout	MJ/kg	41.1	41.1	
natural gas consumption	Nm3/h	5'100	3'200	44'000
mazout consumption	kg/h	10'860	6'780	
CO2 specific, natural gas	kg/Nm3	1.989	1.989	1.989
CO2 specific, mazout	kg/kg	3.117	3.117	
Operating time (for a. m. conditions)	h/a	1'350	1'340	8'300
Flue Gas & Stack Data				
Flue gas volume flow (dry @ 3% O2)	Nm3/h	179'035	111'934	
Flue gas volume flow (dry @ 15% O2)	Nm3/h			1'318'829
Flue gas volume flow (wet, act. O2)	Nm3/h	214'761	130'586	1'360'192
Flue gas temperature @ stack	°C	198	198	90
Flue gas volume flow (actual @ stack)	m3/h	370'522	225'297	1'808'607
Stack heigt	m	65	65	60
Stack flue diameter	m	4.56	4.56	5.68
Flue gas velocity (actual @stack)	m/s	6.30	3.83	19.83
Emission Data				
NOx (as NO2), dry @3% O2	mg/Nm3	461	461	
CO, dry @3% O2	mg/Nm3	98	98	
SO2, dry @3% O2	mg/Nm3	2'660	2'660	
PM, dry @3% O2	mg/Nm3	42	42	
NOx (as NO2), dry @15% O2	mg/Nm3			40
CO, dry @15% O2	mg/Nm3			20
SO2, dry @15% O2	mg/Nm3			0
PM, dry @15% O2	mg/Nm3			0
estim. NO2/(NO + NO2)	%	5	5	10
Emission Mass Flows:				
hourly				
NOx (as NO2)	kg/h	83	52	53
CO	kg/h	18	11	26
SO2	kg/h	476	298	0
PM	kg/h	8	5	0
annually				
NOx (as NO2)	t/a	181		438
CO	t/a	38		219
SO2	t/a	1'042		0
PM	t/a	16		0
CO2 Emission				
hourly	kg/h	43'989	27'495	87'501
annually	t/a	96'228		726'259

Table E-3: Emission Data DHP and new CCPP

The Table E-3 above summarizes all relevant operation, fuel and flue gas data on which the emission calculations and estimations are based as well as the results comprising the components NOx, CO, SO$_2$ and PM (particulate matter).

Besides the emission data of the new CCPP Skopje for comparison reason also the emission data of the existing district heat plant (DHP) have been compiled. These data are based on combustion calculations and on available operational data and measurements. The DHP data distinguish between the typical heating period winter and transition. The DHP uses oil (mazout,with 2.3 % S as average) and gas as fuels.

The calculations and estimations have been based on a ratio mazout/gas of 70% / 30% which represents the conditions of the last years.

For the CCPP Project Skopje emission standards of 75 mg/Nm^3 for NOx and 100 mg/Nm^3 for CO shall apply (see Section B). Because of the use of natural gas as exclusive fuel the emissions of SO_2 and particulates do not matter.

3.2.1.1 CO Emissions

CO emissions concentrations (see Table E-3) of the new CCPP, fired with natural gas will reach approx. 20 mg/Nm^3 (@ 15 % reference O_2) during normal full load operation. This value is well below the standard of 100 mg/Nm^3. This emission concentration corresponds to an hourly CO emission mass flow of 26 kg/h.

3.2.1.2 NOx Emissions

The gas turbine will be equipped with dry low NO_x combustors to achieve low NO_x emission level. An NOx emission concentration of 40 mg/Nm^3 (@ 15 % reference O_2) is expected during normal full load operation of the plant which is below the standard of 75 mg/Nm^3. The NOx emission mass flow amounts to 53 kg per hour.

3.2.1.3 Dust and SO_2 Emissions

CCPP Skopje will use natural gas as exclusive fuel. Insofar there are no particulate emissions and no SO_2 emissions.

3.2.1.4 Specific Emissions of CCPP Skopje

The specific emissions (related to produced MWh of electricity) of NOx and CO are shown in the following diagram. The diagram also includes the value for CO_2. As mentioned, particulates and SO_2 are not relevant for the CCPP Skopje.

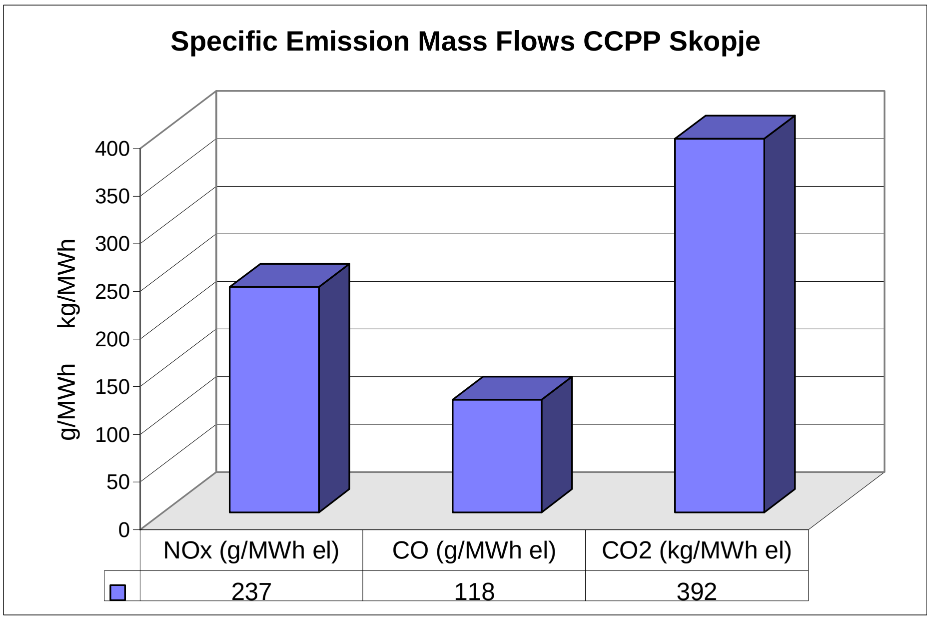


Figure E- 2: Specific Emissions

3.2.2 Comparison with Existing District Heating Plant

In this section, the emission data of the new CCPP Skopje shall be compared with the emission data of the existing district heating plant (DHP). The new CCPP will be in operation and produce electricity the whole year over. The extraction of heat will be in operation during the heating seasons whereby the same cases and times shall apply as for the existing DHP. The defined operation cases and their estimated time shares are compiled in the following table.

Operation Cases and Heat Cycle Calculations

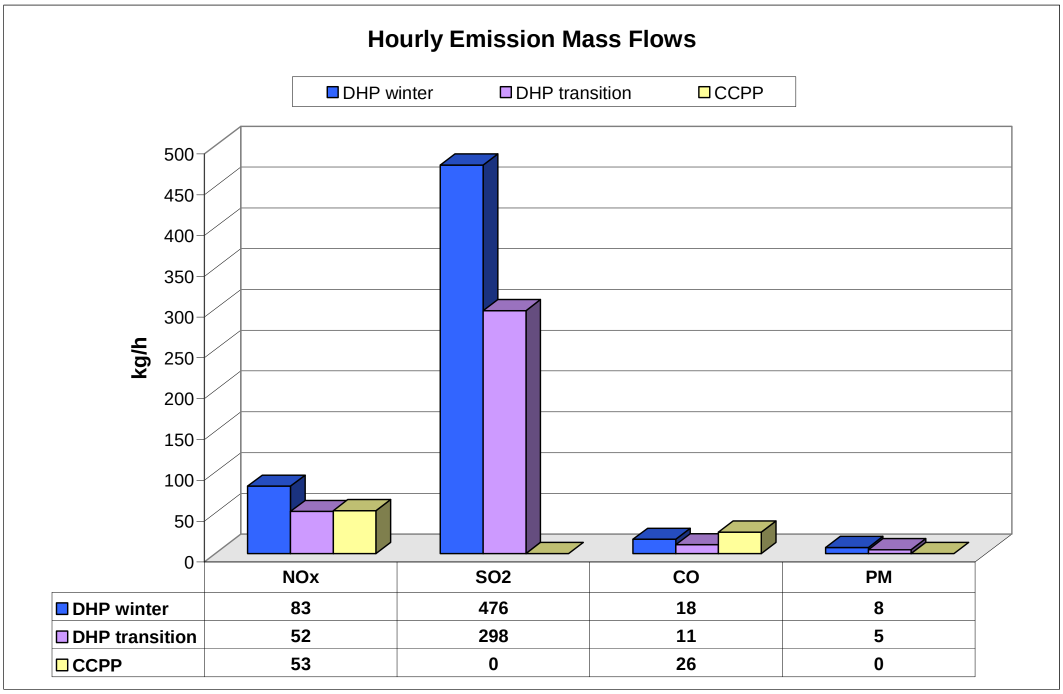
	Operation cases & Estimated time share				**Heat Calculation Results**			**Annual Consumption / Production**		
	Operation case	aver. T °C	share %	time h/a	gas heat input (MW)	el. power MWel	th. power MWth	gas	electricity MWh/a	heat
1	summer	25	40	3'320	422	217	0	1'402'368	720'440	0
2	transition (without heating)	15	28	2'291	440	229	0	1'007'723	524'593	0
3	transition *)	10	16	1'340	449	218	100	601'326	292'218	134'045
4	winter *)	2.5	16	1'349	462	231	160	622'853	311'561	215'800
	total / weighed average		**100**	**8300**	**438**	**223**	**42**	**3'634'270**	**1'848'813**	**349'845**

*) *heating shut down in the night (approx. 1/3 of a day) considered in the electr. power*

Table E-4: Operation Cases

The DHP emission data (see also Table E-3) distinguish between the typical heating periods winter and transition with heating. The DHP uses oil (mazout,with 2.3 % S as average) and gas as fuels. The calculations and estimations have been based on a ratio mazout/gas of 70% / 30% which represents the conditions of the last years.

The hourly emission values of the new CCPP in comparison to the existing DHP are compiled in the following Figure E-3.



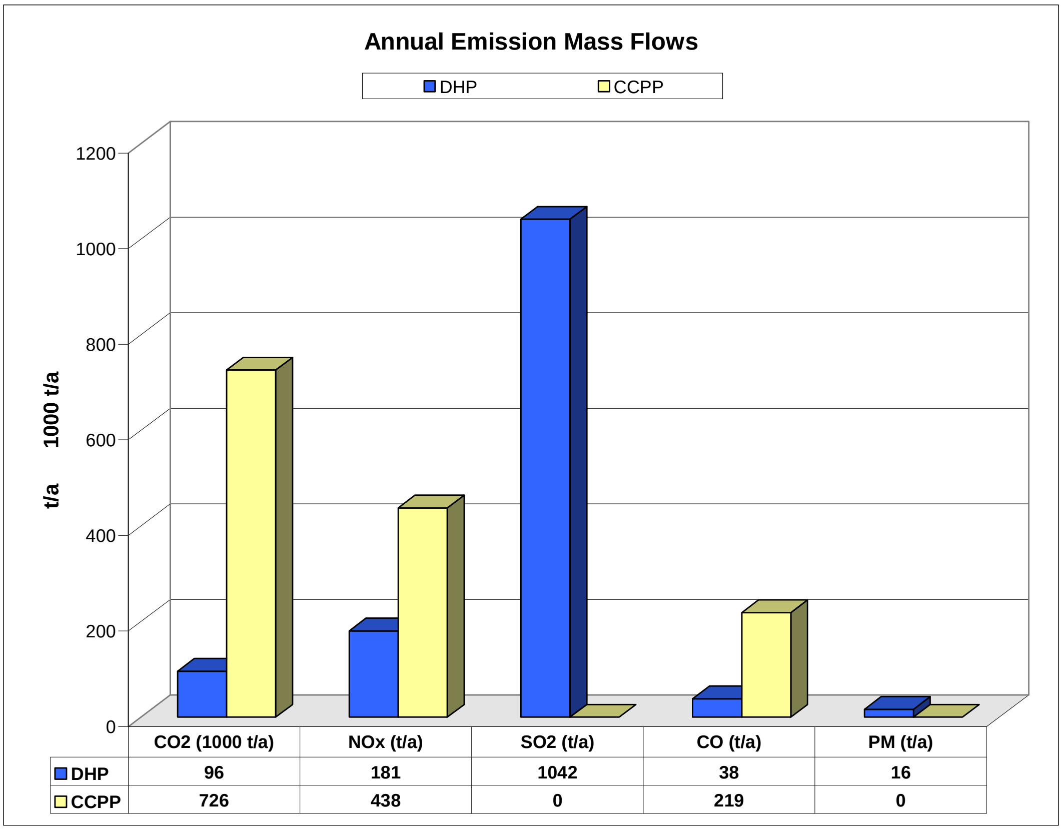
	NOx	SO2	CO	PM
🟦 **DHP winter**	83	476	18	8
🟪 **DHP transition**	52	298	11	5
🟨 **CCPP**	53	0	26	0

Figure E-3: Comparison Hourly Emissions

The hourly NOx and CO emission mass flows of existing DHP and new CCPP are of a comparable order of magnitude, but the SO_2 and particulate emissions will drop down to zero with the new CCPP in operation.

The following diagram shows the comparison of the annual emission mass flows. Due to the CCPP operation over the whole year compared to the short heating period of the DHP the annual emissions of CO_2, NOx and CO are higher for the combined cycle plant; SO_2 and PM are higher for the district heating plant.

But in this context it has to be considered that the existing DHP only produces heat during heating seasons. The new CCPP however will produce as main product electricity (and additional heat during heating seasons). As a consequence the electricity which will be produced by the new CCPP leads to corresponding emission savings elsewhere. This aspect will be treated in the following section.



	CO2 (1000 t/a)	NOx (t/a)	SO2 (t/a)	CO (t/a)	PM (t/a)
🟦 DHP	96	181	1042	38	16
🟨 CCPP	726	438	0	219	0

Figure E-4: Comparison of Annual Emissions

3.2.3 Savings to be Considered

In the following, the total emission saving potential is estimated when comparing the operation of the new CCPP (electricity and heat production) with the operation of the existing DHP (only heat production) and a lignite-fired or oil-fired power plant (only electricity production) elsewhere.

As fuels for these comparisons, a typical fuel oil and a lignite have been taken. The major part of the electricity in Macedonia is produced in lignite-fired boilers (approx. 70%; see Section B 1.1). In both cases lignite as well as fuel oil, the SO_2 emissions have been assumed as in cases with a flue gas desulphurization plant installed.

The data on which the estimation is based are summarized in the following table.

Comparison of Power Plant Alternatives

Comparison of CCPP Skopje's Emissions with Oil- and Lignite-fired Power Plants of the same Electricity Production

		gas-fired CCPP Skopje	oil-fired Power Plant	lignite-fired Power Plant
Specific CO2	kg/Nm3 resp. kg/kg	1.99	3.12	1.05
LHV	MJ/Nm3 resp. MJ/kg	36.0	42.0	9
Power production efficiency		51%	39%	38%
Electrical output (average)	MW	223	223	223
Needed fuel heat input	MW	438	572	587
Annual operation	h/a	8'300	8'300	8'300
Annual power production	MWh/a	1'850'900	1'850'900	1'850'900
Specific emissions				
CO2	kg/MWh	392	686	1'100
NOx	kg/MWh	0.24	1.07	1.85
SO2	kg/MWh	0	1.07	1.64
Emissions hourly				
CO2	kg/h	87'501	152'978	245'300
NOx	kg/h	53	239	413
SO2	kg/h	0	239	366
Emissions annual				
CO2	t/a	726'259	1'269'717	2'035'990
NOx	t/a	440	1'980	3'424
SO2	t/a	0	1'980	3'035
Remarks:		heat production DHP shut down	no heat prod. DHP in operation	no heat prod. DHP in operation

Assumptions lignite-fired PP:
SO2 emission = 400mg/Nm3, i. e. with FGD @ 6% O2
NOx emission = 450mg/Nm3 @ 6% O2
Assumptions oil-fired PP:
SO2 emission = 400mg/Nm3, i. e. with FGD @ 3% O2
NOx emission = 400mg/Nm3 @ 3% O2

Table E-5: Data for Comparison of Power Plant Alternatives

The calculated savings are compiled in the Table E-6 below. The following Figure E-5 illustrates the possible emission savings due to the operation of the new CCPP instead the existing DHP and power production elsewhere in lignite- or oil-fired power unit.

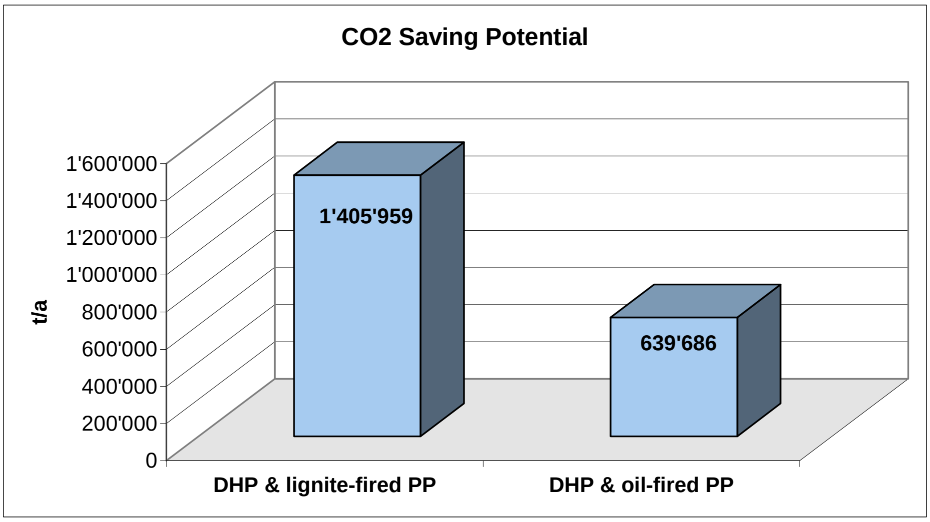
Comparison of Existing and New Situation

Existing: Heat production in existing DHP and electricity production in lignite- or oil-fired power plant elsewhere

New: Heat production and electricity production in new CCPP Skopje

		gas-fired CCPP Skopje	oil-fired Power Plant	lignite-fired Power Plant
1. Annual Emissions				
CCPP or PP respectively				
CO2	t/a	726'259	1'269'717	2'035'990
NOx	t/a	440	1'980	3'424
SO2	t/a	0	1'980	3'035
2. Annual Emission of DHP				
CO2	t/a		96'228	
NOx	t/a		181	
SO2	t/a		1'042	
3. Annual Emission total (DHP + PP)				
CO2	t/a	726'259	1'365'945	2'132'218
NOx	t/a	440	2'161	3'605
SO2	t/a	0	3'022	4'077
4. Potential Savings				
CO2	t/a		639'686	1'405'959
NOx	t/a		1'722	3'165
SO2	t/a		3'022	4'077

Table E-6: Calculation of Potential Savings



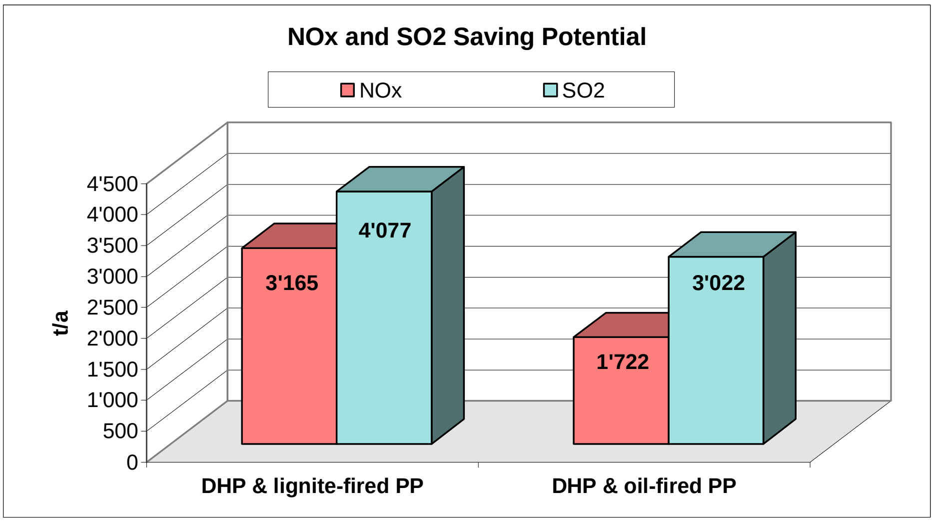


Figure E-5: Estimated Emission Savings

As mentioned in the previous section, from the local point of view the annual CO_2 and NOx emissions will be higher, but looking on the overall situation, i. e. considering also the electricity production, a substantial CO_2, SO_2 and NOx emission saving potential will be reached with the new CCPP in operation. Based on a lignite/oil ratio of 70%/30% in the Macedonian power production, saving potentials of approx. 1.2 mio t/a CO_2, 2700 t/a NOx and 3800 t/a SO_2 are estimated.

3.2.4 Dispersion Calculations

3.2.4.1 Description of available Data

Topographical data

The wind and diffusion field is influenced by the topography of the area. Skopje valley is a depression area with a length of about 30 km which is surrounded by mountains.

In the north–eastern part of Skopje valley, about 9 km off the site, the mountain Skopska Crna Gora is situated, with summits over 1500 m heights. Opposite of this mountain massif, in the south-western part of the valley, the mountain Karsijak is located with summits up to 1050 m height. Between these mountain massifs, the terrain is nearly flat with some isolated hillocks. Topographical data or land use data in digital data format were not available. The elevation heights necessary for the calculations were taken from GlobDEM50. This is a digital elevation model (DEM), providing elevation heights on a global 50 m grid in several co-ordinate systems and map projections. The data are based on the Shuttle Radar Topography Mission (SRTM) data, which were collected in a joint project of the NASA, NIMA, DLR and ASI in February 2000. SRMT-3 raw data have been processed and revised for the GlobDEM50 DHM. A typical value for the roughness length, which is the characteristic scale for land use, was assessed from aerial photographs.

Emission data

Based on combustion calculations, on available operational data and measurements, the emission concentrations and emission rates of the new CCPP and of the existing district heat plant (DHP) were calculated. The emissions of the DHP were compiled for comparison reasons. All relevant operation, fuel and flue gas data for the emission calculations and estimations for the DHP and the new CCPP are summarized in Table E-3 (see chapter 3.2.1).

The DHP data distinguish between the typical heating periods, winter and transition. The DHP is not in operation during summer. Because of reduced flue gas volume flow during transition time, the emission mass flow for all four components as well as the momentum flux is lower as compared to the winter time. Compared to the buoyancy flux as a result of the high flue gas temperature, the momentum flux plays a minor role for the waste gas plume dispersion. Consequently the winter operation represents the conservative case with regard to air pollution concentrations for identical meteorological conditions.

The new CCPP will be in operation the whole year through.

Relevant pollutant components are NO_x, CO, SO_2 and PM10 for the DHP and NO_x and CO for the CCPP. Particulates and SO_2 are not relevant for the new CCPP Skopje.

Meteorological data

A description of the relation between emission and air pollution needs information on the horizontal and vertical dispersion conditions in the atmosphere. These conditions depend on meteorological parameters. In addition to wind, these parameters include factors influencing turbulence (such as solar radiation, cloud cover, stability of atmospheric layers). Wind has a substantial effect on the dispersion and transport of gases and particles, on their dwell time, their mixing, and changes in their concentrations. Reliable meteorological data are the basic requirement for dispersion calculations. Wind speed, wind direction and turbulence parameters should therefore be measured continuously with a high resolution and as near as possible to the site under investigation.

The nearest meteorological stations in Skopje, where data have been measured for more than 40 years, are Petrovec in the east and Zajcev Rid in the northwest from

Skopje. Both stations are official measuring locations of the Republic Hydrometeorological Institute (RHI). Readings were taken discontinuously. The measurements at both these stations show the following main meteorological characteristics:

- the meteorological parameters wind velocity and wind direction are strongly influenced by the Skopje valley; wind blows mostly along the valley. Therefore, the wind directions with highest frequencies are west to northwest and east to southeast;
- wind velocities are low. The mean wind velocity over longer periods rarely exceeds 2 m/s related to 10 m height;
- there is a high frequency of very low wind velocities or situations with no wind near the ground,
- during winter, the frequency of ground based temperature inversions is high; this is the reason for high pollutant concentrations during winter;
- during summer months, so-called lifted inversions occur frequently; these situations are characterised by thermal induced turbulence in the ground-based mixing layer with low to medium mean wind velocities. A capping inversion prevents air exchange with air masses above.

As mentioned, the meteorological long term measurements were not done continuously.

Since April 1998, four measuring stations have been installed at different locations in Skopje, equipped with automatic and continuous analyzers for pollutants and some meteorological parameters, among others wind direction and wind velocities (see Section D, Table D-7 and Figure D-8). The location of the heating plant and the new CCPP respectively is middle between three of the four stations. Thus, the wind conditions at these three stations are representative for the site. In consideration of the high occurrence frequency of low velocities these stations are equipped with ultrasonic measuring transducers.

For the dispersion calculations neither the discontinuously measured wind data of the RHI nor the continuously measured wind data at the four stations were available. Thus, the meteorological data needed for the dispersion calculations were re-analysed from the data listed in the following (Study on Air Pollution Monitoring System in the former Yugoslav Republic of Macedonia, Interim report (2); Environmental Analysis of CHP Project):

- wind rose for the non heating and the heating season period and the annual wind rose for all dispersion categories, based on long term discontinuous measured values
- wind roses for the heating and non heating seasons measured from 1998 to 1999 at the four city-stations in Skopje for air quality monitoring
- relationship between wind speed classes, dispersion categories (overall 7 categories) and solar radiation (day time) respectively cloud cover, given in tenth (night time);

- frequency of each dispersion category during day and night in the heating season, the non heating season and for the year.

The data were processed in the following way:

- for the 5 velocity classes given in the wind statistics the Weibull-parameters were determined;

- the velocity classes given in the measured wind statistics were transformed to 9 TI Air classes with the Weibull-parameters for measured wind statistics;

- 16 wind direction classes of measured wind statistics were transformed in 36 classes with 10°sectors, according to TI Air;

- the given 7 dispersion categories were transformed to usual 6 dispersion categories (according to Klug-Manier);

- assignment of given relationships between wind speed classes, dispersion categories and solar radiation respectively cloud cover to the dispersion categories of Klug-Manier and wind velocity classes according to VDI guidance 3782, Part 1;

- transformation of the 2-dimensional-wind statistics to 3-dimensional-stability class frequency distributions for the heating season and the year.

The stability class frequency distribution enables to estimate mean annual values of additional air pollution caused by a defined emission source. Calculations of mean annual values have been executed with the new CCPP Skopje and for comparison reason also with the existing DHP as emission source. Additionally, momentary values (1-h-values) for SO_2 and NO_2 with a certain upper deviation frequency, according to the European Air Quality Standard, can be estimated.

3.2.4.2 Estimation of Air Pollution caused by the existing DHP (winter) and the planned new CCPP.

The numerical calculation of trace species dispersion has been carried out using a Lagrangian particle model. This model is in compliance with the new German Guidance TI Air. The model calculations deal with the major pollutants sulphur dioxide (SO_2), oxides of nitrogen (NO_x), particulates (PM) and carbon monoxide emitted from the stacks of the existing DHP and the new CCPP Skopje.

Description of the numerical model

The Lagrangian particle model differs fundamentally from the majority of the established numerical modelling techniques which are founded on the computed solution of the advection-diffusion equation. This model tracks point-like particles representing a trace species on their path through the atmosphere. The particles travel with the mean wind and are additionally subjected to the influence of turbulence. The effect of the turbulence is modelled by adding an additional random velocity to the mean motion for the particle. This random velocity, which is derived from a Markov process, is a function of the turbulence intensity and is different for each particle. The concentration distribution is determined by counting the particles in given sampling volumes and expressed as mean values over the volume and time intervals. The main advantages of the Lagrangian particle model are that the model concept largely reflects the natural phenomena involved in turbulent diffusion. It can be applied to any source geometry desired for any temporal behaviour of a spatially variable source. Required meteorological input information includes the fields of the mean wind components, the wind fluctuations and the diffusion coefficients which can be generated by meteorological pre-processors. The wind fields taking into account the topography and land use data of the investigation area were calculated with a so-called diagnostic wind field model. For time-dependent calculations, these input parameters must be made available as a time series of fields. Furthermore, emission data will be required. The model output is a time sequence of the spatial distribution of the concentration of the emitted species and its transformation products. Based on the calculated time sequences mean values and momentary values for different time periods can be calculated for the comparison with standards for the ambient air quality.

Model options for the calculations

The following options have been used for the calculations:

- The calculations have been done for a terrain (study area) of 8 x 8 km² with a resolution of 50 m; centre of the calculation area is the stack of the new CCPP.
- The Monin-Obukhov-Length (M-O-Length) describes the atmospheric stability. This parameter is derived from the stability classes defined in the 3-d-statistics. For unstable situations (corresponding to stability classes IV and V according to Klug / Manier-classification) the mixing length was fixed to 1100 m height; for stable and neutral situations, the mixing depths were calculated as function of the shear velocity of the wind profile and the Coriolis parameter.
- The mean wind field was calculated by a diagnostic wind field model; the variation of the velocity fluctuations and the diffusivity tensor are generated by a meteorological pre-processor as a function of the thermal stability of the atmosphere, the representative surface roughness as well as the wind velocity and the wind direction at the measurement site.
- The plume rise formulas are based on equations developed by Briggs for the temporal behaviour of the plume centreline in neutral stratification conditions and the maximum height of the plume centreline in stable stratification conditions, and have been generalised using an interpolation algorithm.
- It is assumed that the pollutants do not undergo any physico-chemical transformation.
- For the purpose of a worst-case-estimation it is assumed for the calculation of air pollution concentration that there is no pollutant removal by dry deposition.

Estimated cases

As mentioned, the dispersion calculations were done for the existing DHP, operation time between October 1st and April 30th , for the emissions of winter time, and for the new CCPP, operation time over year, constant emission values. The emission values for both szenarios and the required flue gas and stack data are summarized in Table E-3. The DHP dispersion calculations were done with the 3-dimensional-stability class frequency distributions for the heating season. Because of the poor meteorological data base it was not possible to produce a 3-D-statistics for the transition time.

3.2.4.3 Results

The dispersion calculations were done for the input data summarised before. The following parameters were calculated:

- mean annual ground level concentrations in [µg/m³] for SO_2, NO_2, CO and PM10 for the existing district heat plant (DHP) in winter
- mean annual ground level concentrations in [µg/m³] for NO_2 and CO for the new CCPP
- momentary values (1-h-values) for SO_2 and NO_2 with a certain upper deviation frequency, according to the European Air Quality Standard.

Reliable mean 24 h values cannot be calculated on the base of a 3-d-wind statistics.

Ground-level concentrations

The maximum mean annual values and momentary values near the ground (GLC) within the study area are given in Table E- 7 for SO_2, NO_2, PM and CO. Beside the concentration values, the locations, where these values appear, are also given in this table. The positive x-axis is directed to the east, the positive y-axis to the north. The x and y-values refer to the stacks of the DHP and the new CCPP Skopje. The values given are the additional concentrations caused by the DHP resp. CCPP without any ground level concentration, caused by other sources in the study area. Typical mean values for the background concentrations are measured at four automatic ambient air quality monitoring stations. These data are summarized in Section D, Chapter 2.4. The results of dispersion calculations are graphically presented in Figure E- 6 to Figure E-13 at the end of this section.

For all estimated components, the additional mean annual values of GLC without typical background concentration are depicted (Figure E- 6 to Figure E- 11). Additionally Figure E- 12 and Figure E-13 show the differences between the mean annual values of NO_2 and CO between the existing DHP and the new CCPP Skopje.

The estimated values are compared to the European Ambient Air Quality Standards, given in Table E- 7.

European Standards

European ambient Air Quality Standard	Mean annual average	average	Remark
		1 h	
SO_2 [µg/m³]	20[1]	350[2]	effective as from 2005/01/01
NO_2 [µg/m³]	40	200[3]	effective as from 2010/01/01
PM [µg/m³]	40		effective as from 2005/01/01
CO [µg/m³]			

[1] protection for biological environment
[2] not to be exceeded for more than 24 times
[3] not to be exceeded for more than 24 times

Table E- 7: European Ambient Air Quality Standards

Figure E- 1 to Figure E-4show for all pollutants of the DHP the first maximum of GLC's in the east, the second maximum in WNW. As was to be expected this corresponds strongly to the dominant wind directions. The maximum mean annual value for SO_2 comes to 3.7 µg/m³ in a distance of about 1,5 km E of the DHP. The contribution of the DHP to the overall SO_2-load amounts to about 20% of the standard value of the European Standards for the protection of biological environment.

The highest mean annual values caused by the DHP for NO_2, PM10 and CO are 0,1 µg/m³, 0,06 µg/m³ and 0,13 µg/m³, estimated 1,5 km east of the plant for PM10 and CO and 2,6 km east of the plant for NO_2. The values for NO_2 and PM10 amounts to less than 0,.25 resp. 0,15% of the limit values given in Table E- 7. The European Standards give no limit value for the mean annual CO-value. An indication can serve the Macedonian Standards with a limit value of 1 mg/m³ for the mean daily average. The estimated mean annual value for CO is extremely low compared to the mentioned limit value.

The European Standards for ambient air quality give 1-h-limit values for SO_2 and NO_2 with a certain exceeding frequency. The estimated 1-h-values which keep these exceeding frequencies are listed in Table E- 8**;** the concentrations clearly remain under the limit values (350 µg/m³ for SO_2 / 200 µg/m³ for NO_2).

Figure E- 10 to Figure E- 11 show the results of dispersion calculations for the new CCPP Skopje. As for the DHP the first maximum of GLC's occurs in the east, the second maximum in WNW. The maximum mean annual value for NO_2 and CO come to 0.8 µg/m³ in a distance of about 3.8 km E resp. 0,13 µg/m³ in a distance of about 2.2 km E of the CCPP. The contribution of the CCPP to the overall NO_2-load amounts to about 0.2% of the standard value of the European Standards. As for the DHP the maximum mean annual load of CO is negligible.

Comparing the calculation results for the DHP and the CCPP (NO_2 and CO) it can be noticed, that the point with maximum mean annual concentration is more distant for the CCPP. This is due to the much higher flue gas volume flow which results in a more rising plume for the CCPP compared to the DHP. It is further noticeable that the estimated concentration values for NO_2 and CO have the same order of magnitude though the annual emission mass flows for the CCPP are much higher. Reasons for that are the mentioned better exhaust conditions on the one hand and the fact, that the meteorological conditions during summer are much favourable for the dispersion on the other hand. The latter results in a low amount to the GLC's during summer compared to wintertime.

In Figure E- 12 and Figure E-13 the differences in mean annual values between DHP and CCPP are shown for NO_2 (E-12) and CO (E-13). In areas with positive values the concentrations of the CCPP are higher than the concentrations of the DHP and vive versa. For NO_2, the calculated mean annual values for the CCPP are lower within the investigation area. For CO, the mean annual values are partly a little bit higher for the CCPP in greater distances east resp. south-east of the plant.

It should be kept in mind that the result of the dispersion calculation is always associated with a certain degree of uncertainty, because of the statistical character of the calculation procedure. The degree of uncertainty for the mean annual values amounts to ± 5 % at the most.

Summarizing Results and Conclusions

Generally, the ambient air quality in Skopje is worse in the high winter months compared to the summer months for all relevant pollutants. This is mainly due to the strong increase in the use of fossil fuels by industry, heating plants and private sector on the one hand and the adverse meteorological conditions with bad dispersion conditions on the other hand.

The analysis of ambient air quality (see **chapter 2.4**) has shown that in the high winter months during heating season a sporadic exceeding of the limit momentary values (1/2 and 1-h values) and the 1-d-limit value for SO_2 can not be excluded. At the automatic measurement stations mean values of 30 to 45 µg/m³ are measured during winter months. Assuming an operation time period of 6 months for the DHP the calculated mean annual SO_2-value comes to about 6,3 µg/m³ corresponding to this time period. With the new CCPP in operation, this contribution from the DHP drops down to zero.

As for PM10, the contribution from the DHP also vanishes. Compared to SO_2, the additional PM10-load caused by the DHP amounts only 0,1 µg/m³ in the mean during the operation time. This shows that other sources, e.g. as traffic and industrial firing are responsible for the high measured PM10-concentrations in winter time.

Despite the increased annual NO_x emission flows (due to much higher operation time of CCPP compared to DHP) no higher NO_2 air pollution concentrations have to be expected within the investigation area with the new CCPP.

Existing DHP	**Mean GL Concentration**				**Momentary values (1-h-values)**			
	Maximum µg/m³	X m	Y m	D m	Maximum µg/m³	X m	Y m	D m
SO_2	3,7	1460	-100	1465	90,0[1]	1960	-100	1965
NO_2	0,1	2620	-200	2630	5,0[2]	-3340	3350	4730
PM10	0.06	1460	-130	1465				
CO	0,13	1460	-130	1465				

New CCPP Skopje	**Mean GL Concentration**				**Momentary values (1-h-values)**			
	Maximum µg/m³	X m	Y m	D m	Maximum µg/m³	X m	Y m	D m
NO_2	0,08	3840	-380	3860	5,3[1]	3690	-3280	4940
CO	0,13	1440	-1680	2210				

[1] 1-h-value not to be exceeded for more than 24 times

D = distance from source

[2] 1-h-value not to be exceeded for more than 18 times

Table E- 8: Estimated GLC for the existing DHP and the new CCPP Skopje

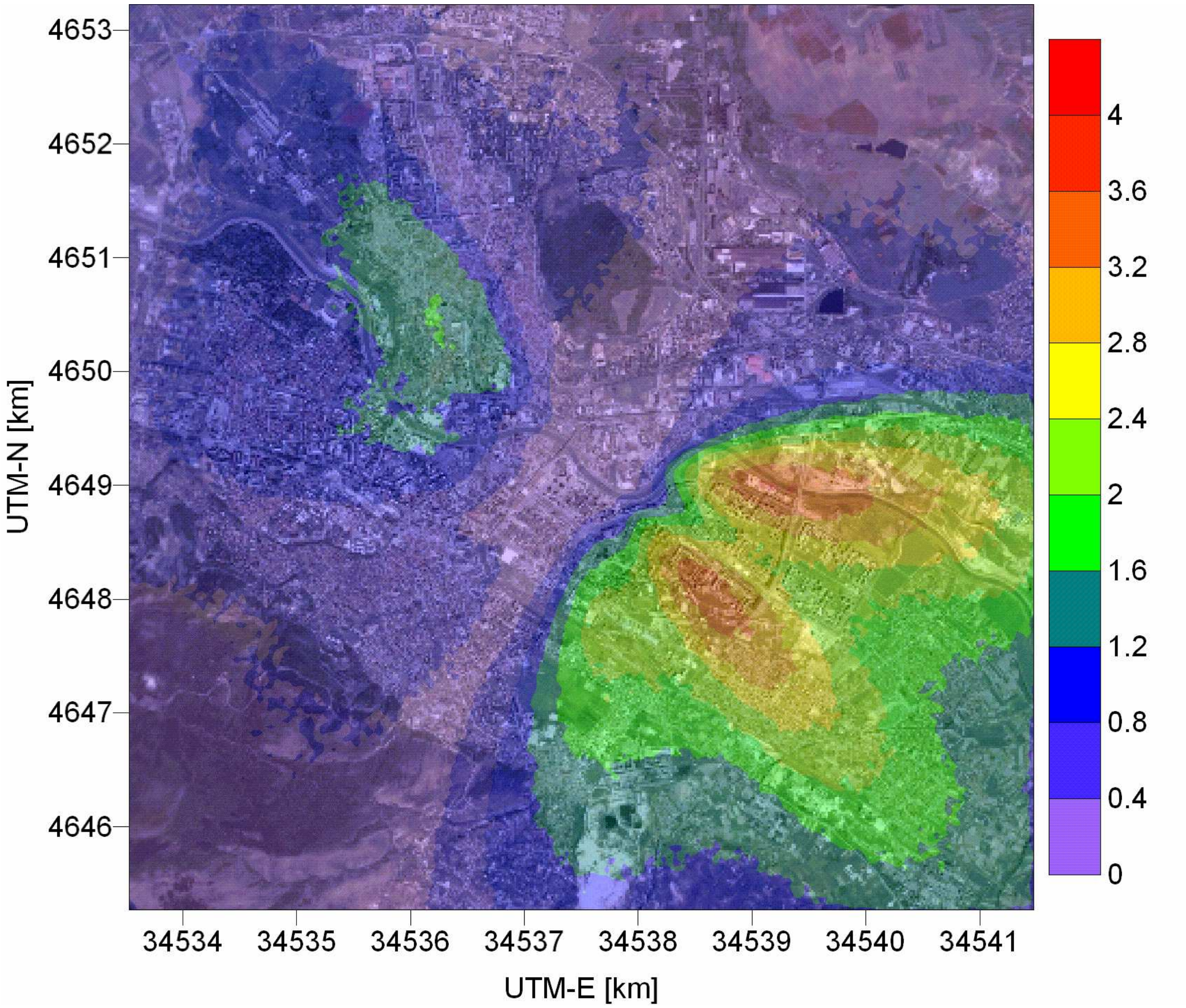


Figure E- 6: Mean annual GLC of SO_2 [µg/m³] for the existing DHP

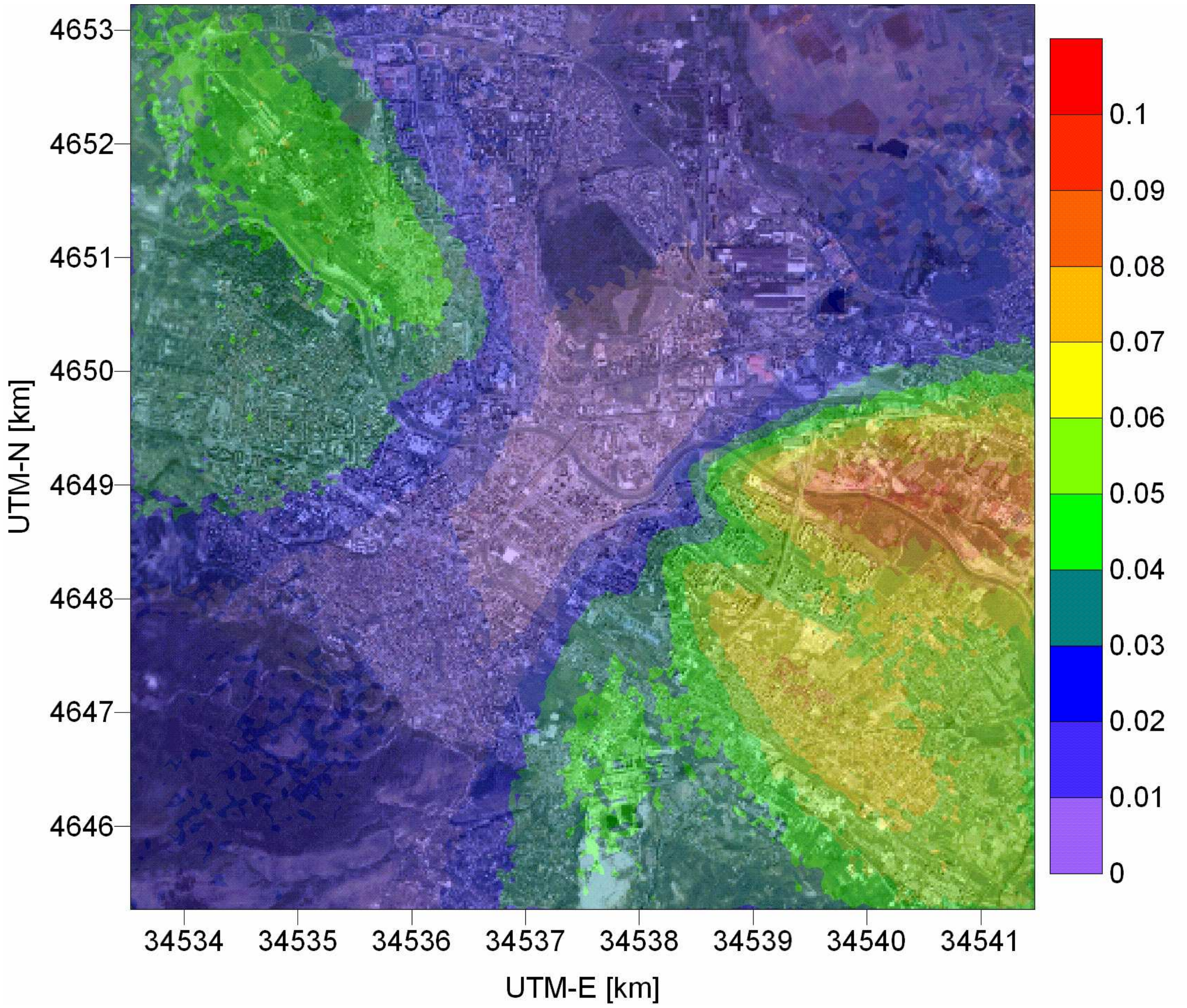


Figure E- 7: Mean annual GLC of NO_2 [µg/m³] for the existing DHP

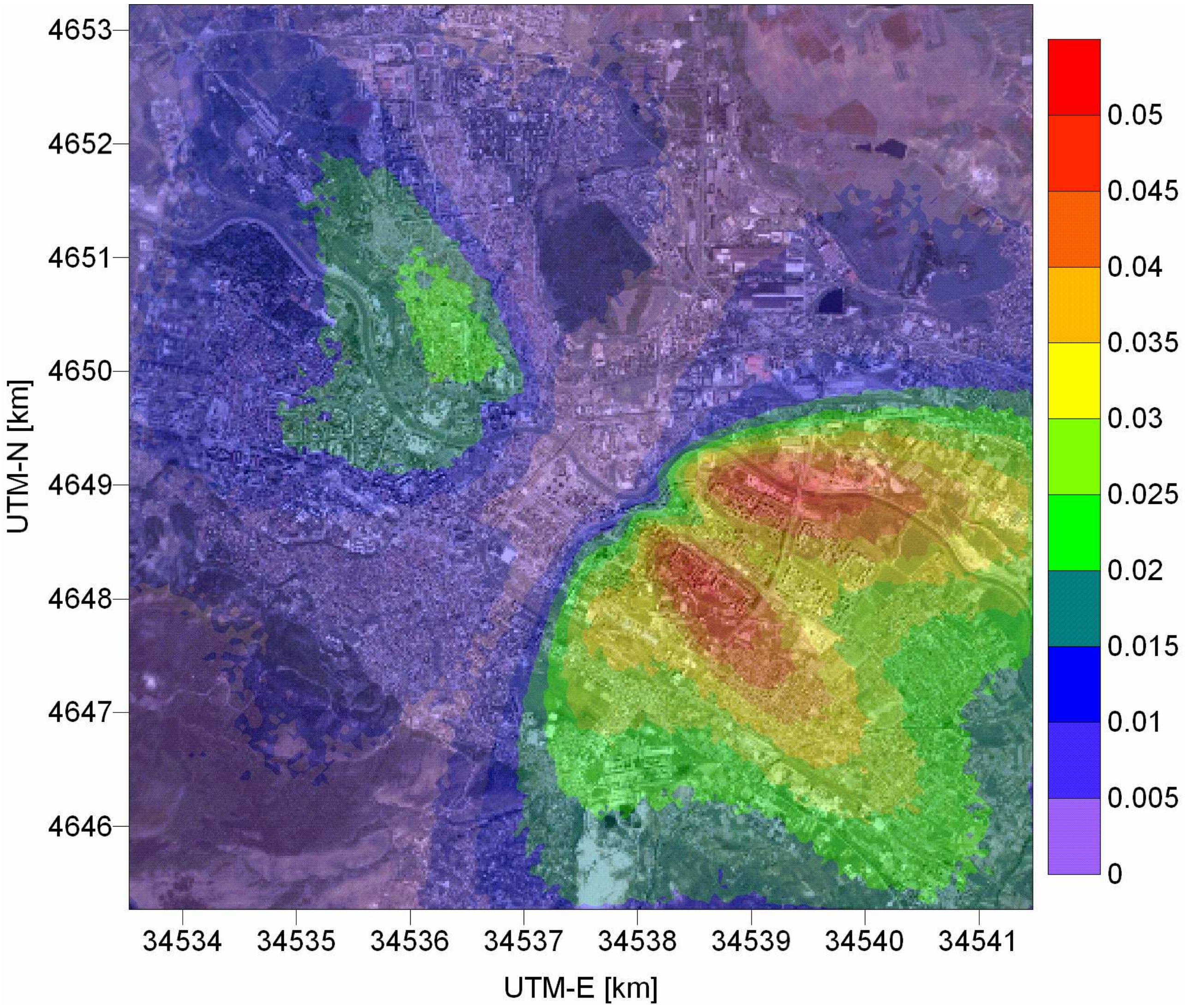


Figure E- 8: Mean annual GLC of PM [µg/m³] for the existing DHP

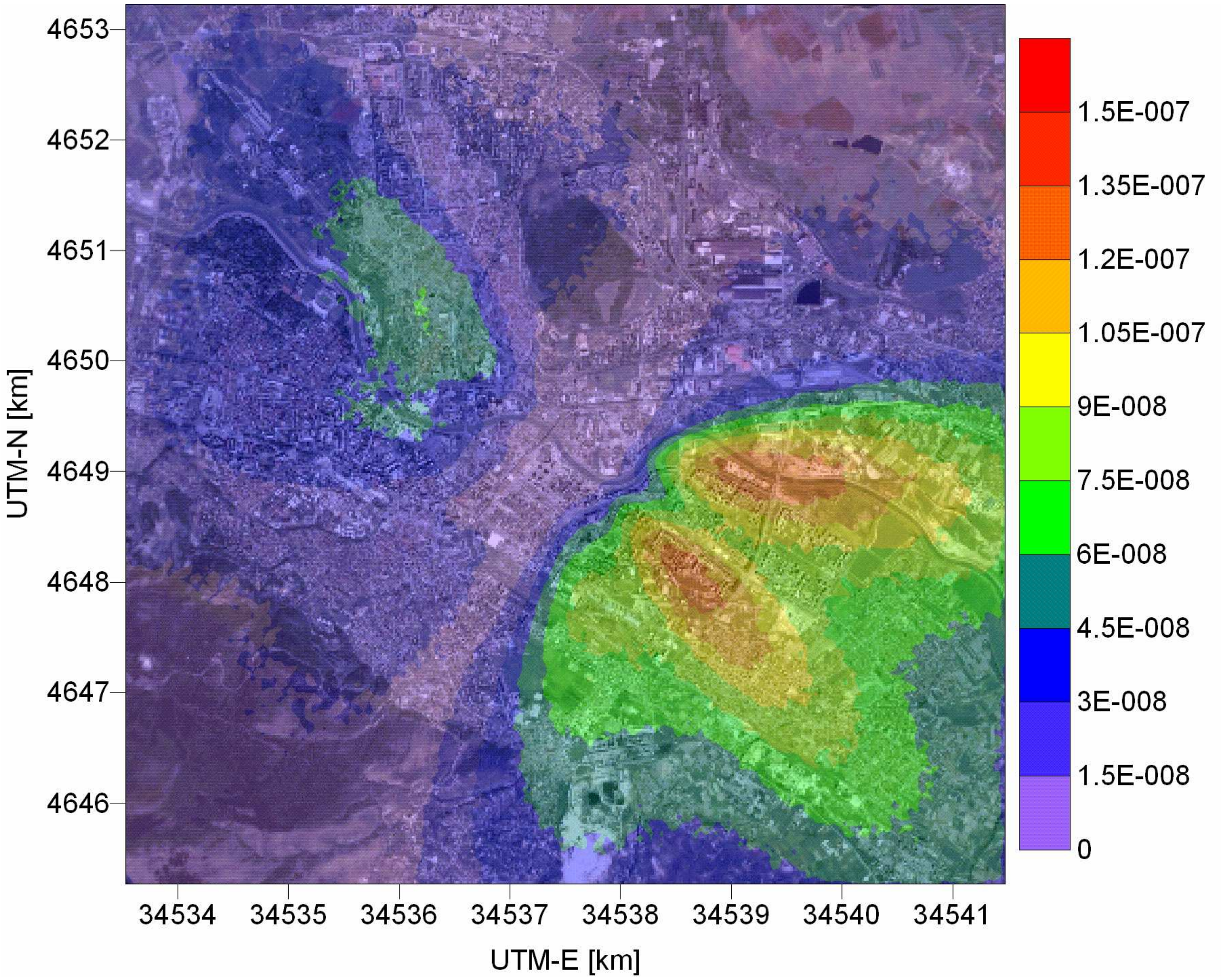


Figure E-9: Mean annual GLC of CO [g/m³] for the existing DHP

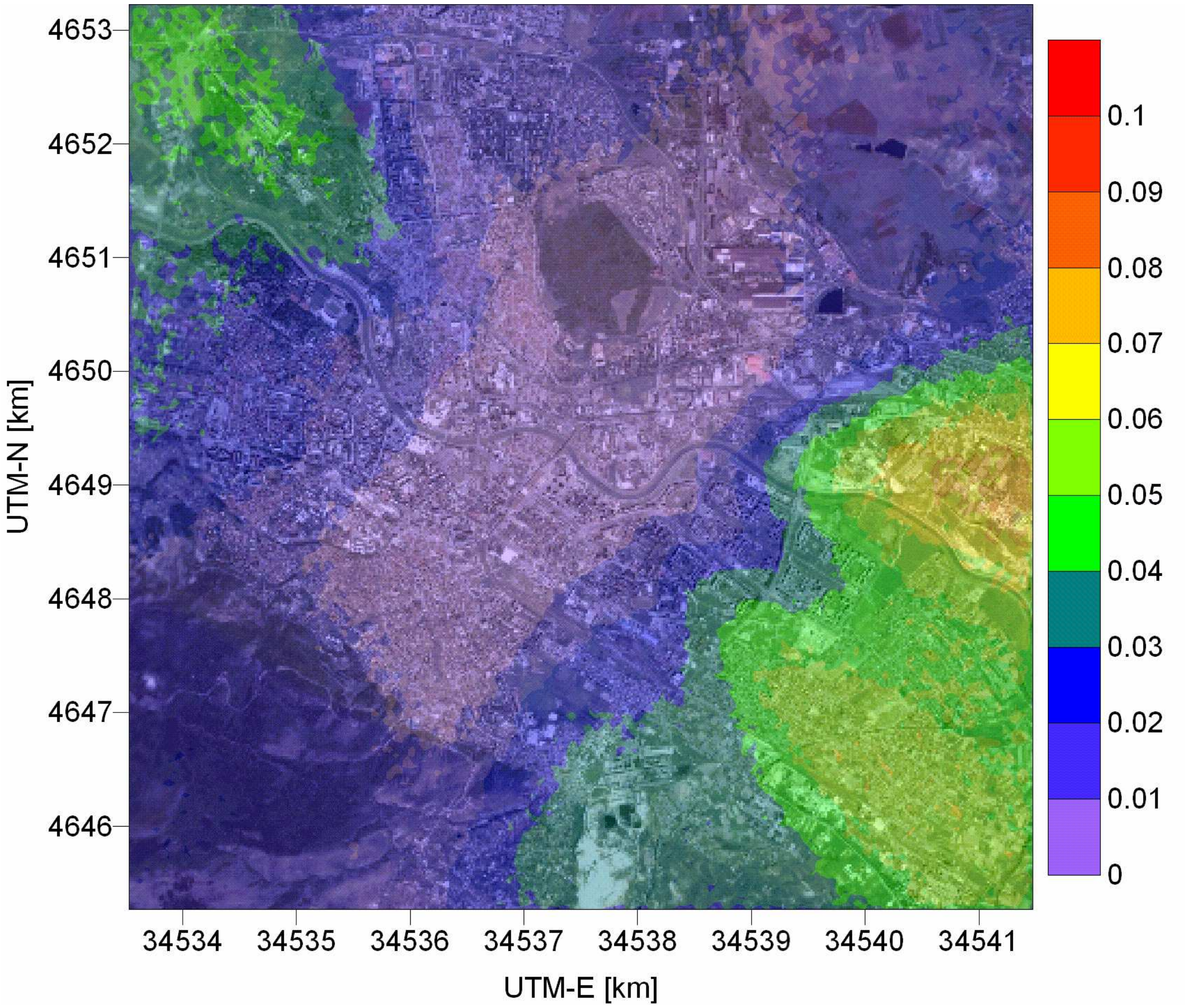


Figure E- 10: Mean annual GLC of NO_2 [µg/m³] for the new CCPP Skopje

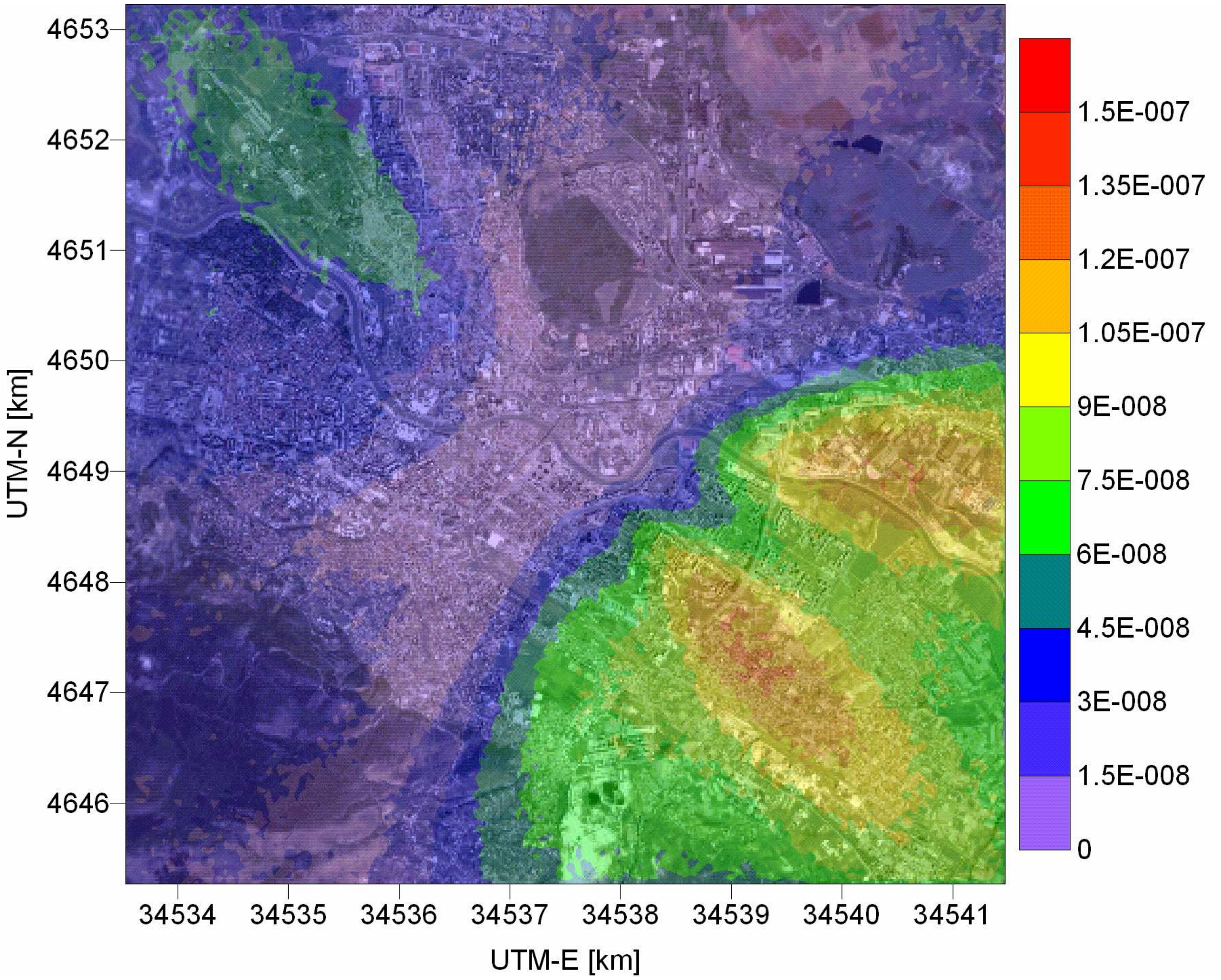


Figure E- 11: Mean annual GLC of CO [g/m³] for the new CCPP Skopje

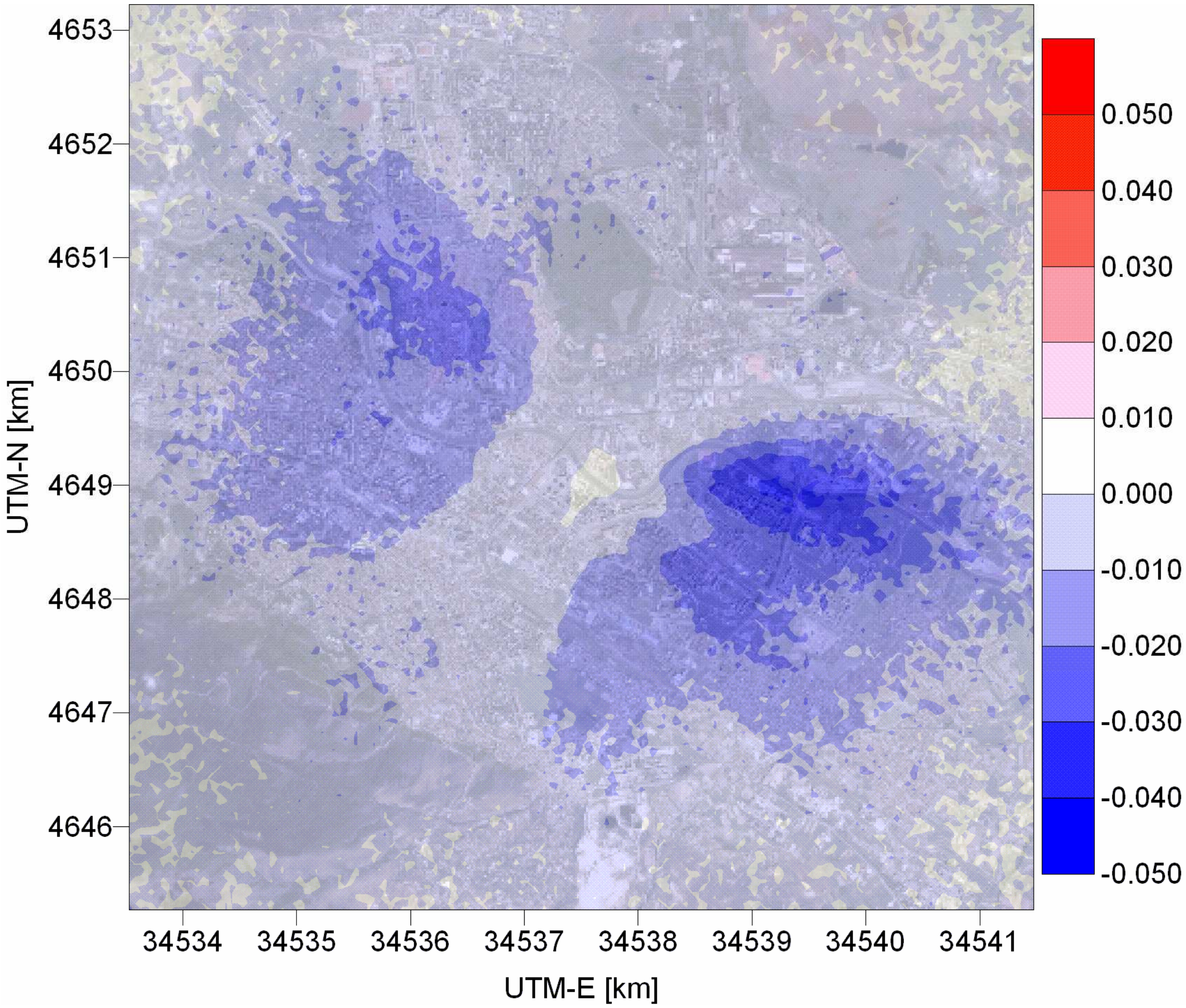


Figure E- 12: Differences of mean annual NO_2-GLC [µg/m³] between existing DHP and new CCPP Skopje

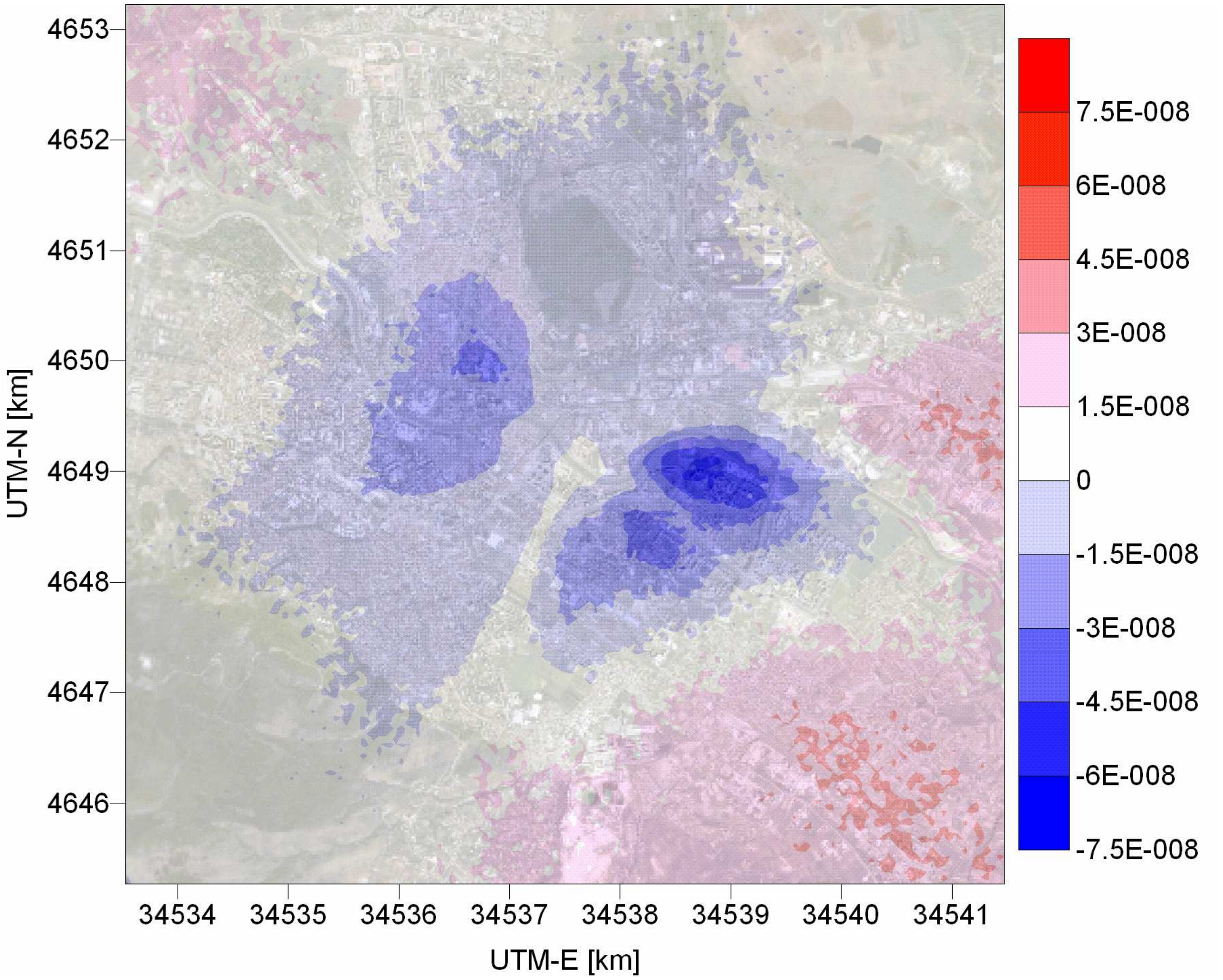


Figure E-13: Differences of mean annual CO-GLC [g/m³] between existing DHP and new CCPP Skopje

3.3 Noise Impact during Plant Operation

The operation of any power plant creates noise. The character and loudness of this noise, the times of day or night during which noise is produced, the proximity of the facility to any sensitive receptor, the existing background situation and the comparison to applicable noise standards are important factors to determine the noise impact resulting from the Project. In general, noise can have a negative impact on human health and well-being.

3.3.1 Noise sources and receptors

The primary noise sources associated with the facility operation are the combustion turbines, heat recovery steam generators, steam turbines and pumps. During its operating, the plant will essentially represent a steady, continuous noise source during day-time and night-time. Occasional short-term increases in the noise level will occur when steam relief valves open to vent pressure, or during start-up or shut-down phases, when the plant transitions to and from steady–state operation. The rest of the time, e.g. when the plant is shut down for maintenance, noise levels of the plant will decrease.

The sensitive noise receptors likely to be affected by the Project are the workers in the plant and a number of residences located to the southwest, the south (approximately 300 m distance), and to the southeast (more than 600 m distance) of the site.

3.3.2 Background situation

Toplifikacija performed a noise survey in the vicinity of the plant site during a time period when HPP “East” was also operating to determine the existing background situation. The results of this survey are presented in Section D, Chapter 2.5. The results show that there is already a high noise burden in the investigated residential and industrial areas exceeding the relevant national limit values (MPLN). This burden is mostly generated by traffic. The existing HPP “East” has only a low proportion concerning the total noise level in the vicinity of the plant site.

3.3.3 Noise impact of CCPP

The noise generated from the primary noise sources can be readily controlled through the application of appropriate acoustic mitigation equipment. According to the main technical data (see Section C, Chapter 4), the future plant will cause noise levels of not more than 60 dB(A) at the south and west fence, and 70 dB(A) at the north and east fence of the site. With 70 dB(A) the national standards (MPLN) for industrial areas (day-time and night-time) given in Section B, Chapter 2.4 are not exceeded in direction to the adjoining industrial area. In direction to the residential areas the corresponding standards are clearly met. This applies to the future plant without regarding the already present noise burden due to traffic. According to the results of the noise survey, that was performed when HPP “East” was operating (see Section D, Chapter 2.5), it can be assumed, that the proportion of the noise level generated by the future plant will also have a low proportion regarding the total noise level in the vicinity of the plant site. The total noise level will be further decreased by reducing or ceasing operation of the HPP “East” plant in the future. Further minimisation of noise can be reached by additional noise control measures. It will be ensured, that the maximal allowed noise levels applied for rooms (see Section B, Chapter 4.4) will be met inside the plant the CCPP.

According to the performed analysis the noise impact during operation of the new plant on the environment can be ***judged as slight***.

3.4 Impacts on Water

The impact of the new Skopje combined cycle power plant on water can be divided in the following three aspects:

- Water consumption (fresh water and cooling water)

- Waste water discharge
- Cooling water discharge

3.4.1 Water Consumption

Raw Water will preferably be supplied through the existing well plus two new wells. The water consumption shall be minimized for economical use of natural resources. Since diverse water qualities are required in the CCPP two different water sources are considered to be used for supply:

- Potable water from the City network
- Water from three groundwater wells of which two will have to be constructed

The Skopje CCPP will consume a maximum of 270 m3/h fresh water as service-, potable-, cooling and demineralised water. The required amount, except the potable water will be supplied via the a.m. groundwater wells. The potable water is supplied from the existing city water network. The majority is used as cooling water for the hybrid cooling tower system. The maximum amount required in condensing mode and high outside temperatures (operation during summer) is approx. 260 m^3/h.

The rest is used for service purposes and as demineralised make-up water. The little amount of city water which is required for sanitary purposes can be estimated to about 60 l/h and is therefore negligible.

Since the a.m. three ground water wells are providing an accumulated amount of up to 285 m^3/h without producing a drastic decrease of the groundwater level, the water supply of the plant can be considered as reliable.

The amount of ground water taken from the wells is considered as not critical to the environment and the ground water level. Since no data concerning this topic have been available the following assumption has been considered:

It can be assumed that the City of Skopje is supplied only from ground water wells since no surface waters can be utilized as drinking water source due to contamination and availability. The average drinking water consumption per person is given with around 160 l/day. When considering the inhabitants of Skopje (estimated to about 500’000 people) and their water consumption (average 160 l/day) a total consumption of ca. 3300 m^3/h, excluding industry, can be calculated. Therefore the ground water consumption of 280 m^3/h for the CCPP is negligible.

Since it is foreseen to implement a hybrid cooling tower the savings of water compared to a common wet cooling tower amount to about 10%.

It should be mentioned that in comparison to the conventional coal-, oil- or gas-fired power plants (cooling water demand for approx. 220 MW power generation approx. 780 m^3/h) the cooling water consumption of a CCPP is more than 70 % lower. The main reason for this is that due to combined cycle technology only about 30 % of the power output is generated by the steam turbines, which require cooling water. The rest 70 % power output is generated in a gas turbine, which does not require cooling water.

3.4.2 Wastewater Discharge

In general, a thermal power plant can have an impact on the surface water and ground water in the surrounding area. The ground water will not be directly impacted by the CCPP Skopje since this plant does not discharge any wastewater in the ground. But the plant will directly impact the surface water. The impact can be caused by the following sources:

- Wastewater from various chemical processes, such as demineralised water treatment
- Wastewater from washing and cleaning of plant and equipment
- Rainwater
- Sanitary wastewater

The power plant shall release waste water to two different connection points:

- Vardar River
- Public sanitary sewerage

Waste water from the process shall be discharged into the river, redeeming the given environmental discharge limits, especially concerning oil, pH and heavy metals. Suspended hematites (rust particles) are not limited as they are natural part of the soil.

Measures shall be taken to prevent any pollution of the river by accidental spillage or discharges outside the required water discharge quality. The waste water has to fulfil the requirements for waters of Class 2 as per the Macedonian regulation on waters.

Sanitary waste water has to be discharged into the municipal sewer for future further treatment.

Rain water shall be handled according to the grade of its spoilage.

- Roof water shall be collected as clean water.
- Water from green areas is deemed as clean as well and should seep away to the ground where possible. Special gravel seeping strips should be foreseen.
- Rain water from paved surfaces and roads and dirt areas shall be guided to the storm sewer pipe system via road or yard gullies and or directly towards the natural run off ditch system. Sand traps to be installed where reasonable.
- Rain water from oil contaminated areas shall be treated as waste water and shall be specially treated

The waste water system consists of the following parts:

- Surface Water run off from oil contaminated areas
- Floor water from halls and drains in loading stations
- Oily Waste Water form transformer area, fuel oil tank area,

- Chemical waste water, drains laboratory area
- Wash and Blow off water (industrial water)
- Sanitary waste water (domestic foul sewer)
- A special concern has to be given to the first 5mm of rainfall on paved areas generally, because they are seen as spoiled under all circumstances and have to be treated accordingly.

The final discharge from the plant and connection to existing natural flow off systems or public waste water pipe nets depends on the site conditions and existing facilities.

Either the waste has to be treated on the plant site before given into the discharge system via a collection and control pit at the border of the plant or it can be directly connected to the pipe nets. Termination point shall be 1.5 m off the plant fence.

3.4.3 Cooling Water Discharge

Hybrid cooling towers are applied in this CCPP project. The losses (estimated 260 m^3/h) which are occurring during plant operation are to be made up again with water from the two wells. The main loss which amounts to ca. 170 m^3/h is caused by the water evaporation into the air from cooling process. The rest of the losses (the remaining 90 m^3/h) is sucked as blow down from the cooling water basin in order to avoid accumulation of additives like biocides, corrosion inhibitors etc. Due to the fact that the blow down is discharged to the river Vardar a sampling system has to be provided to assure that the water discharged is fulfilling the respective environmental requirements.

Water discharged from the cooling system will have a high flow rate and slightly elevated temperature and will contain low concentrations of chlorine. The Cl_2 concentration of intake water will be < 0.2 ppm in normal operation and < 3 ppm for shock dosing. Chlorine in the form of hypochlorite is an active oxidiser and dissipates quickly and harmlessly in the discharge stream. Concentrations of residual chlorine will be lower than the permissible effluent standards of WB which is 0.2 mg/l (24-hour average). In conclusion we assess the impact of residual chlorine will be negligible and harmless.

The average minimal flow rates of the discharge stream river Vardar vary from 22’000 m^3/h in autumn to 86’400 m^3/h in spring. Therefore the temperature increase to be expected from the cooling water is considered negligible.

Considering WB Guideline for cooling water discharge, the following assessment can be made:

According to WB guidelines, effluent temperature increase from thermal power plants at the edge of the mixing zone should be less than or equal to 3 °C. Even in cases where the CCPP Skopje is operating at maximum capacity, increase of the water temperature complies easily with WB Guidelines. The temperature increase of the river water is in an acceptable range. In the area near the cooling water blow down discharge (approx. 30 to 60 m), the temperature increase may reach 2 to 3 °C. In longer distance to the discharge point, the temperature increase will fall very quickly to lower than 0.6 °C, which is according Macedonian law. The reason for this is the water volume and water exchange rate of the river compared to the relatively small discharge amount.

3.5 Impacts on Soil

The site is already used as industrial site and does not show any sensitive soil features. According to the present knowledge on the soil characteristics **no significant impact** is predicted to occur **on the site** during operation of the new plant.

A clear prediction of impacts on the soil in the surrounding study area that is mainly used for agriculture is not possible due to the overall lack of knowledge on soil quality and pollution state of the soil in Macedonia. Theoretically, if deposition of NO_x exceeds the rate of soil weathering, long-term eutrophication of the soil can not be excluded. The CCPP will have zero SO_2 emissions, so that operation of the new plant will not lead to soil acidification.

To keep emissions to the air and hence the deposition to the soil as low as possible, suitable technical and organisatorial measures will be performed (see **Section E, Chapter 3.2**). Good practice and site management will minimise any potential risk.

The CCPP produces only a low quantity of solid wastes during operation. These include:

- general plant wastes like oily rags, broken and rusted metal and machine parts, defective or broken electrical parts, empty containers, miscellaneous refuse;
- packaging waste from operational consumable supplies;
- commercial wastes from offices, canteen and staff facilities;
- sludge;
- used oil;
- hazardous waste.

The main component of solid wastes during operation will be general plant wastes. These wastes will be carefully inspected and revitalised as far as possible (full or partial revitalisation). The good practice for revitalisation and reusing the wastes, e.g. as reserve parts for equipment and machinery in DHS, shows that about 50 % of all general wastes can be used again in the process etc. The other 50 % of general wastes can not be revitalised and will be transported to the licensed recycling companies (mainly to the iron and steel factory in Skopje).

All wastes that can not be revitalised, reused or recycled including general plant waste, packaging waste, commercial wastes, raw-water pre-treatment sludge, tank sludge, interceptor sludge and septic tank sludge will be collected by the municipal disposal service or specialised and authorised disposal companies and will be disposed of by licensed waste contractors. The contractors will evacuate wastes generated at and by the plant from the site. The final disposal of these wastes will be at local landfill sites, as agreed by the relevant competent authority.

The management of wastes during operation of the power plant will generally include mitigation measures to collect and store waste on-site, record all consignments of hazardous or contaminated waste for disposal and periodically audit waste contractors and disposal sites to ensure that disposal is undertaken in a safe and environmental friendly manner.

Due to an adequate treatment, disposal and control of all generated wastes **no negative impacts** on the soil will occur due to waste deposition.

3.6 Impacts on Biological Environment

3.6.1 Impacts on Protected Areas, Vegetation and Terrestrial Fauna

Atmospheric pollutants may have negative indirect impacts on terrestrial flora and fauna in the vicinity of the future plant through deposition. Regarding SO_2, the most damaging air pollutant for plants, the CCPP will have zero emissions and hence no impacts. At a very low dose NO_x and SPM act as atmospheric fertilisers for the vegetation. However, at higher doses they can lead to an accumulation of nutrients in the soil and hence to a change in habitat characteristics. An assessment of this possible impact is done on the basis of the performed air dispersion calculation in Section E, Chapter 3.2.

The plant site is not located within a protected area and does not show any sensitive habitat for plants and animals. After construction of the CCPP the main part of the plant site will be sealed, so that the presence of suited habitats for flora and fauna will be even minor. As shown in **Section E, Chapter 3.2** NO_x and CO emission values will be well below the referring national and international standards and particulates and SO2 will come down to zero. Despite the higher annual values the ambient air quality will not become worse.

Therefore, significant impacts on vegetation and fauna in the study area are not expected, and the impact in future will even be lower than it is today.

No wildlife corridors are evident in the study area and therefore the plant does not constitute a barrier to any traditional animal movements.

Given that good site management practices will be implemented, no significant effects on vegetation and terrestrial fauna are predicted.

3.6.2 Impacts on Water Fauna

Due to its high water pollution, the river Vardar does not represent a good habitat for fishes and other water organisms today. In general, a change of the river Vardar’s water characteristics means also a change of the habitat characteristics for water organisms. In Section E the conclusion has been made that operating the new CCPP will produce and exhaust lower quantities (in absolute and relative terms) of water pollutants, compared with the situation today. All wastewaters and residues of the CCPP Skopje will be collected and treated before their disposal according to the local requirements. Service water and water for cooling tower make-up derived from the river will be of small amount. Hence, a significant impact on the water organisms of the river Vardar is not expected, and the amount of water pollutants will be lower than today.

Under these circumstances even an improvement of the habitat function of the river Vardar will be expected in the future. In order to perform a more detailed impact analysis concerning the water fauna of the river Vardar, performing a baseline study would be necessary.

Given that good site management practices will be implemented, no significant effects on the fauna of the water fauna are predicted.

3.6.3 Conclusion

According to the performed analysis negative impacts due to the operation of the new CCPP Skopje on the biological environment are not expected. Operating the CCPP could lead to an improvement of habitat quality for fauna and flora compared with today’s situation.

3.7 Socio-Economical Impacts

3.7.1 Impacts on Present Land Use

The area at and around the project site is already developed and is used as residential or industrial area, respectively. During operation of the new plant the present land use will not be directly changed at the plant site and in its vicinity. There is no registered residential area located within the site boundary.

In order to operate the Project no land will have to be acquired. If additional land is needed in future, new land can be bought from the nearest paper factory "Komuna".

3.7.2 Impacts on Health

One issue concerning public health during operation of the new plant is the potential effect of air pollution due to the plant’s stack emission. The assessment of the CCPP’s impact on air quality presented in **Section E** demonstrates that ground level pollutant concentrations as a result of emissions from the new power plant will not affect air quality significantly, or even that this impact will be lower in future than it is today. Hence, the health risks from stack emissions are not considered to be significant.

One main risk for the health of workers / employees of the new plant consists in high noise levels generated by different equipment. If noise exceeds permissible levels, they will have a negative impact on human health. Noise can reduce labour productivity and can lead to worker attention being distracted, which could lead to safety incidents. The requirements for noise emissions are based on noise standards for occupational exposure. It will be ensured, that the maximal allowed noise levels applied for rooms will be met inside the plant. The project company will further establish and integrate policies and procedures on occupational health and safety issues regarding the operation of the new power plant and safety issues for third parties bordering the site. Emergency and accidents response procedures will also be included in the operational manual for the power plant.

With the provision of a high standard of health and safety management on site, mitigation measures (e.g. installation of silencers to the noisy equipment, protective devices for workers) and operation of the power plant in accordance with good industry practice, the occupational health and safety risks associated with the operation of the power plant will be minimized and are not significant.

3.7.3 Socio-economical and Socio-cultural Effects

It is anticipated that the new power plant will provide a net positive socio-economical impact through the provision of employment opportunities. Local labour will be supported and through the development of the local skill base an increased demand for local services, materials and products will be generated. More money will also be spent in socio-cultural activities and hence, the socio-cultural life will be improved.

Available employment data presented in **Section D, Chapter 4 and related Appendixes** suggest that the portion of unemployment in Skopje is around 20-21 %. A total of 15-20 persons will be permanently employed in the CCPP. Among the staff members will be e.g. manager, engineers, clerks, secretaries, craftsmen (technicians, electricians, and mechanics) and workers. Local employees that are going to cover management activities will represent approximately 5 % of the staff. During the operation of the power plant, both skilled and unskilled staff will be recruited from the local workforce. Unskilled positions will include drivers, cooks, cleaners, secretaries and security guards. During times of increased work load and extensive maintenance works, additional staff, to some extent with special qualifications, will be necessary, which may be hired from specialised maintenance companies.

Altogether, the Easter industrial zone of Skopje will be further developed and the profile of the region will be raised. Securing the supply of power to the region will attract additional industrial investment resulting in jobs, improved infrastructure and service provision.

3.7.4 Conclusion

Settlements in the surrounding of the plant site are likely to experience the main socio-economical impacts from the operation of the plant. It is indicated that the Project is unlikely to have any adverse socio-economic effects on the local community, district or regional levels. In contrast it will most probably be of substantial political benefit and will create new permanent jobs. In summary, realization of the new plant will have **favourable impacts** on socio-economy.

3.8 Other Impacts

3.8.1 Impacts on Landscape

There is already a high visual burden of the landscape on the plant site and its vicinity due to the existing HPP “East” and the surrounding industrial area. The stack height of the new plant will be around 60 m. Due to the dimension of the existing HPP “East” the CCPP will not have any further substantial effects on the landscape, so that the impact can be judged as **negligible**.

3.8.2 Impacts on Cultural Heritage

From the baseline study conducted by the Government of Macedonia, no available information was found which identified any archaeological, historic or cultural remains on the site or in the surrounding area. Consequently, **no impact** is predicted to occur on any known archaeological, historic or cultural resources.

4 Risks

In connection to the CCPP Skopje project, the following environmental risks could be considered:

Spill of oil and/or chemical consumables:

For the conditioning of e.g. demin water or the turbine washing various acid or basic substances are required. Oil is to be used for e.g. cooling or lubricating purposes. Those substances and oils have to be stored and refilled when running short. Handling those substances therefore can always lead to spill and endanger the surrounding soil, water and staff. To minimize the risk of staff injury and soil/water contamination proper measures like retention basins have to be implemented and safety clothes provided.

Fire accident:

In case of a fire accident, the surrounding environment of the CCPP Skopje plant could be affected. In order to prevent this accident the plant will be designed, constructed and operated according to the requirements of the Fire Fighting Police. The fire protection system is designed in accordance with NFPA and consists of an underground/overhead distribution system extending around all operating areas with a looped configuration to provide multi-directional fire water supply to maintain high reliability.

5 Overall Assessment of Environmental Impacts

Based on the results gained in the forgoing Chapters, the Figure E-14 has been prepared to show the summarized main environmental impacts of the CCPP Skopje Project. The impacts are divided into impacts during construction phase and impacts during operation phase. As mentioned in Section B, the impacts have been divided into 4 categories from "negligible" to "strong". Considering this figure, the environmental impacts of the future power plant can be stated as follows:

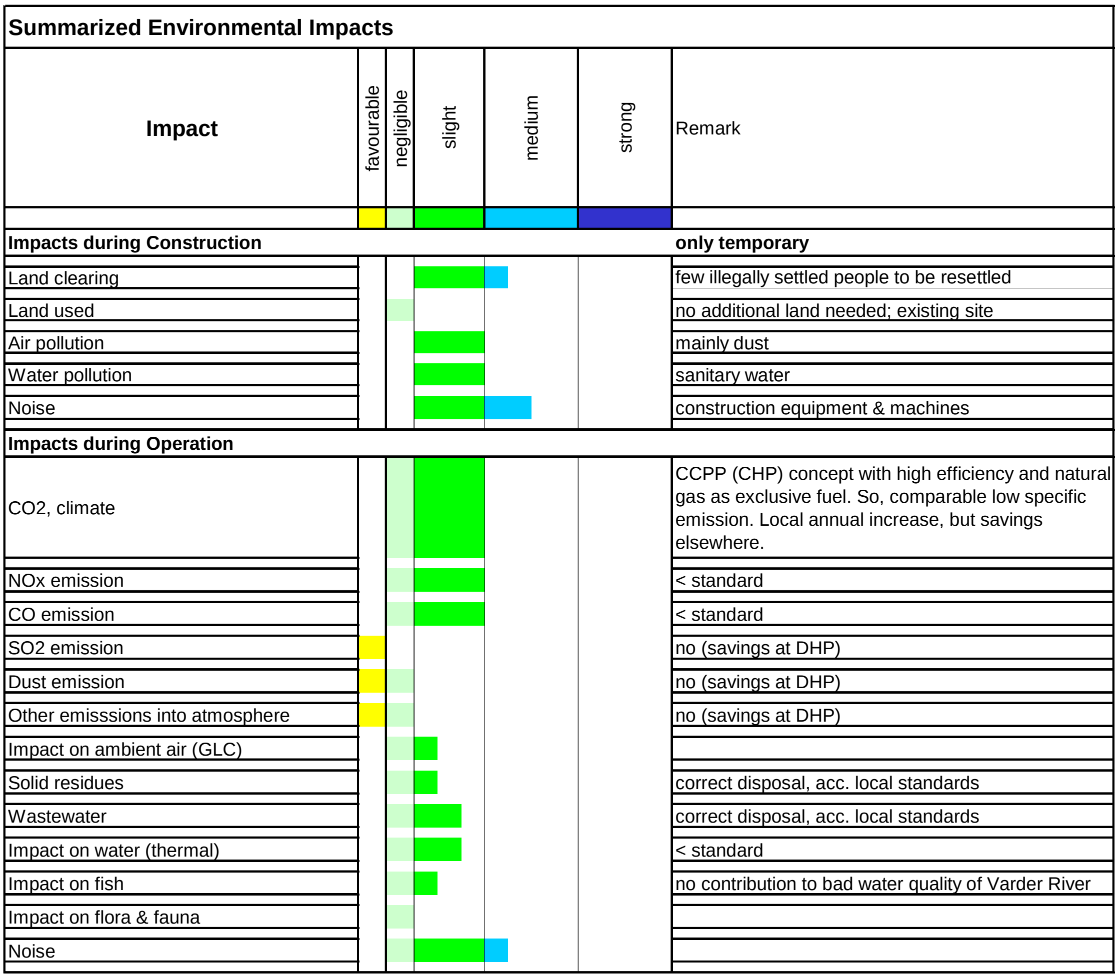
Construction phase:

- The impacts are only temporary
- The impacts can be assessed as slight
- For implementation of such an important project, the impact can be stated as acceptable

Operation Phase:

- In general the applied combined cycle technology represents, environmentally, the best available power generation system
- The considered exclusive fuel, natural gas, is also environmentally representing the best possibility for power generation
- Because of the above mentioned aspects, the overall environmental impact of the plant can be assessed as slight to intermediate
- The positive impact of the project on the local and Macedonian socio-economical development can be assessed as relatively high

The design and construction of the plant will consider the lowest applicable standard (EU, local or WB Standards respectively).



Summarized Environmental Impacts

Impact	favourable	negligible	slight	medium	strong	Remark
	🟨	▨	🟩	🟦	■	
Impacts during Construction						**only temporary**
Land clearing			🟩	🟦		few illegally settled people to be resettled
Land used		▨				no additional land needed; existing site
Air pollution			🟩			mainly dust
Water pollution			🟩			sanitary water
Noise			🟩	🟦		construction equipment & machines
Impacts during Operation						
CO2, climate		▨	🟩			CCPP (CHP) concept with high efficiency and natural gas as exclusive fuel. So, comparable low specific emission. Local annual increase, but savings elsewhere.
NOx emission		▨	🟩			< standard
CO emission		▨	🟩			< standard
SO2 emission	🟨					no (savings at DHP)
Dust emission	🟨	▨				no (savings at DHP)
Other emisssions into atmosphere	🟨	▨				no (savings at DHP)
Impact on ambient air (GLC)		▨	🟩			
Solid residues		▨	🟩			correct disposal, acc. local standards
Wastewater		▨	🟩			correct disposal, acc. local standards
Impact on water (thermal)		▨	🟩			< standard
Impact on fish		▨	🟩			no contribution to bad water quality of Varder River
Impact on flora & fauna		▨				
Noise		▨	🟩	🟦		

Figure E-14: Summary of Environmental Impacts of CCPP Project

The above impacts have been assessed for the new CCPP project. If it is taken into consideration that the new plant will replace heat and electricity production elsewhere, then the overall impacts would even be lower.