TE-TO AD SKOPJE

Combined Cycle Co-Generation Power Plant Project Skopje

Environmental Assessment Report

SECTION C
PROJECT DESCRIPTION

August 2006

Thermal Energy Plants Department

Table of Contents

List of Tables

Page

List of Figures

1 Introduction

The TE-TO AD Company in Skopje/Macedonia was established in 2005 by Itera Energy Holdings London and Toplifikacija AD Skopje with the aim to own and operate a combined heat and power plant in Skopje.

The intended combined cycle power plant of TE-TO AD in Skopje (CCPP Skopje) shall be constructed and operated on the basis of an IPP (Independent Power Producer) Project and shall supply the Macedonian and international electricity market with electric power. In addition, the major part of the required district heat demand of Skopje city shall be generated and supplied by this power plant.

2 Project Location and Infrastructure

The CCPP Skopje will be located in an existing area in the Toplifikacija AD, directly adjoining the existing district heat plant “ISTOK” of Toplifikacija.

2.1 Location and Project Boundaries

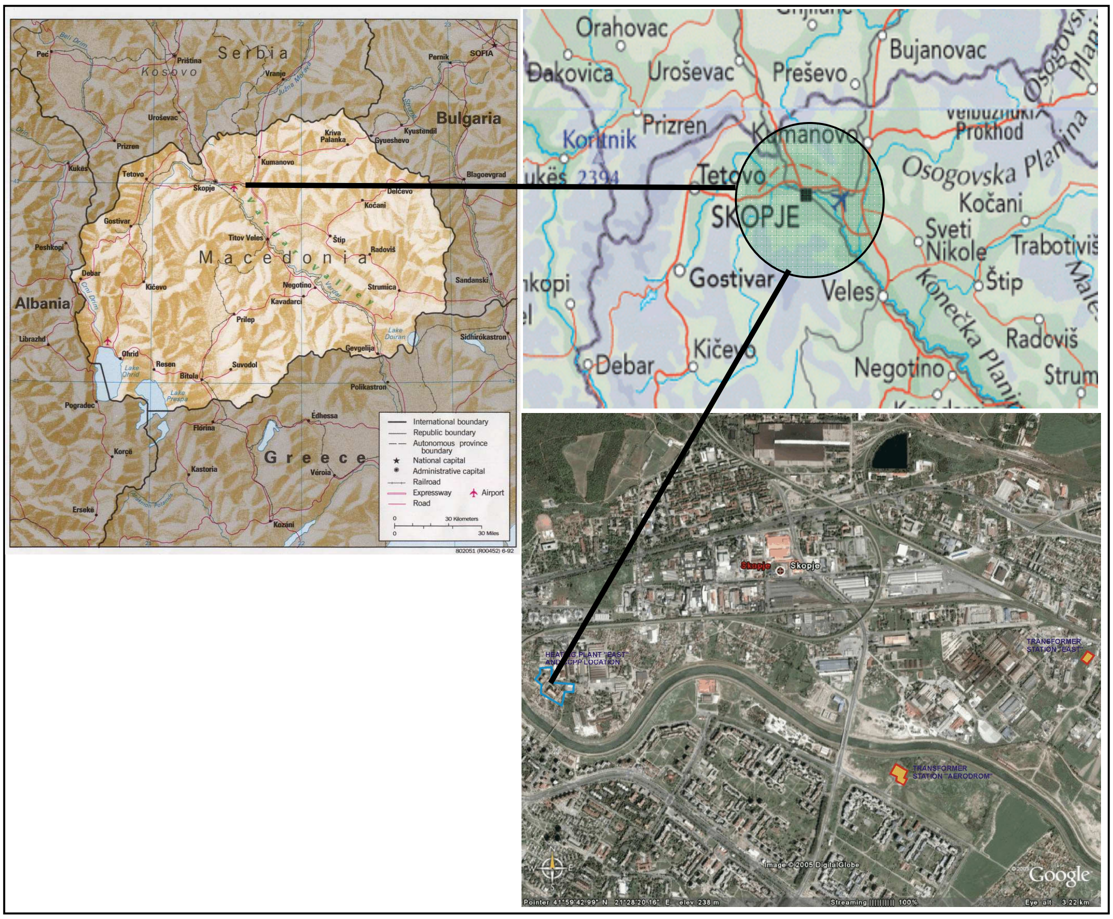

Figure C- 1: Location of new CCPP Project respective existing DHP ISTOK

2.2 Infrastructure

Operating the CCPP Skopje requires, besides a good access to the site and plant, also a reliable supply of various media which have to available for construction as well as for operation. A detailed description of those requirements is provided in this chapter.

2.2.1 Traffic Infrastructure

The plant site is near the river Vardar and can be reached easily by the existing good road connections.

The existing heating plant and site of Toplifikacija has connections via the main access road to the main traffic infrastructure of the City of Skopje. A rail connection can be used for transportation purposes as well. There is no known restriction for heavy transport by any low bridge height or limited load.

2.2.2 Infrastructure of required Media and Electricity for the CCPP Skopje

The following connections to external media are available on site:

- Drinking water
- Waste water
- Fuel and electricity (during construction phase)
- Raw water well (capacity of 85m^3/h)
- River Vardar could be used if an inlet structure and pump station and a transport pipe system would be implemented
- Fuel; Diesel tanks 2 m^3, heavy oil 10’000 m^3 (two tanks each 5’000 m^3, however one tank shall be used in the future for Heating Water Storage)
- Natural Gas with a capacity up to 40’000 Nm^3/h and a pressure of 12 bar is available in 2 km distance. In a longer distance of 8 km a 40 bar pipeline would be available.

The main tie-in points are shown in the Figure C- 2 below.

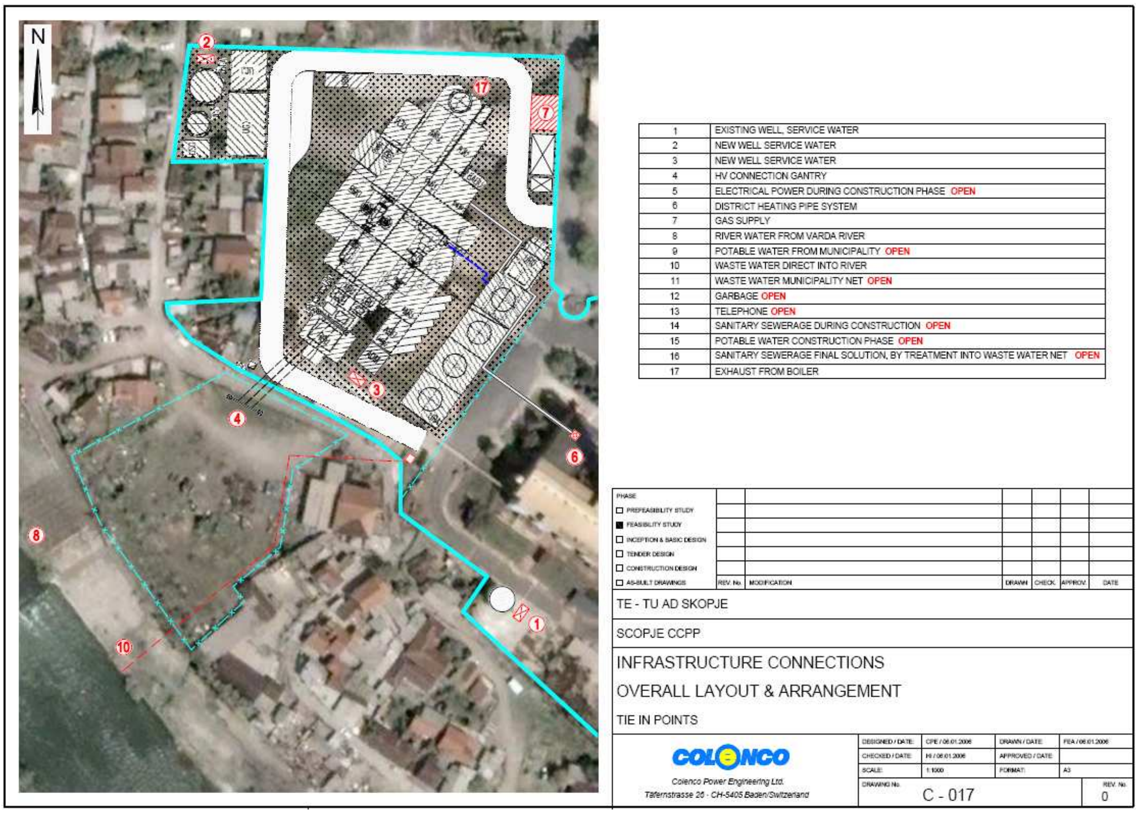

Figure C- 2: Infrastructure Connections - Tie-in Points

Natural gas is considered as the only fuel for the operation of the CCPP Skopje. The plant will be supplied with Russian gas from a nearby high pressure pipeline. The supply of the high pressure natural gas from the existing main pipeline shall be performed by installation of a connecting pipe to the plant site in Toplifikacija AD. The gas supplier will be GASITERA Suisse AG. A second supply agreement with BULGAR GAS, Bulgaria is currently under negotiation.

The specification of the natural gas which will be used as fuel in the planned CCPP Skopje is shown in section 4.5.1.

Potable water for using in social and sanitary buildings will be taken from the city water network. The daily consumption of potable water is estimated to be about 2 to 3 m^3.

Service Water for the operation of the CCPP Skopje service water is required mainly for the supply of the following systems:

- as make-up water for the considered water-air type cooling tower (hybrid cooling tower) with a consumption between 120 m^3/h during winter months and 230 m^3/h during the summer months.
- as demineralised water for the water-steam-cycle process with a consumption of about 4 m^3/h
- as raw water for the fire fighting.

In principal at the considered construction location in Toplifikacija two different sources for the supply of the required service water for CCPP Skopje are available:

- service water supply from deep wells drilled and operated near the plant site
- service water supply from the river Vardar.

The extraction of service water from deep wells is preferred, since this water can be utilised for the cooling tower without further treatment and allows effective bacteria control as well as a space saving high efficiency packing inside the cooling tower. Toplifikacija AD owns and operates one well with a capacity of 85 m^3/h to refill operating leakages during the heating period. The existing data of the existing well indicates that the capability of ground water is sufficient for the supply of all existing plants as well as for the CCPP Skopje. In order to assure the permanent supply two new wells on different locations in Toplifikacija will additionally be drilled.

Process waste water shall flow back to the river Vardar after appropriate treatment to ensure that the discharge is neither contaminated with oil nor chemically aggressive.

Sanitary waste water shall be led to the existing municipality sewer which is connected to the river further downstream of the river.

The water from **district heating** will enter the power plant heat exchangers with water temperatures between 45 and 55°C and a flow rate of approx. 5000 m^3/h. A minimum flow of 1700 m^3/h is possible. During the night time between 21:00h and 06:00h, the district heating is switched off, resulting in higher demand in the morning. During the night operation of the CCPP, it is intended to have some heat stored in one of the two existing heavy oil tanks, converted into a 5000 m^3 water tank.

The district heating system (DHS) is a hot water system and was designed for a nominal delivery temperature of the water of up to 130 °C and 70 °C in the return duct. However in combination with the planned CCPP a feeding temperature of 100°C and a thermal energy supply of 160 MW are requested.

Power Transmission: The power produced in gas turbine generator and steam turbine generator will be transferred to a common step-up transformer designed as a 3-winding type to connect both generators of the Gas turbine and Steam turbine.

Since the heating plant 'ISTOK' is currently not supplying any electrical power to the grid a complete new interconnection has to be planned for the considered CCPP Skopje. Based on several investigations performed by the local engineering company TIMEL the following measures could be possible:

- Interconnection of the plant into the existing 110 kV transmission system: The power evacuation of the CCPP on 110 kV level can be done either by an interconnection to the Transformer Station 'AERODROM' (about 2 km distance), or/and by an interconnection to the Transformer station 'ISTOK' (about 3 km distance).
- Interconnection of the plant into the existing 400kV transmission system: Currently there is no possibility for a direct connection into the 400 kV switchgear in 'Skopje 4' since there is no free field available. However connection possibilities into the 400 kV overhead line or into a parallel 110 kV over head line are under investigation.

3 Existing District Heat Plant HPP “EAST”

HPP "East" or “ISTOK” is the largest plant of DHS (District Heat Skopje). Its location in eastern industrial zone of Skopje, provides a good supply of heat to the residual, industrial and commercial parts of city. Close to plant location is found the river Vardar, the railway and connection to the main eastern access road to city of Skopje (see Figure C- 4).

The HPP “EAST” (see photo on the right) is providing with five boilers 57.8% of the total heating capacity of DHS. Beside the heat generation, two additional boilers are installed for process steam production, which is as well supplied to the industry as used for internal plant processes.

All 5 hot water boilers (2x70 MW and 3x46 MW) are connected to one stack with an average diameter of 4.75 m and a height of 65 m. The 2 steam boilers (2x7.5 MW) are equipped with a separate stack which has a diameter of 1 m and a height of 25 m.

The boilers are fired in the percentage 70% Mazout and 30% natural gas producing annually about 475’000 MW_{th} for the district heat system of Skopje. For the supply of district heat to the city networks the boilers are annually only about 2’650 to 2’700 hours in operation. Since only heat and no electricity is generated, the plant is fired only in the transition and winter periods (from mid October to mid April). In summer, late spring and early autumn the plant is out of service as the average outside temperatures are higher than 15°C. Also during night time (21:00 to 06:00) the plant is out of operation. The existing district heating system (DHS) is designed for a minimum temperature of -15 °C ambient temperature. The design average ambient temperature in winter is 5.3 °C. The Table C- 1 summarizes the main data about the existing district heat production plant HPP “EAST” or “ISTOK” of Toplifikacija AD.

Total installed capacity of 5 hot water boilers	approx. 279 MW_{th}
Total installed capacity of two steam boilers	approx.14.8 MW_{th}
Total annual district heat production	about 475’000 MWh
Total installed capacity of consumer heating stations	about 375 MW_{th}
Consumer's capacity connected to the plant	~ 430 MW_{th}
Total annual operating hours of district heat system	about 2’650-2’700 h/a
Total annual electricity consumption	approx. 12’000 MWh
Annual consumption of water	approx.195’000 m^3

Annual consumption of heavy fuel oil (mazout)	37’000 to 43’000 t
LHV of Mazout	41.05 MJ/kg
Annual consumption of natural gas	13 - 15 x10^6 Nm^3
Annual total fuel consumption (heavy oil equivalent):	48 - 56 x10^3 t
LHV of natural gas	36.02 MJ/Nm^3

Table C- 1: The Main Operating Data of Existing DHP ‘ISTOK’ of Toplifikacija AD

The Mazout is stored in tanks with a total capacity of 10’000 m^3 (2x5000 m^3) while natural gas is supplied via a 12 bar pipeline. A specification of the natural gas respective Mazout used in the HPP “EAST” is shown in Table C- 2 and Table C- 3.

Only in few times of the heating period, the heating demand of 160 MW is exceeded. Therefore the design of the new CCPP is done according to this value. For those exceptions, the HPP “EAST” will cover the peak demand, which will be maximum up to 700 h (see Figure C- 3).

Relevant operation, performance and emission data of HPP "East" for the respective heating period are listed in Table C- 4 and Table C- 5 (calculated for mazout/gas mix 70/30 %). The 160 MW (resp. 100 MW in transition period) is to be understood as an average heat output value covering the whole winter season and already including the 700 additional firing hours of the HPP “EAST”. For an average seasonal emission value this approach can be considered satisfactory but when considering hourly/daily data higher values may occur.

As the additional firing of the HPP “EAST” is planned to be done with natural gas only and up to maximum power of 60 MW, the impact on the environment in this phase can be considered negligible as short time firing will be performed.

The water required for district heating and steam has to fulfil a certain standard in respect to various chemical parameters (e.g. pH value, conductivity, O_2-Content) and needs therefore to be treated chemically with additives etc.

		% vol			% vol
Methan	CH4	98.13	Hydrogen	H2	
Acetylen	C2H2		Oxygen	O2	
Ethylen	C2H4		Nitrogen	N2	0.78
Ethan	C2H6	0.70	Carbon oxide	CO	
Propen	C3H6		Carbon dioxide	CO2	0.04
Propan	C3H8	0.24		H2S	0.00
Buten	C4H8				
Butan	C4H10	0.09			
Pentan	C5H12	0.01	Hexan	C6H14	0.006
	Summe:	100.0			

LHV of Natural Gas Composition = 36.02 MJ/Nm^3

Table C- 2: Natural Gas Composition for HPP “EAST”

		i. raw	
Carbon	C	85.00	mass %
Hydrogen	H	12.00	mass %
Oxygen	O	0.40	mass %
Nitrogen	N	0.10	mass %
Sulphur	S	2.30	mass %
Chlorine	Cl	0.00	mass %
		0.00	mass %
Ash	a	0.10	mass %
Water	w	0.10	mass %
	Sum:	100.00	

LHV of Mazout Composition = 41.05 MJ/kg

Table C- 3: Mazout Composition for HPP “EAST”

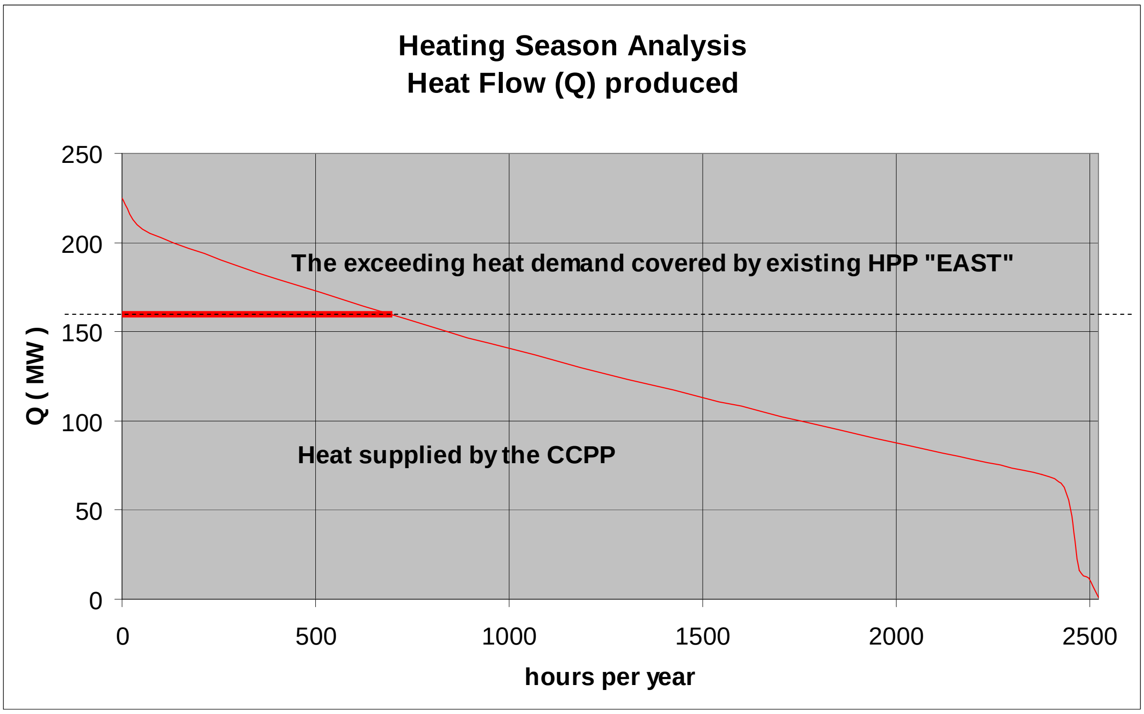

Figure C- 3: Heating Season Analysis

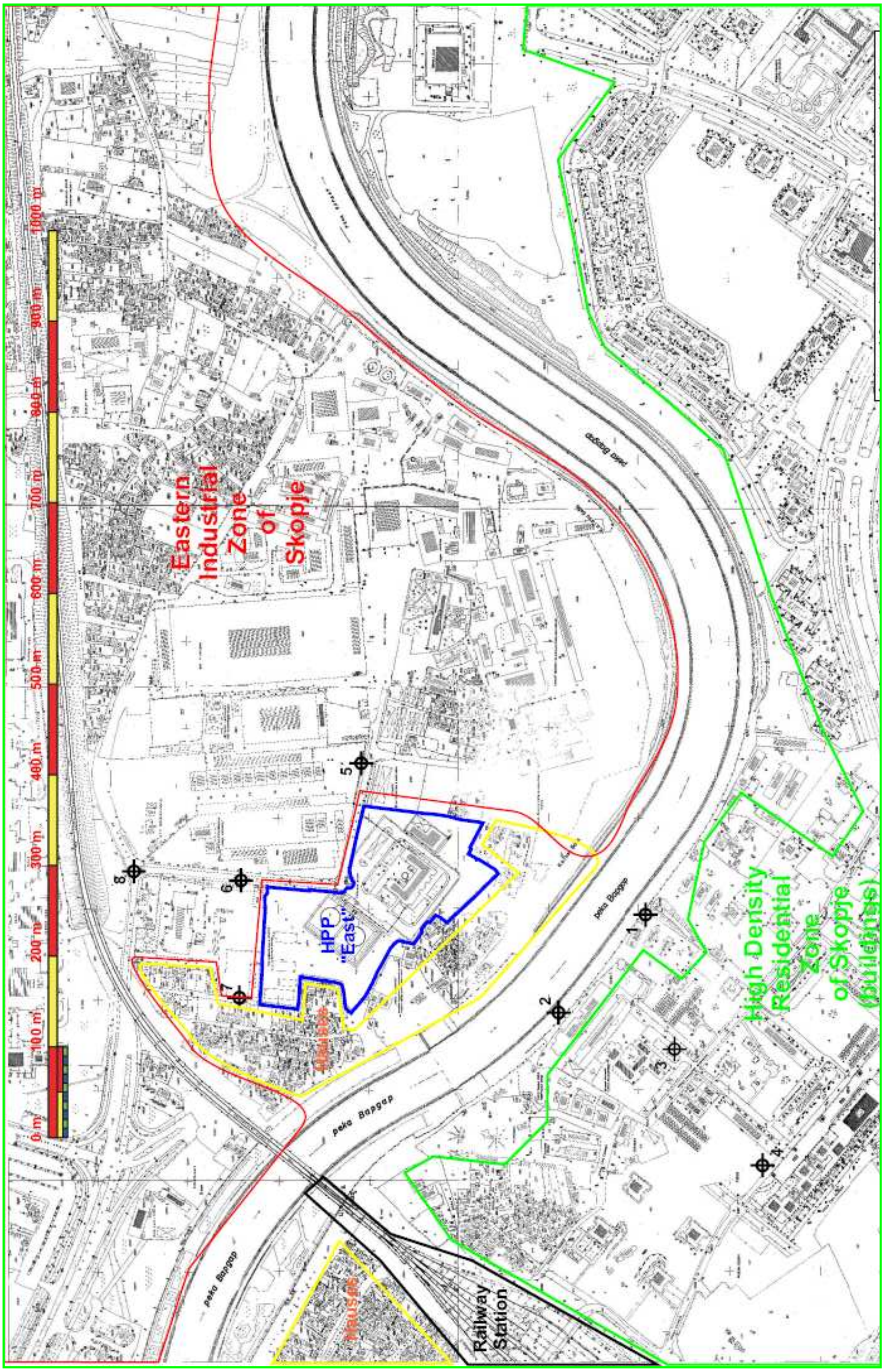

Figure C- 4: Location and heat-supplied areas of HPP "EAST“

Operation and Emission Data of Existing District Heat Plant		
Heating period:	**Transition**	
ratio mazout/gas:	**70% / 30%**	
Operation & Fuel Data		
Firing heat duty by natural gas	MW	32
Firing heat duty by mazout	MW	77
Heat (to DH system)	MW	100
LHV natural gas	MJ/Nm3	36.0
LHV mazout	MJ/kg	41.1
natural gas consumption	Nm3/h	3'200
mazout consumption	kg/h	6'780
CO2 specific, natural gas	kg/Nm3	1.989
CO2 specific, mazout	kg/kg	3.117
Operating time (for a. m. conditions)	h/a	1'340
Flue Gas & Stack Data		
Flue gas volume flow (dry @ 3% O2)	Nm3/h	111'934
Flue gas volume flow (dry @ 15% O2)	Nm3/h	
Flue gas volume flow (wet, act. O2)	Nm3/h	130'586
Flue gas temperature @ stack	°C	198
Flue gas volume flow (actual @ stack)	m3/h	225'297
Stack heigt	m	65
Stack flue diameter	m	4.56
Flue gas velocity (actual @stack)	m/s	3.83
Emission Data		
NOx (as NO2), dry @3% O2	mg/Nm3	461
CO, dry @3% O2	mg/Nm3	98
SO2, dry @3% O2	mg/Nm3	2'660
PM, dry @3% O2	mg/Nm3	42
Emission Mass Flows:		
hourly		
NOx (as NO2)	kg/h	52
CO	kg/h	11
SO2	kg/h	298
PM	kg/h	5
annually *)		
NOx (as NO2)	t/a	181
CO	t/a	38
SO2	t/a	1'042
PM	t/a	16
CO2 Emission		
hourly	kg/h	27'495
annually *)	t/a	96'228

*) annual values represent the sum of transition and winter periods

Table C- 4: Compilation of Operation and Emission data of HPP „EAST“ for the TRANSITION PERIOD (1/2 October, November, March, 1/2 April)

Operation and Emission Data of Existing District Heat Plant		
Heating period:	**Winter**	
ratio mazout/gas:	**70% / 30%**	
Operation & Fuel Data		
Firing heat duty by natural gas	MW	51
Firing heat duty by mazout	MW	124
Heat (to DH system)	MW	160
LHV natural gas	MJ/Nm3	36.0
LHV mazout	MJ/kg	41.1
natural gas consumption	Nm3/h	5'100
mazout consumption	kg/h	10'860
CO2 specific, natural gas	kg/Nm3	1.989
CO2 specific, mazout	kg/kg	3.117
Operating time (for a. m. conditions)	h/a	1'350
Flue Gas & Stack Data		
Flue gas volume flow (dry @ 3% O2)	Nm3/h	179'035
Flue gas volume flow (dry @ 15% O2)	Nm3/h	
Flue gas volume flow (wet, act. O2)	Nm3/h	214'761
Flue gas temperature @ stack	°C	198
Flue gas volume flow (actual @ stack)	m3/h	370'522
Stack heigt	m	65
Stack flue diameter	m	4.56
Flue gas velocity (actual @stack)	m/s	6.30
Emission Data		
NOx (as NO2), dry @3% O2	mg/Nm3	461
CO, dry @3% O2	mg/Nm3	98
SO2, dry @3% O2	mg/Nm3	2'660
PM, dry @3% O2	mg/Nm3	42
Emission Mass Flows:		
hourly		
NOx (as NO2)	kg/h	83
CO	kg/h	18
SO2	kg/h	476
PM	kg/h	8
annually *)		
NOx (as NO2)	t/a	181
CO	t/a	38
SO2	t/a	1'042
PM	t/a	16
CO2 Emission		
hourly	kg/h	43'989
annually *)	t/a	96'228
*) annual values represent the sum of transition and winter periods		

Table C- 5: Compilation of Operation and Emission data of HPP „EAST“ for the WINTER PERIOD (December, January, February)

4 Concept and Layout of new Combined Cycle Power Plant

The CCPP Skopje Power Project mainly consists of a combined cycle facility with one gas-fired gas turbine, one heat recovery steam generator (HRSG), one steam turbine and the balance of the plant (BOP). The plant shall be supplied, erected and commissioned in the framework of an EPC contract (Turn Key Contract). For the time being the EPC contractor for this project has not been selected.

The electrical generation capacity of the CCPP Skopje should be in a range of about 220 to 240 MW_{el} depending on the type of selected gas turbine selected by the EPC bidders. The plant shall produce about 160 MW_{th} as district heat for the supply of the Skopje city.

The main systems and equipments of the planned CCPP Skopje are as follows:

- Natural gas supply system
- 1 gas turbine with generator
- 1 heat recovery steam generator (HRSG) with stack
- 1 steam turbine with generator
- 1 water cooled condenser system
- 1 air-water cooling tower with auxiliary cooling systems
- interconnection piping to the existing district heating system
- process and cooling water storage and treatment systems
- waste water treatment facilities
- electrical equipments and high voltage switch yard
- control and instrumentation systems (I&C)
- civil infrastructures and building

The plant will be based on a two shaft power train composed by one gas turbine, one steam turbine and two synchronous generators with all the relevant auxiliaries. No bypass stack should be installed and therefore no simple cycle operation is envisaged. All routine start-up and shutdown operations should be carried out from a central control room via a DCS control system. Figure C- 5 shows a simplified process flow diagram of CCPP Skopje.

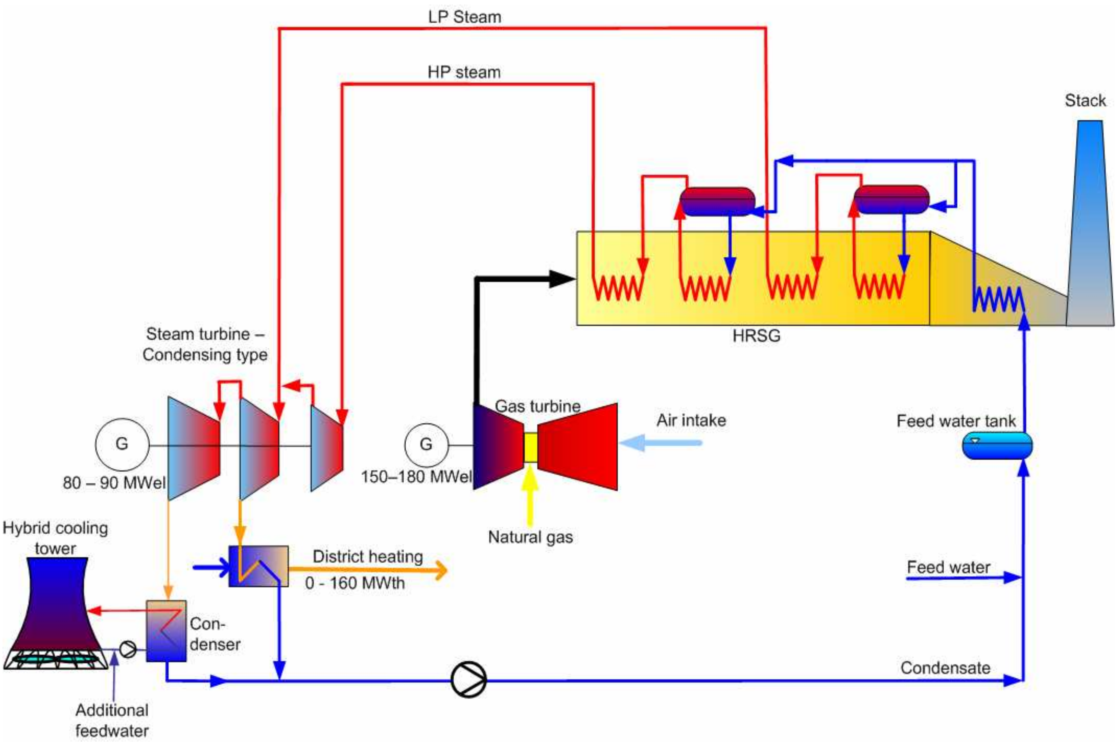

Figure C- 5: Simplified Process Flow Diagram of CCPP Skopje

The basic plant concept consists of two power generation cycles. The first cycle occurs in the gas turbines. Air is compressed and then passed on into the combustion chambers with a rotary compressor. Here, natural gas mixed with air is burned to produce a hot high pressure gas which is expanded through a turbine. The turbine drives both the compressor and an electrical generator to produce electricity.

The second cycle is a steam cycle. The exhaust gas from the gas turbine is still hot and is passed on into a heat recovery boiler (HRSG) where the thermal energy contained in the flue gas is used to generate steam at high pressure (approx. 100 bar). This HRSG is design to be of the natural circulation type with two pressure levels. The generated steam is used to drive a steam turbine in which additional power will be produced.

There is no exhaust gas by-passes for gas turbine foreseen, therefore the isolated operation of the gas turbine is not possible without the related HRSG in operation. In case the related steam turbine is tripped, the steam generated in the HRSG can be by-passed directly to the condenser.

The technical concept of the intended CCPP plant utilizes air-water cooled condenser (hybrid type) instead of conventional wet cooling tower. The use of this condenser is environmentally favourable due to the minimized cooling water consumption and the elimination of the fog associated with the evaporation of cooling water from the wet cooling towers.

In the following Table C- 6 the main technical design data of the CCPP Skopje are summarised.

	Units	Data
Electricity generation capacity: - Gross - Net	 MWe MWe	 about 220 to 240 about 214 to 234
Operating mode		base load operation with approx. 8’300 h/a operating hours
District heat generation capacity	MWth	max. 160
Net plant efficiency - Condensing mode - District heat extraction mode	 % %	 about 50 to 53 about 70 to 85
Net heat rate	kJ/kWh	about 6’800 to 7’200
Fuel: - Type - LHV - Demand	 - MJ/Nm^3 Nm^3/h	 Natural gas 36 about 42’000 to 47’000
Expected emissions (dry, @ 15% O_2): - NOx emissions - CO emissions	 mg/Nm^3 mg/Nm^3	 about 30 to 50 about 20 to 30
Noise Emissions	dB (A) dB (A)	60 (at the south and west fence) 70 (at the north and east fence)

Table C- 6: Main Technical Data of CCPP Skopje

Comment: the final generation capacity of the plant is depending on the plant concept of the selected EPC contractor

The following Table C- 7 summarises the results of the heat calculations as well as the estimated annual time shares of the operation cases.

Operation cases & Estimated time share					Heat Calculation Results		
	Operation case	aver. T °C	share %	time h/a	gas heat input (MW)	el. power MWel	th. power MWth
1	summer	25	40	3'320	422	217	0
2	transition (without heating)	15	28	2'291	440	229	0
3	transition *)	10	16	1'340	449	218	100
4	winter *)	2.5	16	1'349	462	231	160
	total / weighed average		**100**	**8300**	**438**	**223**	**42**
With above values estimated as annual averages:							
	Fuel gas heat input	MWh/a			**3'634'270**		
	Electrical power	MWh/a				**1'848'813**	
	Thermal power	MWh/a					**349'845**
	Fuel utilisation					**60%**	

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

Table C- 7: Operation Cases and Heat Cycle Calculations

The annual average of the fuel gas heat input amounts to approx. 440 MW_{th} and the electrical power is 223 MW_{el} as annual average. The estimated electrical power for the cases 3 and 4 considers the shut down of heating during night, i. e. approx. one third of the day.

The annual production averages of the CCPP Skopje are approximately 1.85 million MWh electricity and 350'000 MWh heat, corresponding to an overall fuel utilization of 60 %.

4.1 Gas Turbine (CTG Unit)

The combustion turbine generation unit (CTG) mainly comprises:

- Air intake system
- Gas Turbine
- Exhaust Gas System
- Generator
- Auxiliaries and related equipment, like lubrication and hydraulic system, gas detection and fire protection system, control system.

Air Intake System

The air intake system for the gas turbine shall consist generally of two-stage inlet air filters, silencers and ducting. The air intake system shall be selected to assure safe operation of the CGT at the ambient air quality prevailing at the site.

The purpose of the air intake filtration system is to remove airborne particles from the intake air which might otherwise adversely affect the performance of the gas turbine and life of the gas turbine components. Since the gas turbine is intended for extended operation, a two-stage high efficiency filter system is required. A weather louver stage shall be mounted in front of the filter system.

The air intake system shall be equipped with an anti-icing system to allow for plant start up and continuous operation at the lowest air ambient temperature. The air intake ductwork shall also be equipped with a silencer section to attenuate the compressor air intake noise to a level compliant with the requirements.

Gas Turbine

The gas turbine consists of the sections air compressor, combustion chamber and hot gas expansion turbine. Via the multi-stage axial-compressor ambient air will be sucked in, compressed and transferred to the combustion chamber. Within the combustion chamber the fuel (here natural gas) will be mixed with the compressed air and this fuel-air mix will be burned. This permanent combustion will generate an extreme hot high pressure flue gas, which will enter the multi-stage turbine section of the gas turbine and while attempting to expand it will consequently spin the gas turbine rotor. The rotor in turn is directly connected with the electrical generator, which will generate the required electricity.

- ***Air compressor:***

  The gas turbine compressor shall be of the standard design and shall at least be able to operate continuously between rated speed plus or minus 5% (equivalent to a frequency range of 47.5 - 52.5 Hz). The compressor design must ensure that there is sufficient margin between its surge line characteristic and the range of operating speeds to remain unconditionally stable at all conditions of load, ambient temperatures and conditions of blade fouling. Inlet guide vanes (IGV) shall be provided both to avoid compressor surge conditions during starting and to allow for modulation control when the gas turbine is exhausting into the heat recovery steam generator (HRSG).

  Provisions shall be made for compressor off-line washing. Periodic compressor cleaning should be carried out to remove accumulation of fouling deposits and to restore unit performance.

- ***Combustion System:***

  The combustion system shall be of a proven DLN-type and designed to start, run up to synchronous speed and properly operate at all loads from synchronous idle up to full peak load and shut down on the fuel specified. To reduce the NO_x emissions which will be formed during the combustion process, the gas turbine shall be equipped with dry low NO_x burners, the so-called DLN (Dry Low NO_x) system, which reduces today's NO_x emissions below 50 mg/Nm^3.

  The fuel flow to the burners shall be regulated in order to:

  - maintain the turbine run at uniform speed free from hunting at all loads
  - limit the turbine inlet temperature from rising above a pre-set level

- ensure that the generator fulfils the governing requirements

The combustion system shall be designed for the single firing capability of natural gas only.

- ***Hot Gas Expansion Turbine (Power Turbine):***

  The power turbine rotor and stator components have to be designed to withstand the maximum temperature differentials that are likely to be experienced in service even under adverse combustion conditions with the machine running at the design mean turbine inlet temperature. The casings, blading and ducts shall withstand the thermal shock associated with repeated starting and loading throughout the operating life of the unit. The blading shall be designed to withstand all vibration, thermal shock, gas and mechanical loads that may be experienced during all operational conditions.

Exhaust Gas System

The exhaust gas system conveys the hot exhaust gases via diffuser and ducting to the Heat Recovery Steam Generator. The exhaust ducting shall be designed so that it does not vibrate during operation and shall be equipped with sufficient expansion joints for compensation of the different expansions between GT and HRSG. The duct system shall be arranged for the least number of changes in the flow direction. Turning vanes shall be provided at changes in direction where necessary to avoid pressure losses and to ensure uniform flow distribution. An axial flow exhaust system will be preferred.

The hot exhaust gases of the gas turbine will be transferred to the HRSG in which the thermal energy of the exhaust gases will be utilized to generate high pressure steam. The exhaust gases from the HRSG will be finally discharged into the atmosphere via the exhaust gas stack.

Generator

The rotor of the gas turbine is directly connected with the electrical generator, which will generate the required electricity. The gas turbine’s generator as well as the steam turbine’s generator will be electrically connected to one common step-up transformer designed as a 3-winding type (see section 5.8).

Auxiliary and related equipment

The CTG unit will be equipped with all necessary systems for reliable and safe operation according latest standards, like the lubrication and hydraulic system, the control system, enclosure including a gas detection system and fire protection system etc.

A digital electro hydraulic governor/controls system shall be provided for speed control and for load/frequency regulation. The electronic controls comprising the governor/control shall be completely integrated into the DCS. The control system shall utilize triple modular redundant (TMR) technology for critical systems. The CTG control equipment operator interface will be located in the control room, and shall be capable of interfacing with facility’s distributed control system (DCS). CTG interface shall be through the DCS consoles. A separate control console is not required. The supervisory equipment cabinets shall be located in an electrical equipment room.

All compartments of the acoustic enclosure shall be force ventilated with air using extracting fans to maintain, at all times, an internal pressure slightly lower than atmospheric and also to limit the temperature at all times within the compartment at a level consistent with the prolonged reliable operation of all equipment contained therein.

A gas leakage detection system shall be provided within the acoustic enclosure and a master gas leak detection and alarm system panel shall be installed in the plant control room.

An automatic fire fighting system will be installed which shall utilize a gas as the fire extinguishing medium such as carbon dioxide.

The main technical and operational data of the CTG are presented in the following Table C- 8:

	Unit	
Approx. Maximum Continuous Rating (MCR) at ISO conditions – gross	MW	160
Type	-	Heavy Duty Industrial
Number of gas turbines		1
Fuel type		natural gas (composition see Table C-11)
Fuel demand	Nm^3/h	ca. 44'000 - 50'000
Operation mode		base load operation with approx. 8300 operating hours p. a.
Combustion System		DLN
expected NO_x (as NO_2)	mg/Nm^3 dry, @ 15 % O_2	< 50
expected CO	mg/Nm^3 dry, @ 15 % O_2	< 30
NO_x (as NO_2) min. requirement to guarantee	mg/Nm^3 dry, @ 15 % O_2	75
CO min. requirement to guarantee	mg/Nm^3 dry, @ 15 % O_2	100
Rotor Vibrations		according to ISO
Expected number of starts per year		≤ 20
Installation		outdoor with removable enclosure

Table C- 8: Main Data Gas Turbine Generating Unit

4.2 HRSG

The HRSG shall be associated with the gas turbine and shall be capable of automatic start-up, shut-down and acceptance of the operational requirements of the gas turbine without excessive thermal stresses.

An outdoor installation of the HRSG is intended and acceptable in case that the required noise level will be met. The following Table C- 9 summarizes main features which shall be taken into account for the design of the Heat Recovery Steam Generator.

	Unit	
Type		natural circulation, min. 2 pressure levels
Number of HRSG		1
Live steam parameters p / T	bar / °C	approx. 100 / 525
Steam capacity	t/h	approx. 200
Inlet gas duct layout	-	horizontal
Bypass stack	-	not applicable
Exhaust gas temperature	°C	approx. 87
Feed water inlet temperature control	-	Yes
Expected operating life	hrs	> 210'000
Stack height	m	approx. 50 - 60
Outer surface temperature of casing	°C	< 50
Cold starts per year		≤ 5
Warm starts per year		≤ 5
Hot starts per year		≤ 10
Installation		outdoor

Table C- 9: Main Data Heat Recovery Steam Generator

The heat recovery steam generator system shall consist of one heat recovery steam generator (HRSG) for the combustion turbine. At least two pressure levels shall be applied. The HRSG shall preferably be arranged horizontally. Vertical arrangement is accepted provided that natural circulation (without installation of circulation pumps) is guaranteed at all operation modes.

Materials of construction shall be selected so as to ensure a minimum design life of 25 years, and a minimum operating life of 210'000 hours for those sections operating in the creep rupture range. Safety relief valves will be provided for overpressure protection of the HRSG.

The HRSG will include the following main components:

- Heat transfer sections including condensate preheater
- Multiple steam drums with steam separators and dryers
- Exhaust gas duct
- Internal insulation and liners
- Expansion joints and casing penetrations
- HRSG exhaust stack (approx. 50 - 60 m above ground level; subject to approval by authorities)

- Support Structure - Access provisions for operation and maintenance
- Interconnecting piping, valves, instrumentation, and accessories.

4.3 Steam Turbine

The steam turbine shall be designed and optimized for continuous operation with steam extraction for district heating purposes (i.e. cogeneration mode during winter time) as well as for continuous operation with no steam extraction (i.e. condensing mode during summer time).

In each mode of operation the steam turbine shall match the requirements of the gas turbine and heat recovery steam generator as well as heat supply required by the District Heating System.

The following Table C- 10 summarizes some steam turbine performance criteria and design features:

	Unit	
Performance Parameters		
Nominal rating (condensing mode operation)	MW	~ 80
Thermal Output for District Heating (rated)	MWth	160
Oxygen concentration in feed water	ppm	0.02
Evacuation time of steam turbine plant (1 atm to 300 mbara)	min	< 30
Design Features		
Number of steam turbines		1
Number of steam admissions		To be optimised by Bidder
Number of steam extractions for District Heating		To be optimised by Bidder
Expected operating life	hours	≥ 210'000
Expansion line end point (ELEP) (condenser vacuum)	$mbar_a$	To be optimized by Bidder
Feed water temperature control (HRSG inlet)	-	Yes
Deaereated water storage tank capacity Retention time at max. output capability *(net storage volume of the tank shall allow for 10 min supply at no inlet flow to the tank)*	min	> 10
Location of installation		outdoor with removable enclosures

Table C- 10: Data Steam turbine

The steam turbine shall be a three-cylinder configuration operating at a nominal speed of 3'000 rpm. Alternatively a two-cylinder configuration such as single HP cylinder and combined IP/LP cylinder could be considered.

Casing:

The HP turbine section shall be of double casing design. The LP cylinder inner casing shall be designed with slits and/or openings to facilitate the removal of condensate from the wet steam and for discharging it to the condenser effectively. The LP casing shall incorporate an exhaust spray water cooling arrangement to allow the unit to run for extended periods at low loads.

Steam extractions for District Heating shall be considered in the design of the casings.

Bypass:

The turbine and the steam system, respectively, shall be provided with bypass facilities in order to

- be used during steam turbine and HRSG start-up and shut-down procedures,
- maintain the steam supply to the District Heating condensers without restrictions in case of steam turbine trip during co-generation mode and
- direct the exceeding steam at all pressure levels to the condenser in case the steam turbine is tripped due to any reason (in cogeneration mode as well as in condensing mode).

Due to the fact that no bypass stack is required the turbine bypass system shall be able for long time operation without restrictions.

Auxiliary and related equipment

The ST unit will be equipped with all necessary systems for reliable and safe operation according latest standards, like the lubrication and hydraulic system, gland sealing system, barring gear, the control system, enclosure etc.

Control system:

A digital electro hydraulic governor/control system shall be provided for speed control during run up and for load-frequency control during normal operation. The electronic controls comprising the governor/control shall be completely integrated into the DCS. This is a requirement to facilitate coordinated control of the HRSG turbine generator unit and the steam bypasses, for all operating modes including gas turbine load following operation. Turbine Control System shall incorporate also control of the heat supply to the District Heating System.

The governor response shall be sufficiently rapid to prevent action of the over speed emergency governor in the event of a full load rejection. The active droop setting shall be adjustable.

An automatic sequencing system shall be provided for the steam turbine. Its duty is to assist the operator in the co-ordination of the starting and shutdown of the various auxiliary systems such as lubrication, turning gear, drains, gland steam and extraction steam, in addition to the supervisory system. It shall form part of the DCS system.

Protection:

An emergency over speed governor shall be provided to protect the turbine against over speed in the event of any failure of the normal governing scheme.

A turbine protection system shall be provided to protect the turbine from any hazardous operating condition by either tripping it or by initiating the unloading procedure. Being a critical system, it shall be engineered with adequate triple modular redundant (TMR) system to ensure reliable trip action and to minimize the possibility of spurious trips.

Condenser and Feed Water System

The condenser shall be of the surface type arranged for circulating water cooling in conjunction with a cooling tower, preferable of hybrid, mechanical draft type. The condenser shall be capable of effectively condensing all the steam exhausted by the turbine at its rated output whilst achieving the design back pressure in condensing mode operation. The condenser shall be appropriately designed to ensure continuous operation during steam bypass mode at full HRSG steam production for extended periods.

Means shall be provided to avoid damage to condenser internals from impingement of flashing steam and incoming condensate or spray water.

A cleanliness factor of not more than 0.85 shall be used for design proposed with the H.E.I. code or equivalent approved code. Automatic cleaning equipment shall be provided for cleaning the condenser tube internals whilst on-load.

Air removal equipment for the condenser shall be included and sized to reduce the condenser pressure from atmospheric pressure to a pressure of 300 mbara in less than 30 minutes.

Condensate extraction pumps are required to transport condensate from the steam turbine condenser hotwell to the feed water storage tank. A deaerator shall ensure residual oxygen content and free carbon dioxide content as in the limits recommended by HEI. A storage tank for deaerated water shall be foreseen with a capacity to ensure a retention time of at least 10 minutes without condensate and make-up water supply. Alternative with storage tank and deaerator combined with LP drum in the HRSG may be proposed, if the above requirement will be fulfilled.

Fully redundant (2x100%) feed pumps at each pressure level shall be supplied with feed water through vertical down comers from the deaerator storage tank and shall pump water through a feed water pipe work to the HRSG.

The condensate preheater inlet water temperature shall be sufficiently higher than the moisture dew point temperature of the flue gas during all operating loads.

4.4 District Heat Supply

The CCPP Skopje will provide thermal energy to the existing district heating system ‘ISTOK’ of Toplifikacija AD, which currently produces and distributes district heat to their consumers in the city of Skopje (See chapter 3). After commissioning of the new CCPP Skopje about 64 % of the necessary district heat energy of the city should be provided by this particular plant.

Under normal weather conditions the new CCPP Skopje will completely replace the current heat production of the existing heating plants. Depending on the requirements of the existing district heating system the necessary heat will be supplied from the CCPP through hot water pipes directly to the header of Toplifikacija heat distribution system. At this interface also the cold district water (temperature about 60 °C) will be taken over and fed into the heat exchanger of the CCPP. This heat exchanger will be capable to heat the water from 60°C to about 93 °C. The peak heat extraction from the new CCPP should be about 160 MW_{th}.

4.5 Balance of Plant

4.5.1 Fuel Supply

Natural gas is considered as the only fuel for the operation of the CCPP Skopje. The plant will be supplied with Russian gas from a nearby high pressure pipeline. The gas supplier will be GASITERA Suisse AG. A second supply agreement with BULGAR GAS, Bulgaria is currently und negotiation. The specification of the natural gas which will be used as fuel in the planned CCPP Skopje can be found in Table C- 11.

The fuel gas is currently delivered with a pressure of 12 bar. This gas needs to be measured, filtered and compressed to suit the gas turbine needs. As an alternative, a new 40 bar gas pipeline may be built. In such a case the fuel gas compressor, which is a high cost item, can be omitted, saving costs and improves the net performance of the power plant, making it even more environmentally friendly.

Combustion calculation for					LHV in MJ/kg	49.3
Fuel:	**Natural Gas**				LHV in MJ/Nm³	36.0
with following composition					Input MW th.	440.3
		% vol				% vol
Methan	CH4	98.13	Hydrogen	H2		
Acetylen	C2H2		Oxygen	O2		
Ethylen	C2H4		Nitrogen	N2		0.78
Ethan	C2H6	0.70	Carbon oxide	CO		
Propen	C3H6		Carbon dioxide	CO2		0.04
Propan	C3H8	0.24		H2S		
Buten	C4H8					
Butan	C4H10	0.09				
Pentan	C5H12	0.02	Hexan	C6H14		0.006
	Sum:	100.0				
air ratio:	3.1	H2O in air:	0.006	O2 in air	21%	
Fuel (Nm³/h)	44'000	kg/h	32'133	Density (kg/Nm3)	0.730	

Table C- 11: Natural gas composition for the CCPP Skopje

4.5.2 Cooling System

A hybrid cooling tower fulfils the water and plume requirements. To a wet cooling tower, where cooling water is pumped from the cooling tower through the condenser back to the top entry of the cooling tower, where it is sprayed downwards against an air flow, a dry part is added. There, the warm water returning from the condenser is cooled by a water/air heat exchanger before proceeding into the wet part as described above.

The warmed air from the dry heat exchanger is mixed with the damp air from the wet part, bringing the mixture to a temperature above its dew point. This will suppress the plume to some extent and minimize the evaporation of water. The evaporation losses are made up with clean water.

4.5.3 Water Supply

Three potential water sources are available on site:

- City water (potable) network, limited flow only
- Deep well on site (clean groundwater), current deep well with 40 to 85 m^3/h, two additional deep well may cover all power plant needs.
- River water from the Vardar River (sometimes questionable quality), available in sufficient quantities for cooling tower make-up.

The principle of the water supply system is shown in

Figure C- 6.

Potable water for lavatories is recommended to be taken from the city water network. This ensures supply of the required water quality

The raw water for the demineralization shall be taken from the existing deep well of the DHP. For this purpose a sufficiently high amount is available all year. The high quality of this water allows producing demineralized water with a simpler water treatment plant and saves on chemicals.

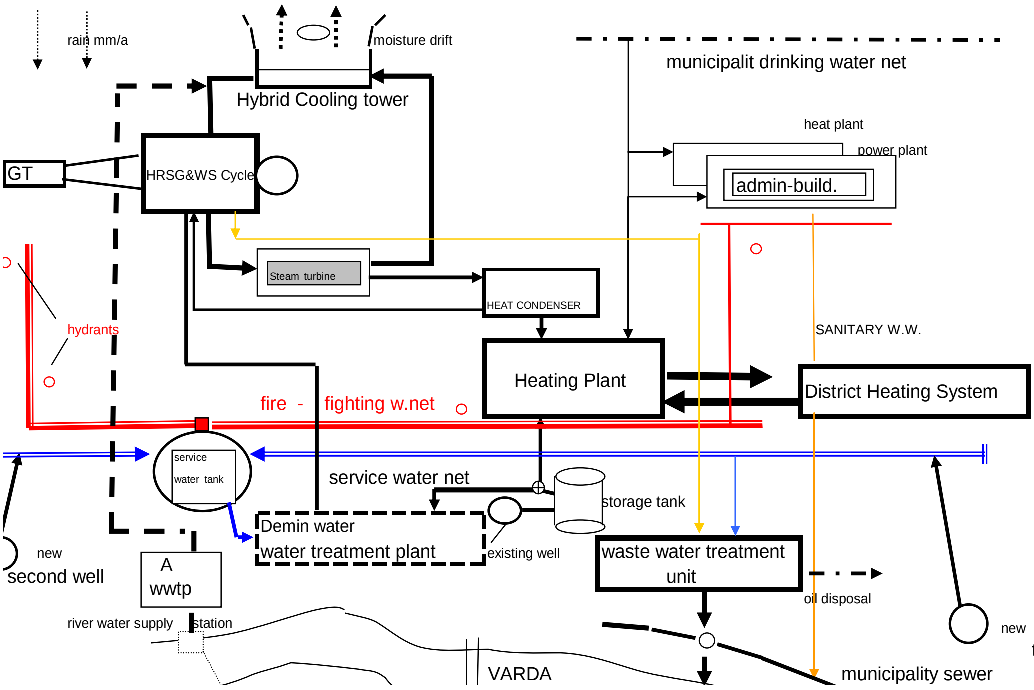

Figure C- 6: Water Supply Scheme

The cooling tower make-up water is recommended to be fed from two additional deep wells on site and during summer month from the existing deep well. Using deep well water omits a large raw water treatment plant, and helps to keep the chemical consumption of the cooling tower low.

In case of insufficient capacity of the deep wells, alternatively a river water intake shall be considered and offered as an option. In order to keep the impact on the river low, a low water intake screen (Johnson or Taprogge) shall be used with an underground pipe to the pumping station on the river bank. River water shall be used as a back-up solution only as the potential contamination with a number of different contaminants require a sophisticated water treatment plant on order to fulfil basic requirements for cooling tower make-up. Such water treatment would increase the investment costs and the operational costs due to the chemical consumption.

4.5.4 Wastewater Discharge

Process waste water:

Process waste water will be treated in separate streams as deemed necessary before it is collected and discharged into the Vardar River. The treatments shall ensure that the waste water composition stays within the discharge limits. The waste water streams are treated as follows:

Potentially oil contaminated waste water such as

- Rain water and fire fighting water from transformer areas,
- Floor drains from turbine hall and workshop

shall be conducted to an oil separator that shall reduce the oil content in the waste water to 10 mg/l.

Hot waste water with potentially high pH such as

- boiler blow down
- steam / water cycle drains

shall be cooled and neutralised as far as needed to fulfil the discharge requirements.

Contamination of TRO (total residual oxidant), i.e. chlorine can be expected in the

- cooling tower blowdown water

In case the content is above the discharge limits, addition of a reducing agent, e.g. bisulphite shall be foreseen.

Other contaminated waste water in small quantities such as

- GT compressor washing water
- boiler cleaning water

shall be collected locally for external disposal by a licensed company.

Sanitary Wastewater:

Sanitary wastewater will be collected by a separate duct and discharged to the municipal sewerage.

Other Wastewater:

A rainwater retention bund is foreseen. Fire fighting water will be collected in a separate disposal system, covering all relevant areas of the plant and collecting in new retention bunds. Only after analyses have proven that the water complies with the standards it will be discharged into the wastewater system. Otherwise the contaminated water has to be specially treated and disposed of by a licensed company.

The EU rules will be redeemed for the given environmental discharge limits, especially concerning oil, pH and heavy metals and for temperature. The discharge temperature will normally not exceed 40°C. The requirements not to exceed the river water temperature by more than 0.6°C above normal temperature will be obtained.

Summarising, it can be stated that due to the cooling concept, low water consumption and wastewater treatment according state of the art the environmental impact from the water side will be kept low.

The waste water composition can be checked any time from a representative sample take by a composite sampler which shall be installed at the waste water outfall to the river.

4.5.5 Emission Monitoring

The emission monitoring system (EMS) shall monitor all relevant emissions and shall collect the needed operational and reference values. As today for both - in situ and extractive measurements - reliable instruments are available, the choice shall be left to the EPC contractor to select a proven system. The local rules and the following requirements shall be fulfilled:

A continuous Emission Monitoring System (EMS) has to be installed for the concentrations of

- nitrogen oxides NOx (= NO + NO2 as NO2)
- carbon monoxide CO

The NOx concentration may be measured as NO (and corrected mathematically for NO_2) if NO_2 part in total NOx is below 10 %.

Additionally, the process parameters

- O_2 in flue gas
- flue gas temperature
- flue gas pressure
- water content in the flue gas (not needed in case the flue gas sample is dried before entering the emission analyzers)

shall be monitored continuously.

As it is about a gas turbine plant, the EMS must not include analyzers for SO_2 and dust. The emission monitoring system shall include a storage and calculation unit for the registration, storage, evaluation and presentation of the emission data in accordance with the requirements of 2001/80/EC.

4.6 Electrical Systems and Power Transmission

The gas turbine's generator and steam turbine's generator will be electrically connected to one common step-up transformer designed as a 3-winding type. The connections between generator terminals and the medium voltage (MV) windings of the step-up transformer shall be done as insulated phase busducts (IPB) and each shall be equipped with a generator circuit breaker (GCB). The high voltage (HV) winding of the step-up transformer shall have bushing terminals for connection with the outdoor air insulated switchgear of either 110 kV or 400 kV, depending on the chosen system voltage to be connected to, as described here below.

Since the heating plant 'ISTOK' is currently not supplying any electrical power to the grid a complete new interconnection has to be planned for the considered CCPP Skopje. Based on several investigations performed by the local engineering company TIMEL the following measure could be possible:

- Interconnection of the plant into existing 110 kV distribution substations or to an existing 110 kV transmission line.

- Interconnection of the plant into the existing 400kV transmission system.

110 kV System:

The power evacuation of the CCPP on 110 kV level can be done either by an Overhead Line (OHL) or by underground cable interconnection to the Distribution Substation 'AERODROM' (about 2,3 km distance), and / or by an interconnection to the Distribution Substation 'ISTOK' (about 3,6 km distance).

400 kV System:

The 400 kV switchgear in 'Skopje 4' has no possibility for a direct connection because it has no free feeder bay available and also the busbar can not be extended at either side.

However, currently the connection possibilities into a 400 kV overhead line or into a parallel 110 kV overhead line are under investigation. Both transmission lines are passing in a distance of about 8 km south-east of the intended CCPP Skopje.

The Figure C- 7 below shows the locations of the CCPP and the transformer stations.

Figure C- 7: Location of the existing Transformer Stations and of CCPP

4.7 I & C System

The I&C system concept is based on the following main requirements:

- One Distributed Control System (DCS) for the whole power and heat producing process with its sub-systems
- Microprocessor based DCS
- Maximum safety for personnel and equipment
- Safe, reliable, and efficient operation under all conditions
- Very high availability of the power plant
- High degree of automation
- Providing all data required for operation, maintenance, and performance optimization
- Hierarchical structure of the control functionality
- Quality of proposed design extensively proven

The DCS is intended as a fully integrated control, monitoring and supervising system, with flexibility and openness for future modifications or extensions. The general scope includes:

- Redundant Process Control Stations with input/output-interfaces to the process (instrumentation, motors, drives etc) and processors performing drive and group control functions
- Redundant plant bus system based on industrial standards
- Operator Stations based on client/server structure with redundant severs and LAN (terminal bus) between server and clients
- Redundant terminal bus
- Human-Machine-Interface (HIS) by means or TFT-screens, keyboards etc.
- Engineering Station for system diagnosis, configuration and documentation

The Power Plant shall be operated under all conditions such as normal power operation, cold and warm start-up, load rejection, island operation, disturbances, and shut-down in fully automatic mode or remotely controlled by the operator from the plant control room.

All open loop and closed loop control systems shall be based on digital control software functionalities with hot-standby redundancy.

Redundancies provided within the process and/or instrumentation shall be followed and considered in the DCS to further improve the overall system availability. The single failure criteria shall be consequently applied throughout the entire design and implementation. In other words, a single failure in any part of the DCS shall not lead to a trip of a plant main component. All measurement circuits which could ultimately lead to a unit trip shall be based on 2 out of 3 measuring circuits voting and shall be controlled by a reliable protective fail-safe and fault tolerant Emergency shut-down system (ESD) in conformance with international standards such as IEC 61508 and SIL 2.

The Power Plant process including common equipment and all electrical and BOP systems shall be operated, monitored and supervised from the same common HSI located at the plant control room. The operator obtains the complete information via Operator Stations in the plant control room, such as:

- Operating status of the power plant
- Operating status of each and every component and sub-system
- Abnormal operating conditions
- Critical operating conditions
- Failure of components and / or systems
- Trending, logs, long term data storage, historical data analyzing
- Alarm and event display, etc.

Hardwired trip push-buttons for the gas turbine and for the steam turbine shall be provided in the plant control room.

The DCS architecture shall be of hierarchical structure and shall cover functional process areas/segments. As a minimum each of the following functional process areas shall have its own dedicated Process Control Station:

- Gas Turbine
- Heat Recovery Steam Generator
- Steam turbine
- Water/steam cycle incl. district heating control and interface facilities
- Balance of Plant (BOP) systems and Electrical equipment, incl. interfaces with existing district heating plant and interface with the Transmission System Operator's control centre

For some ancillary process systems, separate package systems (autonomous sub control systems, also called Blackbox-systems) with extended interface functionality to the DCS shall be provided, e.g. by means of package system specific dedicated PLC's with local control facilities.

4.8 Civil and Arrangement

4.8.1 Plant Arrangement

The arrangement planning for the Combined Cycle Power Plant Skopje and its single components considers – as far as already known – the following criteria and aspects:

- two separate entrances
- gas station in North East corner next to road
- all units (except existing well) to be placed in Northern part of site
- step up transformer near to switch yard area
- two new locations for deep wells
- cooling towers (long solution parallel to heating plant side)
- parking , guard house, administration facilities, workshop to be considered as well
- crane rail for un- and off loading to be provided on each side of turbine hall complex
- fencing around each plant plot
- cooling tower location arrangement and main wind direction(vapour impact to be minimized)
- noise from cooling towers (impact to noise insensitive facilities to be kept low)
- interconnections (location of all supply- and discharge systems, especially the district heating pipe system, the connection to the HV grid and gas supply net),
- technological aspects (shortest ways for all energy mass flows within water/steam cycle)
- maintenance requirements (easy access to all components)

The HRSG unit is foreseen in an outdoor arrangement. The gas turbine and steam turbine set will be installed as outdoor arrangement with removable enclosures. The DCS system and the electrical modules will be placed indoor. The step up transformer shall be implemented as 3 winding transformer due to very narrow space condition

An internal road network for the existing heating plant next to the plot area of the power plant is already integrated. This will be connected to the city street net of Skopje

The following Figure C- 8 shows the proposed plant arrangement from a wider point of view in correlation to the overall industrial plant area.

1	POWER CONTROL CENTER
2	POWER CONTROL CENTER FOR COOLING TOWER
3	LV - AUXILIARY TRANSFORMER
4	LOW VOLTAGE TRANSFORMER
5	HV - AUXILIARY TRANSFORMER
6	GENERATOR TRANSFORMER
7	STRUCTURE FOR OIL COLLECTING PIT
8	GENERATOR CIRCUIT BREAKER
9	GAS REDUCING STATION
10	GAS COMPOUND PREHEATER, FILTER
11	RAW WATER TANK
12	DEMINERALIZED WATER TANK
13	WATER TREATMENT PLANT
14	STRUCTURE FOR MAKE UP WATER TREATMENT
15	STRUCTURE FOR SEWERAGE PLANT
16	HEAT RECOVERY STEAM GENERATOR
17	AUXILIARY BOILER
18	FEED WATER PUMP BUILDING
19	STEAM TURBINE BUILDING
20	GAS TURBINE BUILDING
21	PIPING AND CABLE BRIDGE
22	COOLING TOWER STRUCTURE
23	COOLING WATER PUMP STRUCTURE
24	FIRE PUMP HOUSE
25	CIRCULATING WATER PIPING SYSTEM
26	GAS STATION
27	WORKSHOP
28	GUARD HOUSE

Figure C- 8: Location of Plant Equipment

The Combined Cycle Power Plant under the described concept will occupy an overall footprint area of approx. 1.2 +0.4 ha after it was decided to replace the existing two 5000 m^3 tanks to get a suitable construction site size. While performing the detailed arrangement design the proposed preliminary arrangement plan will be further optimised and coordinated with the EPC Contractor.

4.8.2 Buildings

Soil Conditions

The proposed power plant unit as well as the existing heating plant lies in the river regime of the River Vardar with sedimentation over the geological periods. Thus one founds under a 30 cm Top soil layer course sand and gravel and granular material down to deep horizon with proper bearing capacity. Only in the first 3.0 m depth below the ground level clay lenses may be found which requires a proper soil exchange with suitable compactable borrow material. A special investigation by the EPC contactor has to be undertaken prior to project start

The existing stack was founded on a concrete block and the several stores high buildings in the neighbourhood have been erected without piling works.

According to this conditions and findings it is recommended to use shallow foundation for the structures of the power island and the cooling tower and single or strip foundations for smaller buildings. The tanks shall be founded on concrete slabs.

TOPLIFIKACIJA will timely perform further soil investigation on own behalf prior to the start of the construction period, comprising activities such as test drills and corresponding analysis and a pump test for the planned well for back filtrated water in the regime of river Vardar.

Foundation

According to the above said and the final result of the soil investigation report 3 meter soil exchange (if necessary) in the upper soil layer are deemed to be sufficient as base for the reinforced concrete slabs for the heavy construction and mechanical and electrical components as turbines, generators, the HRSG and substructure for the overhead crane . Vibrating equipment foundation shall be implemented separately from the hall floors. Embedded steel parts for the anchoring of heavy rotating equipment shall be integrated into the reinforcement of the concrete blocks.

Structural and Architectural Design of the Buildings and Structures

The principle implementation concept has

- single separate buildings (BOP units and guard house) with own accesses, the power island complex with
- outdoor structures as the HRSG and step up and auxiliary transformers; the cooling tower and
- indoor facilities enclosed by the turbine hall complex consisting of a GT hall and ST hall , separated by a fire resisting wall and equipped by a overhead crane for both units running with its bridge track over the roof top of both turbine units. Some units as control room and power control centre shall get an own annex building to the power island complex.

The necessary buildings and the main structures of the power station are compiled in the following Table C- 12:

Building / Structure	Enclosed Facility	approx. Dimension / Size	Type of Construction
1. Main Units Power Island			
turbine hall complex	GT ST generators	22x 30x12 air inlet on top 22X30 X20	concrete foundation slab structural steel skeleton, steel panel walls insulated roof panel partly removable fire retention wall, ventilation, laydown areas below crane, evtl lowest side walls up to 2m brick masonry
HRSG	outdoor structure with stack	45x12x 35 Ø6m	concrete base slab, structural steel for load carrying parts, side insulation panels
Power control centre as annexes	electrical features	12x12x5 and 6x3x5	structural steel skeleton wall & roof panels
control room with admin facilities as annex	DCS and monitoring system, meting room social facilities , offices, etc	8x15 x9 with 4 floors	concrete foundation, walls , interim deck and roof, cable floor, air conditioning

feed water pump building as annex next to HRSG	fed water pump and hoist	7x18x5	concrete base slab walls and roof
heat condenser building	condenser, pipe equipment pumps, etc	15x10x5	structural steel skeleton wall & roof panels, ventilation
Transformer foundation and fire ret. walls	step up and auxiliary transformer	300 m2	concrete base slabs and walls, oil retention pits
2. BOP Units			
cooling towers	pipe distribution system, electrical driven vents	70x14x15	concrete wall elements base chamber of concrete, wall lamella elements
gas station	metering station pressure reducing station low voltage and control system	12x9,20x3.20	concrete foundation slab walls and roof structure
water treatment building	demin water system, pumps , neutralization tanks, etc	28x10x8	concrete base slab, strip foundation, pre-cast concrete wall elements, steel roof panels
fire fighting water station	fire fighting water pumps (diesel, electrical, jockey p.)	3x2.20x3.5	concrete block foundation for diesel pump, concrete basement slab, noise insulated wall and roof panels
3. Other			
Tanks	Service water tank & demin water tank	Volume according calculation	concrete base slab
well stations (2 new)	deep water well with pump	2.2x2.2 4 two times	concrete base and pump block foundation steel structure insulated against noise, steel cladding
pipe rack	basement for cable and pipes	diverse	steel structure ladder handrails. Concrete pedestal foundations
oil collection pit	leakage oil	70 m3	concrete with protected wall coating
workshop and storage building	electro mechanical tools , crane , ventilation	16x9x7	concrete base slab, structural tell skeleton, fire retention wall separator between units steel girders for roof substructure roof steel claddings.
Waste water treatment	tanks and pipe system	area for plant staff and maintenance personal sanitary facilities	concrete collection pit pipes and tanks
4. Civil Work Portions			
site preparation, destruction of structures, removal of surplus material, interim surface water handling,			
excavation and soil exchange and diverse earth work			Quantities acc. offer EPC Contractor
Foundation work and substructure piping			“
road work and pavement			“

structural work on shell and core	“
Facades and enclosures, including necessary insulation	“
Finishing (plastering , painting, corrosion protection)	“
landscaping, fencing	”
provision of furniture	

Table C- 12: Buildings and Structures

5 Operational and Maintenance Aspects

5.1 Operation Regime and Expected Production Figures

The CCPP Skopje is designed for basic load operation with about 8'300 operational hours per year. Depending on the selected gas turbine type by the EPC supplier the gross electrical generation capacity of the plant will be in a range between approx. 220 to 240 MW (net capacity about 214 to 234). In cogeneration operation mode the plant will deliver up to 160 MW_{th} heat energy as hot water to the existing district heating network of Skopje city.

The table below summarises the main operational data of the CCPP Skopje for a maximum plant electrical generation capacity of 240 MW.

	Unit	Data
Plant operational modes: - pure condensing mode - co-generation mode (heat extraction)	 - -	 during April 16 to October 14 during 15 October to April 15
Plant operational hours: - base load operation - condensing mode - co-generation mode	 h/a h/a h/a	 about 8’300 about 5’600 about 2’700
Plant availability	%	90 to 93 (depending on maintenance requirements)
Net electrical power generation: - capacity - annual production	 MWe GWh	 approx. 230 approx. 1’800
District heat extraction: - extraction capacity - annual heat extraction	 MW_{th} MW_{th}	 160 350’000
Natural gas consumption: - per hour - annually	 Nm3/h Nm3/a	 approx. 48’000 approx. 400’000’000

Table C- 13: Main Operational Data of the CCPP Skopje

5.2 Staff Requirements

Under a 24-hour operation scenario of the CCPP Skopje, five shifts have to be considered. The shift crews will work in a rotating 3-shift-mode, altered weekly between the morning- the afternoon- and the night-shift.

Due to the high degree of automation of both plant concepts it can be assumed as suitable that a shift comprises a total of two persons only (one shift manager, one for inspection walks). During the day shift a plant director and one more employee (e.g., a secretary or a clerical employee) will be present to perform administrative tasks.

Consequently a total of 15-20 persons will be permanently employed in the CCPP, whereas the qualifications of all the staff members should be diversified as such, that each shift would be represented by technical disciplines such as mechanical, electrical and I & C.

The following Table C- 14 provides an overview on the staff requirement and their qualifications:

Item	*Description*	*Number*	*Qualification 1*	*Qualification 2*
1	number of shifts	5		
2	number of staff per shift	2	power plant operator / technician as shift manager	craftsman (electricians / mechanics) for inspection walks
3	overall number of staff for shift work	10		
4	administration staff	2	engineer / business administrator as plant director	clerical employee, secretary
5	overall number of staff employed	12	6	6

Table C- 14: Staff Requirements and their Qualifications

During times of increased work load, e.g., during minor service- or maintenance work the Cogen Plant would perform independently, the staff on duty could be supported by shift staff, who are not on duty. Extensive maintenance works, especially if that would require significantly more staff and/or with special qualifications, dedicated crew members can be hired from specialised maintenance companies. For this purpose dedicated service- and maintenance contracts for those important plant components such as for the gas turbine, the steam turbine, electrical and I&C equipment, etc. can be awarded.

5.3 Maintenance Aspects

Dependent on the operation and maintenance conditions, as well as on the overall operation time of a power plant, the power output and the heat rate of the plant will alter due to wear and tear. This effect can be observed especially on gas turbines, whose performance data will be impacted. To minimize those effects, periodic service and maintenance works have to be performed.

Service and maintenance works to the balance of the plant will be conducted in parallel to those services performed on the gas turbine. Major inspection and maintenance works for example on the steam turbine and on the HRSG will be performed in cycles of 6 to 8 operation years.

Within the framework of these inspection works, faulty parts or parts which have consumed their lifetime will be replaced.

All such maintenance works will take place during the scheduled standstill of the plant usually during the summer months.